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Hoang Quoc Nam

**EVALUATION OF LAND RESOURCES FOR SUSTAINABLE
AGRICULTURAL PRODUCTION UNDER CLIMATE CHANGE
CONDITIONS IN THAI BINH AND NAM DINH PROVINCES**

**SUMMARY OF NATURAL RESOURCES AND
ENVIRONMENTAL GEOGRAPHY DOCTOR THESIS**

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INTRODUCTION

1. The urgency of the thesis

Under climate change conditions, land degradation and desertification are seriously increasing, properly assessing land potential is the stepping stone for sustainable planning and management of land resources because it helps us to know whether the resources is degraded or improved in quality. Investigation and assessment of land potential in Vietnam has been carried out for years and is an important basis for spatial orientation and proposing solutions for sustainable use of land resources. Previous studies have not only clarified the characteristics, properties and potential of land resources in many territories, but also provided solutions to reasonably exploit land potential, serving as a basis for make strategic decisions on planning and sustainable use of land resources.

Thai Binh and Nam Dinh are coastal provinces in the Red River Delta region, fully converging natural and human conditions for diverse and comprehensive agricultural development. Over the past in the study area, land use types have been strongly transformed to improve economic efficiency. However, this conversion carries many risks without in-depth research because the suitability of each type of land use with the ecological conditions of each area is different. Especially with the length of the coastline of the two provinces being about 128 km, agricultural production in the area has been suffering many direct negative impacts of climate change, typically flooding and saltwater intrusion.

In the Red River Delta region and especially the two provinces of Thai Binh - Nam Dinh, there have been a number of studies on land assessment for agricultural production and land use planning under climate change conditions. However, the land assessment results were carried out for the entire Red River Delta region in general without going into the specific characteristics of the coastal plain area, specifically the key agricultural production area of Thai Binh - Nam Dinh.

Originating from urgent practical requirements and arguments on the rational use of land resources, analyzing and evaluating land for sustainable agricultural production under climate change conditions in

Thai Binh and Nam Dinh provinces is a research issue with current scientific and practical significance.

2. Objectives of the thesis

- To assess the current status of land resources and the level of land suitability for agricultural production under climate change conditions in Thai Binh and Nam Dinh provinces.
- To orientate and propose solutions to rationally use land resources for sustainable agricultural production under climate change conditions in Thai Binh and Nam Dinh provinces.

3. Main research contents of the thesis

Chapter 1: Theoretical basis and methodology of land research and assessment for sustainable agricultural production under climate change conditions

1.1. Overview of research works related to the thesis

1.1.1. Overview of research on land assessment for agricultural production under climate change conditions in the world

1.1.1.1. Research and evaluation of land for agricultural production in the world

In farming and agricultural production, land is an "irreplaceable means of production". The need for land assessment arises from fierce competition and pressure for land resources through various land uses and also because a growing population poses a threat to the way resources are managed and used sustainably, optimally. Therefore, land use assessment is a core component of spatial planning for agricultural production development and is highly respected by countries. Many typical family appraisal systems have been proposed and applied, of which the most popular are in the United States, China, the former Soviet Union and Eastern European countries, Western countries, India, etc.

By the late 1960s, due to differences in standards and assessment results of each country and territory, comparing, exchanging and applying research results encountered many obstacles. Therefore, in 1976, FAO established a common land assessment method to unify assessment criteria globally on the basis of both assessing land potential and calculating the socio-economic efficiency of LUTs. In 1996, FAO continued to clarify the contents of classification systems, and perfected assessment methods for each specific assessment need.

1.1.1.2. Research and evaluation of land for agricultural production under climate change conditions in the world

Climate change poses serious risks to food supplies, security and the economy. Therefore, assessing the suitability of agriculture and productivity loss under climate change conditions is an urgent issue for sustainable agricultural production. The issue of family assessment related to climate change is mainly research in two main directions: Family assessment considers factors changed due to climate change; The assessment is based on climate change scenarios that have been forecast according to changes in some climate factors such as rainfall and temperature.

1.1.2. Overview of research on land assessment for agricultural production under climate change conditions in Vietnam

1.1.2.1. Research and evaluation of land for agricultural production in Vietnam

The concept of land classification has existed in Vietnam since feudal times to serve the collection of land taxes. However, starting in the 1960s, systematic and detailed assessments of land potential were carried out.

In 1976, some authors applied the Soviet land use assessment method to zone specialized farming, divide land classes and determine land use taxes. In 1984, the US land capacity classification was applied in Vietnam. By 1990, Vietnam approached and applied FAO's land appraisal process at many scales and territorial scales. These studies have contributed significantly to perfecting the land assessment process according to FAO in accordance with conditions in Vietnam, to have the necessary practical basis in the current land use status of ecological regions and the whole country. Up to now, more detailed micro-level studies such as district and commune levels have been periodically carried out for agricultural production or crop restructuring.

With the development of computer science and geographic information systems, land assessment in our country is now carried out in a GIS environment. Technology software has been a great help in making quick decisions during the evaluation process.

1.1.2.2. Research on land assessment for agricultural production under climate change conditions in Vietnam

In Vietnam, there are two perspectives on the impact of climate change as follows:

- The impact causes gradual change: Temperature gradually increases, rainfall gradually decreases, rainy season, hot season, cold season gradually shift, or sea level gradually increases, etc.

- Impacts related to changes in extreme weather phenomena. For example, the amplitude of temperature fluctuations increases, leading to an increase in the number of hot days and the intensity of heat; The number of cold days has decreased, but there have been more severe and harmful cold spells with greater intensity, storms, tropical depressions are more unpredictable, etc. Besides, another issue is also very worrying. is the variation in sea level fluctuations.

Having a territory located in the Asian monsoon region, adjacent to the East Sea, every year Vietnam is affected by many natural disasters of meteorological origin. Under the influence of climate change, natural disasters are increasing and have very unpredictable developments, causing negative impacts on the country's socio-economic development. Therefore, researching climate change, assessing the impact of climate change and thereby proposing solutions and response strategies has become an urgent issue.

1.1.3. Research on land assessment for agricultural production under climate change conditions in Thai Binh and Nam Dinh provinces

Recently, there have been quite a few studies and land use assessments that have been carried out in Thai Binh and Nam Dinh provinces on different scales, but land assessment for agricultural production under climate change conditions and land use planning have not gone into depth. on the specific characteristics of the coastal plain, specifically the key agricultural production area of Thai Binh - Nam Dinh. Therefore, analyzing and evaluating land for sustainable agricultural production under climate change conditions in Thai Binh and Nam Dinh provinces is a practical significance research.

1.2. Theoretical basis for research and land assessment for sustainable agricultural production in climate change conditions

1.2.1. Related basic theoretical issues

1.2.1.1. Evaluation of agricultural production land

There are 6 basic principles given by FAO:

- The selected land use types must be consistent with the natural, socio-economic characteristics and development goals of the study area.

- Selected land use types need to be described and clearly defined with their technical, socio-economic attributes.
- Land evaluation includes a comparison between two (or more) types of land use.
- The level of land suitability needs to be based on sustainable land use.
- Evaluation includes a comparison between the level of investment and the yield obtained for that type of land use.
- Soil assessment requires an integrated multi-disciplinary approach.

1.2.1.2. Climate change and adaptation to climate change

Climate Change

The United Nations believes that climate change is long-term changes in temperature and weather patterns. Such changes may be natural, caused by changes in solar activity or major volcanic eruptions. But since the 1800s, human activities have been the main cause of climate change, mainly due to the burning of fossil fuels such as coal, oil and gas.

According to the Ministry of Natural Resources and Environment, climate change is global warming and rising sea levels, the main cause of which is greenhouse gases from human activities.

Adaptation to climate change

In the coming years, countries will have to perfect the art and skills of adapting to climate change. The views can be generalized in two directions as follows:

- Adaptation to climate change mainly reduces the harmful effects it brings. Examples include adjustments to human behavior and economic structures to reduce society's vulnerability to changes in weather.
- Adaptation to climate change not only reduces harmful effects, but also takes advantage of the opportunities that climate change brings. For example, the process by which humans reduce the adverse effects of weather on health and life, while taking advantage of the favorable conditions it may bring.

1.2.2. Directions for land research and evaluation for planning and sustainable agricultural land use in climate change conditions

Soil is considered a product over time of the interaction between source rock/matter, terrain, climate, hydrology, organisms and especially humans. Climate is one of the most important factors. Climate change disrupts the rain regime, causing more hot weather, leading to more soil loss of nutrients; Erosion and drought phenomena occur with more frequency and more severe intensity. In areas bordering the sea, natural disasters like storms and floods will increase the phenomenon of landslides, waterlogging, saltwater intrusion, etc., greatly affecting the characteristics and quality of soil. The impact of climate change on land potential for agricultural production all comes from climate components. Land evaluation to select types of agricultural land use appropriate to the land potential of each region under climate change conditions is an effective solution for sustainable agricultural land use.

1.2.3. Scientific arguments on land research and assessment for planning and sustainable agricultural land use under climate change conditions in the Thai Binh - Nam Dinh region

The selection of land use types for assessment must be consistent with the differentiation of natural, socio-economic characteristics as well as development goals of the area.

Assessing the level of land suitability for each type of land use in the current period needs to pay close attention to the impacts of climate change, especially flooding and saltwater intrusion.

1.2.4. Land assessment process

- Select appropriate land use types
- For each selected land use type, land use requirements must be clearly defined
- Develop land unit maps
- Compare land use requirements of land use type with land conditions

- Classification of land suitability level: S1-Very suitable, S2-Suitable, S3-Less suitable, N-Not suitable

1.3. Perspectives and research methods

1.3.1. Research perspectives

- Systemic and synthetic perspective
- Sustainable land use perspective
- Inherited historical perspective

1.3.2. Research methods

- Inheritance and synthesis methods
- Field investigation and survey methods
- Professional solution
- Map and GIS methods
- Methods of evaluating and classifying land
- Natural geographical zoning method

1.4. Research procedures

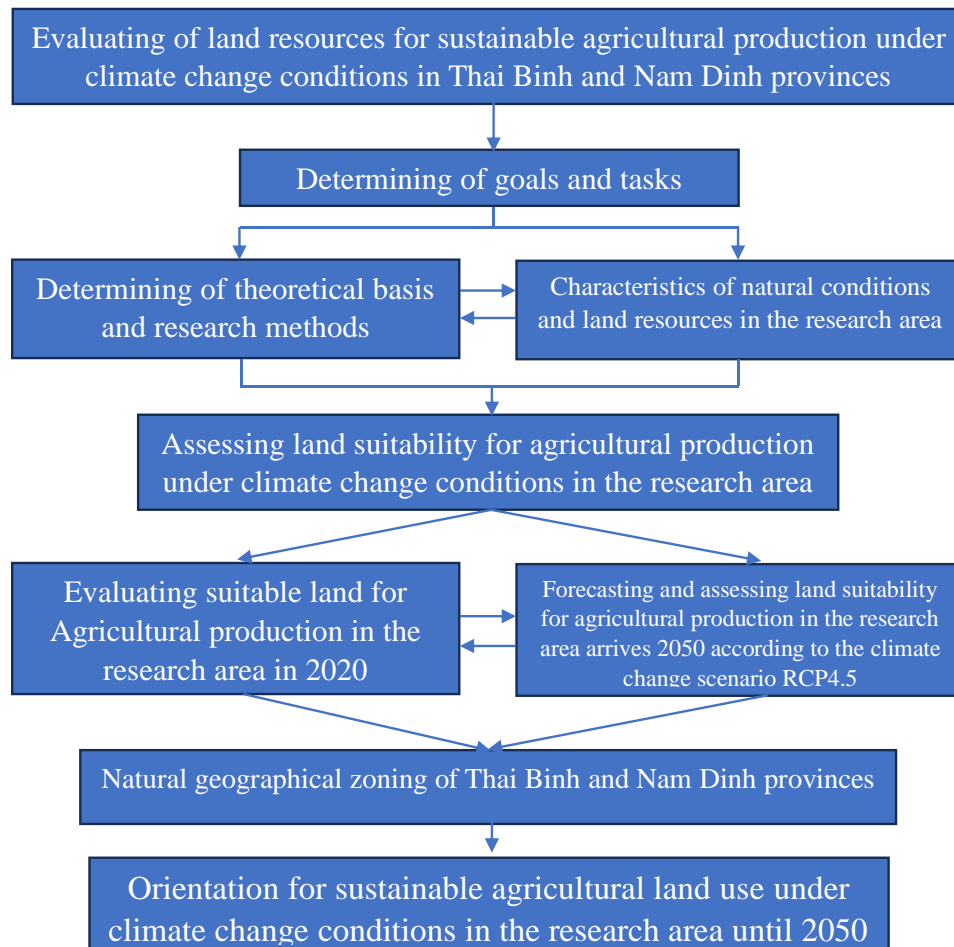


Figure 1.4. Diagram of research procedures

Chapter 2: Characteristics of soil resources in Thai Binh - Nam Dinh

2. Characteristics of natural conditions in Thai Binh - Nam Dinh area

2.1. Characteristics of natural conditions in Thai Binh - Nam Dinh area

2.1.1. Geographical location

The research area has a total natural area of about 325,344 hectares, accounting for 15.2% of the natural area of the Red River Delta and 0.97% of the country's natural area, with geographical coordinates extending from 19⁰50' to 20⁰44' north latitude and from 105⁰35' to 106⁰37' east longitude.

Regarding administrative boundaries, the North of the Research Park borders Hai Phong and Hung Yen; The West borders Ha Nam and Ninh Binh; The East and South border the East Sea.

2.1.2. Topography and geomorphology

Thai Binh - Nam Dinh area belongs to the Red River Delta, the terrain is relatively flat, the average height above sea level is from 1.5 - 2 m. Every year in the research area, riverside strips of land are built up and the river bed is sedimented, causing the river water level to flood into the lowlands inside the dyke, affecting agricultural land. The area's terrain can be divided into two areas: Continental Terrain and Tidal Terrain.

The differentiation of terrain creates three geomorphic regions: Coastal plains, low-lying plains, and hilly terrain.

2.1.3. Climate

The research area has a tropical monsoon climate with cold winters. On the general background of the tropical monsoon, due to the impact of circulation, climate and weather anomalies have been created, such as the phenomenon of cold and wet rain, considered a variation of the tropical climate. creating an alternating cold, wet winter.

The average temperature is about 23.5-23.7°C, corresponding to a total annual temperature of about 8600°C. The average annual rainfall

ranges from 1,500mm to over 1,700mm, distributed quite evenly across the entire area, heavy rain often occurs in the rainy months from July to September. Due to geographical location bordering the sea (Gulf of Tonkin), the area is often affected by storms or tropical depressions. Storm season lasts from July to September causing heavy rain and high winds.

2.1.4. Hydrological

2.1.4.1. River system

The study area is located entirely in the downstream delta of the Red River and Thai Binh River and is directly surrounded by tributaries of these two river systems to the sea with large estuaries such as Tra Ly and Ba Lat, Lach Giang.

In addition to the main river systems, Thai Binh and Nam Dinh also have quite dense intra-provincial river systems, bearing many traces of the process of renovating, deepening, and straightening the flow of intra-field rivers for the purpose of convenient irrigation, and a part serving waterway transport.

2.1.4.2. Hydrological characteristics

In general, the flow regime of the river system in the study area depends on water sources generated from rain in rivers in the upstream part of the basin, climate change and human socio-economic activities.

The hydrological regime is one of the factors contributing to the region's soil salinization and drought. The uneven flow distribution rate, focusing mainly on the rainy season, is one of the causes of drought in some areas of the region during the dry season.

2.1.5. Vegetation

Vegetation plays an important role in the soil formation process. In the study area, vegetation includes

- Natural vegetation: Areas outside the sea dyke and areas inside the sea dyke

- Plant carpet

2.1.6. Human activities in agricultural land use in Thai Binh - Nam

Dinh region in the period 2010-2020

Human production activities that impact land in both positive and negative directions are an objective necessity, so in related economic and development issues, land use from the perspective of Ecology and sustainable development need to be given due attention.

2.1.7. Impact of climate change on land use

Climate change has many potential impacts on the process of sustainable land use. In this study, researchers only considered two main factors: salinity intrusion and flooding.

- Saltwater intrusion: Saltwater intrusion is a process that occurs regularly in coastal estuaries. The effects of climate change and sea level rise have opposite effects. During the dry season, rainfall and incoming water flow decrease but sea level increases, leading to very complicated developments in the hydraulic regime on river routes.

- Flooding: According to statistics from 2000 to present, the study area has had more than 40 storms and tropical depressions affecting the study area. Unusually heavy rain, divided into many periods, causes flooding, seriously affecting agricultural production of people in the inland areas.

2.2. Characteristics of soil resources in Thai Binh - Nam Dinh area

From the results of field surveys, analytical data of soil samples in the room and inherited results, the Thai Binh - Nam Dinh area has 5 groups and 24 soil types.

Table 1.1. Soil classification table for Thai Binh and Nam Dinh provinces

No	Symbol	Soil name	Nam Dinh		Thai Binh		Total	
			Area (hectares)	%	Area (hectares)	%	Area (hectares)	%
1	C	Arenosols	1.384,73	0,83	7.548,94	4,76	8.933,67	2,75
2	M	Salic Fluvisols	36.196,29	21,69	11.578,99	7,31	47.775,28	14,68
3	S	Thionic Fluvisols	2.880,74	1,73	15.573,09	9,83	18.453,83	5,67
4	P	Fluvisols	78.335,60	46,94	75.164,07	47,43	153.499,67	47,18
5	E	Leptosols	129,64	0,08	-	-	129,64	0,04
		Total area	118.927,00	71,27	109.865,00	69,33	228.792,00	70,32
		Specialized land	31.142,00	18,66	30.585,00	19,30	61.727,00	18,98
		Residential land	11.466,00	6,87	13.860,00	8,75	25.326,00	7,78
		Rivers, streams, lakes	5.348,00	3,20	4.151,00	2,62	9.499	2,92
		Total natural area	166.883,00	100,00	158.461,00	100,00	325.344,00	100

Chapter 3: Land assessment for sustainable agricultural production under climate change conditions in Thai Binh - Nam Dinh provinces

3.1. Selection of land use types

From Thai Binh and Nam Dinh current land user map, land inventory results and land use statistical yearbook from 2010-2019, 4 types of agricultural land use with development prospects are being selected, including:

- Rice cultivation land use type: Total cultivated area in 2019 is 152,212 hectares
- Other annual crops cultivation land use types: Total cultivated area in 2019 is 12,896 hectares
- Perennial crops cultivation land use: Total cultivated area in 2019 is 16,387 hectares
- Aquaculture land use: Total cultivated area in 2019 is 30,335 hectares

3.2. Land unit maps building

3.2.1. Selecting and decentralizing indicators

Based on land use requirements of the 4 selected land use types and actual land conditions, 10 indicators belonging to 4 criteria were selected to build a land use map at a scale of 1:50,000, including: Land type, soil layer thickness, mechanical composition, organic matters, CEC, terrain type, average annual rainfall, irrigation regime, level of salinity intrusion, level of flooding.

Some indicators with uniform values at a very suitable level (S1) throughout the study territory are terrain slope $< 3^{\circ}$ and average annual temperature $> 22^{\circ}\text{C}$, which are not included in the creating process of the land unit map.

In addition, based on the climate change scenario RCP 4.5 announced by the Ministry of Natural Resources and Environment, the indicators of average annual rainfall, level of inundation and level of salinity intrusion have been decentralized in more detail for the year 2050.

Classification of criteria for building land unit maps in Thai Binh and Nam Dinh provinces is shown in Table 3.1 (2020) and Table 3.2 (2050).

3.2.2. Results of building land unit maps

The land unit map of Thai Binh - Nam Dinh area was built by the method of overlaying simple maps of 10 selected indicators. The results have identified 221 land units in 2020 and 200 land units in 2050.

Table 3.1 Classification of criteria for building land unit maps in 2020 in Thai Binh - Nam Dinh provinces

Criteria	Symbol		Criteria classification
Soil characteristics and quality			
1. Soil types	G	1	C, Cc
		2	Mm, Mn
		3	M, Mi
		4	Sp2, Sp2M
		5	Sp1Mn
		6	Sp, Sp1
		7	Phb, Pbe
		8	Ph, Pc, Pe, Pf, Phf, P/c
		9	Pg, Phg, Pj
		10	E
2. Soil layer thickness (centimeters)	TD	1	<50
		2	50-100
		3	≥100
3. Mechanical components	TPCG	1	a (Sand)
		2	b (Mixed sand)
		3	c (Light loam soil)
		4	d (Average loam soil)
		5	e (Heavy loam soil)
4. OM (%)	OM	1	<2 (low)
		2	2-4 (average)
		3	>4 (high)
5. CEC (1d/100g)	CEC	1	≥25
		2	10-25
		3	<10
Terrain criteria			
6. Relative terrain	DHTD	1	Low
		2	Average
		3	High
Climate criteria			
7. Average annual rainfall (millimeters)	R	1	<1600
		2	1600-1700
		3	>1700
Hydrological and irrigation criteria			
8. Irrigation mode	I	1	No
		2	Yes
9. Level of saline intrusion (months/year)	Mh	1	No saltwater intrusion (<1)
		2	Slight saltwater intrusion (1-3)
10. Level of flooding (days/year)	N	1	No (<5)
		2	Yes (5-30)

Table 3.2. Classification of criteria for building land unit forecast maps in 2050 in the Thai Binh - Nam Dinh provinces

Criteria	Symbol	Criteria classification	
<i>Soil characteristics and quality</i>			
1. Soil types	G	1	C, Cc
		2	Mm, Mn
		3	M, Mi
		4	Sp2, Sp2M
		5	Sp1Mn
		6	Sp, Sp1
		7	Phb, Pbe
		8	Ph, Pc, Pe, Pf, Phf, P/c
		9	Pg, Phg, Pj
		10	E
2. Soil layer thickness (centimeters)	TD	1	<50
		2	50-100
		3	≥100
3. Mechanical components	TPCG	1	a (Sand)
		2	b (Mixed sand)
		3	c (Light loam soil)
		4	d (Average loam soil)
		5	e (Heavy loam soil)
4. OM (%)	OM	1	<2 (low)
		2	2-4 (average)
		3	>4 (high)
5. CEC (1d/100g)	CEC	1	≥25
		2	10-25
		3	<10
<i>Terrain criteria</i>			
6. Relative terrain	DHTD	1	Low
		2	Average
		3	High
<i>Climate criteria</i>			
7. Average annual rainfall (millimeters)	R	1	<1600
		2	1600-1700
		3	1700-1800
		4	>1800
<i>Hydrological and irrigation criteria</i>			
8. Irrigation mode	I	1	No
		2	Yes
9. Level of saline intrusion (months/year)	DB_Mh	1	No-salinization
		2	Slight salinization
		3	Average salinization
		4	Severe salinization
10. Level of flooding (days/year)	DB_N	1	Flooding land according to scenario
		2	Not-flooding land according to scenario

3.3. Determining ecological requirements of land use types

Evaluation criteria are based on the ecological requirements of the four selected land use types, adjusted to suit natural conditions and the

impact of climate change on land characteristics and quality for agricultural production (in terms of rainfall regime, flooding and saltwater intrusion) in the study area.

Summary of land use requirements according to 4 levels of suitability: S1 - very suitable, S2 - suitable, S3 - less suitable and N - not suitable, for 04 selected land use types in Thai Binh province and Nam Dinh are shown in Table 3.3..

Table 3.3. Classification of ecological requirements of land use types

Type of use	Criteria	Relevance/Restriction			
		Very suitable (S1)	Suitable (S2)	Less suitable (S3)	Unsuitable (N)
Rice	1. Soil type	Pf, Pe, Pc, P/c, P _g	M, Sp2, Sp2M	Pbe, Sp1	Other
	2. Soil layer thickness	≥100	<100	-	-
	3. Mechanical components	d	c	b	a
	4. OM	≥2	1-2	<1	-
	5. CEC	≥25	10-25	<10	-
	6. Relative terrain	Average	Low	High	-
	7. Irrigation mode	Yes	-	-	No
	8. Level of saline intrusion	<1	-	≥1-3	-
	9. Level of flooding	<5	≥5-30	-	-
Other annual crops	1. Soil type	Pf, Pe, Pc, P/c, Pbe	-	P _g , M, Sp2, Sp2M, C, Cc	Other
	2. Soil layer thickness	≥100	<100	-	-
	3. Mechanical components	c, d	b	a	-
	4. OM	≥2	≥1-2	<1	-
	5. CEC	≥25	≥10-25	<10	-
	6. Relative terrain	Average	High	Low	-
	7. Average annual rainfall	≤2000	-	≥2000	-
	8. Irrigation mode	Yes	-	-	No
	9. Level of saline intrusion	<1	-	≥1-3	-
	10. Level of flooding	<5	-	≥5-30	-
Perennial crops	1. Soil type	Pf, Pe, Pc, P/c	Pbe	P _g , M, Sp2, Sp2M	Other
	2. Soil layer thickness	≥100	<100	-	-
	3. Mechanical components	d	c	b	a
	4. OM	≥2	≥1-2	<1	-
	5. CEC	≥25	≥10-25	<10	-
	6. Relative terrain	High	Average	Low	-
	7. Average annual rainfall	>1200	1000-1200	-	-
	8. Irrigation mode	Yes	-	No	-
	9. Level of saline intrusion	<1	-	≥1-3	-
	10. Level of flooding	<5	≥5-30	-	-
Aquaculture	1. Soil type	M, Mn, Mm	Sp2, Sp2M, P _g	Pf, Pe, Pc, P/c, Pbe, C, Cc, Sp1, Sp1Mn	Other
	2. Mechanical components	c, d	b	a	-
	3. Relative terrain	Low	Average	High	-
	4. Irrigation mode	Yes	-	No	-
	5. Level of saline intrusion	≥1-3	<1	-	-
	6. Level of flooding	≥5-30	<5	-	-

3.4. Results of land suitability assessment and classification

Comparing the properties of land use zones with the ecological requirements of land use types and 4 suitability levels (S1, S2, S3, N) on ALES automatic land survey software and geographic information system. GIS. The results of land suitability classification for 04 land use types are presented in tables 3.4 and 3.5.

Table 3.4. Results of land suitability classification for agricultural production in Thai Binh - Nam Dinh provinces in 2020

Type of use	Adaptation level	Nam Dinh		Thai Binh		Total	
		Area (hectares)	Percentage (%)	Area (hectares)	Percentage (%)	Diện tích (ha)	Percentage (%)
Rice	S1	29.631,53	17,76	24.837,83	15,67	54.469,36	16,74
	S2	63.409,47	38,00	66.012,00	41,66	129.421,46	39,78
	S3	3.105,70	1,86	5.192,44	3,28	8.298,14	2,55
	N	18.698,28	11,20	10.991,73	6,94	29.690,01	9,13
Other annual crops	S1	480,81	0,29	11.267,18	7,11	11.748,00	3,61
	S2	39.175,54	23,47	15.576,03	9,83	54.751,57	16,83
	S3	62.683,96	37,56	77.347,07	48,81	140.031,03	43,04
	N	12.504,65	7,49	2.843,71	1,79	15.348,36	4,72
Perennial crops	S1	175,01	0,10	6.925,21	4,37	7.100,23	2,18
	S2	305,80	0,18	5.900,97	3,72	6.206,77	1,91
	S3	100.890,55	60,46	85.315,47	53,84	186.206,02	57,23
	N	13.473,61	8,07	8.892,34	5,61	22.365,95	6,87
Aqua-culture	S1	0,00	0,00	9,80	0,01	9,80	0,00
	S2	61.605,50	36,92	33.790,51	21,32	95.396,01	29,32
	S3	53.131,40	31,84	73.233,69	46,22	126.365,09	38,84
	N	108,06	0,06	0,00	0,00	108,06	0,03
Total accessed area		114.845,00	68,82	107.034,00	67,55	221.879,00	68,20
Non-agricultural land		52.038,00	31,18	51.427,00	32,45	103.465,00	31,80
Total natural area		166.883,00	100,00	158.461,00	100,00	325.344,00	100,00

Table 3.5. Results of land suitability classification for agricultural production in Thai Binh - Nam Dinh provinces in 2050

Type of use	Adaptation level	Nam Dinh		Thai Binh		Total	
		Area (hectares)	Percentage (%)	Area (hectares)	Percentage (%)	Diện tích (ha)	Percentage (%)
Rice	S1	31.049,89	18,61	34.439,08	21,73	65.488,97	20,13
	S2	61.785,49	37,02	54.836,97	34,61	116.622,46	35,85
	S3	3.105,71	1,86	5.789,892	3,65	8.895,60	2,73
	N	18.904,15	11,33	11.968,06	7,55	30.872,21	9,49
Other annual crops	S1	480,81	0,29	12.655,63	7,99	13.136,45	4,04
	S2	39.583,70	23,72	15.649,31	9,88	55.233,01	16,98
	S3	61.775,38	37,02	75.458,67	47,62	137.234,05	42,18
	N	13.005,39	7,79	3.270,39	2,06	16.275,78	5,00
Perennial crops	S1	175,02	0,10	8.225,654	5,19	8.400,67	2,58
	S2	305,80	0,18	4.436,179	2,80	4.741,98	1,46
	S3	100.684,45	60,33	85.250,98	53,80	185.935,44	57,15
	N	13.680,02	8,20	9.121,19	5,76	22.801,21	7,01
Aqua-culture	S1	0,00	0,00	0,00	0,00	0,00	0,00
	S2	59.066,29	35,39	33.149,51	20,92	92.215,80	28,34
	S3	52.465,80	31,44	72.706,33	45,88	125.172,13	38,47
	N	3.313,20	1,99	1.178,162	0,74	4.491,36	1,38
Total accessed area		114.845,00	68,82	107.034,00	67,55	221.879,00	68,20
Non-agricultural land		52.038,00	31,18	51.427,00	32,45	103.465,00	31,80
Total natural area		166.883,00	100,00	158.461,00	100,00	325.344,00	100,00

Chapter 4: Orientation for sustainable agricultural production land use under climate change conditions in Thai Binh - Nam Dinh provinces

4.1. Spatial orientation for sustainable agricultural production land use under climate change conditions in Thai Binh - Nam Dinh provinces

4.1.1. Principles

- For land units in the very suitable or suitable category (S1, S2) for various uses, it is necessary to base on the current land use status: If it is suitable for the current status, respect the current status; If the current situation does not exploit the land's potential, priority should be given to proposals for land use purposes that bring high socio-economic efficiency and are consistent with the development plans of the study area.

- For land units in the less suitable category (S3), if the locality is currently using land for that purpose, the possibility of overcoming the problems will be considered before proposing to keep it or convert it to another more suitable purpose.

- For land units in the unsuitable category (N) that are still producing for that type of use, consider converting to another more suitable use type that is more suitable in terms of land potential and socio-economic efficiency.

- For land units belonging to unused land, appropriate agricultural development space is proposed based on the level of suitability for the assessed uses, the socio-economic efficiency of the types of uses and the orientation of agricultural development planning in the study area.

- For land units whose current status of use is forestry land and non-agricultural land, it is recommended to maintain the current status of use and only propose land protection solutions according to the forecast of the impact level of the change and rising sea levels in the study area.

4.1.2. Spatial orientation for sustainable agricultural land under climate change conditions in Thai Binh and Nam Dinh provinces according to land units

- Land for rice cultivation: Proposed reduction of 12,188.89 hectares of rice growing land to 139,928.11 hectares. In particular, the area of land under rice cultivation with appropriate grades (S1, S2) is

maintained. Reducing 12,989.13 hectares of rice growing land on low-class and unsuitable land areas (S3, N) to other types of use.

- Land for other annual crops cultivation: Proposed to increase an additional 5,929.74 hectares of land for growing cash crops, to 18,798.74 hectares. Of which, the land area under cultivation of crops on land units with appropriate grades (S1, S2) and land units with grade S3 but actively irrigated is 11,580.77 hectares and remains the same. Reducing 1,288.23 hectares of land under other annual crops on less suitable land units (S3) to other types of use.

- Land for perennial crops cultivation: Proposed to increase 1,543.96 hectares of land for perennial crops, up to 17,924.96 hectares. Of which, maintaining the land area under cultivation of perennial crops on suitable land units (S1, S2) or less suitable S3 but with convenient irrigation water sources, is 16,381 hectares. Transfer an additional 1,543.96 hectares of land suitable for growing perennial crops, from land units currently growing rice (1,039.28 hectares) and other annual crops (407.87 hectares) to less suitable levels (S3) and unused flat land (96.81 hectares) at the appropriate level (S2).

- Aquaculture land: Proposed to increase 3,860.82 hectares of aquaculture land, to 34,179.82 hectares. In particular, the remaining land area for aquaculture on appropriate land units (S1, S2) is 28,121.70 hectares. Converting 2,197.30 hectares of aquaculture land in less suitable land units (S3) in the coastal area to production forestry. Transfer an additional 6,058.12 hectares of land suitable for aquaculture, from land units growing rice (4,871.63 hectares) and other annual crops (225.04 hectares) at less or unsuitable levels. (S3, N) and unused flat land (961.45 hectares) at the appropriate level (S2).

- Unused land: Based on the characteristics of land units in this land use type and the level of land suitability for specific land use types of land units, full exploitation is proposed. unused land area used for agricultural purposes. Specifically, transfer 3,500 hectares of unused land to: rice cultivation is 144.92 hectares, other annual crops are 139.75 hectares, perennial crops are 96.81 hectares, aquaculture is 961.45 hectares and 2,157.08 hectares in coastal areas to plant protective forests

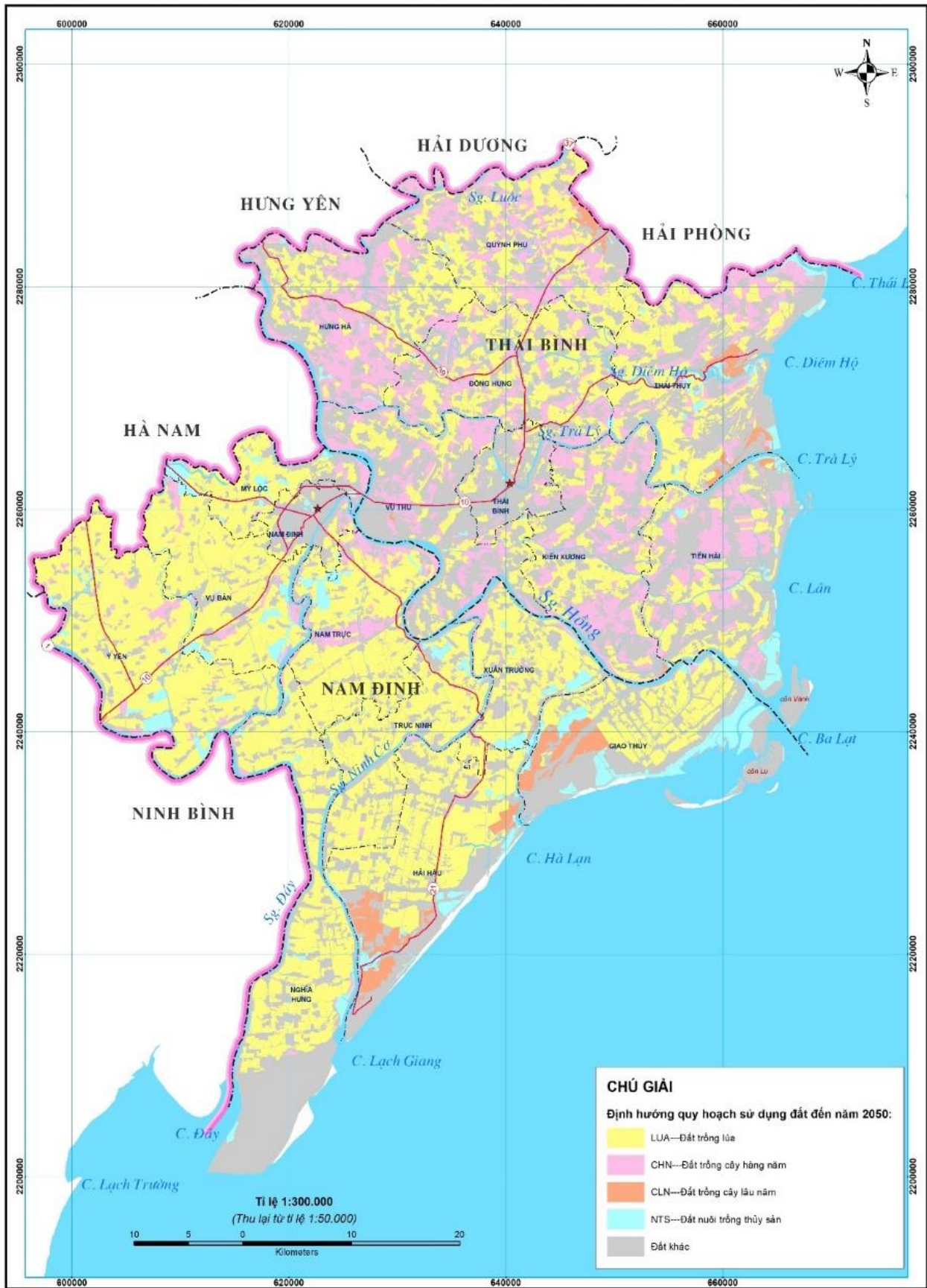
Table 4.1. Results of spatial orientation of land use for sustainable agricultural production under climate change conditions in Thai Binh - Nam Dinh provinces until 2050

No	Type of use	Current status in 2020		Proposal in 2050		Increasing/ Decreasing (Hectares)
		Area (hectares)	Percentage (%)	Area (hectares)	Percentage (%)	
1	Agriculture land	218.378,00	67,12	221.878,00	68,20	3.500,00
1.1	Land for rice cultivation	152.117,00	46,76	139.928,11	43,01	-12.188,89
1.2	Land for other annual crops cultivation	12.869,00	3,96	18.798,74	5,78	5.929,74
1.3	Land for perennial crops cultivation	16.381,00	5,03	17.924,96	5,51	1.543,96
1.4	Land for aquaculture	30.319,00	9,32	34.179,82	10,51	3.860,82
1.5	Land for production forest	0,00	0,00	2.197,30	0,68	2.197,30
1.6	Land for protective forest	2.717,00	0,84	4.874,08	1,50	2.157,08
1.7	Land for special-use forest	1.081,00	0,33	1.081,00	0,33	0,00
1.8	Land for other agricultural	2.894,00	0,89	2.894,00	0,89	0,00
2	Non-Agriculture land	103.465,00	31,80	103.465,00	31,80	0
3	Unused land	3.500,00	1,08	0	0,00	-3.500,00
Total natural area (hectares)		325.344,00	100,00	325.344,00	100,00	0,00

4.1.3. Spatial orientation for sustainable agricultural land use under climate change conditions in Thai Binh and Nam Dinh provinces by regions and sub-regions

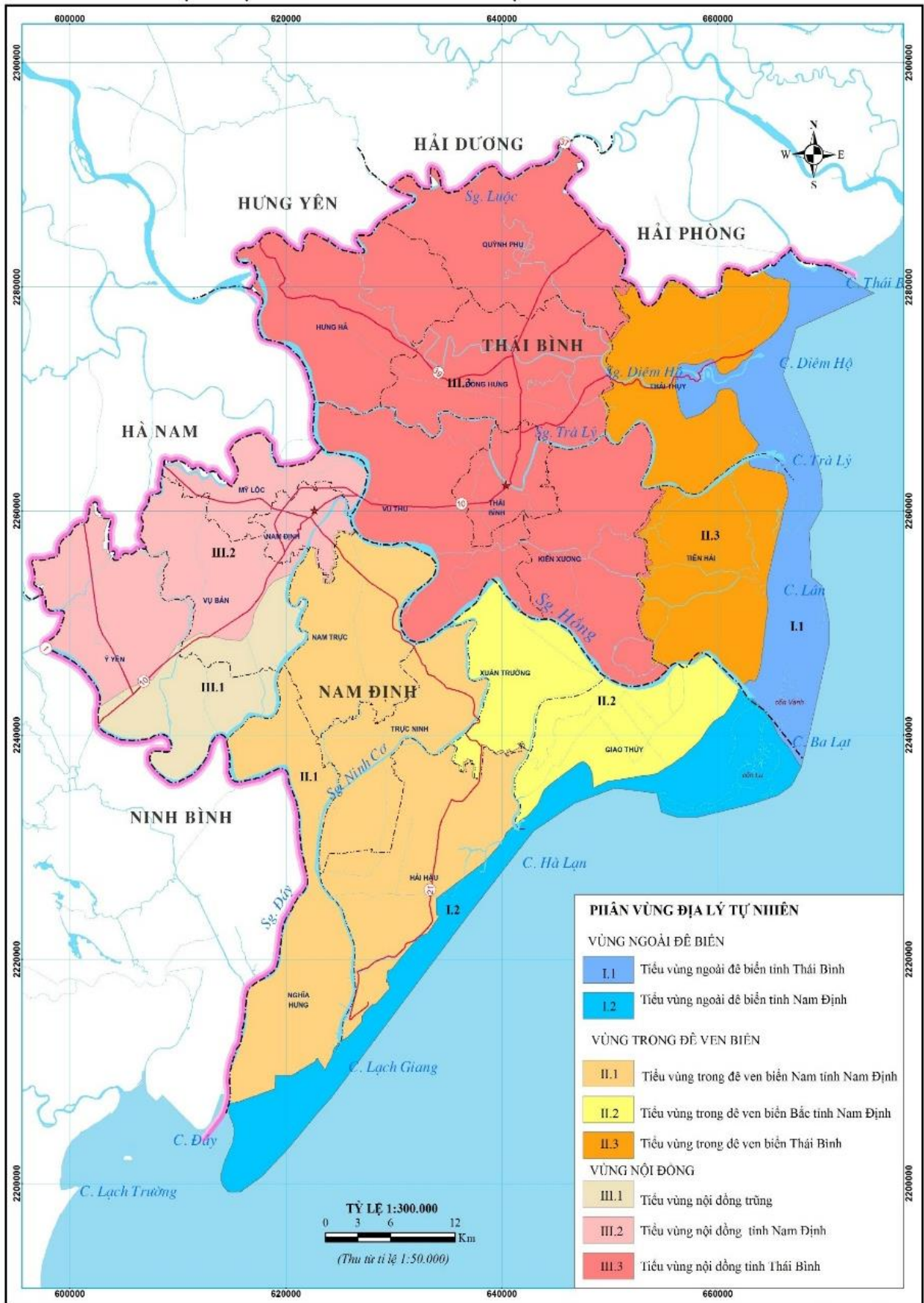
Based on the principle of natural geographical zoning, Thai Binh - Nam Dinh region is divided into 3 regions and 8 natural geographical sub-regions: Area outside the sea dyke; Area inside coastal dykes; Inland area.

Based on the results of assessing and classifying land suitability for agricultural production under climate change conditions in Thai Binh - Nam Dinh region, synthesize the land area according to the level of suitability (S1 - very suitable, S2 - suitable, S3 - less suitable, N - not suitable) for 04 main land use types that have been selected: land for rice cultivation, land for other annual crops cultivation, land for perennial crops cultivation and aquaculture land according to natural geographical sub-regions.



Thành lập: NCS Hoàng Quốc Nam
 Người hướng dẫn: PGS.TS. Lại Vĩnh Cẩm
 PGS.TS. Lưu Thế Anh

Figure 4.1. Map of spatial orientation for sustainable agricultural land use under climate change conditions in Thai Binh and Nam Dinh provinces until 2050



Thành lập: NCS Hoàng Quốc Nam
Giáo viên hướng dẫn:
1. PGS.TS. Lại Vĩnh Cẩm
2. PGS.TS. Lưu Thế Anh

Figure 4.2. Natural geographical zoning of Thai Binh - Nam Dinh region

4.2. Proposing solutions for sustainable agricultural land use under climate change conditions in Thai Binh and Nam Dinh provinces

4.2.1. Synthesize land use solutions according to natural geographical area, type of use and land potential

4.2.2. Solutions to cope with flooding and saltwater intrusion

4.2.2.1. Solutions for management and protection of protective forest land

4.2.2.2. Irrigation solutions

4.2.2.3. Technical solutions in improving and using salic and thionic fluvisols

4.2.2.4. Solutions to enhance appropriate management and forecasting

4.2.3. Reasonable solutions for converting crop structure under climate change conditions

4.2.3.1. Convert ineffective rice land to other crops

4.2.3.2. Change the crop structure appropriately to form a concentrated specialized commodity farming area

4.2.3.3. Converting rice growing areas on salic and thionic fluvisols to aquaculture

4.2.4. Solutions on land use policy

4.2.4.1. Improve the quality and feasibility of Land Use Planning

4.2.4.2. Manage and effectively use wet rice land area

4.2.4.3. Promote agricultural land accumulation policy

4.2.4.4. Measures to use land for crop development

4.2.4.5. Solutions to enhance research and transfer of science, technology and technical advances to serve agricultural development

Conclusions and recommendations

Thai Binh and Nam Dinh are coastal provinces in the Red River Delta region, with very favorable natural and ecological conditions for diverse and comprehensive agricultural production development. The thesis provides a scientific basis for spatial orientation and proposes solutions for sustainable agricultural land use for the provinces under climate change conditions, which are mainly affected by climate change, which are flooding and saltwater intrusion.

The land suitability assessment scale in Thai Binh - Nam Dinh provinces includes 10 indicators belonging to 4 criteria, of which: Criteria for soil characteristics and quality include 5 criteria: soil type, soil layer thickness, soil composition. mechanical part, OM, CEC. Terrain criteria include 1 indicator which is relative terrain. Climate criteria include one indicator: average annual rainfall. Hydrological criteria and water regime include criteria on irrigation regime and 2 criteria on the level of sedimentation and the level of flooding.

The study has oriented the land use space for sustainable agricultural production in Thai Binh and Nam Dinh provinces under climate change conditions in 2050 according to the following land use zones: Land for rice cultivation decreased by 12,188.89 hectares, to 139,928.11 hectares; Land for other annual crops cultivation increased by 5,929.74 hectares, to 17,798.74 hectares; Land for perennial crops cultivation increased by 1,543.96 hectares, to 17,924.96 hectares; Land for aquaculture increased by 3,860.82 hectares, to 34,179.82 hectares; Unused land is fully put into exploitation for various suitable agricultural purposes.

Through analyzing the characteristics, land quality and land potential for main types of agricultural land use in Thai Binh and Nam Dinh provinces, solutions have been proposed including: Summary of solutions Land use by natural geographical area, type of use and land potential, Solutions to cope with flooding and saltwater intrusion, Solutions to change crop structure appropriately in climate change conditions , Land use policy solutions.

NEW CONTRIBUTIONS OF THE THESIS

1-Clarifying the changes in characteristics and area sizes of land units until 2050 according to the climate change scenario RCP4.5 and classifying the level of land suitability for agricultural production in Thai Binh and Nam Dinh provinces on maps at 1:50,000 scale.

2-Proposing spatial orientation and solutions for sustainable agricultural land use, adapting to climate change until 2050 in Thai Binh and Nam Dinh provinces.

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