Cost-benefit analysis of rehabilitation and opening new cultivation land for tangerine cv Madu impacted by volcanic ash fallout of Mount Sinabung, North Sumatra, Indonesia

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Abstract. *Mufidah L, Sugiyatno A, Ratule MT. 2017. Short Communication: Cost-benefit analysis of rehabilitation and opening new cultivation land for tangerine cv Madu impacted by volcanic ash fallout of Mount Sinabung, North Sumatra, Indonesia. Nusantara Bioscience 9: 339-345.* Indonesian tangerine plants which have diverse varieties possess the adaptability from lowlands to highlands in the tropical region. Some of the tangerine production centers in Indonesia, such as Karo, Mandailing Natal, Dairi, Malang, Batu, and Bali are located in the volcano path which is prone to eruption. The eruption of Mount Sinabung in 2013 and 2014 had caused damage to the local tangerine cv Madu cultivation which was estimated to reach more than 476 billion rupiahs. The eruption affected a cultivation area of 7.202,89 ha and has been predicted to be one of the factors that caused the decline of North Sumatra's contribution to tangerine production. Therefore, this paper has tried: (i) to analyze the financial feasibility of rehabilitating tangerine cv Madu cultivation located in between 7-10 km radius of the eruption center (zone 1) and in between 5-7 km radius of the eruption center (zone 2), and (ii) to consider the option of opening up a new tangerine cultivation land.The results showed that the BCR for the immediate rehabilitation of zones 1 and 2 were 3.33 and 2, respectively. Thus, the rehabilitation scheme was feasible to be implemented and can reduce the damage and losses suffered by farmers. On the other hand, the opening of new land still takes approximately three years to be productive. The BCRof the option of opening new land within that period of time was 0.47, which is lower compared with that of the rehabilitation of zones 1 and 2 (2.61 and 2.57, respectively).This study was intended as an initial guidance for making decisions and determining the potential benefit to be gained and the losses that can be avoided. This study also gave an overview of the budget that should be prepared. In conclusion, we recommended the farmers to carry out the rehabilitation over opening up new cultivation land.

Keywords: cost-benefit analysis, tangerine cv Madu rehabilitation, volcanic ash

INTRODUCTION

Indonesian tangerine and mandarin fruits has diverse variety and unique characteristics and have become the most widely consumed fruits by Indonesian households (BPS 2010). The market opportunity for tangerine is wide open, as the Indonesian middle-class increase and the population become more aware of the nutritional importance of fruits for their daily consumption. The government policy, Permendag (No.70/M-DAG/PER/12/2013), that gives access to local tangerines to enter the modern retail market and the economic criteria fulfillment have made this crop cultivation worthy to consider.

Tangerine has a wide adaptability, ranging from lowlands to highlands of tropical climates. Altitude (elevation) reflects the temperature of an area. Every plant variety will grow and produce optimally when grown at the appropriate altitude with customized cultivation techniques of planting (Ladaniya 2008). In 2010-2014, Indonesian tangerine and mandarin centers had experienced a change in their contribution compared to 2005-2009. In 2005-2009 the tangerine and mandarin centers contribution were as follows: North Sumatera 40.30%, East Java 13.80%, West Kalimantan 7.50%, West Sulawesi 5.80%, South

Kalimantan 5.40% and others 27.20%. In 2010-2014, the contribution of the production centers were as follows: North Sumatera 29.82%, East Java 23.89%, West Kalimantan 9.04%, South Kalimantan 6.56%, Bali 6.64% and others 24.05%. The tangerine and mandarin production in North Sumatera was supported by five main regions, Karo Regency (59.31%), Simalungun Regency (16.22%), Dairi Regency (10.41%), Tapanuli Utara Regency (5.12%), Mandailing Natal Regency (3.37%), and others (5.58%). In East Java and West Kalimantan, the production was supported by five and four regions, respectively. In East Java, those regions are Banyuwangi (48.08%), Jember (25.98%), Malang (3.77%), Ponorogo (4.40%), Batu (2.32%) and others (15.45%). In West Kalimantan, the production areas are Sambas Regency (78.66%), Singkawang City (11.51%), Bengkayang Regency (6.68%), Pontianak Regency (1.95%) and others (1.20%) (BPS 2010; Pusdatin 2015)

The decline in tangerine and mandarin production in North Sumatra, in which the Karo Regency suffer the biggest plunge, needs to be observed because the decline reached 10.48%. Between 2013-2014, the area suffered from volcanic eruptions in which volcanic ash severely coverd many crops cultivation including the tangerine cv Madu. The particular characteristic of tangerine cv Madu is

its cultivation in the highlands, while other tangerines, in general, are cultivated in the lowlands. From the maintenance point of view, one of the primary concerned in tangerine cultivation, is the pest management of fruit fly. The ash fallout that has corrosive, abrasive and conductive properties can potentially damage the agricultural system. Therefore, the impact of volcanic ash fallout needs to be understood to minimize the damage (Wilson et al. 2012; Craig et al. 2016). Mount Sinabung itself, in the beginning, was not included as an active volcano because of its last eruption that occurred in 1600, but after the earthquake and tsunami in Aceh in 2014, the activity of the volcano has been changing.

The tangerine cv Madu cultivation in Karo Regency suffered a tremendous loss of more than 476 billion rupiahs because of the Mount Sinabung's eruption. In addition, the five primary tangerine production areas have been under constant threat of volcanic eruption impact because Indonesia is located along the ring of fire, an area occupied by a string of volcanoes and high seismic activity along the edges of the Pacific Ocean (Bangun et al. 2014). Considering the significant impact of the volcanic eruption and its potential to inflict damage to tangerine cultivation in the future, this paper aimed to analyze the financial feasibility of: (i) the Tangerine cv Madu Rehabilitation in Karo that damaged by the volcanic ash fallout of the Mount Sinabung eruption and (ii) the option of opening new

cultivation land, by using the cost-benefit analysis (Shreve et al. 2014; Asa and Tobias 2015; Mechler 2016). We hope that this study can serve as an initial guidance for making decisions and determining the potential benefit to be gained and losses that can be avoided, as well as to providing an overview of the budget that should be prepared.

MATERIALS AND METHODS

Study area

The study was conducted in Mount Sinabung, Karo District, North Sumatra, Indonesia, includes Simpang Empat Sub-district which is situated in between 7-10 km radius of the eruption center of Mount Sinabung, henceforth referred to as zone 1; and Naman Teran Sub-district which is located in between 5-7 km radius of the eruption center, henceforth referred to as zone 2. Both sub-districts are situated in Karo regency area and have been previously described by Sugiyatno and Nainglon (2014). The two zones showed the prospect to be rehabilitated. The research and the financial analysis of these areas were carried out from February to March 2014. Meanwhile, the newly open cultivation area is located in Merek Sub-district of Karo District (Figure 1). The area was expected to be safe and suitable for tangerine cultivation. The technician surveys were conducted in 2014 and 2017.
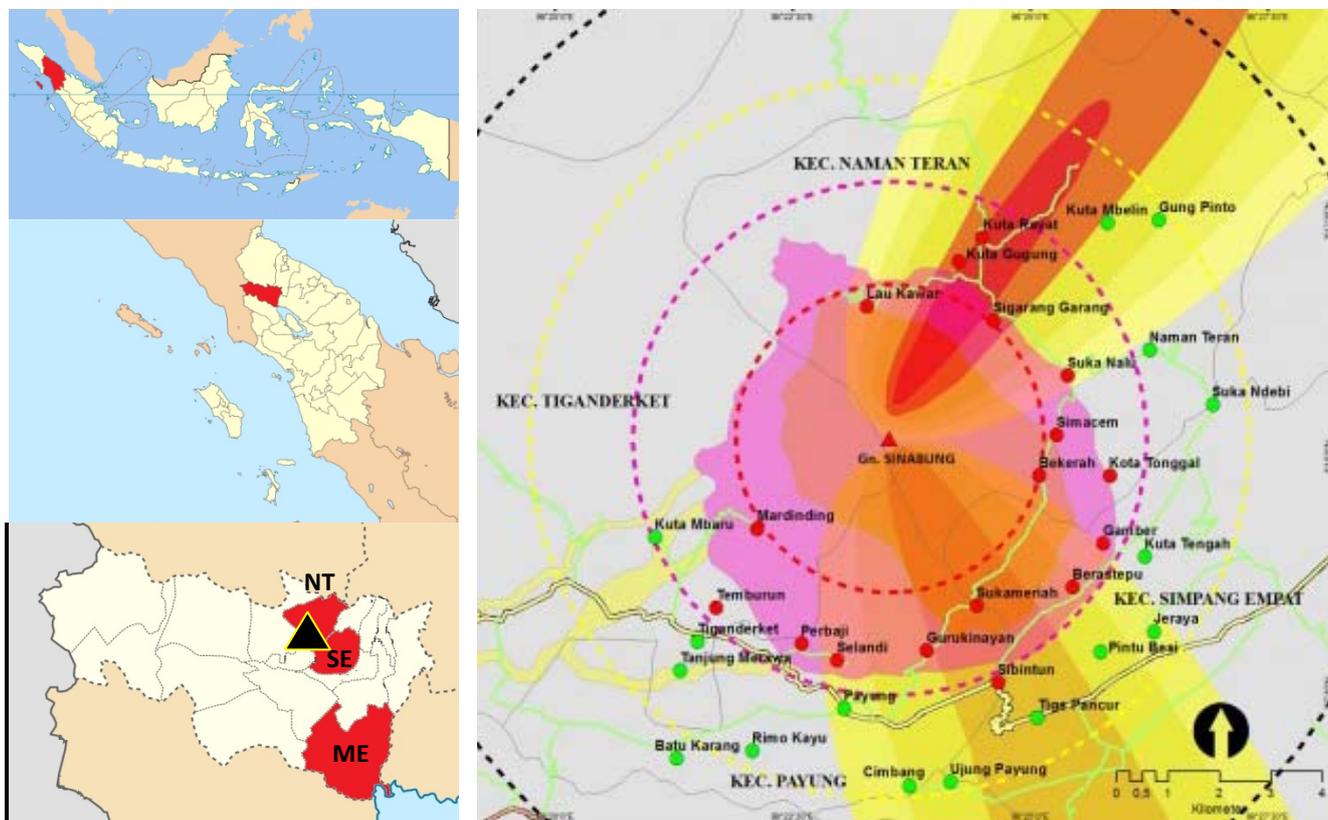
Figure 1. Research location maps in Province of North Sumatra, Indonesia. Location of Mount Sinabung (indicated as black triangle), Naman Teran Sub-district (NT), Simpang Empat Sub-district (SE), and Merek Sub-district (ME). Maps of Mount Sinabung eruption impact on February 1, 2014 that continues until today (*right*). The center of the concentric circles is the eruption center of Mount Sinabung.

Procedures

This research used secondary data obtained from Sugiyatno and Nainggolan (2014) research, Department of Agriculture, Province of North Sumatera (2014) and BPS (2016). The damaged cultivation areas were classified and selected for zones 1 (± 5.972,60 ha) and 2 (± 293.08 ha), where rehabilitation was still a viable option. The calculation of the costs and benefits was done in Indonesian Rupiah (IDR). The advantage of the rehabilitation was quantified by using the average losses that could be saved. The rehabilitation in this research was defined as an attempt to repair, restore and improve the land condition of tangerine cv Madu that damaged by Sinabung Mountain eruption. The rehabilitation was intended to optimize the land function as an element of production. The rehabilitation activities in zone 1 and zone 2 were conducted differentially according to the damage level of each zone. In the newly open cultivation land located in Merek Sub-district which was outside of the zone 1 and 2, the activities consisted of land acquisition, land preparation, and maintenance of the tangerine trees until ready to produce.

Data analysis

The cost-benefit analysis allows decision makers to appraise projects in a comparable manner and consistency. Cost-benefit analysis can be used: (i) to provide information for decision-makers, whether the rehabilitation project investment is a feasible solution (Djukic et al. 2016), and (ii) to weigh which one of the two options, *i.e.,* the rehabilitation or the option of opening a new cultivation land, is more feasible (Salisu et al. 2012; Lekh and Virendra 2014). Some assumptions need to be made to determine the input data (Asa and Tobias 2015; Andre et al. 2016). In this case, three options and assumptions were considered as described in Table 1.

The method that was chosen for the data analysis was the benefit-cost ratio (BCR). It involved summing up the total discounted benefits for a project over its entire duration and dividing it over the total discounted costs of the project, with the following formula:

$$BCR = \frac{[\sum B_i / (1+d)^i]}{[\sum C_i / (1+d)^i]} \text{ summed over 0 to n years}$$

B_i = benefit of the project in year i, where i = 0 to n years

C_i = cost of the project in year i, where i = 0 to n years

n = the year duration that was taken into account in the project (time of period)

d = discount rate

Time period

The rehabilitation scheme was evaluated in two time-points, firstly, at one year after the rehabilitation, and secondly, at three years after the rehabilitation.

Discount rate

The discount rate based on the Ramsey formula (1928) for the Social Rate of Time Preference (SRTP) for Indonesia, which was 6.1%. SRTP was used because the project had been aimed at the government which was the measure of society's willingness to postpone private consumption now in order to consume later (Zhuang et al. 2007; Halicioglu and Karatas 2011). The SRTP approach was based on the framework that the main goal of economic prosperity is to maximize the community benefits (Moore et al. 2013).

The interpretation of the BCR value

If the BCR ≥ 1 (project received); BCR< 1 (project rejected) and BCR = 1 (whether a project is implemented or not implemented has no effect); while, to determine which project was more feasible, a comparison was made among the BCR values. Upon comparing multiple schemes, the options with the highest BCR are preferred and deem feasible.

The data of cost (Table 2) refers to the rehabilitation activities and the new cultivation land opening. Data of tangerine cv Madu maintenance for 10 and 3 years old trees are shown in Table 3.

Table 1. The comparison of the cost and benefit of three scenarios

Options	Costs/Issues	Benefits
Do nothing	Tangerine cv Madu is facing a decline in production that has been estimated to reach 30% and a loss cost of Rp. 476.109.849.600,-.	No benefit will be gained. However, it will cost nothing for rehabilitation and open up new land.
Tangerine cv Madu rehabilitation for zones 1 and 2	Requires rehabilitation cost. It does not require time to wait because the crop age is in the productive age (ranging up to10 years old).	Productive crops can be saved, thereby, reducing the loss from crop failures.
Opening up new land for tangerine cv Madu cultivation	The cost of finding suitable land for cultivation and land clearing. Need to wait for three years for the tangerine trees in the new cultivation area to bear fruit (harvest). The loss of tangerine cv Madu that was left because of volcanic ash fallout	The cultivation area will be safer.

Table 2. Preliminary analysis of costs for the rehabilitation of tangerine cv Madu affected by volcanic ash fallout for 1 hectare (assumption 1 ha=620 tree)

Areas	Rehabilitation Activity	Volume	Unit price (Rp.)	Amount (Rp.)	Total (Rp.)
Zone 1					19,841,000
	High-pressure spraying				
	Water	1750 l	72	126,000	
	Automatic power sprayer	1	4,000,000	4,000,000	
	Hose	1	550,000	550,000	
	Workers needed (smd)	4	55,000	220,000	
	Prune the dry branches				
	Pruning shears (Prohex)	2	82,500	165,000	
	Workers needed (smd)	2	55,000	110,000	
	Weed control (4x)				
	Workers needed (smd)	14	55,000	770,000	
	Cultivate the soil under the plant canopy (mixing the volcanic ash with the soil and applying manure at a dose of 30-40 kg)				
	(1 sack of manure $\pm$@30-40 kg)	620	11,000	6,820,000	
	Applying NPK fertilizers at a dose of 1 kg/plant/year				
	NPK fertilizers	620	10,000	6,200,000	
	Controlling fruit flies				
	Trap	10	88,000	880,000	
Zone 2					25,686,000
	High-pressure spraying				
	Water	1750 l	72	126,000	
	Automatic power sprayer	1	4,000,000	4,000,000	
	Hose	1	550,000	550,000	
	Workers needed (smd)	4	55,000	220,000	
	Prune the dry branches				
	Pruning shears (Prohex)	2	82,500	165,000	
	Workers needed (smd)	2	55,000	110,000	
	Applying NPK fertilizer 2kg/rod/year (twice a year)				
	Applying manure 30-40 kg/plant				
	NPK fertilizer	1240	10,000	12,400,000	
	(1 sack of manure $\pm$@30-40 kg)	620	11,000	6,820,000	
	Controlling insecticide				
	Abamectin	2	125,000	250,000	
	Workers needed (smd)	3	55,000	165,000	

Source: Sugiyatno and Nainggolan (2014); Balitjestro technician survey results (2014, 2017)

RESULTS AND DISCUSSION

Results

The BCR for the rehabilitation of tangerine cv Madu plantation for one year are 3.33 for zone 1, and 2 for zone 2, respectively, with a total benefit value and total cost value as shown in Table 6. The total areas expected to be saved were 6,265.68 ha, consisting of 5,792.6 ha in the zone l and 293.08 ha in the zone 2. These results illustrate that the rehabilitation project could be implemented because it could minimize the impact of the farmer's loss by 86%. On the other hand, for the three-year period, the BCR values were 2.61 and 2.57 in zones 1 and 2, respectively, taking into account the maintenance cost for 10-year-old tangerine cv Madu (according to the observation result), the selling price of Rp. 7.946,-/kg (based on the average price, BPS 2010), and the average production of 50 kg per tree. The BCR value for rehabilitation project within one-year period (direct handling) means that the cost to rehabilitate 1 unit gives a benefit of 3.23 (for zone 1) and 2 (for zone 2). In the three-year period, the cost to rehabilitate 1 unit gives a benefit of 2.62 and 2.57 for zone 1 and 2, respectively. Overall, the BCR exceeded 1 indicating that the benefit of the rehabilitation outweighs the expense costs.

The BCR for opening up a new land for the cultivation of the tangerine was 0.47, which means that the cost of 1 unit produced would have a benefit of only 0.47 for the three-year period. The total area of the newly opened land for the tangerine cultivation was consistent with the area that was potentially rehabilitated from the volcanic ash fallout impact. Three years after the opening, the trees bear fruit with an average production of 25 kg per tree. The total of the benefit value and the total cost are shown in Table 7.

The obtained benefit for the three-year period after discounted was smaller than the expense costs. Based on this result, for the three-year term, the more feasible project is the rehabilitation of tangerine cv Madu in zones 1 and 2. The rehabilitation project gives a positive impact on the farmers in the first three years post-eruption.

Discussion

The BCR values recommended the rehabilitation for both zones 1 and 2, whereas the BCR analysis gave a different suggestion for the option of rehabilitation and the option of opening up new cultivation land. This difference could be caused by the fact that (i) the tangerine cv Madu cultivation land affected by the mount Sinabung eruption had still been producing, thus, saving the land means saving losses from the harvest failure, while the scheme of opening up new land means throwing away the chance of harvesting from the affected land; (ii) it takes approximately three years in order to reap the results in the case of opening up new land, and (iii) the differences in plants ages between the tangerine cv Madu that affected by the Sinabung mountain eruption (10 years old plants) and

the tangerine in the new cultivation land (3 years old plants), means that they will have different productivity (IPB 2013). Despite the quantitative analyses mentioned above, not all the benefits/advantages and costs can be expressed in number, for example, the safe area for opening up the new land for cultivation and the decrease in tangerine supplies without rehabilitation projects.

The decrease in tangerine supplies due to production issues in North Sumatera might be among the causes of the increased in tangerine and mandarin import in 2014. The limited data on the loss cost in each zone also needed to be considered because the use of the average value could affect the sharpness of the analysis. This is seen from the BCR value of the rehabilitation projects within the three year period that is smaller than that of the direct handling. Furthermore, the land availability becomes an issue that should be noticed. In the long run, the rehabilitation project can provide a sustained benefit (Burnett et al. 2017) considering the limitation of available citrus-cultivation land that was estimated to be around 5.715.198 ha (Mufidah et al. 2016).

Table 3. The maintenance cost of 1 ha tangerine cv Madu aged 10 years (assumption 1 ha=620 tree)

Item description	Vol	Unit price (Rp)	Amount (Rp)
Production facilities			
Manure 1 sack/hole	620	11,000	6,820,000
NPK fertilizer (5kg/plant)	3100	10,000	31,000,000
Urea (kg)	250	2,200	550,000
Antracol Fungicide (kg)	20	107,800	2,156,000
Folicur Fungicide (kg)	14	132,000	1,848,000
Winder Insecticide (kg)	39	66,000	2,574,000
Gandasil D foliar fertilizer (kg)	8	44,000	352,000
ZA fertilizer (1 kg/plant) 1 time per year	620	1540	954800
TSP fertilizer (1 kg/plant)	620	3650	2263000
Mg fertilizer (1 kg/plant)	620	650	403000
Workers needed (smd)			
Digging and filling planting hole	620	5,500	3,410,000
Carry and spreading manure	620	1,100	682,000
Planting	620	1,100	682,000
Pruning, 7x/month (2 workers)	168	55,000	9,240,000
Pest and disease control (4x/ month) (2 workers)	96	55,000	5,280,000
Weeding (12x/year) (2 workers)	480	55,000	26,400,000
Applying fertilizer (3x/year) (2 workers)	6	55,000	330,000
Irrigating 4x/month during the dry season (3 months) (2 workers)	24	55,000	1,320,000
Total cost			65,364,000

Source: Balitjestro technician survey result (2014, 2017)

Table 4. Cost of opening new tangerine cv Madu cultivation land (assumption 1 ha=620 tree)

Item description	Vol	Unit price (Rp)	Amount (Rp)
Land Cost (ha/yr)			
Land lease	1	2,500,000	2,500,000
Production facilities			
Manure 1 sack/hole	620	11,000	6,820,000
Seeds	645	9,350	6,030,750
NPK fertilizer (kg)	250	10,000	2,500,000
Urea (kg)	250	2,200	550,000
Antracol Fungicide (kg)	20	107,800	2,156,000
Folicur Fungicide (kg)	14	132,000	1,848,000
Winder Insecticide (kg)	39	66,000	2,574,000
Gandasil D foliar fertilizer (kg)	8	44,000	352,000
Equipment and supporting materials			
Plant stake	620	165	102,300
Plastic hose	1	550,000	550,000
Semi-automatic sprayer	1	550,000	550,000
Pruning shears (Prohex)	1	82,500	82,500
Workers needed (smd)			
Digging and filling planting hole	620	5,500	3,410,000
Carryingand spreading manure	620	1,100	682,000
Planting	620	1,100	682,000
Seed delivery	1	1,100,000	1,100,000
Pest and disease control (1x/week)	96	55,000	5,280,000
Weeding (1x/month)	36	55,000	1,980,000
Applying fertilizer (1x/3month)	12	55,000	660,000
Irrigating 2x/month during the dry season	48	55,000	2,640,000
Total cost			43,049,550

Source: Balitjestro technician survey result (2014, 2017)

Table 5. The maintenance cost of 1 ha tangerine cv Madu plantation aged 1-3 years (assumption 1 ha=620 tree)

Item description	Vol	Unit price (Rp)	Amount (Rp)
Production facilities			
Manure 1 sack/hole	620	11,000	6,820,000
NPK fertilizer (kg)	372	10,000	3,720,000
Urea (kg)	250	2,200	550,000
Antracol Fungicide (kg)	20	107,800	2,156,000
Folicur Fungicide (kg)	14	132,000	1,848,000
Winder Insecticide (kg)	39	66,000	2,574,000
Gandasil D foliar fertilizer (kg)	8	44,000	352,000
Workers needed (smd)			
Digging and filling planting hole	620	5,500	3,410,000
Carry and spreading manure	620	1,100	682,000
Planting	620	1,100	682,000
Pruning, 7x/month (2 workers)	168	55,000	9,240,000
Pest and disease control (4x/ month) (2 workers)	96	55,000	5,280,000
Weeding (12x/year) (2 workers)	480	55,000	26,400,000
Applying fertilizer (3x/year) (2 workers)	6	55,000	330,000
Irrigating 4x/month during the dry season (3 months) (2 workers)	24	55,000	1,320,000
Total cost			65,364,000

Source: Balitjestro technician survey result (2014, 2017)

Table 6. The calculation of the BCR for rehabilitation of tangerine cv Madu in zones 1 and 2

	Benefit (billion Rp)		Cost (billion Rp)		PV of Benefit (billion Rp)		PV of Cost (billion Rp)	
Year	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2	Zone 1	Zone 2
0	395	19	119	8	395	19	119	8
1	1,471	72	575	28	1,387	68	542	27
2	1,471	72	575	28	1,307	64	511	25
3	1,471	72	575	28	1,232	60	481	24
				NPV	4,320	212	1,653	83

Note: discount factor = 6.10%

BCR for one year
BCR zone 1 = 395/118 = 3.33
BCR zone 2 = 19/8 =2

BCR for three year
BCR zone 1 = 4,320/1,653 = 2.61
BCR zone 2 = 212/83 = 2.57

Table 7. Calculation of BCR for the opening of the new tangerine cv Madu cultivation land

Year	Benefit (billion Rp)	Cost (billion Rp)	PV of Benefit (billion Rp)	PV of Cost (billion Rp)
0	0	270	0	270
1	0	410	0	410
2	0	410	0	410
3	772	410	646	410
		NPV	646	1,498

Note: discount factor = 6.10%; BCR for three years; BCR = 646/1498 = 0.47

The cost-benefit analysis has been widely used to rationalize public projects because it can give an objective view of the projects in question (Lekh and Virendra 2014). The financial feasibility of the benefit-cost ratio has given a preliminary description that the rehabilitation projects of the tangerine cv Madu in the Karo Regency are recommended to be undertaken with the support and participation from the farmers (Walid et al. 2011; Samuel et al. 2016); though in reality, the government is not doing direct handling. This study is intended as an initial guidance for making decisions, determining the potential benefits to be gained and the losses that could be avoided. This study also gives an overview of the budget that should be prepared. Therefore, this analysis is recommended to be performed by policymakers handling public projects. Even though the results of our research may not apply to commodities other than tangerine that affected by volcanic ash fallout, this study has explained the need for detailed analyses of actions needed to be taken upon such situation.

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