BIBLIOGRAPHIC INFORMATION SYSTEM

Journal Full Title: Journal of Biomedical Research & Environmental Sciences

Journal NLM Abbreviation: J Biomed Res Environ Sci

Journal Website Link: https://www.jelsciences.com

Journal ISSN: 2766-2276

Category: Multidisciplinary

Subject Areas: Medicine Group, Biology Group, General, Environmental Sciences

Topics Summation: 128

Issue Regularity: Monthly

Review Process type: Double Blind

Time to Publication: 7-14 Days

Indexing catalog: Visit here

Publication fee catalog: Visit here

DOI: 10.37871 (CrossRef)

Plagiarism detection software: iThenticate

Managing entity: USA

Language: English

Research work collecting capability: Worldwide

Organized by: SciRes Literature LLC

Manuscript should be submitted in Word Document (.doc or .docx) through **Online Submission** form or can be mailed to support@jelsciences.com

Vision

Journal of Biomedical Research & Environmental Sciences main aim is to enhance the importance of science and technology to the scientific community and also to provide an equal opportunity to seek and share ideas to all our researchers and scientists without any barriers to develop their career and helping in their development of discovering the world.

Journal of Biomedical Research & Environmental Sciences
Subject Area(s): ENVIRONMENTAL IMPACTS | SOIL SCIENCE
ORIGINAL ARTICLE

New Theory of Soil and Water Conservation

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ABSTRACT

Water and soil loss affects the carbon and nitrogen cycles of terrestrial ecosystems, forest vegetation ecosystem products and services, and ultimately the quality of life and sustainable development of the public. China has the most serious soil erosion in the world, notably on the Loess Plateau. After years of efforts, soil and water conservation in China has developed rapidly, the surface runoff and soil loss in soil and water loss areas have decreased rapidly, and people's living standards have gradually improved. With these improved living standards, people have higher requirements for soil and water conservation. However, soil and water conservation lacks scientific theoretical guidance. In this paper, through comprehensive analysis of relevant literature, a new theory of soil and water conservation is proposed. The results shows that soil and water losses refer to the process of transferring soil and water resources from one place to another, and the consequences of these losses can be divided into positive and negative effects. Soil and water conservation is not only the use of some methods or measures to reduce soil erosion to soil allowable loss requirements, but also to make efficient use of soil and water resources. The construction standard of soil and water conservation measures must be based on the allowable amount of soil erosion and be applied using spatially optimal allocation, and the work of soil and water conservation should ensure regional ecological security and realize the sustainable development of soil and water conservation.

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DOI: 10.37871/jels1122

Submitted: 02 July 2020

Accepted: 06 August 2020

Published: 11 August 2020

Keywords

- Soil and water loss
- Soil and water conservation
- Food and ecological security
- Soil and water conservation measure
- Most optimum distribution of resources
- Sustainable development

Subject: Environmental

Topic(s): Environmental Impacts

VOLUME: 1 ISSUE: 4

INTRODUCTION

Neotectonic movement is tectonic change occurring in the Tertiary and thereafter, and is characterized by vertical and horizontal movement. Under the influence of many natural background factors, such as mountainous terrain and unstable monsoon precipitation, formed by intense neotectonic movement, as well as the long history of agricultural development and the large population, China has become one of the countries with the most serious soil erosion, notably on the Loess Plateau.

Water and soil loss affects the carbon and nitrogen cycles of terrestrial ecosystems, ecosystem products and services, the ecological environment and economic development, and ultimately the quality of life and sustainable development of the public. Over the past 100 years, great progress has been made in the work of soil and water conservation in China with the unremitting efforts of the vast number of soil and water conservation workers. For example, as evidenced by the establishment of the State Key Laboratory of Soil Erosion and Dryland Agriculture in Yangling, China, the concept of cover degree and cover rate of water conservation forest has been developed [1,2]. Vegetation coverage is the percentage of the total area covered by the vertical projection area of the canopy branches and leaves, and the vegetation cover rate is the proportion of high-quality grassland or forestland area

How to cite this article: Guo Z. New Theory of Soil and Water Conservation. J Biomed Res Environ Sci. 2020 Aug 11; 1(4): 064-069. doi: 10.37871/jels1122, Article ID: JELS1122

of the total land area in a region or a country. The vegetation coverage includes the effective cover degree, critical degree, and potential coverage [3,4]. The establishment of a large area of soil and water conservation vegetation has been established in the area of in the area of soil and water loss region, such as water conservation forest (or vegetation), wind-proof and sand forest and water source conservation forest, and adult forest construction standards and their construction scale and suitable developmemt scale have also been established; the effective coverage rate of wind-proof sand forest, of water conservation forest, and of water conservation forest [2-9]; the theory of soil water resources utilization limit by plants and the bearing capacity of soil moisture vegetation appeared in Guo [10]. However, due to the lag in theoretical research, construction standards of soil and water conservation engineering measures and vegetation measures are low, the spatial allocation of soil and water conservation measures is unreasonable, the work of soil and water conservation attaches importance to quantity and not quality, and its efficiency is low, which cannot meet the modern needs of high quality development of soil and water conservation. Such incidents as drought, forest fires, extreme weather and precipitation, hurricanes, and flash floods lead to widespread erosion of soil and water conservation vegetation, collapse of dams and other incidents, resulting in serious soil erosion, destruction of farmland, villages, roads, and vehicles, which affects transportation, food and ecological security, and cause large losses to the state and society. In order to overcome these difficulties, promote the high quality development of soil and water conservation, and meet current requirements of the public for soil and water conservation, it is necessary to develop a new theory of soil and water conservation. Through comprehensive analysis of relevant literature, a new theory of soil and water conservation is proposed. In order to better understand the new theory of soil and water conservation, this paper introduces it from the following aspects.

SOIL AND WATER LOSS

The term soil and water loss describes a natural phenomenon, and originated in China as a technical term in the early 20th century [11], where it was applied to the Northwestern Loess Plateau. The forces affecting soil and water loss are called soil and water loss external forces and include water, wind and temperature (freeze–thaw). The term erosion has long been used in geology, mostly to express the flattening due to external force, and soil erosion was first mentioned in the book of Kozmenko in 1909 [5]. It was then widely used and was introduced into China in the 1930s. Soil erosion refers to the whole process of soil and its parent material, as well as the destruction, stripping, transport, and deposition of surface components of the land under external forces such as hydraulic, wind, freeze-thaw, and gravity [5]. Water power is the force produced by the flow of water and wind is the magnitude of the force that air exerts on an object. Temperature is the measure of the average translational kinetic energy of the molecular motion, and is the collective expression of molecular thermal motion. At present, people's understanding of water and soil loss is not uniform. It has been argued that soil erosion refers to the destruction and loss of soil and water resources and land productivity under the action of external forces, including surface erosion and soil erosion; most believe that water and soil loss is equivalent to soil erosion, i.e., soil erosion by hydraulic, wind, or gravity erosion, resulting in soil dispersion, transport, and accumulation processes. However, we are entering a new period. In order to promote the high quality development of soil and water conservation in this new period, we should first unify the understanding of water and soil loss. The authors believe that water and soil loss is the process of soil and water resources transferring from one place to another, which includes both generalized and narrow-sense soil erosion. Generalized water and soil loss refers to the process of carbon and nitrogen cycle, land productivity, and ecological environment change caused by the transfer of soil and water resources induced by external forces. Water and soil loss in the narrow sense is equivalent to soil erosion.

CONSEQUENCES OF SOIL AND WATER LOSS

Water and soil loss has obvious consequences, which can be divided into positive and negative effects as follows:

Water and soil loss leads to decline or even loss of soil fertility and land productivity in the water and soil loss regions

The term soil fertility refer to the capability of soil to support plant production in agricultural contexts [12]. Serious water and soil loss will affect carbon and nitrogen cycles in agriculture ecological systems and result in surface soil thinning of fertile soil in the water and soil loss region, and decreases in cultivated land area, soil fertility, and crop yield [13].

Soil and water loss influence people's daily movement

Water and soil loss destroys roads and silts up rivers, lakes, and reservoirs, which affects people's daily movement. Floods, landslides, mudslides, and other serious soil erosion results in siltation of channels, lakes, and reservoirs.

Water and soil loss pollution water quality and affects ecological balance

Water and soil loss accelerates non-point source pollution. In the event of heavy rain, strong surface runoff will pile up surface garbage into rivers, seriously affecting their water quality. A typical example is the poor water quality of the Yangtze River.

Typhoons, haze, dust, and dust storms affect people's health, travel, and social activities

With the development of economy and society, people are increasingly interested in health, and travel and social activities are becoming more frequent, while typhoons, haze, dust-raising weather, and dust storms affect flights and road traffic, and seriously hinder people's rapid travel and social activities.

Water and soil loss accelerates the formation of unique landforms and promotes the development of eco-tourism

Soil and rock through hydraulic, wind, freeze/thaw, and joint action of other external forces form a number of magic, wonderful natural landscapes, which accelerate the development of eco-tourism and help reduce poverty. For example, there are Keshiketeng stone array scenic spots in the northeast of Keshiketeng County, Danxia natural scenic spots in Yulin city, and Zhashui cave in the Qinling Mountains. Zhashui cave is the result of long-term dissolution of groundwater. Calcium carbonate in limestone forms micro-soluble calcium bicarbonate under the action of water and carbon dioxide. Because the limestone layer contains different lime quality with different erosion degrees, it is gradually dissolved and divided into independent, diverse, steep and beautiful peaks, and caves in a strange landscape, which promotes eco-tourism and local economic development. Hukou waterfall was a desolate land but now has become a tourist hot spot.

Water and soil loss forms silt plains and expands land area in estuaries

A large amount of sediment is deposited in estuary areas, over time forming silt plains and expanding the land area, which increase nitrogen density in soil, soil fertility, land production, and carbon dioxide fixation; for example, Chongming Island at the mouth of the Yangtze River and the Huanghe Delta at the mouth of the Yellow River. Chongming Island was originally only a small sand dune and, as more sand was deposited, the sand dunes grew larger and became an island where fishermen lived.

Soil and water conservation workers should broaden their horizons, make best use of the advantages of water and soil loss and bypass the disadvantages of water and soil loss. Thus, they can meet the requirements of rapid and high quality economic and social development, especially to strengthen the prediction and prevention of serious soil erosion phenomena caused by typhoons and haze caused by strong winds, dust-raising weather, and sandstorms.

SOIL AND WATER CONSERVATION

Soil and water conservation refers to the use of certain measures and technologies to reduce the loss of soil and water to a certain goal, i.e., soil allowable loss, increasing land productivity and improving the environment. It is also necessary to make efficient use of soil and water resources in the process of water and soil loss to ensure the safety of the ecosystem and increase the ecological, economic, and social benefits of the ecosystem, and also provide high quality products and services for social development. Soil and water conservation makes rational use of soil and water resources to achieve sustainable development. For example, introduction of flood irrigation with high sediment concentration to form high-quality farmland using water sources of rivers, lakes, and reservoirs in the sand area; drawing water by gravity or by machinery; washing sand dunes using hydraulic power, and carrying sand to positions to form high quality farmland, or using runoff and topography to promote eco-tourism, such as the Shapotou and Hukou tourist attractions in the China Loess Plateau.

Soil and water conservation measures can effectively conserve soil and water [14]. These measures include engineering measures, farming, and biological measures for soil and water conservation. In the restoration of vegetation, natural forces can be used to restore vegetation in uninhabited areas; however, in areas where there is a population, artificial interference should be used to restore vegetation in order to create the vegetation ecosystem goods and services to meet the needs of human production and life.

Over the past 100 years, with the unremitting efforts of the vast number of soil and water conservation workers, China has made great progress in its work on soil and water conservation. A large area of soil and water conservation vegetation has been established in water and soil loss areas, and a large number of reservoirs have been built; some water and soil conservation measures such as water and soil conservation projects including dams or levees have been set up along the tributaries of the Yellow River and other soil erosion areas, which have made great progress in controlling water and soil loss below the allowable amount and promoting regional economic development. However, due to the lag in theoretical research on soil and water conservation, the construction standard of soil and water conservation measures is low and imperfect, and the spatial allocation of soil and water conservation measures is not balanced. For example, silt storage dams for farmland buildings have played important roles in preventing floods, consolidating the return of farmland to forests or grassland, safeguarding ecological security and food security, and promoting the development of economy and social stability. However, in construction of silt storage dams, the problems of low quality construction, serious disease-risk dam, and poor management of reconstruction, especially concerning the large number of small dams, have not received enough attention [15]. Therefore, it is urgent to strengthen the study of soil allowable loss on different underlying surfaces, formulate high quality and strict standards for soil and water conservation engineering and vegetation construction, and carry out spatial optimal allocation to obtain maximum soil and water conservation efficiency. The space optimal configuration is expressed by the spatial optimal configuration coefficient. Spatial optimal allocation coefficient indicates that, in a water and soil loss area or watershed, soil and water conservation funds or measures may have different allocation methods; these different allocation methods result in different soil and water conservation efficiency, i.e., different surface runoff and soil loss. The optimal allocation of space is the allocation that results in maximum soil and water conservation efficiency.

Soil and water conservation and ecological security

Research on ecological security dates back to 1962, when Rachel Carson published her book "Silent Spring", revealing the enormity of the environmental damage to biological species, ecosystems, and humans. In 1989, the International Institute for Applied Systems Analysis first proposed the important concept of "ecological security" and made clear that this a fundamental right to ensure that human life, health and well-being, and the ability of humans to adapt to changes in the environment is not threatened [16].

In the 1996 Earth, Convention on Citizens Facing Global Ecological Security, more than 2 million people from various countries signed its name, calling for the establishment of ecological security with environmental security, sustainable development and responsibility, and demanding that member states and groups coordinate their interests, actively fulfill their responsibilities and obligations, and strengthen international cooperation. At this point, the concept of ecological security began to be recognized by the international community [16]. China, for example, plans to build a hydroelectric dam on the Yarlungtsangpo River, because of the large amount of water and the huge drop off. After completion of the construction of the Metuo County Hydroelectric Power Station, the 60 million-kilowatt super waterfall hydroelectric power station will be more than twice as large as the Three Gorges Hydroelectric Power Station and generate 300 billion kilowatt-hours of electricity annually in China. It is second only to the Inga dams, in Congo River, Republic of the congo and the southern Tibet Region is located at the edge of the Qinghai-Tibet Plateau where earthquakes, landslides, debris flow, and other disasters occur frequently; after the construction of hydropower stations, huge water storage further increases the risk of such disasters. At present, the ecological risk assessment of soil and water and soil conservation measures is lagging behind in the study of ecological security in soil and water conservation areas, especially in regard to extreme weather conditions such as hurricanes and flash floods. Thus, water and soil conservation measures cannot increase ecological risk.

Sustainable development of soil and water conservation

In 1972, Dennis L. Meadows published a study on the limits to growth that clarified the importance of resources and the relationship between resources and population. The limit of growth shows the consequences of unlimited growth on a resource-limited planet, laying the foundation for sustainable development.

The International Union for the Conservation of Nature proposed the concept of sustainable development in 1980. In 1987, the United Nations World Commission on Environment and Development clearly defined sustainable development. Since then, sustainable development strategies have gradually been accepted worldwide, and many countries have begun to implement them. The International Tropical Timber Organization took the lead in developing guidelines for the sustainable operation of tropical forests in 1990. In 1992, sustainable development was the central issue of the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, which emphasized that sustainable forest development was an important component of sustainable economic development. In 1992, the Chinese Government submitted its report on China's environment and development to the United Nations Conference on Environment and Development, which laid out the basic position and views regarding China's sustainable development. In 1994, the Chinese Government made it clear that it would implement a strategy for sustainable development in its economic and social development plans.

In the field of soil and water conservation, it is necessary to implement sustainable management in order to realize sustainable development. For soil and water conservation engineering measures, it is necessary to improve the design standards and formulate corresponding emergency plans to prevent the occurrence of dam breaks caused by hurricanes, tsunamis, and heavy rain during extreme weather. For example, in August 2019, heavy rain occurred in Weifang, Binzhou, and other places in Shandong Province, China, due to Typhoon No. 9 "Liqima". The heavy rain caused floods and destroyed a large number of agricultural production measures, grain fields, road and bridge culverts, houses, and public buildings. The disaster caused widespread concern in the community. In the early morning of August 20, 2019, due to heavy rainfall, a huge debris flow occurred in the Yazigou valley, less than 300 m from the dam of the Wolonglongtan Hydropower Station in Sichuan, China. At that time, the staff on duty found that the dam water level rose and the water level difference across the barrier quickly increased, and to avoid the peak they immediately opened the floodgate. When the three sluices were opened by less than 1 m, the swift and violent debris flow broke the power transmission line of the working power supply, interrupting the power supply to the sluice; consequently the sluice could not be further raised, resulting in a rapid rise in water level and flood flood over dam incident. For the biological measures of soil and water conservation, according to the vegetation carrying capacity, mainly including spatial vegetation carrying capacity, soil water-carrying capacity for vegetation, and soil nutrient carrying capacity for vegetation, it is easy to adjust and control the relationship between plant growth and natural resources in good time to realize the sustainable utilization of natural resources and the sustainable development of soil and water conservation measures to prevent overloading

CONCLUSION

Chinese economic and social development has entered a new phase, and social wealth has improved unprecedentedly. In this new phase, the public has made greater demands concerning soil and water conservation, which requires the protection of air quality, life, property, and health, and ensures the safety of food, ecology, and transportation; thus, work on soil and water conservation has also entered a new phase [17]. To ensure the safety of people's lives and property and meet the needs for people's happiness, we must increase the level of understanding, dialectically and comprehensively view the consequences of soil erosion, take timely and effective measures to deal with serious soil erosion caused by sudden events such as mountain torrents, hurricanes, sandstorms, and other serious accidents that affect the safety of public life and property. To ensure the sustainable use of natural resources and carry out sustainable development of forest vegetation, and sustainable agricultural production in soil erosion areas, we must coordinate and promote comprehensive prevention and control of non-point source pollution, restoration of degraded ecosystems and improvement of living environment in soil erosion areas, and realize the concept of co-construction and co-treatment to achieve green mountains and blue waters and achieve rural revitalization and build a beautiful China, to meet people's yearning for a better life.

To meet people's rising expectations regarding soil and water conservation, we must establish a new theory of soil and water conservation; we must unify understanding of water and soil loss, and fully recognize the 7consequences of soil and water conservation. We then need to take advantage of water and soil loss, giving priority to allowable soil loss, and determine high standards of soil and water conservation measures after taking into account air quality and soil pollution according to local conditions. Soil and water conservation measures should be rationally distributed to ensure sustainable utilization of natural resources in water and soil loss areas and the safety of ecosystems, in order to realize sustainable management of soil and water conservation projects and biological measures. In the future, it will be necessary to strengthen basic research such as on the relationship between different soil and water conservation projects and biological measures with soil allowable loss in soil erosion areas, air quality, and soil pollution. Additionally, research should be strengthened concerning early warnings of risks such as mountain floods, landslides, and debris flow caused by natural disasters including typhoons and tsunamis in soil erosion areas. High standard soil and water conservation measures should be formulated on the basis of this research, and there should be spatial optimization of soil and water conservation measures to ensure high efficiency utilization of soil and water resources in soil erosion areas. This will ensure safety of ecosystems, realize sustainable development of soil and water conservation, result in design of high quality development for upper levels of soil erosion areas, achieve improved soil and water conservation efficiency, meet the needs of the public for food, ecological security, road access, and eco-tourism, and provide a theoretical basis and scientific and technological support for sustainable development.

ACKNOWLEDGMENT

This project was supported by the National Key Research & Development Plan (Project No: 2016YFC0501702) and the National Natural Science Foundation of China (Project Nos: 41271539 and 41071193). We thank International Science Editing (http://www.internationalscienceediting.com) for editing the English language in the manuscript.

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How to cite this article: Guo Z. New Theory of Soil and Water Conservation. J Biomed Res Environ Sci. 2020 Aug 11; 1(4): 064-069. doi: 10.37871/jels1122, Article ID: JELS1122