Climate change and impacts on rice production in Vietnam: Pilot testing of potential adaptation and mitigation measures

Deliverable 1.2
A benchmark report characterizing the three project areas and rice farming systems in the three provinces

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BACKGROUND and SUMMARY

The three year multidisciplinary ClimaViet project (July 2013 to June 2016) implemented jointly by the Vietnam Academy of Agricultural Sciences (VAAS) and the Norwegian Institute for Agriculture and Environmental Research (Bioforsk) is focusing mainly on the future climate change impacts on rice production in Vietnam with financial support of the Ministry of Foreign Affairs, Norway. As a first step, the project has reviewed the current studies and programs related to climate change and agriculture taken by other agencies in Vietnam. The existing climate scenarios were downscaled and the climate impacts on seasonality in rainfall leading to droughts and salinity in coastal areas on rice production were assessed. Potential measures leading to improved rice cropping systems and improved nutrient use efficiency are being pilottested in the three study areas located in Nam Dinh, Soc Trang and Tra Vinh provinces. The results are expected to contribute to sustained productivity and climate change mitigation. Towards the end, the project will develop the institutional and policy guidelines required to adopt the potential measures identified and tested in the project. The project involves stakeholders at the provincial and national level (VAAS, MARD, MONRE and other relevant stakeholders) for better uptake of results.

The project study is being carried out in three provinces (see Figure 1), namely Nam Dinh (in Red River Delta), Soc Trang (in Mekong River Delta) for saline intrusion problems and Tra Vinh province for drought, where selected measures are being pilot tested for their potential adaptation and mitigation impacts, and their performance being validated in cooperation with local agencies and farmers. The project results will indirectly support the MARD strategy for agricultural development, as well as the ARD Action Plan to Climate Change. The wide network of agricultural and extension agencies located across the country under VAAS will be used for dissemination of project results. The interdisciplinary approach in the project will help to address the main concerns in rice production, besides emphasis on stakeholder interaction (farmers, women groups, government authorities, private sector) from the beginning of the project. This is also to ensure strengthening of science-policy linkage in the project.

General objectives
The main goal of the ClimaViet project is to identify and pilot test climate smart rice farming systems that will contribute to improve rice production under changing climate, and at the same time help in mitigation of greenhouse gases (GHGs).

Specific objectives
The main objectives of the project are:

- To identify and characterize rice farming systems that will be most vulnerable to climate change in the selected study areas due to changes in seasonality of rainfall, especially droughts and saline intrusion.
- To identify and pilot test selected climate smart measures that will help in adaption and mitigation, improve rice production and at the same time reduce GHG emissions.
- To assess the current and future institutional framework needed for implementing potential adaptation and mitigation measures tested in the project.
- To actively involve stakeholders, women and farmers in developing climate smart agriculture practices and improve awareness through dissemination of project results.

This report will provide a benchmark survey of the three study areas including the future climate scenarios in brief, a socio-economic profile of the areas, and the main challenges and government initiatives to address climate change impacts in the three provinces. It will start with an introduction, followed by three sections presenting the three different regions.

Figure 1. ClimaViet project study areas in Vietnam: Soc Trang and Tra Vinh in the south and Nam Dinh in the north

1.0 Introduction

Vietnam will see major changes in the rural areas, in its efforts to achieve the set national development goals in the coming years. Addressing the needs of 75% of the population living in rural areas who also constitute 90 % of the poor - is perhaps the most difficult challenge the country has to address in the next 2-3 decades. A majority of the farmers are small scale, with average farm sizes of 0.8 hectare that currently provide only part-time work for most farm families and are highly vulnerable to changes taking place within social, economic and climatic conditions.

Climate change and variability associated with natural hazards such as flooding, storms and droughts have been a continuous threat to the life and property of Vietnamese society in the past. With its 3,260 km coastline and highly varied geography, Vietnam is highly vulnerable to climate change (Das Gupta et.al 2007; Das Gupta et. al 2010). The country is divided into three regions: North, Central, and South, and annual mean temperature in the different regions ranges varies. The monthly mean of the coldest month is about 13-20 °C in the North, while in the South, it is 20-28 °C. Vietnam has a tropical monsoon climate with frequent tropical cyclones affecting the Northern and Central regions, and less frequently in southern areas. Annual rainfall ranges from 600 mm to 5,000 mm, with as much as 70-80% of rainfall concentrated in the rainy season (August to November). The seasonal distribution of rainfall is closely related to the monsoons. In some years, rainfall intensity can be high, producing a rapid run-off and serious flooding. Because of its low coastal topography, Vietnam is exposed to high wind speed and storm surges brought by tropical cyclones.

Rising temperatures, variability in the seasonality of rainfall, and sea level rise are the three main concerns for Vietnam, despite the uncertainty in climate projections. For example, the intrusion of saline water into the Mekong delta used to reach 20 km inland, but now reaches 40-60 km inland according to local sources. Although there has been recorded sea level rice, the effect of increased number of strong low pressure weather systems, is causing a much greater sea level rise in practice. In general, the trends show increasingly wetter wet seasons and prolonged dry periods (Johnston et.al 2010). Studies have found that annual average temperatures have increased by 0.5-0.7 degrees Celsius per decade according to a report by ISPONRE (2009). Simulations of future climate change in Vietnam show that temperatures will increase further by 0.3 °C to 2.5 °C by the year 2070, significantly impacting on food production (Asian Disaster Preparedness Center, 2003). Shifts in temperature will also lead to more incidence of pest and disease and subsequent reduction of yields if not managed properly (Johnston et al., 2010).

Studies to develop climate change projections are generally less certain regarding precipitation patterns than temperature in Vietnam. Scarcity of water resources and droughts are becoming a more common phenomenon in the country, albeit still lower in priority than the serious annual flooding problems. During the mid-dry season (March-April), the maximum water demand, mostly for irrigating rice fields, coincides with minimum discharges from the river. Water demands have increased proportionally with increases in the area under rice cultivation. In order to invest in the future, Vietnam should focus on dry season rice, where efforts have to be made to increase rice production by improving soil, land and water management practices, rice pattern adjustment, promoting rice varieties that can mature in shorter periods, consume less water and tolerate new pest and disease problems. This is also in line with the MARD strategy for agricultural development and the ARD action plan to respond to climate change. However, any new adaptation measures have to be simple, help in reducing GHGs, low cost and easily adaptable, since the majority of farmers are small or marginal land holders with low investment capacity and the government does not have adequate resources.

Sea level rise will have serious implications for Vietnam with its extensive coastline, leading to salinity intrusion and loss of productive land (Asian Disaster Preparedness Center, 2003). Damage to rice production due to loss of rice land, based on scenarios of climate change for Vietnam is very serious (MARD, 2009). Predictions show that by the year 2100, there would be three different possible scenarios of climate change in Vietnam which are developed based on the three different scenarios of

GHG emissions (high, medium and low level). The Ministry of Natural Resources and Environment (MONRE) recommends that ministries, agencies and industries should base their medium and long-term plans on climate change scenarios, as a means of evaluating the impacts of climate change and rising sea water levels, and develop the action plans for coping with climate change. According to the scenario of high level GHG emissions, the sea water level could rise by up to 99 cm higher than the level during the 1980-1999 period. With this scenario, most of the provinces in Cuu Long River Delta Region (located in the Mekong River Delta (MRD) will be submerged or facing serious saline water intrusion (MONRE. 2012). Simulations show loss of rice production in 10 provinces in the MRD hypothesized as the most affected areas, where 38% of land will be submerged under sea water, of which 31% is agricultural land, mainly allocated for rice production. Results show that these areas will lose 7.6 million tons of rice per year, equivalent to 412% of total rice output of the MRD today. In the Red River Delta, although less land will be inundated than in MRD, most of the lands will be affected by the intrusion of saline water from sea rise. The Vietnam Institute of Water Resources Planning reported recently that 4‰ salinity level in water will occur 40 km inland, far from sea borders, and affecting at least 300,000 ha of rice that currently produces the highest yield. In addition about 20 million inhabitants will be affected and 10% of GDP will be lost (National Institute for Planning and Projection, Report, 2003). The World Bank has classified Vietnam as one of five Asian countries that will face food insecurity. Farmers in Vietnam will needs to adjust to a changing climate (with rising sea levels and changed weather patterns) and accordingly become more resilient in their farming practices and investment decisions (The IPCC Fourth Assessment Report, 2007).

Climate change impacts on rice production and food security in Vietnam

Studies for the Southeast Asian region show that climate change could lower agricultural productivity by 2–15 % in Vietnam (Zhai and Zhuang, 2009). And the most serious threat of climate change to agricultural activities will be in the Mekong and Red River Deltas, primarily affecting rice farming and production. Rice farming is the major contributor to agricultural production and food security in Vietnam and provides rural livelihoods for millions of men and women in rural Vietnam (Vu and Glewe 2008). Severe impacts to this system from climate change would therefore disrupt an important part of the Vietnamese economy. According to a recent study, rice cultivation was at least one source of income (in many cases the major or only source) for more than three-fourths of poor households and for about 48 % of non-poor households (Bingxin et al 2010).

A net rice importer in the 1980s, Vietnam has now become the second-largest rice exporter in the world (FAO 2010). The Red River Delta and the Mekong Delta are considered the country's two major granaries, accounting for 14 % and 53 % of rice cultivation area, respectively. With its high level of productivity, the Mekong Delta has in recent years contributed half of Vietnam's total rice production and about 90 % of its total rice exports.

Three seasons are generally suited to rice cultivation:

- Spring (*dong-xuan*): late October to late April or May (cultivation during this season requires active irrigation);
- Autumn (*he-thu*): late April to late September; and
- Winter (*thu-dong*): late May to mid-November.

Rice yields have increased at a rate of 2.3 % annually and have been the main driver of agricultural growth over the past two decades. This is mainly due to introduction of new rice varieties, improvement in irrigation infrastructure and land use policy of the government. The policy for rice export within and outside the country is being relaxed, allowing better pricing and benefit to the farmers, but needs to be put into practice.

The major constraints to rice production in Vietnam are flooding at the end of the rainy season, and drought in the dry season, besides sea level rise (Johhston *et. al*. 2009; Johnston *et. al.* 2010). Decreasing land for rice production due to urbanization is another serious constraint. Furthermore, small farm size which is expected to diminish even further because of population pressure is also very

critical. The increased productivity of rice-based farming systems remains one of the primary goals of the national plan, with a focus on short duration varieties for irrigated areas. Developing climate smart agriculture can help in both adaptation and mitigation. Rice farmers have to be provided with different options that are climate friendly and that can also provide CDM benefits. In addition, efforts are needed towards improving non-farm, *climate-insensitive* or *climate-resistant* economic opportunities (Zhu and Trinh, 2010).

Nam Dinh province

1.1. Basic features

Nam Dinh province is located in the south of the Red River flood plain on the East Sea. The weather in Nam Dinh is primarily a tropical monsoon climate with an annual average temperature of 24^{o}C. December and January are the months with the coldest climate (16-17^{o}C) whereas the hottest month is July, with a mean temperature of 30^{o}C. Nam Dinh has a medium humidity level of 85% with total annual rainfall of 1,800 mm, concentrated between May and October. The local geological structure is dominated by a complex sequence of unconsolidated high and low permeable alluvial and marine sediments. The coastal region in Nam Dinh is a wave dominated delta, and affected by saline intrusion. The population of the coastal part of the province is about 0.5 million with a population density of 1000 per square km which is typical of the Red River Delta. The coastal districts are severely affected by frequent storms, as are the livelihoods of people who are primarily dependent on rice cultivation, aquaculture and salt making. The province's natural land is 1,652 km^2, which is administratively divided into 10 districts and a city, of which three are coastal districts. Its total population is about 1.83 million with 80% of the people living in rural areas. There are four big rivers with a total length of more than 245 km, of which Hong river, Dao river, Ninh Co river and Day river are 70 km, 35.5 km, 60 km and 80 km respectively. The 72 km long coastal bank consists of four large river estuaries: Ba Lat (Red river), Ha Lan (So river), Lach Giang (Ninh Co river) and Day (Day river).

Irrigation is a challenge, as there is a shortage of fresh water for flushing out salts. Fresh water has to be brought from upstream and there is no certainty of fresh water availability due to droughts in some years. In recent years, prevailing weather conditions appears to have negatively influenced agriculture and aquaculture production in the province. There have been unpredictable heavy rains and typhoons (seven typhoons in 2005, rain and floods in 2008, eight typhoons in 2012). Rainfall patterns are irregular, and the province also experienced unpredictable cold spells in early years (2008, 2011, 2012) and sea level increases. It was claimed that those unpredictable weather changes have led to many changes in pest and diseases on crops and animals, leading to appearances of new diseases. Salinity intrusion inland is another serious problem (some years salinity intrudes 30 – 40 km inland), followed by then low water level in rivers. There are 28 coastal communes with a rice cultivation area of 12,000 ha that is usually affected by salinity, of which 5,000 ha is heavily affected. The salinity at the beginning of the spring crop is 0.7– 3‰, in a dry year, increasing up to 8 ‰. Sea level increase impacts aquaculture production as well.

In the context of climate change, there are both difficulties and potential for sustainable development in Nam Dinh. For example, mangrove restoration along the coast can protect the livelihoods and also help in mitigation. The local government is concerned and called on assistances from outside agencies.

1.2. Project area

The representative study areas have been selected based on a set of criteria balancing representativeness of the climate change prospects, impacts on agriculture, and practical aspects of access. The ClimaViet project selected two districts namely Hai Hau and Nghia Hung within Nam Dinh province to conduct field trials and survey data of a wide range of issues, including socio-economic vulnerability to climate change, farmers adaptation capacity, income, agriculture and gender issues.

Survey and assessment methods used:

- two selected study areas include Thinh Long commune, Hai Hau district, and Rang Dong farm, Nghia Hung district;
- a random selection of 40 farmer households participating in rice production in different production groups;
- survey of farmer households through a set of survey questionnaires;
- a stakeholder workshop to prioritize adaptation measures for pilot testing; and
- analysis of primary data collection.

1.2.1. Thinh Long commune, Hai Hau district

Thinh Long is a coastal commune playing an important role in economic development of the district (see Figure 2). Farmers' income in this commune depends mainly on agricultural production. The soils in Thinh Long commune, one of the project areas, are predominantly alluvial soils. The main challenges faced by Thinh Long farmers are salinization, occurring especially in the spring season. Although there are salt-tolerant rice varieties available to the farmers, not many of them produce good quality and high yield. Most salt-tolerant rice varieties grown now are Chinese hybrid rice varieties.

The main method of improving salinity conditions in Thinh Long commune is to use fresh water from canal systems to reduce salinity in fields. There are two water sources in Thinh Long commune used for agricultural production: one from the Hoa Binh Dam about 130 km away and the local river (Ninh Co river); however, farmers in Thinh Long hardly use water from the local river because the water usually has a high level of salinity. Tidal waves lift the sea water levels and increase salinity in the river near the coast, and the local irrigation systems of Thinh Long commune and fields near coast are salinized. Alternate Wetting and Drying (AWD) technique is not feasible in Thinh Long commune because fields need to be flushed with fresh water to keep out saline intrusions.

A stakeholder meeting was held in the province during 2013 to identify main challenges from climate change. At the meeting (Figure 3), Bioforsk scientists, together with the team members from the Vietnam Academy of Agricultural Sciences (VAAS) met with stakeholders at the province-, district- and commune levels to discuss climate change challenges experienced. At the province level, one of the main challenges identified is to provide sufficient irrigation water to the 80,000 hectares of rice land in Nam Dinh. About 12,000 hectares are affected by salinity. The priorities are development and adoption of new rice varieties and improved crop management to address these dual constraints. Policy support on how to manage crop and water to address climate change impacts are required.

1.2.2. Rang Dong farm, Nghia Hung district

Rang Dong is located in Nghia Hung district where salinization is a serious problem. The total natural land in this commune is 1,336 ha, of which 470 ha is rice production. There are three soil types in Rang Dong: sandy soil, alkaline soil and alluvial soil. Most of the rice soils in Rang Dong are alluvial, which has the problem of salinization and flooding. The main reasons for salinization in Rang Dong are sea level rise, lack of fresh water, and long drought periods. The salinity level of rice land in Rang Dong is often higher than in Thinh Long commune. In this commune, the rice land which has a high salinity level (above 6‰) is now used to develop aquaculture. Not many sufficiently salt tolerant new rice varieties are available for planting in Rang Dong because of the high salinity level here.

1.3. Land use and agriculture

1.3.1. Land use

The land surface of Nam Dinh province can be divided into two regions according to the soil type. The northern region comprises Y Yen, Vu Ban and My Loc districts and Nam Dinh City. The southern region consists of Truc Ninh, Nam Truc, Xuan Truong, Hai Hau, Nghia Hung and Giao Thuy districts. The most widespread soils are young alluvial soils (fluvisols) that cover 82% of the land surface. Alkaline soils cover 14% of the province and other soils covering small parts of the land are sandy,

aluminous and ferralitic soils. Generally, the main soils of Nam Dinh province are alluvial, developed from river deposits. The quality is suitable for different vegetation types and agriculture.

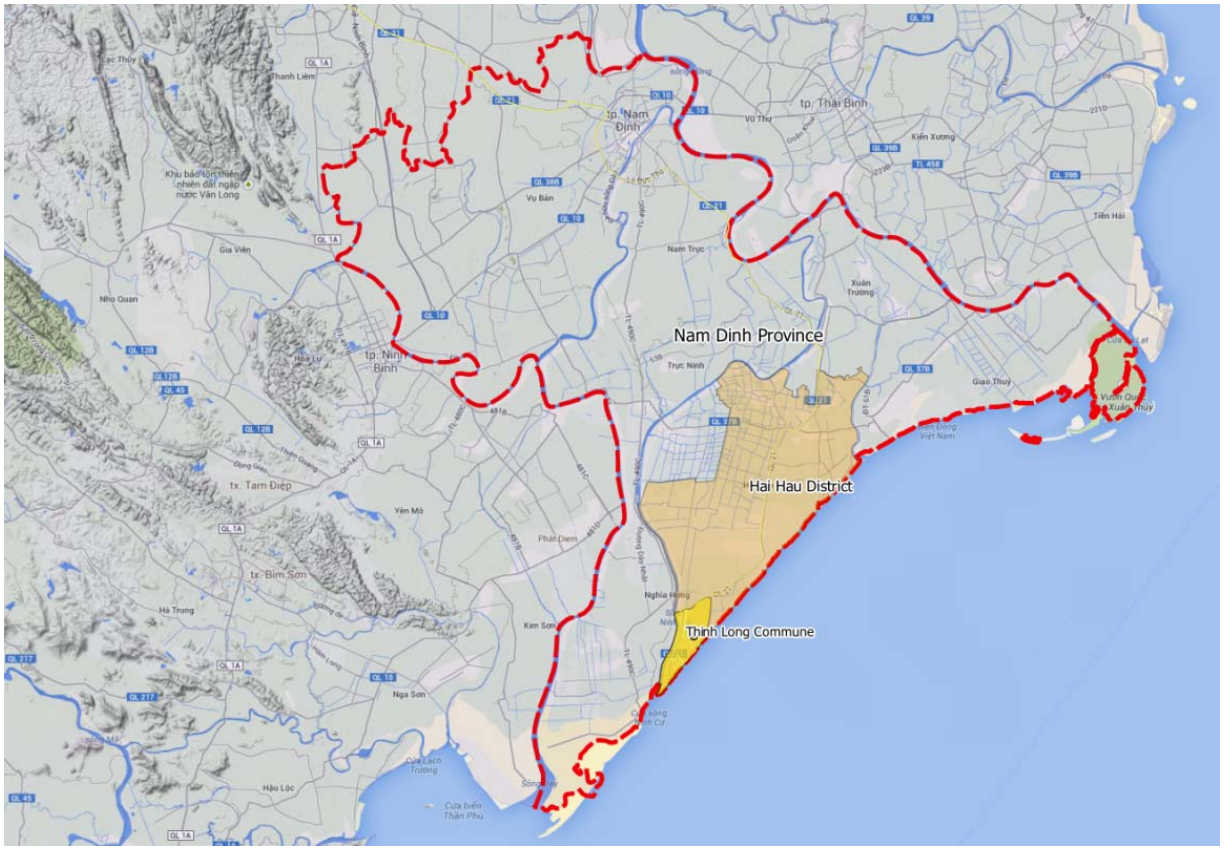

Figure 2. Location of Thinh Long commune, Hai Hau district in Nam Dinh province.

Based on the statistics of Ministry of Natural Resources and Environment in 2010, the total area of natural land in Nam Dinh is 165,1456 ha in which the agricultural land area is 113,433 ha, non-agricultural land area is 47,494 ha, and the unused land area is 4,218 ha. Additionally, Nam Dinh has the advantage of a marine economy, but climate change and sea level rise significantly influence the land use of the province. One of the most serious impacts of climate change on Nam Dinh province is the spread of salinization. Climate change has caused long droughts, such that the dry season is longer than the rainy season, along with sea level rise and development of hydroelectricity on the upper reaches. Consequently, salt invasion is worse than before and lasts longer. There has been 8,765 ha of agricultural land salinized, mostly in three coastal districts including Nghia Hung, Hai Hau and Giao Thuy. Studies in Vietnam show that the nation's agricultural lands, located in river basins and dependent on irrigation, are highly vulnerable to fluctuations in water levels, which may increase with climate change. This could result in lower crop yields and growth rates, the weakening or extinction of particular crop species, increased activity by pests and viruses, and a loss of soil fertility. As the sea level rises, salt water intrusion increases, which affects the availability and quality of water resources vital for irrigation and local drinking water supplies. All of these impacts are a stress on Vietnam's agricultural livelihoods (Raksakulthai, 2002).

1.3.2. Agriculture

Nam Dinh is one of the key agricultural regions in the Red River Delta of North Vietnam, and main agricultural products are rice, corn, soybean etc. (Table 1). Rice is the major crop in Nam Dinh province, cultivated on over 80,000 hectares. The area of land with vegetables is 10,000 hectares. In the three coastal districts (Giao Thuy, Nghia Hung and Hai Hau) with an area of 30,000 ha, 12,000 ha

are affected by salinity. Agro-insurance has been available for the past three years, but does not give farmer's adequate disaster protection.

Figure 3. The stakeholder workshop held in Thing Long commune on November 15th 2013.

Table 1. The area of yield and production of some major crops in Nam Dinh

Major crops	Unit	In 2000	In 2012
Rice			
* Area	ha	166 188	158 358
* Yield	100 kg/ha	58.10	58.83
* Production	1000 tons	965.62	931.62
Maize			
* Area	ha	3 407	5 014
* Yield	100 kg/ha	31.97	41.94
* Production	1000 tons	10.89	21.03
Soybean			
* Area	ha	1 996	2 861
* Yield	100 kg/ha	14.67	16.42
* Production	1000 tons	2.93	4.70
Cassava			
* Area	ha	256	176
* Yield	100 kg/ha	77.97	75.63
* Production	1000 tons	2.00	1.33
Sugarcane			
* Area	ha	127	205
* Yield	100 kg/ha	359.45	300.15

Major crops	Unit	In 2000	In 2012
* Production	1000 tons	4.57	6.15
Sweet potato			
* Area	ha	6 968	2 132
* Yield	100 kg/ha	74.71	87.55
* Production	1000 tons	52.06	18.67

Source: Nam Dinh's Department of Agriculture and Rural Development, survey data in 2012

Current programs to address climate change in the province

To ensure the safety of local people and promote agricultural production and socio-economic development, Nam Dinh People's Committee approved an action plan in response to climate change (2011-2015) with a vision to extend it to 2020. Additionally, Nam Dinh province is one of the few Northern provinces focusing on promoting international cooperation in disaster reduction and adaptation to climate change. Many departments in the province have participated in cooperative activities, and regional and global activities in terms of climate change. The Vietnam-Netherlands Integrated Coastal Zone Management (VNICZM) project is a typical example. The project is creating the foundation for studies in coastal areas in the province. Another project funded by the United States Agency for International Development (USAID) and the Ministry of Agriculture and Rural Development (MARD) officially launched the Vietnam Forests and Deltas climate change project in Nam Dinh province in January, 2014. The estimated $26 million project supports Vietnam's goals for climate-resilient, low emission, sustainable development by improving land-use planning, forest and natural resource management and engaging communities in development of action plans to address climate change impacts.

Below are some of the activities related to climate change mitigation and adaptation in the province:

- Completion of plans at provincial and industrial levels: Plans for development on production of agriculture, aquaculture and salt; forestry projection; flooding projection; irrigation projection to 2020 in according with climate change.
- At provincial and industrial levels: have issued plans on action coping with climate change for 2011 – 2015 and vision to 2050;

Despite many initiatives the province is facing a number of challenges such as:

- Higher demand for research, building performance, and technology extension models but budget for implementing these activities is limited.
- Agricultural production, particularly in rice production, has lower efficiency than other sectors. Thus agricultural labor resource is moving to other production sectors. Additionally, a number of agricultural laborers have less professional and educational qualifications, resulting in difficulties in addressing climate change impacts.
- Climate change is significantly affecting agricultural production, resulting in negative impacts on farmers' investment.

The local government is urgently seeking assistances from outside organizations/individuals to follow up:

1. Capacity building/training to:
   - Enhance educated human resources with better understanding of climate change impacts on agricultural production;
   - Strengthen capacity for officials and technicians in agricultural sector at local, district and provincial level in risk management and adaptation to climate change.
2. Support for new research and seed production, cultivation practices, irrigation management, agricultural extension models, etc in order to increase production efficiency under climate change impacts.
3. Support to develop new technology and scientific results tested successfully in agricultural production regions.

4. Facilitate and support research on adaptation measures to saline intrusion (e.g. seed testing, fertilizers and other measures); building performance modeling of adaptation measures and mitigation of greenhouse gases.
5. Help local governments enhance capacity to forecast and assess climate change impacts, saline intrusion, etc.
To a certain extent, ClimaAdapt project addresses some of these needs, but larger support is required to upscale the results to other districts and communes.

1.3.3. Socio-economic profile and gender
The impact of climate change is different for different population groups, and this applies to Vietnam and the study area as well. Climate change and gender are closely linked because (1) women, due to their social roles, discrimination and poverty are affected in different ways by the effects of climate change and by extreme climate events that often translate into disasters; (2) women are not sufficiently represented in decision making processes on climate change, or in adaptation and mitigation strategies; (3) women must be included in these processes and strategies because of their rights, because they are "more vulnerable", and because they have different perspectives and experiences with which they can contribute, e.g. to implement adaptation measures (United Nations, 2008).

Rural women and men play complementary roles in agriculture, but women tend to play a greater role in natural resource management and ensuring nutrition in Vietnam. Women often grow, process, manage and market food and other garden products and collect fuel and water. Men, by contrast, are generally responsible for cash crops and larger livestock (FAO, 2003, cited in BRIDGE, 2008). Additionally, as stated by Schenk-Sanbergen (2002), women in coastal communities depend on available natural resources for augmenting their families' diets and income. Women are responsible for local fish processing and distribution. Additionally, women prepare baits, mend nets and tend equipment. Women also forage in water, rivers, swamps and lagoons for shells, seaweed, shrimps, crabs and shellfish for food or for sale in local markets. Their labor, however, is often less visible than men. Women seldom own the equipment or machinery used to harvest natural resources. Moreover, women rarely own or control access to the resources they harvest. The more important natural resources, in fact, are seldom subject to private ownership. Thus, subsistence and market-driven harvesting activities of women often escape the attention of researchers who are more attentive to the environmental and biological issues involved in baseline resource assessments. High dependency on land and natural resources for livelihood generation makes women more vulnerable. Vietnam has more than 12 million women farmers. Almost all of the new participants in the agriculture sector are women. One half of men and two thirds of women in rural areas still have their main job in agriculture (United Nations, 2008).

A recent study done in Giao Thuy – a coastal district of Nam Dinh, shows that there is a high dependence on agriculture for sustaining livelihoods. Though agricultural productivity is low, for many households agriculture provides a stable income, e.g. growing rice is for food security and raising livestock and poultry provide subsidiary income. Women's role in agriculture is vital. While men concentrate more on land preparation, transportation and pesticide spraying, women tend to do weeding, transplanting, fertilizing, watering, and selling products. They share the work of harvesting and storing agricultural goods. In families, husbands tend to go out for paid employment or to work in aquaculture, while women do most of the agricultural work alone.

In the ClimaViet project, a survey on current status of the local rice cultivation production as well as the local people's awareness of climate changes was conducted. A brief overview of the results is provided below in the present report. The detailed results will be provided in another report due in 2015.

Survey data in Thinh Long and Rang Dong, Nam Dinh:
About household heads:

- Table 2 shows that mean age of household heads ranging from 43 to 44 years old. The households have experience in agricultural production (about 20-25 years) especially rice cultivation and have good awareness of climate change impacts.
- Education of household heads at Rang Dong farm was higher, with 9.03 years of schooling on an average, and also a focus on vocational education.
- Household size and number of labor per household did not significantly differ. Number of labor/household was 2.39 working in farming sector, with a per capita area of 0.3 ha.
- Land use pattern in two communes has changed over the last 3-4 decades through governmental agricultural policies, thus number of parcels for each household was, on average, 1.2 ha and suitable for rice production.

Table 2. Information on households and farming owners in two selected communes

Items	Thinh Long	Rang Dong	Mean
Mean age (years)	43.93	43.28	43.60
Schooling (years)	7.93	9.03	8.48
Experience in rice farming (years)	25.33	17.78	21.55
Household size	4.75	4.94	4.88
Number of labor per household	2.30	2.48	2.39
Per capita cultivated land (ha)	0.27	0.31	0.29
Farm size /household	1.23	1.20	1.21

Source: ClimaViet survey data in 2013

The sources of household income:

Table 3 indicates that income of households in Thinh Long commune was about twice that of a Rang Dong farm, because households in Thinh Long focus on cultivating more of other crops and developing an aquaculture sector. Diversity of crops helps farmer households increase their income and better adapt to climate change impacts in Nam Dinh. It is worth noting that crop diversity is a good approach to adapt and mitigate climate change impacts now and in future. However, the major percentage of income of farmer households in Thinh Long and Rang Dong still depends mainly on rice production; therefore, improving productivity and marketing through application of technical and scientific processes in rice production is highly desired.

Table 3. Mean household yearly farm income in Thinh Long and Rang Dong farm in 2013

Items	Thinh Long (VND million)	Rang Dong (VND million)	Mean
Income from rice farming	9.84	9.02	9.43
Income from other crops farming	10.34	0.38	6.03
Income from industrial activities and aquaculture	6.12	2.12	4.42
Other non-farm incomes	4.43	7.07	5.71
Mean household yearly farm income	**30.7**	**18.6**	**25.6**

Source: ClimaViet survey data in 2013

As presented in Figure 4, the highest income of households came from rice production with 37%, while income from other crops, husbandry and fishery were 24% and 22%, respectively. In general, the income from growing rice is very low. Households' income was much lower in two surveyed communes than average income in other regions of Red River Delta. To increase income and improve the living conditions for farmers, relevant solutions and policies need to be introduced to strengthen rice production in combination with livestock development, enhanced crop structure, and decreasing of unemployment rate in agricultural sector, etc.

In terms of rice production, farmer households in Thinh Long had higher rice yield and production than at Rang Dong farm (Table 4). Additionally, most of farmers at Rang Dong farm stored rice for

their own consumption. It should be noted that rice production in Nam Dinh should be improved not only to increase farmers' income, but also ensure food security within production regions that are vulnerable to natural hazard.

Table 4. Rice production and rice use of household heads in two communes surveyed in 2013

Item	Thinh Long	Rang Dong	Mean
Total rice production/household head (kg)	1,616.12	1,278.61	1,442.58
% rice production stored by farmers for consuming	51.18	64.57	57.39
% rice production for sale	48.79	35.36	42.56
% rice production for cultivation	0.03	0.07	0.05

Source: ClimaViet survey data in 2013

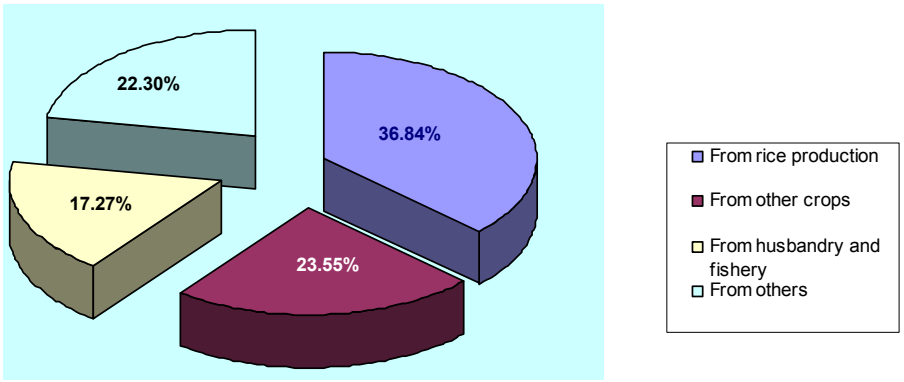

Figure 4. Structure of household income in the two surveyed communes

Farmers' perceptions of changes in climate:
Farmers were asked about their perception of long-term changes in climate. In particular, they were asked, "Have you noticed any changes in weather from year to year in the past 30 years? If so, what changes have you noticed? Farmers' perceptions on each climatic parameter change are presented in Table 5.

- In the present investigation, it was observed that about 93% of the respondents found increasing temperature during the past 30 years. Also, fresh water source for agricultural irrigation and farmers' consumption has been affected significantly by salinity, especially in the estuary. As a result, saline intrusion causes adverse impacts on rice cultivation in particular, and agricultural practices.
- According to responses of farmer households surveyed in both the communes, irrigation water sources from rivers have declined, especially in the dry season.
-

Table 5. Specific changes in climate noticed in the past 30 years (percentage of farmers reporting).

Phenomena related to climate change	Number of respondents	Increase	Decrease
Temperature	80	92.50	7.50
Variability in rainfall patterns	77	76.32	23.68
Salinity intrusion	80	76.06	23.94
Water scarcity for irrigation	76	15.79	84.21

Source: ClimaAdapt survey data in 2013

Farmer households' perceptions to climate change adaptation strategies:
Table 6 shows farmers' responses to the possible technology interventions to reduce vulnerability to climate change and variability. The results show that a high percentage (up to 90%) of the households

agreed to use stress-tolerant crop varieties to adapt to changing climate conditions. However, about 16% of the households in the survey said that they had not adjusted their farming practices or moved to other activities in response to climate change, while more than 50% of households shifted to improved cropping systems or other activities. A range of farming practices that the farmers had agreed to adopt in response to perceived climate change, includes using new crop varieties with various planting and harvesting dates (up to 70%), changing fertilizer application and land management practices (about 60-80%), the application of pest and disease management techniques such as Integrated Pest Management - IPM (80%), development and use of crop varieties resistant to pests and diseases (up to 80%). However, about 35% of the farmers said that instead of using short-duration rice varieties they preferred to use traditional rice varieties, such as TBR45, Nhi Uu 838 and Bac Uu 903 because these varieties are suitable to climate conditions of autumn cropping season and cultivation practices. More importantly, most of the surveyed farmers preferred to use new crop varieties which are well-adapted to changes in climate and natural hazards rather than using pest tolerant crop varieties.

Table 6. Farmers' perceptions of the technology interventions to reduce vulnerability to climate variability

Item	Rating				
	Highly unlikely	**Unlikely**	**Neither likely nor unlikely**	**Likely**	**Highly Likely**
Use of stress-tolerant crop varieties	0.00	2.50	1.25	23.75	72.50
Shift to improved cropping systems or other activities	7.50	16.25	6.25	16.25	53.75
Planting of early, medium or late varieties (please encircle) to avoid crop loss to variations in drought/salinity occurrence	2.50	1.25	18.75	30.00	47.50
Early sowing/production of rice to grow other additional crops	0.00	35.00	8.75	21.25	35.00
New land management techniques	3.75	5.00	8.75	46.25	36.25
Changes in agricultural water-management techniques	8.75	8.75	17.50	33.75	31.25
Pest and disease management techniques such as IPM	2.50	7.50	10.00	58.75	21.25
Development and use of crop varieties resistant to pests and diseases	1.25	3.75	12.50	60.00	22.50

Source: ClimaViet survey data in 2013

The results of our survey show that rice production plays a vital role in farmers' living standards in two study sites of Nam Dinh province. However, average household yearly income was low and depended mainly on rice production which is very vulnerable to changes in climate. Thus, farm households expect to have financial and technical support in agricultural development and mitigating climate change impacts. Farmers already perceive the impacts of climate change and expect support and also to undertake a variety of adaptation measures on their own.

1.3.4. Rice farming systems

Rice production area in Thinh Long is 266 ha, and at Rang Dong farm is 470 ha. In both Thinh Long and Rang Dong commune rice is produced in spring and summer seasons. Salinization in the spring season is more serious than in the autumn season due to lack of fresh water. Popular rice varieties planted in these communes include Nhi Uu 838, Tap Giao, BT7, Tam, and some local sticky rice varieties. A majority of the farmer households apply chemical fertilizers and pesticides in rice.

1.3.5. Knowledge development and transfer mechanisms

In Vietnam, the National Agricultural Extension Center (NAEC) is located in Hanoi within the Ministry of Agriculture and Rural Development (MARD) and also maintains an office in Ho Chi Minh City. The Center is a focal point for countrywide extension covering agriculture, livestock, forestry, fishery and rural industry. It synthesizes extension demands received from extension agencies and farmers, provides guidelines on preparing extension messages, extension methods, and the monitoring and evaluation of extension activities, prepares annual reports for the Ministry, directly handles central level extension communication and cooperates with relevant organizations in training matters, organizes and participates in contests, festivals, workshops, exhibitions and fairs related to extension in all seven ecological zones, and cooperates with other scientific technical departments to identify improved technologies for farmers. Key activities of NAEC are building up demonstration models, information dissemination and propaganda/advocacy, training and education, consultancies and provision of services, and international cooperation.

Agricultural extension systems were established at national, provincial, district and commune levels, with a wide range of functions and tasks. For example, Provincial Agricultural Extension Centers, one in each of the 64 provinces of Vietnam, perform the following functions: (1) propose extension projects that suit the provincial conditions; (2) provide extension guidelines at district level and cooperate with district offices to carry out extension activities; and (3) directly implement extension communication and training activities for district extension staff and key farmers in the provinces. In each province, District Extension Stations which are under the control of the provincial agricultural extension offices or the District People Committees, have the following functions to perform: (1) directly carry out extension activities; (2) offer training courses for commune/village extension staff; (3) organize training programs for farmers. The commune/village level extension offices, located in about 97% of the communes, perform the following tasks: (1) mobilize farmers to participate in extension activities; (2) convey farmers' needs to higher level; and (3) directly implement extension activities at the village level. In 2012[1], total extension personnel in Vietnam were about 35,000. In terms of the plant protection advisory system in Vietnam, Plant Protection Department (PPD) under MARD has functions and tasks as follows: (1) carry out plant protection extension activities; (2) administer plant quarantine activities at the national level; (3) conduct pesticide management including pesticide registration and residue control; and (4) deal with food safety.

According to information updated by Global Forum for Rural Advisory Services (GFRAS), there are no established private companies that provide extension services to farmers on regular basis. A semblance of private services, however, appears in the form of payment for consultancies, technology introduction, product consumption, service contracts with agricultural entrepreneurs, research institutes, universities, etc. Also many farmers, especially in southern Vietnam, pay for commercial services. Most private agricultural companies sell farm inputs to farmers, or run animal breeding farms or are engaged in exporting and importing agriculture-related materials such as plantation or crop seed, chemical fertilizers, pesticides and farm machinery and equipment. Moreover, there are many national and international NGOs in Vietnam engaged in a variety of agricultural and rural community development activities. A group of eleven NGOs spent almost 2.3 million USD on nine projects within the country, in the fields of agriculture, forestry, aquaculture and irrigation, during the first six months of 2011.

[1] Source: Agricultural Extension in Vietnam: Its Roles, Problems and Opportunities. Paper presented by Nguyen Van Bo, President, Vietnam Academy of Agricultural Sciences, at the Roundtable Consultation on Agricultural Extension, Beijing March 15 to 17, 2012.

Although there is an extension service system for farmers, the providers of agrochemicals play a key role in agricultural advisory services to the farmers. This practice is vulnerable to exploitation and mis-information because of the interest of the providers to sell their products. This can lead to over-use of agrichemicals, i.e. both pesticides and artificial fertilizers.

Pests and diseases are also one of the high risks in the rice production sector. Nam Dinh Province's Department of Agriculture and Rural Development reported that the pest infestation and the resulting rice disease had occurred during the winter-spring rice crop in many rice production areas of coastal districts, including Nghia Hung and Hai Hau – two selected study sites of the project (reported by Vietnam news in 2010). Pest and diseases have become less predictable with climate change according to the stakeholders. The main problems in the spring rice crop are rice blast, bacterial leaf blight and brown leafhopper. The rice blast and sheath blast disease are among the most devastating. Pest and disease monitoring in Vietnam is based on a Plant Protection Department protocol and written reports being disseminated on weekly basis (sample in attachment). Plant Protection Department regulates surveillance methods in rice pests and other crops in agricultural production regions. For example, monitoring protocol for plant disease is implemented at each crop growth stage: 1st assessment 30-35 days after sowing; 2nd assessment 50-55 days after sowing (booting to panicle stage initiation); and 3rd assessment 70-75 days after sowing (before harvest).

In terms of climate information in Vietnam, the Vietnam Institute of Meteorology Hydrology and Environment (IMHEN) is a functional organization for science under jurisdiction of the Ministry of Natural Resources and Environment with mandates for research and development of science and technology on meteorology, hydrology, oceanography, water resources and environment. The weather data used to be freely available for scientists, while there is now a fee for weather data delivery by IMHEN.

1.4. Climate change and impacts on agriculture and rice production

1.4.1. Climate

The northern part of Vietnam has a subtropical monsoon climate, with humidity averaging 84% throughout the year. This typical North Vietnamese climate dominates the microclimate of Nam Dinh province with somewhat cooler temperatures and a higher humidity due to its vicinity to the sea. During the winter or dry season (November - April), the monsoon winds usually blow from the northeast along the China coast and across the Gulf of Tonkin, picking up considerable moisture. Consequently the winter season in most parts of the country is relatively dry in comparison to the rainy or summer season. Lowest daily average temperatures occur in January and February with 10 to 13^{o}C and average humidity can be “relatively low” with 94% (November-December), but also reach highest average humidity with up to 98% (January- March). The monthly average rainfall varies between 87 and 118 mm. The southwesterly summer monsoon from May to October is associated with hot temperatures and heavy rain falls. Maximum daily average air temperature occurs generally in June and July varying from 29-31^{o}C. The lowest relative humidity is 86.5% and the highest relative humidity is up to 92% in July, while the monthly average rainfall lies between 87.1 within 428 mm. The climate data from Vu Ly station close to the sea (UTM WGS84 635985E, 2224922N) show the development of the potential evaporation throughout the year. Where open surface bodies, such as channels or irrigated paddy fields exist, the evaporation is quite intense throughout the year. In other areas, evaporation is limited in the dry season. Figure 5 shows monthly average temperature (^{o}C), total monthly rainfall and evaporation (mm) in Nam Dinh station.

1.4.2. Climate change scenarios

The six families of scenarios discussed in the IPCC's Third Assessment Report (TAR) and Fourth Assessment Report (AR4) are A1FI, A1B, A1T, A2, B1, and B2 base on AR4 and identical in TAR (IPCC, 2007).

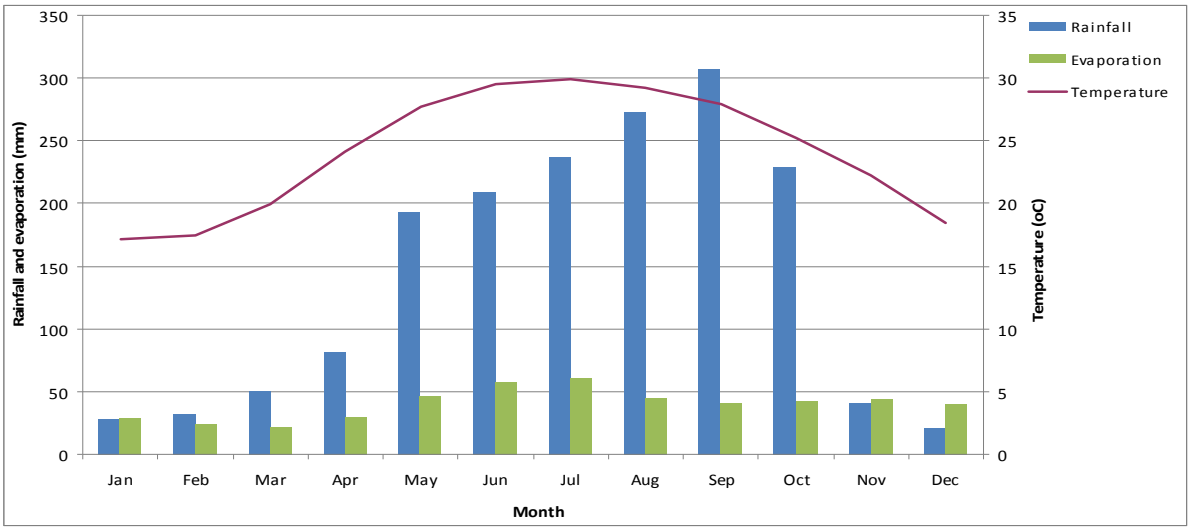

Figure 5. Monthly average temperature (°C); total monthly rainfall and evaporation (mm) in Nam Dinh

A1 Scenario

The A1 scenarios are of a more integrated nature. The A1 family of scenarios is characterized by rapid economic growth, a global population that reaches 9 billion in 2050 and then gradually declines, the quick spread of new and efficient technologies, and a convergent world - income and way of life converge between regions and extensive social and cultural interactions worldwide.

There are subsets of the A1 family based on their technological emphasis:

- A1FI - an emphasis on fossil-fuels (Fossil Intensive).
- A1B - a balanced emphasis on all energy sources.
- A1T - emphasis on non-fossil energy sources.

A2 Scenario

The A2 scenarios are of a more divided world. The A2 family of scenarios is characterized by a world of independently operating, self-reliant nations, continuously increasing population, and regionally oriented economic development.

B1 Scenario

The B1 scenarios are of a world more integrated, and more ecologically friendly. The B1 scenarios are characterized by rapid economic growth as in A1, but with rapid changes towards a service and information economy, population rising to 9 billion in 2050 and then declining as in A1, reductions in material intensity and the introduction of clean and resource efficient technologies, an emphasis on global solutions to economic, social and environmental stability.

B2 Scenario

The B2 scenarios are of a world more divided, but more ecologically friendly. The B2 scenarios are characterized by continuously increasing population, but at a slower rate than in A2, emphasis on local rather than global solutions to economic, social and environmental stability, and intermediate levels of economic development, and less rapid and more fragmented technological change than in A1 and B1.

For climate change in Vietnam, the climate change scenario was defined by MONRE (2012). In the project, three scenarios were applied and described in the following way:

Low emission scenario (B1): By the end of the 21st century, annual mean temperatures in Northern climate zones would increase by 1.6 to 1.9°C relative to the baseline period (1980-1999). The increase

in temperature in Southern climate zones is expected to be less than that of Northern climate zones and is about 1.1 to 1.4°C.

Medium emission scenario (B2): By the end of the 21st century, annual mean temperatures would increase about 2.6 °C in the North West, 2.5°C in the East West, 2.4°C in the North Delta, 2.8°C in the North Central, 1.9°C in the South Central, 1.6°C in the Central Highlands, and 2.0°C in the South compared to the average of 1980-1999.

In the high emission scenario (A2): By the end of the 21st century, annual mean temperature in Northern climate zones would increase about 3.1 to 3.6°C relative to the average of 1980-1999, in which, North West: 3.3°C, North East: 3.2°C, North Delta: 3.1°C, and North Central: 3.6°C. The change in temperatures in the Southern climate zones is 2.4°C in South Central, 2.1°C in the Central Highlands, and 2.6°C in the South.

Climate change scenarios of B1, B2 and A2 were generated for Nam Dinh site for years 2020, 2030, 2040 and 2050 with daily resolution and formatted for DSSAT and Aquacrop crop growth modeling software (in the attached files) and these scenarios can be summarized in Table 7.

Table 7. Seasonal temperature change and percentage of rainfall change in Nam Dinh in 2020, 2030, 2040 and 2050 compare with baseline period of 1980-1999

Season	**B1 Scenario**							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.5	0.8	1	1.3	0.9	1.2	1.8	2.1
Mar.-May	0.6	0.9	1.2	1.5	-1.3	-2.0	-2.7	-3.4
Jun.-Aug.	0.3	0.5	0.7	0.8	2.9	4.4	6.1	7.5
Sep.-Nov.	0.4	0.6	0.8	1.1	0.9	1.4	1.9	2.4
	B2 Scenario							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.5	0.6	0.7	0.8	-0.6	-0.7	-0.8	-1.2
Mar.-May.	0.4	0.5	0.6	0.7	2.0	2.6	3.3	3.9
Jun.-Aug.	0.5	0.6	0.8	0.9	0.8	0.9	2.2	1.3
Sep.-Nov.	0.4	0.5	0.6	0.7	0.7	0.8	1.0	1.1
	A2 Scenario							
	Temparature changes				% Rainfall change			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.5	0.6	0.7	0.8	-0.6	-0.7	-0.8	-1.2
Mar.-May	0.4	0.5	0.6	0.7	2.0	2.6	3.3	3.9
Jun.-Aug.	0.5	0.6	0.8	0.9	0.8	0.9	2.2	1.3
Sep.-Nov.	0.4	0.5	0.6	0.7	0.7	0.8	1.0	1.1

In these scenarios, it seems that temperature keeps increasing all the time and seasons whereas, rainfall both increases and decreases.

1.4.3. Climate change impacts on agricultural production

Agricultural activities in Nam Dinh province not only suffered and expereinced high damage, but were also directly affected by the consequences of climate change. According to the evaluation

results compiled from many sources, including the results of previous studies and annual reports of Nam Dinh province on climate change impacts on agricultural production and rice, the impacts are likely to be as follows:

Severe damage to agricultural production due to storms and floods: According to statistics of the national flood prevention committee, the period 1989 and 2010, Nam Dinh endured 26 hurricanes and, 1 cyclone and 4 major floods causing damages to agriculture up to the trillion.

- In the 2003 crop, heavy rains during the paddy stage caused flooding of nearly 50,000 hectares (submerged 2/3 of paddy plant) and overall yields were decreased by about 30-45%. The value of damage was estimated to be about 500 billion VND.
- In the 2005 crop, storm no.7 with heavy rains during the harvesting stage of paddy nearly submerged 70,000 hectares of paddy crop, causing a yield decrease of nearly 40%. The value of damage was estimated to be about 1,000 billion VND. In addition, storm No. 7 heavily eroded some critical coastal dykes.
- In the 2007, 2009, 2010, 2011 crop, heavy rains caused serious flooding in thousands of hectares of new paddy.

Thus, the impact of hurricanes on agricultural production is very large and difficult to prevent. However, initiatives and prioritization of activities to prevent and deal with the consequences after storms and flooding should be a top priority in order to stabilize production. There is a need to actively develop appropriate farming techniques to restore agricultural production after floods, including alternative cropping systems, crop conversion, land management techniques for areas intruded by sea water, and improved resilience in sensitive areas.

Damage caused by extreme weather events: The annual dry season (Winter-Spring season - from November last year to April year after) often has unusual droughts and prolonged dry periods. The results of the province showed 11,000 hectares of arable land suffering from severe dehydration and 52,000 hectares of paddy land in six Southern districts facing difficulties due to unusual droughts and lack of water supply for irrigation.

Due to extreme, unpredictable and unusual weather events, it is often difficult to actively cope with them. Therefore, research needs to develop farming techniques and land protection measures.

Severe damage to agricultural production due to salinity in the coastal districts:

Taking salinization boundary in Nam Dinh which was 0.1% per year, the largest salinization boundary up to now occurred in Dec 2009 (0.1% saline boundary in the Red River is at drain-gate (next to Mom Ro): in Ninh Co river: Muc 1 drain; in Day river: Tam Toa drain). Despite the breakwater system being almost completed, the saltwater intrusion is up to 34.5 km on the Red River system, 37.5 km on Ninh Co River system and 30.5 km on Day river system.

Saltwater encroachment in Nam Dinh has affected over 38,000 hectares of arable land within the districts of Giao Thuy, Hai Hau, Nghia Hung, Xuan Truong and Truc Ninh annually due to drought, storm surges and saltwater intrusion. In particular, there are over 12,000 hectares of arable land within the three coastal districts (Giao Thuy, Hai Hau, Nghia Hung) severely affected by salinity (salinity ranging from 1.2 to 3 ‰, and in some years even over 4 ‰), so it is very difficult to grow rice using the current varieties available, especially in the first crop. Rice yields in saline coastal areas often decrease by 20-30% compared to other places, while irrigation costs are higher (Table 8).

Table 8. Distance to coast of saltwater intrusion in the river systems in Nam Dinh

River	Medium (km)		The largest (km)	
	1‰(g/l)	5‰(g/l)	1‰(g/l)	5‰(g/l)
Hong River	14	12	34,5	31
Ninh Co River	13	12	37.5	33
Day River	10	6	30.5	25

Source : People's Committee of Nam Dinh province

Based on the impact of climate change on agricultural production in saline areas, it is really important to proactively prevent and adapt to saline lands and provide a choice of saline resistant crop varieties to farmers, appropriate farming techniques to limit the negative impact of salinity on the crop growth, development and yields in areas with the high risk of damage in Nam Dinh.

1.4.4. Ongoing projects related to Climate Change in Nam Dinh

Low carbon agriculture project:

- Funded by Asian Development Bank (ADB) (2013 – 2019)

Low-carbon agricultural production technologies will be transferred to local farmers, focusing on treating waste generated from animal breeding and farming.

Vietnam forests and deltas (VFD) project funded by USAID: Its major objectives are to accelerate Vietnam's transition to climate resilient, low emissions development through investments in reducing net emissions from forests and enhancing resiliency of people, places, and livelihoods in the delta regions to short and long-term climate impacts.

1.5. Major challenges from climate change in Nam Dinh

1.5.1. Stakeholder concerns and some key challenges to climate change

The Deputy Director of DARD, Nam Dinh (Mr. Do Hai Dien) and other officials at a workshop in November 2013, shared their concerns about the impacts of climate change in the province. There are 80,000 ha of rice land in the Nam Dinh Province and the main challenges are irrigation water, as there is a shortage of fresh water for flushing out salts. Sluice gates are used to prevent saltwater intrusion with the extent of intrusion varying from year to year. Fresh water has to be brought from upstream and there is no certainty of fresh water availability due to droughts in some years. About 12,000 ha are affected by salinity each year in the province and a serious problem to be addressed. New rice varieties and improved crop and land management are important to address these dual constraints. Policies on how to manage irrigation water for climate change are required. There are no projects addressing salinity problems at present and thus ClimaViet project is quite relevant and the results from the project can be useful to the province according to the stakeholders. The Vietnamese government has invested in irrigation infrastructure and dams, building sluice gates/walls to prevent sea water intrusion. However, this involves heavy costs in the establishment and maintenance.

1.5.2. Provincial government initiatives and priorities for climate change adaptation and mitigation measures

The Central Committee for Storm and Flood Control, under the Ministry of Agriculture and Rural Development, coordinates disaster management activities like the Department of Dyke Management and Flood and Storm Control, the Disaster Management Centre, the Hydro-meteorological Service, and the Vietnam Red Cross. It main activities are monitoring the effects of storms and floods, gathering damage data, providing official warnings, then co-ordinating and implementing disaster response and mitigation measures. CCSFC relies on the administrative structure of the Dyke Department to carry out its disaster assessment, disaster reporting, and emergency co-ordination duties. To act efficiently at a provincial level, a disaster communications system (emergency mail alert) is used. In each province there a Provincial Committee for Storm and Flood Control has been established. Members are Province's Department of Agriculture and Rural Development.

Stakeholders and local authorities in Thinh Long commune suggested ClimaViet project to look at the following measures:

- Rice varieties: salt tolerant rice varieties which have not only high yield but also good quality and can be tolerant to salinity from 2.5 ppt to 4 ppt.
- Soil management: application of no-tillage and no chemicals; or application chemicals to decompose rice root after harvesting quickly but they are friendly to environment;
- Cropping systems: growing new crops (e.g. peanut, maize) on rice lands, especially in the spring season, which could give high income to farmers.
- Advanced technology in nutrient/fertilizers that reduce greenhouse emissions.

Crop management measures:

- Using salt tolerance rice: province has tested some salt tolerance rice and identified three Chinese hybrid rice varieties suitable for salinized areas: Nhiuu 838, On uu, Thai Xuyen 111 (tolerant to 2.5 ppt of salinity).
- Thai Xuyen 111 (TX 111– sold at price of 130.000VND/kg seed) has not only good tolerance to salty conditions but also good quality, 30 kg seed/ha.
- The commune has applied the System for Rice Intensification (SRI) but modified technique needed to suit the salty conditions.

1.6. Baseline/Benchmark indicators

Benchmark indicators suggested for the study in Nam Dinh province include: exposure indicators, sensitivity indicators, indicators of adaptive capacity (agro-economic and infrastructural indicators).

Sensitivity indicators to be considered are:

- Cropping patterns: spring rice – summer rice – fallow
- Small farmers and adaptation of the results

Agro-economic indicators:

- Mean income per household (VND/household)
- Total income from rice production/household (VND/household)/ current and future
- Benefit cost ratio per ha

Infrastructural indicators:

- Distance from field to fresh water sources
- Irrigation systems and distance from field to the coast

Exposure indicators:

- Yield loss in % caused by salinity compared to potential yield in spring season
- Yield loss in % caused by salinity compared to potential yield in summer season

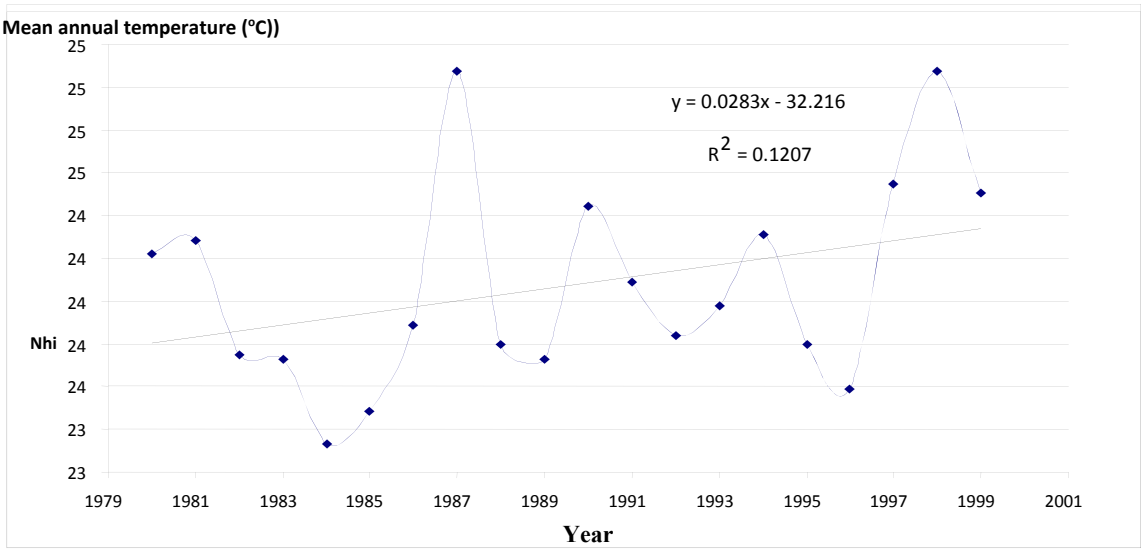

Figure 6. **Trend of temperature from 1980-1999 in Nam Dinh**

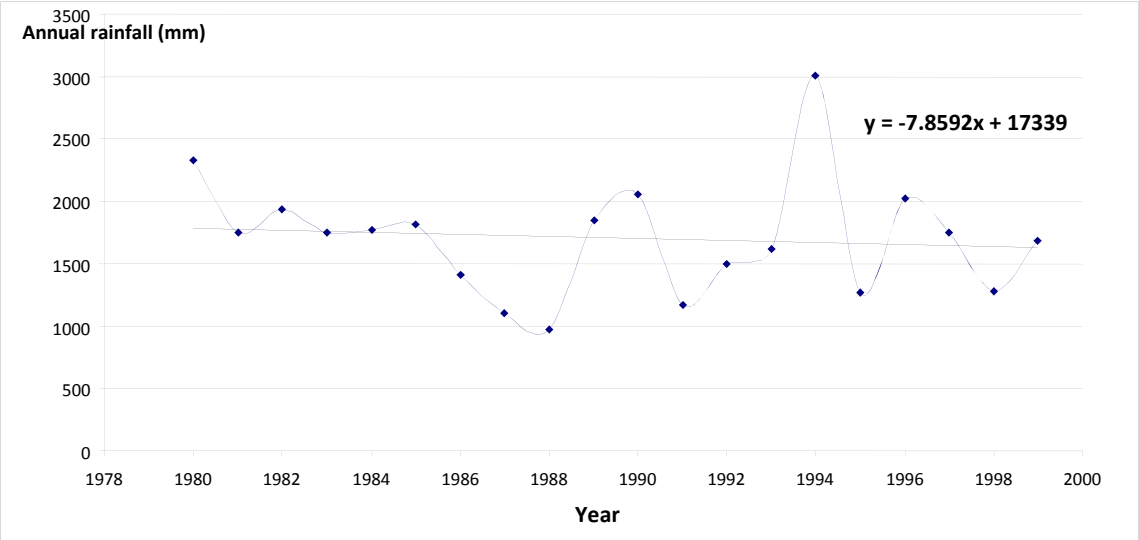

Figure7. Annual rainfall trend during the time 1980-1999 in Nam Dinh

Climate indicators:

Observed climate data of the last two decades showed that temperature in Nam Dinh tended to increase. This coincides with findings of national climate change study (Figure 6). The observed climate data for yearly rainfall has a slight decreasing trend with high variability during the last two decades (Figure 7).

Climate change indicators are summarized in Table 9.

Table 9. Vulnerability due to climate change impacts

No.	Impact factor	Sensitive, vulnerability region	Sectors/field vulnerability
1	Temperature increase	Whole province but coastal areas most strongly affected.	• Agriculture (crops, livestock, fisheries) and food security) • The natural ecosystem, the biodiversity • Energy (production and consumption) • The public health
2	Rising sea levels	The coastal districts and areas with low-lying terrain in the districts Nghia Hung, Hai Hau and Giao Thuy	• Agriculture (crops, livestock, fisheries) • The marine ecosystems and coastal • Water resources (surface and groundwater) • Infrastructure and tourist resorts (Quat Lam, Thinh Long) • Place of residence; community health
3	Hurricanes and tropical depressions	Coastal strip in the districts: Nghia Hung, Hai Hau, Giao Thuy	• Agriculture (crops, livestock, fisheries) • The activities on coastal and marine • Infrastructure and transport, sea dikes • Houses and means of aquatic resource exploitation • Place of residence; community health
4	Drought	Occurs locally in some districts: My Loc, Vu Ban, Truc Ninh	• Agriculture and food security. • Water resources (surface and groundwater) • Water transportation • The health and living
5	Saltwater intrusion	Mainly occurs in the districts: Nghia	• Agriculture (crops, fisheries) and food security • Water resources (surface and groundwater)

		Hung, Hai Hau, Giao Thuy.	• Land resources • People's life • The biodiversity
6	The extremist climatic phenomena (*)	Whole province and especially the coastal areas	• Agriculture (crops, livestock, fisheries) • The health and living

(*): Including the phenomenon: abnormal heat waves, unusually of rainy days, storms, cyclones, tornadoes.

Rice yield declined by 7.2 % to 32.6 % and yields of other crops declined by 4.1 % to 32.9 %. The largest yield reduction can be with either the Dry or Wet scenarios, depending on crops.

1.7. Interventions planned

Based on the results of survey and conditions in Nam Dinh, the interventions to be conducted in this province are:

- Choosing salt tolerant rice varieties which give high yield, good quality and resistance to main pests and diseases on rice.
- Applying new forms of fertilizer (urea, biochar, compost) to reduce the amount of fertilizer used and to reduce greenhouse gas emissions, as well as to increase the effect of fertilizer on growth of rice crop.
- Improving knowledge of farmers and stakeholders about climate change and its impacts on agriculture through improved access to agroclimatic information, e.g. weather forecasts, pest & disease risk forecasts, and then to encourage them to adapt to climate change and improve agricultural production, especially in rice production.
- Improving role of women in rural areas because of their important role in agricultural production and the fact that they are more vulnerable than men.

II. Part 2 – Tra Vinh province

2.1. Introduction

Tra Vinh province lies in the coastal plain region of the Mekong Delta, with 65 km long coastline traversing through nine communal localities and townships in three districts: Duyen Hai, Chau Thanh Bridge and Horizontal, with nearly 17,500 households living in these areas. The coastal districts have nearly 55 km long coastline. Tra Vinh is among the provinces most vulnerable to rising sea levels and salt intrusion in Vietnam. If the sea level rises by one metre, about 45.7 % of Tra Vinh's land area will be flooded. In the last five years, seawater has surged 500 – 800 metres inland and eroded land in Hiep Thanh commune, Duyen Hai district. Saline intrusion has a huge impact on the lives of many households. In particular, there have been a number of large investments made to build dikes, but these have been washed away, forcing investors to rebuild.

Tra Vinh Province is strongly influenced by coastal monsoon tropical climate, especially the strong impact of the northeast wind. The rainy season in the saline regions is often later than upper regions, nearly 1-2 weeks and ends earlier. Total rainfall from mid to low (1,598-1,227mm) distribution decreases from the north to the south. The average number of rainy days ranges from 77 to 118 days. The evaporation is high with an average of 1,293mm/year, especially the evaporation rate in Duyen Hai district is much higher than annual rainfall, causing salt capillary action and concentrating salt on the surface and making land bad and difficult to use. Drought often occurs every year, making it difficult for production in the days without raining continuously from 10-18 days, including two phases: the first crop drought (June, July) and Chang drought (July, August) in which the Chang drought often is more severe.

Tra Cu bears terrain characteristics of the coastal plains with many sand dunes parallel to the coast, and over 2 m high elevation. Located in the tropical areas of coastal monsoon (there are two distinct rainy and dry seasons in a year) and is very favorable for agricultural production. The average

temperature ranges from 24.9 to 28.5ºC and the total annual average rainfall is about 1,900 mm. The land west of Highway 53 suffers from saltwater intrusion in the dry season, mainly from the Hau River, mostly in Tra Cu, Total Long, Vam Ray.

2.2. Project area location and basic features

Don Xuan commune of Tra Cu district which is representative area for salinity and drought has been selected as the project study area (Figure 8). The total natural area of Don Xuan Commune is 2,621 ha out of which 2,230 ha is under agriculture (1,519 ha for rice). The total population is 14,048 with 7,574 females. Total number of households is 1,607 and the poverty rate is 28.62%. In this province, up to 60% of the people are Cambodian (Khmer). Average farm size is 0.5 ha and 50% of the area is affected by salinity, with 20 ppm salinity in the irrigation water. The annual income per capita is 3 million VND (about AUD 150). The commune is divided into two land-use areas: 53% of the area has very high salinity and is used for shrimp culture and rain-fed rice, and the rest 47% of the area has two rice crops per year.

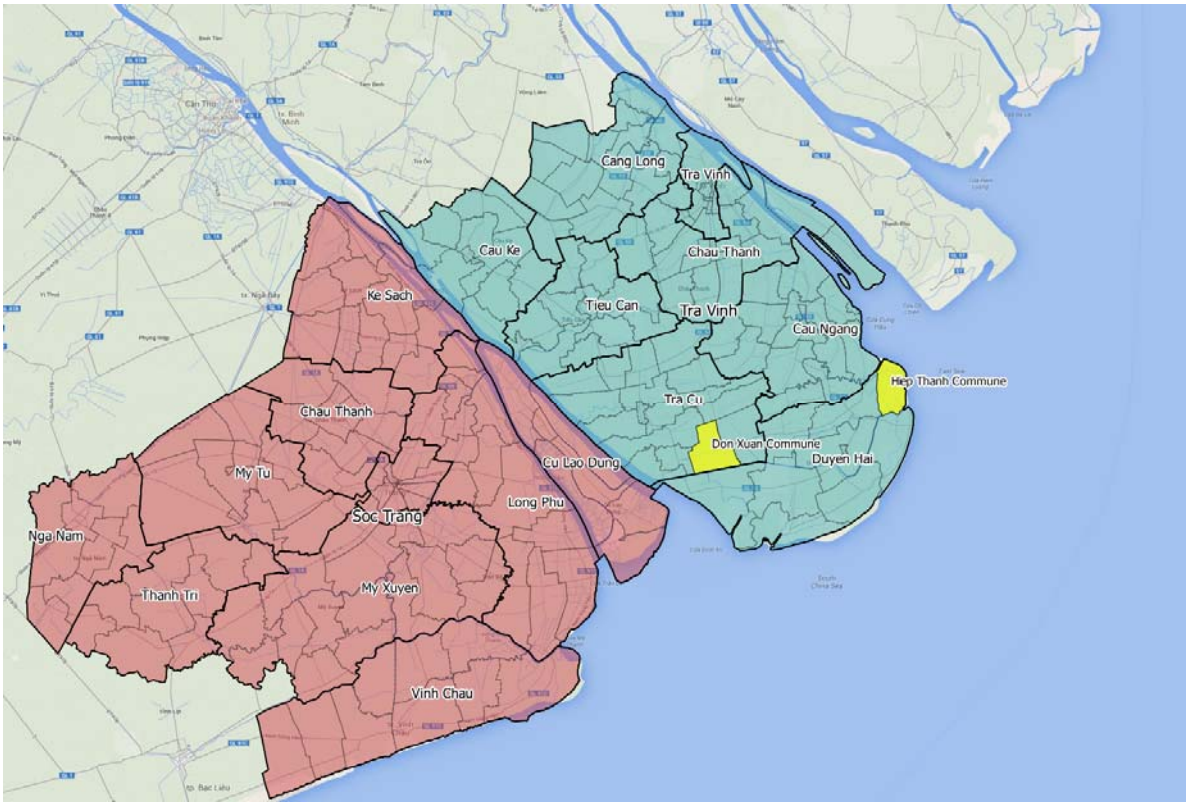

Figure 8. Province borders of Soc Trang and Tra Vinh, with Don Xuan commune shown in yellow.

A stakeholder meeting was held in Don Xuan commune headquarters with participation of scientists from Bioforsk, VAAS team and local officers (Figure 9). At the meeting climate change impacts on agricultural and rice production were discussed and priorities to be addressed for ClimaViet were identified. Irrigation infrastructure is poor and pumping water is a problem and costs are high for farmers.

Drought is the number one problem and salinity number two according to the stakeholders. Drought affects crop production mainly before flowering. The fields are more elevated here, so hard to get water to fields. Farmers need to pump a lot and it is expensive. The most severe drought occurs between mid-November and May. Irrigation infrastructure is high compared with the rice fields, creating further problems.

Average grain yields are 4.5 t/ha in Wet Season 1 (May-August) and 5 tons/ha in Wet Season 2 (August-November). No rice is grown between November and May due to severe drought. Rice variety OM576 is tolerant to salinity levels up to 4 ppm, but low in quality. All crops are hand-sown by broadcasting of pre-germinated seed. After harvest, some of the crop is kept for consumption, some as seed for the next crop, and anything left over is sold for cash.

Water management is difficult. The commune has a water-release schedule and farmers plan their crop activities in line with the release of water by the commune. Therefore the management of water at the individual farm level depends on the commune's decision to open sluice gates. This commune is located far from the water source, so it's hard to get good quality water. The commune leader has not yet heard of the Alternate-Wet-Dry (AWD) water-saving irrigation technology.

Figure 9. Meeting at the with Don Xuan commune

The main challenges to rice production are: a) limited irrigation infrastructure, or b) lack of salt and drought tolerant varieties. The highest priority, according to the commune leader is to develop and make available drought and salt tolerant varieties which may be more effective than improvement in irrigation infrastructure that may be much harder (and more expensive) to achieve. Currently it is not even possible to flush the soil to reduce soil acidity because there is not enough water. Farmers do not have electricity, so they have to use petrol for pumping, thus increasing the costs that farmers cannot afford. Poor transportation also limits capacity to move rice from field to market. Farmers receive no special help from the government in times of severe drought.

2.3. Land use and agriculture

2.3.1. Land use

According to the statistics in 2003, total natural area is 222,515hectares, of which land under agriculture is 180,004hectares, forestry covers 6,080hectares; specialized land is about 9,936hectares, housing land in rural area is 2,806hectares; housing land in urban area is 446hectares and unused land is 22,243 hectares. Farmers' income depends mainly on agricultural production, especially rice.

There are different cropping systems in Tra Vinh province. The area with triple rice system with three rice crop seasons:

- Winter-Spring season: (dry season) from November/December to March/April
- Summer-Autumn season: (1st wet season) from May/June to August/September
- Autumn-Winter season: (2nd wet season) from August/September to November/December

In the area with double rice system, there is Summer- Autumn rice and monsoon rice as following:

- Summer- Autumn season: from May/June to August/September
- Monsoon rice (or Autumn–Winter season) from August/September to November/December
- Fallow: from December to April

In the area with Rice - Rice - Upland crop system, the crop calendar is as following:

- Rice in Summer- Autumn season: from May/June to August/September
- Rice in Autumn –Winter season from August/September to November/December
- Upland crop in Winter Spring season from December to April. The upland crops are peanut, corn.

In the area with shrimp – rice system, the calendar is as following:

- Rice in Autumn –Winter season from August to November
- Shrimp is from February to May
- Fallow periods are from December to January and June to July.

2.3.2. Agriculture

- Rice covers 90,000 ha and the total rice production yearly is about 1.15 million tons.
- Area under coconut is about 14,500 ha and the total production yearly is 130 million.
- Sugarcane occupies 6,500 ha with a yield of 100 ton/ha mostly in Tra Cu and Tieu Can districts.
- Peanut area is cultivated in 4,500 ha. And annual peanut production is 19,200 tons, mostly in Cau Ngang and Duyen Hai district.
- Corn is grown in 5,700 ha and the yearly corn production is 28,000 tons, mostly in Tra Cu and Cau Ngang districts.
- Fruit trees occupy 19,200 ha and total fruit production yearly is 198,000 tons. Some major fruits include mango, pomelo, orange, mandarin orange, longan, rambutan, durian and mangosteen.
- Animal husbandry: It is mostly rearing of pigs numbering 420,000 heads/year, about cows 160,000 heads/year, other cattle include 2,000 heads/year and goats about 8,000 heads/year. Poultry is also a popular (5,300,000 in numbers).
- Area under aquaculture is 51,600 ha with a total production yearly of 163,600 tons.

2.3.3. Socio-economic profile

The total population is 1,015,300 with 500,200 male and 515,100 female. Total households include 260,589, of which 144,128 are agricultural households. The number of rice farming households are 124, 899. The poverty rate is 16.44%. Women in the province play an important role in farming.

2.4. Climate change and impacts on agriculture and rice production

2.4.1. Climate

Meteorological: Located in the Mekong Delta, Tra Vinh province also has common advantages, such as rich radiation light, high and stable temperature. However, due to the distinct characteristics of the inshore climate area, Tra Vinh province has some limits in terms of climate, such as strong northeast wind, high evaporating level and little rain, etc. Figure 10 presents the monthly average temperature (^oC) and total monthly rainfall (mm) in Tra Vinh station.

Temperature: The average temperature of the whole province is 26.6^oC, temperature amplitude between the highest (35.8^oC) and the lowest (18.5^oC), temperature amplitude between day and night is low:= (6.4^oC). In general, the temperature is fairly harmonized and the discrimination between the four seasons is not clear, only dry and rainy seasons.

Rainfall: Total rainfall is from the medium down to low level (1,588 – 1,227 mm), distributed unevenly and strongly split in accordance with space-time. The rainfall reduces gradually from North to South, highest in Cang Long, Tra Vinh and lowest in Cau Ngang and Duyen Hai. As for the

duration of rain, up to 90% of rainfall occurs in the rainy season, starting from May to November. The closer towards the sea, the shorter duration of rain occurs, meaning the rainy season starts late but finishes early. This is a significant limit to the production of this area, because the useful rainfall for cultivated crops is little. Districts enjoy the longest time of rain are Cang Long (118 days), (Tra Vinh township 98 days); those enjoy shortest time of rain are Duyen Hai (77 days) and Cau Ngang (79 days).

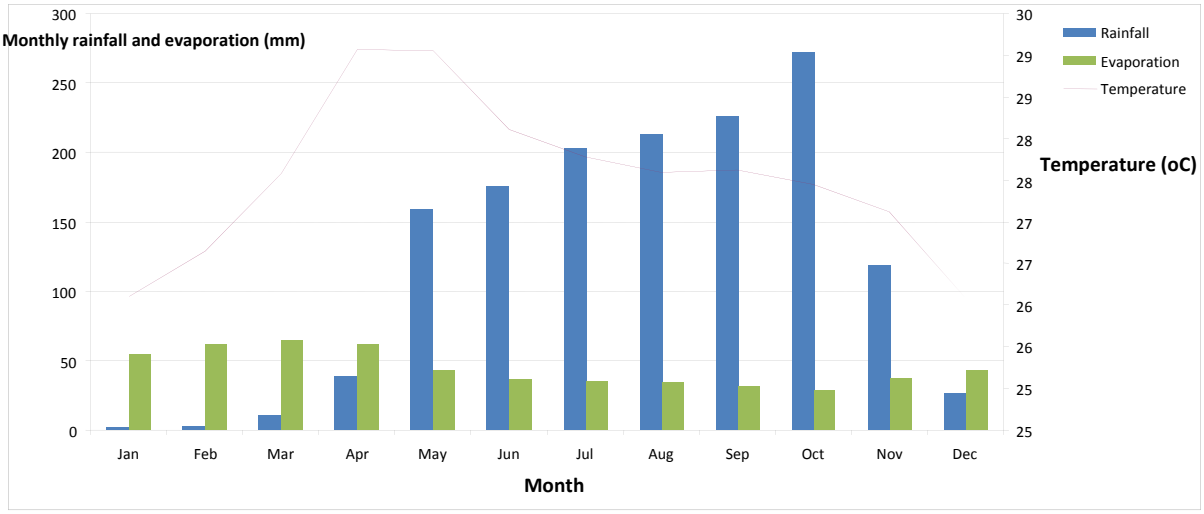

Figure 10. Monthly average temperature (°C) and total monthly rainfall (mm) in Tra Vinh station

Radiation: The duration of sunshine in the province is 7.7 hours per day, photosynthesis radiation is abundant (82,800 cal per year), which enables crops to grow in the whole year. However, with the current method of cultivation, this energy source is not utilized much, especially in the dry season.

Moisture: Annually average moisture ratio varies from 80 - 85% and tends to change in accordance with season; 79% in dry season and 88% in rainy season. The average moisture of all months is often more than 90%, creating favourable conditions for the development and spreading of some epidemic diseases.

Wind: There are two types of major winds:

South westerly monsoon: from solar May to October, winds with steam blow from the sea in the west causing rain.

Northeast wind (South northerly or south easterly monsoon): it is most widespread from November to next March in the direction in parallel with large estuaries. Northeast wind is the cause of high rising seawater and pushing the salty water deep into the inner field. The speed of wind is strongest during solar February and March (with the speed of 5-8 meters per second), especially in the afternoon. Therefore, the appearance of a salty crust because of the effect of northeast wind has affected the production during this period.

Hoarfrost: Hoarfrost appears annually, especially in the year-end months, from solar December to February the next year due to the effect of following factors: high moisture at the end of rainy season combined with lowest temperature for one year and the widespread northeast wind. Containing a considerable salt content in the air, hoarfrost has affected much to the growth of cultivated crops.

Evaporating: Total evaporating volume of the whole province is rather high with the average of 1,293 mm per year. In dry season, the evaporating volume is from 130-150 mm per month, especially in the high sand mound and the area close to the sea, causing the severe drought in these areas. As for Duyen

Hai district, the evaporating volume is higher than the annual rainfall causing the capillarity of salt up and concentrated on the surface layer. That makes soil worse and hard to cultivate.

Drought: Drought occurs annually causing many difficulties for production, with the number of rainy days not continuous, from 10–18 days. Cau Ke, Cang Long and Tra Cu are districts rarely influenced by drought. Tieu Can district is often seriously influenced by drought in the beginning of the crops (in June and July, while others, such as Chau Thanh, Cau Ngang and Duyen Hai, are more severely influenced in the mid-crop (in July and August).

2.4.2. Climate scenario

The six families of scenarios discussed in the IPCC's Third Assessment Report (TAR) and Fourth Assessment Report (AR4) are A1FI, A1B, A1T, A2, B1, and B2 base on AR4 and identical in TAR (IPCC, 2007). Similarly as building climate scenario in Nam Dinh province, table 10 shows climate scenario in Tra Vinh based climate baseline data.

Table 10. Seasonal temperature change and percentage of rainfall change in Tra Vinh in 2020, 2030, 2040 and 2050 compare with baseline period of 1980-1999

Season	**B1 Scenario**							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.6	0.8	-2.7	-4.4	-6.2	-7.7
Mar.-May	0.4	0.6	0.8	0.9	-2.6	-3.6	-5.8	-7.2
Jun.-Aug.	0.5	0.7	0.9	1.1	0.3	0.5	0.6	0.8
Sep.-Nov.	0.5	0.6	0.9	1.2	2.6	3.8	5.0	6.3%
	B2 Scenario							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.6	0.8	-3.0	-4.4	-6.2	-8.1
Mar.-May	0.4	0.6	0.8	0.9	-2.8	-4.1	-5.8	-7.5
Jun.-Aug.	0.5	0.7	0.9	1.2	0.3	0.5	0.6	0.9
Sep.-Nov.	0.5	0.6	0.9	1.2	2.6	3.8	5.3	6.8
	A2 Scenario							
	Temparature changes				% Rainfall change			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.7	0.8	-3.3	-4.5	-5.9	-7.4
Mar.-May	0.4	0.6	0.8	0.9	-3.0	-4.2	-5.5	-7.2
Jun.-Aug.	0.6	0.7	0.9	1.2	0.4	0.5	0.6	0.8
Sep.-Nov.	0.5	0.7	1	1.2	2.8	3.8	5.0	6.5

Table 10 shows that rainfall in Tra Vinh decreases more than that in Nam Dinh province and happens in the dry season (December to May) but increases in wet season (June to November). These rainfall regimes can lead to high peak of extreme event of drought in dry season and heavy rainfall with flood in rainy season.

Statistical data analysis confirms and further explains findings from participatory assessments on the occurrence and impacts of weather abnormalities on rice production in both irrigated and coastal regions. For the dry season rice crop, in both regions local farmers perceived that the return period of

the event of extremely cold temperature or of rainfall during January - February is 3 - 4 years, which causes yield loss of about 10% of the normal yield (an average of 6 tons/ha). Results from multiple regression analysis show rice yields are positively affected by temperature in January and rainfall in January and February. The effect of temperature on rice yield in the coastal region is not significant. The effect on yield losses of abnormal rainfall in February is more significant than in January, suggesting the effect of rainfall during ripening or harvesting stages. The variability of these weather variables explains 15% and 24% of total variability of rice yield in the irrigated and the coastal region, respectively. Statistical results reveal that the probability of the occurrence of temperature below 19°C in January is one-fourth and that in a range of 18–22°C temperature dropping 1°C would causes a yield loss of 0.12 tons/ha in the irrigated region. Similarly, the probability of the occurrence of abnormal rainfall above 10 mm in February is one-fourth and that each event of rainy days with 10 mm would result in yield loss of 0.3 tons in the coastal region or 0.4 tons in the irrigated region.

The Mekong River Delta is one of the three regions that will be affected the most heavily in the world due to climate change. In particular, Tra Vinh is considered to be influenced the most heavily by saltwater intrusion and droughts. With the above geographical conditions, Tra Vinh is one of the areas most severely affected by the impact of climate change in the Mekong Delta, which is seen as Vietnam's red spot of climate change scenarios. Therefore, climate change will directly affect the production and livelihoods if we do not have measures to respond right now.

2.5. Major challenges from climate change in Tra Vinh

Tra Vinh is among the poorest provinces of Vietnam, located between the two largest arms of the Mekong River. While the Mekong Delta is popular as one of the most agriculturally productive and intensively cultivated areas in Asia, the Vietnamese Mekong Delta was also identified as one of the most vulnerable regions to climate change. The population is already being affected by sea level rise, salinity intrusion, stronger and more frequent storms, floods, and changes in rainfall patterns. It is a high priority of the government to address impacts from climate change. Each province has a disaster prevention committee run by the Department of Rural Development (DARD). Until recently, saline water only intruded up to 20 km into rice cropping areas in the dry season. The intrusion of saline water is now occurring 40-60 km inland. Sluice gates are used to prevent the salt water intrusion. However, with no increase or even less water from upstream during the dry season sea water intrusion cannot currently be prevented. Hence drought and salinity are related problems. Heavy rain with high tides results in flooding. Vegetables grown on raised beds are also affected. Usually there is no rain in November, but heavy rains were observed in 2013, damaging squash, watermelon and onion. Heavy rains and high tide submerge the fields and caused damage to the crops. Frequency of typhoons was higher in the last three years and year 2013 alone recorded 15 typhoons. The more frequent typhoons, which are strong low air pressure weather systems cause increased frequency in high tides, which is the strongest factor contributing to local sea level rise.

Dykes are checked and maintained regularly to protect rice fields from typhoons. Early warning systems (a car and loudspeaker) inform local people about any extreme events. Farmers are often provided help to re-build their houses, seed supplies and food, although support varies between provinces. Local people report damage and the government responds.

Drought and salinity both limit rice yield in the Tra Vinh province of southern Vietnam. Water saving strategies are required in both seasons to conserve water resources (there is too little water for a dry season crop).

2.6. Baseline/Benchmark indicators

Tra Vinh province has high percentage of Khmer ethnic people. They constitute 86% of the population in Tra Cu district (based on baseline survey). This indicates that the intervention coping with climate change should target both Khmer and Kinh groups. Most of the lands owned by farmers were inherited and this indicates that farmers do farming from several generations; the experience from farming is transferred from one generation to the next. Thus the introduction of new interventions to cope with climate change must be suitable to integrate farmers' current experience and new innovation to

support climate change coping strategies. One-third of farmers are females and own land. Therefore, new interventions must target women groups together with men. Female farmers' are less educated, mostly at primary level. Thus, new innovation transfers to adapt to climate change must be simple, low cost and easy to implement. The majority of farmers have been affected by salinity and drought in the last 10 years. Thus interventions to cope with these are necessary. Most of the farmers sell rice products to the middlemen and are paid a low price. This shows that improving marketing is important to increase rice income for the farmer.

Climate indicators: Located in the Mekong Delta, Tra Vinh province also has common advantages, such as rich radiation light, high and stable temperature. However, due to the distinct characteristics of the inshore climate area, Tra Vinh province has some limits in terms of climate, such as strong northeast winds, high evaporating level and little rain, etc. Figure 11 and 12 show the changes in temperature and rainfall in Tra Vinh from 1980 to 1999.

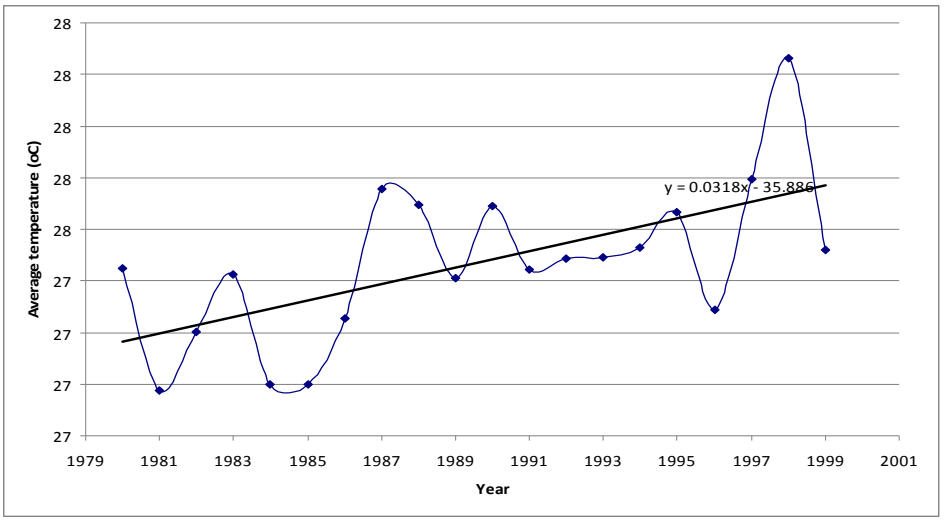

Figure 11. Trend of temperature changes from 1980-1999 in Tra Vinh

The observed climate data also showed that yearly rainfall in this province decrease in last two decades (Figure 12).

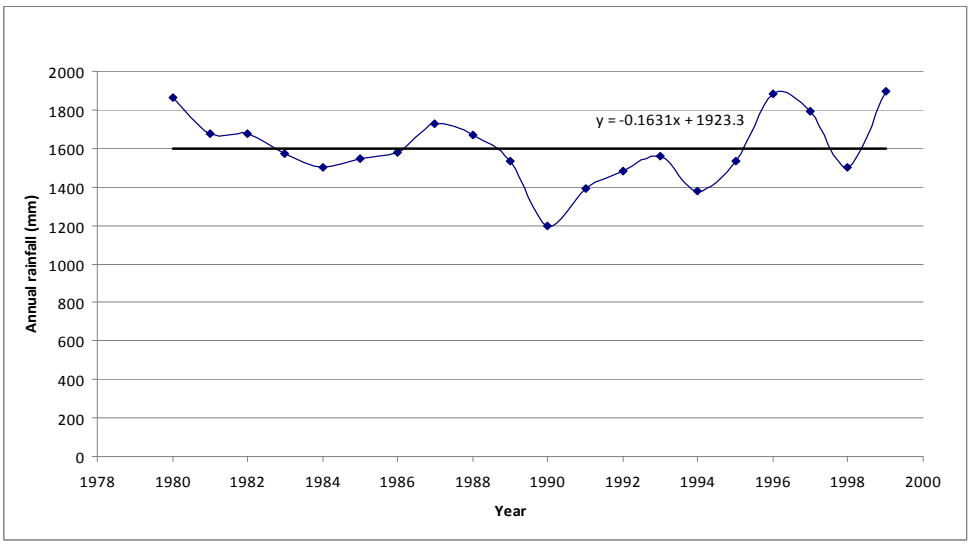

Figure 12. Annual rainfall trend during the time 1980-1999 in Tra Vinh

2.7. Interventions planned

The possible interventions in Tra Vinh are:

- rice varieties which are tolerant to salinity and drought. These should be high yielding, good eating quality, and resistant to insect pest;
- AWD to reduce water use and pumping in rice production;
- fertilizer management; and
- technologies for upland crop production.

III. Part 3: Soc Trang province

3.1. Introduction

Soc Trang is located in the Cuu Long Delta (Figure 8) with a total area of 3,223.3 km^2 and a population of 1,272,200 people, in which the Khmer account for 29%. The poverty rate is high, with 31% and 43% among the Khmer community. Soc Trang has eight districts and 105 communes, with Soc Trang town being the administrative center of the province. Vinh Chau and My Tu are the districts with the highest poverty rate of 52% and 37% respectively. The main reasons for the poverty are lack of capital and land for production, lack of employment and a low level of technology application. Consequently, the local residents still have to sell their land.

The main sources of income in Soc Trang are rice cultivation and aquaculture. Shrimp production in particular has brought rapid economic growth and as a result, large areas of coastal wetlands are now being transformed into shrimp farms. The land is sold or leased to investors, while the landless and poor local people are pushed increasingly inland. The climate in Soc Trang in particular, is suitable for agricultural, forestry and aquatic production, especially for red onions, aromatic/seasonal rice, vegetables and cereals. In recent years, however, natural disasters like storms, tornadoes, floods, landslides, droughts and saltwater intrusion occur more frequently, especially droughts and saltwater intrusion.

3.2. Project area location and basic features

Tan Hung commune of Long Phu district (Figure 13) and Lieu Tu commune of Tran De district represent areas affected by salinity and drought and hence were selected as the study sites. They are located in the coastal area of Soc Trang province. The total area of Tan Hung commune is 3,227 ha with 2,906 ha agricultural land. The area under rice cultivation is about 2,400 ha. Its population is 12,042 with 6,052 females. It has 3061 households, out of which 1,575 practice agriculture. It poverty rate is 20.19 %. The total area of Lieu Tu commune is 5,056 ha with 2,850 ha agricultural land. Area under rice is 2,850 ha. Its population is 14,720 with 7,345 females. It has 3,305 households out of which 1,580 households practice agriculture. It poverty rate is 23.42 %.

3.3. Land use and agriculture

3.3.1. Land use

Soc Trang has a natural land area of 322,330 hectares. There are six types of soil: sandy soil (8,491 hectares), silt soils (6,372 hectares), clay soil (1,076 hectares), salty soil (158,547 hectares) with many subtypes, i.e. highly salty soil, medium salty soil, less salty soil and mangrove soil, of which highly salty soil accounts for the largest area (75,016 hectares) and it is suitable for growing rice, vegetables and cereals, fruit trees and short-day and long-day industrial crops, and acidic soil (75,823 hectares). Soc Trang's forest area is 14,091 hectares, in which natural forests account for 117 hectares, planted forests 3,752 hectares and protective forests 5,278 hectares with mainly in two districts of Vinh Chau and Long Phu. Also, the province has 4,205 hectares of economic forests which are mainly used to grow cajuput in My Tu and Thanh Tri district.

3.3.2. Agriculture

Soc Trang province is a coastal province with 73.2% of agricultural land being saline or acidic. However, this is also an advantage for Soc Trang in making use of its soil and ecosystems for developing areas specialized in agricultural products with high economic value. Areas specialized in aromatic rice, fruit trees, rice – shrimp systems are typical agricultural ecosystems in Soc Trang.
Crop rotation patterns include:

- Rice – shrimp
- Model of red onions – turnips – red onions
- Model of red onions – Japanese yams – aromatic rice
- Model of red onions – tomatoes – red onions model
- Model of red onions – aromatic rice – red onions

Figure 13. Map of Long Phu district shown in red (Source: Soc Trang Department of Agriculture and Rural Development, 2013)

Additionally, planting rice season starts at the onset of rice season because it is partially dependant on rain water. The three rice crop seasons in the coastal area: Winter-Spring: December to March.

- Summer- Autumn: from April to August
- Autumn – Winter: from September to December.
- Cropping system: Rice–Rice: Winter-Spring (December–March) and Autumn–Winter (September to December).

In 2012 with the three rice crops (Winter-Spring, Season and Summer-Fall crop) the total gross rice cultivated area in the province was 365,909 ha which was 7.04% more than the plan, and 4.85% over the previous year, amounting to 16,929 ha. More than 57,000 ha area has specialty rice, fragrant rice, and it has increased nearly 3,000 ha over the same period last year (Table 11).

Table 11. Area, production of major crops in Soc Trang province

Item	Unit	Year	
		2008	2012
Cultivated area of paddy	(1000 ha)	322.3	365.8
Production of paddy	(1000 tons)	1739.5	2246.9
Cultivated area of spring paddy	(1000 ha)	139.3	138.8
Production of spring paddy	(1000 tons)	822.8	909.8

Item	Unit	Year	
		2008	2012
Planted area of autumn paddy	(1000 ha)	160.7	200.5
Production of autumn paddy	(1000 tons)	821.4	1214.6
Cultivated area of winter paddy	(1000 ha)	22.3	26.5
Production of winter paddy	(1000 tons)	95.3	122.4
Planted area of maize	(1000 ha)	3.7	3.8
Production of maize	(1000 tons)	13.4	14.1
Cultivated area of sweet potato	(1000 ha)	2.0	2.4
Production of sweet potato	(1000 tons)	21.9	28.6
Cultivated area of cassava	(1000 ha)	1	0.9
Production of cassava	(1000 tons)	8.5	7.8
Cultivated area of sugarcane	(1000 ha)	12.9	13.3
Production of sugarcane	(1000 tons)	1118.6	999.25

Source: Soc Trang Department of Agriculture and Rural Development, 2013

Rice production in Soc Trang during the past two years (2011, 2012) was continuously higher than the same period in the previous year and exceeded the target of the provincial resolution, which is mainly due to farmers applying scientific and technical advances, using pest resistant rice varieties with high yield, good quality seed and timely pest detection and treatment measures. In fact, in 2010, the provincial average rice yield was only 5.62 tons/ha, and in 2011 increased to 5.99 tons/ha and further to 6.17 tons/ha in 2012.

The province in 2012 hosted a workshop on evaluating rice varieties for summer-autumn cropping season, which selected 16 promising rice varieties including: OM 3673, OM 6976-41, OM 8017, OM 108-5, OM 5451, OM 9604-2, OM 7167-1, OM 4900, OM 9595, OM 9577-1, OM 10431, OM 6893, OM 6327 and OM 9594. These rice varieties are high yielding and relatively suitable for local soil conditions and very popular to local farmers as they have high economic efficiency. OM4900 is the current salt tolerant line with relatively high yield and quality.

In the coastal ecosystem, which is prone to negative effects of droughts and saltwater intrusion in the dry season and salt contamination in rainy season, relevant crop rotation models could be, red onions – other vegetables – red onions; red onions – other vegetables – aromatic rice; and rice – shrimps. This relationship is suitable to the coastal ecosystem in Soc Trang, but farmers need technical and institutional support. This area can support salt-resistant rice varieties such as ST1, ST3, ST5 and ST10 which mature in 100 to 115 days and they give an average productivity of 5-6 tons/ha in salt-contaminated land. Also suitable are vegetables like red onions, Japanese yams, turnips and chili, etc in sandy areas near the coast.

Meeting with DARD's staff at regional headquarters

At the meeting (Figure 14), key problems in rice cultivation in particular, and agriculture in general, due to impacts of climate change were discussed with scientists, local technical staff and DARD officials. To address the climate change-related problems in this area, it is critical to produce and test rice varieties with salt tolerance and drought adaptation and management practices as well (optimum fertilizer usage, integrated pests and disease management). Currently farmers have even tried maize cropping but crops were constrained by salinity and flooding; therefore, salt tolerant rice is the preference. Average farm site in Soc Trang is larger than Nam Dinh, with about 1ha. Direct seeding is more popular with very few farmers transplanting. The meeting also discussed other issues such as water management, fertilizer application, pests and disease management, rice harvesting methods, post-harvest practices, and other issues.

A scientist from Cuu Long Delta Rice Research Institute (CLRRI) stated that there have been attempts to introduce maize as a third crop, but without any success due to water logging and salinity. He suggests that farmers should be encouraged to try salt tolerant rice varieties. In southern region, CLRRI is one of the main crop breeding centres and also a partner in ClimaViet. Some rice varieties such as OM 697, OM667 and OM4900 were introduced in the province, with rice yields ranging from 4 to 7 tons/ha depending on cropping season in a year. However, they need to be tested under proper management conditions. A short duration variety IR 504 is recommended for March – June (spring-summer). It is easy to grow but has low salt tolerance and low quality in general and most suitable for processing. Pests (e.g. leaf folder and case worm) and diseases (blast, leaf blight, seed blight) are also a major problem affecting directly the rice yields in the province.

Figure 14. Stakeholder meeting at Soc Trang Center for Crop Seeds.

3.4. Climate change and impacts on agriculture and rice production

3.4.1. Climate

Soc Trang lies within the monsoon climate with two discrete seasons. The temperature is high, with an average temperature of 26-27^{o}C. Figure 15 shows Monthly average temperature (^{o}C) and total monthly rainfall (mm) in Soc Trang station. The thermal radiation is also high, with 140-150 kcal/cm^2 and the average humidity is around 86%. The number of sunny hours is 2,372 hours/ year. The rainy season is from mid-May to November and the dry season from December to the next May. The average yearly precipitation is 1,799.5mm, in which the precipitation in the dry season accounts for only 2 to 6%. The climate in Soc Trang in particular, is suitable for agricultural, forestry and aquatic production, especially for red onions, aromatic/seasonal rice, vegetables and cereals. In recent years, however, natural disasters like storms, tornadoes, floods, landslides, droughts and saltwater intrusion occur more frequently, especially droughts and saltwater intrusion

According to the forecast on climate change impacts in the Southern Delta, the yearly average temperature can increase up to 1.6^{o}C (in 2050) and 3.7^{o}C (in 2010). While the precipitation decreases in December to May, it is the highest in the March-to-May period (8% in 2050 and 19.6% in 2010). On the contrary, the precipitation decreases from June to November and most 10 from September to November, 10.6% in 2050 and 26.0% in 2100. The sea level rises to about 330 mm in 2050 and to 621 mm in 2100. With the current melting rate of ice and glacier at both Poles, it is expected that the sea

level in Vietnam could rise up to 1 meter or more. Unfavorable weather, especially saltwater intrusion and droughts in dry season, can happen more frequently and seriously.

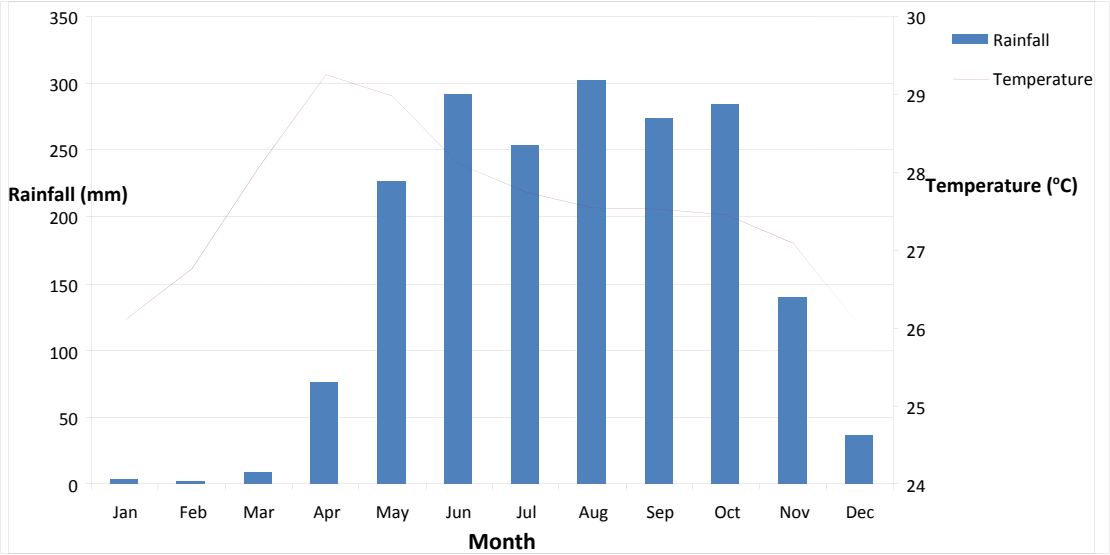

Figure 15. Monthly average temperature (°C) and total monthly rainfall (mm) in Soc Trang station

3.4.2. Climate change scenario

The six families of scenarios discussed in the IPCC's Third Assessment Report (TAR) and Fourth Assessment Report (AR4) are A1FI, A1B, A1T, A2, B1, and B2 base on AR4 and identical in TAR (IPCC, 2007). Similarly as building climate scenario in Nam Dinh and Tra Vinh province, Table 12 shows climate scenario in Soc Trang based climate baseline data.

Table 12. Seasonal temperature change and percentage of rainfall change in Soc Trang province in 2020, 2030, 2040 and 2050 compare with baseline period of 1980-1999

Season	**B1 Scenario**							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.6	0.8	-2.7	-4.4	-6.2	-7.7
Mar.-May	0.4	0.6	0.8	0.9	-2.6	-3.6	-5.8	-7.2
Jun.-Aug.	0.5	0.7	0.9	1.1	0.3	0.5	0.6	0.8
Sep.-Nov.	0.5	0.6	0.9	1.2	2.6	3.8	5.0	6.3
	B2 Scenario							
	Temparature changes				Rainfall (%)			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.6	0.8	-3.0	-4.4	-6.2	-8.1
Mar.-May	0.4	0.6	0.8	0.9	-2.8	-4.1	-5.8	-7.5
Jun.-Aug.	0.5	0.7	0.9	1.2	0.3	0.5	0.6	0.9
Sep.-Nov.	0.5	0.6	0.9	1.2	2.6	3.8	5.3	6.8
	A2 Scenario							

	Temparature changes				% Rainfall change			
	2020	2030	2040	2050	2020	2030	2040	2050
Dec.-Feb.	0.3	0.5	0.7	0.8	-3.3	-4.5	-5.9	-7.4
Mar.-May	0.4	0.6	0.8	0.9	-3.0	-4.2	-5.5	-7.2
Jun.-Aug.	0.6	0.7	0.9	1.2	0.4	0.5	0.6	0.8
Sep.-Nov.	0.5	0.7	1	1.2	2.8	3.8	5.0	6.5

With the same trend with Nam Dinh and Tra Vinh sites, temperature in Soc Trang also increased in all seasons and years and rainfall regime tends to decrease in dry season and increase in rain season.

3.4.3. Impacts of climate change on agriculture

Soc Trang is one of the coastal provinces that suffers from climate change the most. Unfavorable weather tends to occur more frequently and severely than before. Droughts and saltwater intrusion are considered the two most frequent and destructive disasters by the people in Soc Trang.

Saltwater intrusion and droughts:

Saltwater intrusion and droughts are big issues in the province because the increasing frequency and scale of these disasters is seriously affecting the local people's life and production.

Saltwater intrusion: When coming to the south, especially in the second half of the winter (January – March) the winter monsoon tends to blow to the east–southeast. This monsoon blows sea water back into main rivers and canals, contaminating coastal fields with salt. This monsoon, together with high tides, can blow sea water back into the fields. The canal system in Soc Trang is affected by the tides twice a day with the average fluctuation of 0.4 to 1 meter. In the rainy season, parts of My Tu and Thanh Tri district are flooded, while in the dry season, runoff water in Thanh Tri, Vinh Chau, My Xuyen districts and parts of Long Phu and My Tu Districts is salt-contaminated and therefore causes a lot of difficulty to production and life. The attack of monsoon, with the synchronous impacts of high tides, can negatively affect crops and other cereals and vegetables because sea water bubbles brought in by the wind stick to the buds and prevent their development.

Impacts of saltwater intrusion and droughts:

According to recent research in 2005 by the Ministry of Agriculture and Rural development (MARD), the economic damage due to saltwater intrusion in 2005 was 45 million dollars, accounting for 1.5% of the annual crop yield of Cuu Long River Delta. In coastal districts of Soc Trang, rice can only be grown in rainy season and the rice growth greatly depends on the precipitation. In general, there is not enough freshwater for irrigation in the beginning and in the end of the rainy season when saltwater (concentration of NaCl around 0.3%, 5dS/m) can enter the fields and either directly affect rice yields or increase the amount of salt in soil and affect the next harvests. Therefore, rice cultivation has to be carried out in the rainy season to avoid freshwater shortage and saltwater intrusion. Vegetables like red onions, turnips, chili, Japanese yams, etc are also affected although they are grown in the dry season to reduce the amount of irrigation water in the harsh conditions of droughts and saltwater intrusion in Soc Trang.

3.5. Baseline/or Bench mark indicators

Most of the lands in Soc Trang province owned by farmers were inherited and this indicates that farmers do farming from several generations. Introduction of new interventions to cope with climate change must be suitable to integrate farmers' experience and new innovations related to climate change coping strategies. One-third are female farmers with land ownership. Therefore, new interventions must target women together with men. Majority of farmers have been affected by salinity and drought in the last 10 years seriously. Thus interventions to cope with these are necessary.

Climate indicators:

Figure 16 and 17 show the changes in temperature and rainfall in Soc Trang 1980 to 1999.

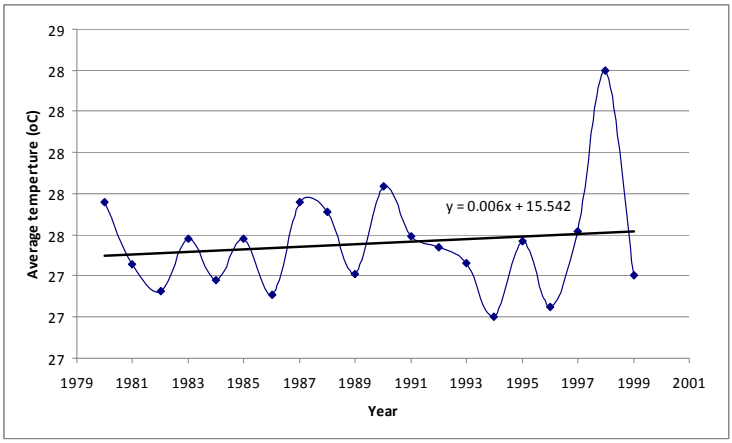

Figure 16. Trend of temperature changes from 1980-1999 in Soc Trang

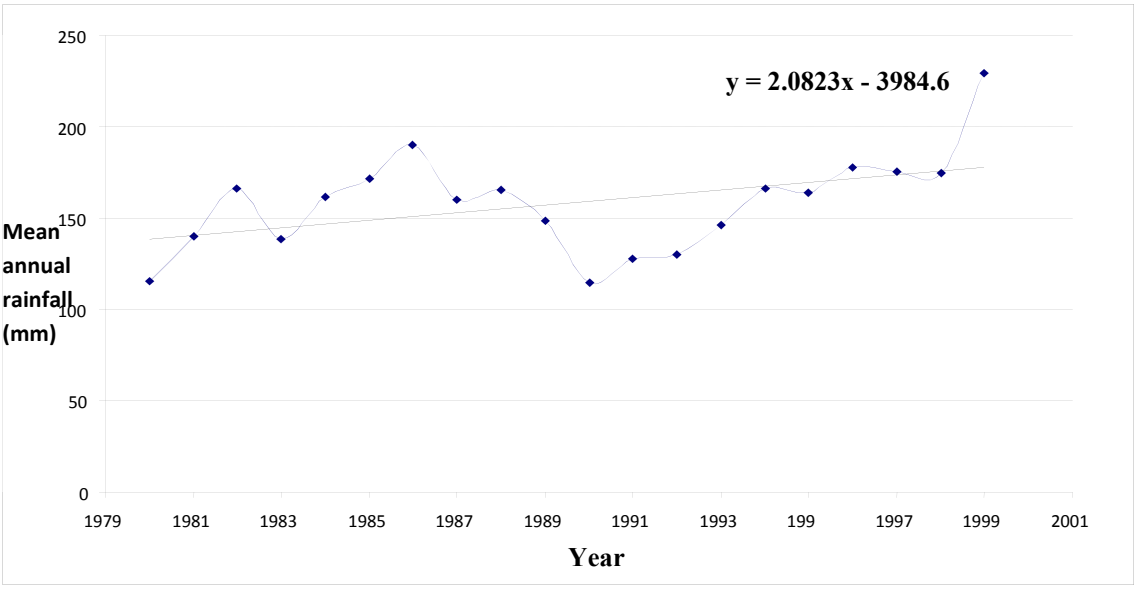

Figure 17. Annual rainfall trend during the time 1980-1999 in Soc Trang

Indicators of climate change are summarized in table 13.

Table 13. Vulnerability due to climate change in Soc Trang province

Impact Factor	Sensitive, vulnerable areas	Vulnerable sectors/areas
Temperature rise	Whole province in particular coastal areas are affected most strongly	• Agriculture (crops, livestock, fisheries) and food security. • The natural ecosystem, biodiversity. • Energy (production and consumption). • Public health.
Sea level rise	The coastal districts, and areas of low-lying terrain of Nga Nam, My Tu, Thanh Tri District	• Agriculture (crops, livestock, fisheries) • The marine ecosystems and coastal • Water resources (surface water and groundwater)

Impact Factor	Sensitive, vulnerable areas	Vulnerable sectors/areas
		• Infrastructure and industrial zones; • Place of residence, public health
Hurricanes and tropical depressions	Coastal areas, such as: Vinh Chau, Cu Lao Dung, Tran De.	• Agriculture (crops, livestock, fisheries). • The activities on coastal and marine • Infrastructure and transport, sea dikes. • Buildings and capture fisheries. Place of residence, health and life
Drought	Occurs in most of the Soc Trang province, in which the most affected districts are: Tran Đe, Soc Trang City, My Xuyen, Nga Nam, and some adjacent areas with Bac Lieu.	• Agriculture and food security. • Water resources (surface water and groundwater). • Traffic waterway. • Health and life
Saltwater intrusion	Mainly occurring in districts such as Vinh Chau, Long Phu, Tran De, Cu Lao Dung, Soc Trang City, My Xuyen.	• Agriculture (crops, fisheries) and food security. • Water resources (surface water and groundwater) • Land resources. • People's life. • Biodiversity
The extreme climate events (*)	Entire province and particularly in coastal areas.	• Agriculture (crops, livestock, fisheries • Buildings • Health and life

(*): Including the phenomena; unusual heat waves, rainy days, storms, hurricanes, tornadoes.

3.6. Interventions planned

The possible interventions in Soc Trang are:

- Rice varieties which are tolerant to salinity and drought. These should be high yielding, good quality and resistant to insect pests.
- AWD to reduce water use in rice production.
- Fertilizer management.

Conclusions

The three provinces selected for study are vulnerable to climate change and the future scenarios show that agriculture and rice production will be affected significantly in all the three areas. Saltwater intrusion and droughts are big issues in the province because the increasing frequency and scale of these disasters is seriously affecting the local people's life and production. The project will attempt to address these two issues by developing adaptation measures based on the priority of the stakeholders. One of the main recommendations from the stakeholders is to identify suitable salt tolerant rice varieties, as well as climate smart land and crop management measures that are suitable to future climate scenarios and extreme weather events. Adaptation strategies to address climate change impacts should consider women farmers and also the poor in the provinces. Measures developed should be simple and easy to adopt.

(This report will be updated as more information is collected and analyzed during the second year of the project).

REFERENCES

BRIGDE (Development -Gender) (2008). Gender and climate change: mapping the linkages. A scoping study on knowledge and gaps. Available at http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/DFID_gender_Climate_Change.pdf

Asian Disaster Preparedness Center (ADPC), (2003) Climate Protection Programme Climate Change and Development in Vietnam: Agriculture and Adaptation for the Mekong Delta Region Published by: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Division 44 - Environment and Infrastructure PN 01.2184.8

Bingxin Yu, Tingju Zhu, Clemens Breisinger, Nguyen Manh Hai (2010). Impacts of Climate Change on Agriculture and Policy Options for Adaptation, The Case of Vietnam IFPRI Discussion Paper 01015.

CZM (2007)Management of Natural Resources in the Coastal Zone of Soc Trang Province http://czm-soctrang.org.vn/en/ home.aspx

Dasgupta, S., Laplante B., Meisner, Craig, Wheeler, David and Jianping Yan. (2007), '*The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis*' World Bank Policy Research Working Paper No. 4136

Dasgupta, S, Laplante B, Murray S, Wheeler D. (2010) Exposure of developing countries to sea-level rise and storm surges. Climatic Change. DOI 10.1007/s10584-010-9959-6

FAO 2010. (eds) Friedrich, Theodor. Agricultural Mitigation Strategies, technical information and recommendations. www.fao.org/ag/ca

IUCN. 2012. Preparing REDD in Viet Nam, Lao PDR and Cambodia. Designing a REDD-compliant Benefit Distribution System. Nguyen Qua gTan, Robert Oberndorf, Ken Serey Rotha, University of Sydney, Jake Brunner, Christoph Muziol, Kong Kimsreng, (Edited by: Robert Mather, IUCN Asia Regional Office), 30 September 2010

ISPONRE. 2009. Vietnam assessment report on climate change. Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), Hanoi 2009.

IPCC (2007). IPCC synthesis report on climate change

Johnston, R. M.; Hoanh, C. T.; Lacombe, G.; Noble, A. N.; Smakhtin, V.; Suhardiman, D.; Kam, S. P.; Choo, P. S. 2010. Rethinking agriculture in the Greater Mekong Subregion: how to sustainably meet food needs, enhance ecosystem services and cope with climate change. Colombo, Sri Lanka: International Water Management Institute. 26p. doi:10.3910/2010.207.
MARD. Active framework to adapt a climate change in agricultural and Rural Development sector in period 2008-2020

MONRE. 2003. Viet Nam: Initial National communication, Under the United Nations Framework Convention on Climate Change. Hanoi

MoNRE (2012). Vietnam climate change and seas level rise, Natural Resources and Environment publishing house, Ministry of Natural Resources and Environment.

National Institute for Planning and Projection. Report 2003

National Statistical Yearbook, 2009

Paustin et al. 2006. Agriculture's Role in Greenhouse Gas Mitigation. Prepared for the Per Center on Global Climate Change

Raksakulthai, V. (2002). Climate Change Impacts and Adaptation Options in Viet Nam. Paper prepared for the Netherlands Red Cross as part of an assessment to develop a project on climate change and disaster preparedness in Viet Nam.

Schenk-Sanbergen, L. (2002). Report of the sociologist/gender spInecialist's second mission. VNICZM, Nam Dinh: Integrated social action plan.

Thuc, T. (2012). Climate change in Vietnam and respond. Presented at the Workshop on Climate change impact and adaptation study: Interim results.

United Nations (2008). Report on gender and climate change in Vietnam – a desk review.
Johnston, R.M.; Hoanh, C.T.; Lacombe, G.; Noble, A.; Smakhtin, V.; Suhardiman, D.; Kam, S.P.; Choo, P.S. 2009. Scoping study on natural resources and climate change in Southeast Asia with a focus on agriculture. Report prepared for the Swedish International Development Cooperation Agency by the International Water Management Institute. 118p. doi:10.3910/2010.201

Vu, L., and P. Glewwe. 2008. Impacts of rising food prices on poverty and welfare in Vietnam. Working Paper Series No. 13. Hanoi, Vietnam: Development and Policies Research Center (DEPOCEN).

World Bank. 2012. Potential climate change mitigation opportunities in the agriculture and forestry sector in Vietnam, (Background Paper Prepared by RCEE Energy and Environment JSC (Vietnam) and Full Advantage Co., Ltd. (Thailand)). Submitted to the World Bank Carbon Finance Assist Program – Vietnam, 58102, June 2014.

Zhai, F., and J. Zhuang. 2009. *Agricultural impact of climate change: A general equilibrium analysis with special reference to Southeast Asia*. Asian Development Bank Institute Working Paper Series 131. Manila, the Philippines: Asian Development Bank.

Zhu, T., and M. V. Trinh. 2010. Climate change impacts on agriculture in Vietnam. In *Proceedings of the International Conference on Agricultural Risk and Food Security*, June 11–12, 2010, Beijing.