CHINESE GEOGRAPHICAL SCIENCE
Volume 4, Number 2, pp.168-173, 1994
Science Press, Beijing, China

COMPLEX ECOLOGIC-ECONOMIC SYSTEM OF AFFORESTATION—AN EXAMPLE OF SUSTAINABLE AGRICULTURE

Li Xiaofang(李孝芳)

(Commission for Integrated Survey of Natural Resources, the Chinese Academy of Sciences, Beijing 100101, PRC)

ABSTRACT: The paper deals with a transformation model of a backward district into a prosperous one. The district is geographically located in Lixiahe region, Jiangsu Province. The region had long been known as one of the poorest area in China, and had been alternatively attacked by flood, waterlogging, drought, salinization, and plague of insect. Since the seventies of this century efforts to open up trenches on lowland and to level up the shoaly land have been made. A kind of tree, which is tolerable to high watertable, was used to afforest the land. Cereal crop, vegetable and beans are grown. In some cases, the shoaly land is used for sheep grazing and fishery. A favorable combination of forestry, agriculture , animal husbandry and fishery has been set up in the region. There are five types of managements in the system: 1) forestry-agriculture complex management, 2) forestry-fishery complex management, 3) forestry-aquatic plant-fishery complex management, 4) forestry-animal husbandry complex management, and 5) forestry-edible mushroom complex management. The principles and ecological benefits of this system can be identified: 1) Increase soil fertility by piling mud from marsh land on top soil, and thicken the arable layer. 2) Enhance the utilization rate of sunlight and energy, due to the change of microclimate in field. 3) As a result of multiple layer cultivation and multi-cropping, the production has been greatly increased. 4) Accelerate the cycling of matter and conversion of energy and nutrient of the system. 5) Decrease the consumption of soil fertility and increase the capability of controlling insect pests. 6) Improve ecological environment by afforestation. 7) Raise income and provide jobs for local peasants, even some ones from other part of this province.

KEY WORDS: Lixiahe region, complex ecologic-economic system of afforestation sustainable agriculture, agroforestry

Lying in the central part of Jiangsu Provence, Lixiahe region is situated on the water divide between the Changjiang (Yangtze) River and the Huaihe River. The region borders the general irrigation canal to the north, the Tongyang Canal on the south, the Beijing–Hangzhou Grand Canal over the west, and Tongyu Canal to the east (Fig. 1). Administratively, the region covers part or whole territory of 11 counties. The total area accounts for $14.5\times 10^6 km^2$, of which $7.05\times 10^5 ha$ are under cultivation. Total population reaches 847×10^4, among them 763×10^4 are peasants. The cultivated land per capita is 0.083ha.

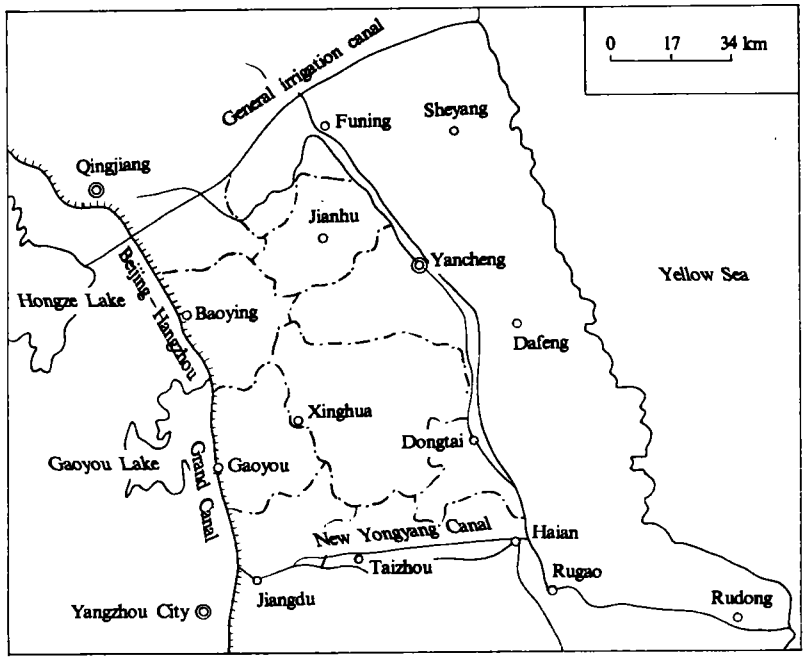

Fig.1 Geographic location of Lixiahe region

I. NATURAL CONDITIONS AND THEIR EFFECT ON PRODUCTION

Formerly, the region was a bay close to the Yellow Sea of China, under the sea surging, a large amount of sand and silt both from the Changjiang River and the Huaihe River were partly deposited in the bay, and partly formed sand bank along slope near the eastern margin of the bay. In the long run, the bay was completely closed both by sand bank and sand spits which were formed on the north bank of the Changjiang River and the south bank of the Huaihe River, and evolved gradually to a lagoon. Because the lagoon was continuously deposited by sand and silt from the Changjiang River, several marsh lands were finally formed in different sizes. Topographically, the marsh land, as a whole,

takes a pan-shaped, with a comparatively high border and low centre. The low surface is generally at an elevation of 1.5-3m. Formerly reed thickly grew and a small amount of fresh water fish and shrimp bred in the marsh.

Before 1949, the region had been alternatively attacked by flood, waterlogging, drought, salinization as well as plague of insect. The disaster area often reached 80% of the total area of the region. The local peasants had lived in poverty, per unit area yield of grain was only 1,500 kg/ ha in a normal year, the grain ration was average less than 50kg per capita. Since the 1950s, a water conservancy project was carried out, the yield of grain and aquatic product had been slightly increased as a result of the improvement of agricultural conditions. However, recently a number of river channels, discharging into the Changjiang River and the Yellow Sea, have continuously changed. Large area of marsh land dried up, meanwhile, seasonal drought more easily turns the marsh land to dry up, so the production of reed had greatly decreased. By that time, a project had been taken to pile sand and silt on marsh land, forming a shoaly land, where crops were planted. Unfortunately, that project greatly damaged water conservancy of the region. It lowered the storage capacity of marsh land, therefore, after storm flood submerged newly-built shoaly land. Finally, local peasants became aware of that the project was not good for reclamation of the marsh land.

II. MODELS OF COMPLEX ECOLOGIC-ECONOMIC SYSTEM OF AFFORESTATION

Since the end of the 1970s, local forest farm had made efforts to level up marsh land into a rectangular which was cut by trenches of cross shape, connecting with rivers outside marsh land. Forest has been planted on the rectangular lowland (locally called buttress), cereal crop has been inter-grown with trees, and fish has bred in trenches. A complex management of forestry, agriculture, and fishery has been spontaneously formed, and a number of models of complex afforestation management were then carried out. According to experiences taking forestry as a key line in the complex management and practising, several combinations of forestry-agriculture, forestry-fishery or forestry-animal husbandry-fishery management have become ideal models for the development and improvement of this region. A new approach in the utilization of resources of the lowland has been adopted by making full use of multi-layer of space above, on and under ground, as well as use of multi-order of time to plant crops, in order of priority, in each season. On a major premise of ensuring well growth of trees, an attempt of intercropping and interplanting has been achieved several times, by using different seeding seasons, and different growing periods. This is an ecologic-economic structure with complex benefit, and also a complex afforestation management system with a favorable mass cycling. Economically, it can achieve sustainable benefit, and provide a new way for the utilization of such a lowland.

Structure and function of different models exert significantly influence upon the full play of benefit in the complex afforestation management system. It is of prime importance to properly evaluate the social, economic, technological and ecological conditions as well as calculation of benefit. On this basis, a reasonable ecological engineering design was carried out. For example, from ecological and economic point of view, how to properly deal with the contradiction between engineering and benefit of water conservancy is of great importance. The underground water level changes greatly all year round in Lixiahe lowland, especially, the underground water table rises fiercely during flood period. In order to ensure a stable underground water level, to have the production of farming, forestry, animal husbandry, sideline production and fishery being in smooth progress, it is necessary to adopt earth bank and shoaly land project. That is to build large earth bank around the marsh land and to build culvert and sluice gate, to let water freely pass through and discharge to river outside earth bank. A good irrigation and discharge equipment is fit out. This project has helped the shoaly land and buttress to have a good function in fighting flood, storing flood water, draining flooded field as well as irrigation.

There are five types of management in Lixiahe complex ecologic–economic system of afforestation.

1. Forestry–Agriculture Complex Management

This type is suitable to shoaly land with moderate underground water table, the earth bank is 2.5m high, and the shoaly land is over 1.2m high. Generally, the underground water table is about 0.7m. After levelling the lowland, destroying wild grass, and mellowing soil, a kind of trees, namely, metasequoia, tolerable to high water table, is planted on shoaly land. The roots penetrate deeply into soils with an underground water table of 10–20m. Wheat, rapeseed, soybean, gourd, taro and vegetable being two crops a year or three crops a year, are intercropped with trees. In trenches fishes are bred. On low–lying shoaly land at an underground water table of 0.5m, forestry–agriculture complex management can also be adopted, by building earth dyke and digging small ditches on shoaly land which is separated in every ten meters wide. The dyke is 3m wide and 0.5m high. Trees are planted on dykes, and broad beans and soybeans can grown under the younglings.Rice is grown in shoaly land.

2. Forestry–Fishery Complex Management

This type of management is suitable for shoaly land with a underground water table lower than 0.5m. Trees are planted on buttress, fishes are bred in deep trenches.Three

subtypes can be distinguished. The first has a buttress of 12m wide, the shallow ditch is 5m in depth. The way of management is primarily to plant trees on the buttress and breed fish and shrimp in the ditches. The second lays equal stress on planting trees on buttress and breeding fish in trenches. The width of buttress is 15–20m, and the width of trench 10m. The third lays stress on breeding fish, with a trench 20–40m wide, working as a semi-intensive breeding fish pond. The yield of fish reaches 3,750kg/ ha. Trees are planted on the buttress 40m wide.

3. Forestry–Fishery Complex Management

When the forest becomes closed, crops cannot be intergrown with forest, but fish can be bred in trenches. During summer time, canopy cast shadow over fish pond, providing a favorable cool microclimate for fish. So far as the mass cycling, there is not close relationship between fish and forest yet, the present model reveals great advantage over unitary management either in the stability of the system and in the use of space.

4. Forestry–Aquatic Plant–Fishery Complex Management

Aquatic plant is a special local product of Lixiahe region. An earth dyke 2–5m wide is built around the shoaly land. Plants on earth dyke are trees. Lotus, arrowhead and wild rice stem are grown on the shallow shoaly land with high water table, crops and vegetable are intergrown with trees. The trenches are also used for breeding ducks and gooses. Another type of management is to plant trees on shoaly land, intergrow crops with tress, and grow aquatic plants in trenches, where we can also breed fish and shrimp. This is a type of multi-utilization of forestry–agriculture–aquatic plant–fishery four layers, namely multidimensional agriculture. This type of management can be adopted throughout the whole period from tree growing until the close of canopy.

5. Forestry–Fishery–Animal Husbandry Complex Management

This type is conducted when the forest is completely closed. On the basis of combination of forestry and fishery, further more, both the land surface and water surface will be sufficiently used to breed sheep, duck as well as chicken. An organic combination of forestry, fishery and animal husbandry is made. It has not only high yield, but also reasonable mass cycling. The excrements of sheep and poultry feed fish or apply forest land, weeds under forest feed sheep and poultry.

6. Forestry–Edible Mushroom Complex Management

When there are dense trees, the land will be shadowed, such condition is favorable for the culture of mushroom. Especially the effect of meteorological factors, such as temperature, moisture and sunlight inside the forest will extend the period for the culture of mushroom, significantly increasing economic benefit.

III. PRINCIPLES AND ECOLOGICAL BENEFITS OF THE SYSTEM

After an effective transformation of traditional agriculture and backward economy into a multidimensional agroforest ecological system with high output in Lixiahe region, the cropping layer becomes thick, and the water table as well as gley horizon of the lowland are lowered. Then, the soil aeration is strengthened, and the soils become fertile, and the utilized ratios of sunlight and energy are increased, due to the changes of microclimate in the field. In virtue of the increase of soil surface area, soil temperature and water temperature in trenches rise. This is good for the reproduction and growth of fish and plankton. The effect of increase of soil surface area is generally called "boundary effect" or "theory of ecological boundary". As a result of the multi-layer cultivation and multi-cropping, the production has been greatly increased. In the complex population, the composition of crops includes green plant, produced by primary product, and fish, shrimp, and bacteria, produced by secondary product. Consequently, in the system, transformation of energy and nutrient as well as matter circulation are greatly improved. The increase of species and the proper proportion of these species decrease the consumption of soil fertility and increase the capability of controlling insect pests. Thus, the ecological environment will be profoundly improved.

The economic benefit of complex ecologic-economic system of afforestation is high. In the system, forest growth speed is generally 5%-30%higher than that in pure forest, and the income from grain and vegetable intergrown with forest is 4-6 times of that in monoculture. As far as the social benefit the system principally provides jobs for local peasants, even some ones from other parts of this province. Peasants from Lixiahe region become rich. A sustainable agriculture is successfully built in Lixiahe region, Jiangsu Province.

REFERENCES

〔1〕 黄宝龙, 黄文丁. 江苏省里下河地区人工林复合经营模式. 见. 兴起的立体农业—全国立体农业开发与普及研讨会论文选集. 北京: 中国科技出版社, 1990, 236-238.

〔2〕 马世骏, 王如松. 社会-经济-自然复合生态系统. 生态学报, 1984, 4(1): 1-8.