THAI NGUYEN UNIVERSITY
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RESEARCH ON THE POTENTIAL OF AGRICULTURAL LAND TOWARDS COMMODITY PRODUCTION IN HILLY LAND AREA OF BACH THONG DISTRICT, BAC KAN PROVINCE

Major: Land Management
Code: 9.85.01.03

SUMMARY OF DOCTOR'S THESIS
LAND MANAGEMENT

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The work is completed at:
The University of Agriculture and Forestry,
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The thesis will be defended before the university-level dissertation committee
Meeting at: University of Agriculture and Forestry,
Thai Nguyen University
At ..... hour ..... minute, date ..... month ..... year

LIST OF PUBLISHED SCIENTIFIC WORKS
RELATED TO THE THESIS
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1. **Pham Xuan Thieu**, Hoang Van Hung (2022), "Assessment of the status of land use and efficiency of land use types (LUT) in hill land area of Bach Thong district, Bac Kan province", *Journal of Science and Technology. Thai Nguyen University*, Volume 227, No. 10, p. 228 - 234.
2. **Pham Xuan Thieu**, Hoang Van Hung, Duong Thanh Nam (2022), "Assessment of the potential land of hill land area of Bach Thong district, Bac Kan province", *Journal of Science and Technology of Thai Nguyen University,* vol. 227 number 14, p. 194 - 200.

PREAMBLE

1. The urgency of the topic

Soil in hilly land area is considered as a land resource with great potential for socio-economic development in general and for agro-forestry production in particular in the midland and mountainous areas of Vietnam. However, up to now, in addition to the effective land use of the people, many productive land areas have low efficiency due to unreasonable use, not paying attention to appropriate farming methods, the investment is still low. Therefore, many areas of hilly land have been degraded, reducing productivity and economic efficiency per unit area.

Bach Thong district, Bac Kan province is a district in the center of Bac Kan province, bordering most districts and cities in the province. Agricultural land in the hilly land area of Bach Thong district is the oldest used and is the main land area for agricultural cultivation. However, the effective use of this land is not high because the potential and suitability of each type of land has not been exploited yet. In addition, attention has not been paid to the development of production to create commodity products on the basis of promoting the strengths of the local land and climate.

In general, the research works on sustainable land use in hilly land area of Bac Kan province in general and Bach Thong district in particular are scattered, unsystematic and lacking in basic survey data on land in relation to land. with the external environment (water, climate, organisms ...).

With the above situation, the study and assessment of the actual situation of land use, the potential of land in the hilly land area of Bach Thong and propose an appropriate land use orientation towards commodity production is the scientific basis. and reliable practice to exploit the land resources well on the one hand and find the optimal solution on the other hand.

Stemming from that actual requirement, the topic *"Study on the potential of agricultural land in the direction of commodity production in hilly land area, Bach Thong district, Bac Kan province"* was carried out, having scientific and practical significance.

2. The research objectives of the topic

2.1. General objective

Assessing the potential status and suitability of land with different types of land use (LUT), as a basis for proposing agricultural land use towards commodity production in hilly land area of Bach Thong district, Bac Kan province.

2.2. Detail objective

- Assessing the current status of agricultural land use in hilly land area, the efficiency of different types of land use and selecting the type of agricultural land use towards commodity production in hilly areas, Bach Thong district, Bac Kan province;

- Assessing the potential of suitable land for agricultural land use in the direction of commodity production in hilly land area, Bach Thong district, Bac Kan province;

- Orienting and proposing appropriate use of agricultural land in the direction of commodity production in hilly land area, Bach Thong district, Bac Kan province and development solutions.

3. The scientific and practical significance of the topic

3.1. Scientific significance

The research results of the topic are a new database that contributes to systematizing the theoretical basis of land potential assessment in the mountainous district in particular and the Northeast region in general.

3.2. Practical significance

The research results of the topic provide a practical database on the actual status of land use, the efficiency of different types of land use, land potential, and the selection of appropriate agricultural land use types in hilly areas. and propose solutions to use land for agricultural development in the direction of commodity production in Bach Thong district. The research results are references for the research, study and training of staff of institutes and schools and practical experience that can be applied to areas with similar conditions.

4. New contributions of the thesis

- Quantitatively assessed the potential of land in hilly land area of Bach Thong district, Bac Kan province and selected 6 suitable agro-forestry LUTs in the direction of commodity production based on the results of integration and classification of land suitability. and optimization problem.

- Built a digital dataset on space and attributes of agricultural land in hilly land area to serve the management of soil quality and direct commodity-oriented agricultural production in Bach Thong district, Bac Kan province.

Chapter 1
LITERATURE REVIEW

In this chapter, the thesis reviews the following issues:

- Theoretical basis for assessing the potential of agricultural land in the direction of commodity production in hilly land area.
- Actual basis of land potential assessment and sustainable land use:
+ Assessment of land potential and sustainable land use in the world.
+ FAO land potential assessment.
+ Assessment of land potential and sustainable land use in Vietnam.
- Reviewed studies on land potential assessment and sustainable land use:
+ Studies on land potential prices and sustainable land use.
+ Some research on GIS application in making land suitability maps.
+ Some research on application of optimization problems in sustainable land use.
- On the basis of an overview of research issues, the thesis has proposed a research approach of the topic.

Chapter 2
RESULTS AND METHODOLOGY

2.1. Research object, scope

2.1.1. Research subjects

- Potential of agricultural land in Bach Thong district.
- Types of agricultural land use (LUT) in hilly land area, Bach Thong district.

2.1.2. Research scope

- Spatial scope: The study was carried out in Bach Thong district.
- Scope of time: The thesis is researched in the period from 2016 to 2020.

2.2. Research content

- Assessment of natural, socio-economic conditions related to agricultural production in Bach Thong district, Bac Kan province;

- Assessment of the current status of land use and types of agricultural land use in hilly areas, Bach Thong district, Bac Kan province;

- Assess the potential of agricultural land towards commodity production in hilly land area of Bach Thong district, Bac Kan province;

- Identify some models of agricultural land use towards commodity production in land area, Bach Thong district, Bac Kan province;

- Orientation and proposal to use agricultural land in the direction of commodity production in hilly land area, Bach Thong district, Bac Kan province.

2.3. Research Methods

2.3.1. Methods of selecting research sites

2.3.1.1. Choose a research point

According to topographic, climate and soil factors, Bach Thong district has been divided into 2 sub-regions, so the study identified two sub-regions as follows:

- Sub-region 1: A sub-region with low terrain, located between two high mountain ranges of Bach Thong; Rainfall < 1,500 mm, total temperature > 8,000°C and dry time in the year is 2 - 3 months; including 9 commune units (Quan Ha, Cam Giang, Nguyen Phuc, My Thanh, Quang Thuan, Duong Phong, Don Phong, Luc Binh and Vi Huong).

- Sub-region 2: A sub-region with high terrain and located to the East and Northeast of Bach Thong district; Rainfall < 1,800 mm, total temperate zone ≥ 7,000 - 8,000°C, number of dry months ≥ 2 - 3 months; including 5 communes and towns (Phu Thong town, Tan Tu, Sy Binh, Vu Muon and Cao Son communes).

On the basis of determining agricultural land for hilly land area with an absolute altitude under of 500 m or less of each sub-region, the study selects two communes. Specifically:

- Sub-region 1: select 2 communes Quang Thuan and Luc Binh;
- Sub-region 2: select 2 communes Cao Son and Tan Tu.

These are communes with characteristics of climate, soil, topography, farming practices, and cropping systems typical for the two sub-regions of the district.

2.3.1.2. Method of selecting survey households

The number of survey samples in 4 communes of 2 sub-regions is selected according to the ratio of households engaged in production of each type of land use, selected households are households with production experience in the target communes according to the method of production. stratified random. There are 60 households in each sub-region, with a total of 120 households.

The topic uses stratification by rich, medium, poor households and a combination based on cultural level (listed by the village head) then reduces the number of communes in each sub-region to randomly select the number of households, follow that commune to conduct the survey.

2.3.2. Methods of investigation and collection of information

2.3.2.1. Investigate and collect secondary information documents

- Collecting documents on socio-economic and current status of land use in the period 2016 - 2020; land use planning, hydrometeorology, affecting the district's land use at departments under Bach Thong District People's Committee (Department of Natural Resources and Environment, Division of Agriculture and Rural Development (RARD), Sub-Department of Statistics Bach Thong - Ngan Son ...), documents on land in the Department of Natural Resources and Environment of Bac Kan province, Department of Statistics of Bac Kan province.

- Collect land map of Bac Kan province and explanatory report.

2.3.2.2. Primary data collection method

Interviewing farmers according to the household survey questionnaire (120 questionnaires).

2.3.3. Methods of assessing economic, social and environmental efficiency of agricultural land use towards commodity production

Types/types of agricultural land use in the direction of commodity production in hilly areas are defined as those types/types of land use in production that create agricultural products with commodity value. The evaluation criteria blocks are as follows:

2.3.3.1. System of indicators to evaluate economic efficiency

- Production Value (GO), Intermediary Cost (IC), Value Added (VA), Return on Capital (VA/IC).

Table 2.1. Hierarchy to evaluate the economic efficiency of land use types agriculture in hilly land area, Bach Thong district

No	Rank	GO (million VND/ha)	VA (million VND/ha)	VA/IC (time)
1	Very high (VH	> 130.0	> 80.0	> 2.5
2	High (H)	100.1 – 130.0	60.1 - 80.0	2.1 – 2.5
3	Medium (M)	70.1 – 100.0	40.1 - 60.0	1.6 - 2.0
4	Low (L)	40.0 – 70.0	20.0 - 40.0	1.0 - 1.5
5	Very Low (VL)	< 40.0	<20.0	<1.0

Note: The above hierarchy is built based on:

+ According to the method of calculating the classification of land use efficiency specified in TCVN 8409:2012 compiled by the Institute of Agricultural Planning and Design and announced by the Ministry of Science and Technology.

+ According to the actual survey in the mound area. hill in Bach Thong district, Bac Kan province.

The economic efficiency classification of the land use types is summarized as follows:

- High economic efficiency (H): Land use type has no low criteria and ≥ 2 indicators achieve high or very high levels.
- Average economic efficiency (M): The land use type has no indicators at low level and ≤ 1 criterion achieves high or very high level.
- Low economic efficiency (L): The land use type has at least 1 of the economic efficiency indicators classified as low and very low.

2.3.3.2. Social performance evaluation criteria

There are the following targets:

- The level of job creation and labor attraction of LUT: It is assessed through the number of labors/ha/year (Hld) = VA/total labor/year/ha.
- The ability to ensure life, meet the needs of farmers: Assessed by the value of working days.
- Product consumption market: Assessed based on the consumption of agricultural products by people.

Table 2.2. Decentralization of criteria for assessing social efficiency of different types of land useagriculture in hilly land area, Bach Thong district

Targets	Rank		
1. Value of working day (Hd) (1,000 VND/worker)	> 200	High	H
	100 - 200	Medium	M
	< 100	Low	L
2. Ability to attract labor (labor/ha/year)	> 400	High	H
	200 - 400	Medium	M
	< 200	Low	L
3. Market the product	Easy	High	H
	Medium	Medium	M
	Difficult	Low	L

Regulations on social performance assessment for LUTs are as follows:

- High social efficiency (H): LUT has no low-level indicators and ≥ 2 high-level indicators.

- Average social performance (M): LUT has no indicators at low level and ≤ 1 indicator achieves high level.

- Low social efficiency (L): The land use type has at least 1 of the criteria ranked as low.

2.3.3.3. System of indicators for assessing environmental performance

Table 2.3 is the classification of criteria for assessing environmental performance of agricultural and forestry land uses in hilly areas in Bach Thong district, showing that:

Table 2.3. Classification of criteria for assessing environmental performance of agricultural land uses in hilly land area in Bach Thong district

Targets	Rank		
1. Coverage (%)	> 75	High	H
	35 - 75	Medium	M
	< 35	Low	L
2. Level of fertilizer use	Enough, according to regulations	High	H
	Lack	Medium	M
	Excess	Low	L
3. Level of pesticide use	Little	High	H
	Enough, according to regulations	Medium	M
	Excess	Low	L
4. The ability to protect and improve the soil	Good	High	H
	Medium	Medium	M
	Least	Low	L

- Coverage rate: Evaluated based on land cover time of LUTs, calculated according to the growth time of a crop from ground cover to harvest, determining the number of months the land is planted cover for 1 year, then calculate the percentage;

- The level of fertilizer use: If fertilizers are used according to the

recommendations, the efficiency is ranked high; if mineral fertilizers and pesticides are used correctly, but organic fertilizers are lacking, but legume crops are present in the crop system, it shall be classified as medium (preservation of fertility); improper use of low-grade fertilizers;

- Level of pesticide use: If pesticides are used sparingly, they should be ranked as high; if properly used pesticides, the average level shall be considered; Using more pesticides than recommended is ranked as low.

- Ability to protect and improve soil: Assessed through crop/soil/year structure.

Regulations on environmental performance assessment for LUTs:

- High environmental efficiency (H): Land use type has no low criteria and ≥ 2 criteria achieve high level.

- Average environmental performance (M): Land use type has no low level criteria and ≥ 1 indicator achieves high level.

- Low environmental efficiency (L): The land use type has at least 1 of the criteria ranked as low.

2.3.4. Methods of supplementary investigation, soil map correction and soil sample analysis

On the basis of inheriting the Land Map and Notes of Bac Kan province, scale of 1/50,000 built in 2005 and the summary report on Investigation and assessment of land quality and land potential for the first time in Bac Kan province, separate In particular, in Bach Thong district, in 2019, conducting an investigation and re-examination of the soil map and properties of the main soil types of Bach Thong district.

Dig additional 8 profiles according to the main soil types. The method of selecting the excavated site according to the Circular No. 60/2015/TT - BTNMT Regulations on techniques for land survey and assessment. Soil analysis according to current methods at Institute of Life Sciences - Thai Nguyen University (Table 2.4):

Table 2.4. Indicators and analytical methods

No	Targets	Unit	Method/Standard
1	pH_{KCL}		TCVN 5979 - 2007
2	OM	%	TCVN 6644 - 2000
3	N total	%	TCVN 6498 - 1999
4	P_20_5 total	%	TCVN 4052 - 1985
5	K_20 total	%	TCVN 8660 - 2011
6	CEC	ldl/100g soil	TCVN 8568 - 2010
7	Density	g/cm^3	Metal cylinders
8	3-level motor components	%	Robinson straws

2.3.5. Soil assessment method

Using FAO's land assessment method in combination with Circular No.

60/2015/TT - BTNMT Regulations on land survey and assessment techniques.

2.3.6. Map construction method

Using Microstation SE software to digitize and build simple maps, including: Soil type map, soil thickness map, mechanical composition map, irrigation regime map, slope map on the base Department of investigation, delineation and correction in the field and processing of internal data. Using ArcGIS 10.2 software in superimposing single-use maps (thematic maps) to build a map of land units of Bach Thong district.

In the thesis, the univariate (thematic) maps are presented at the scale of 1/25,000.

2.3.7. Methods to assess sustainability in agricultural land use

To assess the sustainability of agricultural land use in specific conditions with Bach Thong being a district in the northern mountainous region of Vietnam, the study uses the following criteria and indicators (Table 2.5):

Table 2.5. LUT Sustainability Assessment Indicators

No	Criteria	Targets	Content	Rank	Point
1.	Economically sustainable	Production value (1,000VND)	> 90,000	H	3
			60,000 - 90,000	M	2
			< 60,000	L	1
		Added value (1,000VND)	> 60,000	H	3
			40,000 - 60,000	M	2
			< 40,000	L	1
		Capital efficiency (time)	> 2.0	H	3
			1.5 - 2.0	M	2
			< 1.5	L	1
2.	Social sustainability	2.1. Level of labor attraction (Work/ha)	> 400	H	3
			200 - 400	M	2
			< 200	L	1
		2.2. Value of working day (1.000VND/day)	> 200	H	3
			150 - 200	M	2
			< 150	L	1
		2.3. Market the product	Easy to consume	H	3
			Normal	M	2
			Hard to consume	L	1
3.	Environmentally sustainable	3.1. Increase land cover (%)	> 75	H	3
			35 - 75	M	2
			< 35	L	1
		3.2. The ability to protect and improve the soil	High	H	3
			Medium	M	2
			Low	L	1

Note: H: high; M: medium; L: low

Summary of the assessment of the sustainability of the land use types as follows:

- High level of sustainability: When the score of the land use type reaches 85-100 % of the total maximum score, ie 20-24 points.

- Average sustainability: When the score of the land use type reaches 65 - <

85% of the maximum total score, ie 15 - 19 points.

- Low sustainability: When the score of the land use type is < 15 points.

2.3.8. Methods of studying models

The topic does not design and build models, but does empirical research on typical agricultural models selected from LUTs in the district. Investigate the information on the size of the area, the land user, monitor the production process, determine the efficiency and evaluate the sustainability of the experimental models. The models are implemented over 2 years (from 2019 - 2020), specifically the following 6 models:

- Model of specializing in rice: Spring rice - Seasonal rice: Production of commodity rice in RRD1, Son Lam1: A high quality Japanese rice variety.
- Model 2Rice – Other crop: Spring rice - Seasonal rice - Sweet potato: High quality Japanese sweet potato varieties for commercial use.
- Model 1Rice - Other crop: Tobacco - Seasonal rice: Commodity product is raw tobacco.
- Special crop model: Edible canna: is the raw material for the production of vermicelli with the brand name of Bac Kan.
- Model of fruit trees: Tangerine: Commodity products are Quang Thuan branded tangerines.
- Forestry model: Production forest - Anise: Anise product has high value today.

2.3.9. Methods of analysis, statistics, data processing

- For secondary information and data: after being collected, all these information and data are checked for completeness, accuracy, timeliness and reliability. After that, it is processed and reflected through statistical tables or graphs to evaluate, compare and draw conclusions.
- For primary data information: all data information is checked, supplemented and adjusted, then Excell software is used to process the collected survey data.

2.3.10. Method of setting up the optimal problem model

Applying a multi-objective optimization model to solve the problem of determining a reasonable agricultural and forestry land use structure in hilly areas for Bach Thong district, Bac Kan province on the basis of running the problem of determining land use structure reasonable according to land use type (LUT).

Use the Solver Module in Microsoft Excel to solve optimization problems for objectives. Set up Pay - Off information sheet.

Chapter 3
RESEARCH RESULTS AND DISCUSSION

3.1. Assessment of natural, socio-economic conditions related to agricultural production in Bach Thong district, Bac Kan province

3.1.1. Natural condition

Bach Thong is a mountainous district located in the center of Bac Kan province, the only district bordering most of the districts and cities in the province. The characteristic of Bach Thong is hilly topography, consisting of limestone mountains alternating between narrow valleys. High and steep mountains are popular from 700 to 1,000 m, the slope is over 25°. Mountainous land has a common height of 300 - 600 m, the average slope is from 2^o to 40^o, but is divided by streams and streams, making transportation in the area very difficult.

Bach Thong district is divided into 2 climate sub-regions: Sub-region 1: With rainfall < 1,500 mm, total temperate zone > 8,000°C and dry duration of the year is 2-3 months; consists of 9 commune units occupying most of the western and southwestern areas. Sub-region 2: Rainfall < 1,800 mm, total temperate zone ≥ 7,000 - 8,000°C, number of dry months ≥ 2 - 3 months; located to the east and northeast of Bach Thong district, including 5 communes and towns.

3.1.2. Social and economic conditions

Bach Thong is a mountainous district with a low average socio-economic development rate, mainly engaged in agricultural and forestry production. Population by 2020 is 31,314 people, population density is 57.3 people/km^2. The natural increase rate in 2020 is 1.11%.

3.1.3. General assessment of natural, economic and social conditions affecting economic development in Bach Thong district, Bac Kan province

3.1.3.1. Favorable

The district is located adjacent to most of the districts in the province and surrounds Bac Kan city, which is convenient for economic, cultural and social development exchanges with other districts in the province as well as neighboring provinces. There are quite rich natural resources, in which forests and minerals are the two largest natural resources. Having suitable microclimate and soil conditions for the development of a number of valuable agro-forestry crops such as tangerines, anise, galangal, tobacco, etc., has great potential for area expansion in the future.

3.1.3.2. Difficult

The typical terrain is mountainous and divided by streams, so it is difficult to invest in traffic development and agricultural production, besides it is also prone to erosion and landslides in the rainy season and dry in the summer. dried. The weather situation is complicated, the rainy season often occurs local floods and is accompanied by tornadoes, landslides, seriously affecting the works in the area.

3.2. Assessment of the current status of land use and types of agricultural land use in hilly areas, Bach Thong district, Bac Kan province

3.2.1. Current status of agricultural land use in hilly land area, Bach Thong district

In 2020, the district has a natural area of 54,649.91 ha. In which, agricultural land is 52,859.05 ha (accounting for 96.72%), the rest is non-agricultural land and unused land.

Table 3.3. Current status of agricultural land use in Bach Thong district in 2020

No	Soil type	Code	Area (ha)	Ratio (%)
1	**Agricultural land**	**NNP**	**52,859.05**	**100.00**
1.1	**Land for agriculture production**	**SXN**	**5,469.09**	**10.35**
1.1.1	**Annual crop land**	**CHN**	**3,958.56**	**7.49**
1.1.1.1	Land for rice cultivation	LUA	2,472.50	4.68
1.1.1.1.1	Land specializing in wet rice cultivation	LUC	1,540.75	2.92
1.1.1.1.2	The remaining land for wet rice cultivation	LUK	886.10	1.68
1.1.1.1.3	Upland rice growing land	LUN	45.65	0.09
1.1.1.2	Other annual crops	HNK	1,486.06	2.81
1.1.1.2.1	Flat land for planting other annual crops	BHK	1,255.90	2.38
1.1.1.2.2	Upland land for planting other annual crops	NHK	230.16	0.44
1.1.2	**Land for perennial crops**	**CLN**	**1,510.53**	**2.86**
1.2	**Forestryland**	**LNP**	**47,197.37**	**89.29**
1.2.1	**Production forest land**	**RSX**	**25,484.50**	**48.21**
1.2.2	**Protection forest land**	**RPH**	**16,882.08**	**31.94**
1.2.3	**Special-use forest land**	**RDD**	**4,830.79**	**9.14**
1.3	**Aquaculture land**	**NTS**	**190.71**	**0.36**
1.4	**Other agricultural land**	**NKH**	**1.88**	**0.004**

(Source: Bach Thong District Department of Natural Resources and Environment, 2021)

3.2.2. Current status of agricultural land uses (LUTs) in hilly areas, Bach Thong district

Based on the current land use map, combined with the survey and assessment of the current status of land use and the household interview survey, the topic has identified the types of agricultural land use in the hilly land area of Bach Mai district. Pine (Table 3.5).

Table 3.5. Common types of agricultural land use in hilly land area of Bach Thong district, 2016 and 2020 (Unit: ha)

LUTs	LUT	Area by sub-region			
		Sub-region 1		Sub-region 2	
		2016	2020	2016	2020
1. Annual crop					
1.1. Rice (LUT1)	1. Spring rice - Summer rice	362.1	359.6	273.1	271.2
1.2. Rice – Other crop (LUT2)	2. Spring rice - Summer rice - Sweet potato	38.3	34.7	21.8	20.9
	3. Spring corn - Summer rice	511.5	508.5	385.8	383.6
	4. Spring peanut - Summer rice	28.2	27.1	21.2	20.5
	5. Spring soybeans - Summer rice	30.2	19.6	22.8	14.8
	6. Tobacco – Summer rice	32.7	37.2	90.1	93.3
1.3. Specializing in growing crops (LUT3)	7. Spring corn - Sweet potato	60.9	58.8	21.2	19.9
	8. Vegetables	211.9	258	140.4	185.9
	9. Cassava	169.3	10.9	33.7	0
	10. Edible canna	0	0	40.1	51.4
2. Perennial plants					
2.1. Fruit trees (LUT4)	11. Oranges, tangerines	1,238.7	1,336.9	114.6	119.8
	12. Lychee, longan	35.5	32.2	15.7	13.2

2.2. Industrial plants (LUT5)	13. Tea	30.8	40.0	7.3	8.2
2.3. Forestry (LUT6)	14. Production forest (Acacia)	9,015.3	9,424.5	0	0
	15. Production forest (Anise)	0	0	386.1	406.5

(Source: Bach Thong District Department of Agriculture and Rural Development and survey results)

3.2.3. Evaluation of economic, social and environmental efficiency of agricultural LUTs in hilly land area of Bach Thong district

3.2.3.1. Economic efficiency

a. Sub-region 1:

Calculation data on economic efficiency of agricultural LUTs in hilly land area of Bach Thong district in sub-region 1 in Tables 3.6 and 3.7 shows that 6 LUTs with 13 different land use types for Value of Production (GO), Intermediary Cost (IC), Value Added (VA) and Return on Equity (VA/IC) are different.

Table 3.6. Economic efficiency of agricultural land use types in hilly land area of Bach Thong district in sub-region 1 (Average/1ha)

LUTs	LUT	GO (1000VND)	IC (1000VND)	VA (1000VND)	VA/IC (Time)
LUT1	1. Spring rice - Summer rice	92,829.41	28,246.65	64,582.76	2.29
LUT2	2. Spring rice - Summer rice - Sweet potato	149,234.52	49,989.92	99,244.60	1.99
	3. Spring corn - Summer rice	82,832.93	27,429.43	55,403.50	2.02
	4. Spring peanut - Summer rice	78,725.27	27,114.56	51,610.71	1.90
	5. Spring soybeans - Summer rice	77,426.29	26,214.51	51,211.78	1.95
	6. Tobacco – Summer rice	112,645.45	34,112.31	78,533.14	2.45
LUT3	7. Spring corn - Sweet potato	82,145.23	34,891.25	47,253.98	1.35
	8. Vegetables	81,883.65	30,342.43	51,541.22	1.70
	9. Casava	33,622.54	11,826.53	21,796.01	1.84
LUT4	11. Oranges, tangerines	172,216.21	53,998.35	118,217.90	2.19
	12. Lychee, longan	64,695.11	26,100.52	38,594.59	1.48
LUT5	12. Tea	91,854.23	42,351.25	49,502.98	1.16
LUT6	13. Production forest (Acacia)	94,111.21	30,143.46	63,967.75	2.12

(Source: Compiled from the household survey)

Table 3.7. Economic efficiency of agricultural land use types in hilly land area of Bach Thong district in sub-region 1 *(Average/1ha)*

LUTs	LUT	GO	VA	VA/IC	General assessment
LUT1	1. Spring rice - Summer rice	M	H	H	H
LUT2	2. Spring rice - Summer rice - Sweet potato	VH	VH	M	H
	3. Spring corn - Summer rice	M	M	H	M
	4. Spring peanut - Summer rice	M	M	M	M
	5. Spring soybeans - Summer rice	M	M	M	M
	6. Tobacco – Summer rice	H	H	H	H

LUT3	7. Spring corn - Sweet potato	M	M	L	L
	8. Vegetables	M	M	M	M
	9. Casava	VL	L	M	VL
LUT4	11. Oranges, tangerines	VH	VH	H	VH
	12. Lychee, longan	L	L	L	L
LUT5	12. Tea	M	M	L	L
LUT6	13. Production forest (Acacia)	M	H	H	H

(Source: Compiled from the household survey)

b. Sub-region 2

Calculated data on economic efficiency of agricultural LUTs in hilly land area of Bach Thong district in sub-region 2 in Tables 3.8 and 3.9 show that 6 LUTs with 13 different land use types are also for GO, IC, VA and VA. /IC is different.

Table 3.8. Economic efficiency of agricultural land uses in hilly land area of Bach Thong district in sub-region 2

(Average/1ha)

LUTs	LUT	GO	VA	VA/IC	General assessment
LUT1	1. Spring rice - Summer rice	93,236.34	28,949.68	64,286.66	2.22
LUT2	2. Spring rice - Summer rice - Sweet potato	149,878.56	50,112.12	99,766.44	1.99
	3. Spring corn - Summer rice	81,983.45	26,831.46	55,151.99	2.06
	4. Spring peanut - Summer rice	77,456.37	26,124.55	51,331.82	1.97
	5. Spring soybeans - Summer rice	76,512.08	25,361.62	51,150.46	2.02
	6. Tobacco – Summer rice	115,387.25	35,334.76	80,052.49	2.27
LUT3	7. Spring corn - Sweet potato	82,832.44	35,180.07	47,652.37	1.36
	8. Vegetables	83,334.87	31,681.56	51,653.31	1.63
	9. Edible canna	98,823.65	32,312.17	66,511.48	2.06
LUT4	11. Oranges, tangerines	152,216.35	48,454.36	103,762.00	2.14
	12. Lychee, longan	65,665.16	26,030.42	39,634.74	1.52
LUT5	12. Tea	81,855.23	35,991.25	45,863.98	1.27
LUT6	13. Production forest (Anise)	74,111.21	12,143.46	61,967.75	5.10

(Source: Compiled from the household survey)

Table 3.9. Economic efficiency of agricultural land uses in hilly land area of Bach Thong district in sub-region 2

(Average/1ha)

LUTs	LUT	GO	VA	VA/IC	General assessment
LUT1	1. Spring rice - Summer rice	M	H	H	H
LUT2	2. Spring rice - Summer rice - Sweet potato	VH	VH	M	H
	3. Spring corn - Summer rice	M	M	H	M
	4. Spring peanut - Summer rice	M	M	M	M
	5. Spring soybeans - Summer rice	M	M	M	M
	6. Tobacco – Summer rice	H	VH	H	H
LUT3	7. Spring corn - Sweet potato	M	M	L	L
	8. Vegetables	M	M	M	M
	9. Edible canna	M	H	H	H
LUT4	11. Oranges, tangerines	VH	VH	H	VH

	12. Lychee, longan	L	L	L	L
LUT5	12. Tea	M	M	L	L
LUT6	13. Production forest (Anise)	M	H	VH	H

(Source: Compiled from the household survey)

3.2.3.2. Social efficiency

a. Sub-region 1

The social effects of agricultural LUTs in hilly areas of Bach Thong district in sub-region 1 are presented in Table 3.10. Thus, it can be seen that for sub-region 1 of hilly land area such as Bach Thong district, the types of land used for growing oranges, tangerines and acacia hybrids are key crops to improve people's lives, which should be focused on developing.

Table 3.10. The social effects of different types of agricultural land use hilly land area of Bach Thong district in sub-region 1

LUTs	LUT	Hd	Ability to attract labor		Market consume		Evaluate
		1000VND/ labour	Rank	Labour/ha	Rank	Situation	Rank	
LUT1	1. Spring rice - Summer rice	121.85	M	530	H	Easy	H	H
LUT2	2. Spring rice - Summer rice - Sweet potato	122.68	M	809	H	Easy	H	H
	3. Spring corn - Summer rice	118.89	M	466	H	Easy	H	H
	4. Spring peanut - Summer rice	108.43	M	476	H	Easy	H	H
	5. Spring soybeans - Summer rice	106.91	M	479	H	Medium	M	M
	6. Tobacco – Summer rice	130.67	M	601	H	Easy	H	H
LUT3	7. Spring corn - Sweet potato	102.06	M	463	H	Easy	H	H
	8. Vegetables	98.55	L	523	H	Easy	H	M
	9. Casava	121.09	M	180	L	Difficult	L	L
LUT4	11. Oranges, tangerines	454.68	H	260	M	Easy	H	H
	12. Lychee, longan	150.17	M	257	M	Medium	M	M
LUT5	12. Tea	93.93	L	527	H	Medium	M	M
LUT6	13. Production forest (Acacia)	328.04	H	195	L	Medium	M	M

(Source: Compiled from the household survey)

b. Sub-region 2

Results of assessing the social efficiency of different types of agricultural land use hilly land area of Bach Thong district in sub-region 2 presented in Table 3.11.

Table 3.11. The social effects of different types of agricultural land use hilly land area of Bach Thong district in sub-region 2

LUTs	LUT	Hd	Ability to attract labor		Market consume		Evaluate
		1000VND/ labour	Rank	Labour/ha	Rank	Situation	Rank	
LUT1	1. Spring rice - Summer rice	121.30	M	530	H	Easy	H	H
LUT2	2. Spring rice - Summer rice - Sweet potato	123.32	M	809	H	Easy	H	H

	3. Spring corn - Summer rice	118.35	M	466	H	Easy	H	H
	4. Spring peanut - Summer rice	107.84	M	476	H	Easy	H	H
	5. Spring soybeans - Summer rice	106.79	M	479	H	Medium	M	M
	6. Tobacco – Summer rice	133.20	M	601	H	Easy	H	H
	7. Spring corn - Sweet potato	102.92	M	463	H	Easy	H	H
LUT3	8. Vegetables	98.76	L	523	H	Easy	H	M
	9. Edible canna	201.55	H	330	M	Easy	H	H
LUT4	11. Oranges, tangerines	399.09	H	260	M	Easy	H	H
	12. Lychee, longan	154.22	M	257	M	Medium	M	M
LUT5	12. Tea	87.03	L	527	H	Medium	M	M
LUT6	13. Production forest (Anise)	317.78	H	195	L	Medium	M	M

(Source: Compiled from the household survey)

3.2.3.3. Environmental efficiency

a. Sub-region 1

The results of environmental performance assessment of agricultural LUTs in hilly land area of Bach Thong district in sub-region 1 are presented in Table 3.12.

Table 3.12. Environmental efficiency of agricultural land use types hilly land area of Bach Thong district in sub-region 1

LUTs	LUT	Targets 1		Targets 2		Targets 3		Targets 4		Evalu-ate
		%	Rank	Usage	Rank	Usage	Rank	Soil	Rank	
LUT1	1. Spring rice - Summer rice	75.0	M	Enough	H	Enough	M	Medium	M	M
LUT2	2. Spring rice - Summer rice - Sweet potato	90.0	H	Enough	H	Enough	M	Medium	M	M
	3. Spring corn - Summer rice	72.0	M	Enough	H	Enough	M	Medium	M	M
	4. Spring peanut - Summer rice	69.0	M	Lack	M	Enough	M	Good	H	M
	5. Spring soybeans - Summer rice	68.0	M	Lack	M	Enough	M	Good	H	M
	6. Tobacco – Summer rice	73.0	M	Enough	H	Enough	M	Medium	M	M
LUT3	7. Spring corn - Sweet potato	75.0	M	Enough	H	Little	H	Medium	M	M
	8. Vegetables	60.0	M	Enough	H	Enough	M	Medium	M	M
	9. Casava	40.0	M	Enough	H	Little	H	Least	L	L
LUT4	11. Oranges, tangerines	90.0	H	Enough	H	Enough	M	Good	H	H
	12. Lychee, longan	92.0	H	Enough	H	Little	H	Good	H	H
LUT5	12. Tea	96.0	H	Enough	H	Excess	L	Good	H	H
LUT6	13. Production forest (Acacia)	99.0	H	Lack	M	Little	H	Good	H	H

(Source: Compiled from the household survey)

b. Sub-region 2

Data on environmental performance assessment of agricultural LUTs in hilly land area of Bach Thong district in sub-region 2 are presented in Table 3.13.

Table 3.13. Environmental efficiency of agricultural land use types hilly land area of Bach Thong district in sub-region 2

LUTs	LUT	Targets 1		Targets 2		Targets 3		Targets 4		Evalu-ate
		%	Rank	Usage	Rank	Usage	Rank	Soil	Rank	
LUT1	1. Spring rice - Summer rice	75.0	M	Enough	H	Enough	M	Medium	M	M

	2. Spring rice - Summer rice - Sweet potato	90.0	H	Enough	H	Enough	M	Medium	M	M
LUT2	3. Spring corn - Summer rice	72.0	M	Enough	H	Enough	M	Medium	M	M
	4. Spring peanut - Summer rice	69.0	M	Lack	M	Enough	M	Good	H	M
	5. Spring soybeans - Summer rice	68.0	M	Lack	M	Enough	M	Good	H	M
	6. Tobacco – Summer rice	73.0	M	Enough	H	Enough	M	Medium	M	M
	7. Spring corn - Sweet potato	75.0	M	Enough	H	Little	H	Medium	M	M
LUT3	8. Vegetables	60.0	M	Enough	H	Enough	M	Medium	M	M
	9. Edible canna	70.0	M	Enough	H	Little	H	Good	H	H
LUT4	11. Oranges, tangerines	90.0	H	Enough	H	Enough	M	Good	H	H
	12. Lychee, longan	92.0	H	Enough	H	Little	H	Good	H	H
LUT5	12. Tea	96.0	H	Enough	H	Excess	L	Good	H	H
LUT6	13. Production forest (Anise)	99.0	H	Lack	M	Little	H	Good	H	H

(Source: Compiled from the household survey)

3.2.3.4. Overall assessment of economic, social and environmental efficiency of agricultural LUTs in hilly land area of Bach Thong district

Summary of results of evaluation of effectiveness of agricultural LUTs in hilly land area of Bach Thong district in Table 3.14.

Table 3.14. Summary of the results of the evaluation of the effectiveness of different types of land use agriculture in hilly land area, Bach Thong district

LUTs	LUT	Economic efficiency		Social efficiency		Envir-efficiency		Evaluate	
		Sub-region 1	Sub-region 2	Sub-region 1	Sub-region 2	Sub-region 1	Sub-region 2	Sub-region 1	Sub-region 2
LUT1	1. Spring rice - Summer rice	H	H	H	H	M	M	H	H
LUT2	2. Spring rice - Summer rice - Sweet potato	H	H	H	H	M	M	H	H
	3. Spring corn - Summer rice	M	M	H	H	M	M	M	M
	4. Spring peanut - Summer rice	M	M	H	H	M	M	M	M
	5. Spring soybeans - Summer rice	M	M	M	M	M	M	M	M
	6. Tobacco – Summer rice	H	H	H	H	M	M	H	H
LUT3	7. Spring corn - Sweet potato	L	L	H	H	M	M	M	M
	8. Vegetables	M	M	M	M	M	M	M	M
	9. Cassava	VL	-	L	-	L	-	L	-
	10. Edible canna	-	H	-	H	-	H	-	H
LUT4	11. Oranges, tangerines	VH	VH	H	H	H	H	H	H
	12. Lychee, longan	L	L	M	M	H	H	M	M
LUT5	13. Tea	L	L	M	M	H	H	M	M
LUT6	14. Production forest (Acacia)	H	-	M	-	H	-	H	-
	15. Production forest (Anise)	-	H	-	M	-	H	-	H

3.2.4. Analysis of advantages and disadvantages of agricultural LUTs in hilly land area of Bach Thong district

3.2.5. Selection of agricultural LUTs with economic, social and environmental efficiency in the hilly land area of Bach Thong district

Based on the above selection requirements and the results of the assessment of economic, social and environmental efficiency, combined with the analysis of the advantages and disadvantages of agricultural LUTs in the sub-regions, the following options have been selected. LUTs and agricultural land use patterns for hilly land area in Bach Thong district are as follows (Table 3.16).

Table 3.16. Results of selection of LUTs and agricultural land use types hilly land area of Bach Thong district

No	LUTs	LUT	Sub-regions	Product features
1	Rice (LUT1)	1. Spring rice - Summer rice	1, 2	Food and goods
2	Rice-Other crop (LUT2)	2. Spring rice - Summer rice - Sweet potato	1, 2	Food and goods
		3. Tobacco – Summer rice	1, 2	Food and goods
3	Specializing crop (LUT3)	4. Edible canna	2	Goods
4	Fruit trees (LUT5)	5. Tangerines	1	Goods
5	Forestry (LUT6)	Production forest (Anise)	2	Goods

3.3. Assessing the potential of agricultural land towards commodity production in hilly land area, Bach Thong district, Bac Kan province

3.3.1. Types of agricultural land in hilly land areas of Bach Thong district

3.3.1.1. Classification of agricultural land in hilly land area, Bach Thong district

The results of the construction of a land map of hilly land area (according to the altitude limit from 500 m above sea level) in Bach Thong district, Bac Kan province at the scale of 1/25,000 have identified that the whole district has 3 soil groups with 8 soil types, in which the red and yellow soil group has the largest area with 28,606.49 hectares, accounting for 52.35% of the natural area, the alluvial soil group has an area of 1,322.94 hectares, accounting for 2.42 percent of the natural area. and the group of red-yellow humus in the mountains is only 611.27 ha, accounting for 1.12% of the natural area, details in Table 3.17.

Table 3.17. Classification of agricultural land in hilly land area, Bach Thong district, Bac Kan province

No	Soil group/soil type	Symbol	Area (ha)	Structure (%)

I	**Yellow red soil**	**F**	**28,606.49**	**52.35**
1	Yellow-brown soil on ancient alluvium	Fp	256.59	0.47
2	Red yellow soil on acid magma rock	Fa	11,029.95	20.18
3	Red and yellow soil changes due to wet rice cultivation	Fl	1,635.27	2.99
4	Red and yellow soil on clay and metamorphic rocks	Fs	13,325.77	24.38
5	Red-brown soil on limestone	Fv	2,358.91	4.32
II	**Red yellow humus soil on the mountain**	**H**	**611.27**	**1.12**
6	Red yellow humus soil on acid magma rock	Ha	611.27	1.12
III	**Alluvial soil**	**P**	**1,322.94**	**2.42**
7	Alluvial soil is not accreted sour	Pc	778.71	1.42
8	Alluvial soil from streams	Py	544.23	1.00
Area of investigation and construction of land map			**30,540,70**	**55.88**
No rating *		KDG	24,109,21	44.12
Total area			**54,649,91**	**100.00**

*Notes: * Non-agricultural land, rocky mountain land without forests, land with altitude > 500m above sea level, special-use forest land, protection forest land.*

(Source: Bac Kan Department of Natural Resources and Environment 2019; Review results of the 2019 project)

3.3.2. Building a land unit map (DVD)

The map of land units in hilly land area, Bach Thong district, Bac Kan province is made in accordance with the provisions of Circular No. 60/2015/TT - BTNMT, which is built on the basis of overlapping 6 single-variant maps: soil type map. , soil thickness map, slope map, climate sub-region map, irrigation regime map and soil fertility map.

Statistical results on the number of soil quality units have determined that the hilly area of Bach Thong district, Bac Kan province has 72 quality units of agricultural and forestry land. General data of land units (DVD) according to the quality of hilly land in Bach Thong district in Table 3.32 and Appendix 1.3 show that: Total area of 72 hilly land units in Bach Thong district, Bac Kan province is 30,540.70 ha, accounting for 55.88% of the total natural area. The total number of circles on the map is 1,042.

Table 3.32. Statistics of land units (DVD) by soil quality in hilly land area Bach Thong district, Bac Kan province

No	Soil Unit	Soil characteristics						Number of slices	Area (ha)	Structure (%)
		Soil type	Slope	Soil layer	Climate	Water regime	Fertility			
1	DVD1	G7	SL1	D1	K1	I3	DP2	23	104.58	0.19
2	DVD2	G8	SL1	D1	K1	I3	DP2	37	189.03	0.35

3	DVD3	G8	SL1	D1	K2	I3	DP2	4	26.46	0.05
4	DVD4	G2	SL2	D1	K1	I1	DP2	1	1.7	0.00
5	DVD5	G2	SL3	D1	K1	I1	DP2	29	138.66	0.25
6	DVD6	G2	SL3	D2	K1	I1	DP2	2	3.99	0.01
7	DVD7	G2	SL4	D1	K1	I1	DP2	4	1,248.68	2.28
8	DVD8	G2	SL4	D2	K1	I1	DP2	1	130.03	0.24
9	DVD9	G2	SL5	D1	K1	I1	DP2	197	3,992.06	7.30
10	DVD10	G2	SL5	D2	K1	I1	DP2	63	2,211.72	4.05
..	……						…		……	……
70	DVD70	G3	SL3	D2	K1	I3	DP3	10	50.22	0.09
71	DVD71	G3	SL3	D1	K2	I3	DP2	3	18.68	0.03
72	DVD72	G3	SL4	D2	K1	I2	DP2	5	23.99	0.04
73	KDG*	KDG	KDG	KDG	KDG	KDG	KDG	59	24,109.21	44.12
Sum								1.042	30,540.70	55.88
Evaluation area									30,540.70	55.88
Total area									54,649.91	100.00

*Notes: * Non-agricultural land, rocky mountain land without forests, land with an altitude of >500m above sea level, land mainly for special-use and protection forests.*

Table 3.33. Summary of potential land area in hilly land area Bach Thong district, Bac Kan province

No	Targets	Symbol	Area (ha)	Structure (%)
1	Very potential	TN1	9,779.70	17.90
2	Medium potential	TN2	9,746.90	17.84
3	Less potential	TN3	11,014.10	20.15
4	No rating	KDG	24,109.21	44.12
Evaluation area			30,540.70	55.88
Total			54,649.91	100.00

3.3.3. Appropriate classification of agricultural land in hilly land area, Bach Thong district

Based on the growth and ecological requirements of the LUTs and the quality of land in the hilly land area of Bach Thong district to determine and classify the appropriate level according to the levels: Very suitable (S1); Medium fit (S2); Less suitable (S3) and unsuitable (N). The results of suitable classification of land in hilly land area of Bach Thong district, Bac Kan province are summarized in Table 3.35.

Table 3.35. Land suitability classification results for LUTs in hilly land area of Bach Thong district, Bac Kan province

No	DVD	LUT1	LUT2	LUT3	LUT4	LUT5	LUT6	Area (ha)	Structure (%)
1	DVD1	S2	S2	S2	N	N	N	104.58	0.19
2	DVD2	S1	S3	S3	S2	N	N	189.03	0.35

No	DVD	LUT1	LUT2	LUT3	LUT4	LUT5	LUT6	Area (ha)	Structure (%)
3	DVD3	S1	S3	S3	S2	N	N	26.46	0.05
4	DVD4	N	N	N	N	S3	S3	1.70	0.00
5	DVD5	N	N	N	N	S3	S3	138.66	0.25
6	DVD6	N	N	N	N	S3	S3	3.99	0.01
7	DVD7	N	N	N	N	S3	S3	1,248.68	2.28
8	DVD8	N	N	N	N	S3	S3	130.03	0.24
9	DVD9	N	N	N	N	N	S3	3,992.06	7.30
10	DVD10	N	N	N	N	N	S3	2,211.72	4.05
..	……	…	..	..	..	..	..	……	…..
70	DVD70	S2	S1	S1	S2	N	N	50.22	0.09
71	DVD71	S2	S1	S1	S2	N	N	18.68	0.03
72	DVD72	S2	S1	S1	S2	N	N	23.99	0.04
73	KDG	-	-	-	-	-	-	24,109.21	44.12
				Sum				30,540.70	55.88
				Evaluation area				30,540.70	55.88
				Total area				54,649.91	100.00

Note: LUT1 (Spring Rice - Seasonal Rice); LUT2 (Spring Rice - Seasonal Rice - Sweet Potato); LUT3 (Tobacco - Seasonal Rice); LUT4 (Edible canna); LUT5 (Citrus); LUT6 (Anise, hybrid acacia).

Although it is a lower mountainous district compared to other districts of Bac Kan province, but with mainly hilly features, the land area is very suitable and suitable for rice and cash crops. Mostly unsuitable soil.

Table 3.36. Summary of area according to appropriate grades of each land use type in hilly land area, Bach Thong district, Bac Kan province

Unit: ha

No	Suitable class	LUT1	LUT2	LUT3	LUT4	LUT5	LUT6
1	S1	544.23	1,635.27	1,635.27	1,182.20	4,782.44	14,456.91
2	S2	1,739.85	778.71	433.32	2,179.50	2,358.91	1,227.77
3	S3	674.13	544.23	889.62	283.94	1,779.65	11,286.54
4	N	27,582.49	27,582.49	27,582.49	26,895.06	21,619.70	3,569.48
	Total	**30,540.70**	**30,540.70**	**30,540.70**	**30,540.70**	**30,540.70**	**30,540.70**

3.4. Identifying some models of agricultural land use towards commodity production in hilly land area, Bach Thong district, Bac Kan province

3.4.1. Results of monitoring the economic, social and environmental performance of typical LUTs

From the results of evaluating the effectiveness of different types of land use in hilly land area in the district, the study has evaluated 06 land use models: Specializing in rice: Spring rice - Seasonal rice; Rice – Other crop: Spring Rice - Seasonal Rice - Sweet Potatoes and Tobacco - Seasonal Rice; Specializing crop: Edible canna; Fruit trees: Tangerine; Forestry: Production forest - anise.

3.4.2. Assess the sustainability of the models

The assessment of the sustainability of agro-forestry LUTs in the hilly land area of Bach Thong district is based on three aspects: economic sustainability, social sustainability and environmental sustainability.

Table 3.55. Results of sustainability assessment of agro-forestry LUTs hilly land area, Bach Thong district, Bac Kan province

LUT	Economic			Society			Environment		Total score	Sustainability level
	CT1	CT2	CT3	CT1	CT2	CT3	CT1	CT2		
1. Spring Rice - Seasonal Rice	M	H	H	H	H	H	M	M	21	H
2. Spring Rice - Seasonal Rice - Sweet Potato	H	H	H	H	M	H	H	M	22	H
3. Tobacco - Seasonal Rice	H	H	H	H	M	H	M	M	21	H
4. Edible canna	M	H	H	M	H	H	M	H	21	H
5. Tangerines	H	H	H	M	H	H	H	H	23	H
6. Production forest - Anise	M	H	H	M	H	M	H	H	21	H

Note: Economic sustainability (Criterion 1: Production value; indicator 2: added value; indicator 3: efficiency of capital); Social sustainability (criteria 1: Level of labor attraction; indicator 2: value of working day; target 3: product consumption market); Environmental sustainability (Criterion 1: Coverage; indicator 2: ability to protect and improve soil)

From the combined results of assessing the sustainability of the district's land use types, it shows that: The land use types have achieved a high degree of sustainability and achieved high sustainable results in all three aspects of economy and society, environment. These are Spring Rice - Seasonal Rice, Spring Rice - Seasonal Rice - Sweet Potato, Tobacco - Seasonal Rice, Edible canna, Tangerine and Anise.

3.5. Orientation and proposal to use agricultural land in the direction of commodity production in hilly land area, Bach Thong district, Bac Kan province

3.5.1. Applying multi-objective optimization problem to determine the effective and sustainable land use structure of agro-forestry LUTs

The results of solving the problem with the general goal of determining the optimal area structure of each type of land use for each appropriate type (Table 3.59) show that:

- LUT1: Area 630.80 ha, suitable for cultivation on 2 suitable types III and V.
- LUT2: Area of 637.91 ha, can be optimized on 3 suitable types III and V.
- LUT3: Area 1,104.60 ha, optimal on 3 suitable types: II, III, IV and V.
- LUT4: Area 584.90 ha, optimal in 4 suitable types No. I, II and III.
- LUT5: Area of 4,245.38 ha, optimally 3 suitable types VIII, IX and XI.
- LUT6: The optimal area is 22,725.84 ha, distributed over 8 suitable types VI, VII, VIII, IX, X, XI, XII and XIII.

Table 3.59. Results of multi-objective problem solving for selected land use types in the hilly land area of Bach Thong district, Bac Kan province

Suita-ble style	Số DVD	DVD	LUT						Area (ha)
			1	2	3	4	5	6	
I	2	52.53				328.74			328.74
II	2	2.3			133.00	82.49			215.49
III	19	54-72	584.04	274.37	603.19	173.67			1,635.27
IV	1	1			104.58				104.58
V	1	51	46.76	363.54	263.83				674.13
VI	6	43-48						1,182.20	1,182.20
VII	8	15-22						283.94	283.94
VIII	5	23-27					3,443.86	1,054.64	4,498.50
IX	2	38-39					76.50	1,054.64	1,131.14
X	3	40-42						45.57	45.57
XI	7	4-8.13-14					725.01	1,054.64	1,779.65
XII	10	28-37						8,543.33	8,543.33
XIII	4	9-12						9,506.89	9,506.89
XIV	2	49-50							611.27
Cộng	**72**		**630.80**	**637.91**	**1,104.60**	**584.90**	**4,245.38**	**22,725.84**	**30,540.70**

3.5.2. Orientation to use agricultural land in hilly land area for Bach Thong district

Orientation for sustainable land use to 2025 in Bach Thong district is shown in Table 3.60.

Table 3.60. Summary of area of proposed agricultural LUTs for hilly land area of Bach Thong district by 2025 *(Unit: ha)*

LUTs	LUT	According to the math	DVD No	Proposed until 2025		
				Area	Sub-region 1	Sub-region 2
1. Rice	1. Spring Rice - Seasonal Rice	630.80	1,51,54-72	610.00	400.00	210.00
2. Rice – Other crop	2. Spring Rice - Seasonal Rice - Sweet Potato	637.91	1,51,54-72	300.00	180.00	120.00
	3. Tobacco - Seasonal Rice	1,104.60	1-3,51,54-72	450.60	100.00	350.60
3. Specializing crop	4. Edible canna	584.90	2,3,52-72	180.40	80.00	100.40
4. Fruit trees	5. Tangerine	4,245.38	4-9,13-14, 23-27,38-39	2.354.46	1.413.46	941.00
5. Forestry	6. Anise	22,725.84	4-48	10,569.22	10,164.00	405.22
	Total area	29,929,43		**14,464.68**		

3.5.3. Proposing appropriate solutions to use agricultural land in hilly land area towards commodity production

3.5.3.1. Solutions for different types of land use (crops)

3.5.3.2. Soil use solution

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion

1.1. Bach Thong is a district located in the center of Bac Kan province, with a total natural area of 54,649.91 hectares, the population of the district in 2020 is 31,314 people. In the period of 2015 - 2020, the economy of the district has shifted in the direction of increasing the proportion of the construction industry, reducing the proportion of agro-forestry production. However, agro-forestry production still plays a key role in the economic development of the district.

1.2. The results of research and assessment of the current status of agricultural and forestry land use show that Bach Thong district is quite diverse in terms of crops and land use types with 6 main LUTs and 15 land use types. LUT 2Rice – Other crop for high economic, social and environmental efficiency, net income ranges from 78-99 million VND/ha/year but the investment is quite large. LUT specializing in rice has low economic efficiency but is still an important LUT in ensuring food security in the district. The selected LUTs with high production potential are: LUT Spring Rice - Seasonal Rice - Sweet Potato; LUT Tobacco – Seasonal Rice; LUT Edible canna; LUT fruit trees (tangerines); LUT production forest (anise, acacia hybrid).

1.3. The results of the investigation and construction of the soil map show that the hilly land area of Bach Thong district has 3 soil groups with 8 types of soil, in which the red and yellow soil group has the largest area with 28,606.49 hectares, accounting for 52.35%. natural area.

The results of building a map of land units for potential assessment with 6 target blocks have been built up a land unit map of 1/25,000 scale with 72 land units, the area of map units land is 30,540.70 ha.

The results of land suitability classification show that the areas suitable for LUTs are respectively: rice LUT 544.23 ha; LUT of rice crops 1,635.27 ha; LUT specializes crop of edible canna 1,182.20 ha; LUT of citrus fruit trees is 4,782.44 ha; LUT of production forest is 14,456.91 ha. Thus, compared with the current land use situation, the potential of land for fruit trees and edible canna in the hilly areas of the district is very large.

1.4. The results of monitoring of agro-forestry models from 2019 to 2020, comparison with the results of assessment of socio-economic and environmental performance of LUTs and land use types have confirmed that the LUTs eat fruit (oranges, tangerines); LUT rice – other crop; LUT of spring rice - summer rice, LUT of edible canna, LUT of medicinal plants for high efficiency and sustainability.

1.5. Based on the orientation of agricultural land use towards commodity production in hilly land area of the district, the results of land suitability classification combined with the results of multi-objective optimal problem solving have determined the size of the area, that used for the appropriate LUTs/types for each subregion. Specifically for LUT specializing in rice (Spring rice - Seasonal rice): 610.00 ha; LUT Rice - other crop (Spring rice - Seasonal rice - Sweet potato): 300.00ha; Tobacco - Seasonal rice: 450.60 ha; LUT specialized crop (Edible canna):

180.40 ha; LUT of fruit trees (Tangerines): 2,354.46 ha and forestry LUT (Production forest: Acacia hybrid, anise) is 10,569.22 ha.

1.6. In order to use agricultural and forestry land in hilly land area sustainably according to the above orientations, Bach Thong district needs to synchronously implement groups of solutions for different types of land use: from commodity production area planning; apply science and technology; market; product promotion, branding for agricultural products to solutions for sustainable land use.

2. Recommendation

- Use the results of land assessment and land suitability classification for the development of agro-forestry production development plans in the hilly land area of the district over the years and for the restructuring of the agro-forestry industry for the next stages.

- It is necessary to have an intensive research program on the consumption market of agro-forestry products as a basis to promote research models in the district.