CARRYING CAPACITY ANALYSIS OF PADDY FIELD-BASED FOOD AND ENVIRONMENT IN PURWAKARTA REGENCY, WEST JAVA

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ABSTRACT

Food is a basic human need. The provision of food is realized to meet the needs and consumption of food for the community, both individually and households in a sustainable manner. One of the efforts to realize domestic food availability is to maintain and develop productive lands. The purpose of this study was to analyze the rate of conversion of paddy fields on a spatial basis in the 2013-2017 period and the 2017-2021 period in Purwakarta Regency, project land availability and demand for paddy fields in 2045, and analyze the environmental carrying capacity of the district. The research was conducted in January-April 2022, in Purwakarta Regency, West Java, using a quantitative descriptive method using secondary data analyzed with ArcGIS 10.8, Powersim 10, and Google Earth Pro. The results showed that in the 2013-2017 period, paddy fields were reduced into built-up areas of 195.55 ha, and in the 2017-2021 period there was a reduction of paddy fields into built-up areas of 401.83 ha. Based on the spatial planning for the 2011-2031 Purwakarta Regency area, it is planned that there will be a change of rice fields into a built-up area of 3,742.94 ha. Purwakarta Regency will achieve food self-sufficiency if it has at least 14,439.65 ha of paddy fields, or the equivalent of producing 109,427.20 tonnes of rice. In the period 2031-2045 Purwakarta Regency will experience a food deficit and it tends to continue increasing until it reaches 43,527 tons of rice in 2045. The carrying capacity of the environment through the ecosystem services approach in Purwakarta Regency, namely in the form of providing food services in 2021 will reach 142,506.51 tons with food service recipients of 997,869 people. Recipients of food services will continue to increase to 1,095,934 people in 2045. There is a need for policy intervention through policy scenarios for optimizing paddy fields and increasing productivity, or a combination of both, to increase the carrying capacity of food in Purwakarta Regency.

Keywords: *carrying capacity analysis, land use change, Purwakarta, sustainable food*

1. INTRODUCTION

Food is a basic human need. Fulfillment of food is a human right that is guaranteed in article 28A of the Constitution of the Republic of Indonesia 1945. Article 12 of Law Number 18 of 2012 concerning food also states that the government, the central government and regional governments, is responsible for food availability. Provision of food is realized to meet the needs and consumption of food for the community, both individuals and households in a sustainable manner. One of the efforts to realize domestic food availability is to maintain and develop productive land.

Currently, the commodity of rice or paddy is still a major component of the national food security system (Permadi & Sunandar, 2013). It is estimated that around 95% of national rice production is supplied from paddy fields. Only the remaining 5% is produced from dry land. Thus, paddy fields are still very strategic in meeting national rice needs in the future (Setyorini et al., 2010). Waage (2022) states that the agricultural sector and food production can save countries in Asia from famine, as well as help countries and provide food for their citizens.

Topographically, Purwakarta Regency is very suitable to become a paddy field area because it has lowlands reaching 52.60 percent of its area (BPS Kab. Purwakarta, 2021). The agricultural sector contributes significantly to the economy of Purwakarta Regency, which is 6.90 percent of the total Gross Regional Domestic Product (GRDP). This is also confirmed in the document of Regional Medium-Term Development Plan (RPJMD) of Purwakarta Regency 2018-2023, that the development of the food and agriculture sector is a priority for the development of Purwakarta Regency with one of the set targets namely "realizing food security and increasing the competitiveness of agriculture, fisheries, and livestock".

One of the challenges in realizing food security in Purwakarta Regency is competition in the utilization of regional space. Paddy fields are often defeated by spatial interests to accommodate economic development and other investment so the area of paddy fields continues to decrease. The decrease in the area of paddy fields will not only threaten food security but will also threaten environmental sustainability.

However, the assumption that the decline in food is caused by declining rice production in Purwakarta Regency, in fact, has not been seen as a problem because the people's food needs are still fulfilled, and have no significant impact on environmental damage. Therefore, it is necessary to carry out an analysis of the carrying capacity of food and the environment to strengthen the scientific basis for arguing why it is very necessary to protect paddy fields in Purwakarta Regency.

Research on the analysis of food carrying capacity and the environment based on paddy fields in Purwakarta Regency needs to be carried out to find out the portrait of food security and environmental sustainability in Purwakarta Regency in the future. The purpose of this study was to analyze the spatial-based conversion rate of paddy fields for the period 2013-2017 and the period 2017-2021 in Purwakarta Regency, projecting land availability and demand for paddy fields in 2045, analyzing the carrying capacity of the environment in Purwakarta Regency, and formulating strategic recommendations increasing the carrying capacity of food in order to achieve sustainable food security in Purwakarta Regency.

2. RESEARCH METODOLOGY

The research was conducted from January to April 2022 in Purwakarta Regency, West Java (Figure 1). This research is employing quantitative descriptive methods using secondary data. The secondary data used includes spatial data on paddy fields according to the Decree of the Head of BPN RI No.3296/Kep-100.18/IV/2013 concerning paddy fields in 2013 for Purwakarta Regency, spatial data for paddy fields for 2021 for Purwakarta Regency, spatial pattern data of Regional Regulation No. 11 of 2012 concerning RTRW of Purwakarta Regency 2011-2031, population data, Planting Index (IP), Productivity of Purwakarta Regency in 2021, high-resolution satellite imagery of Spot 6 Imagery of 2018, Sentinel satellite imagery of 2017, European Space Agency, as well as administrative area boundaries in 2018 from Indonesia's Geospatial Information Agency. The data analyzed with ArcGIS 10.8 (Irwansyah, 2013), Powersim 10 (Firmansyah, 2016), and Google Earth Pro.

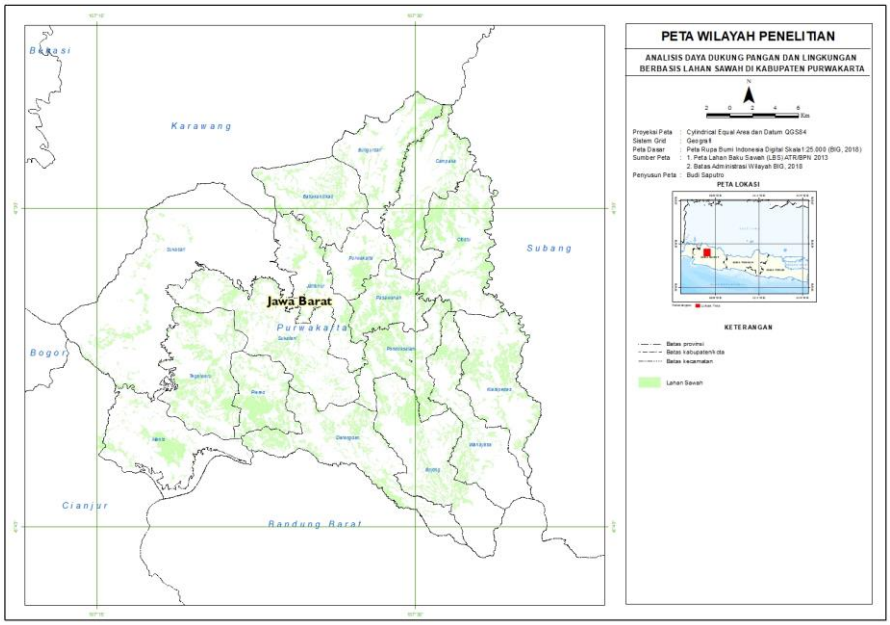

Figure 1. Map of research area

Several analyzes were carried out in this study, including an analysis of the spatial-based conversion rate of paddy fields in 2012-2021, an analysis of the spatial-based conversion rate of paddy fields based on Regional Regulation Number 11 of 2012 concerning the Regional Spatial Plan (RTRW) of Purwakarta Regency in 2011-2031, analysis of the balance of rice fields in 2045 in Purwakarta Regency, availability of paddy fields in Purwakarta Regency, demand for paddy fields in Purwakarta Regency, and analysis of environmental carrying capacity based on paddy fields in Purwakarta Regency. In addition, recommendations for increasing the carrying capacity of food are also formulated in an effort to achieve food security in Purwakarta Regency.

3. RESULTS AND DISCUSSION

The rate of conversion of paddy fields in Purwakarta 2013-2017

One important factor to support food security in an area is the availability of paddy fields. The wider the paddy fields in an area, the higher the food products that will be produced by that area. According to Wahyunto & Widiastuti (2014), if there is no control over the conversion of paddy fields on the island of Java, then the capacity of the island of Java to produce national food will be reduced, thereby threatening national food security, because paddy fields are the main production factor in the food sector (Setyorini et al., 2010).

The conversion of paddy fields to other uses is a serious threat to food sustainability in Indonesia. The conversion of paddy fields has occurred since before infrastructure development in Indonesia developed rapidly. Rice fields were chosen as the object of land conversion because the access is easy to reach. In the period 1981-1986, the conversion of paddy fields in Indonesia reached 37,708 ha per year, while the addition of paddy fields during the same period was only 31,805 ha per year (Hardjoamidjojo, 1997). The conversion of paddy fields in that period showed that 14.54% had turned into settlements. In West Java, during the period 1991-1994 the area of irrigated paddy fields decreased by 90,000 ha (Hardjoamidjojo, 1997). In another study, it was reported that in the period 1992-1999 agricultural land covering an area of 3,134 ha (25 percent) in Bandung

Regency, had been converted into hotels, restaurants, housing, resorts, offices, bare land, and other buildings (Ruswandi et al., 2007a; 2007b).

Based on the results of spatial analysis for the 2013-2017 period, Purwakarta Regency experienced a decrease in the area of paddy fields of 195.55 ha (1%) with details: paddy fields turned into industrial areas of 117.99 ha; paddy fields turned into roads covering an area of 5.72 ha; Paddy fields turned into settlements covering an area of 42.30 ha, as well as paddy fields turning into housing, trade and services covering an area of 29.55 ha (Figure 2). Paddy fields turned into industrial areas occupy the highest rank, namely 60.34% of the total area of paddy fields that were turned into other uses in the 2013-2017 period. Followed by changes in paddy fields into settlements, namely 21.63%. The results of this analysis reinforce the finding that the location of Purwakarta Regency is very strategic because it is located at the confluence between the Jakarta-Bandung route and the Jakarta-Cirebon route, so it has the potential to develop into a new industrial area.

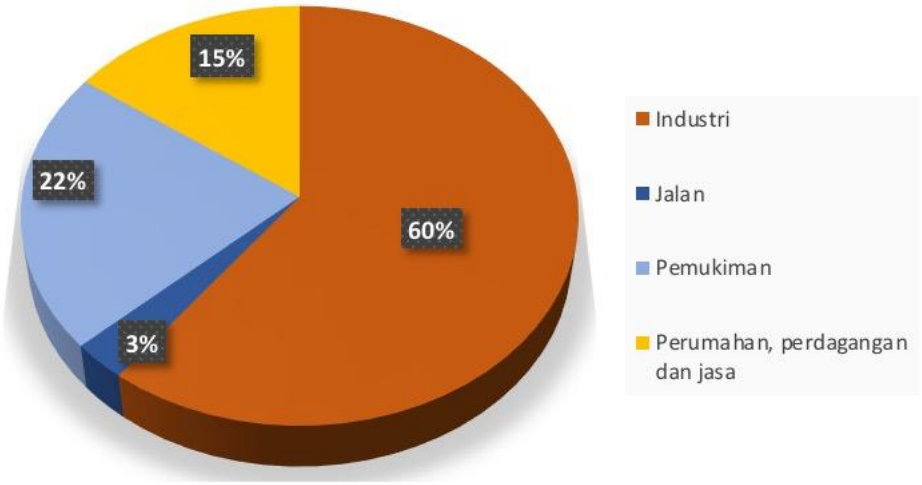

Figure 2. Diagram of changing paddy fields to other uses in Purwakarta Regency for the period of 2013-2017

The pattern of land use change in developing areas is generally dominated by changes to built-up land. Ramadan et al. (2016) reported that in Banjarnegara Regency, the conversion of paddy fields into built-up land ranked second highest, with an area of 570 ha (2001-2008) and 874 ha (2008-2015).

In Purwakarta Regency, paddy fields that turned into industrial areas were spread almost evenly in all sub-districts, where the results of the analysis showed that the largest changes occurred in Cibatu Sub-district, which was 34.38 ha. The same thing happened to paddy fields which turned into community, as well as housing, trading and services. The analysis shows that paddy fields that have turned into settlements with the highest yields are in Purwakarta Regency, which is 15.05 ha, while paddy fields that are turned into housing, trade and services, occur in Campaka Sub-district of 11.05 ha. This change of paddy fields to other uses has a serious impact on the sustainability of food production, because it is permanent where paddy fields that have changed their function will no longer produce food in the long term. Loss of food production resulting from the conversion of paddy fields

is more detrimental than loss of production due to the effects of drought, floods, or due to attacks by pests and plant diseases (Pambudi, 2021).

The rate of conversion of paddy fields in Purwakarta 2017-2021

The results of the spatial analysis of the rate of conversion of paddy fields in Purwakarta Regency for the period of 2017-2021 show that the conversion of paddy fields into settlements is relatively high, namely 196.76 ha. In addition, 151.72 ha of paddy fields turned into industrial areas, 29.81 ha of paddy fields turned into housing, trade and services, as well as 23.54 ha of paddy fields turned into roads (Figure 3).

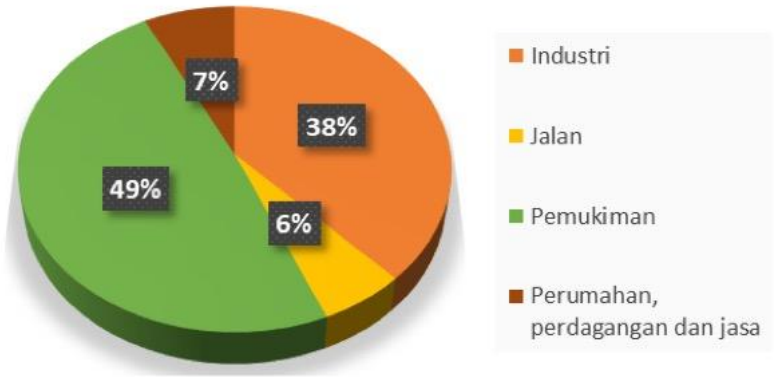

Figure 3. Diagram of changing paddy fields to other uses in Purwakarta Regency for the period of 2017-2021.

Interesting results are shown in the analysis of changes in paddy fields to other uses in the 2017-2021 period. During this period, 2,123.91 ha of paddy fields were converted into bush/shrub areas or 84.09% of the total area of paddy fields which were changed to other uses in 2017-2021. Changes from paddy fields to shrubs are included in the classification of non-permanent changes, so with the support of cultivation technology these bushes can still be restored to function as paddy fields, so that they can contribute to producing food again. There are several factors that cause paddy fields to turn into shrubs, where one of them is the availability of water. If water is not available it will cause the land cannot be cultivated, whereas if there is too much water (continuous stagnation) it will also cause paddy fields to be unable to be cultivated. Paddy fields that are always flooded can cause paddy fields to become shrubs.

The industrial area in Purwakarta Regency has developed rapidly in the last 4 years. This is indicated by the fulfillment of land for industrial areas that use paddy fields covering an area of 151.72 ha. In the 2013-2021 period, 269.71 ha of paddy fields have turned into industrial areas. The data shows that there has been an increasing trend. The same is true of paddy fields that have turned into settlements. In the 2013-2017 period, only 42.30 ha of paddy fields were turned into settlements, while in the 2017-2021 period, paddy fields that were turned into settlements increased rapidly to 196.76 ha or 465% of the total land that was turned into other uses in the 2013-2017 period. the. Meanwhile, paddy fields that changed into housing, trade and services, the increase in changes was very small (Figure 4).

Figure 4. Indications of changes in paddy fields into other uses in the 2013-2017 and 2017-2021 periods in Purwakarta Regency

In the spatial analysis and quantitative analysis reported by Sukiptiyah (2022), the conversion of paddy fields in the 2013-2018 period in West Java in rural industrialized and highly urbanized areas could reach thousands of hectares. Meanwhile, the conversion of paddy fields in industrialized and low-urbanized villages only reaches tens or hundreds of hectares. Referring to this pattern, Purwakarta Regency is an area with low industrialization and urbanization, because the conversion of paddy fields to other uses only ranges from tens to hundreds of hectares. However, if the trend continues to increase, it is very possible that it will develop towards high industrialization and urbanization. This needs to be anticipated and given serious attention considering that the agricultural potential in Purwakarta Regency is very good. Generally, population growth will increase the need for settlement/housing and consumption of agricultural products, so that these conditions can encourage the conversion of paddy fields. The conversion of paddy fields in West Java generally turns into built-up land in the form of settlements/housing and industry/trade (Sukiptiyah, 2022). Meanwhile, Ichwal et al. (2019) reported that the shrinking area of paddy fields for housing and public facilities in Darul Imarah Sub-district, Aceh Besar Regency, was due to its strategic location and also the increasing population growth. Apart from eliminating paddy fields, the housing development has also had a negative impact on the surrounding paddy fields due to the obstruction of irrigation canals which has resulted in these paddy fields becoming unproductive. This can also trigger the further conversion of the function of paddy fields.

In the 2017-2021 period, paddy fields that have turned into industrial areas are also spread evenly in all sub-districts, although significant changes are concentrated in several sub-districts, such as Bungursari, Campaka, Cibatu, Jatiluhur, and Plered. Paddy fields that turned into industrial areas in the 2017-2021 period, the largest occurred in Jatiluhur Sub-district, namely 54.24 ha. Paddy fields that turned into settlement areas, the largest occurred in Purwakarta Sub-district, namely 28.32 ha. Meanwhile, paddy fields that turned into housing, trade, and service were the largest in Campaka Sub-district, namely 19.59 ha.

If the results of the analysis of each sub-district in 2013-2017 are compared with the results in the 2017-2021 period, it can be seen that there is a pattern of regional development centers. Industrial areas are concentrated in several sub-districts such as Bungursari, Campaka, Cibatu, and Jatiluhur Sub-district. In the

2013-2017 period, the Plered Sub-district area was not an industrial area, but in the 2017-2021 period the area developed into an industrial area with an area of 15.34 ha of paddy fields that turned into an industry. Settlement development is centered in the Purwakarta Sub-district which is the capital of Purwakarta Regency. In addition, the development of community settlements is also taking place in Campaka Sub-district. In addition to developing into a settlement area, Campaka District is also a center for housing, trade, and service development.

Campaka Sub-district was originally an agricultural area, then in the early 2000s, it was developed into an industrial area. In 2017 the Campaka Sub-district is growing. Not only as an industrial area but also developing into a center for home industries of handicrafts that are made from industrial waste (https://ppid.purwakartakab.go.id). This indicates that paddy fields in Campaka Sub-district have changed their function to become industrial centers, community settlements, as well as housing, trade, and service areas.

Food carrying capacity of Purwakarta Regency

The food carrying capacity of Purwakarta Regency is illustrated by the balance of paddy fields in the district. The balance of paddy fields in Purwakarta Regency is influenced by two things, namely the availability of paddy fields and the demand for paddy fields. The wider the paddy fields available in Purwakarta Regency, the greater the potential of Purwakarta Regency to produce food and increase its food-carrying capacity. The need for paddy fields is influenced by food consumption per capita of the population. The higher the food consumption per capita, the higher the food needs. Food needs basically do not only depend on the amount of consumption per capita, but also depend on the population. The more the population of an area, the more food needs will increase, even though per capita food consumption remains the same.

The calculation of the paddy field balance is carried out by projecting up to 2045 which is based on Indonesia's 2045 vision in the food sector, namely independent and sustainable food security, self-sufficiency in carbohydrates and protein, and farmer welfare (Bappenas, 2017). In addition, using 2045 as the projection year adjusts to the projected estimate of Indonesia's population in 2045 which refers to Indonesia's Vision for 2045 (BPS, 2018). Analysis of the paddy field balance will also be calculated based on the time period when the Regional Spatial Planning Regulation of Purwakarta Regency is in force, which is 20 years.

The rice field balance category for Purwakarta Regency will refer to the basic representation of the food self-sufficiency category (Clapp, 2015; 2017), which is surplus if the availability of paddy fields is greater than the demand for land; food self-sufficiency occurs if the availability of paddy fields is proportional to the need for land; and, a food deficit if the availability of land is less than the demand for land.

The availability of paddy fields in Purwakarta Regency is influenced by the conversion of paddy fields and the black design of the conversion of paddy fields. Losing paddy fields due to conversion will have a permanent and long-term impact, where paddy fields that have changed their designation will not return to being paddy fields. Thus, these changes are permanent and in the long term will not produce food again. Black design also has a significant effect on permanent reduction of paddy fields. Currently, the existing condition is paddy fields, but in the district spatial planning, it has been allocated for other uses. So, paddy fields in Purwakarta Regency have the potential to massively change their function to other uses. Cases of changing the function of paddy fields to other uses like this do not violate the law. Cases of changes in the function of paddy fields like this are also known as black design over the function of paddy fields.

Paddy field-based environmental carrying capacity

The carrying capacity of the environment basically describes the quality of the environment in an area. The higher the environmental carrying capacity of an area, the better the environmental quality. The quality of the environment is also influenced by the quality of the ecosystem habitat in the region. The type of land use affects the type, nature, and location of the ecosystem. Conversion of land use from land that was initially of high quality to the land of low quality will affect its biodiversity and habitat quality. Conversely, land use with low quality will affect the restoration of habitat quality (Zhang & Lang, 2022).

The carrying capacity of the paddy field-based environment in this study was carried out using an ecosystem service approach in the form of providing food services. One of the ecosystem services according to Millennium Ecosystem Assessment (2005) in the form of provisioning services. The service provision referred to in this study is in the form of food provision. The higher the paddy field is able to provide food for human survival, the higher the carrying capacity of the environment, and vice versa. Food supply services are calculated based on rice production which is produced by the factual area of paddy fields available in Purwakarta Regency. Some of the indicators used to calculate food supply services in Purwakarta Regency are as follows:

1) Paddy field data in 2021 which covers an area of 18,801 ha is used as a baseline.
2) Data on average conversion of paddy fields (0.4 ha per year).
3) The planting index data used in 2021 published by the Purwakarta Regency Agriculture Service is 2.3.
4) Data on crop failures caused by crop pests, floods and droughts, using data on crop failures for 2021 sourced from the Center for Agricultural Data and Information (Pusdatin), Ministry of Agriculture, which are 28 ha each.
5) Productivity data for Purwakarta Regency, which is 5.151 tons/ha (BPS Kab. Purwakarta, 2021).
6) The rice yield data used is the national yield data published by BPS (2018), which is 64.02 percent.

Food supply services are calculated with the help of software Powersim 10 (Firmansyah, 2016), which simultaneously looks at projected food availability from 2021 to 2045 in Purwakarta Regency.

The provision of food services in Purwakarta Regency in 2021 will reach 142,506.51 tons of rice with food service beneficiaries of 997,869 residents. The beneficiaries of this food service will continue to increase to reach 1,095,934 people in 2045 (Tabel 4.10). However, the supply of food from paddy fields in Purwakarta Regency has decreased along with reduced paddy fields and an increase in the number of people who become beneficiaries of its food services.

An important factor in the provision of food as an ecosystem service so that it continues to be sustainable is the existence of paddy fields. The wider the paddy fields that are protected and the more productive the paddy fields in one area, the higher the food production in that area. Thus, the higher the food that can be produced, the higher the provision of ecosystem services, and vice versa. Therefore, it is important for Purwakarta Regency to continue to be committed to protecting paddy fields which are the main capital in providing ecosystem services, so that the carrying capacity of the environment in Purwakarta Regency can be guaranteed.

4. CONCLUSION

In the 2013-2017 period there was a decrease in the area of paddy fields which turned into a built-up area of 195.55 ha, while in the 2017-2021 period there was a decrease in the area of paddy fields that turned into a built-up area of 401.83 ha.

Based on the spatial planning for the Purwakarta Regency for the 2011-2031 period, paddy fields in the area have been planned to be developed into a built-up area of 3742.94 ha.

Purwakarta Regency will be able to achieve food self-sufficiency if the minimum area of paddy fields in the area can be fulfilled, which is 14,439.65 ha or equivalent to a production of 109,427.20 tonnes of rice.
Purwakarta Regency in the 2031-2045 period will begin to experience a food deficit and will tend to continue to experience an increasing deficit until it reaches 43,527 tons of rice in 2045.

The carrying capacity of the environment using an ecosystem service approach in the form of providing food services in Purwakarta Regency in 2021 will reach 142,506.51 tons of rice, with food service recipients of 997,869 people. The number of food service recipients will continue to increase to 1,095,934 people in 2045.

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