Chinese Forestry Development Toward Soil and Water Conservation

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Abstract: Following the generalization of major ecological and environmental problems facing China today and brief introduction of some research results in the country concerning the forest impacts on stream flow, soil erosion and water quality, the current Chinese forestry development toward soil and water conservation was briefly presented in terms of initiatives and techniques in the paper.
Keywords: ecological forestry, soil and water conservation, management techniques

1 Introduction

The total area of China's territory amounts to 9.6 million km^2, making up about 1/15 of the land area in the world. Interactions of geographical, climatic and anthropogenic agents made China one of the countries in the world that suffers most seriously from natural disasters. To achieve the sustainable development of the country' economy, forestry ecological engineering as a recently emerged terms with reference to the forestry development toward ecological protection in China. Following the generalization of major ecological and environmental problems facing China today and brief introduction of some research results in the country concerning the forest impacts on stream flow, soil erosion and water quality, this paper briefly presents the current Chinese forestry development toward soil and water conservation in terms of initiatives and techniques.

1.1 Major ecological and environmental problems of China

The large area of mountains making up the 2/3 of the total area of the country provides the topographical potential agent for the occurrence of soil erosion, torrents, landslides, and debris flows while desert landscape in the northern part of the country provides sand dust sources for wind erosion and sandstorm. On the other hand, the extensive human activities such as overgrazing, reclamation, deforestation, slash and burn accelerated the rate of ecological degradation and environmental destruction.

1.2 Severe soil erosion and water losses

According to the national survey of soil erosion in 1989, the total eroded land area was up to 3.67 million km^2 amounting to 38.2% of the total area of the nation's territory of which 1.79million km^2 belongs to water erosion and 1.88 million km^2 wind erosion. About 5 billion ton of surface soil each year is eroded causing huge amount of organic material, C, N, P, and K transported to national water bodies like rivers, lakes and reservoirs. Each year over 2.667 hm^2 of arable land was damaged and lost by soil erosion and water losses. Recent national monitoring of soil and water losses shows that the total area of soil erosion is tied with that of ten years ago.

1.3 The enlargement of desertificated area

In accordance with the definition of UN Convention to Combat Desertification, the total area of desertificated land area of China is up to 2.62 million km^2 amounting to 27.2% of nation's territory. Desertificated land area is distributed mainly in Northern part, Northwest parts of China covering 18 provinces. Desertification rate by wind erosion has been increased from 1.56 thousand km^2 per year in

60's and 70's to 2.1 thousand km^2 in 80's, however, the increase rate of wind erosion reached up to 2.46 thousand km^2 each year in 90's.

1.4 Frequently occurred droughts and floods

Water resources are unevenly distributed all over the country in terms of area and season. In the south, the rainy season is longer, and the rainfall from March to June or from April to July accounts for about 50% to 60% of the annual rainfall; while in the north, the rainy season is shorter, and the rainfall from June to September accounts for about 60% to 70% of the annual rainfall, often occurring in the form of rainstorm. As a result of over concentration of rainfall, flood and waterlogging occur frequently, drought is liable to occur in the season short of rain.

1.5 Degradation of grassland accelerated

Overgrazing and low maintenances input has been resulted in grassland degradation at the speed of 20 thousand km^2 each year. It was estimated that the total degraded grassland was up to 1.3 million km^2.

2 forest function for soil and water conservation

All the above-mentioned problems are closely related with the low coverage and uneven distribution of forest resources. The latest forest survey result shows that forest coverage of the country is 16.55% on the basis of forest canopy coverage equal or greater than 0.2. Forest functions for ecological restoration and rehabilitation are verified by variety research results worldwide.

2.1 Interrelationship of forest vegetation and water resources

2.1.1 Water retention function of forest vegetation

According to the forest ecological monitoring studies carried out in China, the integrated water retention potential of forest vegetation across the different climatic zones (e.g. tropical, sub-tropical, temperate, and frigid temperate) ranges from 40.93mm to 165.84mm with the median of 103.40mm. In another words, forest vegetation can retain 100mm rainfall each time at the average level (e.g. 1,000t/hm^2).

2.1.2 Stream flow regulation function of forest vegetation

There are two major aspects of forest vegetation regulation on the stream flow situations. First, forest vegetation can impact the total volume of the river flow; Secondly, forest vegetation can reduce the peak flow discharge and increase the base flow and thus increase the availability of water use efficiency.

There are two different conclusions about the forest impacts on the total runoff volume based on the experimental results in different research areas. It was estimated according to the research abroad that the forest coverage increase could decrease the total runoff volume at small watershed scale. The research results from China show that forest coverage increase will reduce the annual runoff volume especially in the arid area and be no significant influence in the enough rainfall area because of the climate, precipitation, geomorphology, and underground water interactions.

Forest vegetation effects on the temporal distribution of stream runoff lie in peak flow reduction and postpone and low flow increase. Two percent of forest coverage increase can reduce the peak flow by 1% and when the forest coverage reaching 100% peak flow reduction approaches to the maximum of 40%—50% at small watershed scale. Generally, for the catchment larger than 100km^2 forest impacts on the peak flow are generally decreased due to the spatial and temporal rainfall variations over the catchment area. Forest can increase and prolong the low flow because of the water retention function of forest soil and exchange with ground water. The experimental results from 3 small watersheds in the Qilian Mountain covered with 65.9%, 32.0%, and 5.9% of the forest trees shows that the low flow are 62.50mm, 61.97mm, and 12.20mm, respectively. It reveals that forest coverage increase can increase the low flow.

2.1.3 Water quality improvement function of forest vegetation

Following 4 aspects can identify Forest influence on the water quality. Firstly, the pollutant in the air can be adsorbed by forest; Secondly, forest can control the soil erosion thus decrease the sediment concentration in the river flows; Thirdly, forest can regulate the chemical substance concentration in the rainfall to a reasonable level; Fourthly, forest can improve some water quality indexes.

2.2 Forest vegetation and soil conservation

The soil conservation function of forest vegetation can be achieved by the canopy interception, forest floor interception, and forest soil adsorption of rainfall and runoff energy. As the result, forest can reduce the sediment concentration in the rivers and sedimentation in the reservoirs. It was estimated soil erosion rate from grass covered land can be up to 61.58t/(hm^2 • a) which is 86.04%, 110.89%, and 248.50% higher than that of Sabina young plantation, mixture stand of Sabina and Querqus and Sabina mature forest, respectively. The study on the benefit of soil and water conservation forest plantation in the Loess area of West Shanxi Province showed that the plantation can reduce soil erosion by 33.4 times and sediment output by 4.3 times.

3 Chinese national forestry programs

Shortage of forest resources and fragile environment makes China a country susceptible to serous natural disasters such as soil erosion, water loss, wind and sandstorm, floods, and drought. To solve the environmental problems above, China has been taking afforestation program as national policy and one of the major components of ecological conservation and environmental restoration along with the economic development since the adoption of reform and open up to the outside world policy. Large-scale forestry ecological engineering construction has made worldwide-known progress along with greening activities of the whole China since then. On the bases of classified forest management policy, two types of forest management could be identified as ecological forestry and commercial forestry. Forestry development toward ecological protection has been referenced to a new ecological engineering branch in China, Forestry Ecological Engineering, in the last five years period. This new integrated disciplinary branch of eco-engineering, could be termed as the artificial complex system buildup dominated by wooden vegetation through the ecological sound layout of different populations of plants, animals, microbial on the basis of ecology, forest science, system sciences, biological cybernetics principles, and eco-engineering processes and in accordance with the natural resources, environments, and social economic development of the region. It consists of several steps including design, planting, management, and regulation. Commercial forestry is referred to the wood or paper pulp production under extensive management.

Ten national forestry eco-engineering projects oriented to soil and water conservation, environmental protection and forest resources expanding have been carried on since 1978. Recently, Chinese government integrated all former 10 forestry programs and forestry program under West Development Strategy into 6 key projects. (1) Natural Forests Protection Program. According this program, natural forest cutting in upper reach of Changjiang River (Yangzt River) and upper and middle reaches of Huanghe River (Yellow River) is totally prohibited. Large-scale decrease of wood production is in effect in major state-owned forest production areas such as Northeast and Inner Mongolia. Other natural forest protection is responsible by local governments. Over 19.91 million cubic meter of wood production will be reduced while over 740 thousands forest workers will be arranged in other fields. (2) Protection forest planting in the “Three North” and lower reaches of Changjiang River. About 2.27×10^6 km^2 protection forest will be planted and 7.19×10^6 km^2 forest protected. (3) Agricultural Used Slope-land Conversion to Forest Use Project. Over 2.27×10^6 km^2 land suffered from soil erosion and water loss and 4yimu from desertificated area will be controlled till 2010. (4) Desertification by wind erosion control project around Beijing. It was planned that forest and grass coverage will be increased from 6.7% to 21.4% in the projected area. (5) Wildlife animal and plant protection and nature protection

reserve construction project. This project was aimed at species protection, natural protection, wetland protection. (6) Commercial forestry bases construction(mainly fast grow wood harvesting forest cultivation). This project will meet wood demand and make the natural forest protection program effective.

4 Forestry techniques toward soil and water conservation

Current techniques of forestry ecological engineering toward soil and water conservation that are widely adopted in China could be identified as following 4 parts.

4.1 Rational layout and planning methods of protection forests system at larger scale

4.2 Structure design, afforestation and regulation methods of soil and water conservation forest at small watershed and stand scales

According to the specific geomorphologic, padelogical, geological, and climatic conditions coupled with social economic ones of the small watersheds in the different zones of Chinese forestry eco-engineering programs, this category of the methods is aimed at the improvement of ecological functions of soil and water conservation forest system and rational use of natural resources. In doing so, the principles of the runoff production and soil erosion in the small watersheds must be clarified at first.

4.2.1 Soil and water conservation forests in the loess plateau of middle reach of Huanghe River

In accordance with the specific site conditions and soil and water losses situation of different locations within the small watershed, to achieve the maximum protective and economic functions of protection forests system as a whole, the spatial layout and stand density should be determined on the environmental capacity of water resources. The idealistic configuration of the system should be oriented on multi forest types, multi tree species, multi layers, and various aged. Farmland shelterbelt system consisted of road protection forest, slope bank protection forest, cash forest, intercropped forest, and scattered forest around villages should be constructed on the flat area of the Loess. For the steep slope-lands over 25º soil and water conservation forest system should be multi-layered and age varied woodland structure or intercropped shelterbelt, farm crop, and grass crop. For the mild slope-land lower than 25º the forest system should be agro-forestry structure consisted of terrace bank forest, belt forest on terrace with slope interval, forest on contour ditch with slope interval. Gully erosion control measures include structure measures and vegetative measures such as sand filtering and bed fixation protection forests via closure and afforestation approaches.

4.2.2 Soil and water conservation forests in the hilly area of eastern “Three North” region

Sever sheet and gully erosion by concentrated overland flow derived from long slope in this region have posted dramatic threats to the slope-land agricultural activities. For another hand, ecological restoration is very difficult in the mountainous area in the region due to vegetation destroy and poor and thin soil layer. Therefore, methods of spatial arrangement for soil and water conservation forests system include (1) structure design and management technology of forest and grass complex system on the mild slope in the hilly area, (2) bio-engineering methods for gully erosion control, sand filtering, and bed fixation, (3) construction methods of multi-layer forest stands in stony mountain area, and so on.

4.2.3 Soil and water conservation forests in the stony mountain area of Taihang Mountain

Soil erosion and water losses mainly in the form of storm floods take place frequently and severely caused by huge mountain, thin soil layer, outcrops, sparse vegetation coverage, and thunderstorm climate. Major methods for the spatial arrangement of soil and water conservation forest system in this region include: (1) rational spatial arrangement of multi forest types, multi tree species, combination of tree, shrub, and grass in the geometrical forms of patches on the slope-lands, and (2) configuration methods for agro-forestry in gullies and bank protection forests, etc..

4.2.4 Soil and water conservation forests in the upper and middle reach of Changjiang River basin

Plentiful plant species resources, radiation resources, and precipitation in contrast with the thin soil layer and extensive mankind activities cause frequent floods and soil erosion. Because soil erosion takes place mainly on the slopes, the methods in this region include, (1) soil and water conservation forests arrangement in accordance with dams, ponds, and rice field to form interwoven agro-forestry system on the slopes, (2) protection forests arrangement in accordance with gully erosion control and hydraulic works and also basic farmland construction to achieve bank stabilization, bed fixation, and sand filtering.

4.2.5 Structure design and regulating methods for stable soil and water conservation forest stand

In the northern China, this methods on the bases of water and forest balance is composed of (1) structure works for water resources collection and rational temporal distribution, (2) structural and biological measures including soil amelioration, runoff collection, stressed water saving irrigation, tree species selection, moderate afforestation, stand density control on the basis rational spatial arrangement, etc. In the basin of Changjiang River, tree species selection and combination, proportion of mixture, and density control are major methods aiming at integrated benefits ecologically, economically, and socially of soil and water conservation forests construction.

4.2.6 Silvicultural techniques of soil and water conservation forests

The priority and key techniques for forestry eco-engineering afforestation in China include (1) site classification techniques in various forestry eco-engineering construction zones by the analysis of climate, soil, geomorphology, vegetation, and so on, (2) tree improvement techniques for specific site conditions by means of species selection, introduction, taming, and improvement of tree, (3) micro environment improvement techniques for specific trees by means of site preparation and soil amelioration, (4) density control techniques, (5) techniques for mixture forest construction and design of typical afforestation models, etc.. Among these techniques of site classification and two-way comply between tree and site in the “Three North” region have been essentially achieved. Furthermore, many research achievements in tree species introduction and taming, improvement, mixture forest construction, and density control also have been made since then.

4.3 Structure design, afforestation and management of water resources conservation forest at stand and small watershed scales

On the analysis of storm peak flow, low flow, ground water changes, water quality, and water environmental situation of the watershed coupled with forest hydrological principles water resources conservation forests system construction and sustainable management could be developed in order to achieve regulation, water saving, and water purification target of the system. The methods include (1) spatial layout for water resources conservation forests system at basin scale characterized with multi forest types, multi tree species, low water consumption, and high water regulation efficiency, (2) stable stand structure design and regulation methods such as tree species selection, species combination, density control in the baseline of low water consumption, high efficient pollution control, and runoff regulation, (3) afforestation and management methods for the water resources conservation forests such as site preparation, planting point arrangement, and tending and regeneration. In addition, methods for oriented recovery of existing water resources conservation vegetation include mainly: (1) low water consumption, low pollution, and high efficient runoff regulation oriented natural vegetation recovery; (2) poor quality, low efficient water resources conservation forests reformulation. For the reservoir catchment, it includes: (1) spatial layout for water resources conservation forests system targeting low water consumption, low pollution, high runoff regulation efficiency, and reservoir bank stabilization, (2) stable stand or belt structure design and regulation methods, (3) afforestation methods in the form of stand or belt for bank protection, sedimentation control of reservoir, and (4) oriented natural vegetation recovery aiming at bank protection and sedimentation control of the reservoir.

4.4 Sustainable management techniques of agro-forestry

4.4.1 Sustainable management techniques of agro-forestry on the Loess Plateau of middle reach Yellow River

By means of structure works for water resources collection and rational temporal distribution and moderate stressed water saving irrigation to increase the water use efficiency, the techniques include (1) spatial and temporal arrangement techniques for sustainable and high efficiency management of agro-forestry, (2) structure design and regulation techniques of stable biological population, (3) improvement and regeneration techniques for poor quality, low efficiency agro-forestry system and farmland shelterbelts, and (4) intensive management techniques for sustainable and high efficiency agro-forestry system. For instance, water and fertilizer regulation target can be achieved for different sized rain-fed agro-forestry systems as following facilities: (1) large water storage well(runoff collected by slope surface treated by ramming, soothing, and glue spraying) for large area forest or agro-forestry system, (2) small water storage well(runoff collected by plastic cover over the slope)for contour ditch, terrace with slope interval, or crop and tree scattered lands, (3) single tree water tank(rainwater collection via framework supported plastic). The main theme lied in the techniques involves the determination of actual water demand by tree on the basis of annual precipitation distribution, soil water dynamics, and major tree species water demand processes and the adoption of moderate stressed water saving irrigation. According to the niche overlay and competition of water and fertilizer, their regulation approaches could be decided in terms of water saving irrigation, fertilization, and the coupling between them to get rainfall resources adjustment in time and space, control soil erosion, use the land and water resources in slope land rationally and reach to sustainable management for agro-forestry.

4.4.2 Techniques for sustainable management of agro-forestry in interface belt of agricultural and grazing of “Three North” region

It is located in these regions with arable land and pastureland that need protect from wind erosion. The techniques for sustainable management in these regions include: (1) the allocating techniques for sand fixation with structures of belts, piece forestland, and network in patterns of agro-forestry, forestry-husbandry and agro-forestry-husbandry. (2) Structure designing and adjustment technology for stabilizing bio-species and community. (3) Techniques for improvement and regeneration in these lower qualities, lower yield and lower effect agro-forestry and over matured shelterbelt regions. (4) Construction techniques for forest-husbandry and agro-forestry-husbandry in pasture land. (5) High effective industrial technology in agro-forestry in crisscross section of agricultural and pasturing area.

4.4.3 Techniques for sustainable management of agro-forestry in Taihang Mountain Region

It includes: (1) The agro-forestry allocating techniques based on soil improvement, rainfall water harvesting in small watershed. (2) Structure designing and adjustment technology for stabilizing bio-species and community. (3) High effective industrial technology in agro-forestry for sustainable management.

4.4.4 Techniques for agro-forestry sustainable management in mountainous regions of upper and middle reaches of Changjiang River basin

These regions are good of water and heat conditions with abundant plant species. Agro-forestry is the main part in protective forest system. Techniques for agro-forestry sustainable management in these regions include: (1) High effectively collocating models with multiple purpose. (2) Species selection techniques for stable community and its collocation in biology, ecology and forestry. (3) High effective industrial technology in agro-forestry for sustainable management, such as rainfall harvesting in slope, irrigating by small pool construction, tea and mulberries trees planting in ridge of terrace, forestland-encircling farmland, tree enchased planting in farmland.

5 Conclusions

To achieve the sustainable development of the whole world for our future generations, forest protection and green campaign is an indispensable responsibilities for the whole society today and tomorrow. Ecological friendly economic development will no matter how be the key challenges for every countries in the world. Therefore, the following aspects are particularly important from Chinese point of view regarding to the forestry development toward ecological protection: (1) National scale initiatives in accordance with 21st Agenda; (2) Governmental prefential policy to support forest environmental protection; (3) Technical development for ecological forestry development; (4) Economic benefits also considered for ecological forestry development to attract participation of farmers; (5) Public awareness of forest environmental importance, public ecological education, ecological culture building-up; (6) Promotion of international cooperation in forestry-related areas by various ways.

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