The effect of rice field conversion and its impact on food availability in North Kalimantan Province

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Abstract. Land use conversion has been well known as the important trigger of climate change issues. However, land use conversion phenomenon in North Kalimantan Province is getting greater to meet the population growth. To find out the effect of rice field conversion and its impacts on food availability, a study of changes in the rice field, changes in rice production, and the effect of changes in the rice field on North Kalimantan rice production were carried out. Quantitative methods of secondary data analysis were carried out to assess rice production and changes in rice field presented in frequency tables, graphs, and maps. Analysis of the effect of the rice field on rice production was carried out using linear regression analysis. The regression analysis shows a relationship between rice field conversion and rice production. This paper aims to examine the trend of broad change rice field, rice production and the effect of a rice field on rice production needs to be done to find a solution that suitable for solving these problems, especially in North Kalimantan Province. The results of calculation regression analysis rice field and rice production shows that in two regencies and one municipality there is significant influence (more 0.05) while for two regencies have no significant influence (with a significance level of less than 0.05) diminish in total area land to rice production. The amount of rice field with rice production in North Kalimantan Province shows that there is significant influence with significance value of 0.269 (more 0.05).

1. Introduction

Indonesia is the 3rd rice producer and the biggest consumption in the world [1]. In 2010 the number of inhabitants in Indonesia more than 220 million people, with the staple food is produced rice by the agricultural sector [2]. Demand for food is remarkably rice expected to increment throughout the years [3]. Population increment is per need of land for development, while rice field does not increment. To meet the problems for land there are changes in the use of land or rice field conversions. Since the worth of the rice field is viewed as lower than that of the non-rice field, the rice field will be changed over into non-rice field to increase its worth [4]. Rice field change will affect various perspectives, including economic aspects for which rice field conversion will diminish rice productions.

Data from The Ministry of Agriculture in 2018 show that the growth of rice field in Indonesia was 12.97%. This implies that the rice field in Indonesia diminishes because of the expanding change of rice field into non-rice field. Rice field conversion does not only occur in Java but in different other islands, including Sumatra, Bali, Nusa Tenggara, Sulawesi, and Kalimantan. The rice field in North Kalimantan Province in 2018 was 13,707 hectares but in 2014 it diminished to 32,072 hectares. This suggests that rice field in North Kalimantan has been diminishing. Population growth is a contributing factor to rice field conversion [5]. The population in North Kalimantan Province in 2020, based on the Population Census 2020 (September) as numerous as 701.8 thousand population comprising of 370.7
thousand male population and 331.2 thousand female population of 701.8 thousand population, 34.59% of the number of inhabitants in North Kalimantan Province is in the Tarakan municipality, and only 3.65% of the number of inhabitants in the North Kalimantan Province is in Tana Tidung regency. During 2010 – 2020, the number of inhabitants in North Kalimantan Province encountered a growth of 2.87%. Population density North Kalimantan Province in 2020 reached 9 population per km². The population density in 5 (five) regencies/municipalities in North Kalimantan Province is very different with the most elevated population density in Tarakan municipality reaching 968 populations per km² and the least in Malinau regency which only reaches at 2 populations per km² [6]. This data indicates that the number of inhabitants has been increasing with the year, while the rice field increasing.

Global climate change issues cannot be dismissed by individuals everywhere in the world, including Indonesia, so that global climate change will be a challenge for Indonesia in accomplishing sustainable food security. Global climate change may cause changes in the factors important in the improvement of farming, for example, changes in precipitation patterns, rising temperatures, changes in air humidity. The changes also impact unfavourable events such as floods, droughts, which can lead to large losses. Various things have been finished by The Government of Indonesia in guaranteeing the supportability of food security, for example, the advancement of rural advances that are versatile to global climate change, foster harmless to the ecosystem cultivating innovations [2]. Diminished area of rice field because of land change will affect a few viewpoints, one of which is the financial aspect specifically a lessening in rice field production. Rice is a need essential since it's anything but a staple food and wellspring of calories for most of the population in Indonesia [7]. Up to right now, rice assumes key part in the food consumption of households. The participation level of rice consumption, both in regency and municipality, has shown an exceptionally high rate, 97 – 100%. It implies that lone 3% of the households do not consume rice [8].

The rice production of North Kalimantan Province in 2018 was 45,063.53 tons (dried milled grain). This volume diminished by 33,357.19 tons or around 11.71% in 2019 [6]. Rice-field conversion has created cumulative effects, which implied that the effect of rice-field conversion on food matters was not perceived during the related years, but also perceived in the future. One of such diminishing rice-field is caused by rice field conversion, which is not relative to the establishment of new rice field. This volume cannot satisfy the need of North Kalimantan Province's people, and to suffice the need the rice must be sent from Java. The rice field production diminish is caused by the rice field diminish.

This paper aims to examine the trend of broad change rice field, rice production and impact of land area on rice production should be done to order to find a solution that reasonable for solving of these problems, particularly in North Kalimantan Province.

2. Methods
The data used as the basis for this present study were data secondary. Data of land use of the 2016 – 2020 period were used to examine rice field conversion supported by land use data gathered from data analysis using geographic information system. The (rice) agricultural production analysis was based on Statistical Bureau’s data. The effect of rice field conversion was examined using regression analysis in which rice field was the dependent variable and the (rice) production volume was the independent variable.

3. Results and discussion
3.1. Rice field land conversion
North Kalimantan Province is one provincial area in Kalimantan Island with a total area of ± 75,467.70 square. km. It is located between 114°35’22’’ – 118°03’00” east longitude and 1°21’36” – 4°24’55” north latitude. At the end of year 2020, North Kalimantan Province is divided into 5 (five) regencies/municipalities, with the total area of each regency/municipality is Malinau regency (42,620.70 km²), Bulungan regency (13,925.72 km²), Tana Tidung regency (4,828.58 km²), Nunukan regency (13,841.90 km²), and Tarakan municipality (250.80 km²). Based on the number of islands,
North Kalimantan Province has 168 islands spread across several regencies/municipalities. 66.67% of the islands in North Kalimantan Province are owned by Bulungan regency. The capital of North Kalimantan Province is Bulungan regency [6]. Map of North Kalimantan Province can be seen in Figure 1.

**Figure 1.** Map of North Kalimantan Province [6].

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Bulungan regency is located between 2°09’19” – 3°34’48” North latitude and 116°04’41” – 117°57’56” East longitude. Administratively, Bulungan regency has been divided into 10 Districts [9]. Tana Tidung regency is located between 6°08’ North latitude and 11°15’ South latitude and between 94°45’ and 141°05’ East longitude and lies on equator line located at 0° latitude line. The Law of the Republic of Indonesia Number 34 in 2007 is about establishment of Tana Tidung in North Kalimantan Province. The district of Tana Tidung from Bulungan parts consist of Sesayap, Sesayap Hilir, and Tana Lia subdistrict [10]. Nunukan regency is located between 115°33’ up to 118°03’ of East longitude and 3°15’00” up to 4°24’55” of North Transversal. It is the most up state's region of North Kalimantan Province. The regency that has been formed in 1999 is the result of the dissociation of Bulungan regency. The regional broadness of Nunukan regency is 14,247.50 km². Administratively,
Nunukan Regency has been divided into 21 districts and consists of 240 villages. Lumbis Ogong Subdistrict is a subdistrict with the highest number of villages than other subdistricts in Nunukan regency [11]. Malinau regency is located between 114°35’22” and 116°50’55” East Longitude and between 1°21’36” and 4°10’55” North Latitude. Malinau regency is one of five regencies that became part of North Kalimantan based on Law Number 20 signed on November 16th, 2012. It has 40,088.38 km² of land and none of the open water area makes Malinau the largest regency in North Kalimantan. Malinau regency was an administrative area of Bulungan regency and became an autonomous region based on Law Number 47 in 1999 and its area is located on the north side of North Kalimantan. The administrative area of Malinau regency consists of 15 (fifteen) districts [12]. Tarakan municipality is located between 3°14’30” – 3°26’37” North latitude and 117°30’50” – 117°40’12” East longitude. Tarakan municipality has 4 subdistrict and 20 villages [13]. The pattern of rice field conversion in North Kalimantan Province in time series can be seen in Figure 2.

It can be seen from Figure 2 that fluctuation in rice field from 2016 to 2020 occurred in North Kalimantan Province, an increase in rice field from 2019 to 2020 occurred in Malinau, Bulungan dan Nunukan regencies, while the conversion from 2019 to 2020 rice field to non-rice field in Tana Tidung regency and Tarakan municipality leads to decrease in its total rice field. Tarakan municipality has the lowest rice field because according to RTRW Tarakan municipality is not to be used as rice field but as economic development area. In the RTRW, the rice field cannot be found in Tarakan municipality because its rice field is part of housing area with low density. Tana Tidung regency has almost no potential in food crop (cereals) sector and has greater potential in plantation.

3.2. Rice production

Rice production is an agricultural activity during certain time and measured in kg, quintal, or ton. In general, rice field production is influenced by various factors, including nature, labour, capital, and management [14]. The natural factor that influences is climate change. Climate change is one of the factors that can cause diminish in rice production in addition to rice field in North Kalimantan Province. In agricultural commodities food crop especially rice, climatic factor is very determined. Other factors such as management land, fertility level and land suitability for agricultural commodities, capital from farmers, seeds, irrigation, fertilization, and harvested area will also affect rice production.

The ability of rice plants to produce unhauled rice is strongly influenced by the growing environment. The more fertile the soil becomes the growing medium for rice plants, the higher the productivity obtained [19, 20]. Provision of ameliorant or soil amendment and fertilizer is an important factor to improve soil conditions and increase land productivity. This material can be in the form of lime or dolomite or organic matter or husk ash and sawdust. Recommendations for the use of fertilizers, if no information on soil nutrient status, the dosage of fertilizer can refer to PHSL fertilizer recommendations or MOA No. 40/2007 and its revisions or other references recommended by the local Dinas/Bakorluh/BPTP. Information on fertilizer recommendations in the revised MOA No. 40/2007 provides of using single fertilizers or compound NPK fertilizers in combination with organic fertilizers [3].

Based on climate data in particular rainfall between 2020, 2018 and 2016 it was found that there has been a change in fluctuating rainfall. For climatological conditions, the average temperature in North Kalimantan Province in 2020 is 27.8 °C, with an average maximum point of 34.6 °C and a minimum point average of 21.2 °C. For rain conditions, the number of rainfalls in North Kalimantan Province in 2020 is 2.356,60 mm with an average number of rainy days of 245 days during 2020. The average temperature in North Kalimantan Province in 2018 is 27.48 °C, with an average maximum point of 35.60 °C and a minimum point average of 21.90 °C. For rain conditions, the number of rainfalls in North Kalimantan Province in 2018 is 3,149.40 mm with an average number of rainy days of 175 days during 2018. The average temperature in North Kalimantan Province in 2016 is 27.70 °C with an average maximum point of 34 °C and a minimum point average of 24 °C. For rain conditions,
the number of rainfalls in North Kalimantan Province in 2016 is 3,598.10 mm with an average number of rainy days of 264 days during 2016.

![Figure 3. Rice production of North Kalimantan Province in 2016-2020 (Source: Primary Data).]

![Figure 4. Orientation map of Delta Kayan Food Estate [17].]

It can be seen from Figure 3 that in general rice field production at North Kalimantan has been fluctuating. The greatest rice field production occurred in Bulungan regency although its production is the highest compared to 3 (three) regencies (Malinau, Tana Tidung, Nunukan) and 1 (one) municipality (Tarakan) in North Kalimantan. This was supported by Delta Kayan Food Estate or DeKaFE.

The Government has also undertaken various breakthrough for conversional of rice field, one of them through the advancement of food estate. Until this point in time, there are 4 (four) programs in 4 (four) regencies that are broad as food estate advancement area, those are improvement of 1 million hectares peatland (PLG) in Central Kalimantan, Merauke Integrated Food and Energy Estate (MIFEE) in Merauke regency - Papua, Delta Kayan Food Estate in Bulungan regency - North Kalimantan, and Jungkat Agri Complex in Kuburaya regency - West Kalimantan [15]. The East Kalimantan food estate proposition arose in 2011 when The Provincial Governor fostered a proposition for a private area that has driven food estate. The Governor set up a most optimized plan of attack interaction to distinguish 100,000 ha of land 'clear and clean' of existing area claims, especially in 'degraded' forestry land, and started to court financial backers. Be that as it may, there were not kidding hindrances for fostering a
private area driven food estate in booming East Kalimantan [16]. Notwithstanding, the food estate programs appear to be not run as expected to form because of different complex limitations. Indeed, even the PLG was stopped because the technology used was dismissed by ecological activists, both at the public and global level [15].

Rice field resource utilization needs to be optimized through the improvement of infrastructure and human resource capacity, as well as the use of technological innovations produced by many research institutions. The consequence of food estate improvement can be a supply of national food security and if excess can be exported. The Regent of Bulungan regency has apportioned a space of 50,000 hectares for DeKaFE in Tanjung Palas, North Tanjung Palas, Central Tanjung Palas, and Tanjung Selor, from which 10,000 hectares were held for immigration land, 8,000 hectares for food estate managed by privately-owned companies (corporate farming), and the leftover 32,000 hectares was the area that has been cultivated by the local community [15]. Figure 4 shows the orientation map of the DeKaFE location.

There are four reasons why Delta Kayan Food Estate is considered to have a decent possibility. To begin with, it is important for the central government program so that supports from the central government guaranteed. The second, Delta Kayan is a prolific area with enough water resources. By setting good irrigation infrastructure, it can be assumed that the farm must be running good. Natural potential also supports. Delta Kayan region has a fairly high rainfall that can dissolve acid content in the soil. The water of the Kayan River is also proved to contain no compounds that could harm the plant. Third, HR is considered adequate. The possibility comes from the transmigrants. In Bulungan, 50% of transmigrants are local people, for example, occupants from encompassing regions who live in three or four families in a single house. Other 50% are those coming from outside Bulungan, from examples from West Java and East Java. The transmigrants from East Java already had good rice field experiences, so they can transmit the technology to the local transmigrants. The fourth, the DeKaFE program has effectively attracted the private sector to invest [17]. As the capital of the most youthful territory in Indonesia, Bulungan regency has several missions to acceleration regional development. Among the missions launched is to adopt the Transmigration program to support food security.

3.3. Rice field conversion and rice production
Based on the above description, the rice field and rice field production in North Kalimantan Province change fluctuation where the rice field increased while the rice production decreased. The effect of rice field conversion on rice production will be examined using linear regression analysis. The results of calculation regression analysis rice field and rice production shows that two regencies (Tana Tidung and Nunukan) and one municipality (Tarakan) there is significant influence (more 0.05) while for two regencies (Malinau and Bulungan) have no significant influence (with a significance level of less than 0.05) decrease in total area land to rice production.

Tabel 1. Results of regression rice field with rice production 2016 – 2020.

| Regency / Municipality | Adjuster R Square | F    | t     | Sig.    | Criteria     |
|------------------------|-------------------|------|-------|---------|--------------|
| Malinau                | 0.7409            | 12.44| 4.84  | 0.0387  | No Significant|
| Bulungan               | 0.9450            | 69.78| 12.61 | 0.0036  | No Significant|
| Tana Tidung            | 0.3250            | 2.93 | 2.79  | 0.1857  | Significant  |
| Nunukan                | 0.1090            | 1.49 | 1.69  | 0.3095  | Significant  |
| Tarakan                | 0.0706            | 1.30 | 2.41  | 0.3367  | Significant  |
| North Kalimantan       | 0.01719           | 1.83 | 1.99  | 0.2690  | Significant  |

Source : Primary Data

Table 1. shows that a general change in the amount of agricultural land with rice production in North Kalimantan Province shows that there is significant influence with a significance value of 0.2690 (more 0.05). Regression results between rice field and rice field production, not everything shows happening significant influence due agricultural land are is only one of factors that take effect.
There are still factors others that can affect number of rice field production, including natural factors (climate and soil), technology, resources human resources. This research using only five years of data because North Kalimantan Province is the newest Province in Indonesia which just ratified in 2012. Statistical analysis of regression that shows a significant value between rice field with rice production, then it can be said that rice field is one of the factors that affect rice field production. The relationship of rice field with rice production is positive, meaning that the wider land, more it will cause rice production is increasing and rice field is narrow increasing, rice production will less. Rice field production is not only affected by rice field but there are other factors. Management of land management, capital, technology, soil fertility, land suitability, climate, seeds, irrigation and fertilization is factor will affect to high and low rice field production.

The change of land use, particularly rice-field that has high productivity, has negative impact on food availability and environmental quality. The effect of rice field conversion could have occurred cumulatively. It means that potential loss of rice field production and crops, working opportunities, and its contribution to PDRB will increase year by year, and such rice-field conversion will not return to rice-field anymore. Rice-field conversion has become serious threat to food security due to its impact on food matters that occur permanently, cumulatively, and progressively. It means that potential loss of crops and rice production, working opportunity, and environmental damages will increase year by year. Such rice-field that has changed into embankment would not return to rice-field anymore. Rice-field conversion has directly reduced quantity of food availability, disturbed stability of food availability, and decreased accessibility to foodstuff as a result of fewer rice field areas for rice cultivation. Therefore, some regulations are required to control rice field conversion to overcome food scarcity. To control such rice field conversion, the economic value of rice-field should be increased at least to approach the economic value of land use by the competitors, which is used as embankment. [18].

4. Conclusions
Rice field fluctuated from 2016 to 2020 occurred in North Kalimantan Province, an increase in rice field from 2019 to 2020 occurred in Malinau, Bulungan and Nunukan regencies, while the conversion from 2019 to 2020 rice field to non-rice field in Tana Tidung regency and Tarakan municipality leads to diminishing in its total rice field. In general rice field production in North Kalimantan has been fluctuating. The greatest rice production happened in Bulungan regency although its production is the most elevated contrasted with the other three regencies and one municipality in North Kalimantan. This was supported by (Delta Kayan Food Estate/DeKaFE). The rice field and rice field production in North Kalimantan Province change fluctuate where the rice field expanded while the rice production diminished. The impact of rice field conversion on rice production will be examined using linear regression analysis. The results of calculation regression analysis rice field conversions and rice production show that two regencies (Tana Tidung and Nunukan) and one municipality (Tarakan) there is significant influence (more 0.05) while for two regencies (Malinau and Bulungan) have no significant influence (with a significance level of less than 0.05) diminish in the total rice field to rice production. that in general change in the amount of rice field with rice production in North Kalimantan Province shows that there is significant influence with a significance value of 0.2690 (more 0.05).

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