Theory and Practice of Watershed Management in China

Wang Lixian

Beijing Forestry university, 100083, Beijing
E-mail: wanglx@bjfu.edu.cn

Abstract: Definition of watershed management in China is, taking a watershed eco-economic system as a unit, the protection, improvement and rational use of water, land and other renewable natural resources of the watershed, on the basis of the eco-economic system diagnosing, integrated management the land resources for agriculture, forestry, grass production and fruit tree, comprehensive restoration for eroded land with bio-engineering measures, to achieve the optimum ecological and social-economical benefits. Natural resources and environment are identical. Watershed management is an important part of eco-environment conservation. The main measures of watershed management are: ①ecosystem diagnosing; ②water, land and other renewable natural resources use planning; ③restoration of eroded land; ④processing of agricultural, forestry and animal husbandry production; ⑤supervision and administration; ⑥evaluation of benefit.

Keywords: watershed management, China, Natural resources conservation, sustainable management, soil and water conservation

1 Definition of watershed management

In China the definition of watershed management is the protection, improvement and rational use of water and land and other renewable natural resources in a watershed, in order to reach the optimal goals of ecological, economic and social benefits. Taking a watershed as an eco-economic system, on the basis of overall planning, with rational arrangement of the land for the uses of agriculture, forestry, animal husbandry and sidelines, the comprehensive control measures are employed to local conditions. In fact, the watershed management is soil and water conservation in mountain areas. Taking a watershed management approach allows for the explicit accounting of certain environmental benefits associated with agriculture, forestry, water resources, and other development projects and helps identify the linkages between environmental improvement and productivity increases over the long term. A river basin is similarly defined as a watershed, but is of a larger scale, for example, the Yellow River Basin.

Through about 50 years' efforts since the beginning 1950's, China has achieved remarkable successes in watershed management. Watershed management has played an important role in improving the basic conditions of agricultural production, increasing agricultural yield, promoting the development of rural economy, accelerating the course of shaking off poverty and building up a fortune in poor mountain areas, raising people's living standard. Watershed management reduces the sediment in the rivers, and protects the national territory and improves ecological environment, etc. Over the past 50 years, the comprehensive control of 859,000km^2 of the area of soil erosion has been completed, of which 43.333 million hm^2 of soil and water conservation forest and 4.67 million hm^2 economic forest were planted. 4.3 million hm^2 were preserved by planting grass, 13.33 million hm^2 basic farmland were built, and lots of facilities of soil and water conservation were built, thus resulting in effectively checking the development of soil erosion. The existing facilities of watershed management can increase their capacity of conserving more than 25 billion m^3 of water and of decreasing more than 1.5 billion tones of soil erosion each year.

2 Principles of watershed management

On the basis of watershed management practices in China over the past 50 years, some principles of sustainable watershed management are summed up as following:

2.1 Principle of eco-economic system

Based on ecological economics, guided by the theory of economics, taking man's economic activities as the centre, centred on the subject of the correlation of development between man's economic activities and eco-environment. Ecological economics deals with the ecological economic compound system formed by the interaction between ecological system and economic system, and with the ecological economic problems occurred in their movement of contradiction. The analysis, assessment, adjustment and management of watershed as an open ecological economic system are the specific application of ecological economics theory in watershed management.

2.2 Principle of systematology

Systematology provides for people the theoretical basis of the knowledge of the structure and function of watershed ecological economic system to make scientific design, management, forecast and policy in the establishment of optimum systems, according to people's requirements and environment conditions.

2.3 Principle of cybernetics of system

How to apply cybernetics to a "man-watershed" ecological economic system management is a new field to be developed. There are many subjects worthy to be studied in it, for example:

(1) "Controllable character" of "man-watershed" system

The application of the theory of "controllable character" to the study of "man-watershed" system contributes to determine the possibility of restoration of watershed system and management measures for controlling water and soil losses and improving environment.

(2) "The most economical control" of a "man-watershed" system

The application of "the most economical control" theory to "man-watershed" system contributes to designing the most economical anti-erosion control system so as to minimize the investment and expenses (such as consumption of energy and materials) for water and soil conservation; the greatest social; and economic benefits and the best improvement of the welfare of people's living quality are obtained as a result of watershed management.

(3) "Observable character" of "man-watershed" system

The application of "observable character" theory to "man-watershed" system contributes to determining the monitoring measures of environment for making the comprehensive assessment of environmental quality, such as the number and rational distribution of the stations of environmental monitoring as well as the ability to handle monitoring data, etc.

(4) "The most economical observation" of "man-watershed" system

The application of "the most economical observation" theory to "man-watershed" system contributes to designing the most economic environmental monitoring network so as to minimize the investment and runtime expenses for monitoring equipment and the number of monitoring stations.

(5) "Stabilization" of "man-watershed" system

The application of "stabilization" theory to the analysis of "man-watershed" contributes to finding out the causes of vicious cycle and destruction of ecological balance, and seeking the conditions of favorable cycle and the rehabilitation of ecological balance.

(6) "Harmonization" of "man-watershed" system

The application of "Harmonization" theory to "man-watershed" system contributes, on the basis of the subsystems improvement of environment and ecological balance, to the realization of environmental improvement and ecological balance of the whole watershed system.

(7) "Intellectualization" of "man-watershed" system

"Man-watershed" system is an active system of intellectualization. The application of the decision-making of intellectual faculties to the watershed management and of the methods of analysis and design of the active system contributes to making the most of man's intellectual faculties and initiative,

effectively utilizing self-balance and self-purification ability of environment itself and economically realizing stabilization and harmonization of a “man-watershed” system.

2.4 Principle of landscape ecology

The basic principle of landscape ecology consists of the principles of structure and functions of landscape, biological diversity, species flow, re-distribution of nutrients, energy flow, changes and stability of landscape, etc.

The essence of watershed management is the preservation and management of landscape. Thorough analysis of the space structure, functions, heterogeneity of a watershed and changes occurring after watershed being disturbed is of great significance to the scientific management of watershed, and to the determination and assessment of the heterogeneity and quality of watershed eco-economic system.

2.5 Principle of sustainable watershed management

History of mankind developing up to the present has come to a critical stage when it is difficult for natural resources to maintain balance with environment. The nature of the scope of modern man’s activities has constituted threats to the existence of man’s future generations. Under the conditions of this background, “sustainability” has become the criterion of the exploitation and utilization of all natural resources as well as all the economic activities of mankind, and, of course, the criterion of the activities of watershed management.

To judge whether the activities of watershed management follow the criterion of sustainability, we suggest referring to the following “Index Frame of sustainable management”.

(1) Social economic criterion of sustainable watershed management

- Approval of all functions of measure system and long-term provision of social benefits
- Long-term provision of diversified economic benefits
- Provision of setups and basic facilities for sustainable management

(2) Environmental criterion of sustainable watershed management

- Biological diversity (diversity of species and diversity of landscape)
- Productive force (productive force of ecological economic system)
- Conservation of land (including erosion and natural disasters)
- Conservation of water (including quantity and quality of water)
- Health and vitality of forest ecological system (including artificial forest)
- Contributions to regional ecological cycle

In addition to the above-mentioned principles, the principle of soil erosion and the principle of watershed hydrology are also the theoretical basis of watershed management. Only with the guidance of the above-mentioned principles can we secure the comprehensive benefits of watershed management, i.e., ecological benefit, economic benefit and social benefit so as to achieve the goal of setting up a stable, sustained and high-effective ecological economic system with watershed as a unit.

3 The main experience of watershed management in china

Based on the practices of soil and water conservation, the main experience of Watershed Management in China may be described as follows:

3.1 Organizatons, regulations and policies

The Chinese Government has placed high priority on Watershed Management and included it in the national economy and social development plan as a basic program. The State Council has accordingly set up a National Coordinating Group consisting of the Ministry of Water Resources, the National Afforestation Committee, the Natural Forestry Agency, the Ministry of Agriculture, the Chinese Academy of Sciences, the State Planning Commission, the Ministry of finance the Ministry of Railways, the Ministry of Sciences and Technology, the National Environment Protection Agency, the Ministry of

Land Resources, the State Administration of Taxation, the People's Bank of China, the Office for Promoting Economic Development of National Agricultural Integrated Development, etc.

The Chinese Government has successfully formulated and promulgated laws, policies and regulations regarding the natural resources conservation such as the Forest Law, the Law of Soil and Water Conservation, the Water Resources Law, the Regulations on Family Planning, the Law of Grasslands, the Land Law, the Law of Environmental Protection, etc. In view of promoting the development of watershed management, the Government also worked out some Policy Measures Concerning the soil and water conservation and a policy on Favourable Terms of Taxation Regarding the Management and Utilization of Eroded Land Resources.

3.2 Comprehensive analysis of watershed problem causes

It is very important for watershed management that the physical, biological, and socioeconomic conditions that lead these watershed problems be put into proper perspective.

The underlying causes of watershed ecosystem degradation and resulting upland and downstream impacts can be due to natural phenomena and human activities; often it is a combination of the two. The causes of watershed ecosystem degradation include:

(1) Natural causes:

- Geologic instability
- Erodibility of soil
- Drought hazard
- High intensity rainfall
- Strong wind
- Fire

(2) Human causes

- Deforestation: unwise and poorly logging; Fuelwood cutting due to fuel shortages; Conversion of forests to grazing lands or cultivated croplands; Forest fire set by local inhabitants.
- Inappropriate collection, transportation and use of water resources.
- Inappropriate use of land resources: Conversion of forests to grazing lands or cultivated croplands; Conversion of grasslands to cultivated croplands.
- Unwise farming-cultivation practices
- Overgrazing by livestock
- Road construction on fragile lands
- System of land ownership
- Inadequate policy and legislative support
- Lack of unified planning and extension for integrated watershed management.

Early in the watershed management project formulation stage, we must assess the existing situation and identify the causes of watershed problem.

3.3 Unified watershed management planning

The most important step in the entire watershed management planning process is to clearly define the goals and objectives of the project. Specific objectives associated with watershed management projects typically involve one or more of the following:

- Reduce the erosion modulus to an acceptable level
- Reduce the sediment yield to an acceptable level
- Provide the water yield which needed by downstream
- Food security
- Increase the income of inhabitants
- Safety of life and property

On the basis of detailed survey of land resources, land types are classified. Local social and economic conditions as well as the state policies are used to rationally determine the direction of land utilization of each block in the watershed, the proportion and specific position of land used for the

productive undertakings of agriculture, forestry, animal husbandry and fishery, and the place and time (where and when) to carry cut different measures of soil and water conservation. In order to raise the quality and efficiency of land utilization planning in the watershed, the techniques of remote sensing, geographical information system and watershed management information system should be applied.

3.4 Integrated restorational measures system

The main restorational measures for comprehensive watershed management are: vegetation measures, engineering measures, and tillage measures.

(1) Vegetation measures

Vegetation measures mainly include the following four items:

- Closing-up hillsides to facilitate afforestation
- Planting soil conservation forest
- Planting cash trees
- Grass seeding

(2) Engineering measures

They include engineering works on slope surface, engineering works in gullies, small storage works, and works for controlling slope disintegration.

Engineering works on slope surface are:

Terracing, surface runoff interception works, gully head protection, etc.

Engineering works in gullies are:

Check dams, sediment-trapping dams, bank protection works, etc.

(3) Conservation tillage measures

The main conservation tillage measures are as follows:

- Contour faming
- Ridges and furrows farmlands
- Contour belts intercropping
- Contour ridge-furrows
- Pit planting
- Rotation cropping of grains and grasses
- Deep ploughing and close planting
- Intercropping and interplanting, etc.
- Development of agroforestry

3.5 Comprehensive exploitation of natural resources

A watershed is the gathering of diversified natural resources. The objects of watershed management are not only the land and water resources, but also the plant, animal, microorganism, the sources of energy, mines landscape resources, etc. Among the plant resources, there are many fruit trees dried fruit trees (e.g. nuts), oil-bearing crops, medicinal plants, fibre plants, perfume plants, forage crops, etc. which can be used for cultivating and processing. Comprehensive exploitation of natural resources is a very important approach for increasing the income of inhabitants.

4 Benefits of integrated watershed management

Significant benefits have been obtained from integrated watershed management. They include the following:

(1) The structure of land use has become more rational. According to investigations on pilot watersheds, after proper management, cultivated farmland has been reduced by 50%—10%, forest and grasslands have been increased by 10%—20%, and waste lands have been reduced by 10%—15%. Also the overall ratio of land use has increased by about 20%.

(2) The productivity of land and the per capita income of farmers have increased by 1—2 times.

(3) In the course of the construction of basic farmlands grain production was increased. In rain-fed land the grain production has increased by 1—2 times. In irrigated land the increase was 3—4 times. Per capita grain supply has reached 300kg—400kg.

(4) Water and soil losses have been reduced significantly. According to analysis of typical watershed, in areas with 50%—79% of land under control, soil and water losses have been reduced by 57%—78% and 46%—76%, respectively. If the degree of control is 80%—100%, the respective figures are 74%—96% and 70%—92%. The reduction in water and soil losses was beneficial to the downstream of river.

(5) Significant ecological and social benefits have been achieved. Along with the improvement of ecological environment the habitat of flora and fauna as well as the adjustment of land utilization structure, the renewable resources have been conserved, and the aquatic production, animal husbandry and processing industry are all developing. Hence the livelihood of farmers has been much improved.

5 Conclusion

The essence of watershed management is the protection, improvement and rational use of the eco-economic systems of watershed. Its ultimate goal is to realize the sustainable management of the watershed and reconcile the economic development with eco-environment conservation.

In order to further improve the watershed management, the Chinese government has put watershed management into the Agenda of 21st century in China. The national plan of watershed management in the period from 1999 to 2050 has been adopted and put into effect. Watershed management will be sure to contribute more benefits to the sustainable development of China.

References

[1] Duan Qiaofu. 1994. Economy of small watersheds. Harbin press, Harbin (in Chinese).
[2] Shen Guofang, Wang Lixian. 2001. Eco-environment conservation and the protection, utilization of water resources in China. Chinese publishing House of Water Resources and Power, Beijing (in Chinese).
[3] Wang Lixian et al. 1994. Information system of watershed management. China Forestry Publishing House, Beijing (in Chinese).
[4] Wang Lixian. 1995. Soil and water conservation. China Forestry Publishing House, Beijing (in Chinese).
[5] Wang Lixian. 1996. Combating desertification in China. China Forestry Publishing House, Beijing (in Chinese).
[6] Wang Lixian. 1999. Watershed management. China Forestry Publishing House, Beijing (in Chinese).