

Study on suitability for Nang Xuan rice variety by combination of soil database and climate change

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1. Introduction

- Hanoi - the capital of Vietnam, which was enlarged in 2008, had increased its area from approximately 1,000 sq.km to 3,324.92 sq.km and became one of 17 largest capitals all over the world.
- Nang Xuan is a new rice variety which is widely cultivated in recent years in northern Vietnam, with many advantages such as high yield, good cold endurance and high quality.
- In the study area, Nang Xuan rice is cultivated down with much of human effort on controlling ecological factors. It is increasingly play an important role in local yield, therefore it is chosen as plot study in this research.

The study aims to:

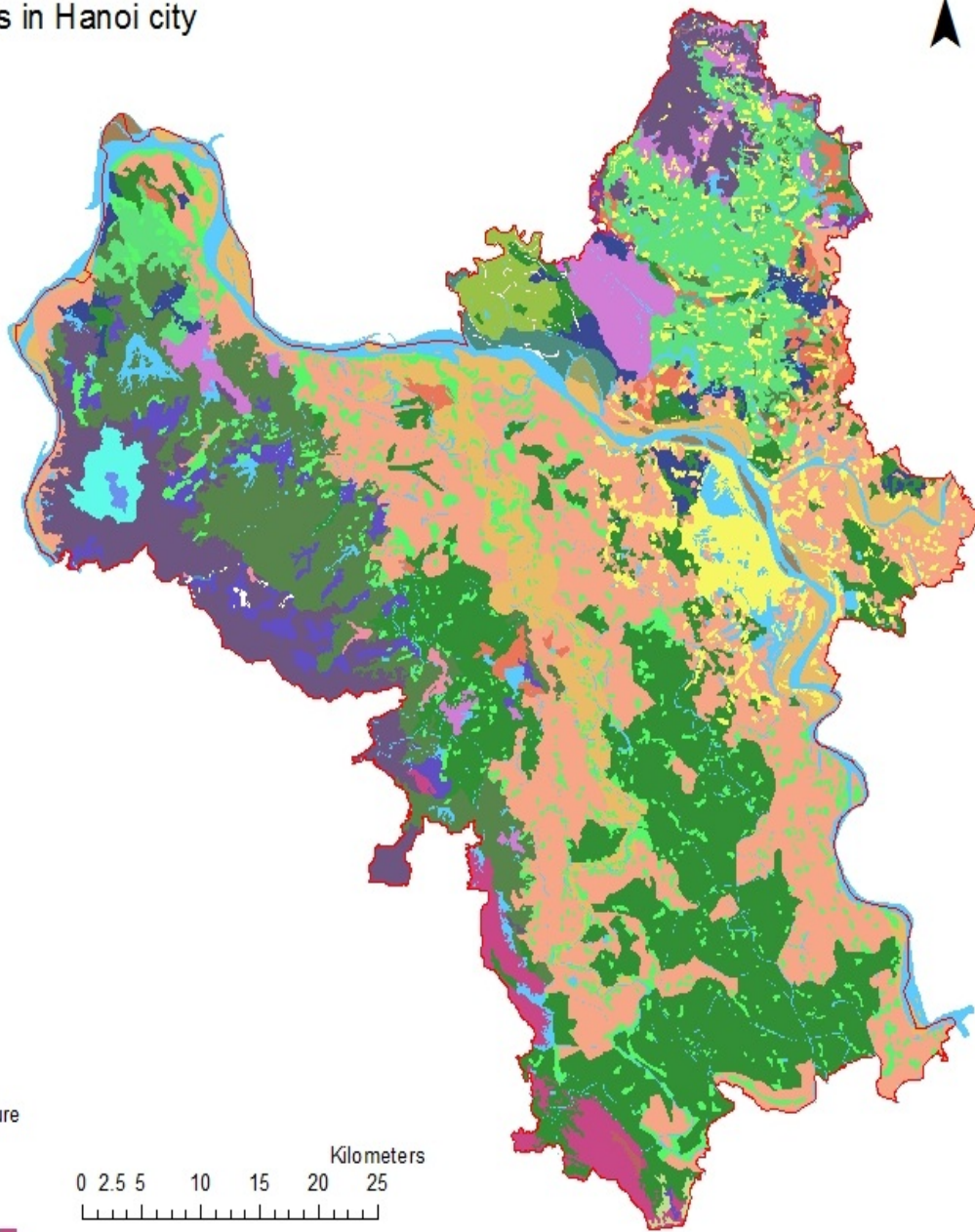
- i) evaluate soil in the study area in regards to specific cultivation demands;
- ii) monitor the dynamic of climate change in study area in regards to ecological limitation of Nang Xuan rice; and
- iii) combine those in a map to show which area is needed to preserve.

Material and methodology



2.1. Data:

Soil data are classified according to standard procedure issued by Ministry of Agriculture and Rural Development of Vietnam with 24 soil types (excluding non-agriculture land-use), accounting for 197,696 ha. The soil types are mapped at VN2000 projection.




Map of soil types in Hanoi city



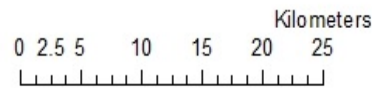
Legend

-  Hanoi boundary
-  <all other values>

KH_DAT

-  B
-  Bg
-  Cb
-  D
-  Residence
-  Fa
-  Fk
-  Fl

- | | |
|--|--|
|  Fp |  Pbe |
|  Fq |  Pc |
|  Fs |  Pe |
|  Fv |  Pf |
|  Hk |  Pg |
|  J |  Pj |
|  Water bodies |  Py |
|  Outside |  Rivers |
|  Land tenure |  T |
|  P |  fl |
|  Pb |  pb |
|  Pbc | |



The climate data is derived from two sources:

- The current condition is interpolated data from WorldClim (<http://worldclim.org/>).
- The future data is derived from Vietnam's climate change scenarios, according to Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN), modeled according to the Forth Report of IPCC (2007) scenario A1B (the medium scenario).

2.2. Method

2.2.1. Soil classification

The classification is divided into 5 levels:

S1: Highly suitable

S2: Moderately suitable

S3: Marginally suitable

N: Currently not suitable

N2: Permanently not suitable

- Class S1 Highly Suitable: Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.
- Class S2 Moderately Suitable: Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.
- Class S3 Marginally Suitable: Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.
- Class N1 Currently Not Suitable: Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner.
- Class N2 Permanently Not Suitable: Land having limitations which appear so severe as to preclude any possibilities Of successful sustained use of the land in the given manner.

Each land-use purpose requires unique soil properties and other natural factors. The definition of land-use requirement is based on:

- Soil properties
- Physiological and ecological requirement of plants.
- Ensuring the economic effect.
- Protecting soil quality and the environment.
- Significant concerning on local cultivation practices and other conditions.

2.2.2. Climate model:

The climate data in current condition is derived from WorldClim (<http://worldclim.org/>). According to WorldClim, the data layers were created by interpolating of average monthly climate data from weather stations all over the world and scaled to 30 arc-second resolution. Variables included are monthly total precipitation, and monthly mean, minimum and maximum temperature, and 19 derived [bioclimatic](#) variables.

The WorldClim interpolated climate layers were made using:

Major climate databases compiled by the Global Historical Climatology Network (GHCN), the FAO, the WMO, the International Center for Tropical Agriculture (CIAT), R-HYdronet, and a number of additional minor databases for Australia, New Zealand, the Nordic European Countries, Ecuador, Peru, Bolivia, among others.

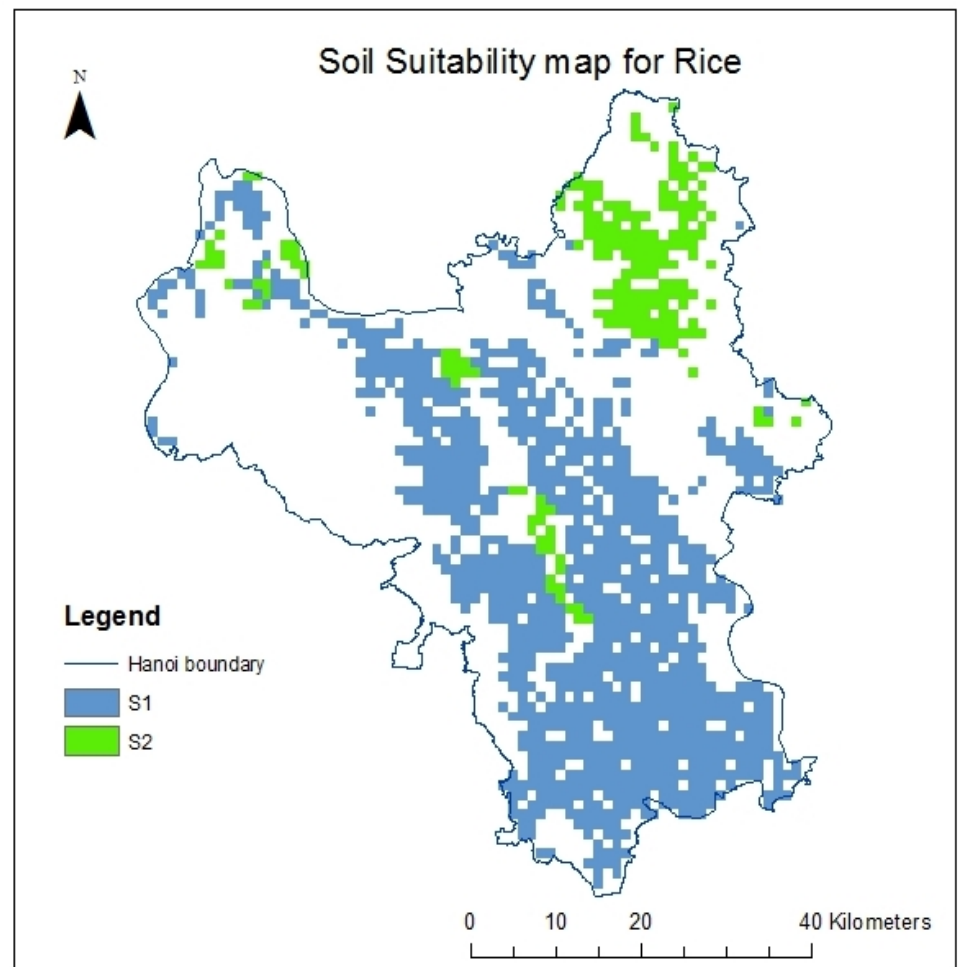
The SRTM elevation database (aggregated to 30 arc-seconds, "1 km")

The ANUSPLIN software. ANUSPLIN is a program for interpolating noisy multivariate data using thin plate smoothing splines. We used latitude, longitude, and elevation as independent variables.

- The predicted climate data is derived from Vietnam's climate change scenarios. According to Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN), the data is reported in format of difference to baseline data, which is the average data from 1980 to 1990. Climate model is built basing on IPCC's climate change scenarios.
- Synchronizing with current climate data from WorldClim, the predicted data includes difference of total precipitation, average minimum temperature, average maximum temperature and average mean temperature.

2.2.3. Calculation:

Figure 1: Soil suitability map for Nang Xuan Rice



The study aims to learn about the lower limitation of Nang Xuan rice, in the coldest month in a year in Hanoi area. According to current condition, the temperature ranges from 6.5 to 14.6 degree through the area.

Combining with the ecological limitation of Nang Xuan rice: When the temperature is between 17 and 22°C, rice grows slowly. If the temperature is 16°C or less, rice stops growing, therefore the lifetime is enlarged. If the temperature is 12°C or less, rice dies. From 23°C is suitable for its growth.

Temperature ranges is divided into 3 levels: >16, 12-16 and <12 Celsius degree.

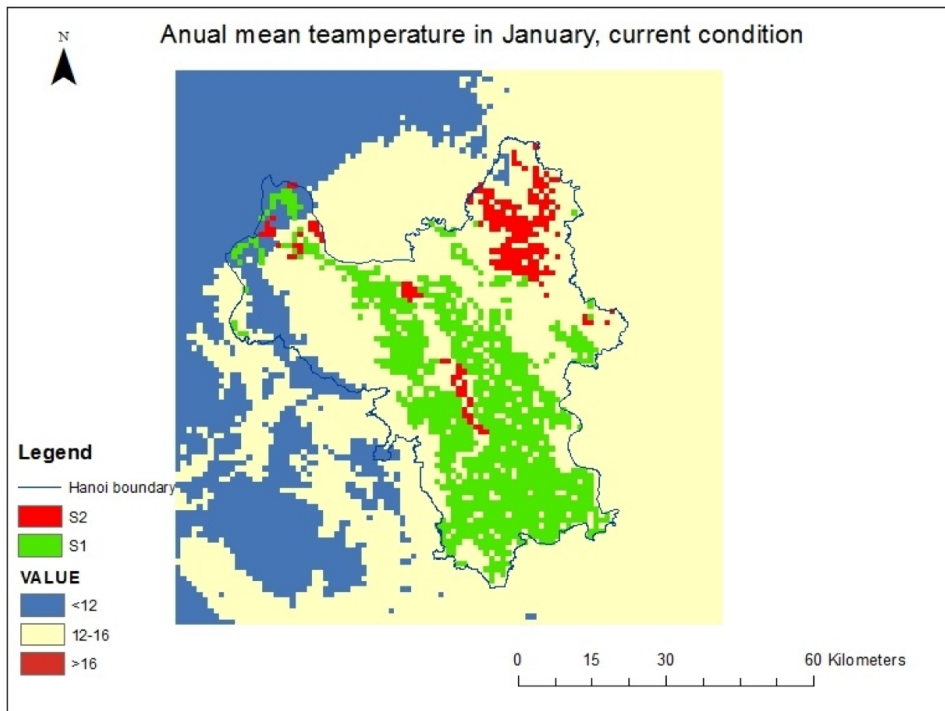
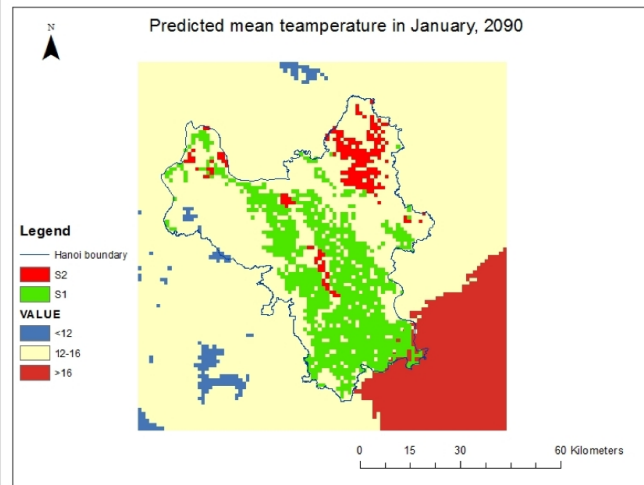
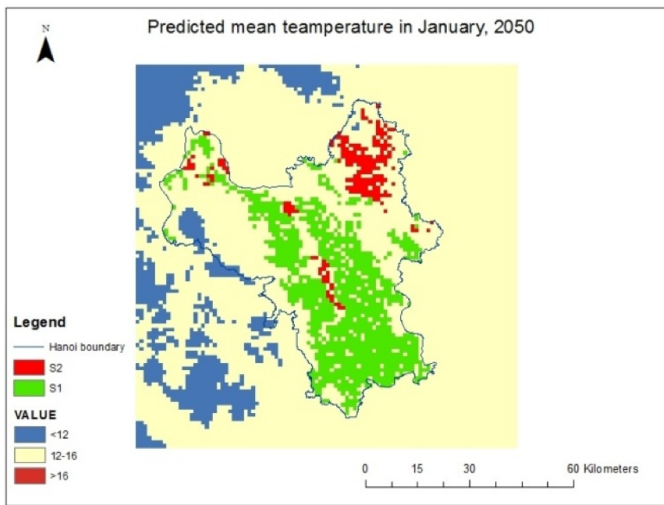


Figure 2: Temperature and suitable area for Nang Xuan rice, in current and future condition.



3. Results and Discussion

3.1. Results

3.1.1. Soil evaluation:

Basing on current land-use and the study objectives, three cultivation purposes are chosen to evaluation the suitability: rice-, vegetation- and flower specialized farming

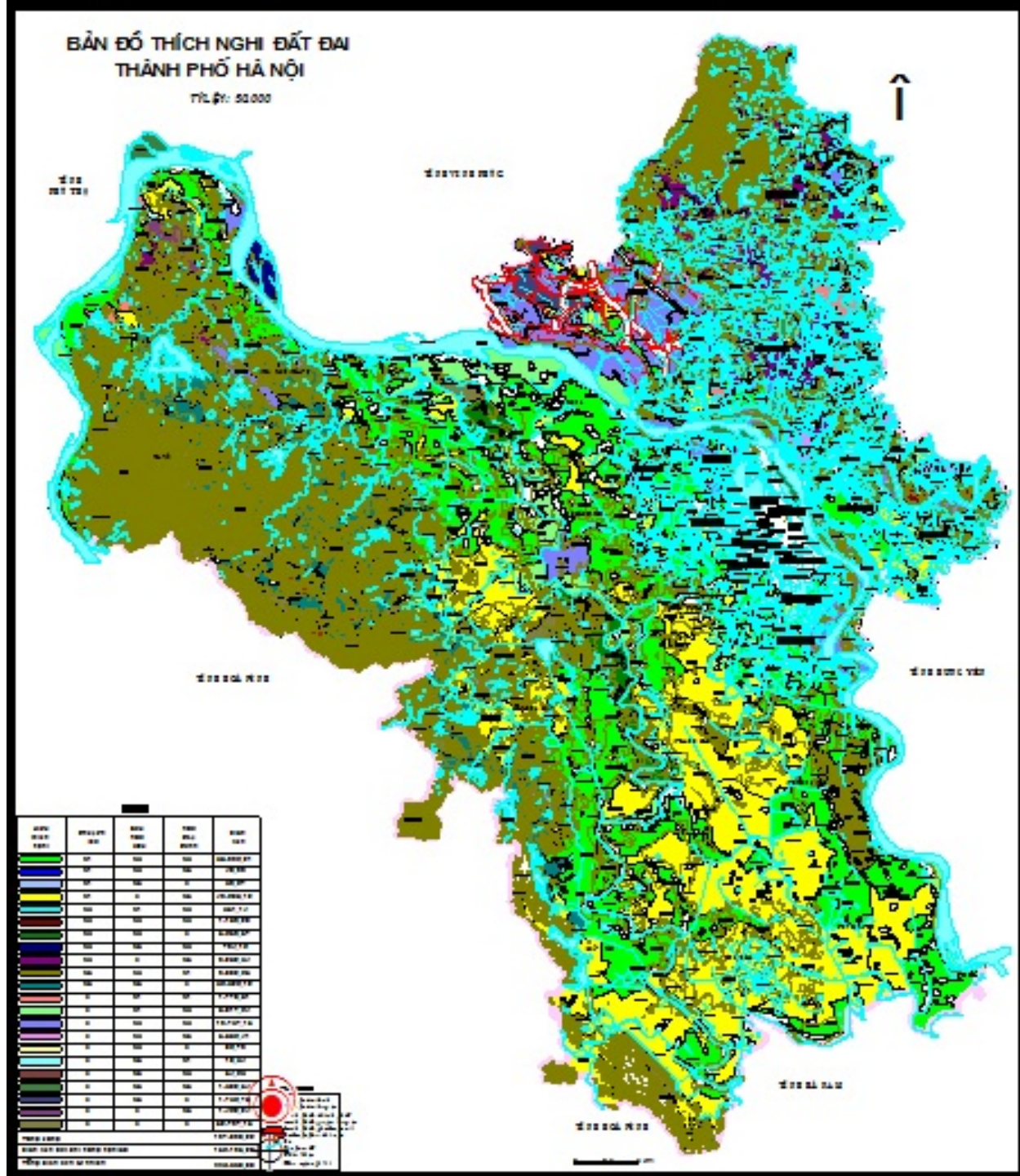
Table 1: Suitability and area

ID	For rice	For vegetation	For flower	Area
1	S1	S2	S2	28,995.01
2	S1	S2	S3	46.99
3	S1	S3	N	29.57
4	S1	N	S3	49,568.10
5	S2	S1	S2	231.14
6	S2	S2	S2	1,189.06
7	S2	S2	N	3,539.37
8	S2	S3	S2	794.15
9	S2	N	S3	9,080.24
10	S3	S2	S1	9,660.53
11	S3	S3	N	25,205.10
12	N	S1	S1	1,776.81
13	N	S1	S2	8,617.54
14	N	S2	S2	19,727.13
15	N	S2	S3	3,885.41
16	N	S2	N	65.79
17	N	S3	S1	16.24
18	N	S3	S2	34.52
19	N	S3	S3	1,260.34
20	N	S3	N	1,725.78
21	N	N	S3	1,450.04
22	N	N	N	30,797.13
Agriculture area				197.696
Non-Agriculture area				135.193
Total				332.889

Table 2: Suitability level

No.	Cultivation purpose	Level				Total area
		S1	S2	S3	N	
1	Rice	78,639.68	14,833.96	34,865.63	69,356.73	197,696.00
2	Vegetation	10,625.49	67,109.29	29,065.71	90,895.51	197,696.00
3	Flower	11,453.57	59,588.57	65,291.12	61,362.74	197,696.00

Figure 3: Soil suitability map of Hanoi



3.1.2. Apply climate change scenarios to monitor the change of suitability for rice specialized farming area.

The soil and temperature are re-classed as number, and then calculate with each other with equally weight. The result has 4 levels of suitability:

Level 2: Lowly suitable

Level 3: Moderately suitable

Level 4: Suitable

Level 5: Highly suitable

In which the areas in level 2 come with the disadvantages both in temperature and soil type, meanwhile areas in level 5 come with highest advantages in both sides.

Figure 4: Predicted map of suitability for Nang Xuan rice in Hanoi area

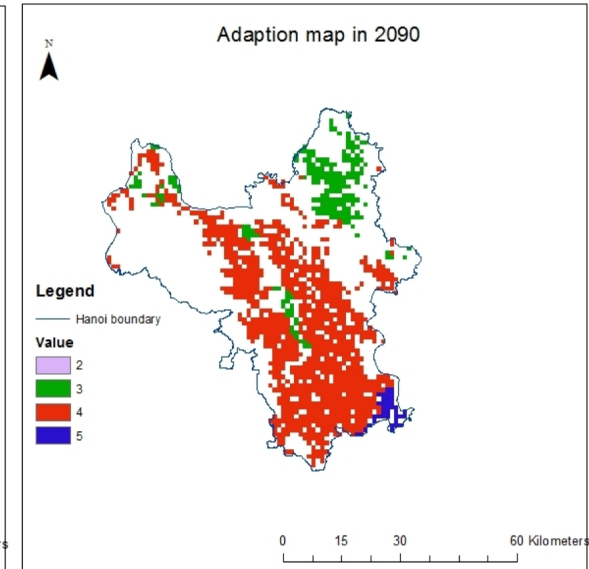
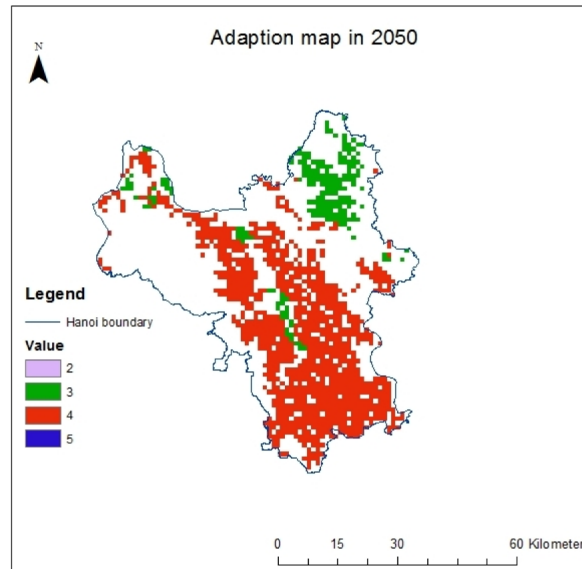
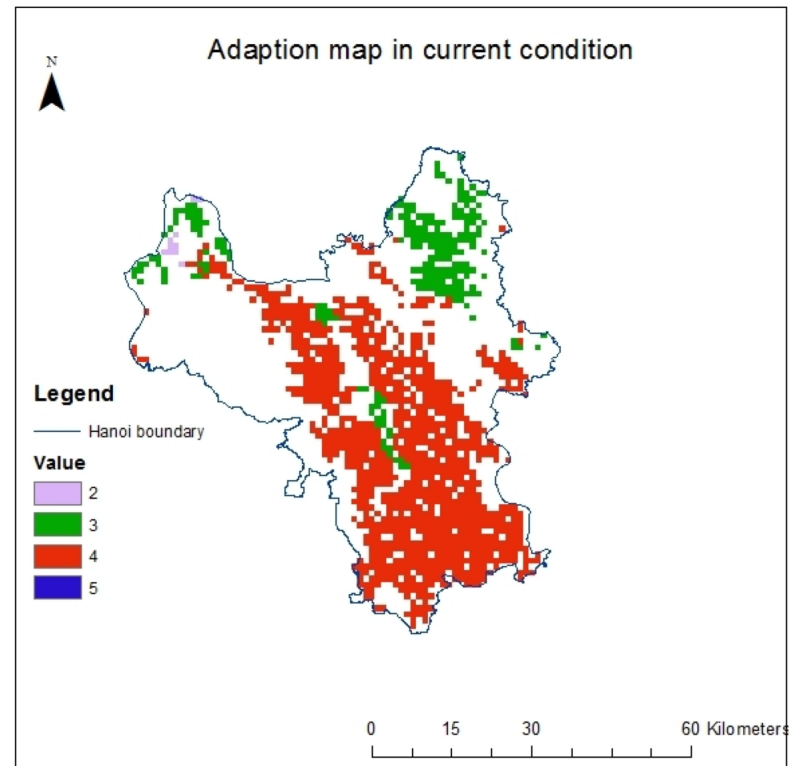


Table 3: Suitability level

Area (km ²)	Current	2050	Change	2090	Change
Level					
2	11.49	-	-100%	-	-100%
3	270.19	244.90	-9%	244.90	-9%
4	1229.21	1,265.99	3%	1,222.16	-1%
5	0.00	-	100%	43.83	100%
Total	1,510.90	1,510.90		1,510.90	

3.2. Discussion

1. This study aims to combine the soil classification with climate condition and ecological limitation of Nang Xuan rice in order to generate the overview of suitability area for cultivation, as well as show how the urban development should be occupied in regards to agriculture. The results are especially meaningful in context of enlarged Hanoi, when a huge agriculture land was added to a capital and the urbanization is being rapidly spreading, therefore management methods are urgently needed.

3.2. Discussion (cont.)

- However, the assumption "land-use situation is not changed" in the time of 90 years is not realistic. The idea for this assuming is to fix one factor and see the dynamic of other. Climate changing is an un-returnable (irresistable) process that we can neither stop nor prevent its impact in local extent. In order to ensure the food security, agriculture land should be preserve in long term land-use planning. Therefore the author decided to fix this factor and monitor the dynamic of climate change. Under the impact of rising temperature and other factors (e.g. increase the frequency and damage of tsunami, change precipitation and so on) the land-use planning should be made flexibly and responsibly. By choosing the lower ecological limitation, the study show which areas have many difficulties in cultivating and which needed to preserve.

3.2. Discussion (cont.)

- Certainly the growth of rice depends on not only the temperature, the temperature is, however, the first and main function of climate changing. On the other hand, some can be ignore like moisture, since rice in Hanoi is cultivated submerging and people can easily control, therefore rainfall does not influence much unless it changed too much. Meanwhile, hydroelectricity dams should be calculated on in planning since it affects the irrigation.

Conclusions

The study has combined the some independent factors: soil type, geo-ecological condition of soil (slop, thickness of clay layer, irrigation etc.), climate condition and ecological limitation of rice. The result is a general view of many factors which affect on rice growth, under the influence of climate change. It is meaningful for decision-makers to preserve agriculture land area under pressure of urbanization in Hanoi city.

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