

Kai ZHANG, Ning LUO, Xiaojing XU, Xiaoniu XU

Sustainable development models of converting cropland to forest in Dabieshan District, Anhui Province

© Higher Education Press and Springer-Verlag 2008

Abstract The characteristics of the eco-environment, extension scale and sustainable models of converting cropland to forest in the Dabieshan District of Anhui were analyzed. The Dabieshan District is a main ecological area with a function of soil and water conservation where seven large reservoirs and irrigation systems of the Pishihang are distributed. Therefore, the extension scale of converting cropland to forest could be enlarged properly in the reservoir area, while it should be limited in the non-reservoir area due to the issues of higher population density and food safety. Great attention should be paid to the model selection and results during the conversion of cropland to forest. Some suitable models and effective approaches were put forward for the sustainable development in the Dabieshan District, Anhui.

Keywords steep slope cropland, ecological function, soil and water conservation, converting cropland to forest, Dabieshan District

1 Introduction

Anhui is one of the main provinces for the engineering project of converting cropland to forest. Dabieshan District is the key area for the project in Anhui. The district includes the whole areas of Jinzhai, Huoshan and Yuexi counties, and partial areas of Shucheng, Qianshan, Taihu, Lu'an, Tongcheng and Lujiang counties, which are important bases for forestry, tea production, headwater, and ecological conservation. The total population in this

Translated from *Science of Soil and Water Conservation*, 2006, 4(5): 107–111 [译自: 中国水土保持科学]

Kai ZHANG, Xiaojing XU, Xiaoniu XU (✉)
College of Forestry and Landscape Architecture, Anhui Agricultural University, Hefei 230036, China
E-mail: xnXu61@yahoo.com.cn

Ning LUO
Department of Forestry, Anhui Province, Hefei 230001, China

district is about 2.8 million. The total area is 12955 km², which forms 9.4% of the total area of Anhui Province. This district is a less-developed, mountainous area with seven large reservoirs (including Meishan, Xianghongdian, Fuziling, Mozitan, Longhekou, Hualiangting, and newly-built Bailianyan) and Pishihang irrigation network (Anhui Provincial Committee of Science and Technology, 1998). The total storage capacity of the seven reservoirs reaches 10 billion m³. In addition, Dabieshan District is the major headwater of Huaihe River, where 70% of the discharge of the mainstream is from Pihe and the Shihe River (Huang et al., 2004). Serious water and soil losses resulted from silting in reservoirs and rivers which causes an abnormality in water conservancy facilities. The amount of sediment deposition of every larger reservoir reached over 5% of its designed storage capacity, some of which were, to a certain extent, in danger. The actual irrigation area of Pishihang irrigation network was less than 90% of what was initially designed. Moreover, the irrigation area is still decreasing at present (He, 2004; Huang et al., 2004; Zhou, 2005).

In order to control the water and soil losses in this district, heavy investments from national and local governments have been made since 1980s. However, the achievements from these investments could not meet the needs of controlling water and soil losses in a comprehensive way (Huang et al., 2004). Therefore, it is necessary to enhance the restoration and reconstruction of the regional ecosystem by the full use of the natural force and self-recovery capacity of ecosystems in combining the engineering of converting cropland to forest (He, 2004). This is the only way to thoroughly achieve sustainable development and changes in the ecological environment and mountainous economics in the Dabieshan District.

2 Study area

The Dabieshan is located on the demarcation line of Qinling-Huaihe which is one of the most important geographical boundaries in China. This demarcation line

is an interim zone from subtropical climate to temperate, humid and semi-humid climates. Thus, Dabieshan District is favorable in natural conditions with abundant rainfall and mild warm climate. Annual mean air temperature is 14.5–15.6°C. Annual mean rainfall is 1300–1600 mm concentrated in 5–10 months. Dry and wet seasons are evident and the aridity index is 0.7–0.8. The natural vegetation is evergreen and deciduous broad-leaved mixture, with high species richness and biodiversity. Forestry land area contributes 68.3% of the regional total area (Table 1). The forest coverage is 68%.

Table 1 Land use regime of Dabieshan District, Anhui

land use types	area/ $\times 10^4$ hm ²	percentage/%
Forestry land	88.5	74.7
Tea and mulberry orchards	2.0	1.7
Water surface	8.1	6.8
Others	19.9	16.8
Total	118.5	100.0

The Dabieshan Mountains are characterized by their complicated geological structure and broken rock body which resulted in exposed bedrock and steep slopes. The steep slopes, with an inclination of over 25°, cover one third of the regional total area. The parent rocks are composed mainly of gneiss and granite, on which the soils developed are usually shallow and sandy with rather low erosion resistance.

Due to the above-mentioned characteristics of the natural conditions, the ecological environment in Dabieshan District is very fragile. Consequently, the district is very vulnerable to serious soil erosion.

3 Area prior to converting cropland to forest and forest types

3.1 Area prior to converting cropland to forest

To determine the reasonable scale for the project of converting cropland to forest in Dabieshan District, the local natural, economic conditions and ecological orientation should be taken into full consideration.

Table 2 Area of soil erosion in Dabieshan District, Anhui

county	total area/km ²	soil erosion area/km ²				total
		mild	moderate	strong	very strong	
Huoshan	2042	762.8	367.7	35.4	—	1165.9
Jinzhai	3814	1488.4	564.3	119.7	—	2172.4
Yuexi	2382	689.9	979.5	249.0	20.4	1938.8
Shucheng	2329	543.7	249.4	156.7	13.0	953.8
Jin'an and Gu'an	3705	405.0	101.0	—	—	506.0

Sources: Anhui Provincial Bureau of Water Resources: The 3rd National Soil Erosion Remote Sensing Survey Data (2001)

First, it should be based on the natural conditions and land use regime, particularly on the cultivated area on steep slopes and its proportion, in order to determine the reasonable scale of converting cropland to forest. The cultivated area in Dabieshan District is very small with only 8.6% of the regional total area, but on slope of over 25° it contributes over 50%. Moreover, the area of the cropland at the reservoir area is not only smaller but the steep cropland exceeds 60%, most of which is low-yield (Zhou, 2005). Those croplands on the steep slopes with low-yield should be made into a forest. This is the basic scale of the project for converting cropland to forest in Dabieshan District.

Secondly, the scale of converting cropland to forest should be determined by the pattern of ecological function. Due to the distribution of the seven major reservoirs and the Pishihang irrigation network in the district, the converted cropland should be assured of a safe work in the long-term. Consequently, soil and water conservation is the basic ecological function in Dabieshan District although there exists certain geographical differences (Wang et al., 2003). The Dabieshan District is the second largest forestry based in Anhui, which ecologically functions in water conservation and in hydrological storage which play an important role in flood regulation in the Huaihe and Taihu Basins and assuring efficient and safe work for the Pishihang irrigation network. Therefore, the scale of converting cropland to forest can be enlarged appropriately in the reservoir area, including the steep cropland over 25° and the low-yield cropland below 25°. Outside of the reservoir area, the eco-agricultural functions play an important role in safe food production without emphasizing on the large scale conversion of cropland to forest. It is necessary to strengthen the construction of soil and water conservation and to establish agro-forestry management systems.

In addition, food safety should be taken into consideration in the determination of the scale of converting cropland to forest. De-farming on steep slopes can save agricultural inputs, improve the ecological environment and reduce the frequency of natural disasters. Moreover, it has a positive impact on grain production because of the limited land resources in Dabieshan District (Chen et al., 2004). The average population density is 220 persons/km² in Dabieshan District. The cropland area is only 0.04 hm²

per capita, most of which is low-yield fields. Therefore, it is difficult to meet the minimum food need for subsistence (Hou, 2000; Zhu et al., 2004). It is impossible to fulfill food self-sufficiency, particularly in the reservoir area. De-farming in Dabieshan District faces the contradiction between ecological environmental protection and existence and development of hillside farmers. Thus it should avoid unrealistic enlargement of the de-farming scale, otherwise the ecological migration must be increased in order to resolve the actual problem of existence and development after de-farming.

3.2 Reasonable structure of forest types for converting cropland to forest

The project of converting cropland to forest should be carried out in line with local conditions. On the basis of ecological conditions in the project area and full use of native species in ecological restoration, it is necessary to select appropriate tree and grass species to establish arbor-shrub-grass multiple systems with rational structure. As Dabieshan District is an important water source area, the project should be focused on the establishment of ecological forests. However, it is important to integrate the project with the regulation of industrial structure of agriculture and to take full consideration of the issues of farmers' existence and development after de-farming. It should be set up a food security production system with the combination of woody grain and oil and livestock breeding. Innovation in management models should center on the foundational question of increasing farmers' income and the village's economic development. In view of its social-economic and natural characteristics, proportion of economic forest could be increased appropriately (particularly outside the area of reservoirs). Meanwhile, it is important to grow economic forests that reflect the regional characteristics and to develop the related processing industry on certain scale under an assurance that the project is focused on ecological construction. Consequently, it can accelerate the departure from poverty and promote prosperity so that the sustainable development of society and economy in Dabieshan District can be obtained.

4 Sustainable development model for the project of converting cropland to forest

Due to the special status of Dabieshan District, consideration must be given to both ecological and economic benefits based on site conditions in the project construction. In order to realize sustainable development, great attention should be paid to tree species selection and their arrangement, and to the extension of the optimal silvicultural models in afforestation.

4.1 Silvicultural models for ecological forests

Since it is a vital water source area, the Dabieshan District plays an important role in the regional socio-economic development. Then, the project construction should be centered on ecological forest (water and soil conservation forest) particularly for the cropland on steep slope over 25° and the ones with serious soil erosion. The major silvicultural models are shown in Table 3.

4.2 Silvicultural models for eco-economic forests

The models can be suitable for the area where it is traffic-convenient and on slope below 25° with thick soil. The project construction should be focused on the development of economic forest in addition to its ecological benefits. The available tree species, such as *Castanea mollissima*, *Ginkgo biloba*, *Toona sinensis*, *Carya cathayensis*, *Eucommia ulmoides*, *Magnolia officinalis*, *Phyllostachys pubescens*, *Camellia sinensis*, *Morus alba*, *Edgeworthia chrysantha*, can be selected. The major silvicultural models are shown in Table 4.

4.3 Management models for forest tourism

Dabieshan District is rich in tourism resources, and basically possesses the feasibility of tourism development due to its increasingly strengthened and improved construction of basic facilities (Feng, 1999; Ma, 2001). The tourism resources in Dabieshan District can be divided into four types, i.e. natural scenery type (such as Wanfo lake-Wanfo Mountain), forest park type (such as Tiantangzhai, Tianzhushan and Yaoluoping forest parks), history memorial type (such as revolutionary site and mausoleums) and special man-made structures (e.g. Pishihang irrigation network and dams), indicating that there are great potentialities to exploit on top of its existing eco-tourism resources (Feng, 1999). Therefore, the project construction of converting cropland to forest should be combined with the eco-tourism development. In order to increase the landscape diversity, it needs to increase the ornamental trees (especially flower trees, fruit trees and colorful leaved trees) in various scenic spots and the surrounding areas. In addition, on the basis of village greening and beautifying, it needs to develop farmer paradise with garden and fruit orchard of distinctive local features through de-farming near the village. The village courtyard greening should be made mainly by economic and fruit trees with great ornamental value. *Phyllostachys pubescens*, *Ginkgo biloba*, *Cinnamomum camphora*, *Prunus mume*, *Cupressus* spp., *Liquidamda formosana*, *Metasequoia glyptostroboides*, *Magnolia biondii* are the main choice. Economic tree species which can be used for both ornament and fruit production, such as *Prunus persica*, *Pyrus pyrifolia*, *Prunus pseudocerasus*, *Carya cathayensis*, *Castanea mollissima*, *Diospyros kaki* and *Zizyphus jujube* are the main choices for orchards. It can make proper

Table 3 Silvicultural models for ecological forests in Dabieshan District, Anhui

types	suitable site type	models
Conifer and broad-leaf mixture (arbor mixture)	Upper slope with thin soil	Major tree species: <i>Pinus massoniana</i> , <i>P. huangshansis</i> Mixed tree species: <i>Liquidamba formasana</i> , <i>Quercus acutissima</i> , <i>Q. variabilis</i> , <i>Albizia macrophylla</i> , <i>Dalbergia hupeana</i> Density: 3300 trees/hm ² ; soil preparation by hole or narrow strip; mixture by lines, or line and strip or groups
	Lower slope with thick soil	Major tree species: <i>Pinus massoniana</i> , <i>Cunninghamia lanceolata</i> , <i>P. huangshansis</i> , <i>P. elliotii</i> , <i>P. taeda</i> etc. Mixed tree species: <i>L. formasana</i> , <i>Sassafras tzumu</i> , <i>Schima superba</i> , <i>Liriodendron chinense</i> , <i>Eucommia ulmoides</i> , <i>Alnus trabeculosa</i> , <i>Q. acutissima</i> , <i>Q. variabilis</i> etc. Density: 2500 trees/hm ² ; soil preparation by hole or strip; mixture by line and strip or groups
Conifer and broad-leaf mixture (arbor-shrub mixture)	Upper slope with sandy thin soil	Main tree species: <i>P. massoniana</i> , <i>P. huangshansis</i> , <i>Cupressus</i> spp. Mixed tree species: <i>Dalbergia hupeana</i> , <i>Ilex purpurea</i> , <i>Amorpha fruticosa</i> , <i>Loropetalum chinense</i> etc. Soil preparation by hole or narrow strip; mixture by lines; close planting
Shrub-herb type	Stony barren slope	This model is suitable to barren slope for vegetation restoration. Optimal vegetation structure and enhanced ecological functions can be achieved by introduction of shrubs with high economic value (e.g. <i>Dalbergia hupeana</i> , <i>Loropetalum chinense</i> , <i>Rhododendron simsii</i> , <i>Ilex purpurea</i> , <i>Amorpha fruticosa</i> etc.), which are based on the existing vegetation.

arrangement of grass and flowers under the arbor canopy, particularly by using the native flowers and plants of Dabieshan District. It should take a full consideration of plant disposition with chronosequence of flowering and fruiting to make sure that there are different flowers and fruits in different seasons. For the development of eco-forestry

tourism, it needs to make a full use of the superiority of the native green products, such as teas (e.g. Lu'an Guapian, Shulu, Huoshan Huangya, Jinzhai Cuimei, Tianzhu Jianhao), Chinese chestnut, bamboo shoots, fern vegetable and edible fungi (e.g. *Gastrodia elata*, *Dendrobium huoshanensis*, *Ganoderma lucidum*, *Smilax glabra*, *Auricularia*

Table 4 Silvicultural models for eco-economic forests in Dabieshan District, Anhui

model type	silvicultural model
Arbor-shrub mixed economic forest	The model has been extensively applied with significant ecological and economic benefits in the Dabieshan District. Tree species with great economic value and a certain scale of cultivation, such as <i>C. mollissima</i> , <i>T. sinensis</i> , <i>Diospyros kaki</i> and <i>Sapium sebiferum</i> etc., can be used in arbor story. The planting density is 450–600 trees/hm ² . The following species, <i>C. sinensis</i> , <i>M. alba</i> and <i>E. chrysantha</i> etc., can be selected in the understory, planting by lines.
Forest-medical multi-management	Arbor-shrub and arbor-shrub-grass mixtures can be used for this model. Tree species with good economic benefits, such as <i>C. mollissima</i> , <i>E. ulmoides</i> , <i>T. sinensis</i> , <i>G. biloba</i> , <i>C. cathayensis</i> and <i>Magnolia officinalis</i> etc., can be selected for the arbor story. The density is 600–750 trees/hm ² . The following shrubs, <i>Forsythia suspense</i> , <i>Taxus chinensis</i> , <i>Litsea cubeba</i> , <i>Cornus officinalis</i> , <i>Ficus carica</i> etc., and medical grass, <i>Lilium</i> spp., <i>Salvia miltiorrhiza</i> , <i>Bupleurum chinense</i> , <i>Pinellia ternata</i> , <i>Anemarrhena asphodeloides</i> , <i>Platycodon grandiflorus</i> , <i>Lindera aggregata</i> etc., can be selected to plant in the understory.
Forest-grass-livestock multi-management model	The model can be applied to de-farming on gentle slope with transport facilities. Economic and fruit tree species with great benefits, such as <i>C. mollissima</i> , <i>Pyrus pyrifolia</i> , <i>D. kaki</i> , <i>Prunus pseudocerasus</i> , <i>C. cathayensis</i> etc., can be selected for the arbor story by the density of 600–750 trees/hm ² . Forage grass, such as <i>Medicago sativa</i> , <i>Trifolium repense</i> , <i>Lolium perenne</i> etc., can be selected to plant under the arbor story. Chickens, ducks and geese can be bred in the stand and the grass can be harvested as forage. This model had successfully been used in Dabieshan District, and should be used extensively.
Bamboo shoot production forest	The model can be used to de-farming on gentle slopes with thick soil. <i>Phyllastachys praecox</i> , <i>P. praecox</i> f. <i>prevernalis</i> , <i>P. pubescens</i> etc. can be selected to cultivate with soil preparation by large holes and density of 600–900 trees/hm ² . Legumes plants can be used for intercropping in order to fix the soil and improve soil fertility and increase yield.

auricular, *Lentinula edodes*) in the Dabieshan District, to develop the deep-processing products and the tourism industry (Liang et al., 2002).

5 Basic ways of sustainable development of the de-farming project construction

The basic purpose of the project of converting cropland to forest is to improve the ecological environment in an ecologically fragile area. In the pursuit of building a well-off society nationwide, the ecological needs of the community have become the first demand in forestry (Zhou, 2005). Therefore, the project of converting cropland to forest is an innovative cause which should center on the ecological benefits but with consideration to economic and social benefits. In addition, to ensure sustainable development for the project, it should be combined with the adjustment of rural industrial structures to foster local economy with regional characteristics (Wu, 2001).

5.1 Implementation of the scientific planning

Scientific planning should be carried out in the project construction of converting cropland to forest with a strategic perspective on regional sustainable socio-economic development. Thereafter, it must persist in following three principles. The first is the principle of ecological priority, highlighting focal point and great attention to protection. The second is suitable measures for local conditions, suitable tree to relevant land, and emphasizing on practical results. The third is comprehensive control, three-dimensional exploitation, and sustainable development. Moreover, on the base of the demands of engineering construction and management, it should focus on the project quality and ensuring that the project is in a virtual cycle to provide a safeguard for ecological restoration and reconstruction.

5.2 Establishment of scientific support system

Advances in science and technology are the technical support for the sustainable development of the project of converting cropland to forest. To ensure the engineering quality, it should establish a feasible scientific support system and give full play to the professional skill of the technical personnel involved in the project area, it should resolve the technical problems in project construction. It should study silvicultural models and related complete techniques, such as tree species selection, spatial disposition and species mixture etc., for different site types and economic levels at different areas. It should apply and extend the practical scientific and technological achievements, and should carry out technical services and

technical training. The technical personnel should be encouraged to contract the project of converting cropland to forest in order to increase the scientific content in the engineering construction. Moreover, it is also necessary to establish a perfect management system of engineering quality. It should carry out dynamic monitoring of the engineering by application of "3S" techniques to promote the modernization of the project management (Wang et al., 2004).

5.3 Innovation in management model of the project of converting cropland to forest

The project of converting cropland to forest is not only an ecological construction project, but also a systematic engineering for the realization of sustainable development of the regional socio-economy through regulation of the rural industrial structure. Practical and effective measures should be taken to resolve the actual problem of existence and development after de-farming in order to achieve the sustainable development of projects of converting cropland to forest. This is the fundament of consolidating the achievements of the project (Zhu et al., 2004). Therefore, the management models of converting cropland to forest should be innovated to set up new ways of increasing income for farmers. The projects should be combined with the construction of various bases (including fast growth and high yield forest base, economic forest base, industrial raw material forest base, Chinese medicinal material base and livestock forage base etc.) and special industries. It should break the long-term decentralized patterns of contracts and promote industrialized management to establish an industrial system with large-scale and intensive management. Under clearing of ownership, stabilization of contract rights, activation of use rights, and respect for farmers' wishes, it is necessary to accelerate the reasonably compensated circulation of collective land and to manage in an appropriate scale in order to improve the management efficiency and open ways of increasing farmers' income and agricultural efficiency, by applying market mechanism, in forms of commissioned subcontract, leaseback contract, land exchange, stock cooperative and lease. Great efforts should be devoted to developing the green industries in various forms such as household cooperation, lease and contract, and stock cooperative system. It needs to build up industries in scale management, particularly to foster and develop the leading enterprises of economic forest products storage and processing, as focused on product deep processing. The famous brand strategy should be put into effect to set up a number of exemplary bases of special resource industries and to cultivate products with regional features, in order to put the impoverished and backward Dabieshan District on the road to sustainable development.

Acknowledgements This study was supported by the Key Project of Natural Science Foundation of Department of Education, Anhui Province (2003KJ030ZD) and the “Tenth Five-year” University Talents Fund of Anhui Province.

References

- Anhui Provincial Committee of Science and Technology (1998). Comprehensive development strategy of Dabieshan District in Anhui. Hefei: Anhui People's Publishing House (in Chinese)
- Chen G J, Li R, Yang Q K, Wang G (2004). Influence of removal lands from cultivation to afforestation and grass planting on rural social economy in Loess hill-gully region in north Shanxi: A case study on Xiannangou watershed and Yanggou watershed. *Sci Soil Water Conserv*, 2(4): 48–52 (in Chinese)
- Feng X G (1999). Tourism development and poverty alleviation in western Anhui. *Econ Geogr*, 19(2): 111–113 (in Chinese)
- He C G (2004). Approach to problems about natural eco-restoration project of soil and water conservation. *Sci Soil Water Conserv*, 2(3): 99–102 (in Chinese)
- Hou J Q, Xiao W G (2000). Convert cropland to forest and the development of food in western region. *Chin Food Nutr*, 3: 45–46 (in Chinese)
- Huang R, Zhu C, Ge X D, Su Q (2004). Soil and water loss and ecological restoration on north hillside of Dabie Mountain in west Anhui province. *Bull Soil Water Conserv*, 24(6): 90–93 (in Chinese)
- Liang X C, Ding D S, Ge X D (2002). Systematic analyzing of socio-economic development and anti-poverty strategies of five reservoirs area in Dabieshan. *J Mount Sci*, 20(2): 199–205 (in Chinese)
- Ma Z Y (2001). On integrating poverty alleviation into framework of tourism development in the project of western China's development. *J Nat Resour*, 16(2): 191–195 (in Chinese)
- Wang F X, Shi M C, Zhou X C, Luo Z D, Zeng H J (2004). Management information system construction of removal lands from cultivation for afforestation. *Sci Soil Water Conserv*, 2(2): 93–97 (in Chinese)
- Wang Q, Zhang Z Y, Xu X N (2003). Soil properties and water conservation function of different forest types in Dabieshan District, Anhui. *J Soil Water Conserv*, 17(3): 59–62 (in Chinese)
- Wu Z W (2001). Industrial structure in returning cropland to forestland—Problems and countermeasures. *World For Res*, 14(3): 75–80 (in Chinese)
- Zhou S X (2005). Fully implement the forestry development strategy for ecological construction. *Macrocon Res*, 3: 3–9 (in Chinese)
- Zhou Y P (2005). Practice and thinking of water resources optimization scheduling in Pishihang irrigation. *Water Resour Manage*, 5: 46–47 (in Chinese)
- Zhu B, Luo H L, Du H B, Mu Y J (2004). De-farming and afforestation in the upper reaches of Yangtze River: Extension and model issues. *J Mount Sci*, 22(6): 675–678 (in Chinese)