PREDICTION CLIMATE CHANGE IMPACTS ON AGRICULTURE LAND-USE USING SALUS-WEBGIS: CASE STUDY IN RED RIVER DELTA, VIET NAM

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ABSTRACT

Vietnam is one of the countries hardest hit by climate change. Climate change impacts on the entire country, but it impacts on North Vietnam, and central Vietnam more frequently than South Vietnam.

Red River Delta in Vietnam has another name is Song Hong. Red river Delta include 10 provinces and cities such as Vinh Phuc, Ha Noi, Bac Ninh, Ha Nam, Hung Yen, Hai Duong, Hai Phong, Thai Binh, Nam Dinh, Ninh Binh. Red river basin is located in northern Vietnam, and it is the largest river on the entire country. The upstream in Yun Nan province, China; and flows 1175 km southeast through deep, and discharge into the Gulf of Tonkin via a great delta. The entire delta region is no more than three meters above sea level, and much of it is one meter or less. The area is subject to frequent flooding: at some places the high-water mark is fourteen meters above the surrounding countryside. Dikes and canals protect the delta from the floodwaters. Today, around fifteen million people inhabit the area, one of the highest population densities in the world. Rice is the principal crop of the delta, but wheat, beans, rapeseed, corn, and subtropical crops are also grown.

This study concentrates to simulation impact of climate change on agriculture land use in Red river delta using SALUS- WebGIS model. The results illustrate the CO2 map, N2O leaching, and yield production in Red river in the future under a different climate change scenarios. The results from this study suggested that mitigation could positively impact agriculture. These information would be assist for the user who will handle the role of planning and decision making related to climate change and environment management.

1. INTRODUCTION

Climate change problems begin when the natural greenhouse effect is enhanced by human-generated emissions of greenhouse gases. Scientists now predict that the Earth's climate will change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases. In order to understand global warming, it is necessary to understand climate.

The changing climate impacts society and ecosystems in a broad variety of ways. For example climate change can increase or decrease rainfall, influence agricultural crop yields, affect human health, cause changes to forests and other ecosystems, or even impact our energy supply. Climate-related impacts are occurring across regions of the country and across many sectors of our economy. Many state and local governments are already preparing for the impacts of climate change through "adaptation," which is planning for the changes that are expected to occur.

Vietnam is planning for the changes that are occuring. Viet Nam has a land area of 320,000 km2 and a coastline of 3,260 km. Hills and mountains is covered ¾ its territory with elevations between 100 and 3400m , while the plain areas include two major river deltas; the

Red River Delta in the north and the Mekong River Delta in the south. The lowlands are extremely fertile and densely populated, and most of Viet Nam's agriculture and industry are concentrated there.

Vietnam is expected to be particularly hard hit by climate change – due to its tropical location, long coastal line, and mega deltas. Climate change impacts on agriculture are channeled through changes in (inter-annual and intra-annual) precipitation, temperature, atmospheric CO_2 concentration, and sea level rise (inundation and salinity intrusion).

Red River system is the second largest river system in Vietnam after Mekong River delta. This river system has a complex topography: mountains and hills, delta and coastal areas. With a population density area, and high economic potential, hosting a diverse, makes a significant contribution to the national economy. The Red River Delta is in reality the delta of two river systems: the Red River System, and Thai Binh River System. In the dry season, water level in Red River fall down very slow.

Some studies for the Southeast Asian region show that climate change could lower agricultural productivity by 2-15 percent in Vietnam. Red River delta is one of the most vulnerable area to the impact. It is estimate that the temperature in those areas may increase by 2.5 degree Celsius by 2070, and sea levels are expected to rise up to 33 centimeters by 2050. The impact of climate change on agriculture in Red River delta in particular come about through changes in variability, seasonality, changes in mean precipitation, and sea level. Therefore, prediction climate change impact on agriculture land-use is necessary for the economic development, incorporated into future response, and solution sought to adapt to their changing world.

2. LITERATURE REVIEW

2.1 Climate change phenomenon

Climate change is a real phenomenon, it's happening all over the world, and we all are responsible for a small part of this life changing event that is taking place on our planet. This is why it's important that we become active in fighting climate change and reduce the impact and slow the changes down so the earth and humanity has a chance to adjust to this phenomenon.

Climate change is making the average world temperature slowly creep up to levels never experienced by humans. The difference this time (it was hotter when the dinosaurs were around) is that humans are the main cause of this climate shift and the temperature is rising much more rapidly than ever before. The negative consequences of this trend include acidifying oceans, dying coral reefs, severe weather patterns like strong hurricanes and El Nino's, deserts that are getting bigger, and droughts. In the face of those large problems, some may believe it's too difficult to fight global warming, but actually it's quite simple to reduce your climate impact. Global warming is a term scientists use to refer to the increase of the Earth's average surface temperature, due largely to a buildup of greenhouse gases in the Earth's atmosphere. Climate change encompasses long-term changes in climate, which include temperature, precipitation amounts, and types of precipitation, humidity, and other factors [4]. On Earth carbon is one of the fundamental elements necessary for life, in the form of carbon dioxide, is fixed by photosynthesis into organic compounds in plants and photosynthetic algae and returned to the atmosphere mainly by the respiration of plants, animals and micro-organisms in the form of carbon dioxide. The problem began with the

Industrial Revolution. This was the period in the late 18th century when industrialization began and changed lifestyles with the invention of steam power, electricity, mechanization, development of fossil fuels, etc.

2.2 Impacts of Climate change on Agriculture in Red River Delta

Song Hong has its mouth on the western coast of the Gulf of Bac Bo (Tonkin) in the South China Sea. It is controlled by the Neogene Red River fault system with stretches northwest-southeast. The sedimentary basin has its own 500km long and 50–60 km wide which is filled with Neogene and Quaternary sediments with a thickness of more than 3 km. Red River Delta plain is divided into wave-, tide-, and fluvial-dominated systems. The southeastern part has strong wave energy is generated by summer monsoon winds, which is wave-dominated; the northeastern part is sheltered from strong waves by Hainan Island, which is tide-dominated; and the western part, which is affected by a relatively strong fluvial flux, is fluvialdominated.

The Song Hong delta is characterized by a tropical monsoonal climate with a pronounced maritime influence, and Pfeiffer (1984) has classed its climate as seasonal, moist subtropical. Annual rainfall is from 1300 mm to 1800 mm, with 85% falls during the summer rainy season (April to October). During in August to September, the heaviest rainfall occur in that time. The average temperature in the summers ranging from 27 degree to 29 degree Celsius. The winter has the average temperature during 16- 20 degree Celsius. The pH of the water varies from 8.0 to 8.4, reaching its highest levels in November and its lowest levels in May and June (World Conservation Monitoring Center, 1992). Changes in climate, and these industrial zone impact on the Red River Delta cause it catchment in Vietnam is the second polluted basin. Along the Red River Delta many chemical, paper plants discharge polluted water to the river. Along the Nhue-Day river more than 4000 plants, 8 industrial zones, 266 private enterprises, more than 450 traditional working villages. Around the Red River delta has a lots waste water of more than 100 millions people discharged to the river system without any treatment. Therefore increasing of solid waste from urbanized areas.

3. INTEGRATING SALUS MODEL AND WEBGIS

3.1 Brief overview of the SALUS model

The SALUS (System Approach to Land Use Sustainability) program is designed to model continuous crop, soil, water and nutrient conditions under different management strategies for multiple years (Fig.1). These strategies may have various crop rotations, planting dates, plant populations, irrigation and fertilizer applications, and tillage regimes. The program will simulate plant growth and soil conditions every day (during growing seasons and fallow periods) for any time period when weather sequences are available [1]. The biophysical model is composed of three main structural components: i) a set of crop growth modules; ii) a soil organic matter and nutrient cycling module and; iii) a soil water balance and temperature module. The SALUS model does not explicitly include submodels to predict pest and disease outbreaks or the occurrence of extreme weather events (e.g., hail). We recognize that these factors can have a major impact on crop production and yield and the sustainability of a particular management system. Instead, SALUS uses the concept of linkage points (Boote et al. 1983; Teng 1988), which enables it to interface with external models of pest dynamics or other information about the type and extent of pest incidence or other damage factors (e.g., integrated pest management models).

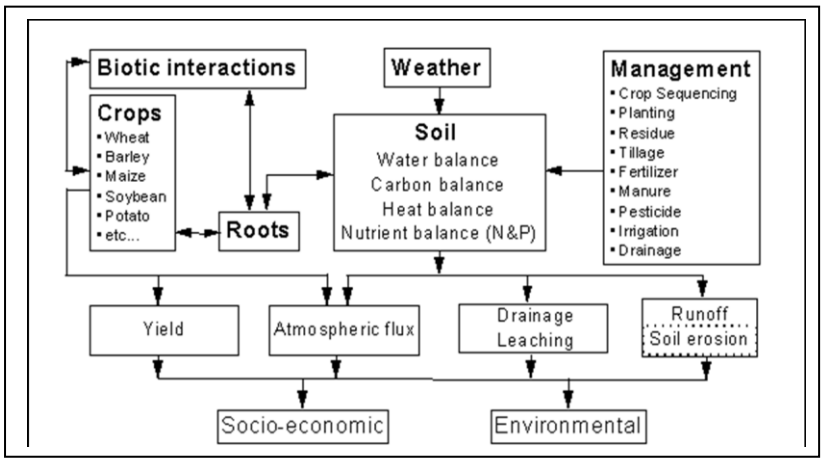

Figure 1. SALUS model

3.2 Integrating SALUS model and WebGIS

SALUS-WEBGIS is an integration system follows a tight coupling strategy integrated SALUS model (Karimi, H. A. etc., 1996) with EasyMap object into a web application. SALUS model is converted into a dynamic link library that can be called from the new application and linked to it at runtime. This allows a smooth integration between GIS and the simulation models.

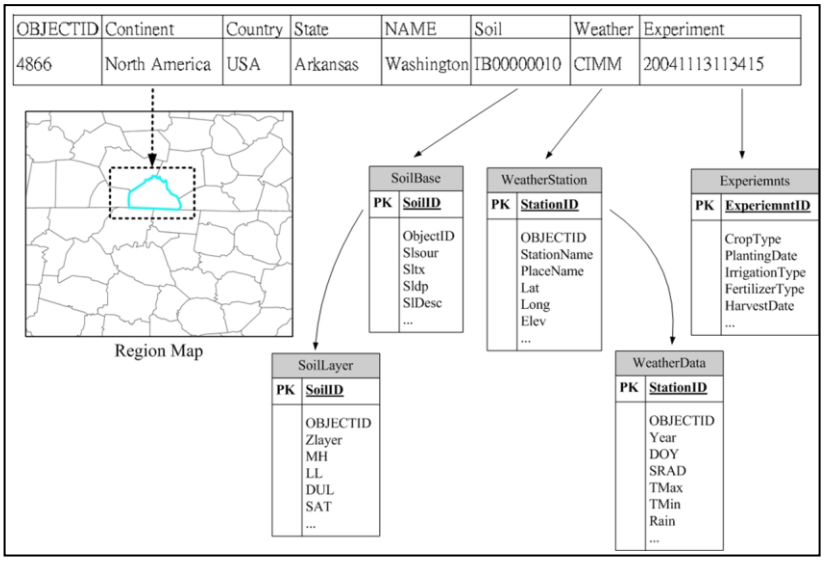

Figure 2. The Integration of polygon and SALUS model

SALUS-WEBGIS adopted ESRI Shapefile to be the data source of spatial data. The geometry type of features was limited to polygons. Polygon features were used to display the spatial variability of simulations. A management practice is called an experiment in SALUS-WEBGIS. To reduce the complexity of using SALUS-WEBGIS, input data were decreased or some data were set default values. Output data also were reduced because only a few simulation results are suitable for mapping.

4. RESULTS AND DISCUSSION

The main methods in this study, we use the MarkSIM^{TM}DSSAT weather file generator to identify the soil data in Red River Delta, Vietnam. Firstly, we selected the place that is Red River Delta. A1b was chose for medium emission scenario. Number of replications for

simulation climate change in Red River delta is 20. The datas proceduced will simulate daily weather data of the average of 20 years later. Red River Delta was identify the location for this experiment. In this experiment, each province was simulated under two difference climate change scenarios (the current scenario, and Scenario T1 – plus 1 degree Celsius). We compared two scenarios to identify the changes in climate impacts on agriculture in the Red River Delta.

We would like to setup for temperature, then evaluating the average value of each province on crop yield, CO_2 emission, Nirate leaching in the climate change scenario in 20 year later. The current scenario was chose A1b in DSSAT the medium emission scenario. All the data are run in SALUS-WebGIS model at http://www.salusmodel.net/

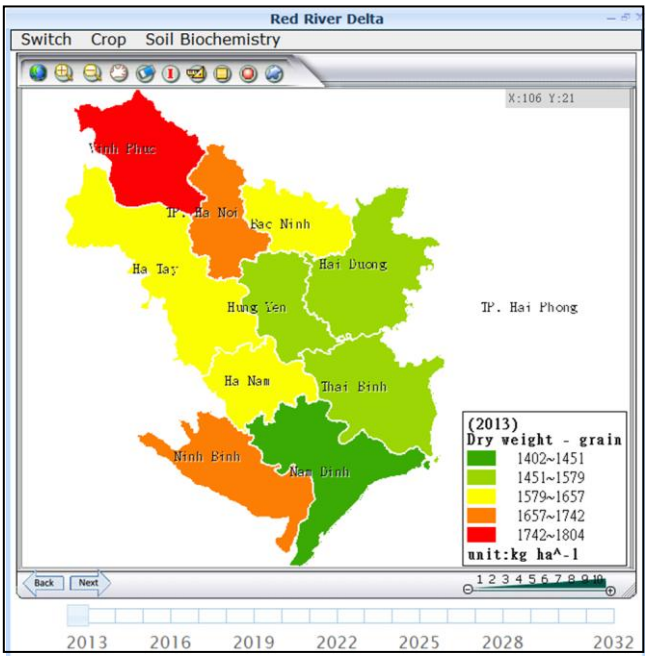

Figure 3. Map showing Dry Weight-grain

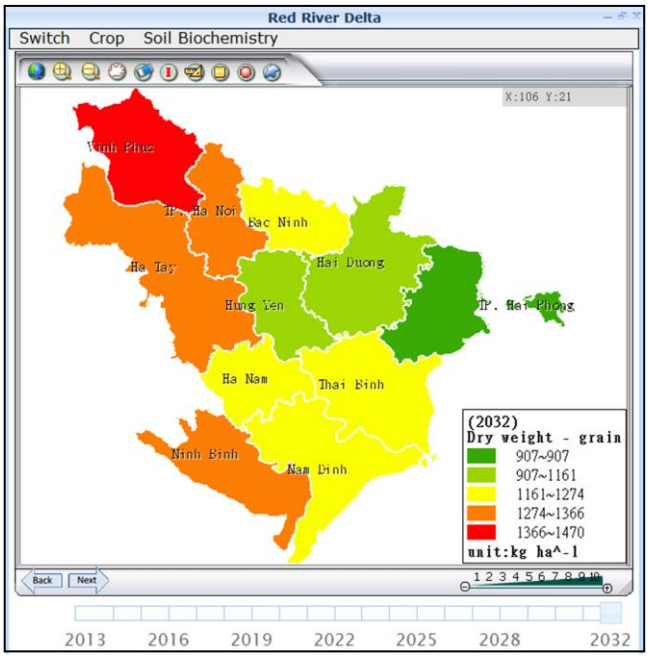

Figure 4. Map showing Dry Weight-grain

In the current scenario, both of two maps show the Dry weight-grain under a changes in climate. These maps illustrate the impact of climate change on crop in Red River Delta, Nam Dinh province has a yield of crop with 1451 kg/ha in 2013, under the impact of climate change in 20 years later in 2032 the dry weight grain is decrease with 1189 kg/ha. In the other province get the same situation like Nam Dinh. This is a good trend even in climate change scenario.

Input data: two kinds of standard data sets are developed in SALUS model, climatic data as temperature data was collected from generator data. Because of lack of the daily temperature, the simulated yield are just compared between the current temperature and the temperature plus one degree Celsius. If the temperature condition is plus one degree Celsius, the crop yield is decrease in almost province of Red River Delta. Since the crop yield of Ha Noi city decrease from 34627 kg/ha to 32945 kg/ha. If the detailed field management information in different areas, such as the cropping system, irrigation, fertilization and tillage, can be obtained and input to the Salus-webGIS model, the simulation accuracy could be improved.

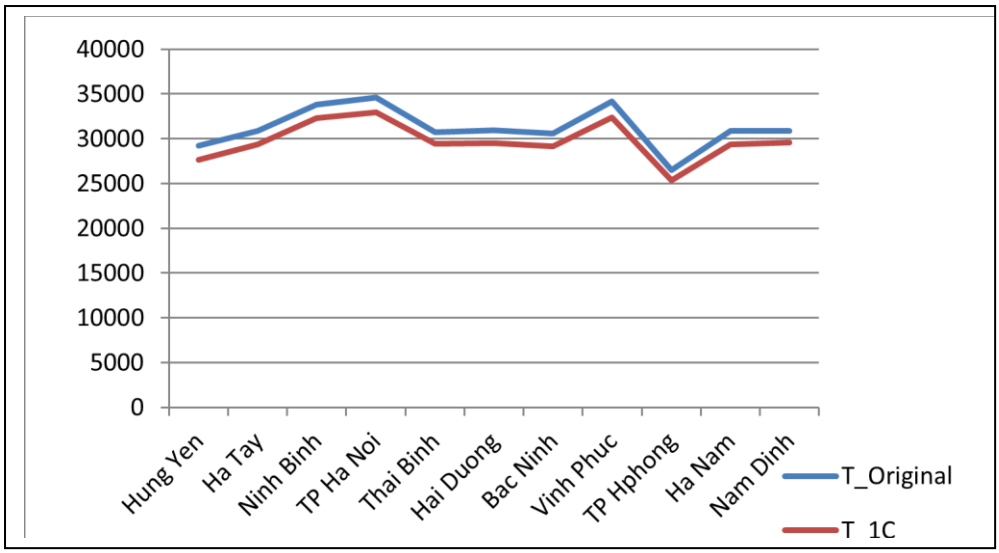

Figure 5. Chart of Dry weight-grain in two scenarios

5. CONCLUSION

This study has showed the method to predict the impacts of climate change on agriculture land-use in Red River delta by SALUS-WebGIS. The main contend obtained as follows: 1) Climate are changing on the world, it has an important effect on agriculture land-use. It is also indicated that Red River delta is affected by sea level rise, increasing vulnerability to flooding, including storm events; accelerated erosion along the coasts and in river mouths, changes in the physical characteristics of tidal rivers. 2) The results indicated that integrating SALUS-WebGIS as a useful tool to predict the changes in climate impact on agriculture land-use in Red River delta in 20 year later, a useful model to extend an experiment not only in Red River Delta- Vietnam, but also in other places. 3) Further studies, we desire that integrating SALUS-WebGIS to simulate the impact of climate change on soil radiation, and precipitation.

6. REFERENCES

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