

## ANALYSIS RISK AND RETURN OF CROPS PORTFOLIO

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### Abstract

*Farming is very vulnerable to risk and uncertainty. Risk in agricultural activities is one of the problem commonly faced by farmers. An alternative that can be done to minimize the risk is by diversification. The combination of two or more crops will form a portfolio that is expected to reduce the risk of farming. The purpose of this study was to analyze the income and risk of vegetable farming in a monoculture and diversification. This research was conducted using the risk analysis method using the calculation of expected return, standard deviation and coefficient variation. This research also analyze the choice of portfolio based on preference using Stochastic Efficiency With Respect To A Fuction (SERF). Research shows that diversification can reduce the risk of longbean, spinach and green mustard. Diversification also provide greater income for farmer. However, spinach will give higher return if cultivated in monoculture. Portfolio with lowest risk is portfolio IX (combination of three crop). Furthermore, farmer that are more risk averse gradually will choose portfolio that provide lower risk.*

**Keywords:** *risk, crop portfolio, risk preference, SERF*

### 1. INTRODUCTION

Horticultural sector has contributed to the national economy of Indonesia, which can be seen from its contribution to the Gross Domestic Product (GDP). In addition, horticultural commodities are also a source of income for the community and small, medium and large scale farmers (Hermanto, 2015). One of the horticultural commodities that chosen by many farming household is vegetable. Farming is very vulnerable to risk and uncertainty. The main sources of risk in agricultural sector are production risk (weather uncertainty, pest attacks and plant diseases) (production risk) and price risk that can be seen from fluctuations in prices (Patrick et al., 1985). Generally, the price fluctuations for vegetables relatively higher than fruits and paddy (Irawan, 2007). Price risk will affect the decisions of farmers in managing or investing in their own land (Rosa et al., 2019).

Furthermore, decision-making in dealing with risks in the agricultural business is also heavily influenced by the risk preferences of the farmers themselves (Wibowo, Rizaldi, et al., 2019; Wibowo, Sumono, et al., 2019). Subdistrict Marelan is one of area that mostly supply vegetables to a lot of markets in Medan. There are three type common plant that cultivated by farmers in the District Marelan namely spinach, long beans and mustard greens. Farmers in Marelan is faced by price risk that can be seen from fluctuation in the market price. Diversification is a strategy that has long been used by farmers to deal with the risk of price and agricultural product volatility. Diversification is done by cultivated more than two types of plants in one cultivated area.

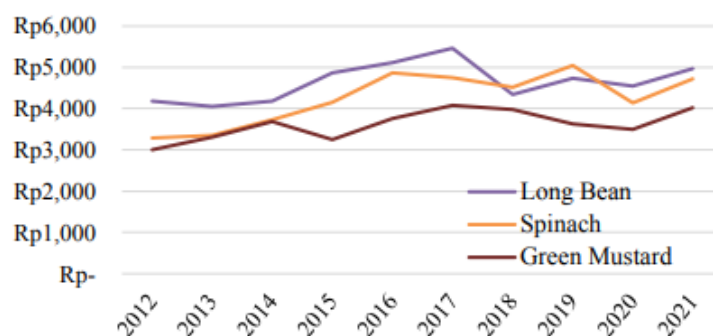


Figure 1. Vegetable Prices in Medan City (2012-2021)

Therefore the purpose of this study is to analyze the return and risks in portfolio that combine long bean, spinach and green mustard as a practice of diversification. This research will analyze the return and risk of crops and explain whether 2 or 3 types of crops is the best combination to reduce the risk to be implemented in diversification. In addition this research also will analyze farmer choice of portfolio based on their risk preference.

## LITERATURE REVIEW

Agricultural diversification is an attempt to replace or increase monoculture agricultural output towards multicultural agriculture. Such diversification is called horizontal diversification, namely plants, livestock or fish, fish-livestock, livestock. In addition, there is vertical diversification, namely efforts to promote processing industries of the agricultural products concerned ((Mubyarto, 1989). The rationale for diversification is to make the profits from one type of cultivated crop greater than the losses from other crops (Debertin, 2012). Diversification can help avoid the disadvantages of emphasis on one or two crop varieties such as declaration in productivity growth, over exploitation of ground water resources and deterioration of soil health Furthermore diversification can offer a number of agronomic benefits, such as improvement in soil fertility and protection of crop from diseases, weeds and insect (Mandal & Maity, 2022; Ogundari, 2013). Previous study also explain that diversification can give more profit to farmers (Hastrianty et al., 2020) because loss from one plant can be covered by income from other plants (Debertin, 2012).

The risks and returns faced by decision makers move in one direction. In other words, the greater the risk faced by decision makers, the higher the return received. Vice versa, the smaller the risk faced by decision makers, the smaller the return received (Hanafi, 2007). Harri M. Markowitz, who first developed the portfolio selection theory, stated that most investors are risk averters (avoiding risk). This means that investors will always try to avoid risk. To avoid this, investors try to diversify their investments (Anaroga & Pakart, 2006). In portfolio management, the concept of risk reduction is known as a result of adding securities to the portfolio. This concept is a very important concept in understanding portfolio risk. This concept states that if we continuously add types of securities to our portfolio, then the risk reduction benefits we get will be greater until we reach a certain point where the reduction benefits begin to decrease (Tandelilin, 2001). There is a foreign saying that "wise investors do not put all their eggs into just one basket". Therefore diversification is carried out to reduce investment risk. To reduce possible losses, investors should invest in various types of assets or business activities (Husnan, 1993).



## 2. IMPLEMENTATION METHOD

Before explaining the method analysis, there are several basic assumptions used in this study. The assumptions are as follows:

1. Production of long beans, spinach and mustard greens is constant every year, so weather, climate and pests (production risks) are factors that are not taken into account .
2. The risk taken into account is the price risk as seen from price fluctuations of long beans, spinach and mustard greens.
3. The values that change are the selling prices of long beans, spinach and mustard greens as well as the prices of farming inputs such as fertilizers, pesticides and labor wages

This research was conducted based on data of long beans, spinach, and mustard farming for 10 years observation. First, we design portfolio that combine longbean, spinach and green mustard. Aftrre that will design ratio of weight for each crop in portfolio to calculate their risk and return to portfolio. Weight of each crop in portfolio can be calculate using formula as below:

$$W_{a,b,c} = \frac{\text{Total farming area (a,b,c)}}{\text{farming area (a)} + \text{farming area (b)} + \text{farming area (c)}}$$

Where Wis weight of portfolio, a is longbean, b is spinach and c is green mustard. Total weight for all crop,  $W_a, W_b$ , dan  $W_c$ , is equal to one ( $W_a + W_b + W_c = 1$ ).

Table 1. Portfolio Designed based on type of plant and weight

Portfolio	Type of Plant	Weight
I	LB:S	0.25:0.75
II	LB:S	0.75:0.25
III	S:M	0.25:0.75
IV	S:M	0.75:0.25
V	LB:M	0.25:0.75
VI	LB:M	0.75:0.25
VII	LB:S:M	0.25:0.5:0.25
VIII	LB:S:M	0.25:0.25:0.5
IX	LB:S:M	0.5:0.25:0.25
X	LB:S:M	0.3:0.4:0.3

\*LB: Long Beans; S: Spinaches; M: Mustard

After design portfolio is complete, we will calculate the expected return and standard deviation for each crop and portfolio. The calculation of return and risk will be carried out using the following formula as below Expected Return Expected return is the sum of the values expected to occur from the probability of each event. In this study, the expected return is the amount of farmer's return that obtained if farmer doing vegetable farming in one hectare of land for one year. Expected return for monoculture farming can be seen in equation (2) and expected return for portfolio can be seen in equation (3) below (Ahmad, 2004; Elton & Gruber, 1977) :

$$E(R_i) = \sum_{i=1}^n P_i \cdot R_i$$

$$E(R_p) = [E(R_a) W_a] + [E(R_b) W_b] + [E(R_c) W_c]$$

Where  $E(R_i)$  is Expected Return of monoculture farming,  $E(R_p)$  is Expected return Portfolio,  $R_i$  is Return,  $W$  is weight of crops in portfolio and a is for longbean, b is for spinach, c is for green mustard. Variance and Coefficient Variation Variance of return is the sum of the squared difference between the return and the expected return multiplied by the probability of each event. Meanwhile coefficient variation can be measured from the ratio of the standard deviation to the expected return. The smaller the value of the coefficient variation, the lower the risk faced by

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farmer. Calculation of Variance and Coefficient Variation for monoculture farming can be seen in equation (3) (Ahmad, 2004) :

$$\sigma^2 = \sum_{i=1}^n P_i (R_i - E(R_i))^2$$

$$\sigma = \sqrt{\sigma^2}$$

$$CV = \sigma / E R_i$$

Where  $\sigma^2$  is Variance of return,  $\sigma$  is Standard Deviation and CV is Coefficient Variation. Furthermore, the variance in the portfolio will calculated using the formula below (Elton & Gruber, 1977).

$$\sigma^2(R)_p = W_a^2 \sigma_a^2(R_a) + W_b^2 \sigma_b^2(R_b) + W_c^2 \sigma_c^2(R_c) + 2W_a W_b covar (R_a, R_b) + 2W_a W_c covar (R_a, R_c) + 2W_b W_c covar (R_b, R_c)$$

Where,  $\sigma^2 (R)_p$  : Variance of portfolio

$\sigma^2 (R_{a,b,c})$  : Variance of Longbean, spinach and mustard

$W_{a,b,c}$  : Weight of Longbean, spinach and green mustard in portfolio

$covar (R_a, R_b)$  : Covariance A & B

$covar (R_b, R_c)$  : Covariance A & C

$covar (R_b, R_c)$  : Covariance B&C

Portfolio choice based on of farmer preference can be analyzed using Stochastic Efficiency with Respect to A function (SERF). The SERF method can explain farmers decision making on each level of preference risk. Preference farmer against risk portfolio represented by the Absolute Risk Averse Coefficient (ARAC). SERF is used Certainty Equivalent value at the level coefficient different risks (RAC) (Hardaker & Lien, 2010; Lien et al., 2007)

3. RESULTS AND DISCUSSION

The expected return value is the amount of income that will be received by farmer in one year of production. Meanwhile, to see the risk, coefficient variation values are used. Risk assessment through the best coefficient variation assessment to determine whether the commodity 5 is risky or not. The greater the value of the coefficient variation, the greater the risk faced and vice versa. The results of calculating the income and risks of farming long beans, spinach and mustard greens on one hectare of land in one year of production can be seen in the following table:

Table 2. Expected Return and Risk of Monoculture Farming in One Hectare of Land in One Year

Plants	Expected Return	Coeff. Variations
LB	529,085,523	0.108
S	964,772,784	0.164
M	616,896,980	0.132

LB: Long Beans; S: Spinaches; M: Mustard

Based on the results in table 2 spinach is crop with the highest risk and return compared to long bean and mustard. This can be seen from the value of coefficient variation as proxy of risk for spinach which is 0.164 and value of expected return as proxy of return which is 964,772,784. The expected return value of spinach is high because spinach has fifteen growing seasons in one year. These results are also in line with study by Limbong (2018) stated that spinach is crops with high risk in agriculture.

Value of coefficient variation for green mustard is 0.132, lower than spinach and value of expected return of green mustard is 616,896,980. Long Beans has lowest risk and return compared to spinach and green mustard. This can be seen from the value of coefficient variation as proxy of risk for long bean which is 0.108 and value of expected return as proxy of return which is 529,085,523. The lower value of return and risk of long bean is because long beans have only 2 times of growing season in one year.

Table 3 . Expected Return and Risk of Portfolio in One Hectare of Land in One Year

Portofolio	Type of Crops	Weight	Expected Return	CV
I	LB : S	0.25:0.75	855,851,044	0.139
II	LB : S	0.75:0.25	638,007,564	0.091
III	S : M	0.25:0.75	703,865,931	0.103
IV	S : M	0,75:0,25	877.803.833	0,137
V	LB : M	0,25:0,75	594.944.191	0.105
VI	LB : M	0,75:0,25	551.038.613	0,086
VII	LB : S : M	0,25:0,5:0,25	768.882.093	0,108
VIII	LB : S : M	0,25:0,25:0,5	681.913.142	0.086
IX	LB : S : M	0,5:0,25:0,25	659.960.353	0,080
X	LB : S : M	0,3:0,4:0,3	729.703.955	0,096

Portfolio is designed to get better analysis of crops combination, whether two or three plants is the best option for portfolio design. Result showed that portfolio IX which is combination of three type of crops is portfolio with the lowest risk value. However, lowest risk is also followed by lowest return. If we continuously add types of securities to our portfolio, then the risk reduction will be greater until we reach a certain point where the reduction benefits begin to decrease (Hanafi, 2007). Similar study also state that we can reduce the risk if we put suitable crops in one portfolio ((Paut et al., 2019). Meanwhile portfolio IV is portfolio with highest return and highest risk. These are in accordance state by Hanafi (2007) that the greater the risk faced by decision makers, the higher the return received. Vice versa, the smaller the risk faced by decision makers, the smaller the return received. Portfolio IV is combination which is the weight of spinach in portfolio is higher than green mustard. Green mustard is still unable to cover the risk of spinach.

With purpose to reduce risk, diversification of longbean and green mustard using our portfolio design is proved can reduce the risk. in addition, long bean and green mustard that is cultivated in diversification can provide greater return than if long bean and green mustard is cultivated in monoculture. This study shows that spinach is crops with highest risk and return. In order to reduce the risk, diversification of spinach is proved can reduce the risk. However, return of spinach that cultivated in monoculture is higher than spinach if combine with other crops. Many studies have explain that preference of farmer finally will influence decision farmer in farming (Wibowo, Rizaldi, et al., 2019; Wibowo, Sumono, et al., 2019)To analyze the choice of portfolio based on farmer preference we use SERF. This method is useful and easily understood on problems involving agricultural risk (Fathelrahman et al., 2011).

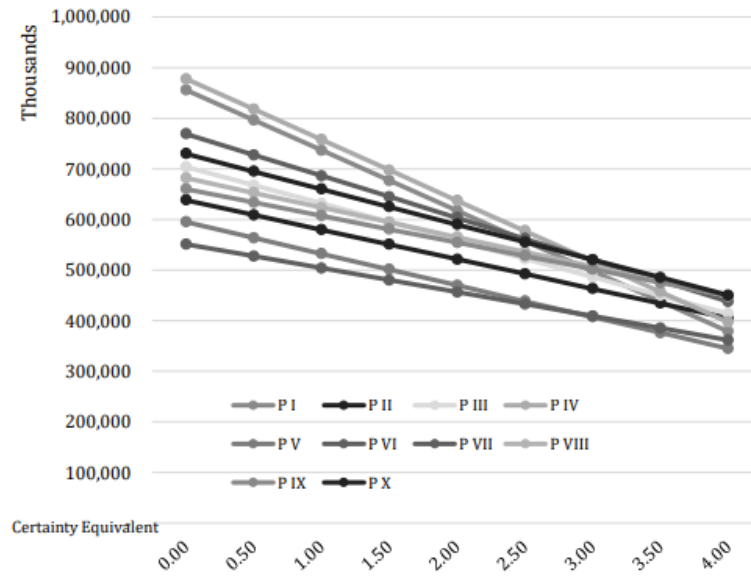


Figure 2. SERF Analysis of Crop Portfolio Combination Long Bean and Spinach

This study shows that farmers' preference of risk is represented by the Absolute Risk Averse Coefficient (ARAC). ARAC value that equal to "0" indicates that decision makers are risk neutral and the greater value of the ARAC or equal to "4" indicates that the decision makers are more fear of risk. Based on Figure 2. It can be seen that farmer preference that are more risk averse, will gradually chose portfolio with lower risk. Farmer that are risk neutral will choose portfolio IV that conduce higher risk and higher return than other portfolio. When farmer risk preference gradually change to risk averse, portfolio that choose by decision marker is portfolio X, which is portfolio with lower risk and return than portfolio IX. This result is inline with other study that farmer that is more risk averse is likely to choose asset or investment with lower risk (Liontakis & Tzouramani, 2016)

#### 4. CONCLUSION

Research shows that diversification can reduce the risk of longbean, spinach and green mustard. Diversification also provide greater income for farmer. However, spinach will give higher return if cultivated in monoculture. With purpose to reduce the risk, portfolio IX (combination of three crops) is the lowest risk portfolio but, this portfolio also come with lower return. this result also conclude that the more crops in one portfolio will reduce the risk. Finally, the preference of farmer as decision making will influence the choice of portfolio. Farmer that are more risk averse gradually will choose portfolio that provide lower risk. This study is still lack by not taking into account the risk of production, and type of plant that suitable to combine in one portfolio. We hope for the future improvement from other researchers.

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