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
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# Comparative Studies of Coffee Processing Methods for Decision Making in Appropriate Technology Implementation

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**Abstract.** Coffee is one of the biggest Indonesian export commodities. To get good quality of coffee, there are many methods in post-harvest coffee processing. Cultivation and post-harvest processing are important phases. They affect about 70% of coffee quality. In the present study, we focus on three general processing methods: dry, semi-dry, and wet processing methods. Each method has different characteristics in terms of the process and the taste of the product. In addition, different processing methods have different costs, and in the end, will affect the price of coffee bean. The purpose of this study was to compare these methods to be applied in the rural coffee community, with a case study of coffee processing in Sumba Barat Daya Regency. Geographically, Sumba Barat Daya Regency has an altitude of 700m above sea level. This elevation is suitable for the plantation of Robusta coffee. Techno-economic analysis was the method used in this study. It was selected to gain the best methods that generate the most efficient and the highest profit. From the analysis, semi-dry processing method indicates the highest value for an area where water is limited. So instead, semi-dry method is the most suitable method to be applied in sufficient water area. However, preferably, the use of water in the post-harvest processing can be pressed to a minimum.

## INTRODUCTION

Indonesia is the fourth biggest of coffee exporter list. Indonesian coffee production is number two in ASEAN and number five in the world. The coffee production reaches 650.000 tons per year; with the potency of export reaches 410.000 tons [1]. Based on the data and publication issued by FAO, in 2013, Indonesia was listed as the third largest coffee producer in the world after Brazil and Vietnam. However, Indonesia's coffee export is not estimated to be as much as Brazil, Vietnam, and Colombia. The popularity and attractiveness of the world towards coffee is mainly due to its unique taste and is supported by history, tradition, social and economic interests [2]. Coffee is one of caffeine resource that has high antioxidant level [3]. Caffeine is also a substance that can cause increased alertness and reduce fatigue [4]. Coffee, a beverage made from coffee bean extract, consumed around 2.25 billion cups every day throughout the world. In 2013, the International Coffee Organization (ICO) estimated that the world consumption of coffee powder was around 8.77 million tons [1].

The popularity of coffee products is related to their unique and favorable flavor. It is evaluated according to various criteria, including bean's size, color, shape, roast potential, processing method, year of harvest, and flavor or cup quality. The contributor to the quality of coffee is a series of post-harvest practices carried out to get dry bean suitable for roasting [5]. These practices involve a number of relatively complex steps, including fruit harvesting, pulping, drying, hulling and saving. Following on farm postharvest processing, coffee beans can be transported to industrial plants, where semi-manufactured or finished products are done for commercialization [6].

Coffee in Sumba Barat Daya Regency has existed since perhaps 50 years ago. With an altitude of around 700 masl, Robusta coffee is a variety cultivated by people with polyculture system. With this system, the coffee produced in Sumba is full of unique aroma and taste. Coffee production in Sumba Barat Daya Regency is approximately 2164 tons per year [7]. This is ranked 5<sup>th</sup> in the production of Nusa Tenggara Timur Province.

Sumba Barat Daya Regency, which is located in the south of Nusa Tenggara Timur Province, is one of the regencies included in the 90 disadvantage regions that are targeted to be improved. According to the Statistic Bureau, the GDP of Sumba Barat Daya regency is 1.896,09 billion, lower than national GDP. In fact, in Nusa Tenggara Timur Province, Sumba Barat Daya Regency only contributed 1.09% to the Provincial GDP Structure, with a growth rate around 4.79%. The population of Sumba Barat Daya Regency is 325,699 people, with 77.6% of population as farmers [7].

The present study discusses the comparison between three methods of post-harvest coffee technology known as dry process, semi-dry process, and wet process [8]. Each method has advantages and disadvantages that affect the quality in addition to various environment impacts [11]. Techno-economic analysis is used to get an efficient result. The purpose of this study is to determine which post-harvest method is the most beneficial to be applied in Sumba Barat Daya Regency.

## METHODS

The method used in this study is a techno-economic approach. It contains how to make a decision (decision making) that is limited by various problems related to an engineer to produce the best choices from various alternative choices. Decisions are made based on a process of analysis, technique and economic calculation.

Alternatives arise because of limited resources, including human, material, money, machinery, and opportunities. With various alternatives, calculation is needed to get the best and most efficient choice, in which it can be done by comparing various alternatives design, making capital investment decisions, and evaluating a financial opportunity. Techno-economic analysis involves making decisions about a variety of limited resources. The consequences for the result usually have a far-reaching effect on the future, in which the consequences cannot be known with certainty. It is a decision-making under uncertainty.

### Resource Data

The present study was conducted in Kadiroma village, Sumba Barat Daya Regency. Primary data were collected through in-depth interview by involving farmers in Sumba Barat Daya and Focus Group Discussion (FGD). To obtain accurate data, we conducted direct observation on the post-harvest coffee processing in the business unit of coffee production in Kadiroma. The collected information included equipment investment capital, working capital, production cost, variable cost, fixed cost, labor cost and other data related to this study. An in-depth interview was used as a method to collect data and information in order to obtain a quantitative description of the financial analysis. Secondary data were obtained from selected literatures used to complete the primary data. The descriptive analysis was used to depict phenomena found in the organizational system of the business unit as the subject of this research.

### Research Method

To explore the financial feasibility of an agro-industry business, a financial analysis method can be applied. Therefore, the data were processed in the form of tabulation to apply the Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index, and Payback Period. An analysis of Net Present Value (NPV) was applied to reveal to what extent the investment value by considering the value of a currency. NPV is a criterion of business feasibility that can be defined as a recent net—the result of the difference between Benefit (B) and Cost (C). A business is declared feasible if the value of NPV is larger than 0. The Internal Rate of Return (IRR) is used to determine the amount of the funds of a planned business which allow the business to cover back the capital and interest issued. Calculation of B/C Ratio (Benefit Cost Ratio) is the business efficiency, which is the comparison size between Benefit (B), for this case, the annual Profit and Total Cost (TC) was used. By estimating B/C value, it can be known whether a business is profitable or not. The business will be appointed as a profitable business if the value of B/C is larger than 1 [9].

# RESULTS AND DISCUSSION

## Coffee Processing

Coffee plants (*Coffea spp.*) are a group of shrubs of the genus of *Coffea*. Linnaeus was the first to describe the species of Arabica coffee (*Coffea Arabica*) in 1753. Currently, there are more than 120 species of coffee have been identified but only one species, namely *Coffea canephora* or commonly known as Robusta coffee that is cultivated almost similar to the amount of Arabica coffee throughout the world. ICO [5] states that almost 64.5% of world coffee production is derived from Arabica coffee and the rest is from Robusta coffee.

Arabica coffee is usually planted at an altitude of more than 1000 m above sea level, while Robusta coffee is relatively cultivated at lower altitude. The taste and aroma of Arabica and Robusta coffee are basically different. The prices of Arabica and Robusta are also much different. For special categories, the price of Arabica coffee can even reach 2 million per kg. Meanwhile, Robusta coffee is usually used for filler, blended with Arabica coffee, so the taste of coffee is almost similar to Arabica coffee with a more reasonable price.

The quality and taste of steeping coffee beans are strongly influenced by the type of coffee, quality of harvest, location of the crop, agronomic system, and method of processing and sorting [10]. The post-harvest coffee processing is divided into three methods: dry method, semi-dry method, and wet method [8]. The choice of method is usually adjusted to the site conditions and the habits of the local community.

In the dry processing, cherry coffee is dried to the sun or hot air dryers until the moisture content is around 10%–12%. After drying, the fruits are cleansed and the next process is to remove the dried skin and pulp. In the wet processing, contrast to the dry processing method, it involves a relatively complex set of steps, including mechanical removal of the coffee skin and pulp, fermentation of the mucilage layer, sun-drying and hulling to remove parchment skins. This process reduces time (from 3 weeks to 8 days) and also reduces the area required to dry the beans in dry processing [11]. Another processing method, semi-dry processing combines the steps of dry and wet methods, in which the coffee fruits is mechanically pulped and the drying process is done without removing mucilage [6,11,10].

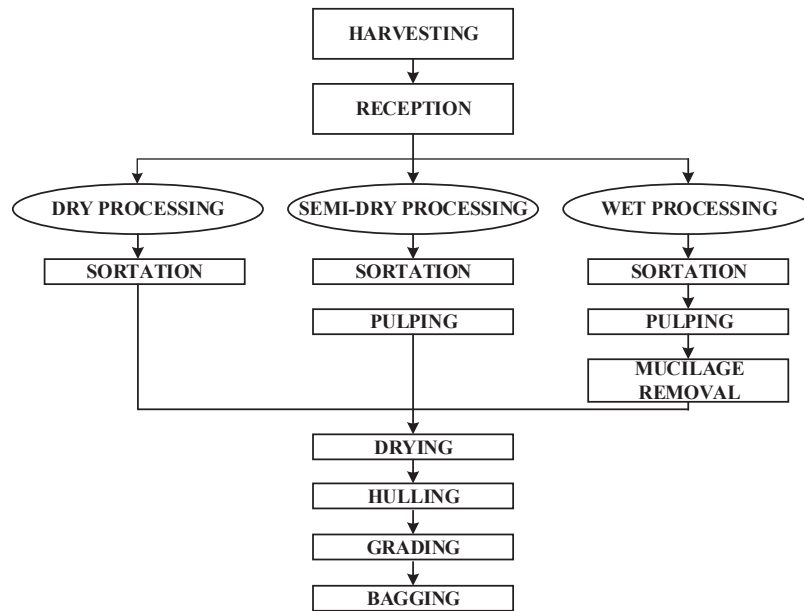


FIGURE 1. The Coffee Processing Flow Chart.

## Techno-economic Analysis

The data analyzed this analysis section are based on information from coffee processing groups in Sumba Barat Daya Regency, Nusa Tenggara Timur Province. Those data and information were simulated to calculate the financial feasibility of green bean business unit. Some investments, such as buildings, production equipment, and capital, were assumed to belong to groups and donation from various stakeholders, especially the related government. There is no loan in this scenario.

The techno-economic feasibility analysis of coffee bean processing consists of calculating the initial investment, calculating production cost, estimating the revenue, forming cash flow, and determining investment criteria (i.e., Net Present Value (NPV), Internal Rate of return (IRR), Pay Back Period (PBP), and Benefit Cost Ratio (B/C ratio)).

The post-harvest processing of cherry bean into green bean is a series of production process that depends on the availability of raw materials (red cherry). Especially for Robusta, its availability is only in the harvest season. This harvest season generally covers four months in a year, from June to September. Meanwhile, the sale of coffee green bean is planned to be carried out throughout the year. Therefore, a warehouse for storing coffee green beans is prepared.

This paper discusses the comparison between the three post-harvest coffee methods known as dry processing, semi-dry processing, and wet processing. Each method has an advantage and disadvantage. In dry processing, the process is simpler because the seeds do not need to be peeled off, but it requires longer duration of drying process and also more labors. In the semi-dry processing, pulper equipment is required. In this method, there is no washing process to remove mucilage, so the drying time is shorter than dry method. In wet processing, there are more steps because it does not only require pulper equipment, but also a lot of water in the process of soaking and washing the beans in order to remove the mucilage. Nevertheless, the drying duration is shorter than the previous methods.

There are no significant quantity differences between the three methods to produce coffee green bean. The yields of three methods are in the range of 23%-24% of cherry. The result of each method is presented in Table 1.

**TABLE 1.** The Mass balance of Coffee Processing

	<b>Dry Processing</b>	<b>Semi-dry Processing</b>	<b>Wet Processing</b>
<b>Harvesting</b>	100.00%	100.00%	100.00%
<b>Sorting</b>	95.40%	95.00%	95.00%
<b>Pulping</b>	-	57.00%	57.00%
<b>Demucilaging</b>	-	-	53.58%
<b>Drying</b>	43.36%	25.91%	25.21%
<b>Hulling</b>	24.28%	24.10%	23.95%
<b>Grading</b>	24.04%	23.85%	23.71%
<b>Bagging</b>	24.04%	23.85%	23.71%

### *Initial Investment*

The initial investment for an industry consists of building and production equipment. The equipment for coffee processing consists of cherry sorting, pulper, huller, and green bean sorting. The building consists of production room, office and warehouse, drying facilities, and washing facilities for wet processing method. The amount of investment depends on the method chosen. Fig. 2. shows the amount of initial investment needed for each method.

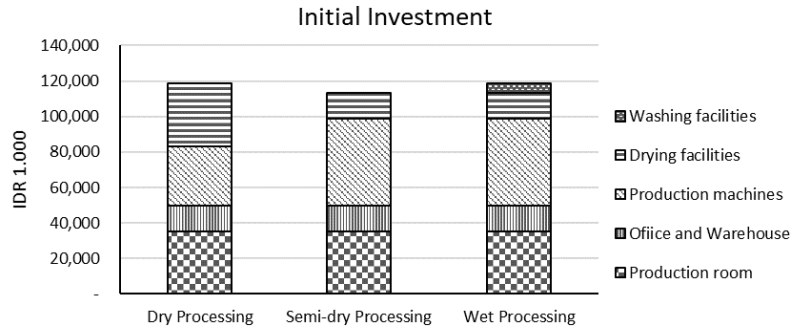


FIGURE 2. The initial investment of coffee processing.

The dry processing requires a lower initial investment in term of equipment, but wider drying facilities. It is because the drying process requires approximately 20 days. Meanwhile, the wet processing method requires high initial investment in equipment because it requires complex equipment. The wet processing method has low requirement for drying facilities, but requires washing machine to remove the mucilage.

### Production Cost

The production of coffee bean is carried out during the harvest for 4 (four) months, while the remaining 8 (eight) months, the specific equipment and building will be unemployed. The other general equipment can be utilized for another production process, but it is not investigated in the present study. The simulation of techno-economics has a pattern for 2 (two) days processing, with the capacity of 400 kg of coffee cherry. The price of cherry at farmer's base is IDR 5,000/kg, while the highest price of coffee green beans in the market is IDR 38,000/kg. The production cost required in the three methods is shown in Fig. 3 below.

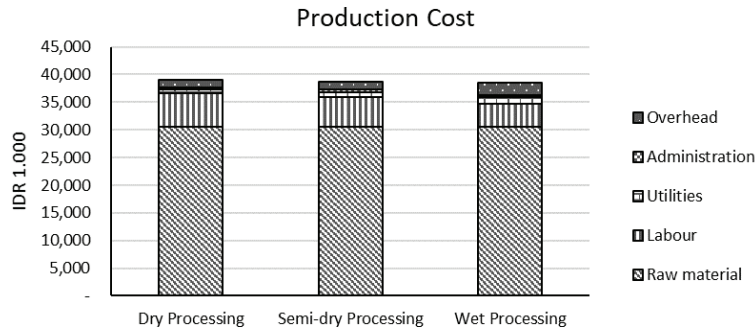
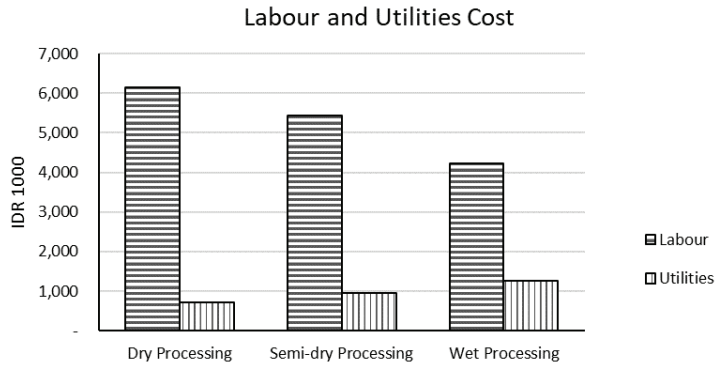


FIGURE 3. The production cost in various coffee processing methods.

Dry processing method has the highest production cost, while wet processing method has the lowest. Fig. 3 shows the comparison of total production cost of the three methods. The cost of production material contributes to 70% of total production cost. The bottle neck in coffee processing is in drying time, which requires longer duration in dry process method. Time influences the labor cost. Meanwhile, wet processing method requires shorter duration for drying process, and semi-dry processing method is in between. The drying time requirement for dry processing, semi-dry processing, and wet processing method is 14 days, 9 days, and 5 days, respectively. Fig. 4 shows the comparison of production cost of the three methods in terms of labor and utility cost.



**FIGURE 4.** The comparison between labor and utilities cost.

The calculation of cost and revenue are shown in Table 2. It shows the differentiation of cost and revenue obtained by the three methods. This differentiation influences the amount of profit. The profit percentages of the three methods are 18.15%; 19.17%, and 14.99%, respectively.

**TABLE 2.** The Differentiation of Cost and Revenue of Three Coffee Processing Methods

IDR 1,000	Dry Processing	Semi-dry Processing	Wet Processing
<b>Revenue</b>	IDR 219,252	IDR 217,553	IDR 216,271
<b>Total cost</b>	IDR 178,111	IDR 175,714	IDR 180,960
<b>Profit</b>	IDR 41,142	IDR 41,839	IDR 35,311

#### Feasibility Analysis

To determine the feasibility of the techno-economic approach on business unit, it can be observed from the financial aspect which includes determination of NPV, IRR, Payback Period, and B/C Ratio. The NPV value is used to decide whether a business is feasible or not. The positive NPV value indicates that the effort is feasible to implement, whereas if the NPV is negative then it means the business is not feasible to implement. The IRR value is used to see whether or not a business is worth developing. If the IRR value is higher than the prevailing interest rate, then the business is feasible to develop. The value of *Profitability Index* (PI) is greater than one, indicating that the business is feasible to run. A business is considered feasible if *Payback Period* value is smaller or equal with the age of business investment [4]. The calculation result of feasibility of three coffee processing methods is shown in Table 3 below.

**TABLE 3.** The Feasibility of Three Coffee Processing Methods

	Dry Processing	Semi-dry Processing	Wet Processing
<b>NPV (IDR 1,000)</b>	87,492	75,553	67,824
<b>IRR</b>	19.50%	21.13%	16.86%
<b>Payback Period</b>	3.0	2.8	3.3
<b>B/C Ratio</b>	1.23	1.24	1.20

From the calculation result, all methods have a positive NPV value. It means that all coffee processing methods indicate that all efforts are feasible to implement. NPV value for dry methods is higher than the values of other methods. Dry processing method has the highest NPV value. Semi-dry processing method has the highest IRR value. It is also higher than the Bank Indonesia (BI) rate. In addition, this method also has a shorter payback period.

By using this method, it only needs about 2.8 years to return the investment. Meanwhile, with dry and wet processing methods, the period is more than 3 years to returning the investment.

## CONCLUSION

Coffee market conditions in Sumba Barat Daya Regency are still classified as traditional markets. There is no price difference for all processing systems. In fact, the insignificant price difference is only for red coffee and random coffee. Based on the results of the techno-economic analysis above, it can be concluded that it is recommended for coffee farmers in the Sumba Barat Daya Regency, with current conditions, to implement the semi-dry processing method in order to gain more profit. By using this method, it does not require much water. It also requires shorter drying time compared to those in dry or wet processing methods.

Basically, in the coffee market, good quality of coffee processed by dry method has higher prices than those generated from semi-dry or wet processing methods. In Sumba Barat Daya Regency, this type of market has not been formed yet. So, it is recommended to use dry processing method until the market can accept the price differentiation. Hopefully, in the future, the government and business sectors can collaborate to devise a policy to improve the well-being of coffee farmers in order to live a more prosperous life.

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