# Supply Chain Brown Sugar Agroindustry in Banyuwangi District: Analysis Study with a Dynamic System Approach

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***Abstract*- The purpose of this research is to find out the basic system in the supply chain, and the dynamic system of the brown sugar supply chain in Banyuwangi Regency. This research is a combination of explanatory research and causal research and uses a system dynamics approach by considering the GAP between supply and demand for local markets. Data analysis was performed using a dynamic system simulation using the powers program with a validation test through the calculation of Mean Absolute Percentage Error (MAPE). The final results show that the basic system of brown sugar agroindustry supply chain in the Banyuwagi Regency can be identified as actors, activities, and outputs. Until 2019, the demand for meeting local brown sugar needs is greater than the supply of brown sugar in the Banyuwangi Regency. To accelerate the fulfillment of local needs for brown sugar, it is necessary to increase the productivity of the sap juice subsystem as the main raw material for the brown sugar agroindustry subsystem in the Banyuwangi Regency.**

**Keywords-** *Supply Chain, Brown Sugar Agroindustry, Analysis Study, Dynamic System Approach, Banyuwangi*

## 1. Introduction

Food is a basic need that plays a very important role in the life of a nation. the food security program is directed at the independence of the community / farmer based on local resources which is operationally carried out through a program to increase food production, maintain the availability of sufficient, safe and halal food in each region at all times; and anticipation so that food insecurity does not occur [1]. In Indonesia, the notion of food security is emphasized in PP No. 68 of 2002, where food security is defined as the condition of fulfilling food for households which is reflected in the availability of sufficient food, both in quantity and quality, safe, equitable and affordable. The problem of food security in Indonesia is not only rice as the main commodity, including crystal sugar. Indonesian Central Statistics Agency (BPS) data states that the average consumption of brown sugar per capita between 2007 and 2014 has decreased. The recording of the Indonesian Central Statistics Agency data on average consumption of crystal sugar per capita in 2007-2014 can be seen in Figure 1.

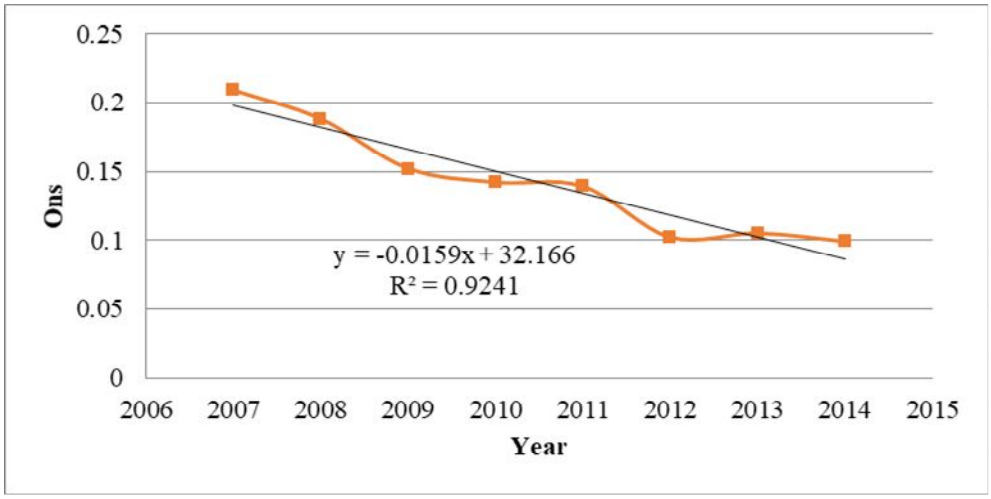


**Figure 1.** Average per Capita Consumption of Crystal Sugar per Capita in 2007 – 2014

In current conditions, demand for brown sugar continues to increase. This increase is due to the increasing population and the position of brown sugar as a substitute item from white crystal sugar available on the market which is still the first alternative in meeting the people's sugar needs. The potential to develop brown sugar as a substitute item makes opportunities as well as challenges in the brown sugar agroindustry in the community [2]. the failure of the sugar self-sufficiency efforts so far shows that the sugarcane-based industry needs to develop alternatives

to meet national sugar needs. Efforts to increase sugarcane production are constrained by the difficulty of developing planting areas, decreasing soil fertility and sugarcane productivity. Distillers are very old and also cannot be replaced with new sugar plants that require a very large investment. This situation causes inefficiency and sugarcane yields have decreased. To meet the needs of national sugar, there is a great opportunity to develop palm sugar as a raw material for the sugar industry [3].

Brown sugar agroindustry is feasible to be developed because it has a large market demand[4]. brown sugar from coconut produced by community groups can lift the economy of the community especially the coconut sugar community [5]. Coconut sugar also has a very good prospect because the world market demand for palm sugar in Indonesia is quite significant [6]. Coconut sugar has garnered attention as being a low-carb sugar substitute that is more nutritious than typical granulated sugar [7]. Brown sugar has a price potential and a broad market because many of these products require starting from households for the soy sauce industry, even overseas markets that are ready to use brown sugar products [8].

The strategy that is considered feasible to be applied to brown sugar agroindustry is concentration through horizontal integration. This strategy aims to expand the business by increasing the amount of production and expanding the market by means of promotion [9]. Development Strategy for brown sugar agroindustry that is increasing cooperation between craftsmen in the development of palm sugar agroindustry and increasing awareness in maintaining cooperation between craftsmen to regenerate craftsmen [10]. The absence of information media processes used by producers can cause the marketing of products to be far beyond the province [11]. The development of good brown sugar agroindustry will involve various parties, namely: Farmers/farmer groups, Cooperatives, Local Government (Office of Plantation and Forestry, Office of Trade and Cooperatives), with different roles [12].

The solution to the problem of national sugar at the production level can be done by finding alternative solutions to replace sugar cane as the main raw material for white sugar. The offer of this solution has not turned into a drug of hope, because of the conversion factor of agricultural land to non-agricultural land and issues related to product distribution [13]. the problems faced by brown sugar producers vary, ranging from the difficulty of getting capital to the problem of information about the selling price of brown sugar [14]. household-scale palm sugar agroindustry has the opportunity to develop and innovate in product marketing [15]. This problem is a problem that occurs in almost all brown sugar agroindustry including brown sugar agroindustry in Banyuwangi Regency.

system dynamics approach in the form of a model that is considered as a representation of the real world [16]. Modeling can be interpreted as a simplification of the real world. The system dynamics approach is expected to be able to provide solutions to complex problems that many agroindustries faces from the upstream to downstream levels. System dynamics are used to see a structure that is the basis of complex situations and identify patterns that cause changes in behavior that occur. the simulation results encourage further improvements to be implemented [17]. Good planning can provide opportunities to choose alternatives or choose the best combination so that providing limited resources will be more efficient .

Supply Chain Management (SCM) deals with managing all activities along the organization's network to provide goods or services to end customers [1-20]. The supply chain is a series of value-added activities that connect suppliers and customers of the company. The current supply chain is a linear economy model that directly or indirectly fulfills supply needs. five main categories for supply chain management that are supported towards SCM collaboration, continuity, collaboration, risk management and proactivity [20-22].

Brown sugar production in Banyuwangi is not only for local consumption, but also distributed to national food companies. The level of brown sugar production in the Banyuwangi Regency to meet industrial needs is still lacking. Complex issues in solving food security problems cannot be solved partially. Resolving the problem of food security means having to solve various problems in various subsystems while still paying attention to relations between subsystems. The system dynamics approach is expected to be able to answer this problem with greater detail and better accuracy. The purpose of this study is to determine the basic system in the supply chain, and the dynamic system of the brown sugar supply chain that exists in Banyuwangi Regency by considering the gap between supply and demand for the Banyuwangi local market.

## 2. Research Method

This research is a combination of explanatory research and causal research which is a combination of secondary and experimental data analysis. Explanatory research with secondary data analysis to find out the basic system in brown sugar supply chain and compile supply chain dynamic models in Banyuwangi Regency, while causal research with experiments to find out the relationship between phenomena by implementing dynamic simulation of brown sugar supply chain system by paying attention to the gap between supply and demand for local market needs in Banyuwangi Regency.

Data analysis was performed using a dynamic system simulation using the powers program with a validation test through the calculation of Mean Absolute Percentage Error (MAPE). An outline of the stages of problem solving with a dynamic system approach is (1) understanding the system to be analyzed related to the situation and condition of the problem, (2) the conceptual system preparation includes identifying the actors involved in the system, identifying the relationships that occur between the actors that are the basis to compose causal loops and need to limit system

analyzed, because a system can be very broad and complex, (3) formulation of models to translate relationships between elements or between actors in the system into programming languages, (4) simulations and validations, models are simulated for seeing how the behavior of the model which is a picture of real system behavior, Therefore, the model that has been made to be imitated must be tested to see whether the model really represents the actual system as a means to study the system.

## 3. Results and Discussion

### 3.1 Basic System of Brown Sugar Supply Chain in Banyuwangi Regency

The brown sugar agroindustry supply chain in Banyuwangi Regency is the primary supply chain, which is a supply chain that involves several actors who are able to change the added value of a product through production activities, among others the sap juice subsystem, the brown sugar Agroindustry subsystem and consumers both household consumers, consumers outside Banyuwangi Regency and industrial consumers. Supply chain flows from upstream in the form of roomie to downstream in the form of brown sugar and its derivative products. *Penderes* roomie groups as well as individually supplying roomie directly or indirectly to the brown sugar Agroindustry subsystem. The basic system of the brown sugar agroindustry supply chain can be seen in Figure 2.

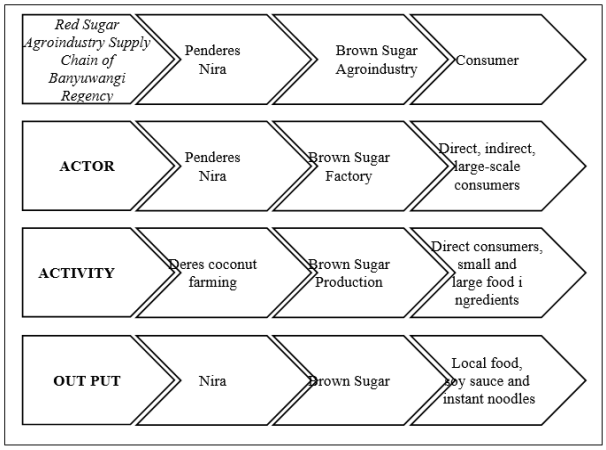


**Figure 2.** Basic system of brown sugar agroindustry supply chain, Banyuwangi Regency

The brown sugar agroindustry subsystem is a producer of brown sugar in Banyuwangi Regency on a household scale or under the auspices of PTPN XII. *Penderes* under the auspices of PTPN XII are given land facilities for dwellers and furnace equipment for brown sugar agro-industry producers to process palm water Brown sugar. In addition, PTPN XII also helps control the quality of the results by applying brown sugar processing management standards to the producers/producers to meet the standards requested by large-scale industrial companies. The brown sugar agroindustry subsystem receives a supply of roomie from farmers and collectors. From an area of 1237 hectares, it is able to produce 68 million liters and is able to be converted into sugar by 4000 tons of brown sugar in 2011. The main activity of the brown sugar Agroindustry subsystem is to process the sap into brown sugar. The highest quality is the quality of non-sulfite (NS) brown sugar which is used for the needs of large-scale industries. The increase in demand for large-scale industrial needs is able to increase the revenue of brown sugar agroindustry because the price level offered is higher than brown sugar that is sold for local needs of Banyuwangi and outside Banyuwangi.

The flow of the supply chain of brown sugar agroindustry in Banyuwangi from the subsystems of sap tappers to producers through collectors with a percentage of 15% indirect and 85% direct. While 82% of the sap juice occupants as well as producers of brown sugar. Of the total production, 60% is for meeting the needs of large-scale industry, 11% is for needs outside Banyuwangi Regency and 29% is used to meet local needs. Local needs are divided into two parts, namely 18% direct consumption and 82% indirect consumption. Indirect consumption is used to meet local Banyuwangi needs such as raw materials for local food and or small-scale industries. brown sugar agroindustry supply chain flow can be seen in Figure 3.

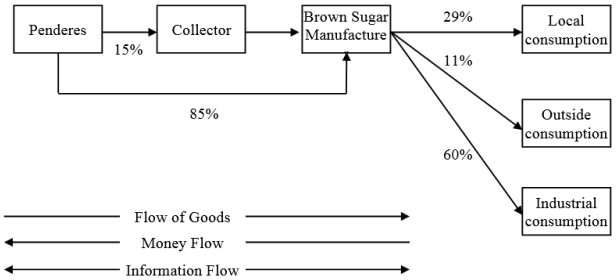


**Figure 3.** Red Sugar Supply Chain Flow Patterns of Banyuwangi Regency

### 3.2 Dynamic system of brown sugar supply chain

The dynamics model of the brown sugar agroindustry supply chain system in Banyuwangi is declared valid because it is based on a validation test of the MAPE value of 8.2%. Model validation is conducted on actual data, namely population, and production data for the last 5 years, from 2011 to 2015. Model validation aims to determine the feasibility of a model that is built and is representative of the reality being studied, so as to produce conclusive conclusions. The formulation of the brown sugar agroindustry model in Banyuwangi can be seen in Figure 4.

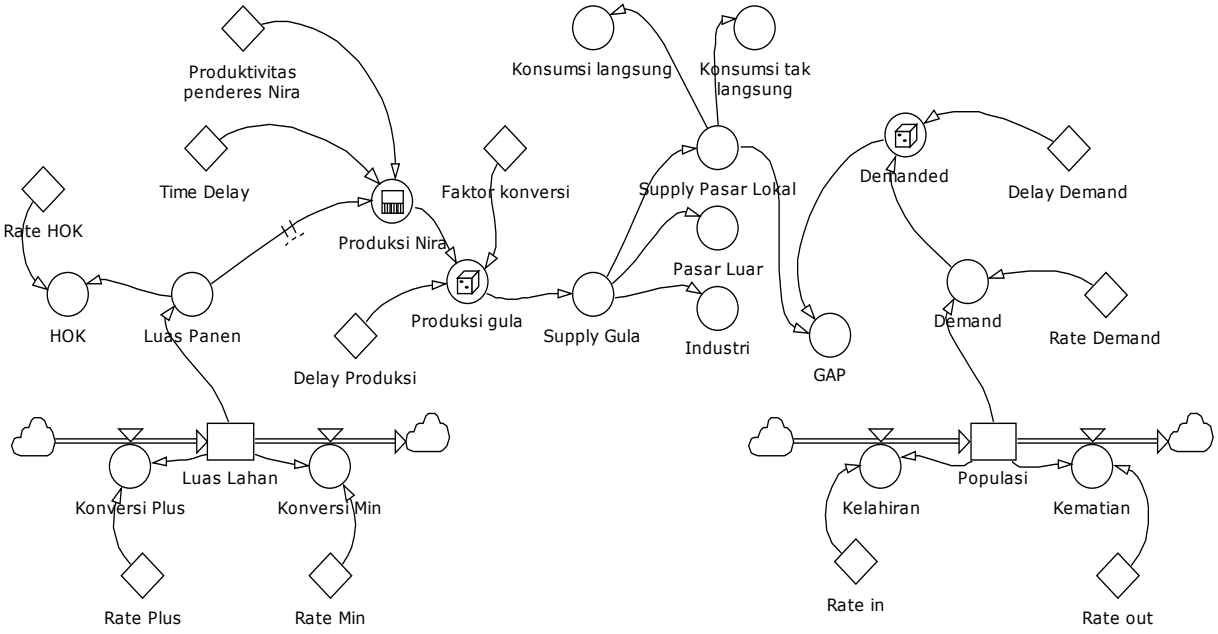


**Figure 4.** Formulation of brown sugar agroindustry model in Banyuwangi Regency

Information about the explanation from Figure 3 can be seen in Table 1.

**Table 1.** information from Figure 3

| No | Variable | Unit | Information |
|---|---|---|---|
| **1** | Delay Demand | week | The average time needed to buy back brown sugar again |
| **2** | Delay Produksi | Hour | The average time needed to do one process of brown sugar production |
| **3** | Demand | Kg | Gross request |
| **4** | Demanded | Kg | Request |
| **5** | *Faktor konversi* (The Conversion factor) | Kg/Liter | Converting juice Nira into sugar |
| **6** | GAP | Kg | Difference between supply and demand for local needs Banyuwangi |
| **7** | *HOK* | Person | Daily work people |
| **8** | *Kelahiran* (Birth) | Person/Year | - |
| **9** | *Industri* (Industry) | Kg | Supply brown sugar for industrial needs |
| **10** | *Konsumsi langsung* (Direct consumption) | Kg | Supply brown sugar for direct consumption |
| **11** | *Konsumsi tidak langsung* (Indirect consumption) | Kg | Supply brown sugar for indirect consumption |
| **12** | *Konversi Min* (Minimal Conversion) | Ha/Year | - |
| **13** | *Konversi Plus* (Maximal Conversion) | Ha/Year | - |
| **14** | *Luas Lahan* (Land Area) | Ha | The area of land in the plant produces 2011 year |
| **15** | *Luas Panen* (Harvested Area) | Ha | Harvested area in year t |
| **16** | *Kematian* (Died) | Person/Year | - |
| **17** | *Pasar Luar* (Outdoor Market) | Kg | Supply for market needs outside Banyuwangi |
| **18** | *Populasi* (Population) | Person | Total population in 2011 |
| **19** | *Produksi Gula* (Sugar Production) | Kg | Amount of sugar production |
| **20** | *Produksi Nira* (Roomie Production) | Liter | Amount of roomie production in the t-year |
| **21** | Produktivitas *penderes* Nira (Productivity of Nira's tappers) | Liter/Ha | The productivity of roomie juice |
| **22** | Rate Demand | Kg/Person | Average demand per person |
| **23** | Rate HOK | Person/Ha | Average workers per hectare |

| No | Variable | Unit | Information |
|---|---|---|---|
| **24** | Rate in | %/Year | Percentage of birth rates per year |
| **25** | Rate Min | %/Year | Percentage of mortality per year |
| **26** | Rate out | %/Year | Conversion of agricultural land into non-agriculture |
| **27** | Rate Plus | %/Year | Conversion of non-agricultural land into agricultural land |
| **28** | *Supply Gula* (Sugar Supply) | Kg | Total sugar produced in Year t |
| **29** | *Supply Pasar Lokal* (Local Market Supply) | Kg | Sugar supply for the integrity of the local market of Banyuwangi |
| **30** | Time Delay | Hour | The time is taken to produce roomie |

### 3.3 Dynamics of supply chain system simulation results

Simulations carried out using the base year being 2011 to 2020. Results from 2011 to 2015 are used to assess the quality of the model being built. The results of the model from 2016 to 2020 are used to predict the difference between supply and demand based on two main things namely, land area on the supply side and population on the demand side. The results of the simulation of the Banyuwangi Regency's brown sugar production can be seen in Table 2.

**Table 2.** Banyuwangi Regency brown sugar production simulation

| Year | Harvested Area (ha) | Sugar production (kg) | *Local Market Supply* (kg) | *Demanded* (kg) | GAP (kg) |
|---|---|---|---|---|---|
| **2011** | 1,273.00 | 4,092,131.60 | 1.,24,890.15 | 1,128,178.65 | -3,288.50 |
| **2012** | 1,278.33 | 4,106,380.20 | 1,128,806.96 | 1,132,076.98 | -3,270.02 |
| **2013** | 1,283.68 | 4,123,552.06 | 1,133,527.35 | 1,136,428.18 | -2,900.83 |
| **2014** | 1,289.06 | 4.140.864,13 | 1,138,286.28 | 1,140,566.03 | -2,279.75 |
| **2015** | 1,294.45 | 4,158,185.59 | 1,143,047.80 | 1,144,968.69 | -1,920.89 |
| **2016** | 1,299.87 | 4,175,597.41 | 1,147,834.15 | 1,149,148.80 | -1,314.65 |
| **2017** | 1,305.32 | 4,193,094.13 | 1,152,643.84 | 1,153,554.59 | -910.75 |
| **2018** | 1,310.78 | 4,210,644.89 | 1,157,468.38 | 1,157,866.97 | -398.59 |
| **2019** | 1,316.27 | 4,228,244.28 | 1,162,306.30 | 1,162,147.77 | 158.53 |
| **2020** | 1,321.78 | 4,245,970.09 | 1,167,178.96 | 1,166,536.58 | 642.38 |

Table 2 illustrates the results of the simulation of harvested area, level of production of brown sugar, Supply for local markets, Demand and GAP in the Banyuwangi district. The results of the test with MAPE were 8.2%. The biggest brown sugar production dispute with real data occurred in 2013 which was 13.21% of the simulation results as a result of the socialization tie conducted by the Banyuwangi Regency government to continue to increase brown sugar production, especially non-brown sugar sulfite which was carried out in 2012. the graph of the results of a simulation comparison between the supply and demand sides of brown sugar in Banyuwangi can be seen in Figure 5.

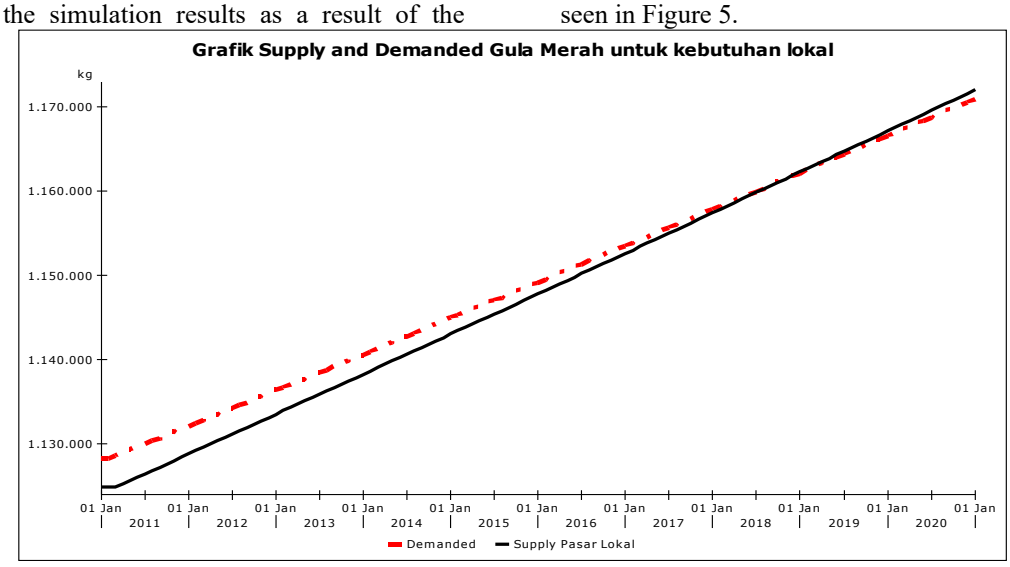


**Figure 5.** Dynamics Simulation of the Supply and Demand System of Brown Sugar

The simulation graph of the dynamics of the supply and demand system of brown sugar in the Banyuwangi Regency shows that the demand and supply patterns continue to increase over time. It is known that between 2011 and 2018 the demand side was greater than the supply side. That is, the production of brown sugar to meet local needs in Banyuwangi Regency is still smaller than the demand for both direct and indirect consumption. In the conditions between 2011 and 2018 to meet the local needs of Banyuwangi, it can be done by finding a brown sugar substitute product. In 2019 until 2020 the supply side is greater than the demand side. This means that the fulfillment of local needs in the Banyuwangi Regency will be fulfilled in 2019. If the conditions in 2019 until 2020 are allowed to have an impact on increasing brown sugar stock. To overcome this problem, the rest of the production for local needs can be diverted to the demand for large-scale industrial needs and demand for needs outside the Banyuwangi Regency. To accelerate the fulfillment of local demand in Banyuwangi Regency, it is necessary to increase the productivity of the sap subsystem to increase the supply of sap to the brown sugar agroindustry subsystem in Banyuwangi Regency. in 2020 based on the simulation results as many as 3584 people for an area of 1327.32 ha.

The main problem faced by the brown sugar agroindustry subsystem is related to the supply of roomie that enters this subsystem. In addition to the quality of the sap which is sometimes low as in the rainy season, there is a decrease in the quality of the sap produced. The result is that only 92% of the sap produced by the sap subsystem can be utilized to the maximum by the subsector of the brown sugar agroindustry. In addition to the supply of roomie, the problem faced by this subsystem is related to the availability of wood fuel used by the brown sugar agroindustry subsystem. The next problem in the brown sugar agroindustry subsystem is related to the equipment in producing brown sugar. Brown sugar agroindustry at the household level still uses makeshift equipment with a productivity level that is still far lower than the productivity of brown sugar agroindustries which is under the auspices of PTPN XII. To overcome this problem, local governments need to take part in increasing access to capital for producers of brown sugar as well as to increase the ability of producers by increasing the ability of actors in the household slake brown sugar agroindustry subsystem. This will have a direct impact on increasing productivity by applying fixed technology to the agroindustry of brown sugar at the household level so that it can meet the requirements demanded by large-scale industries. To clarify the difference between demand and supply in meeting local brown sugar needs in Banyuwangi Regency can be seen in Figure 6.

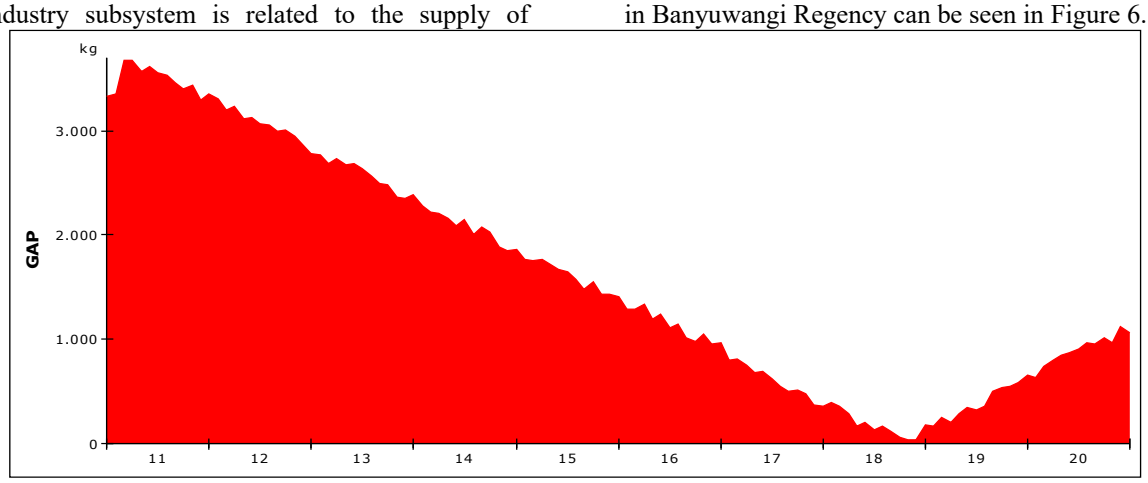


**Figure 6.** GAP Banyuwangi Regency's supply and demand for brown sugar

## 4. Conclusion

The basic system of brown sugar agroindustry supply chain in Banyuwangi can be identified as actors, activities, and outputs. Supply chain actors consisting of brown sugar agroindustry in the Banyuwagi Regency consist of *penderes*, brown sugar producers and consumers. Until 2019, the demand for local brown sugar needs in Banyuwangi is greater than the supply of brown sugar in the Banyuwangi Regency. To accelerate the fulfillment of local needs for brown sugar, it is necessary to increase the area of land and increase the productivity of the tappers.

## 5. Recommendation

So that the results of this study are more capable and broader in generalizing, the conclusions and recommendations in this study need to be justified by conducting further research on similar agroindustries, while at the same time expanding the scope of the area not only to the Banyuwangi Regency.

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