International Journal of Agriculture Innovations and Research
Volume 7, Issue 1, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 02/06/2018 | Accepted on: 09/06/2018 | Published: 09/07/2018

Profitability of Local Shallot Farms Under Different Watering Systems in Central Sulawesi Indonesia

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***Abstract* – Central Sulawesi Indonesia has a large area of dryland. One commodity that can be planted in dryland area is shallot. There are local varieties of shallot which farmers in Central Sulawesi used to plant. Even though it can be planted in the dry area, the availability of water need to be a consideration for developing local shallot become sustainable. The profitability is one of parameters for the sustainability of a business. The study aimed to analyze the input uses and measure the profitability of local shallot farms under three watering systems in Central Sulawesi namely: rain fed, canal, and sprinkler. Conducted in 2017, the study covered the districts of Sigi and Donggala, and had 285 small hold farmer-respondents. The analysis of variance (ANOVA) was employed to determine significant differences in the 285 mean levels of input use and the profitability of local shallot farms in three watering systems. Profitability analysis and computations included cost and return analysis and break-even price. The highest productivity and profitability was reached by farms in sprinkler watering system, followed by canal and rain fed systems with net revenues per hectare are 39,841,648 IDR; 28,641,645 IDR; 15,611,254 IDR respectively.**

***Keywords* – Profitability, Local, Shallot, Central Sulawesi.**

I. INTRODUCTION

Shallot is one of the agricultural commodities that play a significant role in the Indonesian economy. Shallot is a spice that is needed as a daily ingredient in the household and food industries. Generally, the production of shallot in Indonesia is still below of the consumption need. Especially for the local shallot varieties, farm productivity is still lower than the national average. Local shallot varieties in Central Sulawesi showed a production of only four tons per hectare [1]. In addition, the volume of production is also not the same throughout the year.

Shallot production, which is fluctuactive, does not meet the continuously increasing demand of the increasing population. The consumption level of shallot in Indonesia is 2.9 kilograms/capita/year and is increasing at 0.05 percent per year. In 2016, shallot needs were projected to reach 1,220,583 tons [2]. For an average shallot productivity of 9.24 ton/ha, it would take about 132, 097 ha of harvest area. Referring to the area harvest in 2013, which amounted to 98, 937 ha, the fulfillment of shallot in 2016 requires the expansion of harvest area to about 33,160 ha. The cultivation of shallot in Indonesia, mostly in Java Island, represents about 80 percent of the country's total production [3]. The rest is sourced in Sumatra and Sulawesi Islands. This regional distribution of production promotes regional trade. The flow of shallot from production areas to other regions is largely influenced by transportation cost and weather. The instability of regional production and oil prices exacerbates the price variability on shallots.

To stabilize the price and meet the domestic demand, the government imports shallot. Other research [4] report that for Indonesia case, shallot production in Indonesia has been increasing in recent years. Nevertheless, demand outstrips supply, and Indonesia is reliant on imports to satisfy demand. Shallot ranks third amongst all vegetable crops in Indonesia in terms of cultivated area. As a key condiment in Indonesian cuisine, demand for shallots is high. In order to meet domestic demand, imports of shallots have increased sharply over the past decade. Imports account for 7 to 15% of annual domestic shallot consumption. The shallot market is highly seasonal with significant high and low periods and large corresponding price fluctuations. While planting times vary depending on location, in most areas the crop is mainly grown during the dry season.

The data on the shallot retail prices obtained from the Ministry of Commerce show that the average monthly retail price of shallot ranged from 18,898 to 60,768 rupiah per kg in 2013-2014 with an average price of 28,479 rupiah/kg. On the other hand, prices of shallot imports are much lower, ranging from 2,433 to 12,269 rupiah per kg with an average price of 5,139 rupiah per kg ([5]. The large price difference indicates the weak competitiveness of the locally produced shallot which may give impact on local shallot market. These impact will indirectly effect to the farm' profitability and sustainability of local shallots.

In general, problems in developing shallot farming lies on how to maintain production quantity and quality as much as the market demands. Some other constraints faced by shallot farming are: high cost of production, seasonal or fluctuating production without good stock management, and capital availability. However, an efficient use of resources can provide the farmers with higher production from the available resources such as production input, water, and land. This situation is particularly critical in developing countries like Indonesia where per hectare recommended amount is seldom used in production. As a result, farm level yield of shallot is very low compared to their recommended yield. Farmers in the study areas also follow different levels of available resources and management depending upon their infrastructural facility and socio-economic conditions. This ultimately results to variability in yields. Therefore, there is a need to study about the input use and profitability of local shallot using different available resources and management systems to get the precise program directions that would increase and sustain shallot production to meet not only its potential demand on one side but also to increase farmer's profitability.

This research sought to evaluate the profitability of local shallot farms under three different watering systems, namely: rain fed, canal and sprinkler systems.

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II. Methodology

The study was conducted in Central Sulawesi Province of Indonesia. Central Sulawesi is the new target development area of shallot production outside of Java Island. Specifically, the study focused on two districts namely: Donggala, and Sigi. These two districts were selected purposively for their similarity in agro-ecosystem in Palu Valley and the presence of the five big producers of shallot in Central Sulawesi.

Fig. 1. Map of Central Sulawesi Indonesia.

Both primary and secondary data were used in this study. The primary data were collected from the local shallot farmers with the use of pre-tested questionnaires while secondary data were gathered through the conduct of a farm household survey. At five percent expected error level, the sample size for this study was about 285 farmers [6].

$$n = \frac{N}{1 + N\,(e)^2}$$

Where:
n = the sample size.
N = the population size.
e = the level of precision.
The samples were stratified by watering systems namely, rain fed, canal, and sprinkler. Stratification based on watering systems considered the fact that shallot is a commodity which sensitive to the rain and dried weather. [7].

Rain Fed System

The rain fed system uses rain to water the shallot plants. It is available during the rainy season. The location of farms is in the hills about 4-5 kilometers from the farmer's settlement. The rain fed area does not use irrigation installations like in canal or sprinkler systems. It is located in the dry areas of the hills. In rain fed areas, water for irrigation is sourced only on rainfall; therefore, farmers only plant shallots during the rainy season.

Canal System

The canal watering system is constructed by the government and uses open irrigation infrastructure. It is available in irrigated areas where canals are available. The main source of water is from the river. Water is made available through an irrigation furrow system continued by manual sprinkle method by farmers. The investment required to develop the canal water source is fairly smaller than the sprinkler system.

This system is located in the lowland areas, relatively near the settlement. Some villages, including Solove, Guntarano, Labuan, and Maku are dry parts in the lowland areas. Where canal irrigation can be applied. However, since this is a dry area and the available water is not enough, commodities that need a lot of water cannot be planted in these areas, for example rice.

Sprinkler System

Sprinkler watering system is used in dry areas where open irrigation infrastructure (canal) is not available. It uses pressure to form droplets of rain water to meet the water needs of the plants. Water flows from the source through a pipeline called mainline and sub-mainline and to some lateral, each of which has several eye dumpers (sprinkler). The investment and operational costs among others are quite high for this kind of watering system.

This system is for the dry areas around hills. The water resource is about 7-9 kilometers from the land. This research identified two villages that use these water source systems. These are the Oloboju and Bolupountu villages. Oloboju is 6-7 kilometers from the source of water while Bolupountu is 8-9 kilometers from the water source. Bolupountu is a village under the transmigration program so that the house and the land are packaged in one hectare land.

The analysis of local shallot production and productivity included:

1. Analysis of variance for comparing the input, cost, and profitability of local shallot farms under rain fed, canal, and sprinkler watering systems.

Under the ANOVA-test, the hypotheses were as follows:
Ho: All means are equal.
H_A: Not all means are equal.

The ANOVA test statistic is the variance ratio, VR which is distributed as F with the appropriate number of numerator degrees of freedom and denominator degrees of freedom at the chosen α level.

$$VR = \frac{\text{Among groups mean square}}{\text{Within groups mean square}}$$

A big value of F means to reject the null hypothesis while a small value means not to reject. The Analysis of Variance test was used to compare means of three groups of watering systems, namely, rain fed, sprinkler and canal system.

The financial analysis includes total revenue, total variable cost, gross margin, net revenue, and break- even price. Based on the formula [8, 9].

1. Total Revenue (TR). Revenue from shallot production comes from the sales of shallot bulbs. It is sold to the fried shallot industry and the market for household consumption. Total revenue of each farm was calculated as follows:

TR = PY

Where:
R = Revenue from sales of output (shallot).
P = Price of shallot per kilogram in rupiah.

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IJAIR
International Journal of Agriculture Innovations and Research
Volume 7, Issue 1, ISSN (Online) 2319-1473

Y = Total volume shallots in kilograms.

2. Total Variable Cost (TVC). This is the sum of the total cost of each of variable input used by farmers in shallot production (seed, labor, inorganic fertilizer, organic fertilizer, herbicide, pesticide, watering). This was calculated using the following formula:

$$\text{TVC} = \sum_{j=1}^{7} C_j = \sum_{j=1}^{7} P_j X_j$$

Where;

C_j = Total cost of each variable input j. j = 1, 2 …7. 1–seed, 2 – labor, 3 – inorganic fertilizer, 4-organic fertilizer, 5-herbicide, 6- pesticide, 7-watering.

$P_j X_j$ = the product of the price (or cost) per unit of input j (P_j) and the total volume of input j (Xj) used in the production of shallot

3. Gross margin (GM). This is amount left after deducting from the Total Revenue the Total Variable Cost.

$$\text{GM} = \text{TR} – \text{TVC}$$

This is supposed to pay for the fixed input used in shallot production, as well to provide returns to farmers for their labor and management, and also for their risk taking

4. Net Revenue (NR). This is the amount left after deducting from the Gross Margin the Total Fixed Cost, or deducting from Total Revenue the sum of the total variable cost and total fixed cost.

$$\text{NR} = \text{GM} – \text{TFC or NT} = \text{TR} – (\text{TVC} + \text{TFC})$$

Fixed costs are cost associated to the use of fixed assets and management. Fixed cost in this study included rent of the land. The study also included interest as one of cost items and was calculated using the formula:

$$\text{IOC} = \text{AIit}$$

Where IOC = Interest on operating capital

Al = Total investment/2 I = Interest rate per year (9 percent)

T = length of the crop production period in month (4 month)

5. Another financial measurement used was the Break-Even Price (BEP) which was calculated using the formula:

$$\text{BEP} = \frac{TFC}{VP} + VC/unit$$

Where:

BEP = Break-Even Price
TFC = Total fixed cost
VP = Volume production
VC = Variable cost

III. Result and Discussion

1) Differences of Input Use and Yield and Cost among Rain fed, Canal, and Sprinkle Watering Systems

The input use of local shallot farms was different among three water source systems. The significance of the input differences among the three watering systems was also analyzed using variance analysis. Table 1 shows that at least one of the three watering systems is significantly different at 1% significance. This significance is based on the variables seed, inorganic fertilizer, organic fertilizer, labor, herbicide, and pesticide.

From field observations, the use of production inputs depends on the socio-economic environment in the area. For example, seed availability will depend on the presence of seed breeders in the location. In the case of rain fed system, farmers always buy seeds because there is time lag for the next rainy season. Expensive seeds limit the use of seeds. Although the rain fed areas have the largest farm sizes, the farmers use the fewest number of seeds (Table 1). This affects production, wherein rain fed areas have the lowest production compared with the two other watering systems. The lower of using seed because of high cost of seed. Seed cost one kilograms up to 35 000 IDR, therefore farmer plant seed below the number recommendation. One alternative for saving seed cost is using true seed shallot which plant grown from the seed not the bulb [10]. Furthermore, ANOVA of input used is shown in Table 1.

Table 1. Comparison between the mean level and ANOVA of input use and yield, 285 farmer-respondents, Central Sulawesi Province, Indonesia, 2016/2017

Input	Rain fed	Canal	Sprinkler	P-Value
Average farm size (hectare)	0.51	0.43	0.40	0.000
Shallot yield (kg)	1665	2540	3150.28	0.000
Seed (kg)	465.85	598.60	607.54	0.001
Inorganic Fertilizer (kg)	138.15	355.34	407.54	0.000
Organic Fertilizer (kg)	16.51	552.87	201.41	0.009
Herbicide (liter)	4.09	5.14	6.83	0.000
Pesticide (liter)	3.68	8.27	8.87	0.000
Labor (man-days)	98.12	163.36	121.37	0.000

Inorganic fertilizer use is influenced by aspects such as the distance from field and the location of the field. For example, in rain fed areas, the input store is far from the field. The road is also far, as rain fed areas are located in the hills. The challenge of bringing the fertilizer to the field has caused the farmers to use only a small amount of chemical

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fertilizers. Another consideration is that the farmers in the rain fed area prefer to minimize the use of fertilizer because they believe that applying more chemical fertilizers will make the shallot juicier making it not proper for the fried shallot industry. On the other hand, the younger farmers in the two other water source areas prefer to increase production by increasing the use of in fertilizer. The government should also consider the future effects of inorganic fertilizer overuse on the environment.

The use of organic fertilizers are also influenced by factors such as the availability of the fertilizer in the area and the quality of the organic fertilizer itself. Organic fertilizers are usually used in larger volumes compared with the inorganic fertilizer. Even though these are cheaper compared with inorganic fertilizers, they are not as easy to use. These are applied during land preparation stage. The effect of organic fertilizer is to improve the soil structure. But, the longer period to realize the effects of the organic fertilizer makes farmers hesitate to use it. Another factor is the role of extension workers in promoting the use of organic fertilizers. In places where the extension worker is active, farmers use organic fertilizers while less is used in rain fed areas as the soil is still rich in organic material.

The use of labor in shallot farming is very intensive. It differs substantially with the labor requirements of other crops, the farther the distance of the rain fed area from the main road, the more labor is needed. Because of the difficulty in bringing big tractors, farmers use manual hoes that need more labor. In canal system, more labor is also used. As practiced by farmers' group working in the area, a farmer-member needs also to work in other nearby farms without pay as a return favor.

Shallot is regarded as a high value horticultural commodity with high price but greater risk in production. The high cost of shallot production exerts pressure for farmers to succeed in production. As a result, the farmers tend to use more pesticides to avoid crop failure as many of them are risk averse. Even before pests and diseases appear, farmers already spray pesticide as a preventive measure. The application of pesticide is also not controlled. Farmers tended to apply more pesticides than what is needed or recommended.

Another factor in the extension of shallot production is the pesticide seller. They give promotions for some new products which farmers willingly try just to lower their risk of loss. But, this situation does not support farmer's health and sustainable environment in the long term. In case the pesticide is systemic, the shallot bulb may retain the harmful chemical material of the pesticide and carry it until it is consumed by humans.

The difference of mean of input quantity and cost of the three-watering systems was analyzed using Analysis of Variance. The used of input production affect the production and also related to the cost production and further the profitability. The result analysis of ANOVA for input used in local shallot farming under three watering systems can be seen at Table 2.

Table 2. ANOVA of Inputs utilization cost per hectare, 285 farmer-respondents from Central Sulawesi Province Indonesia, 2016/2017

Input	Rain fed	Canal	Sprinkler	P-value
Land cost	993,846	2,263,729	2,152,113	0.000
Seed (Rupiah)	18,634,051	21,350,220	24,040,87	0.000
Inorganic Fertilizer (Rupiah)	452,667	932,341	1,921,138	0.000
Organic Fertilizer (Rupiah)	14,282	290,223	145,648	0.006
Herbicide (Rupiah)	269,015	364,866	461,587	0.000
Pesticide (Rupiah)	143,282	1,039,759	1,402,996	0.000
Labor (Rupiah)	5,887,154	6,886,601	7,281,952	0.0012
Irrigation (Rupiah)	0	30,000	70,000	

Similar with the result of Analysis of variance of input utilization, input cost also significantly differed in all of the variables. Cost of seed, inorganic fertilizer, organic fertilizer, labor, herbicide, pesticide and land cost were significantly different at 5% and 10% significance levels. The difference was not only on the amount of input use but also on its price.

Based on the ANOVA, all input costs were different in the three watering systems. The difference in costs was based on the quantity of input which also differed. Likewise, the price of input also differed due to distance to the input market. There were similar costs in the same watering system because of the availability of the input, and the similar habit to use common or same brand of input. The source of the input recommendation was also similar in the same location/system.

2) *Profitability of Local Shallot Farms under Rain fed, Canal, and Sprinkler Watering Systems*

The comparison of profitability across the three water source systems is presented in Table 3 which shows varying profitability performance of shallot farms across systems. Comparison using ANOVA shows that at least one or more items in profitability is significantly different in the three watering systems. The highest productivity was observed in the sprinkler system, followed by canal system; the last was observed in the rain fed system. Based on the input used rating, farmers in the sprinkler system areas have the highest input used, followed by canal and then the rain fed systems. Even though it has the highest input used which merely the highest cost but it also have the highest total revenue. It can be seen in the Table 3.

Table 3. Comparison of the gross income, 285 farmer-respondents from Central Sulawesi Province, Indonesia, 2016/2017

ITEMS	Rain fed	Canal	Sprinkler	F-value
GROSS INCOME				
Quantity of shallot (kg)	1,665	2,548	3,150	24.07
Selling price (Rp /kg)	25,454	24,423	24,752	1.79
Total Revenue	42,386,558	62,232,345	77, 976,766	18.66

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Cost is divide in fixed and variable cost. Land cost represents the cost of the land, whether rented or owned. The land cost also varied across locations. Farms near the road, water source, and other public facilities have higher costs compared with those located farther away. Village which is nearer to the water source have a more expensive land compared the village located farther away. Farm in the canal system has higher costs because of its proximity to the public facilities. In sprinkler areas, the land cost is also high even though it is located on the hills. This is because the soil and climate good in the area are good for horticulture commodities, which are categorized as a high value commodities.

The quantity of the seed use is correlated with the capital of farmers. The sprinkler system area used more seeds compared to the canal and rain fed system areas. Farmers in the rain fed area have the largest farm sizes but used the least amount of seeds mainly because of lack of capital. Shallot seeds are very expensive, costing as much as 40,000 rupiah per kilogram. In rain fed areas, farmers do not continuously plant shallot. They need to buy the seeds and store for the next planting season.

Labor expense is the largest costs in shallot farming. One finding by [11] stated that seed and cost have highest cost in shallot farm. Seed cost around 27, 46-44, 36 percent which 37. 80 percent in average. Labor cost is around 31.75-41.91 percent with 35.55 percent in average. Labor costs include the cost for cultivation, line making, manual planting, chemical grass clearing, fertilizing, and harvesting. Labor cost was highest in the rain fed areas since labor efficient technologies like tractors are not available. This substantially increased labor cost particularly for activities such as soil cultivation and harvesting. In some parts of the rain fed areas, there was difficulty in using tractors because of the terrain and using hoe and manual labor is the alternative but this increases the number of man-days. Transporting shallot after harvesting also contributed to cost as it uses human labor particularly in areas farther from the road. In general, labor in the rain fed area is more costly compared to that in the two other systems.

Another factor influencing labor cost is culture. In the canal system areas, with the Guntarano Village as the center for local shallots, there is a practice followed by farmer's wherein they help each other in farming operations to reduce the cost of labor. In this system, farmers help each other in groups called "Gotong Royong" in Bahasa. This reduces the cost because farmers just provide food for the laborers. The "Gotong Royong" practice is supported by the active farmers' group making the activity sustainable.

Two techniques are used in grass clearing, namely, chemical and manual. The manual technique entails higher labor cost compared to the chemical technique. Chemical grass clearing needs only half day of labor or four hours of work but for manual clearing, it takes one or two days to finish the work depending on the farm size. The cost of labor also includes the meals and sometimes cigarettes. Herbicides are used in chemical grass clearing normally in two applications - one before soil cultivation and second after planting. Labor cost for harvesting includes the cost of uprooting, transporting from field to house or storage place, cleaning, and binding. Harvesting is counted by man-days or counting the number of plant lines. Whether it is counting the line or by volume, conversion to the man-days system is practiced.

Inorganic fertilizer expense is greatest in the sprinkler system. Farmers use inorganic fertilizers in large amounts to increase production. In the rain fed areas, farmers' fertilizer costs are lower because they do not have enough capital to buy more fertilizers. The effects of inorganic fertilizer compared to organic fertilizer can be easily seen. The cost of fertilizer is subsidized by the government. However, the subsidy is often made available during the rice planting season, not coinciding with the time to fertilize the shallots. Distance from the input source also affects fertilizer cost. The use of an organic fertilizer is lower compared with using inorganic fertilizers. Organic fertilizer is cheaper at an average price of 35,000 rupiah per sack of 50 kilograms. In rain fed areas where land is not intensively used, farmers think that there is really no need to apply organic fertilizers.

The cost of pesticide application depends on the quantity used. Farmers in the sprinkler area used higher amounts of pesticides thereby increasing their cost significantly. Farmers are very much dependent on pesticides. Some farmers ask recommendations from input dealers on pesticide use. But in some cases, application is beyond the recommendation resulting to higher costs.

The irrigation cost is determined by the irrigation association. The fee depends on what has been agreed upon in the irrigation association. The sprinkler area irrigation cost was higher because more work is needed in terms of managing and maintaining the irrigation installations.

Generally, the revenue of local shallot farming in Central Sulawesi is lesser than non-local shallot farming. Result research of [12] stated that shallot farming actual revenue in East Java reach Rp. 73.263.046/ha in 2012 then increasingly become Rp. 155.162.630,84/ha in 2013.

Table 4. Gross margin, Net revenue, and break- even price of local shallot farms under rain fed, canal, and sprinkler watering systems, 285 farmer-respondents from Central Sulawesi Province, Indonesia, 2016/2017

ITEMS	Rain fed	Canal	Sprinkler	F-value
Gross Margin	16,986,107	31,363,335	42,722,574	11.54
Net Revenue	15,611,254	28,641,645	39,841,648	10.32
Break-even price	15,079	13,182	12,105	

The price of shallot is almost the same in both the sprinkler and canal area but, different in the rain fed area because of better quality shallot. The minimum application of inorganic fertilizer has been believed to make the bulb solid and hard. This is good for fried shallot quality. The shallot in rain fed areas have lesser insecticide inputs therefore more environment-friendly. Pricing in rain fed area is still traditional and based on bundles of about 14 kilograms relative to other areas.

The fluctuations in shallot prices guide the government in setting the minimum price. The minimum price should consider the break-even price where the total cost just

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equals the return per unit. The break-even prices differed in the three areas. The break-even price of shallot in rain fed system was 15,079 rupiah per hectare as compared to the canal system with 13,182 rupiah and sprinkler system with 12,105 rupiah. The high break-even price in the rain fed area is due to the low volume of production. The higher the volume of production, the lower is the price.

The profitability also influenced by central government policy. Conclusion of [13] that the price reference policy has an impact on protection and profitability of shallot farmer. Based on result, for achieving higher rate of farmer protection and profitability it should be considered to reformulate the import restriction policy, and the price of shallot at the farmers level should be at least IDR 15,260/kg. Therefore, the implementation of import restriction on price reference basis policy has an impact to the shallot farmers' income. The policy suggests that the price at farmer level is IDR 11,935/kg which decreased the farmer protection and profitability for 46% and 233 %, respectively. This decrease was caused by the escalation cost of farming inputs and the lower added valued. It is then proposed that the price reference of shallot should be at least IDR 15,260/kg at the farmer level to achieve a higher rate of protection and revenue that would be most beneficial to farmers.

Furthermore [14] stated that prices of input and output in the market are given for the shallot farmers. They face asymmetric information of input and output prices that cause high risks in agricultural production. One way in the short run to increase farmer's income is coming from the efficient input allocation which will result in optimum output and input for maximizing profit. The management of marketing systems are needed for anticipating the sharp fluctuation of local shallot price [15].

A policy to increase shallot production should support public infrastructure including irrigations in farms area. It will reduce the inefficiency in cost production. If the local shallot farms are already efficient in using the inputs, the next step is to introduce new technologies in shallot production.

IV. Conclusions and Recommendations

The shallot cultivation is found profitable in the study areas although the yield is lower than the potential yield. Among the three water source systems, local shallot farms in sprinkle area had highest production and profitability, followed by canal, and rain fed systems respectively.

Based on the findings of the study, the following recommendations can be made; shallot seed should be made available to the farmers at proper time and price to increase the production of shallot. The construction of public facilities including water facilities need to become a major priority of the government, especially in rain fed area. Another concern is the implementation of input policy in terms of improving the distribution mechanism for the farmers' subsidy needs.

Consider an output price policy that is more transparent and improves the economic welfare of the farmers. Minimizing the asymmetric information by increasing market information dissemination to local shallot farmers that includes prices and onion supply in market.

The minimum price recommendation should considerate on the break-even price which different among three watering systems area. The developing of shallot should be supported by Central Government by making price policy which are support to farmer's profitability.

Acknowledgment

Author is grateful to Indonesian Agency for Agricultural Research and Development (IAARD) Ministry of Agriculture for funding the study and to Dr. Andi Baso Lompengeng Ishak S.Pt, MP as The Head of Central Sulawesi Assessment Institute for Agricultural Technology (AIAT) for guiding and supporting the study.

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