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Integrating Agriculture Model into WebGIS: Case Study in Red River Delta, Vietnam

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***Abstract* – This research employed the SALUS (System Approach to Land Use Sustainability) model to simulate the impact of climate change on rice production in the Red River Delta (RRD) area in northern Vietnam. The SALUS model was integrated into GIS (Geographic Information System) to simulate plant growth and soil condition on a day-to-day basis using weather data collected from meteorology stations over a 30 year span (1982-2011). Next, using the SALUS model we compared observed yield with simulated yield. Finally, we validated the impact of climate change on rice productivity in the study area. The residual mean square of the comparison proved (87% confidence) that the model successfully simulated yield output changes for each year.**

***Keywords* – Climate Change, Vietnam Agriculture, Red River Delta, SALUS Model, Geographic Information System.**

I. INTRODUCTION

Over the years, human activities such as transportation, agriculture, fossil fuels combustions, waste treatment/disposal, land use change, biomass burning etc. have tremendously affected the atmospheric quality. Climate change scenarios were developed according to the Spatial Report on Emission Scenarios (SRES-IPCC). The SRES scenario with the lowest greenhouse gas emission (B1) between the years 2090-2099 were compared with those between 1980-1999, during which temperature is projected to increase by 1.8^0C. Vietnam is one of the countries located in the Southeast Asia monsoon circulation, which is influenced by the South Asian monsoon, in the summer and the East Asian monsoon in the winter. Climate in Vietnam is also affected by the inland movement of tropical convergence zones that move over Vietnam from Siberia.

RRD is one of the most important rice producing regions in Vietnam, being second only to the Mekong River Delta. Historically, rice production in RRD has contributed to 15% of the nation's entire rice output [20]. Rice has been identified as the most important staple food, on which about two-thirds of the world's population depend [8]. Hence, RRD's role in rice production is vital not only from the Vietnamese perspective, but from the world perspective as well.

II. RELATED WORK

A. Study Site

The RRD in northern Vietnam (Fig.1) is the second largest delta in Vietnam with the second highest population density, behind Mekong River Delta. RRD is used as the study area for this research that employs the SALUS-WebGIS model to simulate climate change impacts on rice productivity.

Approximately 47% of RRD is used for agriculture and aquaculture. Over 90% of the area is used for annual crops such as rice [1]. Based on Vietnam Statistic Year Book [20], the population density of RRD is 961 person/km^2, which is approximately four times the national average. RRD has a complex hydraulic channel system including irrigation and drainage arroyos [7]-[15]. In accordance with present economic division plan, 63 provinces and cities of the country are divided into 7 regions, one of them is RRD. RRD covers 10 provinces or cities including Hanoi, Bac Ninh, Vinh Phuc, Ha Nam, Hai Duong, Hai Phong, Hung Yen, Nam Dinh, Ninh Binh and Thai Binh. RRD includes 85 districts and 96 towns and spans over a total area of 14.806 km², covering about 4% area of the country.

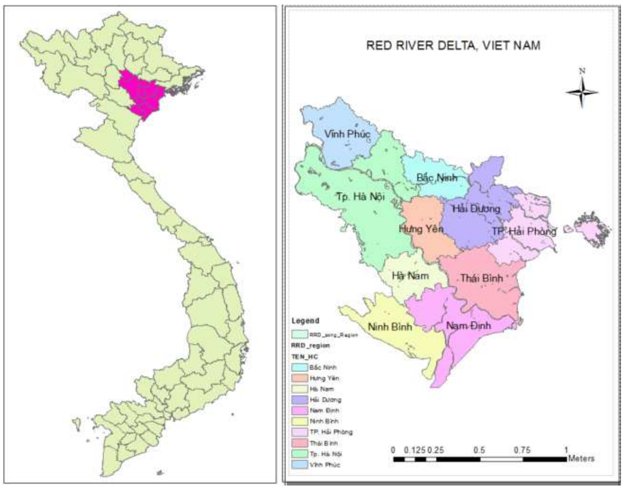

Fig. 1. Red River Delta in Vietnam

RRD delta has the highest population density in Vietnam (about 1225 people/km²) (2006), where the total population reaches about 17.649.700 people (2003). Therefore, the RRD region is enduring significant population pressure, having population density of 254 person/km2 making it the highest among seven regions, and is nearly 6-7 fold bigger than average rate of the country.

B. Related Work and Threats for Agriculture in Vietnam

Although the country experienced a rapid rate of industrialization over the last two decades agriculture remains the dominant economic sector in Vietnam's economy, and of the total 33095,1 thousand ha land in the country, agricultural land use occupies 26280,5 thousand ha. Climate change in southeast Asian region could reduce agricultural productivity by 2 to 15% in Vietnam [23]. This is partly due to the impact of climate change and also because the country has a long coastline which makes it

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vulnerable to an increased frequency and magnitude of extreme events and to sea level rise [18]-[11]. The area most seriously threatened by climate change and environment conditions are RRD (North Vietnam), and Mekong River Delta (South Vietnam) and as both are important rice-producing areas, the risk to the national economy is significant. Vietnam is characterized by crop rotation (rice) that results in two seasons of rice production as follows: i) Spring crop rotation (dong-xuan) : From the late October to the late April or May; ii) Autumn crop rotation (he-thu): from the late April or May to the late September or October.

According to EACC [22] would effect on rice yields ranging from 12 percent (Mekong River Delta) to 24 percent (Red River Delta). Changes in rice yield are vary widely through crops, agro-ecological zones, climate change.

There are many studies such as simulation of climate change on rice by DSSAT in English literature. This research is the first research using SALUS model integrate Web-GIS to predict climate change impact on rice productivity in Vietnam's North delta over space and time.

III. Methodology

A. Modelling System: System Approach to Land Use Sustainability (SALUS) Model

The SALUS model derived from the CERES model [16] and IBSNAT [17]. And the model has been shown the input data such as management practices, water balance, soil organic matter, nitrogen and phosphorous dynamics, heat balance, plant growth and plant development [6]. The components of SALUS model are also shown in Fig.2:

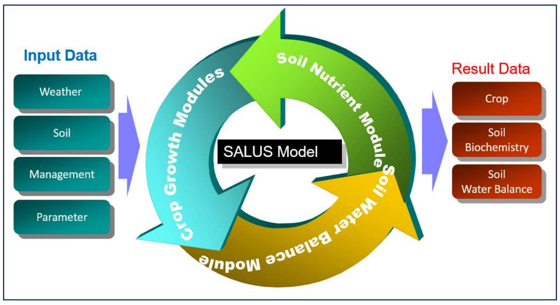

Fig. 2. Components of SALUS
Sours: [3]

The SALUS model [4] is freeware and can be downloaded from http://www.salusmodel.net

B. Integrating SALUS Model – WebGIS

SALUS-WEBGIS employs the ESRI shapefile as the source of spatial data with geometry type limited to polygons. Polygon features were used to display the spatial variability of simulations. A management practice is called an experiment in SALUS-WEBGIS. Experiments record weather data, soil data and the strategies of cultivation including planting, irrigation, tillage, residues, fertilizer and harvest (Fig.3). Each polygon was linked to a unique experiment. Similarly, the simulation results of experiments were appended to the attributes of polygons [6].

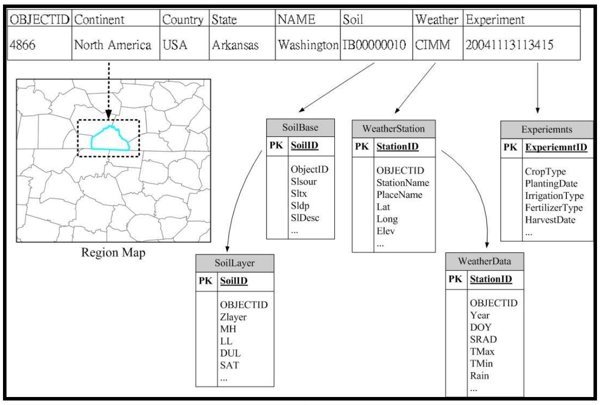

Fig. 3. The integration of polygons and SALUS data
Source: [3]

C. Data Collection

There are 10 provinces of the Red River Delta, the author collected all the meteorological data such as soil data, daily weather including daily temperature, rainfall, sunshine hour data are used in this research. All the data are supported from Vietnam National Centre for Hydro-meteorological forecasting in the past 30 years from 1982-2011. These data are obtained for seven major meteorological stations which representative for 10 provinces in the Red River Delta (Ha Nam, Hung Yen, Lang, Nam Dinh, Ninh Binh, Phu Lien, and Thai Binh station)

IV. Results

A. Simulation Results

THAI BINH Station

The SALUS model was used to simulate rice productivity for the past 30 years from 1982 to 2011. A validation model was used to adjust some parameter co-efficient inside the model such as soil, genetic, management, and real daily weather data. We tried to adjust simulation parameters to fit with observed results. The outcome shows that simulated results are quite fit with observed one. Hence the model can predict rice yield very well. It illustrates almost the same pattern observed ones. The model can predict for true conditions under different climates and as the simulated rice yield line fits closely to the observed one (Fig.4).

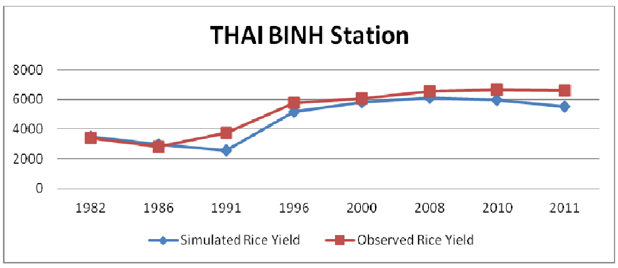

Fig. 4. Comparison of Observed data and Simulated Data at Nam Dinh station

At Thai Binh province, the actual rice yield in 1982 is 3400 kg/ha, after adjusting data the simulated yield is 4977 kg/ha. In 2010: the observed yield is 6640 (kg/ha), after adjusting data in model, the simulated yield is 4731 (kg/ha). In 2011: the observed yield is 6590 (kg/ha), after adjusting data in model the simulated yield is 4143 (kg/ha). In face the underestimate is quite substantial, trends are similar and this process shows that rice productivity has increased during the last three decades.

B. Calibration and Validation: RMSE

Model accuracy was evaluated by calculating the root mean square error (RMSE) between observed and simulated value:

$$RMSE = \sqrt{\frac{1}{m}\sum_{k=1}^{m}(t_k - y_k)^2}$$

Where, tk is the actual value, yk is the predicted value produced by the model, and m is the total 31 observed years. In the two validation studies with the CROPSYST model, RMSE was between 383 and 560 kg ha-1. In the study with the APSIM model, RMSE was obtained from simulated and observed above ground biomass at 1200 kg ha-1. In our study, RMSE range from (-1000) to 294. The weather data were obtained from VNCHMF and from each local meteorological station located about 10-20 km from the study area. Soil input data (sand, silt and clay content, bulk density, organic carbon and water limits) were determined, to minimize the RMSE values for the complete field and obtain an average percentage difference between simulated and measured values of yield within the stable zone.

The simulation accuracy regarding the soil water contents shows two different patterns. The simulation quality was also evaluated using RMSE obtained from simulated and observed rice yield. RMSE obtained from the comparison of observed yield with those simulated by SALUS model. The grain yield was obtained in the model from a conversion that R2 = 0.8715 the model (Fig.5) shows that the observed data fits closely to the simulated data.

Using the data in the past 30 years, it was shown that SALUS model is a very good model to simulate the impact of climate change on grain yield (Fig.5).

SALUS generates precipitation, daily maximum and minimum temperatures, and solar radiation. For each station, we first parameterized SALUS by using daily precipitation data from 1982-2011 as well as daily maximum (Tmax) and minimum (Tmin) temperature and solar radiation data. SALUS helps the users to prepare and analyze weather data for parameterization and generation.

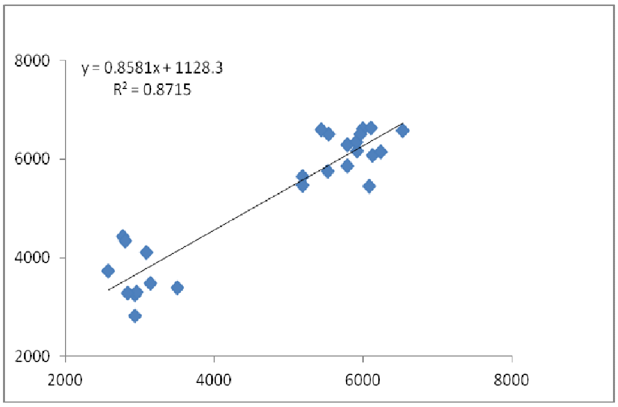

Fig. 5. Comparison the simulated yield and observed yield in 30 years of Red River Delta

SALUS model was used to generate 30 years (1982-2011) of daily weather data of maximum and minimum temperature, precipitation, and solar radiation for each station to represent the baseline climate conditions. To evaluate the performance of SALUS, we extracted 30 years of daily weather data, and compared these values with actual daily weather data.

C. Development of Climate Scenarios for Study Site

SALUS model was run in a continuous condition of soil, crop, water, nutrient under different management strategies. The rotational simulations were performed as follows:

According to MONRE report, Table I shows that the average annual temperature in RRD would increase from 0.70 to 2.21^{0}C by 2050 under MONRE and IPSL scenario.

Table I Average annual temperature increase in degrees by agro-ecological zone

Agro-ecological Zone	*IPSL - 2030*	*IPSL-2050*	*GISS-2030*	*GISS-2050*	*MONRE-2030*	*MONRE-2050*
North West	1.18	2.22	0.91	1.39	0.80	1.33
North East	1.18	2.22	0.89	1.41	0.73	1.28
RRD	1.19	2.21	0.87	1.42	0.70	1.28
North Central Coast	1.14	2.02	0.85	1.41	0.85	1.55
South Central Coast	0.86	1.61	0.99	1.62	0.53	0.93
Central Highlands	0.84	1.57	0.94	1.55	0.50	0.85
South East	0.81	1.49	0.78	1.30	0.63	1.03
Mekong River Delta	0.81	1.54	0.78	1.31	0.62	1.02

Source: [5]

Table II shows that the average percentage changes in annual rainfall in RRD varies from -(14.2)% to (+10.1)% of IPSL and GISS scenario under climate change by 2030, and 2050.

Table II Average percentage changes in annual precipitation by agro-ecological zones

Agro-ecological Zone	IPSL - 2030	IPSL-2050	GISS-2030	GISS-2050	MONRE-2030	MONRE-2050
North West	-16.5	-12.7	9.8	19.4	1.7	2.8
North East	-16.5	-11.8	10.5	13.5	1.8	3.0
RRD	-14.2	-9.2	8.6	10.1	2.1	3.5
North Central Coast	-11.9	-7.0	7.6	10.0	2.2	3.6
South Central Coast	-7.8	-9.7	5.2	5.7	1.6	2.8
Central Highlands	-11.0	-5.6	4.3	6.0	0.1	0.0
South East	-10.7	-5.0	5.1	6.3	0.7	1.3
Mekong River Delta	-10.5	-6.3	5.2	6.3	0.9	1.5

Source: [5]

i) Current scenario (30 year period 1982-2011): This was set for rotational simulations with the goal of comparing observed and simulated results.

ii) Scenario A:

Scenario A: was set for rotational simulations for the above 30 year period based on the climate change scenario of MONRE report for: i) temperature: plus, minus 1 degree; ii) Rainfall :plus, minus 10%; iii) CO2: 550ppm

iii) Scenario B:

Scenario B was set for rotational simulations which were executed for the 30 year period, it was set up for: i) Temperature: plus, minus 2 degree, ii) Rainfall: plus, minus 14%; iii) CO2: 550ppm

According to the Statistic Year Book of Vietnam General Statistic Office, there are two different rice rotations due to Vietnam government policy:

i) from 1982-1992: the rice yield was around 2000-3000 kg/ha;

ii) from 1992-2012: rice yield increased three-fold as the Vietnam government applied the innovation policy for all issues.

Therefore, the study area was researched during 31 years (1982-2011), which was divided into two aforementioned periods to run data in SALUS Model. The results reveal predicted differences in a wide range of parameters (eg. dry weight grain, CO2, N leaching).

D. Rotational Simulation Results for the Period 1992-2012

Meteorological and soil data were collected for each province in RRD. The 10 year period (2001-11) was chosen for medium emission scenario because rice yield has been relatively stable during the past 10 years. Number of replications for simulation climate change in RRD was 10. The simulation of daily weather data was generated the 10-year average. In this experiment, simulation was performed under two difference climate change scenarios (scenario A and B) in each province. Results were compared to identify the impact of changing climate on agriculture in RRD. The estimated rice yield obtained from SALUS model for RRD fluctuated by year and between the agro-ecological areas.

Thai Binh station (1992-2012)

a) Dry weight grain at Thai Binh station:

The results of comparing dry-weight grain production with observed yield for the years 1992-2012 are presented in Fig.6 which indicates the bianual crop rotations Dry-weight grain yields are shown to increase in Thai Binh station for Thai Binh province. Out of three scenarios, grain yield in scenario B has slightly decreased under climate change.

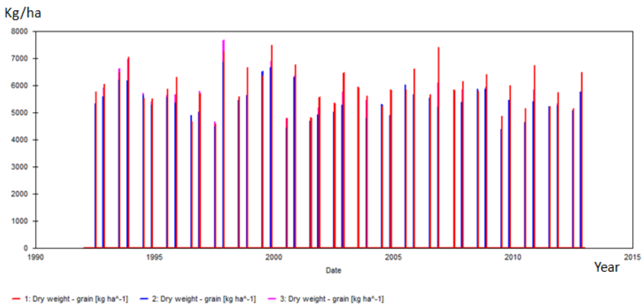

Fig. 6. Dry weight crop at Thai Binh station from 1992-2012 (1: current scenarios; 2: Scenario B; 3: Scenario A)

Average rice yield over the past twenty years from 3872 kg/ha that has decreased to 3010 kg/ha in scenario A, but increased by 624 kg/ha in scenario B under climate change, and management policy.

b) CO2 emission at Thai Binh station

Fig.7 presents the simulation results of the SALUS model in estimating the effect of the conventional tillage, minimum tillage and no tillage on carbon loss from the soil surface as carbon dioxide (CO2) [3]. No tillage management clearly shows a reduction in carbon losses which is to be expected due to lower soil mineralization and higher accumulation of organic matter in this tratefy. The no tillage treatment sequestered about 114948 kg ha-1 of carbon compared to the minimum and conventional tillage treatment in the simulated period of the past 20 years (1992-2012), and it has slightly decreased by 109780 kg ha-1 in scenario A.

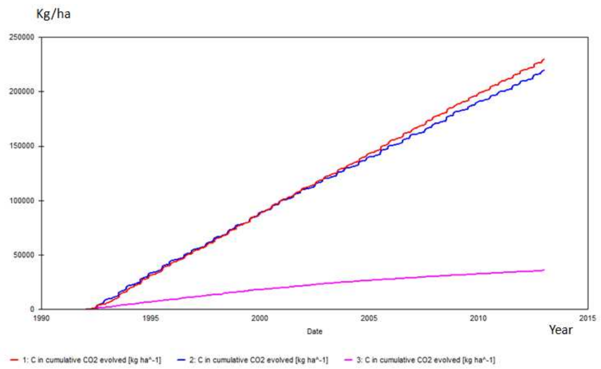

Fig. 7. CO2 emission at Thai Binh station from 1992-2012 (1: current scenarios; 2: Scenario B; 3: Scenario A)

In Thai Binh province, CO2 slightly decreased from 109780 kg ha-1 in scenario A to 104190 kg ha-1 in scenario B. There were no significant differences. Two types of tillage practices were modeled (till and no till). Tillage practices disturb soil structure lead to fracturing which increases the movement of CO2 out of the soil and oxygen into it [14]-[9]-[10]. In this study, the reduction of CO2 emission in the no tillage systems converts into an increase in carbon storage which builds organic matter and long term productivity.

c) N leaching at Thai Binh station

Environmental protection is emerging as an important issue in what may be described precision agriculture. There are many variable ways to manage the landscape that will be opened the new opportunities for the environmental policy and protection. According to researches by tillage [2], plant population [12], etc., the researches show the variable nutrients that can be offered the possible of management small units in a field not only economic gross margins but also environmental policy.

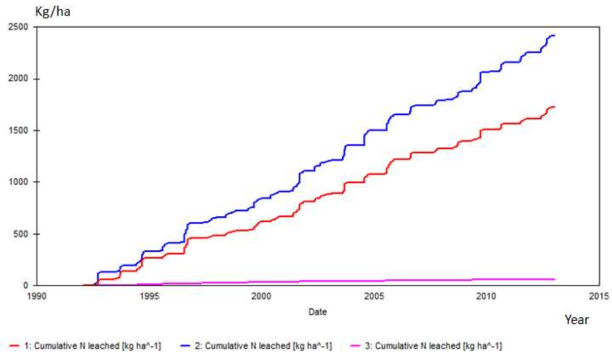

Fig. 8. N leaching at Thai Binh station from 1992-2012 (1: current scenarios; 2: Scenario B; 3: Scenario A)

Results from the research by [13] indicate that crop growth models play a significant role in quantifying the climate change impact on yield. This can be linked to the environmental policy with producer economics. Therefore, the following simulated experiments can be shown as the demonstration on the management areas in the field.

There is relationship between nitrogen application rate and yield, and nitrogen leaching, Fig. 8 shows cumulative N leaching of Thai Binh station above that N leaching response to 864 kg ha-1 at Thai Binh station over 20 years (1992-2012).

Fig. 8 shows that a moderately elevated N leaching rate from scenario A (295.33 kg ha-1) for RRD, but it was not significantly different from 1992-2012 (864 kg ha-1). The reasons for differences in N leaching among the zones relate to soil characteristics and the different of application of N that can be applied. Nitrate leaching increases from 864 kg ha-1 in the current scenario to 1207 kg ha-1 in scenario A (Fig. 8), but it decreases to 223 kg ha-1 in scenario B because of different management practices, lower precipitation, and decreased water levels.

The output of the SALUS model for rice yield, CO2 emission, and N leached per unit are shown in as Table 6.

Table III Rice yield per unit in Red River Delta 2001-2011 (kg/ha)

Province	*2001-2011*	*Scenario A*	*Scenario B*
Hung Yen	5957	6181	5488
Ninh Binh	6447	4925	5591
Thai Binh	5838	5225	5289
Hai Duong	6176	5028	5498
Bac Ninh	4294	4356	4009
Hai Phong	6176	5028	5498
Ha Nam	5319	6116	5883
Nam Dinh	5589	5832	5044
Vinh Phuc	4294	4356	4009
Ha Noi	4294	4356	4009

The area most suitable for rice production in RRD are in Thai Binh, Nam Dinh, Ha Nam, Bac Ninh and Hung Yen provinces (Fig. 9).

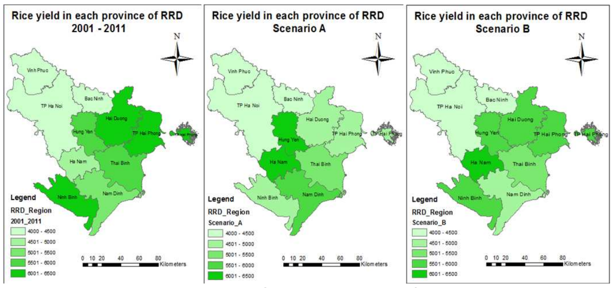

Fig. 9. Comparison of Rice Yield of each province by three scenarios

These provinces have potential agriculture areas of about 76 000 ha (for rice productivity especially). Potential agriculture production varies between the crop seasons in the RRD basin. The maximum rice production level attained was about 3616 kg/ha in the past 30 years, but this decreases slightly in both scenario A and scenario B because of climate change impacts and management interventions. The rice yield was decreased through three scenarios because of the increased average temperature and less rain with the reduced average annual? rainfall 16-20 mm in 30 years (statistic). RRD have soil depth with 4 layers (60 cm, 120 cm, 180 cm, the lower limit of soil water is 0.17 (it means even it is in dry weather, still have 17% of water inside this layer).

Based on the output data from SALUS model, the maps (Fig. 9) reveal that Thai Binh has highest rice yield in RRD in the past 30 years (1982 -2011), but that has decreased by almost a factor of two in scenario B. For rice yield in each province among three scenarios of RRD:

Shown below are the results of SALUS model (Table III) demonstrating the change in rice yield for the ten year period (2001-2011) and how it differs from other stations: (Rice yield for 10-year period – Ry10).

1-Hung Yen station: Ry10 of experiment=5957 kg/ha (slightly increased by 4% in scenario A, and decreased by 12% in scenario B.

2-Ninh Binh station: Ry10 of experiment is 6447 kg/ha, it is decreased by 24% in scenario A, and it is lightly increased by 12% in scenario B.

3-Thai Binh station: Ry10 is 5838 kg/ha, it is decreased by 11% in scenario A, and it is also lightly increased by 5% in scenario B.

4-Hai Duong station: Ry10 is 6176 kg/ha, it is decreased by 19% in scenario A, and it is lightly increased by 9% in scenario B.

5-Bac Ninh station: station: Ry10 of experiment is 4294 kg/ha, it is lightly increased by 2% in scenario A, and it is lightly decreased by 8% in scenario B.

6-Hai Phong station: station: Ry10 of experiment is 6176 kg/ha, it is decreased by 19% in scenario A, and it is increased by 9% in scenario B.

7-Ha Nam station: station: Ry10 of experiment is 5319 kg/ha, it is increased by 14% in scenario A, and it is lightly decreased by 4% in scenario B.

8-Vinh Phuc station: station: Ry10 of experiment is 4294 kg/ha, it is lightly increased by 2% in scenario A, and it is lightly decreased by 8% in scenario B.

9-Nam Dinh station: station: Ry10 experiment is 10488 kg/ha, it is lightly increased by 5% in scenario A, then it is lightly decreased by 4% in scenario B.

10-Ha Noi station: station: Ry10 of experiment is 4294 kg/ha, it is lightly increased by 2% in scenario A, and it is lightly decreased by 8% in scenario B.

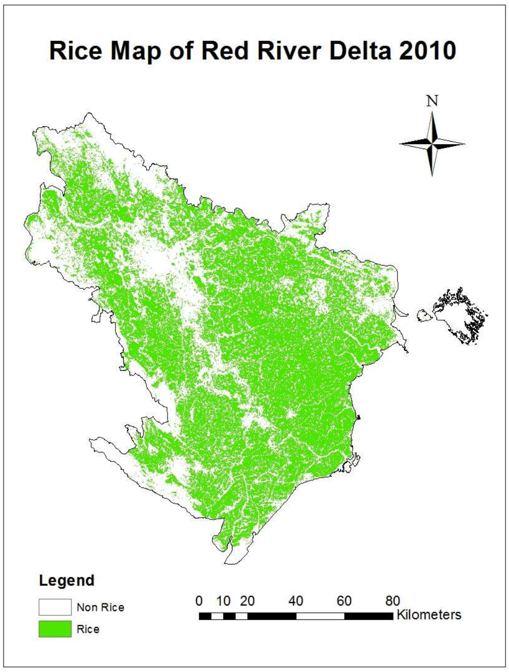

Fig. 10. Rice Map in Red River Delta in 2010. Source: IMHEN – RIICE project 2010

According to RIICE project 2010 (Remote Sensing based Information and Insurance for Crops in Emerging Economies) by the Institute of Meteorology, Hydrology of Environment (IMHEN), Vietnam Ministry of Natural Resources and Environment, RICE map 2010 (Fig. 10) has been created to identify rice area and non-rice areas for RRD, based on this rice map together with the outputs for SALUS model, and paddy land area of RRD, using GIS tools, the author set up for production rice, CO2, N leaching for entire RRD from 2001-2011.

During this period, observed production of rice, CO2, and N are relatively stable and there are high yields. In the past two decades, the Vietnam government has enacted laws, strategies, plans and programs consistent with the principles of sustainable development, including the National Target Programme to Respond to Climate Change (NTP-RCC). The NTP-RCC provided the basis for action planning in all sectors and localities until 2015 and supported research and awareness raising, and helps coordination.

Vietnam could be impacted by climate change on agricultural productivity from 2 to 15% [23]. The results indicated that RRD will be threatened the most by climate change on rice farming, production [21]. Research by [5] showed that rice cultivation was 48% of non-poor households' income. Vietnam become the second biggest rice exporter since 1980 [8] in which RRD plays an important role by contributing 15%.

Table IV Total Paddy Land of each province in Red River Delta

RRD	*Unit (ha)*
Hung Yen	82000
Ninh Binh	81000
Thai Binh	165000
Hai Duong	126673
Bac Ninh	73000
Hai Phong	79000
Ha Nam	70000
Nam Dinh	158000
Vinh Phuc	59000
Ha Noi	204000

Source: Vietnam General Statistic Office 2012

Thai Binh has the largest rice cultivation area in RRD with 165000 ha, and Nam Dinh province ranks second with 158000 ha (Table IV).

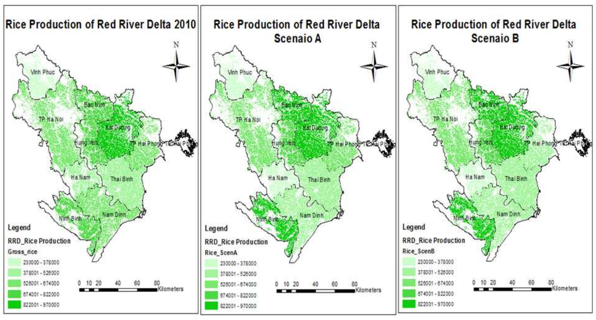

Fig. 11. Compare Rice Production of each province among three scenarios

In the current scenario 2001-2011, rice productivity of Thai Binh province increased under climate change impact, but still has the highest production in RRD with 963270 ton (Table 7), it was decreased by 10% in scenario A, and it slightly decreased by 2% in scenario B. Rice production in Nam Dinh province was increased from 883026 ton to 796952 ton (Vietnam Statistic Year Book 2011) while rainfall increased 10%, but rice production sharply increased to 921465 ton in scenario B even decreasing precipitation (minus 14%). N leached of each province also increased, and decrease in somewhere, while Nam Dinh has the second rank in rice production but N leached rate doubled from the current scenario to scenario B (Fig. 11).

V. Discussions and Conclusions

A. Discussions: New Point in this Research

Research Innovation: This is the first experiment using the SALUS Model [4] to predict rice yield for the RRD region. By executing the simulation under different predicted climate conditions, it becomes possible to consider the impact on rice crop productivity spatially. Model output also included impacts on carbon emission, nitrate leaching and irrigation demand for the RRD. The simulation runs showed increased rice productivity in this field due to predicted temperature rise.

In Vietnam, rice production faces severe challenges from climate change. It is necessary to understand the relationship between climate change and crop production to enable improved food security in the country. Using this approach it possible to develop a holistic understanding of future rice production in the region that integrates socio-economic and environmental conditions.

The study found that the average annual rice productivity is slightly decreased in future climate scenario A, and increased in scenario B. Basically, through adjustments in the practice of agronomy and investment of rural infrastructure, it is possible to both mitigate and adapt to the negative consequences of climate change. By improving rural infrastructure and social services such as education and irrigation it is possible to increase crop yield. By improving productivity and integrating climate change into long-term strategic planning, the experiment results have been provided a method to ensure supply food for the country and this can be incorporated into future policy formulation. Labor and market conditions may also influence crop productivity in the future. In order to promote productivity and climate change resilience, the government can plays an important role by targeting ethnic-minority and poor communities and provide them with more effective instruments to deal with the stress of climate change. Modern technology and crop diversification should be promoted as appropriate to the local conditions because the predicted decline in yield of 7.5 to 19.1 percent varies widely between different agro-ecological areas.

B. Conclusions

In recent years, global climate change presents a serious challenge to the socio-economic development of many countries around the world. Indeed, Vietnam may be considered one of the countries that is the most severely threatened by climate change. Measures to adapt to climate change have very important roles to play in the agricultural sector of developing countries in particular.

The study explores the situation for ten provinces in the RRD region and shows that CO2 emissions, N leaching and agricultural production varies. Understanding these spatial differences is important to develop regional and national solutions to the kinds of problems imposed by climate change.

The main aim of this research was to employ the SALUS model to estimate rice yield for RRD under various climate change scenarios and, in so doing, to predict its impact on CO2 emissions, N leaching. Dynamic crop simulation by SALUS model can contribute to the calculation of climate change on rice production in the RRD.

The first task was to apply the physical crop growth model SALUS (System Approach to Land Use Sustainability for the experiment (RRD, Vietnam), while the second task was to use SALUS model for simulation the possible climate scenarios on agriculture productivity and other aspects of the environment in the RRD region of Vietnam. According to the fifth assessment report of the IPCC 2013, the extreme weather events are likely to increase significantly in both intensity and frequency, severely affecting most countries in the world, especially Vietnam.

Acknowledgments

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