Analysis of income and risks of potato farming in the highlands of Wonosobo Regency, Central Java, Indonesia

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Abstract Potatoes serve as a leading horticultural commodity in Wonosobo, boasting high economic value and significant market opportunities both nationally and internationally. Climatic conditions in highland such as strong winds, low temperatures, and high humidity threaten potato production stability. Climate-related disturbances encourage the emergence of pests and fungal diseases, especially during prolonged rainy periods resulting farmers facing higher yield volatility. The research aims to analyse production and income risks, net revenue, and feasibility of potato farming. The study was conducted purposively in Wonosobo Regency, based on consideration that most of population works as farmers and relies on potatoes as their primary crop. A total of 40 potato farmers were selected randomly as respondents. Production and income risk were analysed using Coefficient of Variation, while farming feasibility was assessed based on Revenue-Cost Ratio, labour productivity, and capital productivity. The results revealed that production and income risk of potatoes fell into high category. The income from potato farming on 2,533 m² of land was IDR 36,140,995. Potato farming was feasible based on revenue cost ratio, labour productivity, and capital productivity. Farmers have been advised to utilize windbreaks, selecting seed varieties tolerant to highland environments, and enhancing irrigation management for sustainable potato farming.

1 Introduction

Potatoes (*Solanum tuberosum*) have become one of the leading commodities in the agricultural sector, especially in horticultural crops. Potatoes are the fourth most essential food crop globally after rice, wheat, and maize, and play a growing role in Indonesia's food system [1]. In Java, highland regions such as Wonosobo, Dieng, and Pangalengan are major centres of potato production, supplying fresh produce for domestic consumption and the food processing industry [2]. Therefore, there are many market opportunities for potatoes both domestically and internationally [3].

In Wonosobo Regency, Central Java, potatoes have long been recognized as a flagship commodity due to their relatively stable market prices, high demand in both domestic and

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international markets, and significant contributions to household income and regional economic development. Despite their economic potential, potato farming in highland areas encounters numerous challenges. Climatic conditions in highland such as strong winds, low temperature, high humidity and limited access to irrigation water threaten potato production stability. Increasing climate variability, such as unpredictable rainfall patterns, extreme weather events, and changing seasonal cycles, exacerbates these challenges. Irregular rainfall reduces soil moisture, delays planting schedules, and increases crop water stress. Meanwhile, extreme events such as storms or prolonged dry spells directly damage potato crops and reduce yields. Climate-related disturbances encourage the emergence of pests and fungal diseases, especially during prolonged rainy periods. As a result, farmers face higher yield volatility, increasing the risk of production failure and reducing income stability [4].

Production risk in agriculture generally arises from variability in yields driven by uncontrollable factors such as climate, pests, and diseases [5]. In potato farming, these risks are especially pronounced due to the crops' sensitivity to temperature fluctuations, excessive soil moisture, and disease pressure. One major climate-linked threat is potato late blight, caused by Phytophthora infestans, whose incidence increases significantly under wetter and cooler conditions commonly associated with climate variability. In Indonesia, late blight is a major contributor to potato crop failure, especially during increasingly unpredictable and intense rainy seasons, with losses ranging from 10% to total crop failure [6].

Risk management and feasibility analysis are, therefore, crucial to ensure the sustainability of potato farming. Previous studies have highlighted the significance of assessing income, revenue-cost ratios, and productivity. indicators to evaluate farm feasibility [7]. However, few studies specifically address the integrated assessment of production risk, income, and feasibility in potato farming. This study aims to analyze the production and income risks, income levels, profit, and feasibility of potato farming in highlands of Wonosobo Regency. The findings are expected to provide evidence-based recommendations for farmers and policymakers to enhance the sustainability and profitability of potato farming in Indonesia.

2 Research method

2.1 Sampling method

The study was conducted in the highlands of Wonosobo Regency, Central Java, an area known for its major centers of potato production. The location was determined purposively based on the consideration that most of the population works as farmers and relies on potatoes as their primary crop. Respondents consisted of 40 farmers who regularly cultivated potatoes, selected randomly to ensure representativeness. This research utilized primary and secondary data. Primary data were collected through structured interviews using questionnaires, covering farmers' characteristics, production inputs, potato production, costs, and revenues during the planting period of February - April 2025. Meanwhile, secondary data were obtained from the Central Statistics Agency (BPS = *Badan Pusat Statistik*), the Agriculture Service of Wonosobo Regency, and the Agricultural Extension Center (BPP = *Balai Penyuluhan Pertanian)*.

2.2 Technical analysis

2.2.1 Risk analysis

Production and income risks were analyzed using the coefficient of variation (CV), defined as the ratio of standard deviation to the mean yield, mathematically written as follows:

$$CV = \frac{SDy}{Y} \quad (1)$$

Description:
CV = Coefficient of variation of production or income of potatoes
SDy = Standard deviation of production or income of potatoes
$\bar{Y}$ = Production or income of potatoes
Production and income risk of potato farming is categorized as low if CV < 0.25, moderate if $0.25 \leq CV < 0.5$), and high if $CV \geq 0.5$ [5].

2.2.2 Net revenue and profit

Net Revenue or income of potato farming indicates the difference between total revenue and total explicit costs, mathematically written as follows:

$$NR = TR - TEC \quad (2)$$

Description:
NR = Net Revenue
TR = Total Revenue
TEC = Total Explicit Cost

Profit of potato farming refers to the difference between total revenue and total costs, mathematically written as follows:

$$\pi = TR - TC \quad (3)$$

Description:
π = Profit
TR = Total Revenue
TC = Total Cost

2.2.3 Feasibility analysis

The feasibility analysis was evaluated using three indicators: revenue-cost ratio, labor productivity, and capital productivity. Revenue-Cost Ratio, specifically the comparison between total revenue and total costs, is mathematically written as follows:

$$R/C = TR/TC \quad (4)$$

Labor productivity denotes the ability of the workforce to generate income, measured by IDR/workday, mathematically written as follows:

$$Labor\ productivity = \frac{NR - own\ land\ rent - interest\ on\ own\ capital}{number\ of\ family\ labour} \quad (5)$$

Capital productivity represents the ability of capital to generate income, measured as a percentage (%), mathematically written as follows:

$$Capital\ productivity = \frac{NR - family\ labour\ cost - own\ land\ rent\ x100\%}{Own\ capital} \times 100\% \quad (6)$$

Potato farming is feasible if R/C > 1, labour productivity > labor wages and capital productivity > savings interest.

3 Results and discussion

3.1 Characteristics of potato farmers

The characteristics of potato farmers provide crucial insight into their socio-economic background and capacity to adopt and sustain agricultural innovations. Based on the survey results, the farmers were predominantly within the middle-aged to older age groups. It indicates that most potato farmers were in their productive years, though there was a tendency toward an aging farming population. Farmer age can influence the adoption of innovation, where younger farmers are generally more open to new technologies, while older farmers tend to rely more on traditional practices [8].

Concerning education level, the majority (77.5%) of farmers completed elementary school. It suggests that most potato farmers possessed relatively low formal education, which may limit their access to information and participation in advanced training programs. Education is a crucial factor influencing farmers' decision-making and ability to adopt modern farming practices [9]. Higher education levels are often associated with improved farm management, greater openness to innovation, and more effective resource utilization.

Table 1. Characteristic potato farmers in Wonosobo Regency

Characteristic	Amount (Person)	Percentage (%)
Age (year)		
40 – 40	10	25.00
41 – 51	10	25.00
52 – 62	15	37.50
>62	5	12.50
Education		
Elementary School	31	77.50
Junior High School	4	10.00
Senior High School	4	10.00
College	1	2.50
Farming organic rice experience (year)		
2– 10	2	5.00
11 – 20	11	27.50
>20	27	67.50
Land area (m^2)		
< 1,000	22	55.00
1,000 – 10,000	13	32.50
>10,000	5	12.50

Regarding farming experience, 67.5% of farmers have been cultivating potatoes for more than 20 years. It reflects a highly experienced farmer group with a deep understanding of local agronomic conditions. Long experience often correlates with higher productivity and risk management capability [9]. However, experienced farmers may also be more conservative and slower in adopting new technologies compared to newer entrants.

In terms of land ownership, most farmers operated on small-scale landholdings, with 55% cultivating less than 1,000 m^2, averaging 2,533 m^2 in size. It suggests that smallholder farmers

dominated potato farming in the study area. Limited land size can constrain production capacity and income but can also encourage farmers to maximize land productivity through intensive cultivation and efficient resource management.

3.2 Production and income risk

Production and income risks were measured using the coefficient of variation, displaying the variation in production and income across farmers. The coefficients of variation in production and income are presented in Table 2.

Table 2. Coefficient of variation of production and income

Description	Production (kg)	Income (IDR)
Average value	11,161.00	98,962,459.00
Standard deviation	13,088.00	97,010,213.00
Coefficient of variation	0.85	0.98

The analysis discovered that the high level of production and income risk for potato farming fell into the high category, as the coefficient of variation exceeded 0.5 [5]. A high CV value for production indicates variation in potato production among farmers. This high variability is often associated with natural conditions, such as high altitudes on mountain slopes, characterized by strong winds, low temperatures, high humidity and high rainfall which can lead to crop damage and increased attacks by pests and diseases. It aligns with previous research [10], which reported that pests and diseases are the primary sources of production risk. Potato cultivation in the highlands also faces the challenge of accessing water for irrigation. Farmers must use pipes to channel water from reservoirs to the fields, which are quite far away. This situation will impact potato production. This aligns with research by [11], which found that agricultural yields depend on irrigation infrastructure.

Income risk was higher than production risk, as indicated by a higher coefficient of variation. Production costs and the price of potatoes influenced this. The highest costs in potato farming were seed, pest, and disease control. This finding aligns with research by [12], which disclosed that potato price, marketing, and yield are significant sources of risk for potato farmers.

3.3 Production cost of potato farming

Costs in potato farming are divided into explicit and implicit costs. Explicit costs indicate the actual expenses incurred by farmers for farming, including the purchase of production inputs, labor wages, land rent, profit sharing, and transportation costs. Conversely, implicit costs are expenses not directly incurred in farming but are calculated, such as the value of family labor, rent on private land, and interest on private capital.

Based on Table 3, the highest explicit cost was for seed purchases, accounting for 48.41% of the total costs. The seed requirement for potato farming was quite large, specifically 808 kg for a land area of 2,533 m² or 3,200 kg/ha. Farmers in Wonosobo utilized two different potato seed varieties: the Granola L variety from Bandung and Tedjo MZ, a variety native to the Dieng region. The Granola L and Tedjo MZ varieties demonstrate high and stable yields, good quality, and resistance to several types of diseases that attack potato plants. The Granola L variety is more affordable, has high production, a short lifespan, and is adaptable to various conditions [13], prompting most farmers to use Granola L potato seeds. Meanwhile, the Tedjo MZ variety has the advantage of a relatively short harvest period, solely around 70-80 days.

Purchasing pesticides emerged as the second-highest explicit cost. The types of pesticides utilized by potato farmers included fungicides and insecticides. Fungicides control fungal

diseases, such as leaf blight and stem rot. Temperature and humidity also influence the growth of fungi on potato plants. The Wonosobo highlands are characterized by low temperatures and high humidity, encouraging the growth of fungi. At low temperatures, around 15 - 20°C, and high humidity ≥ 90%, the fungus grows optimally [12], causing damage to potato plants. High rainfall throughout February - April can worsen the situation because it can trigger massive infections and accelerate the spread of fungi between plants. Potato plants in the Wonosobo highlands are also susceptible to attacks by thrips, aphids, mites, caterpillars, nematodes, and beetle larvae. Hence, farmers utilized an insecticide with the active ingredient Abemacicin to control thrips, aphids, and mites, while caterpillars, nematodes, and mites were controlled using an insecticide with the active ingredient carbofuran.

Table 3. Potato farming costs in Wonosobo Regency

Description	Value (IDR)	Percentage (%)
Seed	14,871,625	48.41
Fertilizer	1,786,627	5.82
Pesticide	4.330,125	14.09
Plastic mulch	795,625	2.59
Land rent	109,688	0.36
Land tax	19,438	0.06
Non-family labor	859,688	2.80
Tool depreciation	178,064	0.58
Profit sharing	337,500	1.10
Bank loan interest	21,875	0.07
Transportation	2,123,750	6.91
Total Explicit cost	25,434,005	
Family labor cost	4,117,700	13.40
Rent on own land	765,281	2.49
Interest in one's own capital	423,220	1.32
Total implicit cost	5,306,201	
Total Cost	30,740,206	100.00

Low temperatures in the highlands can also inhibit potato growth. Farmers in Wonosobo utilized plastic mulch to modify the temperature and growing environment, thereby optimizing conditions for potato growth [14]. Furthermore, plastic mulch also suppresses weed growth. Plastic mulch can be employed three times during the growing season.

3.4 Income and profit of potato farming

Income of potato farming signifies the difference between total revenue and total explicit costs, while profit denotes the difference between total revenue and total costs.

Table 4. Income and profits from potato farming in Wonosobo Regency

Description	Value (IDR
Total explicit cost	25,434,005
Total implicit cost	5,306,201
Total revenue	61,575,000
Income	36,140,995
Profit	30,834,794

As displayed in Table 4, the income from potato farming was IDR 36,140,995 per 2,533 m² per planting cycle, which was about four months, and appeared relatively high when compared to other region studies. For example, research in the Batur District, Banjarnegara Regency reported average per-season incomes of around IDR 7,099,612; however, that study employed a different plot size and cost structure [15]. Differences in income levels across studies can be attributed to variations in farm size, yield per hectare, price realization at harvest, and whether post-harvest grading and market access add value [4].

The profit from potato farming was IDR 30,834,794 per 2,533 m² per planting cycle, which lasted approximately four months. It indicates that every four months, potato farmers in the Wonosobo highlands earned a net income of IDR 30,834,794, where family labor, their own land, and interest on their own capital were calculated as costs.

3.5 Feasibility of potato farming

The feasibility of potato farming in the Wonosobo highlands was analyzed using three criteria: revenue-cost ratio (R/C), labor productivity, and capital productivity. A Revenue-Cost Ratio of 2 means that for every IDR 1 spent on potato farming, IDR 2 in revenue is generated. Potato farming in Wonosobo Regency was feasible because the revenue-cost ratio was greater than 1. The revenue cost ratio was higher than that of potato farming in Batur District, Banjarnegara Regency, and Pakis District, Magelang Regency [7,15].

Table 5. Labor and capital productivity in potato farming in Wonosobo Regency

Description	Value
Total revenue (IDR)	61,575,000
Total cost (IDR)	30,740,206
R/C	2
Income (IDR)	36,140,995
Rent on own land (IDR)	765,281
Interest in own capital (IDR)	423,220
Family labor (workday)	62
Labor productivity (IDR/workday)	566,656
Family Labor cost (IDR)	4,117,700
Owner's equity (IDR)	24,184,005
Capital productivity (%)	129

Labor productivity is the ability of the workforce to generate income in potato farming. Table 5 exhibits labor productivity, indicating that each worker on a potato farm generated IDR 566,656 in income per day. Meanwhile, the daily wage in Wonosobo Regency was IDR 125,000. Therefore, labor productivity exceeded the daily wage, making potato farming a feasible option. Family labor was better utilized for potato farming than working for others. Labor in potato farming in the Wonosobo highlands was more productive than in Pakis District, Magelang Regency, due to their higher labor productivity [7].

Capital productivity is the ability of capital to generate income, measured as a percentage (%). Based on the capital productivity value, the capital invested in potato farming for four months yielded a 129% profit. Meanwhile, the savings interest rate was 3.4%. Hence, potato farming was feasible because the capital productivity exceeded the savings interest rate. Capital is better allocated for potato farming than for savings.

4 Conclusion and recommendations

Potato farming in the Wonosobo highlands was profitable and feasible. However, production and income risks were also high due to strong winds, pests, diseases, and irrigation constraints. Farmers have been advised to implement risk management strategies by utilizing windbreaks, selecting seed varieties tolerant to highland environments, and enhancing irrigation management for sustainable potato farming.

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