Abandoned land reclamation planning in coastal area in North-East of China[1]

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Abstract. The damaged environment is a global problem. It is more serious in China because of the cultivable land destroyed. So the agroecosystem reconstruction is the primary object in China. A case of reclamation planning in LiaoNing Province was studied in this paper. A large number of abandoned land sites have become an urgent task for the local government since farmland is so short in this area. The land suitability and usage should be determined before the land reclaimed. Based on land-use mathematical models and software MATLAB 6.0, optimum land-use structure should fit for local ecological and economic requirement. The horizontal, vertical structure and food chains of the system should be considered. Ecological engineering was used to planning as the shelter-forest, farmland and livestock farms. Irrigation work was designed to remove the salt. The forestry, fishery, poultry breeding were set up after rehabilitation. Therefore, the regional environment can get a great progress and their economy will have a sustainable development.

Additional Key Words: Abandoned land, reclamation planning, Ecological engineering

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Introduction

The site locates in the southeast of LiaoDong peninsula, warm-temperature zone, moist and semi-moist monsoon climatic region, and the climate is suitable for the crop growth. The soil of this area is classified as arable meadow soil, also fit for the plant growth. The preponderant plant species in this area are some kinds of herbaceous halophile, e.g. *bulrush, s.salsa* etc. Rice, fruit and aquatic products are the main products.

In the early 1990's, the farmers in this area expanded the scale of he shrimp feeding blindly to gain the high profits. But most of the little shrimp died because the farmers didn't know how to breed them. Their income decreased greatly so that most of the shrimp fields were abandoned. Since the farmland per capita is only 0.06 ha in this area, it become an urgent task to reclaim the abandoned shrimp fields and reconstruct the local landscape. The paper described a case how to reclaim the abandoned land, and how to improve the salinized environment during reclamation planning. The land use map before reclamation is showed as Fig. 1.

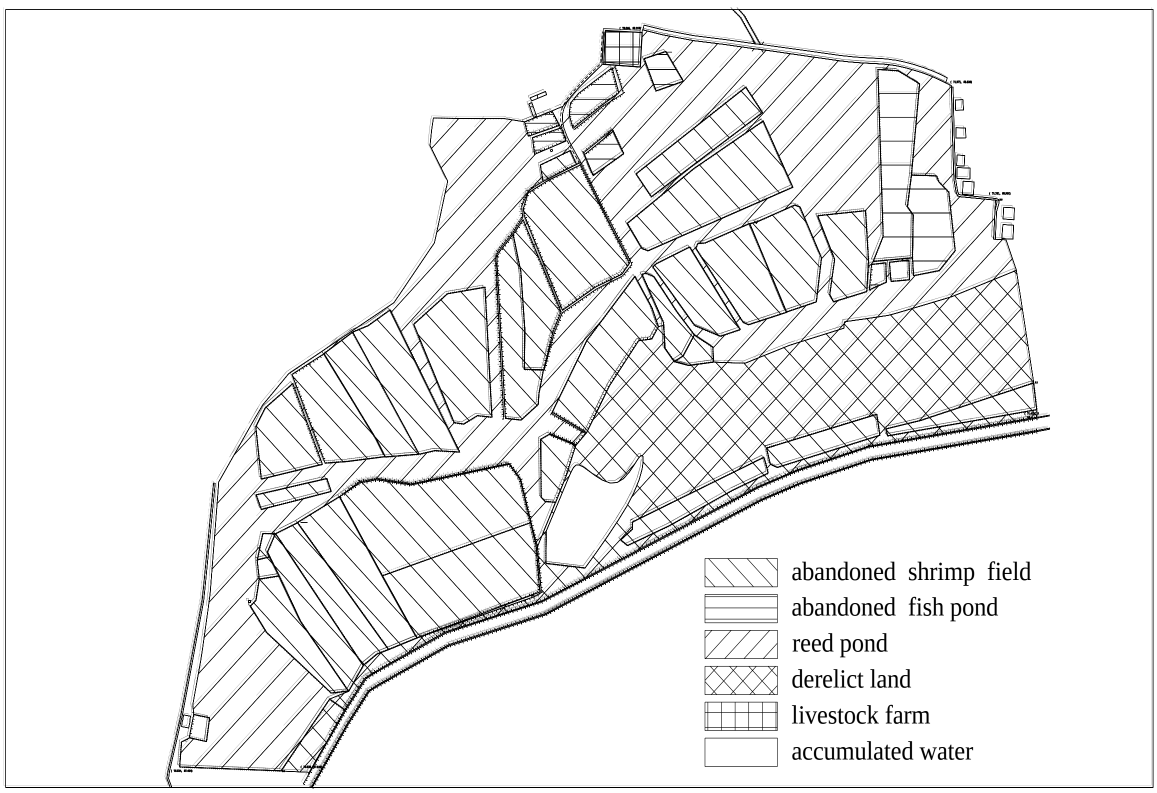

Figure 1. The land use map of experiment site before reclamation.

Land Use Decision Making

The principle of reclamation planning

Soil salinity, land subsidence, and food requirement are the main restraining factors in planning. Thus, three principles were used to make the reclamation planning: (1) The constituent of ecosystem and their arrangement must be suitable for local conditions. (2) The land should conduct to agriculture as more as possible so that local farmers could become richer after reclamation. (3) The renewable resources should be exploited moderately to ensure the sustainable development.

System division

According to the theory of "structure and function", landscape design should depend on the destructiveness. The multifunctional ecosystem, which combines breeding into planting, should be established following the land destructive characters. The component of agroecosystem was showed as Fig. 2.

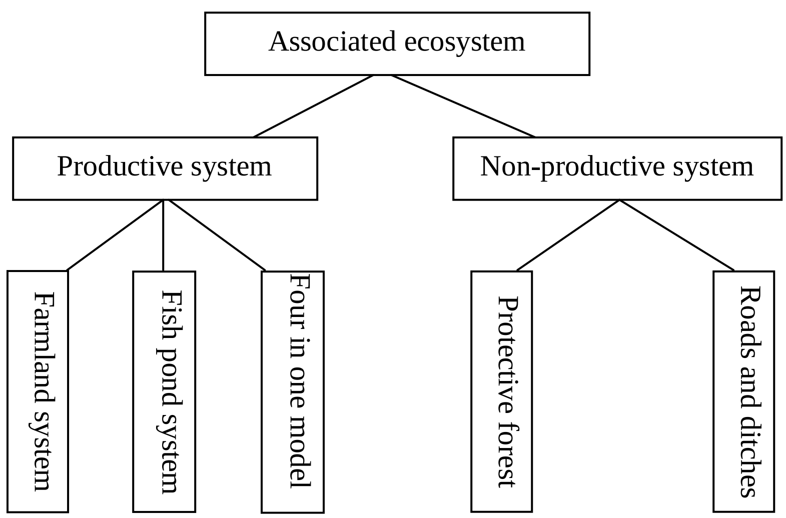

Figure 2. The component of agroecosystem

Land use structure optimization

Objective decision model. The key of land-use structure optimization is how to decide the utilizing strategy of reclaimed land. The linear model is a general way to optimize land structure. It can work out a series of variables:

$$X=\{X_1, X_2, X_3, \cdots\cdots X_n\}^r$$

Which restrained by following conditions:

$$\sum_{j=1}^{n} a_{ij}Xj \leq bi \qquad (I=1, 2, \cdots m, j=1, 2, \cdots m)$$

and the objective function can be maximized (minimized)

$$f=\sum_{j=1}^{n} C_jXj \text{ —max(min)}$$

X_j is the decision-making variable, which means the land use types after optimization; A_{ij} is a series of coefficients, which means economic profits and resource consuming; b_i (right) indicates the resource limitation, including land, labor and water resource, etc.; c_j is the price coefficient; m is the number of equations, which equals to the number of restrained conditions, n is the number of decision-making variables; x>0 means the solutions must be non-negative.

<u>Results</u>. The participant variables are chosen based on the land destructiveness and their usage. By applying MATLAB6.0, the optimum structure of land utilization could be obtained (Table1) dependent on allocation of fund, land suitability, human resource, requirement of local denizen and market. The profits and cost of each product are fixed by field survey.

Table 1 The optimum land use structure

variables / results	X_1	X_2	X_3	X_4
Land use type	crops	fish	Protective forest	Vegetable greenhouse
Area(ha)	39.23	40.00	2.87	20.00
Percentage	38.4%	39.2%	2.8%	19.6%

Although the resolution was calculated by mathematical model and computer, they cannot be copied in the practice. The resolution would be adjusted based on regional landscape planning.

<u>Agroecosystem Design</u>

The first step is evaluate the advantages and disadvantages of the former system. Then need choice the new system's functions. In this case, land salinity, soil quality and land reclaimed elevation should take as the consideration.

Elevation design

It is crucial to determine the elevation of reclaimed land. The inaccurate elevation design, whether higher or not, can affect the irrigation and plant growth. It also affects the engineering quality. In saline-alkali area, the elevation should be 0.8m higher than critical water level. The following formula was used to decide the elevation of the site.

$$H_{farmland} \geqslant h_k + Max\{h_{underground\ water\ level\{}\ h_{river\ level\ \}}\ h_{5\text{-}year\text{-}met\ flood}\}$$

$H_{farmland}$ {—— the elevation position after reclamation}

Max{—— The maximum of the three value}

$H_{underground\ water\ level}$ {——underground water level}

$H_{river\ level}$ ——river level}

$H_{5\text{-}year\text{-}met\ flood}$ {——5-year-met flood level}

h_k {——critical water level}means the highest underground water level which can be adapted by plants

In this area, h_k=1.2m{h $_{underground\ water\ level}$} =2m; the $H_{river\ level}$ and $H_{5\text{-}year\text{-}met\ flood}$ are not influential, so $H_{farmland}$=3.2m.The elevation design must be higher than 3.2m in this area.

Environmental improvement

It is the foundation of reclamation engineering to improve the salinized environment. The basic principle is to dispel abundant water from soil, so as to prevent the salt water into the earth's surface. Three major ecological engineering ways were used.

Irrigation design. Irrigation Design is primary in the whole engineering. The key role of irrigation is controlling the underground water level. Based on the principle, a full-scaled irrigation system should be built. The procedures are done as follows: (1) Protective embankment and gate should be built to prevent the tide erosion. (2) The platform fields and its 3-scale irrigation system should be done. The purpose of platform fields is to underlay the farmland, so that the water level is lower comparatively. The scale of the platform fields is 60m ×100m×1.5m. According to the hydraulic engineering formulas, the primary ditches are 2.0m depth and 6.5m width with 500m space. The secondary ditches are perpendicular to the primary ditches, with 1.9m depth, 5.0m width and 200m space.

Vegetation improvement. It is necessary to revegetate in a short time. An ecological protective forestry is planned to prevent the salt erosion. Some pioneer plants should be selected first, then planted profitable trees with high endurance to salt. On the base of existent s*uaeda.salsa,* a multi-layer mixed forest is built by imitating nature species coordination. According to the community succession, s*uaeda.salsa and tamanx* will be plant as pioneer species to decrease the salinity and increase land surface covering. Jujube or other profitable trees will be planted after the soil fertility becomes rich enough.

Agronomic measure improvement. Irrigation engineering should be helpful to clean salt out from the soil, but the soil still can't arrive the standard of plant growth because of lacking organic matters. Endurance salt species, for example soybean and wheat were introduced by wheat-soybean rotation. Thus soil fertility can be increased gradually by crop promotion. Besides plowing also can control the salt movement.

Agroecosystem design

The agroecosystem design includes function design, landscape pattern optimization and landscape unit design.

System function design. Biological production, environmental service and cultural support are the general landscape functions. In this case, the system functions are showed as follows: (1) The soil fertility and revegetation rate can be increased. (2) The steady system productivity can be achieved to increase the farmers' income. (3) The system self-sustaining ability can be enhanced dependent on biological diversity. So the relationship among fishery, plant production and stock raising will be established by their biological structure adjustment.

Landscape pattern optimization. An optimal adjustment had been done between former and new patches so that the irregular abandoned shrimp fields became regular fish ponds. On the verge of farmland patches, an ecological buffer region---protect forest was introduced to prevent the salt erosion. The vegetable greenhouses, livestock houses were set up to make full use of resource. The corridors with high performance were built. The emphasis is the contribution of ditch and road net. The reclamation planning details are showed in Table 2, Fig. 3 and Fig. 4.

Table 2 The reclaimed land use plan

Land use type	crops	fish	Protective forest	Vegetable greenhouse
Area(ha)	41.99	36.32	1.45	18.17

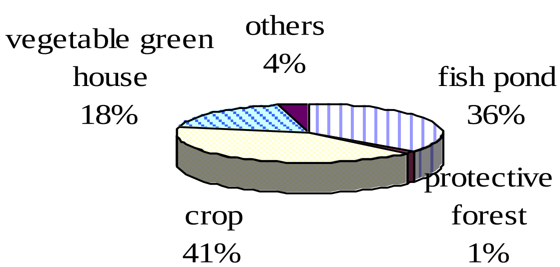

Figure 3. The distribution(ha) of reclaimed lands, Dalian, China

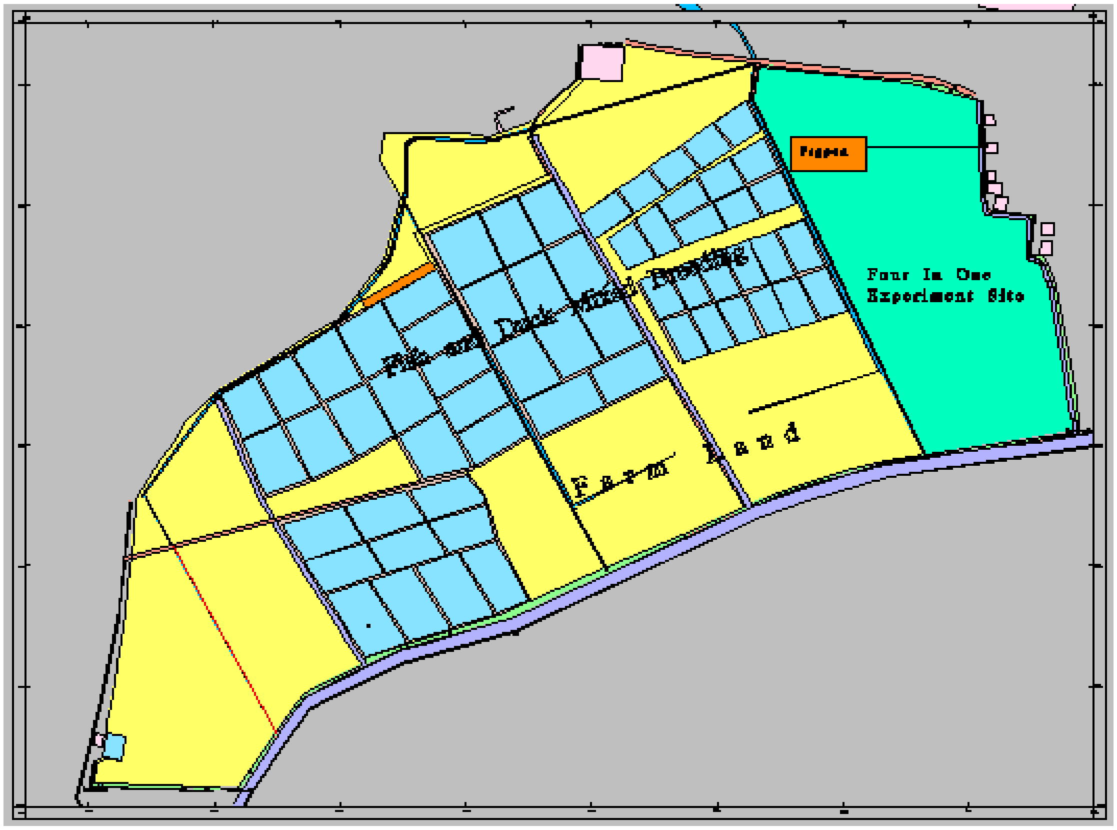

Figure4 The map of reclamation plan at PuLandian, LiaoNing, China

Landscape unit design. The landscape unit design put emphasis on how to design land use mode and ecosystem in order to make the land reuse match with the ecological process.

(1) "Four in one" ecological model: The materials build up an integrated energy utilization system. The recycle process showed as follows: Excrements produced in toilet and pigpen collected into the marsh gas tank. After fermentation in the tank, the methane will be produced to provide the farmers' cooking energy and keep the green house warm. The dregs of fermentation are used as fertilizer of vegetables. Some excrement of pigs can be also used as vegetable fertilizer without chemical pollution. Others return to the marsh gas tank again.

(2) Fish-duck mixed breeding: The duck's living space is water surface, while fish live in the water. The utilization of different ecological space has three advantages: ① The duck's castoff, including dung and the feed remnants in the fish pounds are used as fish feedstuff , which can make ducks' feed used completely and save the resources. ② The castoff of ducks helps the phytoplankton grow, which can enhance the efficiency of light energy. The water

oxygen also increase because of the stirring by ducks. ③ The incidence of disease is reduced by castoff clean. From experiences, the fish product in this model is higher 15% than control model. 1500 ducks can be raised per ha.

The illustration of "four in one" model and "fish duck mixed breeding" model are presented in Fig. 5 and Fig. 6.

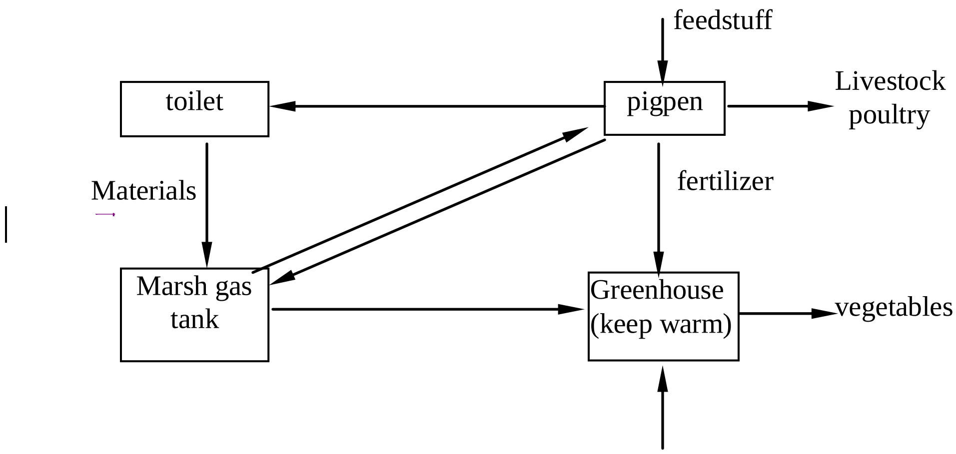

Figure 5. The material recycle of "four in one" model

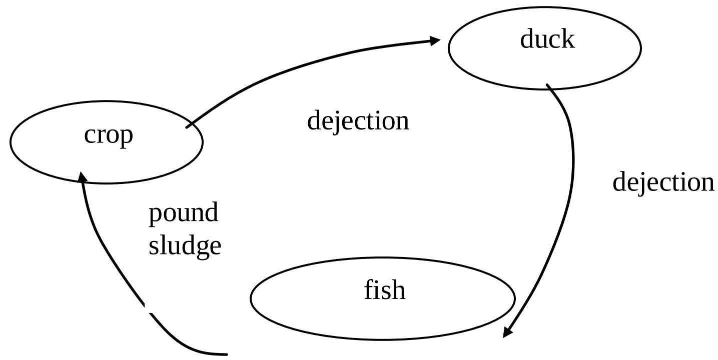

Figure 6 The material recycle of "fish duck mixed breeding" model

The energy flow direction of the agroecosystem is presented in Figure 7.

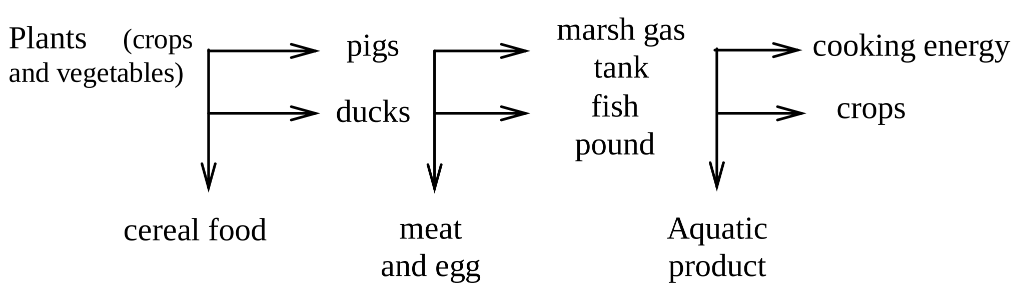

Figure 7 The energy flowing direction

Analysis of Benefits

(1) The arable land can be up to 41.99 ha. Land area increased to 57.5%. The reclamation process will promote agricultural structure reasonability and sustain the social stability.

(2) A total 36.1 million Yuan should be invested. Economic benefits will be obtained at the rate of 8.6 million Yuan each year. Thus the payoff period of the investment would become 3.98 years.

(3) The salinized land and landscape could be improved by the comprehensive reclamation.

Further, it can afford a favorable living environment for local denizen.

Conclusions

Since the reclamation purpose is to enhance the people's living quality while considering environmental benefits, the key guidance of the plan is regarding the abandoned fields as a nature-economic-social complex system. An integrative reclamation approach in saline environment is suggested in the paper. Combined with the saline environment, an optimum landscape pattern should be built. Since reclamation is a new field in China, international cooperation is necessary to obtain high reclamation effectiveness.

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