Implementation of environmental-economic concepts through farming risk management in highland vegetable agroforestry

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Abstract. Agroecology-based farming in the management of highlands that is effective and targeted can provide economic benefits and protect land and the environment simultaneously. Sustainable land use is the use of land that meets current needs, and at the same time preserves these resources for future generations. This study aims to compare the farming income of cabbage monoculture, clove monoculture, and agroforestry of cabbage with cloves. Next is to look at the level of risk of each farming system and determine the farming system used by farmers as a form of risk management through the selection of cultivation technology by utilizing the suitability and adaptation of vegetation. The results showed that an agroforestry system is a form of risk management strategy for highland vegetable farmers with a monoculture cropping system that has prospects from an economic aspect but has a high risk from an ecological aspect.

1. Introduction

The concept of environmental economics is a solution and reaction to environmental damage and the depletion of natural resources by ensuring optimal resource prices and preventing the impact of externalities in the use of natural resources [1] and effort of prevention and mitigation has been integrated into development programs in various sectors [2]. Environmental economics seeks to bridge human-economic-Environmental interaction to steer the economy towards sustainability [3]. A new paradigm is needed that approves various agriculture for development in the context of promoting economic growth, reducing poverty, increasing food security, and providing environmental services [4]. The regional autonomy policy encourages each region to produce various agricultural commodities within the framework of self-sufficiency and reduce dependency on food needs from other regions [5].

Indonesia's territory is 45% in the form of hills and plateaus, so that upland agriculture has a strategic position in agricultural development. However, upland agriculture has biophysical limiting factors, namely relatively steep slopes, soil sensitivity to landslides and erosion, and relatively high rainfall. Incorrect management of land resources can cause biophysical damage or pressure in the form
of degradation of soil fertility and water availability [6]. In farming practice, despite having long experience in farming for the commodity being cultivated, farmers cannot always achieve the level of efficiency and productivity as expected [7,8]. Biophysical factors such as soil type and climate can be opportunities and/or problems in agricultural development, depending on the mastery of farmers’ land management technology. Increased productivity is only possible when there is a gap between actual and potential productivity caused by technological and management gaps [9].

Global climate change can reduce agricultural output, increase production instability, and degrade natural resources. Without good management, agricultural output will decrease by 20% in 2050, and the national GDP will erode 1% every year. Adaptation and mitigation are needed in the development of climate-smart agriculture [10]. Adaptation is a key strategy that can reduce the severity of climate change in highland agriculture and increase farmers’ incomes [11]. Adaptation strategies will not be effective without understanding the economics and ecology that farmers demand. Several studies of crop diversification with suitable varieties can improve farming systems in the short term. It can also be a long-term land and water management strategy [12]. Based on this, the study was conducted to determine the income of cabbage monoculture, clove monoculture, and cabbage and clove agroforestry. Next, analyze the economic and ecological risks in each farming system and determine risk management in accordance with the farming system’s adaptability.

2. Method

2.1. Time and Research Site

This research was conducted in January-March 2020 in Watumaeta Village, Napu Plateau in Central Sulawesi, Indonesia, which borders directly with Lore Lindu National Park (TNLL). Watumaeta Village is about 102 km from Palu City, the provincial capital that is connected via the trans Sulawesi national road. The location of the study was determined using a purposive method with the consideration that Watumaeta Village was the center of production of cabbage horticulture and clove plants as annual crops through a monoculture and agroforestry cultivation system. Determination of respondents was also carried out by a purposive method consisting of 10 cabbage farmers, 10 clove farmers, and 10 farmers who practice the agroforestry system of clove and cabbage so that the total respondents were 30 people.

2.2. Data Collection and Analysis

Data collection related to the economic aspects of farming in the last 5 years (2015-2019) was carried out through interviews using a questionnaire containing structured questions [13]. While data collection related to ecological aspects includes rainfall data from the Wuasa climatology station, temperature measurements using HOBO tools, measurements of sunlight intensity using lux meters, wind speed measurements using anemometers, land slope measurements using clinometers, and soil fertility measurements are carried out with observations to find out the structure of the soil.

Data analysis relating to economic aspects was carried out using descriptive-analytic analysis methods to explain the factors of production, prices, revenues, costs, and income obtained by monoculture and agroforestry farmers [14]. While the data analysis relating to ecological aspects was carried out using descriptive analysis methods to illustrate the microclimate and land factors that influence farming with monoculture and agroforestry systems. Farming risk management is carried out through the following stages of data analysis:

1. Analysis of farm income by calculating production, prices, costs, revenues, and income of cabbage monoculture, clove monoculture, and clove + cabbage agroforestry using income analysis [15], which can be mathematically written:

\[ I = TR - TC \]
\[ I = \text{Income/Profits} \]
\[ TR = \text{Total Revenue (Y.Py)} \]
\[ Y = \text{Yields} \]
Py = Price of Yields

TC = Total Cost (FC+VC)

FC = Fixed Cost

VC = Variable Cost

(2) Analysis of farm risk based on economic aspects including production, price, revenue, costs and income which is carried out quantitatively on cabbage monoculture farming, clove monoculture, and clove + cabbage agroforestry by using of coefficient variants to measure the relative risk level of each investment that is different from the rate of return different [16], using the formula:

\[ CV = \frac{\sigma}{Xr} \]  \hspace{1cm} (2)

CV = Koefisian variasi

\[ \sigma = \text{Standar deviasi (simpangan baku)} \]

\[ Xr = \text{Nilai rata-rata} \]

The criteria used are:

- a. \( CV \leq 0.5 \), farming has a low risk
- b. \( 0.5 < CV \leq 1 \), farming has a moderate risk
- c. \( CV > 1 \), farming has a high risk.

(3) Analysis of farmers' perceptions based on ecological aspects was carried out qualitatively to describe climate and land factors from cabbage monoculture farming, clove monoculture, and clove + cabbage agroforestry using a Likert Scale. Likert scale is used to describe respondents' agreement on a problem, which is commonly used in descriptive survey research [17]. Criteria interpreted based on scores are:

- a. \( CR \leq 10 \), farming has a low risk
- b. \( 10 < CR \leq 30 \), farming has a moderate risk
- c. \( CR > 30 \), farming has a high risk.

3. Results and Discussion

3.1. Farming Income of Monoculture and Agroforestry System

Farm income describes how much success the farming activity is and to be used as a benchmark for future state design. To calculate farm income, cost information is needed in the time specified and the amount of revenue. While farm receipts are multiplication between production volume and selling price [18]. Farm income during the analysis period is presented in Table 1 below.

| No. | Farming System                  | Production (kg) | Price (IDR/kg) | Revenue (IDR) | Cost (IDR) | Income (IDR) |
|-----|--------------------------------|-----------------|----------------|---------------|------------|--------------|
| 1.  | Cabbage Monoculture            | 121,253         | 1,500          | 181,879,500   | 26,121,655 | 155,757,845  |
| 2.  | Clove Monoculture              | 1,215           | 80,000         | 97,200,000    | 7,118,615  | 90,081,385   |
| 3.  | Clove+Cabbage Agroforestry     |                 |                |               |            |              |
|     | - Clove                        | 1,572           | 80,000         | 125,760,000   | 5,235,700  | 120,524,300  |
|     | - Cabbage                      | 127,165         | 1,500          | 190,747,500   | 21,231,322 | 169,516,178  |

Table 1. Average Farming Income of Monoculture and Agroforestry for 5 Years (2015-2019).
Table 1 and Figure 1 show that cabbage farming in the short term provides higher income compared to clove farming if it is done monoculture even with lower selling prices and higher farming costs. While clove monoculture farming, in the long run, provides benefits because the value of production does not only come from clove flowers but also from trees. The value of clove trees when they are cut (> 30 years) is IDR. 307,530,000/ha for monoculture farming and IDR. 127,800,000/ha. On the other hand, farming with clove + cabbage agroforestry systems provides higher incomes compared to cabbage and clove monoculture farming systems. This is because the volume of clove flowers (dry weight) and cabbage heads (fresh weight at harvest) in agroforestry systems is higher than the volume of clove and cabbage flowers in the monoculture farming system.

The increase in yield volume in the agroforestry system is influenced by climate suitability, inorganic fertilizer application, and intensive maintenance of cabbage plants, which also influence the growth of clove plants and reduce the costs of production and maintenance inputs for both types of plants. Intensive fertilization of cabbage plants also provides opportunities for nutrient uptake from fertilizers in the clove plant root complex on the same land. Whereas in the monoculture system, clove farmers generally do not carry out routine fertilization and sanitation, which results in lower crop production compared to agroforestry systems [19].

3.2. Economic Risk of Farming in a Monoculture and Agroforestry System

Farming risk from the economic aspect is the possibility of loss, which is not achieving the expected level of income or the possibility of return received deviating from the expected [20]. Farming economic risk is the value of the variance coefficient by dividing the standard deviation of the risk factor by the average value of the risk factors (production, price, revenue, cost, and income) in monoculture and agroforestry farming, presented in table 2 below.

| Table 2. Economic risk criteria of farming. |
|-------------------------------------------|
| Risk Factor                          | CV Value | Risk Criteria |
|----------------------------------------|----------|---------------|
| Cabbage Monoculture                    |          |               |
| Production                             | 1.98     | High          |
| Price                                  | 0.10     | Low           |
| Revenue                                | 0.96     | Moderate      |
| Cost                                   | 2.68     | High          |
| Income                                 | 2.14     | High          |
| Clove Monoculture                      |          |               |
| Production                             | 0.63     | Moderate      |
Table 2 shows that the income risk of upland vegetable farming in this case cabbage is influenced by production risk and costs. Cost risks that affect production are the prices of fertilizers, medicines, seeds, and labor costs for crop maintenance and terrace construction to prevent erosion. This risk causes a high risk of production if farmers do not have access to capital. High consumer demand and relatively stable prices help farmers reduce the risk of revenue, but high farming costs in terms of ensuring soil fertility and reducing the impact of high rainfall and slope causes high-income risks for cabbage farmers with a monoculture system. Conversely, the risk of monoculture clove farming income is mainly influenced by price risk due to fluctuations in clove prices and reduced production risk due to the age of the plant that has passed its productive period (> 20 years). However, the risk of income is not as high as monoculture cabbage plants because the costs incurred by clove farmers with the same system are relatively lower because clove plants are included in annual plants that are more tolerant of climate risk factors and slope.

3.3. Ecological Risks of Farming in a Monoculture and Agroforestry Systems

Ecological aspects have a significant influence on on-farm production and acceptance. Ecological factors affecting highland vegetable farming are climate (humidity, rainfall, sunlight and wind speed), soil fertility, and topography (slope). If the types of plants cultivated are not in accordance with these ecological factors, there will be risks to farming management. High and low risks caused by ecological factors depend on the suitability and adaptation of plants, as presented in Table 3 below.

| Table 3. Ecological Risk Criteria of Farming |
|----------------------------------------------|
| Risk Factor       | Risk Value | Score | Risk Criteria |
|                  | 5 | 4 | 3 | 2 | 1 |
| Cabbage Monoculture |            |      |      |      |      |
| Humidity         | 8 | 2 | 0 | 0 | 0 | 42 | Moderat |
| Rainfall         | 10| 0 | 0 | 0 | 0 | 50 | High    |
| Sunlight         | 0 | 0 | 2 | 8 | 0 | 32 | Moderat |
| Wind Velocity    | 0 | 0 | 1 | 9 | 0 | 21 | Low     |
| Soil Fertility   | 10| 0 | 0 | 0 | 0 | 50 | High    |
| Slope            | 10| 0 | 0 | 0 | 0 | 50 | High    |
| Clove Monoculture |            |      |      |      |      |
| Humidity         | 0 | 0 | 0 | 8 | 2 | 18 | Low     |
Table 3, shows that monoculture cabbage farming in the highlands has a high risk of rainfall, soil fertility, and slope. Farmers will devote significant amounts of money and energy on land management through fertilizing and manufacturing terraces. Upland vegetables need more intensive land and crop maintenance than annual crops. Cultivation of the soil in cabbage plants by hoeing, stirring the soil, and other methods can destroy soil aggregates so they are easily eroded. The greater the slope of the land, the higher the surface flow rate. Clove farming with a monoculture system has lower risk because clove plants can grow and produce at an altitude of 0 - 900 m above sea level (asl) and are more adaptive to environmental conditions.

Clove + cabbage agroforestry practices are farmers’ decision making in risk management efforts through vegetative land conservation by utilizing plants to reduce erosion, protect soil from runoff, and increase water and nutrient absorption into the soil [24]. The agroforestry system aims to minimize the risk of clove farming from cabbage farming by reducing the risk of biophysical limiting factors such as relatively high rainfall, slope, and soil sensitivity to landslides and erosion that can cause land fertility to decrease. The application of agroforestry systems from the ecological aspect is an effort to preserve soil and water [25].

4. Conclusion and Suggestion
In the context of sustainable agriculture, the value and economic potential of cabbage in terms of production and prices have the opportunity to increase farmers' incomes and have prospects to continue to be developed. But in its development, it will require high costs on environmental management and the use of production inputs. Also, increased production by expanding the planting area in the conservation area will be constrained by the availability and condition of the land. On the other hand, clove commodities have decreased due to the age of plants that have passed the productive period and the level of land fertility but have a relatively high level of environmental adaptation. Farm risk management through an agroforestry system aims to increase farmers' incomes by minimizing the economic and ecological risks faced by farmers.

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Reference
[1] Neo H 2009 Resource and Environmental Economics Int. Encycl. Hum. Geogr. 376–80
[2] Hanifa L, Sadat A, Mahmuda D, Nazar A, Jasiyah R, Wijaya R S, Unde A A, Ichsani N, Anwar S and Nurfida R A F 2019 Handling disaster risks with the community-based approach IOP Conference Series: Earth and Environmental Science vol 235 (IOP Conference Series: Earth
[3] Venkatchalam L 2007 Environmental economics and ecological economics: Where they can converge? Ecol. Econ. 61 550–8

[4] Byerlee D, De Janvry A and Sadoulet E 2009 Agriculture for development: Toward a new paradigm Annu. Rev. Resour. Econ. 1 15–31

[5] Pujiharto P 2011 Kajian Potensi Pengembangan Agribisnis Sayuran Dataran Tinggi di Kabupaten Banjarnegara Propinsi Jawa Tengah Agritech J. Fak. Pertan. Univ. Muhammadiyah Purwokerto 13 4216

[6] Simbolon S D, Nasution Z, Rauf A and Delvian D 2017 Sistem Pertanian Berkelanjutan Pada Lahan Dataran Tinggi di Kawasan Hulu DAS Deli Sumatera Utar J. Serambi Eng. 1

[7] Saptana 2012 Konsep efisiensi usahatani pangan dan implikasinya bagi peningkatan produktivitas Forum Penelit. Agro Ekon. 30 109–28

[8] Suharyanto S, Rinaldy J and Arya N N 2016 Analisis risiko produksi usahatani padi sawah di Provinsi Bali Agrar. J. Agribus. Rural Dev. Res. 1 70–7

[9] Waddington H, Snilstveit B, White H and Anderson J 2010 The Impact of Agricultural Extension Services: Study Protocol. 3ie Synthetic Reviews SR009 (New Delhi: International Initiative for Impact Evaluation)

[10] Singh R B 2012 Climate change and food security (Wiley Online Library)

[11] Alam G M M, Alam K and Mushtaq S 2017 Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh Clim. Risk Manag. 17 52–63

[12] Shikuku K M, Winowiecki L, Twyman J, Eitzinger A, Perez J G, Mwongera C and Läderach P 2017 Smallholder farmers’ attitudes and determinants of adaptation to climate risks in East Africa Clim. Risk Manag. 16 234–45

[13] Sugiyono 2008 Metode Penelitian Kuantitatif dan Kualitatif (Bandung: R&D Alfabet)

[14] Djarwanto P S and Subagyo P 2001 Mengenai beberapa uji statistik dalam penelitian (Yogyakarta: Liberty)

[15] Soekartawi S 2002 Prinsip Dasar Ekonomi Pertanian Teori dan Aplikasi. Edisi Rev. (Jakarta: PT Raja Grafindo Persada)

[16] RR C I R J S and Qonita A 2015 Analisis Risiko pada Usahatani Kedelai di Kabupaten Gobogan Grobogan Agrista 3 45–55

[17] Windani I 2017 Manajemen risiko usahatani jagung (Zea Mays L) sebagai salah satu upaya mewujudkan ketahanan pangan rumah tangga petani AGROSCIENCES (AGSCI) 6 30–6

[18] Normansyah D, Rochaeni S and Humaerah A D 2014 Analisis Pendapatan Usahatani Sayuran di Kelompok Tani Jaya, Desa Ciaruteun Ilir, Kecamatan Cibungbulang, Kabupaten Bogor Agribus. J. 8 29–44

[19] Haeruddin and A R Produktivitas tanaman sayuran dan pohon pada sistem agroforestri di Kecamatan Palolo Kabupaten Sigi Sulawesi Tengah J. Kehutan. Trop. Humida 4 126–35

[20] Dewi R K 2017 Risiko dalam Manajemen Usaha Tani DIKTAT Universitas Udayana

[21] Suryani E and Dariah A 2012 Peningkatan produktivitas tanah melalui sistem agroforestri J. Sumber. Lahan 6

[22] Jumiyati S, Arsyad M, Pulubuhu D A T and Hadid A 2018 Cocoa based agroforestry: An economic perspective in resource scarcity conflict era IOP Conference Series: Earth and Environmental Science vol 157 p 12009

[23] Idjudin A A 2011 Peranan konservasi lahan dalam pengelolaan perkebunan J. Sumber. lahan 5

[24] Jumiyati S, Rajindra R, Tenriawaru A N, Hadid A and Darwis D 2017 Sustainable Land Management and Added Value Enhancement of Agricultural Superior Commodities Int. J. Agric. Syst. 5 198–206

[25] Hani A and Suryanto P 2014 Dinamika Agroforestry Tegalan di Perbukitan Menoreh, Kulon Progo, Daerah Istimewa Yogyakarta J. Penelit. Kehutan. Wallacea 3 119–28