

Changing of shoreline during the Late Quaternary in relationship with geodynamics and their affect to the coastal environment of the Red River

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Abstract. In many years, changing of shoreline has caused a lot of difficulties for the sustainable development of socio-economics in the coastal zone of the Red River delta. Here, in after the Flandrian transgression, accretion process of expanding delta has continuously developed. The eroded sections of shoreline appeared at the beginning of the Twentieth century (1905). The most intensive segment is in Hai Hau district. The Erosion related mainly to the lack of sediment caused by exogenous and human activities. Affect of endogenous process to erosion is very weak. The Erosion in Hai Hau has continuously developed because sediment at the Red River mouth is mainly being transported to the SW to the depth of 5-25m, 62 percent of which is transported cross-shore. In order to use land effectively in the coastal zone, at intensive eroded shorelines geotechnical measures have to be applied such as strong sea dyke and groins. In case of areas typhoon landing at the spring tide, people in the vulnerable areas at the coast have to move to safe areas.

Keywords: Holocene; Red River Delta; Shoreline; Coastal Zone; Hai Hau coast.

1. Changing of shoreline in Late Pleistocene

The trace of ancient sea activities left on land (ancient sea level, sea benches, geological formations) and sediment on bottom surface allow reconstructing ancient shorelines. The Vinh Phuc formation formed in Late Pleistocene was developed and distributed on a large scale on land and sea floor. On land, they are exposed in Bac Ninh, Bac Giang, Vinh Yen, Ha Tay and

Ninh Binh provinces. On the sea floor, they are exposed at the depth of 25-30m [1]. The identify characteristics of the formation is the weathered clay with motley colour. The Vinh Phuc formation formed in relationship with the Vinh Phuc transgression and the shoreline had reached in mentioned provinces, somewhere reached to Dong Trieu in the North of basin that created an eroded surface at the height 10-15m (Fig.1).

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on identifying the land fund and areas of agricultural land reserved for households, and proposals for continuing planting of annual and perennial plants in steep land without any solutions for the following problems:

- Orientations on land use and agricultural production organization for ensuring stable long-term production activities of resettled people in the new sites.

- Mitigation of land degradation and erosion when planting annual crops. Most of areas in Yen Chau District are mountainous and hilly areas. According to research results in 8 resettlement areas, the land with slope more than 15° consists of 92% of the total area, while the rest area of land is only 8%.

- Most of resettled people in Yen Chau District are the Thai ethnic group. They have to change their cultivation habit from paddy rice to upland rice cultivation on steep land.

- Lack of attention on support for production, education, and transfer of high-effective and sustainable land use models.

- There are some problems in term of social relation between the resettled and local people. In fact, the local people have to share the land fund for resettled ones, but they are insignificantly benefited from investments of the fund for resettlement activities.

2. Scientific base of land use and agricultural production organization for resettled people on the viewpoint of sustainable development

Rational use of natural resources, including land resource, is given a special attention in the most countries of the world. According to researches conducted by United Nations, the conditions for rational use of some reserved resources are: i) quality and advantages of position; ii) the requirement for satisfying the

needs of a certain group of residents; iii) the effectiveness of possible results; iv) the possibility to maintain those results for a long period; v) the investment cost; and vi) the impacts of using these resources on other activities of residents. In order to rationally use reserved resources, especially water resource, it requires a comprehensive socio-economic and political cooperation. The success also depends on the awareness of the society on the problem [1]. Several scientists tried to give a definition of rational land use. An attention is given to the definition of Russian scientist - V.P. Troiski: "rational land use is the use in accordance with the interest of economics in general, and it has the highest efficiency while ensures a non-negative impact on environment and protects effectively the land fund" [2].

In the condition of limited land resources and growing pressure of land use, the rational and sustainable land use for fulfilling the needs of not only current but also the next generations becomes more important. FAO pointed out 5 main principles of sustainable land use [7]:

1. Maintaining and improving productivity;
2. Maximizing security;
3. Protecting potential of natural resources and preventing degradation of soil quality;
4. Economic viability;
5. Social acceptability.

There are many provinces in the mountainous areas of Vietnam that have a complex topographical condition and a land fund consisting of steep land (in some areas more than 90% land have slope more than 25°). In this condition, the problem of resolving the relation between environmental protection and socio-economic development (food security, poverty elimination,...) has a contradicting character. However, this contradiction can be resolved step by step based on the proposal of a

suitable land use model that has both socio-economic and environmental benefits. There are three basic requirements:

- In term of economy, it has a relatively high effectiveness, acceptable by the market;
- In term of society: it attracts labors, provides employment and improves living standard of local people;
- In term of environment: it reduces and prevents soil degradation and pollution; improving environmental conditions.

For achieving rationality in land use towards sustainable development and ensuring

agricultural production effectiveness of resettled people, the ecological-economic approach in spatial planning has proved its effectiveness. Establishment of models of ecological economic household is based on determination of what to plant and breed in accordance with the ecological conditions of the territory and cultural level of the local people. Based on the assessment of conditions of the study area, especially the ecological status of land resources and the attributes of economic and social life, suitable for resettled people models of models of ecological economic household and land use are established (Fig. 1).

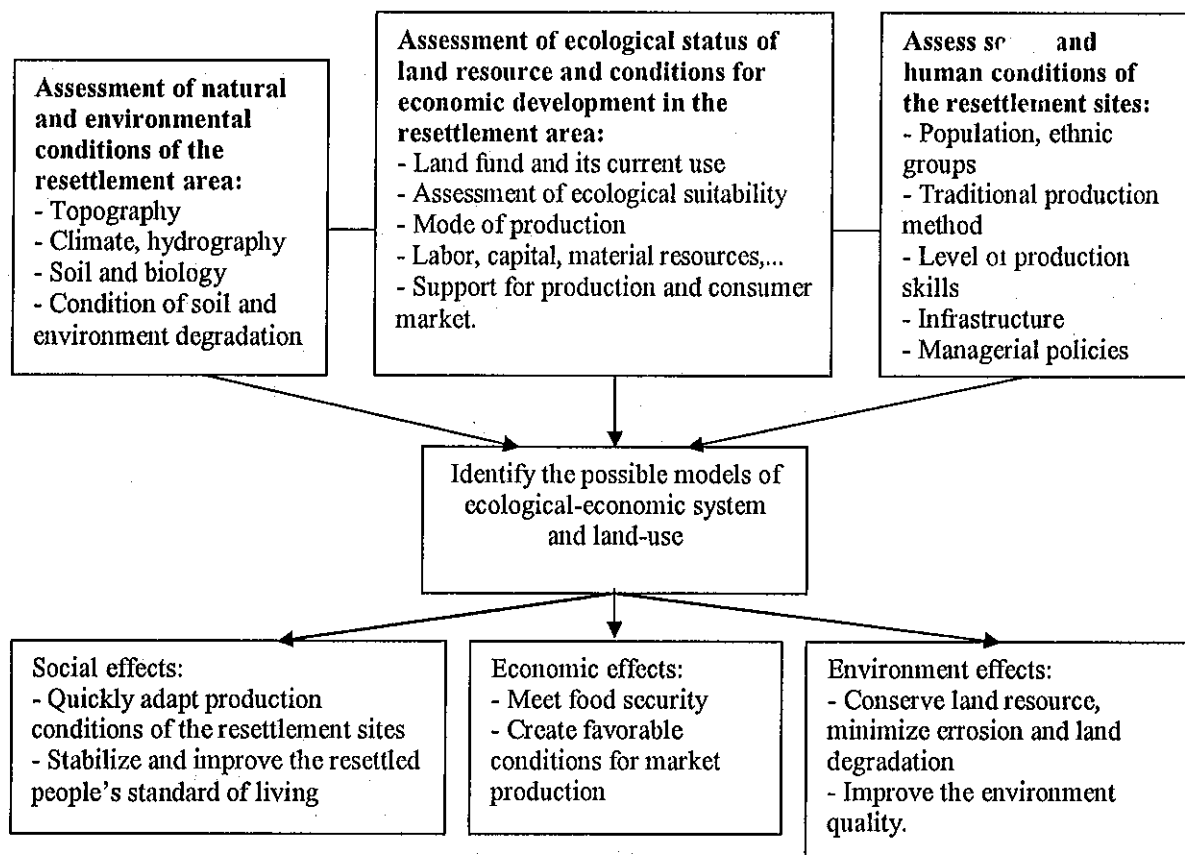


Fig. 1. Framework for building model of ecological-economic system and land use in the resettlement sites.

3. Assessment of natural, socio-economic conditions and land fund for SHPS's resettlement work in Yen Chau District

Yen Chau is a mountainous District of Son La Province. The district is located in 64 km away from Son La City, it has 47 km of boundary line with Laos. The district is crossed by the National road No 6, provincial roads No 103 and 104, which make favorable conditions for cooperation and developing a market economy.

According to the Resettlement Plan of Son La Province, around 750 households are planed to be resettled in Yen Chau District. Most of them are the Thai ethnic group from Quynh Nhai District [4]. Until August 2008, the district resettled 273 households to eight resettlement areas in five communes: Tu Nang, Long Phieng, Phieng Khoai, Yen Son, and Muong Lum. In general, these areas have relatively favorable natural and socio-economic conditions, but there are still some difficulties for the resettlement.

Natural conditions: Mountains and hills are the dominated topographic features in Yen Chau District. As a result, the resettlement areas have a complex topographical condition, most of them have a slope more than 15° . These make difficulties for living, agricultural production organization, and transportation. Among the eight resettlement areas, only the one in Tu Nang is located in the Yen Chau valley with elevation about 400 m, the others are located in highlands with elevation from 900 to 1000 m.

Yen Chau District has a monsoon climate with an average rainfall of about 1400 mm, but there are notable differences from place to place. The resettlement areas located in valleys are affected by southwest wind from Laos. They have a higher average temperature and more sunny days, which are favorable for

planting cereals, annual plants, and tropical fruit-trees. However, since the rainfall season is concentrated in the period from May to October, there is an acute shortage of water for irrigation in the dry season from November to April. The resettlement areas located in high elevation areas have a cool and wet climate what is favorable for cattle breeding and planting tea, subtropical fruit-trees, etc. However, these areas still have limited water resources, especially in the dry season.

The main surface water resources in the district are Nam Pan, Vat, and Sap streams, and the system of smaller streams. However, these streams usually are dried in the dry season that leads to the shortage of water resource.

The pedologic pattern of the resettlement areas are divided into some soil types, including red - yellow humic soil type formed in metamorphic rock that taking largest area, and other types as deluvial soil type formed in valley, red - brown soil type formed in limestone and red - yellow soil type altered by exiting paddy cultivating.

Socio-economic conditions: in 2008, the population of Yen Chau District is 64483 people belonging to six ethnic groups. These are Thai (53.6% of population), Kinh (19.2%), H'Mong (12.7%), Sinh Mun (8.9%), Kho Mu (0.4%), and Muong (0.2%). The people of ethnic groups live as communities, creating separate and independent villages. The Thai group mainly lives in low elevation areas. This makes favorable conditions for resettled people to integrate into the local communities. Most of ethnic people live base on agricultural production. The production model of the Thai ethnic group is a traditional model paddy field - rice terrace - garden - husbandry in integration with forestry. The Sinh Mun and H'Mong people already use the model forestry - rice terrace - garden - husbandry.

The infrastructure in the resettlement areas has been invested. There are some newly constructed roads connecting the resettlement areas to the national and provincial roads of the district. The local roads inside resettlement areas are developed too. The water and electric supply systems are constructed and ready for use. Each resettlement area has its own system of social services (kinder gardens, schools, cultural and communal house,...). These will greatly help the resettled people in their new sites.

The assessment results show that through there are still some difficulties, but in general, the natural and socio-economic conditions of Yen Chau District are relatively favorable for the resettled people.

Land fund for resettlement: It is defined in the detailed planning of each resettlement area. In those eight areas that already received resettled people, each household has in average 400 m² for making house, garden,... and 1.5 ha for agricultural production. However, in some areas, such as Phieng Khoai, Yen Son, due to some problems in land recovery from the local people, each resettled household still has only about 1 ha for agricultural production.

4. Models of ecological-economic system and land use for SHPS resettled people in Yen Chau District

Based on the assessment of natural and socio-economic conditions, as well as the current status of land fund in the resettlement areas, it can be seen that the models of eco-economic system suitable for resettled households are the following models: 1) forest - rice terrace - paddy field - garden - husbandry; 2) forest - rice terrace - garden - husbandry; 3) paddy field - rice terrace - garden - husbandry; and 4) rice terrace - garden - husbandry. In these models, the "husbandry" part includes

cattle and poultry breeding with estimated number of 3-5 pigs and 2-3 buffaloes or cows for each household. This will, along with cultivation activities, contribute a significant income for resettled people. Based on the current price of pork and beef, the income of each household from breeding is estimated about 10-15 million VND per year. The experienced households can breed the Sin cross-bred cows for a more effectiveness. The initial investment for breeding can be taken from the resettlement support fund of SHPS project.

In land allocation, though the area for paddy field is limited but it must be distributed for all households in order to help them to stabilize their life and partially fulfill the requirement on food. The land for forestry is recommended to be allocated (2-3 ha per household) to those households that have enough labor forces for forest planting and protection. The area for perennial plant is recommended as 1.5-2.0 ha per household depending on the status of land fund in every resettlement areas. Furthermore, each household should have 100-200 m² of garden for planting vegetables and fruit trees. The orientation on choosing a suitable planting system for resettled households is based on the analysis of socio-economic and environmental effectiveness of the main land use types in the district:

- Land for corn planting: corn is the main cereal product of the district. In 2007, the district had 9888 ha of corn with an average productivity of 4000 kg / ha [5]. The corn has a high economic effectiveness with profit of about 9 million VND / ha (Table 1). In recent years, some high effective types of corn have been applied. However, the corn monoculture in the slope area can lead to soil erosion and degradation.

- Land for cassava planting: cassava can be supplied to the Tapioca Production Plant in Mai

Son District. The area for cassava planting was 1105 ha in 2007 year. The average productivity is about 10000 kg/ha. However, the effectiveness of cassava planting is not high enough, only about 5 million VND / ha. Moreover, the land for cassava planting is strongly eroded.

- Land for soybean and peanut planting: these cereal are planted in the summer-autumn season. They are suitable for the soil in Yen Chau District with high economic effectiveness (6-7 millions VND / ha). Soybean and peanut can be planted in mix with fruit-trees for better use of land.

- Land for cotton planting: cotton is an industrial crop that are planted in Tu Nang, Sap Vat, Chieng Hac, and Chieng Khoi communes. The cotton has a relatively high economic effectiveness of about 7-8 millions VND / ha. However, due to the low quality of planted cotton variety and due to the requirements on high technology, the productivity of cotton is not stable.

- Land for tea planting: Tea is planted in high elevation area and frontier areas. It has a high economic effectiveness, reaching 9 millions VND / ha. In 2007, the district has 393 ha of tea, having productivity of 1501 tones in total. Tea planting becomes an activities that

help to makes new jobs and improve income for local households.

- Land for fruit tree planting: tropical fruit-trees, such as mango and longan, are quite suitable with soil and climate conditions in the Yen Chau valley. However, at present they are mainly planted only in the gardens of households with economic effectiveness of about 8 millions VND/ha. With a good investment and insect prevention, an hectare of mango and longan can give a profit of about 15-20 millions VND per year. The sub-tropical fruits, such as plum, apricot, persimmon, peach, etc., currently are planted in high elevation area and frontier areas, but mainly in the gardens of households.

- Land for grass planting: it is required for breeding buffaloes and cows which have a high economic effectiveness. Grass also has a ability to prevent the soil erosion. The grass fields for breeding the high quality Sin cross-bred cows should be allocated in the foot hill sides and in the easily irrigated areas.

- Land for forest planting: this type of land use should be allocated in the areas with slope more than 25° and in the hilltops for environmental protection purpose. Resettled people can combine production forest planting with protection forest preserving purposes.

Table 1. Eco-economic effectiveness of main land use types in Yen Chau District

Land use type	Economic effectiveness (avg. Profit, 10 ³ VND / ha)	Social effects	Ecological and environmental effect
Corn planting	9130	Being the major cereal products	Monoculture leads to soil degradation
Cassava planting	5160	Have consumer needs	Soil is highly eroded and degraded
Bean planting	7770	Accepted by people	Can improve soil
Peanut planting	6360	Accepted by people	Can improve soil
Cotton planting	7770	Only on the test stage, being still not accepted by people	The soil is quickly exhausted
Tea planting	9084	Accepted by people	Good capacity of erosion prevention
Fruit-tree (mango) planting	8265	Being planted mainly in gardens	Erosion prevention

Based on the characteristics and effectiveness of the above described land use types, one can propose a land use model according to the segments of the model of eco-economic system for the resettled people as follows:

- Forests: planting local trees like *Tectona Grandis* in the hilltops, hillsides with steep slope in order to regulate water resource and mitigate erosion.

- Terrace fields: planting one crop of corn in summer-autumn season in mix with lanes of peanut, bean or grass for preventing erosion. In the areas with a high moist keeping capability, it can have an additional crop of peanut in spring-summer season, and a crop of soybean and corn in autumn-winter season.

The gently slope hillsides with a good irrigation capability can be used as grass fields for cow breeding.

- Paddy fields: applying intensive cultivation of rice, using new rice varieties to increase productivity.

- Gardens: planting perennial trees (fruit-trees and tea) in the gardens of those households that are willing to do and have capabilities. In the early stage, it is recommended to mix with lanes of soybean, peanut for better utilization of land and soil erosion prevention. The gardens inside living areas of households can be used to plant vegetable, cereals and fruit-trees.

If the above described production structure, the estimated average income of a resettled household through cultivation activities is about 12-15 millions VND/year, in combination with breeding activities, the total income of a household can be around 20- 25 millions VND /year.

In order to increase the economic and ecological effectiveness of land use, it should

pay a special attention on the high economically effective perennial trees in combination with grass fields for cow breeding. However, due to the new production habits, low production levels, and limited economic potential of resettled households, we propose to implement the models in two stages:

- The first stage (5 years) is designated for stabilization of life of resettled people and agricultural production: keep the current areas for planting fruit-trees and tea in the resettlement areas; and evenly reallocate them to households. Put a priority on planting annual trees, such as corn, soybean, and peanut, in combination with grass fields to ensure the food security.

- The second stage is designated for intensive cultivation and changing planting structure towards sustainable development: reduce the area for corn planting for the sake of high value fruit-trees. Plant tea in high elevation areas and frontier areas and grass planting areas for cattle breeding based on the market demands and investment capacity of households.

5. Conclusions

Land utilization based on establishment of models of eco-economic system is an effective solution towards sustainable development for the SHPS resettled people as well as the local people. To make the proposed models realizable, it should apply the following policies and solutions as the followings:

- Investment policy for those households that are willing for planting perennial fruit-trees, tea, and developing cattle breeding.

- Investment in irrigation systems, including the irrigation system for grass fields.

- Policy encouraging planting green belt, lanes of peanut and soybean, grass in slope land in conjunction with corn with investment from the production support fund. This is made to ensure that the income for people from this land is at least equal the income obtained by planting only corn in the same land.

- Strengthen forestry and agriculture promotion activities, education and transfer of sustainable land use models.

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