Journal of Economics and Development Vol. 15, No.2, August 2013, pp. 79 - 94 ISSN 1859 0020

Climate Change and Land Use Change of Rural Households in The Red River Delta, Vietnam

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Abstract

Climate change (CC) and its impacts on the socio-economy and the development of communities has become an issue causing very special concern. The rise in global temperatures, in sea levels, extreme weather phenomena, and salinization have occurred more and more and have directly influenced the livelihoods of rural households in the Red River Delta – one of the two regions projected to suffer strongly from climate change in Vietnam. For farming households in this region, the major and traditional livelihoods are based on main production materials as agricultural land, or aquacultural water surface Changes in the land use of rural households in the Red River Delta during recent times was influenced strongly by the Renovation policy in agriculture as well as the process of industrialization and modernization in the country. Climate change over the past 5 years (2005-2011) has started influencing household land use with the concrete manifestations being the reduction of the area cultivated and the changing of the purpose of land use.

Keywords: Land use change, climate change, salinization, extreme weather phenomena, response, adaptation.

1. Introduction

Since the Intergovernmental Panel on Climate Change (IPCC) was established in 1988, the theme of climate change has attracted the attention of the international community and has become the priority topic in many international agendas. Vietnam is considered one of the countries that would be most severely affected by climate change. According to the Human Development Report 2008, if the earth's temperature increases 2°C and the sea level rises by 1m at the end of the 21st century, about 22 million people in Vietnam will lose their houses, 12.3% of the farming land area will be lost and 40.000km^2 of delta area will be affected by the flood level not being predicted (UNDP, 2008). In fact, during the past 50 years, the average temperature in Vietnam has increased about 2-3^{o}C and the sea level raised by about 20 cm. In addition, the average rainfall level for the whole country has decreased about 2% per year. Extreme weather phenomena have also increased; particularly intense storms occur more and more and the storm season ends later. (Ministry of Natural Resources and Environment, 2009).

The Red River Delta is evaluated as one of the regions which is most severely affected by climate change, especially with sea level rises and the unpredictable appearance of extreme weather phenomena (To Van Truong, 2008). The life of rural households, especially those in the coastal plain area, has been threatened because the main livelihoods of the people are cultivation, livestock, aquaculture and fishing, with their main production capital goods are agricultural and aquacultural land.

Several years ago, rural agricultural land use change in the Red River Delta was strongly affected by the Renovation policy on agriculture and by economic restructuring after the year 1986. The economic restructuring was characterized by the transfer of labor from areas with low productivity to areas where there was higher productivity. Economic restructuring entails the consequences of changes in land use structure; changes in proprietorship, level of land agglomeration; changes in business customs, in plants and animals structure, household income and income differences. The general trend of changing plant and animal structure in the Red River Delta after the Renovation focused on food crops for food self-sufficiency at first, and after that converted to plants for animal foods and breeding, then developed valuable oil, protein plants, and fruit and vegetables for the market (Bui Dai Dung, 2011). As a result, many rice areas were converted to crops, fruits, vegetable and fresh vegetable, and even trees were planted or grass grown to support cow breeding. One of the typical signs of land use change and plant and animal structure change in the Red River Delta is the rapid area increase of aquaculture (from around 60.000 ha in 1995 up to 125.000 ha in 2009). The principal reason here is that the natural conditions in the Red River Delta are an advantage for developing aquaculture (Bui Dai Dung, 2011). Apart from the impact of policy and socio-economic development factors, both at the macro level and household level, agricultural land use change in the rural areas of the Red River Delta needs also to be considered in the context of the climate changes.

2. Literature review

The coastal zone in the Red River Delta is an area of high population density and agriculture and fisheries depending much on climate and water sources (Peter Chaudhry and Greet Ruysschaert, 2007). This is coastal lowland of which 30% of the area is less than 2.5m above sea level and is always strongly influenced by natural disasters, especially by sea disasters. If the sea level rises around 1m, it is estimated that there are approximately 5.000 km^2 in the Red River Delta which will be flooded (To Van Truong, 2008). Some studies reveal that salinization and flood-tides are partly a consequence of climate change and these have had a strong influence on the livelihoods of coastal rural households (Tran Tho Dat, Vu Thi Hoai Thu, 2011).

Typically, a case study based on the qualitative approach in 02 communes, namely, Giao Xuan and Giao Thien, Giao Thuy District, Nam Dinh province, showed that in the last 5 years (2005-2010) the salinization phenomenon tends to be stronger. Previously, the salinity still occurred but to a lesser extent when seawater penetrated inland around 15-20 km. Currently, the sea water intrudes into the land to 25-30km. The causes of this salinization reported by local people is due to the rising sea level and the decrease in rainfall upstream causing a reduction of the fresh water source and consequently the land becomes saltier. This salinization has led to a large area of land no longer being cultivated. Many areas of lakes cannot grow clams and shrimps. Though based on a quantitative approach, this study also showed that if the soil is too salty, rice could not be grown, and households would either leave the land to avoid losing more resources or some households would change their planting strategy in the salinized land by switching from rice to vegetable growing or even to digging a pond for growing fish (Tran Tho Dat, Vu Thi Hoai Thu, 2011).

While the influences of climate change on the coastal rural area in the Red River Delta are clearly observed over time, the influences in the inland-rural areas are of less concern. But in the rural delta areas, the suburban or the midland, the extreme weather phenomena such as extreme hot temperature, drought, extreme rain, flood and extreme cold temperatures have started attacking the life and the production activities of rural households. The main livelihoods of households in these areas are field crops, vegetables, afforestation and pig and cow breeding, which are beginning to be affected by climate change and need to be changed for adaptation. (Nguyen Thi Kim Hoa et al., 2011).

It has been seen that land use change under the impacts of climate change has occurred. However, the question on the level of those changes is still unanswered. Some studies on the impacts of climate change on livelihood change of households in the Red River Delta have been conducted. These studies however have applied only a qualitative approach to detect some kind of changes. They have not quantified the level of changes as well as its rule. There have not been any previous study measuring the impact of climate change on land use change of the rural households in the Red River Delta. In particular, it is noted how to identify clearly the trends as well as the level of land use change influenced by climate changes or strongly influenced by policies,

planning or other socio-economic factors such as industrialization and modernization.

3. Data sources and analytical approach

In the framework of a project funded by DANIDA, International Center on Advanced Research of Global Change - Hanoi National University and Institute for Population and Social Studies carried out a survey on *"The impacts of climate change on land use change in the Red River Delta and its community livelihood change"* in May and June, 2011. The purpose of this survey was to collect data of households in Red River Delta by quantitative questionnaires on land use, occupation, structure of production, livestock, crop, and structure of revenues in the period 2005-2011.

Five communes of five provinces which represent 3 rural areas with differences in geological characteristics in the Red River Delta were selected as the study sites in this research. Con Thoi commune, Kim Son district, Ninh Binh province; Thai Do commune, Thai Thuy district, Thai Binh province; and Giao Thien commune, Giao Thuy district, and Nam Dinh province represent the coastal rural area. Van Noi commune; and Dong Anh district, Ha Noi represent the suburban area. And Tan Linh commune, Ba Vi district, Ha Noi represents the midland rural area. The main livelihoods of the residents in the three costal communes are rice cultivation, livestock, poultry growing and aquaculture. They also have other types of livelihoods, such as making handicrafts or as freely unskilled workers. For the suburban area, the households use land to grow rice, fresh vegetables, livestock and aquaculture. People tend to "leave agriculture" to work in factories or enterprises in the newly established local industrial zones. In the rural midland area, land is used for growing rice, crops, ornamental trees, and grasses for milk cow feeding. In addition, they also provide ecotourism services (Pham Van Cu et al., 2009).

In each commune, around 200 households, living there from 2005 and earlier (i.e. excluding new households moved into after 2005), were selected for interviews by the random sampling method that ensures the representative nature of all households in the community. The sample size was estimated based on the formula in which the overall sample was not known. Statistical reliability was 90%, the sampling error was limited by a coefficient equal to 2. The survey sample was taken from all the villages in the commune and based on a list of all eligible households provided by the local authority.

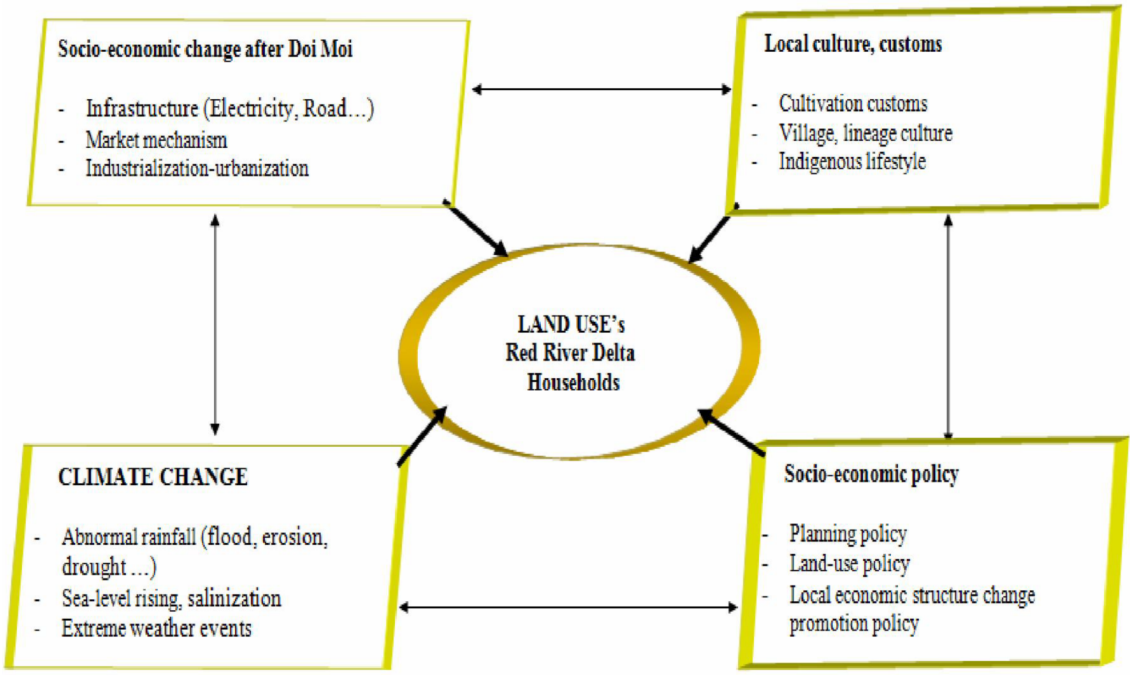
Regarding the demographic characteristics of the sample, the average size of households in the surveyed communes is 4.4 people/household, higher than the average size of households in the whole country according to the results of the 2009 Population and Housing Census (Census 2009). (In the whole country in general, the average size of households in the rural area is 3.9 people/household, in the rural area of the Red River Delta it is 3.5 people/household) (General Statistics Office, 2010). Regarding the socio-economic characteristics of the sample, 61.4% of surveyed households have 1-2 members, 31.4% of households have 3-4 members working for income. The percentage of households in which there are no people working for income or there are more than 5 people working for

income is not large (respectively 2.2% and 4.9%). Half of the surveyed households own permanent houses. Van Noi, Giao Thien, Thai Do are communes in which the proportion of surveyed households owning permanent houses is relatively high (respectively 67.5%, 56.2%, 67.5%). 48.1% of surveyed households are currently living in a house with a tiled roof . Only 1.2% of surveyed households have to live in the simple leaf thatched house. From 2005 to 2011, the proportion of households owning a permanent house has increased by 9.5%. The proportion of households living in a tiled roof house decreased by 8.1%. The proportion of households living in the simple leaf thatched house was also cut down by half. This fact shows that the living standard of the people in the study areas in particular and the living standards of rural households in the Red River Delta region have been greatly improved in recent years.

A quantitative approach was applied in this analysis of land use change. The current situation of household land-use was investigated through the information on the residential area, the farm land area for each crop, and the cultivated water surface area for each type of seafood. The mean value of area for each type of land or water surface related to the period 2005 to 2011. Change of land use is determined by the change in area, the purpose of land use, water surface use and the cause of these changes.

Reasons causing the changes in land area and the purpose of land use were determined in

Figure 1: Theoretical framework on the determinants of land use



a global approach, from the elements of the socio-economic development, the elements of the policy to the elements of climate change that affect to the research variables such as rainfall changes (causing drought, soil erosion, landslides or flooding, etc.), sea level rise caused sea water intrusion phenomenon, salinization, polluted water, or the occurrence of extreme weather phenomena (Figure 1).

4. Changes in household residential land use and climate change's influence

4.1. Changes in residential land use

Residential land includes land used for constructing houses, yards, home gardens, and ponds in the garden. On average, each surveyed household had around 830m^2 of residential land area at the time of the survey. The households in Tan Linh own a relatively large average of 1,650m^2 residential land area, 1.5 times higher than that of the households in Con Thoi (1,046m^2) and about 3 times higher than in Giao Thien and Thai Do (536m^2 and 527m^2 respectively). The households in Van Noi own the least residential land area (each household

Table 1: Average residential land area of the surveyed households in 2005, 2011

Indicators	Van Noi	Tan Linh	Giao Thien	Con Thoi	Thai Do	Overall
The total residential land area (m^2)						
2005	394.6	1,806.4	570.6	1,132.7	542.1	***895.1
2011	366.8	1,650.9	535.9	1,046.2	527.6	***830.7
Difference	***-27.8***	***-155.5***	***-34.7***	***-86.6***	***-14.5***	***-64.3***
Housing area (m^2)						
2005	104.4	121.9	95.0	105.6	88.0	**103.1
2011	112.2	130.0	94.7	106.5	89.7	***106.7
Difference	***7.8***	***8.1***	***-0.3***	***0.9***	***1.7***	***3.6***
Yard area (m^2)						
2005	59.3	79.4	75.1	68.3	53.4	*67.1
2011	87.5	76.0	76.7	67.1	51.3	71.7
Difference	***28.2***	***-3.3***	***1.6***	***-1.2***	***-2.1***	***4.5***
Home garden area (m^2)						
2005	211.2	1,399.2	280.9	588.0	332.6	***566.9
2011	183.2	1,300.4	253.2	574.6	319.5	***530.5
Difference	***-28.0***	***-98.8***	***-27.7***	***-13.3***	***-13.1***	***-36.4***
Pond area (m^2)						
2005	11.4	186.4	109.0	265.8	56.8	***126.8
2011	2.2	189.8	101.9	247.7	57.1	***120.7
Difference	***-9.2***	***3.4***	***-7.1***	***-18.1***	***0.3***	***-6.0***
N	**194**	**200**	**194**	**199**	**197**	**984**

*Statistical significance ***: p=0.000; **: p<0.01; *: p<0.05*

has an average of 367m^2). It can be noticed that the rural population density in suburban areas is much higher than that in coastal areas and the most sparse area is in the midlands. This may be a basis to reflect trends and types of land use change among different regions.

The results of analysis show that from 2005 to the present, the residential land area of each household has decreased by an average of 64.3m^2 (about 7.2% lower than that of 2005). The greatest reduction is concentrated in communes with a high average of residential land area such as Tan Linh and Con Thoi with 155m^2 and 87m^2 lost respectively. On average, each household in Giao Thien lost 35m^2, in Van Noi 28m^2, and in Thai Do 14.5m^2 (Table 1). The proportion of households with a decrease in residential land area in most surveyed communes is only over 10% of the total households, especially only 5.1% in Thai Do.

The causes of this residential land area reduction are shown as follows: 11.3% of the households claimed it was due to land acquisition for planning, 39.2% selling or transfer, 49.5% giving, inheritance, or donation, and just 2.1% saline intrusion or landslides. Around 10% to nearly 20% of the households in Tan Linh and in the three coastal communes with a reduction in land area claimed the reduction was due to land acquisition for planning purposes. In addition, some households left residential land for their children to inherit when they set up a new nuclear family. The percentage of households reducing their residential land area because of this reason was relatively high in 3 coastal communes (75%, 50.0%, and 60.0% in Giao Thien, Con Thoi, and Thai Do respectively). Impacts of climate change on residential land use change obviously existed and mainly in coastal communes, but at a low rate (climate change actually influenced only 5.0% of households in Giao Thien commune and 5.6% in Con Thoi). Reasons for the decrease in residential land area in farm households in recent time were mainly attributed to socio-economic factors (Table 2).

Statistical results show that in the period of 2005 to 2011, in Tan Linh and Van Noi more than 21% of households have converted the purposes of residential land use due to their own needs. While in coastal communes, these proportions were less (17.5% in Giao Thien, 16.6% in Con Thoi, and 11.1% in Thai Do respectively). Of these, only 6% of households in Thai Do had to change the purposes of residential land use due to landslides. However a depth analysis on changes in residential land structure identified a variation in different aspects: Housing and yard areas increased (3.6m^2 and 4.5m^2 respectively) while home garden and pond areas decreased (36.4m^2 and 6.0m^2 respectively). This proves that households have converted a lot of the home garden area to housing area.

Households in Tan Linh and Van Noi have seen the largest increase in housing area. These are two communes belonging to the Hanoi administrative area, where the urbanization trend has strongly occurred and many new permanent houses have been built. There is not much change in home yard area of households in Tan Linh, Giao Thien, Con Thoi, and Thai Do. This type of land of households in Van Noi has increased by nearly 30m^2. In contrast, home garden area in households in Tan Linh, followed by Van Noi and Giao Thien, tend to

Table 2: Percentage distribution of surveyed households by reasons for a reduction in residential land area in the period 2005-2011

Indicator	Van Noi	Tan Linh	Giao Thien	Con Thoi	Thai Do	Total average
Land revoked by planning	-	19.2	10.0	16.7	10.0	11.3
Sea/river erosion	-	0.0	5.0	5.6	-	2.1
Selling/Transfer to another	47.8	65.4	20.0	27.8	10.0	**39.2
Giving for inheritance/donation	56.5	19.2	75.0	50.0	60.0	**49.5
Others	-	7.7	5.0	-	20.0	5.2
N	23	26	20	18	10	99

*Statistical significance ***: p=0.000; **: p<0.01; *: p<0.05*

have strongly decreased. The decreased level of households in Con Thoi and Thai Do was the same (Table 1). Household home garden area in Tan Linh and Van Noi has been reduced giving way for newly built housing and the selling of land for extra income since land prices in suburban areas of Hanoi in recent years have highly increased. Many households have sold part of their land to get money for house construction (47.8% of households in Van Noi and 65.4% in Tan Linh).

4.2. Changes in farmland use

Farmland of the surveyed households is comprised of land for paddy cultivation, cash crops, flowers, ornamental plants, fruit trees, intercropped land for paddy and cash crops or paddy and fruit trees, forest land, pasture, land for livestock and poultry raising, farmland for lease, and fallow farmland. At the time of the survey, the average farmland area of the surveyed households was 1,607m^2 (equal to 4.4 "sao"" in the North, 1 "sao" equals 360m^2). On average each household in Tan Linh own 2,158m^2, much higher than that in Van Noi (1,220m^2). In the 3 coastal communes, households in Con Thoi own more farmland than households in Giao Thien and Thai Do (1,809m^2 compared to 1,553m^2 and 1,260m^2). Compared with 2005, Van Noi in Ha Noi and Thai Do in Thai Binh are communes in which the total average farmland area of households has dramatically decreased (157m^2 and 305m^2), while the farmland area in Tan Linh, a midland commune, has increased at an average of 4.8m^2/household (Table 3).

Results of the survey reveal that in the past 6 years 25% of households have experienced a change in farmland area at a different level. On average, the paddy land area of households in the Red River Delta has decreased 154.9m^2, the cash crop area decreased 20.3m^2, intercropped land decreased 21.7m^2, and land area for livestock and poultry raising decreased 10.3m^2. Conversely, the land area of flower, ornamental plants, and fruit trees has increased 13.9m^2. Forest land increased 2.8m^2, grass growing area increased 45.4m^2, and land for lease increased 43.6m^2 and fallow land also increased 1.5m^2. Specifically, the data in Table 3 presents that there is a difference in the tran-

Table 3: The average area of farmland of surveyed households in 2005, 2011

Indicators	Van Noi	Tan Linh	Giao Thien	Con Thoi	Thai Do	Overall
The total farmland area (m^2)						
2005	1,377.9	2,153.3	1,568.7	1,828.2	1,565.1	***1,703.1
2011	1,220.4	2,158.2	1,553.7	1,809.7	1,260.2	***1,607.4
Difference	***-157.5***	***4.8***	***-15.0***	***-18.5***	***-304.9***	***-95.7***
Paddy area (m^2)						
2005	672.4	1,314.6	1,520.6	1,859.6	1,433.9	***1,372.5
2011	527.0	1,139.4	1,555.5	1,743.2	1,045.5	***1,217.6
Difference	***-145.4***	***-175.2***	***35.0***	***-116.3***	***-388.3***	***-154.9***
Cash crop area (m^2)						
2005	443.2	486.4	4.4	11.1	115.2	***204.2
2011	400.6	422.3	0.6	11.1	122.3	***183.9
Difference	***-42.6***	***-64.1***	***-3.8***	***0.0***	***7.0***	***-20.3***
Areas for flower, fruit trees, and ornamental plants (m^2)						
2005	5.1	1.1	0.8	1.9	-	1.8
2011	4.0	60.3	14.4	1.9	-	15.7
Difference	***-1.1***	***59.1***	***13.7***	***-***	***-***	***13.9***
Intercropped area (paddy – cash crop or paddy – fruit trees) (m^2)						
2005	267.4	292.1	4.9	15.5	51.6	***122.0
2011	188.4	273.7	4.8	13.1	39.9	***100.3
Difference	***-79.0***	***-18.4***	***-***	***-2.4***	***-11.7***	***-21.7***
Forest land (m^2)						
2005	-	148.8	5.7	-	-	**29.6
2011	-	159.1	6.5	-	-	***32.4
Difference	***-***	***10.3***	***0.8***	***-***	***-***	***2.8***
Pasture area (m^2)						
2005	-	145.7	-	-	-	***27.9
2011	-	384.2	-	-	-	***73.3
Difference	***-***	***238.5***	***-***	***-***	***-***	***45.4***
Land area for livestock and poultry raising (m^2)						
2005	-	58.0	0.2	-	-	11.1
2011	3.1	0.6	0.4	-	-	0.8
Difference	***3.1***	***-57.5***	***0.2***	***-***	***-***	***-10.3***
Farmland for lease (m^2)						
2005	58.7	21.9	43.9	13.4	30.9	33.6
2011	144.9	68.6	55.6	15.3	107.8	**77.2
Difference	***86.2***	***46.6***	***11.7***	***1.9***	***76.8***	***43.6***
Fallow arable land (m^2)						
2005	5.1	16.0	-	-	-	4.0
2011	13.7	14.6	0.5	-	-	5.6
Difference	***8.6***	***-1.4***	***0.5***	***-***	***-***	***1.5***
N	**177**	**175**	**192**	**193**	**182**	**919**

*Statistical significance ***: p=0.000; **: p<0.01; *: p<0.05*

sitions of farmland of households in Van Noi. The average land areas for paddy, cash crops, and intercropping between paddy and cash crop have decreased (-145m^2, -42m^2, and -79m^2). In contrast, farmland for lease and fallow farmland has increased (86.2m^2 and 8.6m^2). In Tan Linh, the average farmland areas for paddy, cash crop, intercropping between paddy and cash crops has reduced (-175,2m^2, -64,1m^2, -18,4m^2), but areas for ornamental plants/fruit trees, forest land, and grass growing land have increased (59.1m^2, 10.3m^2, and 238.5m^2). In Con Thoi and Thai Do, the average farmland areas for paddy cultivation has decreased (-116.3m^2 and -388.3m^2), while farmland for lease has increased (76.8m^2) and water surface area for aquaculture also has increased (will be analyzed in the next section).

Analyzing the land use change by the purposes for using different farmland shows that there is a dramatic change in the purposes of farmland use in Van Noi and Tan Linh (nearly 30% of surveyed households). In rural coastal areas, this feature is less seen in Giao Thien and Con Thoi but more in Thai Do with 15% of the households (Figure 2).

The tendency of the decline in the farmland of households is largest in Van Noi (22.6% of households). This is understandable because Van Noi is situated in the suburban region of Hanoi that has a high level of urbanization. 65.9% of households have seen their cultivated land area reduced due to reclamation for planning purposes, 17.1% is due to selling and transferring a part of their farmland to others, 22.0% a share of farmland, as inheritance for their children's new settlement. 30.9% of households in Tan Linh have transformed an area of farmland, of which nearly half (14.3%) have increased their farmland area by purchasing, hiring or borrowing and half (16, 6%)

Figure 2: The percentage of surveyed households that have changed the farmland use purposes in the period 2005-2011

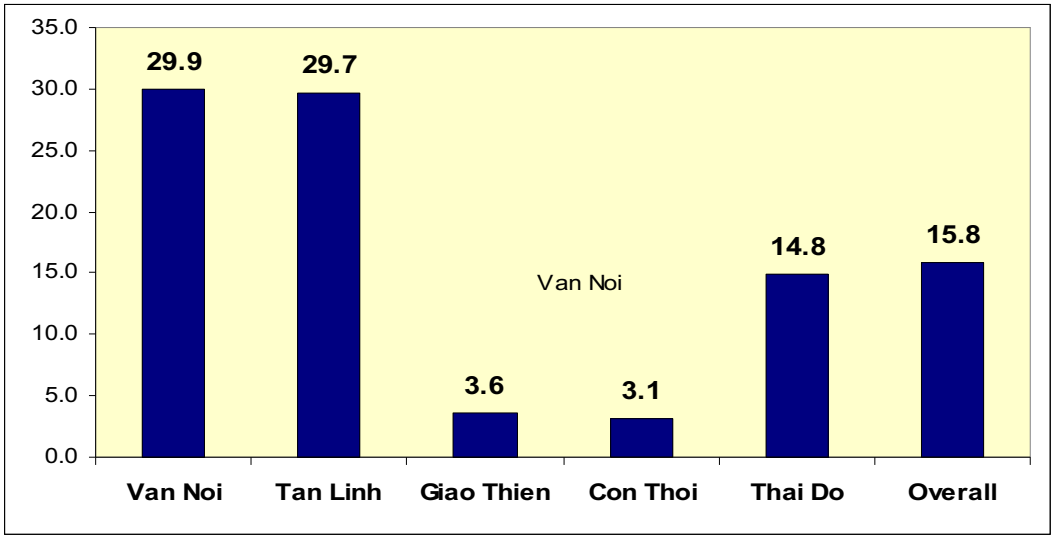


Table 4: Percentage distribution of surveyed households by the situation of farmland use change in period 2005-2011

Indicators	Van Noi	Tan Linh	Giao Thien	Con Thoi	Thai Do	Overall
No change	72.3	68.6	81.8	74.5	75.8	74.7
Increase	4.5	**14.3**	6.8	5.7	4.9	7.2
Reduce	**22.6**	**16.6**	**11.5**	**18.2**	**19.2**	17.5
Both increase and reduction	0.6	0.6	-	1.6	-	0.5
Total	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	****100.0***
N	**177**	**175**	**192**	**192**	**182**	**918**

*Statistical significance: ***: p=0.000; **: p<0.01; *: p<0.05*

have reduced the farmland area due to sale/transfer to others (43.3%) and inheritance for the children (43.3%). Only 10% of households have their farmland reclaimed for planning purposes. The percentage of households that have seen a decline in the area of farmland in the three coastal communes is 19.2% in Thai Do, 18.2% in Con Thoi, and 11.5% in Giao Thien (Table 4). The causes of the decrease of farmland area in Giao Thien and Thai Do are due to the sale/transfer and sharing for the children or returning the leased area. In Thai Do, 88.6% of households have seen a decrease in farmland area because they have excavated land for aquaculture ponds. However, the transfer for aquatic farming is attributed to its higher economic performance and the communal policy to plan the sector rather than for reasons related to the impact of climate change.

The main reasons for the conversion of farmland use purposes of households include: "change for more efficient use" (55.9% of households), for planning (12.7%), lack of workforce or for lease (37.5%); climate change (4.9%) (including soil erosion (2.1%),

Table 5: Percentage distribution of surveyed households by reasons for farmland use change in the period 2005-2011

Reasons	Van Noi	Tan Linh	Giao Thien	Con Thoi	Thai Do	Overall
Soil erosion	3.9	1.9	-	-	-	2.1
Salinization	-	-	14.3	-	3.7	*1.4
Changing for more efficient use	45.1	75.0	42.9	-	55.6	***55.9
Cope with harsh weather	3.9	-	-	-	-	1.4
Changing for planning	19.6	5.7	-	16.7	14.8	12.5
Other (lack of labor or for lease)	37.3	30.2	57.1	83.3	33.3	*37.5
N	51	53	7	6	27	144

*Statistical significance ***: p=0.000; **: p<0.01; *: p<0.05*

salinization (1.4%) and coping with harsh weather (1.4%). Except for Giao Thien, the four communes all saw that some local households have used their farmland for other purposes due to the policies of production restructure of the local areas. It is noteworthy that climate change has impacted on the transition in farmland use among households. Of households experiencing transition in farmland use, 14.3% in Giao Thien and 3.7% in Thai Do claimed it was because of saline intrusion: 3.9% of households in Van Noi because of adapting to extreme weather, and 3.9% of households in Van Noi and 1.9% in Tan Linh claimed the change in land use was due to soil erosion (Table 5).

4.3. Changes in cultivated water surface use

The cultivated surface water area includes areas for freshwater and brackish or saltwater aquaculture. In addition, areas of unused water surface and for lease are also calculated. Only 6 households in Van Noi and 15 households in Tan Linh among nearly 200 surveyed households in each commune, have water surface area used for aquaculture. Observed cases do not ensure a statistical significance; therefore the change in cultivated water surface for aquaculture in Van Noi and Tan Linh is not considered in the analysis below. In Giao Thien, 18.1% of surveyed households owned cultivated water surface area while it was 29.5% in Con Thoi and 80.2% in Thai Do.

In terms of area, at the time of the survey, among households owning aquaculture surface water, the average areas for fresh water aquaculture, brackish water aquaculture and for lease that a household in Giao Thien had was 815.9 m2, 15,696.0 m2, and 1176.5 m2 respectively. Compared with 2005, these areas all increased. While in Con Thoi these figures were 957.2 m2, 9108.8 m2 and 189.5 m2. Compared with 2005, the areas of freshwater and brackish aquaculture increased while the area for lease dropped. In Thai Do, on average each household had 98.6 m2 for freshwater aquaculture, 2.915m2 for brackish aquaculture, 337.6 m2 for lease and 289.9 m2 of unused area. Compared with 2005, the area for salt water/brackish aquaculture of households in Thai Do decreased dramatically while area for lease and especially the unused surface area increased (Table 6).

Thus, it can be seen that although they are located in rural coastal areas, the average water surface area for salt/brackish water aquaculture in Giao Thien is 1.7 times and 5.4 times larger than that in Con Thoi and in Thai Do respectively. The area for lease sees a similar trend. The area of freshwater aquaculture in Thai Do is much less than that in Giao Thien and Con Thoi. However, while there is almost no unused surface area in Giao Thien and Con Thien, this area in Thai Do has increased.

The analysis of the structure of the households which experienced a transition in aquaculture farming area in the period 2005-2011 shows that the area of 12.1% of households in Giao Thien has increased and a similar proportion of 12.1% has seen a decrease. While in Con Thoi, 13.6% of households experienced an increase and 27.1% of households saw a decline. In Thai Do, the corresponding rates are 16.8% and 2.0%. The increased areas in Giao Thien and Con Thoi are mainly from newly allocated areas, and areas recently pur-

Table 6: The average area of surface water for aquaculture of the surveyed households in the period 2005 – 2011

Types of water surface	Giao Thien	Con Thoi	Thai Do
Water surface area for freshwater aquaculture (m^2)			
2005	794.0	717.2	47.9
2011	815.9	957.2	98.6
Difference	***21.9***	***240.0***	***50.7***
Water surface area of salt/brackish water aquaculture (m^2)			
2005	15,541.7	7,285.4	3,139.1
2011	15,696.0	9,108.8	2,915.0
Difference	***154.3***	***1,823.3***	***-224.2***
Water surface area for lease (m^2)			
2005	1,176.5	315.8	80.2
2011	2,647.1	189,5	337,6
Difference	***1470.6***	***-126.3***	***257.4***
Unused water surface area (m^2)			
2005	2.4	-	48.3
2011	3.5	-	289.9
Difference	***1.1***	**-**	***241.6***
N	**34**	**57**	**150**

*Statistical significance ***: p=0,000; **: p<0,01; *: p<0,05*

chased, hired or inherited from parents. Particularly, of households with increased surface area in Thai Do, 80% said they had converted from farmland for agriculture to aquaculture with a higher economic value.

Among households with reduced cultivated water surface area, 11.8% of households in Con Thoi informed that the cause of the decrease has resulted from "sea erosion" and 15.4% informed that it was due to surface water contamination. These rates in Giao Thien are 25% and 33% respectively. This suggests that climate change has become a causal factor of the decline in the cultivated water surface areas.

The analysis of the purposes of water surface use at the time of the survey and in 2005 reveals that between 20-25% of the households of the studied communes has transited the areas for other purposes (20.6% in Giao Thien, 22.0% in Con Thoi and 24.8% in Thai Do). Among these households, one third in Giao Thien informed that the transition was caused by salinization. "Response to extreme weather" is given as the cause for the transition of 7.7% households in Con Thoi and 20.0% in Thai Do. One third in Giao Thien, 15.4% in Con Thoi and 28.6% in Thai Do claimed it was

Table 7: Percentage distribution of surveyed households by reasons for the cultivated water surface areas use changes in the period 2005-2011

Reasons	Giao Thien	Con Thoi	Thai Do
Soil erosion	**33.3**	-	-
Salinization	**33.3**	**15.4**	**28.6**
Changing for more efficient use	16.7	15.4	22.9
Cope with harsh weather	-	**7.7**	**20.0**
Changing for planning	-	15.4	8.6
Other (lack of labor or for lease)	33.3	53.8	*65.7
N	**6**	**13**	**35**

*Statistical significance ***: p=0.000; **: p<0.01; *: p<0.05*

the contaminated water (Table 7). These are clear manifestations of climate change impact in cultivated water surface changes.

5. Conclusions and recommendations

Changes in the use of agricultural land and the livelihoods of households in rural areas in the Red River Delta over the past two decades have been seriously affected by the Renovation policy in agriculture and the process of industrialization and modernization in whole country. The Red River Delta is also one of the most heavily impacted areas by climate change with global warming, sea level rise and more and more extreme weather events in Vietnam. Some qualitative studies on the impacts of climate change on livelihood changes of some communities in the Red River Delta region were carried out and revealed that climate change had started influencing the land use of households in some areas, but the volume of those changes was not measured.

The quantitative analysis of data collected from the survey on *"Impacts of climate change on land use changes in the Red River Delta and its community livelihood change",* which was conducted by the International Centre on Advance Research of Global Change - Hanoi National University and the Institute for Population and Social Studies – National Economics University, in May and June 2011, with 984 households in 5 communes representing different geographical areas of the Red River Delta including coastal rural areas, midland areas and rural suburban areas, has permitted the identification of a change in the level of household land use and the reasons for this change, of which the climate change was one reason.

The residential land use change of households in the period 2005-2011 has also occurred in the tendency of decreasing garden areas and increasing housing areas. This tendency happens frequently in developing areas, such as rural suburban areas (Van Noi) and coastal rural areas where people are able to raise/grow aquatic products of high economic value (Giao Thien). Climate change rarely affects changes in the residential land use of households in the rural suburban area and the midland rural area. Only a small rate of households in coastal rural areas may have to face changes in the areas of residential land due to soil erosion (this has happened in Thai Do - 5%).

Along with change in the farm land use due

to policies and economic - social development, areas of land for growing rice and cash crops have decreased because this farmland is used for other purposes. For example, the land is planted to trees, which have a higher economic value (Van Noi, Tan Linh), or are sold to other people or divided to their children or revoked for planning (Van Noi, Tan Linh, Giao Thien, Con Thoi) or switched to water surface (ponds) for raising aquatic products (Thai Do). Changes in purposes of using different types of farmland are witnessed in rural suburban areas (Van Noi) and midland rural areas (Tan Linh) (nearly 30% of surveyed households). In coastal rural areas, this occurs with a lower frequency (lower than in Giao Thien and Con Thoi, 15% of households in Thai Do).

Climate change has influences on change in the purposes of using different types of farmland belonging to households, including salt intrusion of land in coastal rural areas (14.3% of households in Giao Thien, 3.7% of households in Thai Do), severe weather conditions in rural suburban areas (3.9% of households in Van Noi) or eroded soil in both rural suburban areas and semi-mountainous rural areas (3.9% of households in Van Noi and 1.9% of households in Tan Linh).

Changes in the use of water surface for farm work are only measured in households in coastal rural areas. In general, the average areas for raising fresh water aquatic products by households tends to increase. The average area of raising salt-water aquatic products per household has increased in some areas (Giao Thien, Con Thoi) but there is a tendency for decrease or being deserted in some other areas (Thai Do). The rate of households changing the areas of water surface for cultivation (increasing or decreasing) is relatively high (24.2% in Giao Thien, 40.7% in Con Thoi and 18.8% in Thai Do).

Climate change has decreased the areas of water surface for farm work with coastal erosion and surface water pollution being the cause. (11.8% and 15.4% of households in Con Thoi, 25% and 33% of households in Giao Thien). About 20-25% of households of the 3 coastal communes have switched the purpose of using different types of water surface for farm work due to climate change such as salt intrusion (33.3% of households in Giao Thien), severe weather conditions (7.7% of households in Con Thoi and 20.0% in Thai Do), polluted water (33.3% of households in Giao Thien, 15.4% in Con Thoi and 28.6% in Thai Do).

From the above results, to respond to the impacts of climate change relating to land use change of the rural households in the Red River Delta, the following recommendations are proposed:

- In the rural areas of the Red River Delta at present, even though the impact of climate change on land use change is not much, it has happened. The consequences of climate change impacts are severely devastating and over a long time in the life of residents. Thus households in these areas need to receive great support from the Government and other organizations, especially in planning to prepare for responding to landslide phenomenon or extreme weather events.

- There is a need to integrate the factors of prevention, disaster mitigation, response and mitigation of climate change impacts into strategies, programs, master-planning and the plans of socio-economic development, sectoral development, local and regional development. The households in rural coastal areas need to be supported in long-term strategy-building to cope with the salinization that results in land use change. The households in suburban rural area and households in midland rural areas

should develop short-term plans for the farming land use change in extreme weather conditions and soil erosion.

- A key strategical issue in water resource planning is to ensure the security of the flow. At the coastal estuaries in Nam Dinh, Thai Binh, there is a need to build sewer systems and dams to prevent intrusion of rising sea levels and salinization; to upgrade and improve the sea dyke and drain systems, and along the coast, more mangroves should be planted. The coastal rural households need be supported to respond to the sea intrusion phenomenon that causes salinization and farming water pollution as well as changes in the purpose of farming water use in order to cope with the extreme weather events.

- In order to reduce the strong impact of climate change on land use change, farmer households need to make efforts in the adaptation to climate change by positively and actively reforming cultivation methods and developing plant varieties and breed-feeding animals that will better suit the changed soil condition.

- More data on the impacts of climate changes on land use change needs to be collected. This useful information needs to be disseminated to local authorities in the process of building the strategy for response to climate change impacts. The determination of the extent of impact will also allow the local authority to rank the order of priority for response activities.

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