Feasibility and Risk Analysis of Red Chili Farming With Irrigation Systems on Coastal Sandy Land, Bantul

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Abstract. The porous characteristics of the coastal land cause greater water requirements compared to rice fields, this creates risks in farming. Much research has been conducted on red chili farming on coastal land, but there is still little related to red chili farming using various irrigation systems on coastal land.This study aims to determine the cost, income, profit, feasibility, and risks of red chili farming with shower and mist irrigation systems on coastal sandy land. The number of respondents with shower irrigation was 60 farmers, and for mist irrigation there were 10 farmers. The total number of respondents was 70 farmers. The analysis techniques comprised income analysis, farming feasibility analysis based on the R/C ratio, labor productivity, capital productivity, and risk analysis based on the coefficient of variation. The research results show that in terms of costs, shower irrigation is greater than mist irrigation. However, the revenue, income and profits of mist irrigation are greater than shower irrigation. Based on the feasibility analysis, both irrigation systems are feasible in terms of R/C, labor productivity and capital productivity. Judging from production and price risks, mist irrigation has a lower risk compared to shower irrigation.

1 Introduction

As paddy fields shrink in Sanden District, the community has utilized sandy land to produce high-quality agricultural products. Sanden District is one of the centers of horticultural agriculture in Bantul Regency. Among the vegetables and spices grown are shallots, water spinach, tomatoes, eggplants and red chilies. Shallots and red chilies are the standout commodities.

Table 1 displays how much red chili production in Sanden District has fluctuated. The highest production occurred in 2017, but from 2017 to 2020, red chili production continued to decline. Furthermore, in terms of productivity, 2017 had the highest productivity. Production factors and climate changes can increase or decrease the production and productivity of red chilies. Climate affects plant growth and the quality of the fruit produced [1] .

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Table 1. Harvested Area, Production, and Productivity of Red Chilies in Sanden District in 2016-2020

Year	Harvested Area (ha)	Production (q)	Productivity (q/ha)
2016	9	459	4.13
2017	25	4,217	168.68
2018	29	3,551	122.45
2019	25	1,730	69.2
2020	47	743	15.80

Creating productive farming land out of sandy coastal areas has long been thought to be an appropriate answer for small-scale land ownership through a drawn-out process and mechanism. Since the 1980s, a few skilled farmers have begun to plant in the sandy coastal farming land. Leading farmers have been converting marginal sandy farming land into more productive farming land that is utilized for production and growing of agricultural products [2].

The agricultural sector's productivity, binding ability, and water storage of sandy land are all low. Sandy land requires a large supply of water to make plants grow. Sandy land is characterized by a sandy texture, grained structure, low shaft and consistency, high intensity of sunlight, high temperature, excess air and strong wind [3]. Irrigation systems play a very important role in providing water needs. However, irrigation systems must be efficient, especially in providing optimal distribution of available water resources, especially on sandy land [4].

One agricultural crop that is very vulnerable to price volatility, quality variation, and climate change is red chile. Red chilies are rotting, damaged, and have shrunk significantly, which puts production and quality [5].

The physical properties of the coastal sandy land are coarse grain and contain gravel. Sandy land is porous, absorbing water easily and causing air in the soil to move more smoothly. In addition, the excessive intensity of sunlight raises temperatures and declines humidity. It escalates the rate of water loss and promotes stress to plants. Plants on sandy land require sufficient water and regular watering. Hence, an irrigation system can facilitate farmers' red chili farming on sandy land. Irrigation management and N fertilizer application aim to overcome production limitations in vegetable crops especially for red chili farming [6].

Red chili farmers in the sandy land of Sanden District encounter several obstacles, encompassing the high costs of fertilizers, pesticides, and farming risks. The nutrient content in sandy soil is low, demanding additional fertilizer as a growing medium. Other obstacles include plant destruction organisms (PDO) attacks such as caterpillars, anthracnose (Patek), and downy mildew. PDO attacks can damage chilies and kill chili plants. Challenges faced by the chili farmers were pest and disease attacks [7].

The characteristics of sandy soil are strong wind, axial nature causing low moisture storage, high evaporation, and low fertility, imposing the high risks of farming failure on sandy land. Sand land is also very easy to infiltrate or absorb water into the soil layer very easily and a high level of evaporation, this causes plants grown on sand land to easily lack water so that it can interfere with the cultivation process of these plants [8]. With different characteristics of sandy land, the irrigation system must be considered in running a farming business. Farmers on sandy land widely employ mist and shower irrigation systems to minimize the risks of farming.

Therefore, several questions emerged concerning such conditions. How much is the cost, revenue, income, and profit of red chili farming with shower and mist irrigation systems on sandy land in Sanden District? Is red chili farming with shower and mist irrigation systems feasible to be developed in Sanden District? Moreover, how big are the risks farmers face in red chili farming with shower and mist irrigation systems in Sanden District?

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2 Methods

The research location was determined purposively under various considerations. Following the advice of agricultural extension workers, Sanden District was selected as the research location because a large population of farmers in this area utilized shower and mist irrigation systems in their farming on sandy land.

This study employed both random sampling and census. Simple random sampling allows the researchers to gather samples randomly without looking at the strata in the population (Sugiyono, 2019). Meanwhile, a census allows the entire population to be sampled. Table 2 displays the sample of red chili farmers from sandy land in Sanden District.

Table 2. Name and number of farmer groups

Village	Farmer Group Name	Population	Shower Irrigation	Mist Irrigation
Srigading	Pasir Makmur	59	20	9
	Manunggal	54	20	1
Gadingsari	Tani Raharjo	64	20	-
Total		177	60	10

The population of this study was all red chili farmers on coastal sandy land. Of 177 red chili farmers implementing the shower irrigation system, 60 were taken as the sample. In contrast, red chili farmers applying the mist irrigation system were collected using census, generating nine farmers from the Pasir Makmur farmer group and one from the Manunggal farmer group.

Descriptive and quantitative analyses were run. Descriptive analysis described red chili farming on sandy land with shower and mist irrigation systems. In comparison, quantitative analysis tested the feasibility of farming. This study employed the following quantitative data analysis.

2.1 Total Cost

The cost of red chili farming is all expenses used for red chili farming.

$$TC = TEC + TIC \tag{1}$$

Information:
TC : Total Cost
TEC : Total Explicit Cost
TIC : Total Implicit Cost (Soekartawi, 1995)

2.2 Revenue

According to Soekarwati (1995), revenue is obtained by multiplying the selling price by the number of products produced.

$$TR = P \ x \ Q \tag{2}$$

Information:
TR : Total Revenue
P : Selling Price (Price)
Q : Total Production (Quantity)

2.3 Income

As Soekartawi (2006) asserted, farming income is the difference between revenue and the cost incurred within a certain period (TC).

$$NR = TR - TC\ (explicit) \tag{3}$$

Information:
NR : Income (New Return)
TR : Total Revenue
TC : Total Cost

2.4 Profit

Following Soekarwati (1995), profit refers to the difference between revenue and total cost.

$$\Pi = TR - TC\ (explicit + implicit) \tag{4}$$

Information:
Π : Profit
TR : Total Revenue
TC : Total Cost

2.5 Feasibility Analysis

2.5.1 R/C system

R/C is the comparison between business results and total production cost.

$$\frac{R}{C} = \frac{TR}{TC} \tag{5}$$

Information:
R/C : Revenue Cost Ratio
TR : Total Revenue
TC : Total Cost (implicit + explicit costs)

The criteria for the R/C Ratio include:
R/C Ratio > 1, farming is profitable
R/C Ratio = 1, farming is BEP
R/C Ratio < 1, farming experiences loss

2.5.2 Labor Productivity

Labor productivity is the ability of the workforce to produce products.

$$Labor\ Productivity = \frac{NR\ \text{-Own Land Rent Value-Own Capital Interest}}{\text{Number of FL}} \tag{6}$$

Information:
FL : Family Labor
Number of FL : Number of Family Workers (WDP)

Criteria:
If labor productivity > labor wages, it is eligible.
If labor productivity < labor wages, it is not eligible.

2.5.3 Capital Productivity

Productivity of capital is the ability of capital to produce products.

$$Capital\ Productivity = \frac{NR\text{-}Own\ Land\ Rent\text{-}FL}{TEC} x\ 100\% \tag{7}$$

Information:
FL : Family Labor
TEC : Total Explicit Cost

Criteria:
If capital productivity > loan interest rate, it is feasible.
If capital productivity < loan interest rate, it is not feasible.

2.5.4 Risk Analysis

a. Coefficient of Variation
Farming risks are uncertain conditions caused by external factors beyond farmers' control. The standard deviation was calculated using the following formula.

$$\sigma = \sqrt{\frac{\Sigma(xi-\bar{x})^2}{n-1}} \tag{8}$$

Information:
σ : Standard deviation
xi : Production or price received by farmers
$\bar{x}$: Average production or price
N : The amount of data

The following formula was employed to discover the production risks and price risks of red chili farming.

$$Production\ risks : CV = \frac{\sigma}{Q} \tag{9}$$

$$Price\ risks : CV = \frac{\sigma}{P} \tag{10}$$

Information:
CV : Coefficient of variation
σ : Standard deviation
Q : Average production (Kg)
P : Average price (IDR)

The coefficient of variation indicates the risks that farmers must bear. The lower limit of production and price (L) depicts the lowest possible value that farmers can accept. The formula for the lower limit of production and price is as follows.

Production Lower Limit : L=Q-2V and Price Lower Limit : L = P-2V

The value of the lower limit of production and price is related to the value of the coefficient of variation. If CV ≤ 0.5, L ≥ 0. Conversely, if CV > 0.5, L < 0 [9].

It implies that
If CV ≤ 0.5, farmers are free from risks in red chili farming.
If CV > 0.5, there is a risk opportunity for farmers in red chili farming.

3 Results and Discussion

3.1 Analysis of Red Chili Farming

The analysis of red chili farming included the total cost, revenue, income, profit, feasibility, and farming risks.

3.1.1 Total Cost

Total cost refers to farmers' production cost in red chili farming during one growing season. The following is the total cost of red chili farming with shower and mist irrigation systems.

Table 3. Total Cost of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower (IDR)	Mist (IDR)
Explicit Cost		
Saprodi	3,777,031	4,025,278
Tool depreciation	342,133	987,293
Family labor costs	2,869,064	3,595,665
Other costs	3,918,001	3,792,762
Amount	**10,906,230**	**12,400,997**
Implicit Cost		
Manure	36,757	60,000
Family labor costs	7,737,333	3,012,552
Own capital interest	327,187	372,030
Own land rent	-	-
Total	**8,101,277**	**3,444,582**
Total Cost	**19,007,506**	**15,845,579**

Table 3 demonstrates the explicit cost incurred by red chili farmers in Sanden District, with IDR 10,906,230 for those implementing shower irrigation and IDR 12,400,997 for those applying mist irrigation. The shower irrigation system depicted a higher explicit cost than mist irrigation due to the different water pump fuel. Most red chili farmers with shower irrigation utilized gasoline-powered water pumps, while those with mist irrigation deployed electric pumps.

In addition to the explicit cost, farmers should also consider the implicit cost even though they did not incur it. Most red chili farmers on sandy land worked on their land, assisted by other family members, such as their wives and children. The total implicit cost incurred by red chili farmers in Sanden District was IDR 8,101,277 for those implementing shower irrigation and IDR 3,444,582 for those applying mist irrigation. The implicit cost of the shower irrigation system was high because the watering was performed by human labor daily during one growing season.

3.1.2 Revenue

Table 4 illustrates the revenue of red chili farming obtained by multiplying the production by the selling price.

Table 4. Total Revenue of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower	Mist
Production (kg)	2,893	3,835
Price (IDR)	15,179	20,243
Revenue (IDR)	**43,920,711**	**77,634,014**

As displayed in Table 4, red chili farming with mist irrigation generated greater revenue than shower irrigation. The mist irrigation system produced high production and selling prices. Farming revenue was influenced by the presence or absence of pests and diseases attacking plants, affecting production. Besides functioning as watering, the mist irrigation system also repels pests, making it easier for farmers to obtain good production results. The production of red chilies with the shower irrigation system was less because, during the study, several red chili plants were affected by jaundice. Jaundice attacked plants when they were tiny, causing plant growth not to be optimal and fruit produced not good. Jaundice was difficult to control because no drugs or pesticides could eradicate it. Thus, farmers threw away diseased plants to prevent them from infecting others.

3.1.3 Income

Income is the difference between revenue and explicit cost. The following is the income of red chili farmers with shower and mist irrigation systems.

Table 5. Income of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower (IDR)	Mist (IDR)
Revenue	43,920,711	77,634,014
Explicit cost	10,906,230	12,400,997
Income	**33,014,482**	**65,233,016**

Following Table 5, red chili farmers with mist irrigation acquired higher income than those implementing shower irrigation. The high revenue led to the high income of farmers employing mist irrigation. The revenue of red chili farmers with mist irrigation was high, and the explicit cost was low. The auction costs appeared as the most obvious cost chili farmers incurred for the mist irrigation system. The auction costs were determined based on the selling price of red chilies. The higher the selling price and production, the greater the contribution of auction cash will be. It aligns with research in Sidodadi Village, revealing that with a high selling price of IDR 50,000/kg, red chili farmers earned an average income of IDR193,591,248 per planting season [10].

3.1.4 Profit

Profit is the difference between revenue and the total cost. Following is the profit earned by red chili farmers from the shower and mist irrigation systems.

Table 6 displays that red chili farmers with mist irrigation were more profitable. The use of labor for watering could save costs. With this mist irrigation system, farmers only needed to turn on the water pump, and watering happened automatically. Farmers did not expend energy for watering, allowing them to do other work. It supports previous research on red chili farming in Andongsari Village, Ambulu District, where farmers obtained a profit of IDR 111,327,403 per hectare or IDR 22,265,481 per 2,000 m2 [11].

Table 6. Profit of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower (IDR)	Mist (IDR)
Revenue	43,920,711	77,634,014
Total cost	19,007,506	15,845,579
Profit	**24,913,205**	**61,788,435**

3.2 Feasibility Analysis

The feasibility of red chili farming on sandy land in Sanden District was measured using the Revenue Cost Ratio (R/C) and capital and labor productivity analyses.

3.2.1 R/C

Revenue Cost Ratio (R/C) is the ratio between the revenue and the total cost incurred by red chili farmers during one planting season. Table 7 demonstrates the R/C value of red chili farming on sandy land with shower and mist irrigation systems.

Table 7. R/C of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower	Mist
Revenue (IDR)	43,920,711	77,634,014
Total Cost (IDR)	19,007,506	15,845,579
R/C	**2,31**	**4,90**

As portrayed in Table 7, red chili farming acquired an R/C of 2.31 for shower irrigation and 4.90 for mist irrigation, signifying the feasibility of red chili farming with both irrigation systems. It is in line with research in Kalianda District, Lampung Regency and Sudodadi Village, Sariwangi District in West Java [12] [13] [14].

3.2.2 Labor Productivity

Labor productivity is the ability of the workforce to produce red chili products. Farming is feasible if labor productivity is greater than the minimum wage in the study area. The following is the labor productivity of red chili farming with shower and mist irrigation systems.

Table 8. Labor Productivity of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower	Mist
Income (IDR)	33,014,482	65,233,016
Own land rent (IDR)	0	0
Own capital interest (IDR)	327,187	37,030
Family labor costs (WDP)	102.06	33.69
Labor productivity (IDR)	**320,269**	**1,925,042**

Table 8 depicts that red chili farming with shower irrigation required more labor, raising the use of labor. The labor productivity with two irrigation systems was greater than the minimum wage in Sanden District, IDR 70,000/WDP, implying the feasibility of red chili farming. These findings are consistent with previous research in Ngargoyoso District, Karanganyar Regency, revealing that the labor productivity of farmers in intercropping farming of java ginger and cayenne pepper [15].

3.2.3 Capital Productivity

Productivity of capital refers to the ability of capital to produce products. Farming is feasible if capital productivity exceeds the prevailing bank interest rate. Table 9 displays the capital productivity of red chili farming with shower and mist irrigation systems.

Table 9. Capital Productivity of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	**Irrigation System**	
	Shower	**Mist**
Income (IDR)	43,920,711	65,233,016
Own land rent (IDR)	0	0
Family labor costs (IDR)	7,737,333	3,012,552
Total explicit cost (IDR)	10,906,230	12,400,997
Capital productivity (%)	**332**	**502**

As presented in Table 9, capital productivity in red chili farming with shower and mist irrigation systems was greater than the prevailing loan interest rate. In other words, red chili farming on sandy land with both irrigation systems was feasible because farmers could repay the loan capital. The BRI bank loan interest rate through the BRI KUR program in Sanden District was 6% per year or 3% per planting season (six months). It would be easy for farmers wanting to enlarge their red chili farming to obtain capital loans from banks due to the greater farming productivity of capital over the loan interest rate.

3.3 Farming Business Risk Analysis

The risks of red chili production on sandy land were caused by pest attacks, strong wind, and salt content, reducing yields. Production risk is a loss for farmers caused by the occurrence of factors during the production process that cannot be handled by farmers [16]. The major production risks red chili farmers faced with shower and mist irrigation systems are as follows.

Table 10. Production Risks of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	**Irrigation System**	
	Shower	**Mist**
The standard deviation of production (kg)	1,488	1,825
Average production (kg)	2,893	3,835
Coefficient of variance	0.51	0.48
Production lower limit(kg)	-82.52	185.03

As displayed in Table 10, red chili farming with shower irrigation depicted a greater coefficient of variation than with mist irrigation. In short, the risks of red chili production with shower irrigation were higher than with mist irrigation. However, this is different from red chili farmers in Banaran Village, Kulonprogo because the production risk of red chili farming is very low with coeefficient of variance of 0,03 [17].

Weather, pest attacks, and the strong wind with salt content caused the magnitude of the risks of red chili production on sandy land. Pests damaged plants and chilies, thereby affecting chili production. Pests that often attacked red chili plants included caterpillars, fruit flies and whiteflies. Red chili production on sandy land with mist irrigation had low risks because this irrigation system drove away pests on the plants. Pests did not like the splash of water from the misting hose. Hence, apart from being a watering mist, irrigation also served as pest control.

The strong wind containing salt due to the evaporation of seawater appeared as another risk for chili farming on sandy land. The salt content carried by the wind stuck to the leaves, damaging or killing the chili plants. Chili farmers anticipated strong wind by planting cypress, corn, and sunflower windbreakers. In addition to wind-breaking plants, daily watering cleaned the salt content sticking to the chili plant leaves.

The production risks of red chili farming align with research in Sikur District, East Lombok Regency, in the high category. [18]. A study on farming risks disclosed that the main source of risks was climate change, causing chili plants to be susceptible to pests and diseases [19]. Moreover, price risks emerged as another obstacle farmers encountered. This obstacle was due to price fluctuations of red chilies. The coefficient of variation is as follows.

Table 11. Price Risks of Red Chili Farming with Shower and Mist Irrigation Systems in an Area of 2,000 m^2

Description	Irrigation System	
	Shower	Mist
Standard deviation price (IDR)	5,526	3,918
Average price (IDR)	15,179	20,243
Price coefficient of variance	0.36	0.19
Price lower limit (IDR)	4,127	12,407

As listed in Table 11, red chili farming with shower irrigation demonstrated a higher coefficient of variation than mist irrigation. But both of irrigation systems were free from the price risks in red chili farming.

Chili price fluctuations triggered the price risks of red chili farming on sandy land. In addition, the planting season for red chilies in several areas occurred almost simultaneously, resulting in abundant chili production and goods available in the market. Hence, it caused the price of red chilies in the market to fall. Red chili farmers from sandy land in Sanden District were free from price risks because most red chili sales were through the auction markets. The selling price on the auction markets was higher than that of local middlemen or traders.

The auctions were the close ones. The prospective traders wrote down the price on the papers provided by the auction committee. Then, the auction commitee collected all the papers and read them out, witnessed by all the traders who had written the price. The trader who wrote the highest price emerged as the winner. Several auction markets in Sanden District have made it easier for farmers to sell their products. The auction markets were usually held from August to December.

The price risks encountered by red chili farmers in Sanden align with research at Pasar Baru Kranggot, Cilegon City, unveiling that the simultaneous planting season caused abundant yields. However, it becomes more risky if farmers plant in inappropriate land conditions and seasons. Hence, farmers must consider obstacles in red chili production and an introduction technology package, red chili can be developed on sandy land, and its implementation requires intensive assistance [20] [21].

4 Conclusions and Suggestions

4.1 Conclusions

The research on the feasibility and risk analysis of red chili farming with shower and mist irrigation systems on coastal sandy land in Sanden District generated several conclusions.

a) The research results show that in terms of costs, shower irrigation is greater than mist irrigation. However, the revenue, income and profits of mist irrigation are greater than shower irrigation.
b) Based on the feasibility analysis, both irrigation systems were feasible in terms of R/C, labor productivity and capital productivity.
c) Judging from production and price risks, mist irrigation has a lower risk compared to shower irrigation.

4.2 Suggestions

Farmers are advised to utilize a mist irrigation system to boost their profit and minimize farming risks.

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