The feasibility of Indonesian potato’s farming and its global competitiveness

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Abstract. Potato’s farming in Indonesia is thought to be profitable. However, its competitiveness in global production is questionable. The purpose of this study is to analyze the financial feasibility of potato’s farming in Indonesia and its competitiveness in global production. The data used were the results of National Farmers Panel (PATANAS) surveys in 2008, 2011 and 2017. The cost and benefit analysis were used to analyze the financial feasibility. In addition, productivity and producer price were used to measure its global competitiveness. The results showed that potato’s farming during the period of 2008 to 2017 was highly profitable. The R/C ratios were high and continued to increase. These results showed that potato’s farming in the study area is profitable and feasible to be done. In contrast, although potato’s farming in the study area is very profitable, it has no competitiveness in global production, due to the relatively low yield and high cost shown by producer price. The highest cost component was seed. Therefore, there should be a significant effort to find out the efficient use of seed, as well as to increase the capacity of farmers in producing good quality seeds efficiently. It is a challenge for breeding research to produce potato’s varieties with higher yields than currently exist in Indonesia. Another challenge is the research on the use of cut seed into pieces with minimum of two shoots per section.

1. Introduction
The application of advanced technology is an important part of increasing productivity and farmer’s income. Therefore, a success in agricultural development is largely determined by the availability of advanced technology that continues to improve. The main objective of introducing advanced technology is to increase production efficiency, so as to produce certain products at a lower cost. Efficient farming can only be achieved by applying appropriate technology. The main problem of potato’s farming in Indonesia is the high use of input, resulting in high cost of production. Although potato’s farming in Indonesia is thought to be profitable, however its competitiveness in global production is questionable. In this context, the choice of efficient technology is very important for potato farmers to reduce cost of production as well as to earn more income.

Various studies on the profitability of potato’s farming have been done. The previous studies in South Sulawesi revealed that potato farming has a high profitability with the R/C ranged from 2.80 to 9.41 [1,2]. So that it is very feasible to work on.
In other countries, both the studies of Mukul et al. [3] in Bangladesh and Jovanovic et al. [4] in Montenegro showed a profitable potato’s farming. Even if the technology is improved by investing in improved irrigation systems, the income of potato’s farming in Montenegro could be doubled. An increase in adoption of improved potato varieties in Nepal could increase food production, nutrition and farmers’ income [5]. The studies of Bajracharya and Sapkota [6], Sapkota et al. [7] and Subedi et al. [8] showed that potato’s farming in 5 districts of Nepal provided farm income with the R/C ratios ranged from 1.44 to 2.13. These mean that potato’s farming in these areas were very feasible to cultivate. The need for seed of potato’s farming is around 1,200-1,500 kg per hectare. So that, seed is the highest cost component. In summer, seed use can be minimized to 500-600 kg/ha. Summer seed savings were accomplished by cutting the seed into pieces with a minimum of two shoots per section [9].

In contrast to the previous studies, which are mostly conducted at one location and all at one point in time, the uniqueness of this study was done both across locations in two provinces and at three points in time, namely 2008, 2011, and 2017. This article aims to analyze the financial feasibility of Indonesian potato’s farming and its competitiveness in global production. Another objective is to formulate alternative policies in the context of technological development to increase productivity, reduce cost, and increase potato’s farmers income.

2. Materials and method
2.1. Time, location and data sources
The surveys on potato farming were carried out by The Indonesian Center for Agricultural Socio Economic and Policy Studies (ICASEPS) in the form of National Farmers Panel (PATANAS) on highland agroecosystems of West Java and Central Java, at three points in time, namely in 2008, 2011 and 2017. The two villages were selected, namely Margamulya village in Bandung district, West Java and Karangtengah village in Banjarnegara district, Central Java. These two locations were selected, because they are the main centers of potato production in Indonesia. The number of samples in each village was 32 farm households, so that from the two villages 64 sample farmers were obtained. By surveying the same farmers at three points in time, panel data was obtained with 192 observations.

2.2. Data analysis
The analysis of the financial feasibility of potato farming is carried out using the following mathematical formula.

\[
Pp = TRp - TCp \tag{1}
\]

where:
- \(Pp\) = Income earned from potato’s farming (IDR/ha/season)
- \(TRp\) = Total revenue of potato’s farming (IDR/ha/season)
- \(TCp\) = Total cost of potato’s farming (IDR/ha/season)

A farming is said to be profitable and feasible if \(Pp > 0\), or \(TRp > TCp\) or \(TRp/TCp = R/C > 1\). The greater the positive value of \(Pp\) and R/C, the more feasible a farm is. Another measure of financial feasibility is the break-even point of productivity which is lower than the actual productivity. Financial feasibility can also be seen from the price break-even point, which is lower than the actual price received by farmers. Mathematically, the productivity break-even point and the price break-even point can be formulated as follows:

\[
Yp* = TCp/Pp \tag{2}
\]

where:
- \(Yp*\) = the productivity break-even point.
- \(Pp\) = actual price of potato received by farmers (IDR/kg).

The price break-even point can be formulated as in equation (3).

\[
Pp* = TCp/Yp \tag{3}
\]

where:
Pp* = the price break-even point.
Yp = actual potato’s productivity achieved by farmers (kg/ha).
The farther is Yp* below the actual productivity, the more feasible a farm is. Likewise, the farther is Pp* below the actual price received by farmers, the more feasible is the farming of this commodity.

3. Results and discussion
3.1. The application of technology
The land preparation was done by human labor using hoes. No farmer used tractor. This is due to highland conditions that are generally sloped with a narrow surface for cultivation, making it difficult to use tractor. In addition, there is no specific tractor available for sloping highland in the study area.

In terms of seed, most potato farmers used uncertified seeds, either from their own production or buying from the closest uncertified seed producers. There were at least two reasons why did farmers use uncertified seeds, namely (1) certified seeds are more expensive, (2) uncertified seed is not only cheaper but also not inferior to certified seeds, because they are produced with the same technology. The use of certified seeds in Marganulya village, Bandung district is greater than that of farmers in Karangtengah village, Banjarmegara district. This is due to the existence of a business partnership between potato farmers and private companies engaged in the potato processing industry in Bandung district. Farmers’ behavior in determining the choice of seeds is influenced by many factors such as farmers’ expectation on selling price, availability of cash capital, farm size, farmers’ access to technology sources, and access to market [10,11].

Farmers did weding manually twice per season, and partly using herbicides. The use of herbicides on potato decreased during the 2008-2011 period, but increased again during the 2011-2017 period. The study of Lestari et al. [12] showed that application of mulch made from straw can suppress weed growth as well as improve the quality of yield and production.

Potato farmers in research sites used high doses of fertilizer, exceeding recommended doses, because of farmers’ expectation to have high yields. According to Koch et al. [13] that balanced fertilization of macro nutrients of nitrogen, phosphorus, potassium, magnesium, calcium and sulfur are very important for tuber formation and the safety of potato’s yield. Potato’s farmers use manure about 10-12 tons/ha. Although according to Nurjanani [14] that potato’s farming requires 20 tons/ha of manure, even the study of [9] revealed that potato’s farming need about 30-37 tons/ha of manure, however, at the research location to apply 10-12 tons of manure per hectare is difficult and requires high costs.

Pests and diseases control activities are quite intensive, starting from the beginning of planting until just before harvest, using various pesticides. In one season, the spraying frequency of potato crops can be around 16-20 times. The reason is to reduce the risk of crop failure. The application of pest control thresholds on potato’s farming can save pesticide use by 70.59-76.47%, increase productivity by 32.7%, increase the proportion of good tubers quality by 114%, and increase farm income [15]. According to Haverkort and Kempenaar [16] and Kempenaar et al. [17], that New precision farming services and products in potato’s farming in the Netherlands are thought to have an effect on increasing production, reducing pesticide and nitrogen use, that benefits the environment more sustainable.

The harvesting activities on potato’s farming at research sites used hired labor, both in 2008, 2011, and 2017. The potato’s farmers in the research sites only carry out simple primary post-harvest handling, namely transportation, tubers cleaning and rafting. After cleaning, some of it is set aside for seed purposes. The rest is sold as consumption potato to middlemen or collectors who come to the village.
3.2. Financial feasibility

3.2.1. Cost structure. The farming cost components included materials, labor and other costs, as well as land rent. The results of the study showed that the nominal value of each component of production costs, especially the materials (seeds, fertilizers and pesticides) and the labor force, increased significantly over time. This was due to the increase in the nominal prices of materials and labor wages. The largest proportion of the cost is for the value of seeds followed by labor. Apart from seeds, pesticides also have a high share. The high intensity of pesticide use, not only causing high costs, it also endangers farmers and consumers. Consumers (including farmers themselves) in some areas do not want to consume potato with high spraying frequency.

3.2.2. Financial profitability. The productivity of potato’s farming in the two research locations fluctuated over time. During the period of 2008-2011, there was an increase in productivity, while in the 2011-2017 period productivity declined both in Margamulya, and in Karangtengah (Table 1). The decline in productivity in the 2011-2017 period was caused by too high rainfall, so that some plants died due to waterlogged. However, the nominal revenue of potato’s farming increased in 2017 caused by an increase in the nominal price of potato in the two locations, exceeding the decrease in productivity. Therefore, although the cost of farming continued to increase during the three points in time of the study, the nominal revenue and profitability of potato’s farming continued to increase. The R/C ratios of potato’s farming in Margamulya and Karangtengah villages in 2008 and 2011 were almost the same, however in 2017 the R/C ratio of potato’s farming in Karangtengah Village was relatively higher. The selling price of potatoes in the two research locations were almost the same, so that differences in revenue and farm income were caused by differences in productivity.

Table 1. Costs and benefits analysis of potato farming in the research location, 2008, 2011 and 2017.

| Costs and benefits components | Margamulya | Karangtengah |
|-------------------------------|------------|--------------|
|                               | 2008<sup>a</sup> | 2011<sup>b</sup> | 2017<sup>c</sup> | 2008<sup>a</sup> | 2011<sup>b</sup> | 2017<sup>c</sup> |
| Seed (IDR 000/ha)             | 11,500     | 13,240       | 23,750           | 11,900       | 14,800       | 19,638       |
| Fertilizers (IDR 000/ha)      | 5,280      | 6,720        | 9,867            | 5,420        | 6,275        | 10,235       |
| Pesticides (IDR 000/ha)       | 5,710      | 7,440        | 11,372           | 5,270        | 7,355        | 12,118       |
| Labor (IDR 000/ha)            | 7,600      | 9,960        | 18,570           | 8,160        | 9,850        | 15,980       |
| Land rent (IDR 000/ha)        | 5,000      | 5,500        | 7,500            | 5,000        | 5,250        | 7,600        |
| Others (IDR 000/ha)           | 840        | 920          | 1,123            | 1,180        | 1,260        | 5,755        |
| Total cost (IDR 000/ha)       | 35,930     | 43,780       | 72,182           | 36,930       | 44,790       | 71,326       |
| Productivity (kg/ha)          | 18,200     | 19,800       | 15,145           | 17,740       | 19,550       | 16,420       |
| Price (IDR/kg)                | 3,000      | 4,950        | 10,450           | 3,210        | 5,000        | 10,385       |
| Revenue (IDR 000/ha)          | 54,600     | 98,010       | 158,265          | 56,945       | 97,750       | 170,522      |
| Income (IDR 000/ha)           | 18,670     | 54,230       | 86,083           | 20,015       | 52,960       | 99,196       |
| R/C Ratio                     | 1.52       | 2.24         | 2.19             | 1.54         | 2.18         | 2.39         |
| Productivity BEP (kg/ha)      | 11,977     | 8,444        | 6,907            | 11,505       | 8,958        | 6,868        |
| Price BEP (IDR/kg)            | 1,974      | 2,211        | 4,766            | 2,082        | 2,291        | 4,344        |

Sources: <sup>a</sup>Kustiari et al. 2008; <sup>b</sup>Purwoto et al. 2011; <sup>c</sup>Saptana et al. 2017. Computed.

The financial feasibility of potato’s farming in the two research sites changed over time. In 2008, the nominal income of potato’s farming were 52% of the total production costs in Margamulya and 54% in Karangtengah. In 2011 and 2017, the income were still above 100% of the total costs incurred by farmers. In other words, potato’s farming in the research locations are very feasible to cultivate. In 2008 the break-even point (BEP) of productivity in Margamulya was 11,977 kg/ha which was far below the actual productivity (18,200 kg/ha). In the same year, the productivity break-even point in Karangtengah
was 11,505 kg/ha, while the actual productivity was 17,740 kg/ha. In 2011 and 2017, the break-even point for potato’s productivity at the two research sites were also well below the actual productivity. These mean that from the perspective of break-even point of productivity, potato’s farming in the two research sites are very feasible to be done.

In terms of price break-even point, its dynamics in Margamulya at three points in time were IDR 1,974/kg in 2008, IDR 2,211/kg in 2011, and IDR 4,766 in 2017. In the same period, actual price dynamics received by farmers in Margamulya were IDR 3,000/kg in 2008, IDR 4,950/kg in 2011, and IDR 10,450/kg in 2017. It is clear that the actual potato’s prices received by farmers in Margamulya were far above their break-even points. The similar dynamics also occurred in Karangtengah. In the same time period, the break-even point of potato’s prices in Karangtengah were IDR 2,082/kg in 2008, IDR 2,291/kg in 2011 and IDR 4,344/kg in 2017. At the same time, the actual prices of potatoes were IDR 3,210/kg in 2008, IDR 5,000/kg in 2011, and IDR 10,385/kg in 2017, which were far above their break-even prices. The dynamics of the break-even point of potato prices at three points in time confirmed with the results of the financial analysis above that potato’s farming in the two research sites are very profitable and feasible to work on.

3.3. Competitiveness with other countries

The competitiveness of a commodity among some countries can be seen from the productivity and unit cost of production which can be proxied by producer prices. The producer price is the selling price at the farm level which reflects the unit cost of production. In terms of productivity, FAO data showed that the average productivity of Indonesian potato for the past 3 years was 17.46 tons/ha. This national average productivity was almost similar with the average potato’s productivity (17.81 tons/ha) in the study areas. This finding indicates that potato’s productivity in the study areas can be used to represent the average national productivity.

In global production, the data of FAO showed that Indonesian potato’s productivity was in 51st position, far below the other 50 potato’s producing countries. The highest productivity was achieved by Kuwait with an average of 50.67 tons/ha. The second and the third places were achieved by New Zealand and the USA with an average of 50.10 tons/ha and 48.93 tons/ha, respectively during the same period.

Considering unavailability of cost structure data in various countries, the comparison of production costs among countries is proxied by the comparison of producer prices in each country. FAO data showed that over the last three years (2016-2018), the average producer price of Indonesian potato was the highest in the world, reaching USD 785.47/ton. The lowest producer price with an average of USD 104.50/ton was achieved by Poland, followed by Ukraine and Bangladesh with USD 121.53 and USD 174.83/ton, respectively during the same period (Table 2).

Table 2 shows that compared to other countries, the average producer price of potato in Indonesia is very high, reaching 4.49 times the producer price of potato in Bangladesh, and even 7.52 times the producer price in Poland. This finding showed that although potato’s farming in Indonesia is financially profitable and feasible to be cultivated, it does not have competitiveness at the global production. Low productivity and high producer price reflect low production efficiency. Technological breakthroughs are still needed to increase productivity and reduce production cost. It is a challenge for breeding research to create potato’s varieties with higher yields than currently exist in Indonesia. In addition, agronomic and economical cultivation technology breakthroughs are also needed that can reduce production costs. IAARD through the Indonesian Center for Horticultural Research and Development has the main mandate to create the technology needed to increase productivity and reduce production costs.
Table 2. Average producer price of potato in several countries, 2016-2018.

| No | Country          | Average 2016-2018 (USD/ton) | Ratio to other country |
|----|------------------|------------------------------|------------------------|
| 1  | Indonesia        | 785.47                       | -                      |
| 2  | France           | 396.87                       | 1.98                   |
| 3  | China            | 335.60                       | 2.34                   |
| 4  | United Kingdom   | 238.33                       | 3.30                   |
| 5  | Canada           | 225.50                       | 3.48                   |
| 6  | Germany          | 206.03                       | 3.81                   |
| 7  | USA              | 196.33                       | 4.00                   |
| 8  | Russian Federation | 183.97                   | 4.27                   |
| 9  | Netherlands      | 183.73                       | 4.28                   |
| 10 | Bangladesh       | 174.83                       | 4.49                   |
| 11 | Ukraine          | 121.53                       | 6.46                   |
| 12 | Poland           | 104.50                       | 7.52                   |

Source: FAO Stat 2020. Computed.

4. Conclusions
The high profit indicates that potato’s farming is very feasible and prospective to be developed in other highlands of Indonesia. However, there are still problems with the high price of seeds which is the highest cost component, as well as the high use of pesticides that can endanger potato’s farmers and consumers as well as threaten the sustainability of potato’s farming.

Although domestic potato’s farming is very profitable and feasible to be cultivated, however at the global production it is not competitive. In terms of productivity, it is still far below the 50 potato’s producing countries. In terms of unit cost which is proxied by producer price, Indonesia is the highest in the world. These two parameters reflect that potato’s farming in Indonesia is still inefficient.

To increase productivity, and reduce production cost, several strategic policies are needed, including: (1) increasing the capacity of local seed producers and farmers in producing good seeds through training or field schools for potato’s seed production; (2) intensive extension accompanied by Dem-Farm on the use of pesticides, in accordance with the concept of Integrated Pest and Disease Management (IPM); (3) creation of superior varieties with higher yields than currently available through more intensive breeding research; (4) technological breakthroughs are needed to increase productivity and decrease unit cost of production; (5) collaborative research on the application of potato’s technology with other countries that have succeeded in achieving high productivity is required. Among others, the research on the use of cut seed into pieces is important to be done in Indonesia. This new technology then could be transferred to potato’s farmers in Indonesia.

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