Roles of Science and Technology in Soil and Water Conservation in the New Era

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Abstract Firstly, current situation and main problems of science and technology development of soil and water conservation were analyzed, and then roles of science and technology in soil and water conservation were studied. At last, exploration ways of roles of science and technology in soil and water conservation were proposed.

Key words Soil and water conservation; Science and technology development; Water and land resources; Ecological environment

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The contradiction between man and nature is an important issue in the concept of sustainable development. Water resources are important resources for human survival and are not renewable, so people must pay attention to the protection of water resources[1]. At present, the lack of fresh water resources in China has become an inherent problem. In order to meet people's daily water needs, China's water conservancy departments are constantly developing and applying water resources. At the same time, to meet the requirements of sustainable development, it is necessary to pay attention to the protection of water resources in water conservancy projects, and soil and water conservation is a part that needs to be paid attention to in the process of its development[2-3]. The 17th National Congress of the Communist Party of China clearly stated the strategic goal of " building ecological civilization and basically forming an industrial structure, a growth mode, and a consumption mode for saving energy resources and protecting the ecological environment". Controlling soil and water loss and improving ecological environment have become the hot spots of the whole society. The ecological construction of soil and water conservation and the development of science and technology in China are facing a rare opportunity. At the same time, China has a vast territory, diverse types of biological climate and land use, and prominent contradictions between people and land. Long-term unreasonable use of land has caused serious soil erosion. Especially in the process of industrialization and urbanization, new man-made soil erosion will continue to occur. China has entered a new stage of building a well-off society in an all-round way and accelerating modernization, and soil erosion has become one of the most prominent problems in ecological environment construction, so protecting soil and water resources has a long way to go.

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1 Current situation and main problems of science and technology development of soil and water conservation

At present, China has entered a very critical period of ecological civilization construction. In order to fundamentally realize the effective protection and sustainable use of soil and water resources as soon as possible, it is necessary to establish a mechanism for the promotion of scientific and technological achievements. At first, it is necessary continue to carry out research on the basic theory and practical technology of soil and water conservation to enhance the ability of science and technology support, so that the promotion of scientific and technological achievements and key soil and water conservation projects are closely integrated. Secondly, the transformation of results should be pay more attention to, and the scope of application should be expanded. Colleges, scientific research institutions, management departments and production units should be combined to closely link technology development, theoretical research, experimental demonstration and application promotion. Thirdly, all parties should be mobilized to participate in the practice of soil and water conservation to promote the formation of diversified input mechanisms. Finally, the contribution of scientific and technological achievements of soil and water conservation to national ecological construction will be continuously improved through the roles of demonstration, promotion and radiation.

1.1 Current situation of science and technology development of soil and water conservation Scientific and technological progress plays an important role in economic growth[5]. Schultz suggests that the contribution rate of material capital accumulation in the growth of post-war agricultural production in the United States is only 20%, and the remaining 80% is caused by science and technology. The connotation of scientific and technological progress includes two aspects, including the improvement of scale and level of scientific and technological activities itself and the enhancement of influence of science and

technology on economic development and social environment. Relying on scientific and technological progress and strengthening scientific and technological promotion are the key measures to promote the comprehensive management and sustainable and healthy development of soil and water loss areas. At present, the research, popularization and application of science and technology lag behind, which has become a limiting factor for soil and water conservation projects. At present, China is also facing the serious problem of soil and water loss, and controlling soil and water loss and strengthening soil and water conservation are urgent tasks for water conservancy projects. Soil and water conservation can effectively prevent soil and water loss, strengthen the utilization and protection of soil and water resources, and ensure the effective improvement of land productivity.

Since the industrial revolution, human society has developed rapidly, and the use of various resources has been continuously increased to better promote soil and water conservation practice and accelerate the control of soil and water loss in China. Years of soil and water conservation practice, especially the construction of soil and water conservation monitoring network, comprehensive investigation of soil and water loss and ecological security, remote sensing census of national soil and water loss, and a series of scientific research achievements in the field of soil and water conservation, have laid the foundation for the development of science and technology in soil and water conservation in China[4]. Firstly, the theoretical system of science and technology of soil and water conservation was initially formed, such as proposing " soil and water loss" , " soil and water conservation" and other basic concepts with Chinese characteristics, forming " ecological restoration" , " watershed management" and other governance strategies in line with China's national conditions, finding out the intensity and distribution of soil and water loss in China, and determining the types and divisions of soil and water conservation in various regions. Secondly, a network system for research and monitoring of soil and water conservation in China has been established, such as establishing a monitoring system composed of national soil and water conservation monitoring centers, basin central stations, provincial monitoring stations and local monitoring substations, establishing national and local soil and water conservation research institutions and forming a research team composed of more than 4 000 people, constructing a 1∶100 000 national database of soil and water loss and databases of soil and water conservation in key areas, approving 49 scientific and technological demonstration parks integrating prevention and demonstration, scientific and technological promotion, publicity and education, and leisure and sightseeing, and building a series of soil and water conservation experimental bases. Thirdly, the technology system of comprehensive management of soil and water loss has been basically summarized, including small watershed comprehensive treatment technology, slope runoff regulation and utilization technology, silt dam project control technology of Loess Plateau, soil and water loss prevention technology of changing slopes to terrace, ecological restoration technology by banning, ecological greening technology for protection of steep slopes, comprehensive treatment technology of slope collapse in hilly areas of southern China, land reclamation technology of industrial and mining abandoned land, construction and breeding techniques of soil and water conservation vegetation, *etc.*

1.2 Main problems China's ecological environment is fragile, its natural conditions are complex, and soil erosion is very serious. As a result, the promotion of scientific and technological achievements in the field of soil and water conservation has lagged behind the practice of ecological construction, and there is still a big gap between it and the overall goal of national ecological construction of soil and water loss control projects, the awareness of social soil and water conservation, and the general requirements of ecological civilization construction. At first, the prevention speed and scale of soil and water loss need to be further improved. At present, more than 1.8 million km^2 of land suffering from soil and water loss needs to be controlled in China. Due to human factors, the area has increased by one million hm^2/a, and the area of wind erosion and desertification has rose by 246 000 hm^2/a. As a result, land output has declined, and problems such as siltation of lakes and reservoirs, water and environmental pollution, degradation of ecosystems, and aggravation of flood have not yet been fundamentally resolved. Facing the goal of sustainable development in the new era, it is bound to continuously improve the scientific and technological level of soil and water conservation, enhance supporting capacity, and expand radiation range, thereby better promoting soil and water conservation practice and accelerating the pace of soil erosion control in China. In addition, the prevention theory and technology of soil and water loss need to be further strengthened. Soil and water conservation is a complex system engineering. With the deepening of ecological construction and social development, some problems that have not been solved for a long time are more prominent, and some problems that have not appeared have emerged, such as soil erosion mechanics mechanisms and processes, dynamic prediction and simulation of soil and water loss, environmental effects and regulation of soil and water conservation, regulation effects of long-term large-scale soil and water conservation on river sand, monitoring and forecasting of man-made soil and water loss in production and construction projects, ecological restoration mechanisms and control techniques of different soil and water loss areas, prevention of non-point source pollution caused by soil and water loss, control of ecological clean watersheds, and soil and water conservation measures for small and medium rivers. These have become the key technologies that determine the rapid development of soil and water conservation at present. Finally, the promotion and social cognition of soil and water loss prevention technology need to be further improved. Soil and water conservation is the practical science that is closely integrated with production. However, the current promotion and application of scientific research results in practice is slow, and the transformation efficiency of the results is low. Science popularization and the public awareness are insufficient, and effec-

tive radiation, promotion, missionary channels and models are not especially available. These have become the main bottlenecks limiting the technological support capability of soil and water conservation.

2 Roles of science and technology in soil and water conservation

The problem of soil and water loss has caused widespread concern in all countries of the world. The United Nations has also listed soil and water loss as one of the three major environmental problems in the world. At present, some economically developed regions attach great importance to environmental protection. Here the comprehensive development and utilization of soil and water resources is better, and development and comprehensive management are conducted at the same time. Moreover, they pay great attention to the investment in soil and water conversation. Soil and water conservation is a fundamental measure to improve agricultural production conditions and ecological environment and has become the main body of China's ecological environment construction. Therefore, correctly understanding the importance of soil and water conservation, adhering to the strategic policy of " maintaining soil and water according to law and promoting sustainable development" , rational developing, utilizing and protecting land and soil resources are of special significance for alleviating human-land conflicts and developing agriculture, forestry and animal husbandry production. In addition, development is the eternal theme pursued by mankind. Under the premise of protecting the environment and rationally utilizing resources, developing economy is the goal pursued by the world today, and sustainable development is the effective and only way to achieve this goal. Only when the sustainable use of water resources and water conservancy projects is ensured can the sustainable development of the national economy be ensured. Only when the sustainable development of water conservancy is ensured can the coordinated development of economy, population, resources and the environment be ensured. Sustainable development of water conservancy is not only an important part of China's overall sustainable development but also the basis and guarantee for the sustainable development of the entire national economy and society.

2.1 Soil and water conservation can reduce the destructive power of drought and flood During the dry season, groundwater is slowly released, which increases water flow during the drought period and plays a role in drought resistance. In general, plant measures can adjust the temporal and spatial distribution. Flood control and drought resistance are certain. Soil and water conservation can effectively maintain or increase the water storage capacity of soil. In the flood season, soil and water conservation by water conservancy projects can enhance the flood control and discharge capacity of rivers. In the dry season, it can supplement runoff effectively to minimize the annual variation of runoff.

2.2 Soil and water conservation can enhance the capacity of reservoirs to control flood Soil and water conservation is the lifeline of mountain development, the foundation of national rectification and river governance, the foundation of national economic and social development, and a basic national policy that must be adhered to for a long time. Plant measures can first intercept rainfall, and branches and leaves can intercept runoff. The litter under forests holds water like sponge to increase the infiltration time of water into soil. Compared with the exposed ground, the peak of flood during rainfall will decrease, naturally controlling flood. Soil and water conservation can reduce silt accumulating in reservoirs, thereby enhancing the water storage capacity of reservoirs, extending their service life, and avoiding the occurrence of dam overtopping and collapsing. It also reduce the flow of sediment into rivers, thus reducing the rising of riverbeds, enhancing the flood discharge capacity of rivers, and enhancing the flood control capacity of water conservancy projects.

2.3 Soil and water conservation can reduce the occurrence of mudslides and other natural disasters Soil and water conservation can reduce the occurrence of some natural disasters such as mudslides and landslides and improve the quality of water environment. It can effectively protect vegetation to enhance the water storage capacity of vegetation and soil, thus reducing the extent of damage to geological structures such as mountains and rivers. It can not only protect the natural environment, but also reduce the hazards of mudslides and natural disasters and the impact and damage of these natural disasters to water conservancy projects. China is one of the countries with serious soil erosion in the world. Therefore, soil and water conservation has always been a policy encouraged by the country. In recent years, the comprehensive management of soil and water loss has been carried out in small watersheds, and various water conservancy projects have been built, thereby achieving the purpose of flood retention, water storage, sand retention and soil conservation, improving ecological environment, and improving economic benefits and achieving the sustainable development of society.

2.4 Soil and water conservation can improve the quality of water environment Water is the source of life, and soil is the basis of survival. soil and water are the basic materials for human survival, the main factor for the development of agricultural production, and an irreplaceable basic resource for the sustainable development of China's economy and society[6]. Water conservancy is an important pillar of sustainable development of national economy. Adhering to sustainable development is an inevitable choice for people to live in harmony with nature. Water conservancy is an important basic industry for the development of society and national economy. It is necessary to adhere to sustainable development[7-8]. Soil and water conservation is an important means to curb soil and water loss. Soil and water conservation is also the most important component of sustainable development of water conservancy, and plays a very positive role in the sustainable development of water conservancy.

2.5 Soil and water conservation can improve agricultural production conditions Through the management of soil and

water conservation, the ability of water conservancy to resist disaster can be better improved, which is of great significance for the virtuous cycle of ecological environment and the sustainable development of social economy. According to the characteristics of soil and water loss and frequent rainstorm, the control of soil and water loss in water source areas mainly insists on the strategy of controlling slopes and channels by taking small watersheds as units and runoff regulation as the main line[9]. To develop farmland construction based on this, it is necessary to continuously sum up experience on the basis of actual needs, change all the gently sloping arable land adjacent to water sources, villages and roads to horizontal terraces, and build a perfect slope water system and field roads. Through the management of small watersheds, the control of gullies within the system can be incorporated into the management of integrated prevention and control, which is of great significance to the development of water conservancy systems[10-13]. Therefore, only by ensuring the sustainable use of water resources and water conservancy projects can the sustainable development of national economy be ensured. Only by ensuring the sustainable development of water conservancy can the coordinated development of economy, population, resources and the environment be ensured. Sustainable development of water conservancy is not only an important part of China's overall sustainable development but also the basis and guarantee for the sustainable development of the entire national economy and society. The sustainable development of water conservancy is a complex system engineering, involving development, utilization, control, allocation, conservation and protection of water resources, application and management of projects, water conservancy investment and construction, development and use of talent, soil and water conservation, flood control, systems and mechanisms, science, education and regulations. Among them, soil and water conservation is an important part of sustainable development of water conservancy.

3 Exploration ways of roles of science and technology in soil and water conservation

The focus of soil and water conservation science is to study the laws of soil and water resources and environmental evolution and the interaction process between various elements in soil and water loss areas, establish a comprehensive control theory and technical system of soil erosion, and promote the harmony between man and nature and sustainable development of economy and society[14]. Scientific and technological work of soil and water conservation is a complex natural and social system engineering. In the future, scientific and technological work of soil and water conservation should be developed towards the direction of comprehensive management and combine prevention and control of soil and water loss, regional ecological restoration, comprehensive development of river basins, construction of green barriers, optimization of industrial structure, sustainable use of resources, rural economic development, and new rural construction. Therefore, on the one hand, it is necessary to adhere to the application of existing scientific research results to make it work as soon as possible in the control of ecological environment. On the other hand, it is necessary to strengthen the research and exploration of ecological environment control in soil erosion areas. In the new era, when serious soil erosion and deterioration of ecological environment have not been contained, large-scale infrastructure construction has caused new problems of soil and water loss. It is necessary to establish and improve the science and technology system of soil and water conservation, promote the implementation of the "digital soil and water conservation" plan, build an effective soil and water conservation test demonstration and science education base, strengthen the combination of scientific and technological forces in various industries, enhance the effectiveness of soil and water control and protection, and improve local ecological environment.

3.1 Strengthening scientific and technological promotion

Scientific and technological promotion refers to scientific research achievements and practical techniques applied in planting, forestry, animal husbandry and fishery, including breeding of improved varieties, application of fertilizer, pest control, cultivation and culture techniques, processing, preservation, storage and transportation of agricultural and sideline products, agricultural machinery technology, and agricultural aviation technology, farmland water conservancy, soil improvement and soil and water conservation technology, rural water supply, rural energy use and agricultural environmental protection technology, agricultural meteorological technology and agricultural management techniques[15-17]. Relying on scientific and technological progress and strengthening scientific and technological promotion are the key measures to promote the sustainable and healthy development of comprehensive management of soil erosion areas. It is necessary to establish test and demonstration projects for comprehensive prevention and control of different scales and types of soil erosion, promote the comprehensive control and development of soil erosion in surrounding areas through the demonstration, promotion and diffusion effects of the test area, and continuously improve the scientific and technological contribution rate of soil and water conservation. Besides, it is needed to edit and publish popular science readings about soil and water conservation, establish science and education bases for soil and water conservation, and raise people's awareness of soil and water conservation.

Soil and water conservation is not only a scientific undertaking, but also a mass and social practical work[18]. Therefore, how to make the technical achievements of soil and water conservation apply faster and better to the prevention and control practice of soil and water loss, and how to make the public understand the status and significance of soil and water conservation more thoroughly and deeply, have become the key factors ultimately determining the scientific and technological promotion and development of soil and water conservation in China. At present, China has achieved a lot of scientific and technological achievements in soil and water conservation. By national and local key control methods, many scientific and technological achievements have played a huge role in the preven-

tion and control of soil and water loss. Since 1949 – 2017, China has conducted comprehensive, systematic and comprehensive research on soil and water loss areas, not only obtaining detailed information on the formation of soil and water loss areas, land types, disaster hazards, economic development, and remediation processes, but also mastering the development roles of soil erosion, and carrying out scientific experiments on soil and water conservation, construction of an excellent ecology, and promotion of agricultural development.

The main contents of scientific and technological transformation and promotion of soil and water conservation include regulation and optimization allocation technology of slope runoff, comprehensive control technology of soil and water loss in southern granite areas, remote sensing monitoring technology of soil and water loss in the Three Gorges Reservoir, afforestation technology of a dry heat valley, soil conservation tillage technology, comprehensive control technology of collapsing hills, comprehensive control technology of arbors, shrubs and herbage, soil and water conservation and ecological civilization construction technology, ecological models of fruit, grass and animals (or pigs – methane – fruit) for soil and water conservation in small watersheds, early warning technology of landslide and debris flow, banning and breeding technology in soil and water loss areas, rural biogas, replacing wood with electricity (coal), land reclamation by purple rock blasting, improvement of farming system in ethnic areas, transformation of low-yielding fruit (tea) gardens, cultivation of fast-growing and high-yield forests, economic utilization of terraces, cultivation of high-quality economic fruit, cultivation of rare flowers and commercial development technology. It is necessary to attach great importance to the advantage integration, assembly and matching of science and technology, focus on the integration, assembly and matching of technologies such as land preparation, afforestation means, tree species composition, and restoration paradigms, and effectively exert the effect of science and technology. Starting from the reality of drought and water shortage in soil and water loss areas, it is necessary promote scientific and technological promotion throughout the whole process of comprehensive management of soil and water loss areas, strengthen scientific and technological promotion with drought-resistant afforestation as the center, highlight the promotion of excellent tree species and native tree species with strong resistance, applying afforestation technology by " water collection, conversation and supply" , runoff forestry, and water-saving afforestation, and improving the survival rate of afforestation.

Teaching, scientific research and competent departments at all levels must face production practice and establish a grass-roots technical services and scientific and technological technology promotion system to ensure that the promotion work is implemented, strengthen the training of the masses, and combine outdoor classrooms with practical technical training to promote the transformation of scientific and technological achievements into real productivity, and continue to summarize and vigorously promote new practical technology. It is necessary to encourage scientific research units and scientific and technological personnel to accelerate the transformation of scientific and technological achievements into real productivity by establishing scientific and technological demonstration sites, carrying out technology contracting, sending science and technology to the countryside and technology shares, and improve the application rate, conversion rate and contribution rate of scientific research results. Meanwhile, it is necessary to carry out extensive and multi-level technical training and cultivate a construction team with culture, technology, good knowledge of management, and truly transfer the comprehensive control of soil and water loss areas to the track of relying on scientific and technological progress and improving the quality of workers. In addition, it is necessary to strengthen communication and cooperation, introduce and promote advanced technologies at home and abroad.

3.2 Strengthening science and technology demonstration

Under the dual influences of changes in climatic conditions and human activities, the surface biological, physical and chemical processes, especially the surface hydrological processes directly affecting soil and water loss, and the evolution process of soil erosion types have also produced new features, and the discipline theory and connotation of soil and water loss and conservation have also changed. The combination of agricultural technology and various elements of agricultural productivity can generate huge economic impetus. The combination of scientific and technological services and agricultural laborers can form a high-quality labor force to transform agricultural economy from " physical economy" to " intellectual economy" .

Severe soil and water loss has seriously affected the production and life of local people, which has greatly restricted economic development and the improvement of people's living standard and seriously hindered the full playing of economic and social benefits of land and water resources [19]. Governments at all levels should attach importance to scientific and technological work in soil and water conservation, support the development of soil and water conservation disciplines and construction of a system composed of industry, universities and research institutions, strengthen technical training and personnel training, focus on the basic research of soil and water loss mechanism, prevention and control principles and technology, dynamic monitoring technology, information technology, *etc.*, organize scientific and technological research and support scientific and technological innovation. It is necessary to combine the construction of comprehensive demonstration zones for soil and water conservation with the comprehensive management of soil and water loss areas and give full play to the supporting role of science and technology. Besides, it is needed to do a good job in project promotion, combination of science and enterprises, distribution implementation, technology integration and industrial upgrading. At the same time, it is necessary to popularize information management technology in soil and water conservation departments at all levels and basically realize the modernization of soil and water conservation management methods.

The full name of the soil and water conservation science and technology demonstration park shall be the " soil and water conservation science and technology demonstration park of the

Ministry of Water Resources". It refers to the scientific research experiment, demonstration and promotion park that has social propaganda, demonstration and promotion roles and popular science demonstration function of soil and water conservation, where soil and water loss should be typical and can represent the main types, extent, hazards, ecological environment, geological geography and other basic characteristics of soil and water loss in the area. Meanwhile, its area is not less than 50 hm^2, and various measures for comprehensive prevention and control of soil and water loss can be taken, while it is convenient for scientific research and technology promotion[20-22]. All construction counties should also treat demonstration and leading as the " soul" and " essence" of project construction from the perspectives of natural sites, economic and social development, and major types of disasters, and comprehensively use administrative, economic, market, scientific and technological means to build a series of comprehensive demonstration zones with various features and functions in soil and water areas.

It is necessary to increase investment in science and technology of soil and water conservation. In the funding of soil and water conservation projects, a certain percentage of funds is used for technology demonstration and promotion, and the scientific and technological content and level of governance projects are improved. It is needed to give full play to the guiding role of the government in the investment, guide and mobilize the enthusiasm of local government and enterprises to invest in public welfare science research of soil and water conservation by actively seeking various policies such as direct financial input and tax preference at all levels. Relying on key prevention and control projects for soil and water conservation, slope farmland control, collapse control, and rocky desertification control in the upper and middle reaches of the Yangtze River, it is planned to build 9 large soil and water conservation demonstration zones in the nine key soil and water conservation control areas in the basin, 50 soil and water conservation demonstration counties, and 300 comprehensive governance demonstration small watersheds by 2020. The demonstration project construction is based on the promotion of comprehensive control modes of soil and water loss in different types of areas. The construction plan of demonstration projects in the basin is shown in Table 1.

Table 1 Construction plan of demonstration projects for soil and water conversation in the Yangtze River basin

Region	Main demonstration content
Lower reaches of the Jinsha River	Slope runoff utilization, water saving irrigation and industrial development demonstration
The Wujiang River, the Qingjiang River and the Chishui River basins	Comprehensive control of rock desertification and demonstration of drinking water safety
The Jialing River basin	Demonstration of comprehensive improvement of slope farmland and slope runoff regulation, non-point source pollution and demonstration of beautiful homeland construction
The lower reaches of the Minjiang River and the Tuojiang River basin	Demonstration of disaster prevention and mitigation and ecosystem restoration
The Three Gorges Reservoir	Demonstration of industrial structure adjustment and construction of soil and water conservation ecological barrier zone in reservoir areas
The upper and middle reaches of the Hanjiang River	Demonstration of non-point source pollution control
The Dabie Mountains and the Mufu Mountains	Demonstration of vegetation resource protection, development and utilization
The middle reaches of the Xiangjiang River, the Zijiang River, the Yuanjiang River and the upper and middle reaches of the Lishui River	Demonstration of prevention and control of mountain flood disasters and industrial development
The upper and middle reaches of the Poyang Lake	Demonstration of water source protection and ecological agriculture for lakes

Soil and water conservation and ecological civilization construction must rely on the promotion, demonstration and guidance of advanced science and technology. It is necessary to organize technical forces to carry out scientific and technological research, trial, summary and promotion of soil and water conservation and ecological civilization construction, and conscientiously study and formulate ecological restoration programs and designs in different regions[23]. In addition, it is needed to strengthen the monitoring of soil and water conservation and ecological civilization construction, timely understand the implementation dynamics and effects of soil and water conservation and ecological civilization construction projects, carry out forecasting, establish and improve the comprehensive technical service system of counties, townships and villages, and vigorously promote the matching and advanced applicable technology according to local conditions, and improve overall efficiency. Scientific research on soil and water conservation is conducted from the aspects of basic applied theory, control technology, benefit evaluation, dynamic monitoring technology, policy and development strategy to improve the scientific and technological level of soil and water conservation (Table 2).

3.4 Strengthening scientific and technological problems in tackling soil and water conservation Practice has proved that to solve the problem of soil and water loss, control and prevention should be combined at both macro and micro levels, which must rely on science and technology. The main science and technology of soil and water conservation include key technology for rapid restoration and ecological restoration of forest and grass vegetation in soil and water loss areas, regulation and efficient utilization technology of surface runoff caused by rainfall, non-point source pollution control and environmental remediation technology in soil and water loss areas, develop-

ment and construction projects and prevention and control technology of urban soil and water loss, soil and water loss test methods and dynamic monitoring technology, slope farmland and erosion ditch soil and water comprehensive improvement technology, agricultural technology measures of soil and water conservation, digital technology of soil and water conservation, new materials, new processes and new technology for soil and water conservation[26-27].

Table 2 Plans for science research on soil and water conservation in the Yangtze River basin

Research direction	Research content
Basic application theory	Soil erosion, sediment production and evolution process, soil and water conservation, ecological water use, non-point source pollution, sediment sources and transport, slope runoff erosion hydraulics, and preliminary establishment of multi-scale soil erosion prediction models
Control technology	Different types of small watershed comprehensive management modes, ecological restoration technology, control technology of purple soil and red soil areas, prevention technology of non-point source pollutants, rapid recovery and optimization technology of regional vegetation, key technology of soil and water conservation engineering construction, comprehensive prevention and control technology of soil and water conservation in development and construction, and demonstration control technology of landslides and debris flow
Benefit evaluation	Analysis of ecological and economic benefits of soil and water conservation measures, identification system and model of watershed ecosystem health diagnosis indicators, damage, recovery and reconstruction process of degraded ecosystem, driving factors and regulation mechanisms of ecosystem succession, study on the influence of soil and water conservation ecological construction on regional hydrology, soil erosion and sediment production process, biodiversity, vegetation succession, rural economic development and ecological security
Dynamic monitoring technology	Research on the application of "3S" technology and digital photogrammetric system
Policy and development strategy	Study on soil and water conservation investment mechanism, engineering layout, development strategies, development direction, implementation approaches, ecological compensation mechanism, and property rights system of soil and water conservation

The scientific and technological development of China's soil and water conservation has made great progress in the discipline system construction of soil and water conservation, soil and water loss laws and soil erosion mechanisms, dynamic monitoring and benefit evaluation, and comprehensive control and experimental demonstration of soil and water loss in small watersheds. At the same time, an efficient research team for soil and water conservation has been formed, which has played a positive role in promoting the development of disciplines, scientific decision-making, and science and technology communication of soil and water conservation. To realize the transformation from traditional soil and water conservation to modern soil and water conservation and establish a modern soil and water conservation and comprehensive management system, it is necessary to clarify development direction, refine work orientation, accelerate scientific and technological innovation, implement integrated promotion, rely on science and technology to develop agriculture, develop ecological economy, and ensure sustainable use.

Recent research focuses on investment and management systems. It is necessary to implement the integration system and paradigm of science and technology and projects and draw a part of the funds from the funds of project construction to support a number of scientific and technological issues that need to be studied and solved in project construction. The governments of all counties (cities and districts) must take effective measures and adhere to the principle of combining the state and the individual, mainly rely on local and mass investment, conscientiously implement the current capital investment policy of soil and water conservation, increase investment in soil and water conservation, and establish a stable channel for the investment. It is necessary to formulate the national scientific plan for soil and water conservation as soon as possible and organize national soil and water conservation research units to jointly tackle the major scientific and technological issues[28]. Soil and water conservation involves the protection and development of land. The governments of all counties (cities and districts) shall incorporate soil and water conservation work into the national economic and social development plan, and formulate the overall plan of scientific research on soil and water conservation according to the division of key prevention and protection zones, key supervision areas and key control areas in a region. Meanwhile, the control of soil and water loss should be combined with the construction of ecological agriculture and ecological environment to propose feasible control measures and effective policy measures. The scientific research plan of soil and water conservation is implemented year by year after being approved by the government at the same level.

In the construction of vegetation, primary dominant population should be investigated in detail to determine the configuration of tree species. For example, along the railways in windy desert areas of northern Shaanxi, a banded grass sand barrier is set up on the sand-covered land, where the seeds of *Astragalus adsurgens* Pall., *Melilotus officinalis* L. and *Medicago sativa* L. are sown to make vegetation coverage increase rapidly. The nitrogen fixation of leguminous plants is used to increase soil fertility, and the amount of native dominant shrub species is increased. To promote biodiversity, shrubs such as *Caragana korshinskii*, *Amorpha fruticosa* Linn., and *Hippophae rhamnoides* Linn. are planted. After the coverage of forest and grass increases until they can inhibit wind erosion, arbor species such as *Pinus tabulaeformis* Carr., *Ulmus pumila* L. *Populus simonii* Carr, *Populus hopeiensis*, *Populus simonii* × *P. pyramidalis* 'Opera 8277', *Salix matsudana* Koidz., and *Pinus sylvestris* L. var. *mongholica* Litv.[29-30]. It is necessary to mow shrubs on time and remove trees with pests and diseases, promote root growth, rejuvenate tree growth, promote

sprouting, increase flowering and fruiting rate, and ensure stable forest stand. According to the vegetation construction and succession status of different types of sites, as well as the experience and lessons of construction of windbreak and sand-fixing forest system along the railways in the windy desert areas, based on the experimental demonstration research, a structural optimization configuration paradigm suitable for the reconstruction of degraded inefficient wind prevention and sand fixation forests in different types of sites along the railways in the windy desert areas of northern Shaanxi is proposed (Table 3).

Table 3 Optimization structural paradigm of wind prevention and sand fixation forests in different types of sites along the railways

Site type	Original dominant species	Planted species	Configuration and afforestation method
Windward slope of moving dunes	*Salix cheilophila*	*C. korshinskii*, *H. fruticosum*, *A. adsurgens* Pall., *P. sylvestris*, and *Hedysarum scoparium*	Laying a grass square sand barrier (1.0 m×1.5 m), planting seedlings for afforestation, planting coniferous trees with soil balls, planting 255 trees and 1 200 – 1 800 holes of shrubs in 1 hm^2 of land, mixing them between plants and rows, sowing pasture seeds, and making community coverage up to more than 50%
	Artemisia ordosica	*S. vulgaris*, *P. sylvestris*, *C. korshinskii*, *P. simonii Carr*, *A. fruticosa* Linn., and *A. adsurgens* Pall.	
	Hedysarum fruticosum	*P. sylvestris*, *H. scoparium*, *C. korshinskii*, *Artemisia desertorum*, *A. adsurgens* Pall.	
	A. fruticosa Linn.	*H. scoparium*, *H. fruticosum*, *P. sylvestris*, *C. korshinskii*, *S. vulgaris*, *A. desertorum*, and *A. adsurgens* Pall.	
	P. simonii Carr	*A. fruticosa* Linn., *S. vulgaris*, *P. sylvestris*, *C. korshinskii*, and *A. adsurgens* Pall.	
Shifting sand	*Salix microstachya* Turcz.	*H. rhamnoides* Linn., *P. sylvestris*, *U. pumila* L., *A. fruticosa* Linn., *M. sativa* L., and *A. adsurgens* Pall.	Laying a grass square sand barrier (1.0 m × 1.5 m), planting seedlings for afforestation, planting coniferous trees with soil balls, stumping shrubs every 3 – 5 a, planting 660 trees and 1 800 holes of shrubs in 1 hm^2 of land, mixing them between plants and rows, sowing seeds of leguminous pasture, and making the coverage of forests and grass up to about 55% after forest establishment
	S. cheilophila	*P. simonii*×*P. pyramidalis* 'Opera 8277', *S. matsudana* Koidz., *S. vulgaris*, *A. fruticosa* Linn., *H. rhamnoides* Linn., *M. sativa* L., and *A. adsurgens* Pall.	
Land between dunes	*P. simonii*×*P. pyramidalis* 'Opera 8277'	*P. sylvestris*, *C. korshinskii*, *S. vulgaris*, *M. sativa* L., and *A. adsurgens* Pall.	
	H. rhamnoides Linn.	*H. rhamnoides* Linn., *A. fruticosa* Linn., *U. pumila* L., *P. sylvestris*, *M. sativa* L., and *A. adsurgens* Pall.	
	S. matsudana Koidz.		
	S. cheilophila		
Gently sand	*S. cheilophila*	*A. desertorum*, *H. fruticosum*, *H. scoparium*, *A. fruticosa* Linn., and *P. sylvestris*	Setting up a banded sand barrier, planting seedlings for afforestation, planting coniferous trees with soil balls, applying new materials for drought resistance and water retention, planting 255 – 330 trees and 1 200 – 1 800 holes of shrubs in 1 hm^2 of land, mixing them between plants and rows, sowing seeds of leguminous pasture, and making the coverage of top community coverage more than 50%
	A. ordosica	*C. korshinskii*, *A. fruticosa* Linn., *H. rhamnoides* Linn., *P. simonii*×*P. pyramidalis* 'Opera 8277', *P. sylvestris*, and *S. vulgaris*	
	H. fruticosum	*H. scoparium*, *A. fruticosa* Linn., *A. desertorum*, and *S. vulgaris*	
	C. korshinskii	*A. desertorum*, *U. pumila* L., *P. sylvestris*, and *P. simonii* Carr	
	P. simonii×*P. pyramidalis* 'Opera 8277'	*H. rhamnoides* Linn., *A. fruticosa* Linn., *C. korshinskii*, and *P. sylvestris*	
	S. matsudana Koidz.	*A. fruticosa* Linn., *C. korshinskii*, *H. rhamnoides* Linn., *P. simonii* Carr, and *P. sylvestris*	
Yellow land covered by sand	*C. korshinskii*, *A. ordosica*	*A. fruticosa* Linn., *P. simonii* Carr, *P. sylvestris*, *A. adsurgens* Pall., and *M. sativa* L.	Setting up a banded grass sand barrier, planting seedlings for afforestation, planting coniferous trees with soil balls, promoting and applying water retention agents and other new materials for drought resistance and afforestation, planting 330 – 660 trees and 1 800 holes of shrubs in 1 hm^2 of land, mixing them between rows, sowing seeds of pasture by aerial seeding, and making the coverage of top community coverage more than 40% – 50%
	H. rhamnoides Linn., *P. simonii* Carr	*C. korshinskii*, *A. fruticosa* Linn., *P. simonii*×*P. pyramidalis* 'Opera 8277', *S. matsudana* Koidz., *P. sylvestris*, and *A. adsurgens* Pall.,	
	S. matsudana Koidz., *S. cheilophila*	*C. korshinskii*, *H. fruticosum*, *A. fruticosa* Linn., *A. desertorum*, *P. sylvestris*, *A. adsurgens* Pall., and *Melilotus suaveolens* Ledeb.	
	P. tabulaeformis Carr.	*C. korshinskii*, *S. vulgaris*, *A. fruticosa* Linn., *P. hopeiensis*, *A. adsurgens* Pall., *M. sativa* L.	
	U. pumila L.	*C. korshinskii*, *P. tabulaeformis* Carr., *S. vulgaris*, and *A. adsurgens* Pall., *M. sativa* L.	

(To be continued)

(Continued)

Site type	Original dominant species	Planted species	Configuration and afforestation method
Ditch edge	*C. korshinskii*	*U. pumila* L., *Platycladus orientalis*, *Caryopteris mongholica* Bunge, and *Lespedeza bicolor* Turcz.	
Beam top	*C. korshinskii*	*P. simonii* Carr, *P. tabulaeformis* Carr., *A. fruticosa* Linn., *L. bicolor* Turcz., and *Ziziphus jujuba* Mill. var. spinosa (Bunge) Hu ex H. F. Chow	
River valley slope	*P. orientalis*	*C. korshinskii*, *P. tabulaeformis* Carr., *A. fruticosa* Linn., and *H. rhamnoides* Linn.	
	P. tabulaeformis Carr.	*C. korshinskii*, *A. fruticosa* Linn., *L. bicolor* Turcz., and *U. pumila* L.	

In the face of serious soil and water loss, reasonable and effective measures should be taken to strengthen soil and water conservation and reduce the damage of natural environment. With the development of social science and technology, in order to solve the problem of soil and water loss, soil and water loss regions have been divided into several zones to reduce the damage caused by soil and water loss, which is of great significance to strengthening the construction of ecological environment. Soil and water conservation zoning is an important basic work of soil and water conservation and is the prerequisite for soil and water conservation planning. Therefore, it is very important to systematically understand soil and water conservation zoning in China. The control work of soil and water loss has achieved remarkable achievements so far, which proves that the control route of soil and water loss in China is correct and also shows China's determination to control soil and water loss. However, there are still many shortcomings and deficiencies in the current control work. Based on the national first-level and second-level zoning of soil and water conservation and preliminary investigation, according to the principles and methods of the national three-level zoning of soil and water conservation, the current status of soil and water loss, rocky desertification, water resources, vegetation, and mountain disasters are evaluated. Referring to the results of the restricted development zones and the prohibited development zones involving basins in the main functional areas of China, as well as the division results of soil erosion zones and soil and water zones, a preliminary plan for the three-level zoning of soil and water conservation in the basins is proposed. The characteristics of regional natural conditions, social economy, and soil erosion are analyzed comprehensively, and the basic function positioning and main prevention and control approaches of each third-level zone are clarified. The main problems encountered in the division of the third-level zones are discussed, and some suggestions are proposed.

3.5 Strengthening the construction of soil and water conservation institutions China has a vast territory, where there are significant differences between regions in natural conditions, and the types and causes of soil erosion are complex. According to the characteristics of landform, bioclimate and soil erosion in different types of regions, the main soil erosion areas of China are divided into hydraulic erosion, wind erosion and freeze-thaw erosion areas[31]. Among them, hydraulic erosion areas are further divided into northeast black soil areas, northern soil and rock mountain areas, the Loess Plateau area, the upper reaches of the Yangtze River and southwest rivers, southwest karst areas and southern red soil areas. According to the regional characteristics of soil and water loss in different types of areas and the major strategic issues of soil and water conservation and ecological construction, as well as the hotspots, difficult problems and key technologies that need to be solved in the practice of soil and water conservation in various areas, the research directions and tasks of different types of areas are proposed to service regional soil and water conservation. Relying on major scientific research and construction projects, a series of soil and water conservation research teams composed of primary, middle and high levels and with suitable proportion, moderate quantity and professional support will be created. Meanwhile, it is necessary to strengthen the training of academic leaders, actively promote the construction of innovative teams, and cultivate a group of senior experts in soil and water conservation with world-leading levels.

In addition, it is necessary to stabilize and strengthen scientific research institutions, build and improve the four major systems of basic theory, monitoring and evaluation, technical standards and technology research and promotion around the practice of soil and water conservation and ecological construction, enhance the scientific and technological level of soil and water conservation, and promote the sound and rapid development of soil and water conservation. According to incomplete statistics, more than 20 colleges and universities across the country have set up majors related to soil and water conservation science, and are engaged in the task of training undergraduates and postgraduates. At the same time, soil and water conservation research networks at national, river basin, provincial, prefecture, county levels have been basically established. In addition to the national soil and water conservation research institutes, which is mainly composed of the Institute of Soil and Water Conservation of the Ministry of Water Resources of the Chinese Academy of Sciences, various major river basin institutions, provinces, cities and autonomous regions have established corresponding research institutions to be responsible for the research of soil and water conservation in the areas under their jurisdiction. At the same time, each county (city and district) also have corresponding soil and water conservation research and observation institutions. Scientific research institutions at all levels have clear division of labor and cooperate cooperate with each other to constitute a research team for soil and water conservation with Chinese characteristics, and this team has about 10 000 people. The competent national authori-

ties also set up corresponding professional research centers according to the particularity of soil and water conservation work, such as the Soil and Water Conservation Monitoring Center of the Ministry of Water Resources, the Soil and Water Conservation Plant Center, and the Engineering Technology Research Center, *etc.* The water and soil conservation technology system has been developed, and a number of experimental demonstration bases for the comprehensive control of soil and water loss have been built. The Chinese nation has thousands of years of successful soil and water conservation experience. In recent years, the state has organized a series of soil and water conservation projects, and a water and soil conservation technical system adapted to different types of areas has been initially formed and widely used in production practice. Obvious economic, ecological and social benefits have been achieved. It is necessary to give full play to the important role of education in the cultivation of innovative talents, strengthen the organic combination of talent training and scientific and technological innovation in soil and water conservation, and encourage research institutes to cooperate with higher education institutions to cultivate research-oriented talents, support graduate students to participate in or undertake research projects, and encourage undergraduates to take part in scientific research.

The construction of soil and water conservation institutions is the key to the success of the development of soil and water conservation, and must be continuously strengthened. At present, in order to adapt to the rapid development of soil and water conservation, it is necessary to strengthen the construction of water and soil conservation institutions. It is needed to improve the scientific and technological management system for soil and water conservation in the Yangtze River basin and the soil and water conservation test system. It is planned to build 20 new ecological science and technology demonstration parks for soil and water conservation integrating ecology, scientific research, monitoring, demonstration, promotion, popular science education, leisure and sightseeing in different water and soil loss areas in the Yangtze River basin by 2020. Relying on science and technology demonstration parks for soil and water conservation, a number of soil and water conservation experiment and research projects are carried out. It is necessary to strengthen and improve the management system combining basins and regions, form the synergy of soil and water conservation and ecological construction, and promote soil and water conservation work in soil and water loss areas to a new level.

According to the *Opinions on Strengthening the Construction Management of Public Welfare Water Conservancy Projects* (Guofa[2000]No. 20), *Regulations on Quality Management of Construction Projects* (No. 279 Order of the State Council), *Measures for the Management of Soil and Water Conservation Ecological Environment Monitoring Network* (No. 12 Order of Ministry of Water Resources) and *Regulations on the Management of Water Conservancy Construction Projects* (*Trial*) (Shuijian[1995]No. 128), construction management is guided and supervised, and major issues in construction are coordinated and solved. The national key areas for the control of soil and water loss are valued. National and regional control monitoring is combined with localized local observation to achieve resource sharing with relevant industries, and to build networks that meet different levels of scientific research, technology development, plan design, prevention and demonstration, monitoring management and decision-making. It is needed to strengthen the monitoring of soil and water conservation in key areas and key projects. For the key projects of soil and water conservation and ecological construction in the middle and upper reaches of the Yangtze River, the middle reaches of the Yellow River, northeast black soil areas and the upper reaches of the Pearl River, the quantity, quality and control effects of soil and water conservation measures is monitored. In the national soil and water conservation monitoring network and management information system, the key issues are monitoring network structure, monitoring site layout, monitoring indicator system, collection of dynamic data, development of soil and water conservation management information system, *etc.*, which needs to be studied and solved. Except for information concerning state secrets, trade secrets, and personal privacy, the credit files of market entities are open to the public and subject to social supervision. Any unit or individual who discovers that the credit information of the market subject is false may apply to water administrative departments in accordance with the principle of territorial and hierarchical management.

At present, China's society has gradually entered the crucial period of ecological and civilized society development. In order to solve the problem of soil and water loss hindering environmental and economic development, it is necessary to establish a set of promotion and operation mechanisms of scientific and technological achievements, comprehensively explore and study various problems in soil and water lass in social development, and enhance reasonable and effective scientific basis and support system. It is needed to comprehensively mobilize the enthusiasm of all parties involved in soil and water conservation practice and promote the formation of a diversified investment mechanism. In the end, the contribution of advanced scientific and technological achievements of soil and water conservation in ecological construction can be enhanced by demonstration, promotion, and radiation[31].

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(To page 20)

change and implementing agricultural production activities.

Ninthly, it should enlarge coverage surface of meteorological service. It should enhance construction of research type of meteorological service products, which could provide calculation and evaluation report of wind energy resource for energy, electricity, transportation, ocean, architecture and other departments, calculation and evaluation report of wind speed and pressure in reappearance period for large building, benchmark tornado assessment report for nuclear power plant design, to promote meteorological specialized service ability.

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(From page 14)

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