Current situation and solutions for efficient use of dragon fruit planting land in Bac Binh district, Binh Thuan province

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ABSTRACT

The objectives of the study were to evaluate the current state of land use for dragon fruit cultivation in Bac Binh district, Binh Thuan province, identify influencing factors, and propose solutions for the sustainable and effective use of this land. The study utilized survey data from dragon fruit growers and expert consultations to assess the current situation and development trends, serving as a basis for proposing solutions. The key findings were as follows: (1) The area planted with dragon fruit increased by 3,767 ha from 2010 to 2020, but it began to decrease sharply from 2021. By 2023, the cultivated area declined to 2,933 ha, a reduction of 1,718 ha (36.94%) compared to 2020. (2) Productivity remained relatively high, with an average output of about 25 - 30 tons/ha during the on-season and 20 tons/ha during the off-season. From 2010 to 2020, the average profit was approximately 6,000 - 6,800 USD/ha per year, but since 2021 profits had declined sharply, averaging only about 3,744 USD/ha per year, with a continued downward trend leading to a gradual reduction in dragon fruit cultivation. (3) The main factors contributing to the shrinking area of dragon fruit land included economic factors such as selling price, profit, and export challenges, as well as technical and production planning factors. (4) The study proposed solution groups, including organizing production based on the value chain, supporting the development of large-scale enterprises, policy solutions, and human resources solutions.

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1. Introduction

Dragon fruit belongs to the cactus family (Cactaceae), a plant originating from dry tropical regions, making it well-suited to withstand heat and drought. Currently, it is grown in many parts of the world, especially in Asia, including Vietnam, Thailand, Malaysia, Indonesia, and China. In Vietnam, dragon fruit is mainly cultivated in the provinces of Binh Thuan, Long An, and Tien Giang, which together account for nearly 85% of the country's dragon fruit cultivation area. Among these, Binh Thuan was once the largest dragon fruit-producing province, contributing 52% of the cultivation area and more than 50% of the total output nationwide (Vo et al., 2021). Dragon fruit is considered a key fruit crop in Vietnam and holds a competitive advantage in the global market. It is grown on a commercial scale with a total area of about 37,000 ha. By the end of 2020, Binh Thuan had approximately 33,730 ha under cultivation, yielding an output of 650,000 tons per year, which represents 80% of the country's total dragon fruit production (PCBTP, 2022). Dragon fruit from Binh Thuan is consumed in two forms: domestic consumption (about 15%) and export (about 85%), with the majority exported to China. Between 2016 and 2022, Binh Thuan province officially exported nearly USD 53 million worth of dragon fruit, equivalent to 43,748 tons. The remaining amount was sold abroad through unofficial channels via border gates. The value of these border exports contributed USD 2,637 million to Binh Thuan province, averaging about USD 376.7 million per year (SOB, 2022).

The export market for agricultural products is increasingly competitive, requiring high quality and strict adherence to food hygiene and safety standards. Since 2006, ASEAN has established a common GAP- Good Agricultural Practices process for member countries, and in 2008, the Ministry of Agriculture and Rural Development of Vietnam issued the VietGAP-Vietnamese Good Agricultural Practices standard to define the necessary criteria for agricultural products. This underscores the importance for Vietnamese agricultural products in general, and Binh Thuan dragon fruit in particular, to ensure high quality and food safety in order to expand export markets.

Bac Binh is a mountainous district of Binh Thuan province, located 68 km northeast of Phan Thiet city. The district's main economic activity is agricultural production, which accounts for 75% of its economy. The area planted with dragon fruit represents 12.04% of the total area in Binh Thuan province. However, in recent years, both the area and output have tended to decrease sharply.

Therefore, researching „Current situation and solutions for effective land use for dragon fruit cultivation in Bac Binh district, Binh Thuan province" is highly necessary.

2. Materials and Methods

2.1. Overview of the research area

Bac Binh is located in the north of Binh Thuan province, with the center being Cho Lau town. It covers a natural area of 1,865.76 km², making it the largest district in terms of area among the districts of Binh Thuan province.

Figure 1 shows that the geographic coordinates range from 108°06'30" to 108°37'34" East longitude and from 10°58'27" to 11°31'38" North latitude, with:

- East longitude and from.

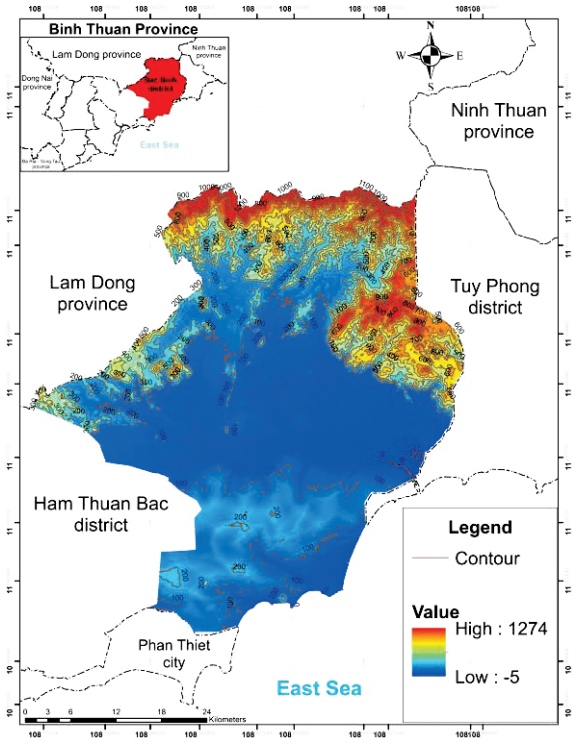

Figure 1. Digital elevation model map of study area.

- The West and Northwest bordering Ham Thuan Bac district and Di Linh district, Lam Dong province.

- The East and Northeast bordering Tuy Phong district.

- The Southeast bordering the East Sea.

- The South and Southwest bordering the East Sea and Phan Thiet city.

Bac Binh district has 16 communes and 2 towns, with diverse and potential natural resources. The terrain is complex, gradually tilting from Northwest to Southeast, with altitude decreasing towards the plains along the Luy River and Mao River.

The climate is tropical monsoon with low rainfall, which often results in droughts during the dry season and floods during the rainy season. The land resources of this district are highly specific, including 6 main soil groups, with the gray soil group accounting for the highest proportion at 56.77%. This soil is widely distributed in Phan Hoa, Phan Ri Thanh communes, Luong Son town, and other areas. Bac Binh district has land resources, water resources, and a climate that are very suitable for growing dragon fruit trees (SOB, 2022).

Socio-economically, the population of Bac Binh district is 131,680 people, with an average population density of 70.46 people/km^2, and rural areas account for 78.50% of the total population. The average income per capita is estimated at 1,707.2 USD/person per year. The economic structure among the sectors: Agriculture- Industry and Construction-Trade and Services was 29.61%, 20.69%, and 49.70%, respectively (PCBTP, 2022).

2.2. Materials and Methods

2.2.1. Materials

Documents and secondary data collected from relevant agencies are listed in Table 1 below:

Table 1. Secondary documents and data

No.	Documents/data	Place of supply
1	Data on natural conditions, natural resources and socio-economic development.	Statistics Department, Department of Agriculture and Rural Development, Department of Economics, People's Committee of Bac Binh district
2	Report on the socio-economic situation.	
3	Data on productivity, output and export of dragon fruit in Bac Binh district.	
4	Assessment of land adaptation in Bac Binh district; Land inventory results 2015, 2020, 2021, 2022	Bac Binh district Department of Resources and Environment.
5	Data on land use planning and agricultural planning.	Department of Agriculture and Rural Development; People's Committee of Bac Binh district.

2.2.2 Methods

Primary documents and data: Consulted with experts identified as managers in relevant fields, comprising 20 respondents including: agricultural officials in communes with relatively large dragon fruit growing areas, the Division of Agriculture and Rural Development, the Department of Natural Resources and Environment, enterprises and cooperatives purchasing dragon fruit.

In addition, the study conducted a survey of households directly growing dragon fruit. The number of survey questionnaires was determined using the formula proposed by Yamane (Yamane, 1967):

$$n = \frac{N}{1 + N \times e^2}$$

In there:

n: the number of household to be investigated;

N: the total number of households growing dragon fruit in the area;

e: the level of significance (with a confidence level of 90 to 99%).

According to the Statistical Yearbook of Bac Binh district in 2022, there are 3,800 households growing dragon fruit (N = 3,800), with a significance level of e = 0.1, n = 98 votes can be determined. The survey content mainly covers area, yield, selling price, use of seeds and fertilizers, profit efficiency, and jobs brought from growing dragon fruit trees.

- Method to evaluate economic efficiency: The economic efficiency of land used for growing dragon fruit is evaluated using the formula: Pr = GO - C

In there:

Pr: profit

GO: production value

C: the total cost

The assessment level hierarchy is presented in Table 2:

Table 2. Hierarchy of economic efficiency assessment

Rating level	Symbol	Total cost (million VND/ha per year)	Total revenue (million VND/ha per year)	Profit (millio VND/ha per year)	Rate (times)
Very high	VH	> 100	> 200	> 100	> 2.0
High	H	70 - 100	150 - 200	70 - 100	1.5 - 2.0
Medium	M	50 - 70	100 - 150	30 - 70	1.3 - 1.5
Short	L	< 50	< 100	< 30	< 1.2

Source: Sub-NIAPP (2020).

- Map construction method:

+ Digital elevation model (DEM) map: The DEM map shows the geographical position of Bac Binh district, and also shows the slope and convexity of the terrain, which are factors of interest in the arrangement of agricultural land use.

+ Thematic maps: This study employs Microstation and ArcGIS software to arrange and edit land use status maps. Dragon fruit land allocation map has been built using AcrGIS software on the basis of the current land use status map of Bac Binh district combined with the layer of current status of dragon fruit trees allocated in communes in 2022.

3. Results and Discussion

3.1. Current status of agricultural land use

3.1.1. Current status of agricultural land use

Table 3 shows that agricultural land during this period increased by 4,575.73 ha compared to 2010. Specifically, the area of land planted with dragon fruit in 2010 was 669 ha (accounting for 0.4% of the total agricultural land area). By 2020, it had increased to 4,436 ha (2.57%) (PCBTP, 2023).

Table 3. Situation of agricultural land use in Bac Binh district in the period 2010 - 2020

No.	Land use criteria	Current land use status (ha)				
		2020	2015	Compared with 2015	2010	Compared with 2010
	Total agricultural land area	172,370.79	174,257.15	-1,886.36	167,795.06	4,575.73
1	Rice growing land	16,322.88	12,119.73	4,203.15	10,678.12	5,644.76
2	Other annual crops	29,182.02	38,933.46	-9,751.44	44,352.47	-15,170.45
3	Other annual crops	35,247.27	31,642.22	3,605.05	19,484.95	15,762.32
	Growing dragon fruit	*4,436.00*	*2,500.00*	*1,936.00*	*669.00*	*3,767.00*
4	Protective forest land	47,000.66	47,150.48	-149.82	58,640.82	-11,640.16
5	Production forest land	44,129.47	44,104.74	24.73	34,200.17	9,929.30
6	Aquaculture land	400.88	283.70	117.18	418.92	-18.04
7	Other agricultural land	87.61	22.82	64.79	19.61	68.00

Source: Division of Resourc.es and Environment of Bac Binh district (2022).

3.1.2. Evolution of main crops

The data of Table 4 shows that crop areas tend to increase, particularly in cassava, rice, fruit trees, and vegetables. Notably, the area planted with dragon fruit increased sharply during the period 2015 - 2021, but by 2022, it had suddenly decreased to only 2,933 ha.

Table 4. Developments of main crops in Bac Binh district in the period 2010 - 2022

No	Type land use	Area (ha)				
		2010	2015	2020	2021	2022
1	Rice 2 - 3 crops	26,305	29,793	27,996	28,028	28,058
2	Cassava	6,308	5,162	6,067	6,072	6,076
3	Dragon fruit	669	2,500	4,436	4,549	2,933
4	Beans of all kinds	4,052	4,573	3,972	3,975	3,979
5	Fruit tree (mango, grapefruit, jackfruit...)	1,935	1,874	2,449	2,336	2,340
6	Vegetables	1,827	1,271	1,864	2,664	3,454
7	Peanut	2,514	2,445	1,783	1,785	1,788
8	Cashew tree	1,089	1,089	653	1,453	2,243

Source: Division of Agriculture and Rural Development of Bac Binh district (2022).

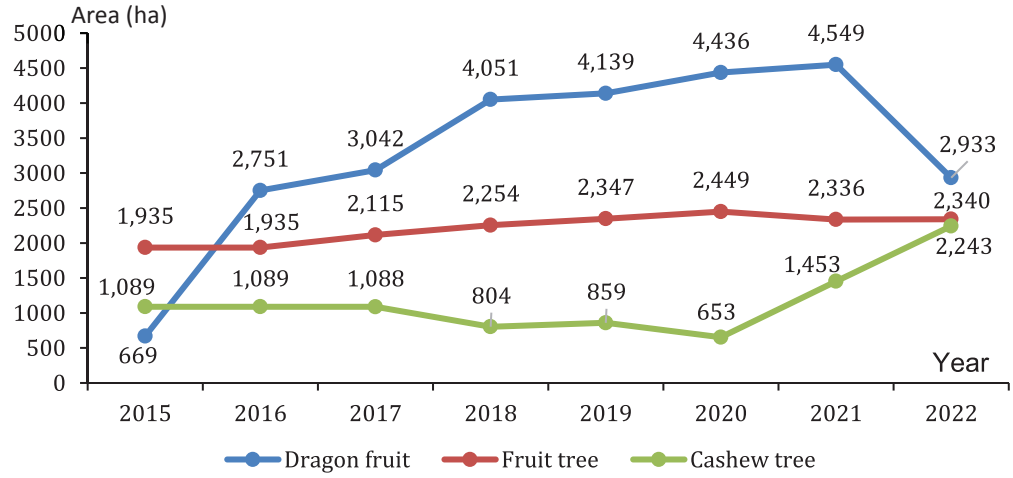

Figure 2. Evolution of perennial crop area in Bac Binh district in the period 2015 - 2022.

The majority of perennial tree areas in the study area are dragon fruit trees, cashew and fruit trees of all kinds (mango, grapefruit, jackfruit...). Figure 2 shows that the area of dragon fruit trees will decrease sharply from 2021, while the area of cashew trees will increase sharply, steadily from 2020 to 2022 while the area of fruit trees is more stable.

3.2. Current status of dragon fruit cultivation

3.2.1. Area, yield and output

The data Table 5 and Figure 3 show that during the period 2015 - 2021, the area planted with dragon fruit increased steadily each year, with a particularly sharp increase of 1,009 ha from 2017 to 2018. However, beginning in 2022, the area of dragon fruit shows signs of a sharp decline, dropping from 4,549 ha to just 2,933 ha. Additionally, productivity has shown a slight and steady increase over the years as growers increasingly adopt new technical processes. Due to the sharp decrease in the cultivated area, dragon fruit production in 2022 was only 61,475 tons, a reduction of 33,644 tons compared to 2021.

Table 5. Area, productivity and output of dragon fruit in the period 2015 - 2022

Year	Area (ha)	Productivity (ton/ha)	Output (tons)
2015	2,500	21.89	54,725
2016	2,751	18.21	50,096
2017	3,042	20.08	61,083
2018	4,051	20.36	82,478
2019	4,139	20.87	86,381
2020	4,436	20.89	92,668
2021	4,549	20.91	95,119
2022	2,933	20.96	61,475

Source: Division of Agriculture and Rural Development of Bac Binh district (2022).

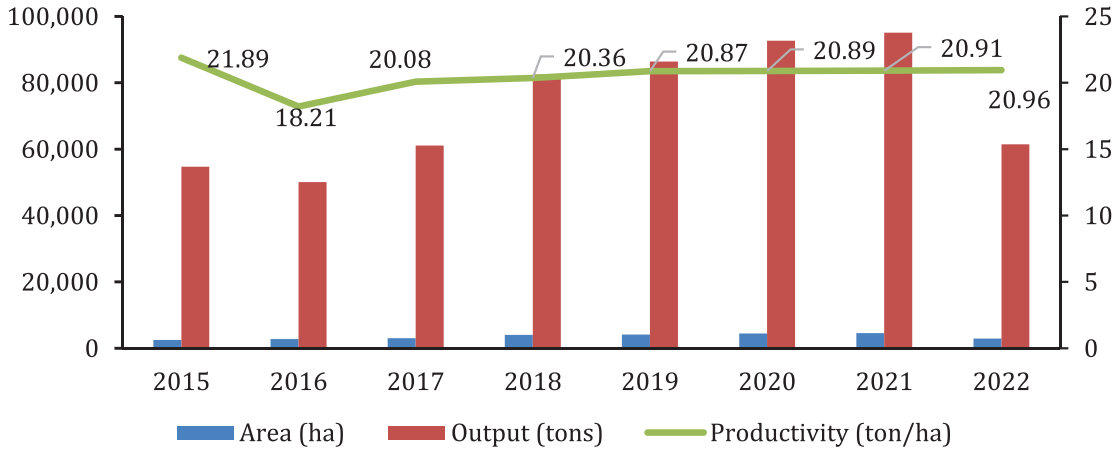

Figure 3. Development of dragon fruit area, productivity, and output in the period 2015 – 2022.

3.2.2. Distribution of dragon fruit

Table 6 shows that by 2020, the area of dragon fruit planted across all communes and towns totaled 4,436 ha, with an annual increase. However, dragon fruit trees are primarily distributed in the following communes and towns: Phan Hiep (478.5 ha), Hong Thai (456.7 ha), Phan Thanh (439.8 ha), Cho Lau Town (425.7 ha), Hai Ninh commune (425 ha), Song Luy commune (413.5 ha).

Table 6. Current distribution status of dragon fruit

No	Administrative unit (commune/town)	Area over the years (ha)				
		2010	2015	2020	2021	2022
1	Cho Lau town	35.5	175.7	425.7	438.7	268.0
2	Luong Son town	20.4	153.1	203.1	203.1	60.0
3	Binh Tan	42.0	162.0	181.0	181.0	86.0
4	Phan Tien	10.0	25.0	25.0	25.0	9.0
5	Song Luy	32.0	259.5	413.5	454.8	180.0
6	Phan Lam	3.0	15.0	55.0	55.0	0.0
7	Phan Son	2.0	9.0	14.0	14.0	0.0
8	Phan Đien	42.3	86.8	219.8	129.8	129.0
9	Phan Thanh	67.9	189.8	439.8	442.8	147.0
10	Phan Hiep	45.8	178.5	478.5	492.6	270.0
11	Phan Ri Thanh	88.0	178.9	278.9	288.9	236.0
12	Phan Hoa	35.0	215.8	265.8	265.8	157.0
13	Binh An	96.0	176.0	226.0	226.0	159.0
14	Song Binh	25.8	146.7	146.7	146.7	53.0
15	Hoa Thang	25.5	82.1	124.1	124.1	207.0
16	Hong Thai	85.1	156.7	456.7	487.8	760.0
17	Hai Ninh	79.5	175.0	425.0	425.0	211.0
18	Hong Phong	5.0	25.0	35.0	35.0	1.0
	Total	669.0	2,403.0	4,436.0	4,549.0	2,933.0

Source: Division of Agriculture and Rural Development of Bac Binh district (2022).

In 2022, the area of land used for dragon fruit cultivation decreased sharply. Table 6 and Figure 4 show that some units, such as Phan Lam and Phan Son, have no cultivated area.

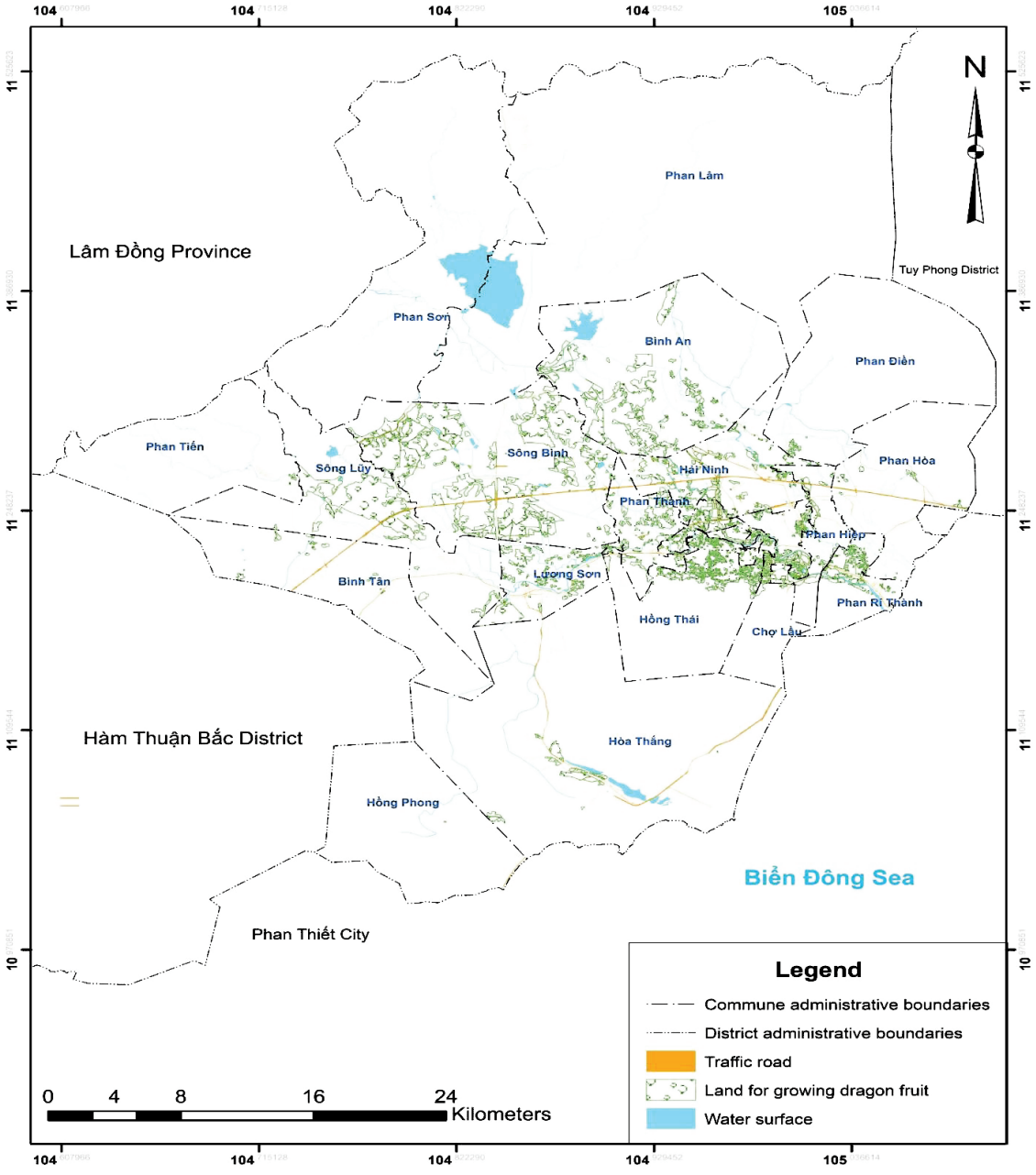

Figure 4. Map of current distribution status of dragon fruit in Bac Binh district in 2022.

3.3. Evaluation of the effectiveness of land use for dragon fruit cultivation

3.3.1. Land adaptation of dragon fruit

Regarding ecological requirements, the most suitable temperature for growing dragon fruit is between 21 and 29°C, with a maximum of no more than 40°C. It is especially suitable for growing in areas with average rainfall and a distinct dry season. Dragon fruit prefers strong light intensity; if it is shaded or the number of hours of light is low, the stems will become weak and flowers will develop slowly (Nguyen, 2022).

Dragon fruit is highly resistant to unfavorable environmental conditions such as drought, but its ability to withstand waterlogging is not high. Dragon fruit can be grown on many different types of soil, from sandy loam to clay loam. However, sandy loam soils with high organic content and good drainage are most suitable for growing dragon fruit. Suitable soil pH ranges from 5.5 to 7.0 (Nguyen, 1997). For the tree to grow well and produce many large fruits, it is necessary to plant dragon fruit in areas with active irrigation, especially during the periods of flower bud development, flowering, and fruiting (Pham et al., 2016; Nguyen, 2022).

Results of assessing natural adaptability according to the method of FAO (1976) show that dragon fruit growing soil in Bac Binh district has a degree of adaptation expressed in the following order: S1 - very adaptable, S2 - adaptable , S3 - less adaptable. Dragon fruit in region S1 has a yield of 24 - 25 tons/ha, S2 was 20 - 21 tons/ha and S3 was 15 - 18 tons/ha. More than 80% of dragon fruit growing land in Bac Binh district has natural adaptation level S2 (Nguyen & Le, 2021).

Assessing sustainable adaptation according to the FAO method (1993, 2007), in addition to natural factors, socio-economic factors also contribute significantly to the level of crop adaptation. For example, dragon fruit in the natural adaptation zone S2 have good yields (20 - 21 tons/ha), but due to high costs (in some places with unfavorable traffic conditions or small-scale production), the proportion of mechanization application is still low. Transportation costs and production costs are high, leading to low economic efficiency (profit (GM) = 2,400 USD/ha, B/C = 1.2). The level of people's acceptance is low, and these factors cause the level of sustainable adaptation to decrease to S3 or even N- no adaptation (Nguyen & Le, 2021).

3.3.2. Analysis of land use efficiency for dragon fruit cultivation

3.3.2.1. Economic efficiency

The results of processing 98 survey forms on the effectiveness of growing dragon in Bac Binh district, considering the cost, revenue, and profit levels, are divided into three levels: high, medium, and low in Table 7.

Table 7. Analysis of economic efficiency of dragon fruit under normal production conditions

No	Category	Unit	Level		
			High	Medium	Short
1	Total cost/ha	USD	5,839.7	5,399.1	4,944.8
1.1	Material costs	USD	2,336.6	2,052.2	1,768.2
1.2	Labor costs	USD	1,920.0	1,920.0	1,920.0
1.3	Other costs	USD	1,583.1	1,416.9	1,256.6
2	Total revenue/ha	USD	11,000	8,652	7,416
2.1	Productivity	(tons/ha)	25	21	18
2.2	Price (average)	USD/kg	0.44	0.41	0.41
3	Economic efficiency/ha				
3.1	Profit	USD	5,160.3	3,747.3	3,460.0
3.2	Aggregate profit	USD	6,816.3	5,667.3	5,300.0
3.3	Revenue/Cost (R/C)		1,88	1,60	1,50
3.4	Profit/Cost (P/C)		1,17	1,05	1,09

In general, the productivity of dragon fruit cultivation in Bac Binh district are relatively stable, and costs are less volatile. Therefore, economic efficiency (profit) mainly depends on the price. According to the results, when the price of dragon fruit is stable at 0.41 - 0.44 USD/kg, growers had profitable, and higher output yield more profit. However, from the end of 2022 until now, the price of dragon fruit has continuously decreased, fluctuating between 0.08 and 0.16 USD/kg. At times, the price fell below 0.08 USD, and traders did not buy it. And currently, the price has increased to between 0.32 - 0.48 USD/kg. In reality, stable dragon fruit production depends greatly on the selling price, particularly the export price.

Additionally, according to the results of calculating the economic efficiency of the dragon fruit production model following VietGAP standards, for every 1 USD of VietGAP-standard production cost, the revenue is 2.26 USD, and the profit is 1.26 USD. The ratio of profit to revenue is 0.56, meaning that for every dollar of revenue, there is 0.56 USD of profit (Tran & Nguyen, 2017).

Table 8. Comparison of economic efficiency of dragon fruit produced normally and according to VietGAP standards

No	Category	Unit	Normal production	Manufactured according to VietGAP standards
1	Total cost /ha	USD	4,944.8 - 5,839.7	10,124
2	Revenue/Cost (R/C)	-	1.50 - 1.88	2.26
3	Profit/Cost (P/C)	-	1.09 - 1.17	1.26

Table 8 shows that the total cost of production according to VietGAP standards is twice as high as normal production costs, but in return, the selling price of products is also higher, so the profit/cost ratio is higher, and the products can be consumed domestically as well as meet more export market demands.

In addition to the economic efficiency analyzed above, using land to grow dragon fruit in Bac Binh district has also created jobs for a large number of agricultural workers. Survey results showed that 16% were less satisfied, and 8% were dissatisfied, with the main reason being the erratic fluctuations in dragon fruit prices, leading to unstable income for growers. As a result, they tend to want to switch to other more stable crops.

3.3.2.2. Social and environmental efficiency

Survey results of 98 dragon fruit growing households showed:

- Growing dragon fruit has created better jobs for farmers (56.67% of households are satisfied and 19.33% of households are very satisfied). However, there are also 16% of households who are less satisfied and 8% of households who are dissatisfied when growing dragon fruit because the selling price is unstable.

- There are 69.7% of surveyed households thought that costs would increase if too much chemical fertilizers and pesticides were used. Therefore, farmers have increasingly tended to choose pest-resistant crop varieties and use organic fertilizers to improve the quality of finished products.

- And in the assessment of sustainable adaptation of dragon fruit trees in Binh Thuan province, Bac Binh has a high level of S1 adaptation, meaning it has little impact on the environment (Nguyen & Le, 2021).

3.4. Solutions to improve land use efficiency for dragon fruit cultivation in Bac Binh district

3.4.1. Factors affecting land use for dragon fruit cultivation

According to the above evaluation results and the survey results of 20 managers related to the research field, it shows that dragon fruit productivity and output in Bac Binh district depends on the following factors:

- Dragon fruit selling price (95%).

- Production scale: dragon fruit growers are spontaneous, unplanned, and ready to change when selling prices decrease (85%).

- The export market is not stable; it still depends on the Chinese market (80%).

- Care techniques: introduction that applies science and technology is not yet popular (75%).

- Domestic consumption enterprises are small-scale and spontaneous (70%).

- Dragon fruit Seedlings (55%).

3.4.2. Proposing solutions to improve land use efficiency for dragon fruit cultivation

Based on an assessment of the current status of dragon fruit cultivation and a survey of dragon fruit growers and experts in agricultural land management and use, this study proposes several specific solutions:

(i) Development of production along the product value chain:

- To increase reliability of product quality.

- Meets export requirements to markets of many countries.

(ii) Solutions to support large-scale business development:

- Increase professional production output.

- Attract businesses with capital, science, technology, and market capacity to lead the value chain efficiently and sustainably.

(iii) Policy solutions:

- Support and create favorable conditions for the development of large-scale dragon fruit processing and consumption enterprises.

- Implement policies to support cooperatives, ensuring output for dragon fruit.

- Create a convenient process for farmers to grow dragon fruit according to GAP standards.

- Attract investment and build large-scale dragon fruit processing factories in industrial zones, helping to consume a large amount of output products during the on-season.

(iv) Human resources solutions:

- Training and equipping farmers with new farming techniques.

- Organize dragon fruit industry seminars and regularly update new technology.

- Attract highly qualified agricultural workers.

4. Conclusions

Bac Binh district had natural conditions, land resources, and climate that are highly favorable for growing dragon fruit. The highly adaptive S1 area used more than 25% of the total area, while the medium and low adaptive areas use only 14.87% and 2.88%, respectively. The potential to

expand the area for this crop in terms of natural adaptation was significant. Research results showed that dragon fruit output in Bac Binh district remained stable, fluctuating between 18.21 and 21.89 tons/ha. Therefore, the quantity of dragon fruit produced mainly depended on the area under cultivation. If the area was large, the quantity would be high, and vice versa. When grown according to VietGAP standards, yield and product quality were higher, but the investment cost of production according to this standard was 1.73 to 2.05 times higher.

The results also indicated that more than 85% of dragon fruit consumption came from foreign markets, mainly exported to China. If dragon fruit from Bac Binh district, and Binh Thuan province in general aims to expand export markets to countries such as Japan, Korea, and Canada, it is essential to improve product quality and ensure food safety according to GAP standards.

Therefore, this study proposed four groups of solutions to improve the efficiency of land use for dragon fruit cultivation: (i) development of production along the product value chain; (ii) solutions to support large-scale business development; (iii) Policy solutions; (iv) Human resources solutions.

Conflict of interest

The authors declare that they have no conflict of interest in this article.

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