

Environmental Risk Study of the Yuanjiang-Lishui River Basin in the Enshi Area

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Abstract. The Yuanjiang-Lishui River Basin in the Enshi Prefecture is located in the southwestern part of Hubei Province, China. It is an important tributary of the Qingjiang River Basin and falls within the secondary region of the Qingjiang River Basin. The total area of this basin is approximately 5,320 square kilometers, with most of the region falling under the administrative jurisdiction of Enshi Prefecture. This paper investigates the environmental risks faced by the Yuanjiang-Lishui River Basin in Enshi Prefecture, conducting an in-depth study and discussion of the existing environmental issues in the region and their causes. The study reveals that the Enshi area of the Yuanjiang-Lishui River Basin currently faces significant environmental problems, including severe flood disasters, an increasingly acute conflict between the supply and demand of water resources, and water pollution.

Keywords: Yuanjiang-Lishui, environmental risk, Enshi.

1. Introduction

The Yuanjiang-Lishui River Basin in Enshi is part of the Yuanjiang-Lishui secondary basin within the Qingjiang primary basin of Hubei Province. Qingjiang originates from Lichuan City in Enshi Prefecture, Hubei Province, with a total length of 423 kilometers. It flows through Enshi, Xuan'en, Jianshi, Badong, Xianfeng, Xuan'en, Hefeng, Changyang, Wufeng, and other areas, eventually merging into the Yangtze River at Yidu. The Qingjiang River is renowned for its scenic beauty, often praised as "a picturesque river stretching 800 li." The entire Qingjiang Basin within Hubei Province covers a total area of 29,700 square kilometers, with the Yuanjiang-Lishui Basin accounting for 5,320 square kilometers.

After years of continuous efforts, the basin's water conservancy development has made significant progress, with the infrastructure network becoming increasingly complete and the capacity for disaster prevention and mitigation gradually improving. However, some risks still remain.

In terms of flood control and disaster reduction, various counties and cities within the basin have suffered from varying degrees of flood disasters, highlighting the shortcomings in urban flood control and drainage.

Regarding water resources, the basin's supply capacity and efficiency have reached the highest levels in history, but some rural areas still experience seasonal water shortages.

In terms of water ecology, the overall trend in the basin is continually improving, but there is still a gap between the current state and the public's expectations for a beautiful river [1].

2. Environmental Risk Analysis

2.1. Severity of Flood Disasters

2.1.1. Historical Flood Occurrences

The statistics of flood occurrences at meteorological stations in Xuan'en County, Hefeng County, and Laifeng County from 1970 to 2020 are shown in Table 1-1 and Table 1-2.

Table 1-1. Statistics of Flood Years at Meteorological Stations in Xuan'en County, Hefeng County, and Laifeng County (1970–2020)

year	Heavy waterlogging	Flooding	Waterlogging
Xuan'en County	1980 1982 1983 2020	1996 1998	1973 1975
Hefeng County	1982 1983 1991 1998 2007 2016 2020	1970 1987 2008 2017	1996
Laifeng County	1980 1983 1998 2018 2020		1997 1999 2010 2016

Table 1-2. Statistics of Flood Occurrences at Meteorological Stations in Xuan'en County, Hefeng County, and Laifeng County (1970–2020)

frequency	Heavy waterlogging	Flooding	Waterlogging	Total
Xuan'en County	4	2	2	8
Hefeng County	8	4	1	13
Laifeng County	5	0	4	9

Based on the data from Table 1-1 and Table 1-2, it is evident that over the 50-year span from 1970 to 2020, this basin experienced a total of 30 flood disasters. Specifically, Hefeng County encountered 13 floods, Laifeng County had 9, and Xuan'en County experienced 8. These figures clearly illustrate the distribution of flood disasters within the basin during this period and reveal the severe challenges faced by the counties in their flood control efforts.

2.1.2. Causes of Flooding in the Basin

(1) Abundant Precipitation and Complex, Variable Climate

The climate of this basin is characterized by a subtropical continental monsoon humid climate, with an average annual rainfall of 1,568 millimeters. Historically, the year with the highest annual precipitation was 1980, with a total annual rainfall of 2,335.9 millimeters. During the flood season (April to September), rainfall accounts for about 70% of the annual average, with summer (June to August) being the main flood occurrence period, having a frequency as high as 56%. During this time, the maximum flood peak discharge can reach 7,000 cubic meters per second.

Atmospheric precipitation is the primary driving force behind flood disasters. The basin's climate is distinctly characterized by a typical subtropical monsoon humid climate, where rainfall and heat occur simultaneously. Due to the climate's instability, precipitation often becomes abnormal, and rainfall is geographically concentrated, often occurring in the form of heavy downpours. This climatic feature makes it easy for rainwater to accumulate, leading to concentrated surface runoff [2].

(2) Topographic and Geomorphic Influences

This basin is located in the southwestern corner of Hubei Province, within the middle and lower reaches of the Yangtze River region. The terrain is dominated by three mountain ranges, with higher elevations in the northwest, northeast, and southeast, gradually sloping towards the central and southern areas, creating a terrain of progressively decreasing relative heights. Geomorphologically, the basin exhibits a stepped development, with karst phenomena particularly prominent. Due to the intermittent activities of new tectonic movements, large areas have uplifted to form mountains, while localized areas have subsided to form basins and multiple levels of terraces.

Additionally, this basin is an integral part of the Qingjiang River, a significant tributary of the Yangtze River. In areas with well-enclosed terrain, such as karst depressions and valleys, the middle areas are relatively low-lying, while the surrounding areas are higher. Combined with the well-developed river network, these geographical conditions often facilitate the convergence of surface water and groundwater [2].

Given that 80% of the entire Loushui River consists of canyon areas with a total drop of about 1,670 meters and an average valley width of approximately 50 meters, the destructive force of floods can be extremely severe once they occur.

(3) Impact of Human Activities

The main human activities affecting flooding in the basin include: ① Rapid socio-economic development, leading to increased water extraction and consumption; ② Accelerated urbanization, resulting in the expansion of built-up areas and urban land use [3].

The complex impact of human activities has significantly exacerbated flooding phenomena. With the rapid growth of population and economy, the exposure to floods has shown an upward trend. In the process of urbanization in Enshi Prefecture, changes in land use and vegetation cover have profoundly affected the region's hydrological characteristics, the most notable being the significant increase in impervious surface areas. In summary, unreasonable human activities have become a major factor increasing the likelihood of floods.

(4) Incomplete Flood Control Infrastructure

In the main stream area of the Youshui River in the Hubei section, there are evident shortcomings and defects in the flood control system. Currently, the flood control infrastructure is relatively weak, resulting in many river sections lacking effective protective measures. More critically, although some river sections have been equipped with embankments and bank protection projects, their flood control standards clearly do not meet current needs, as they are set too low. Particularly when encountering flash floods from mountain streams, the concentrated peak flows and their destructive force have already caused severe damage to some existing projects [4].

Additionally, special attention must be given to the fact that the bank slopes of some key river sections are particularly vulnerable to erosion. Under continuous flood scouring, these slopes are retreating year by year, creating an increasingly serious safety hazard. This situation has now posed a severe threat to the safety of life and property for residents along the banks, and it urgently requires effective measures to address it.

2.2. Sharp Contradiction Between Water Supply and Demand

2.2.1. Analysis of Drought Conditions in the Basin

First, let's review the drought situation in the basin in 2022. Starting from late July, the basin experienced prolonged high temperatures with little rainfall, no heavy precipitation, and over 18 consecutive days without effective rainfall, leading to moderate to severe drought conditions. In August, the meteorological situation did not improve, with an average rainfall of only 6.3 millimeters, a 90% decrease compared to the previous year. Rainfall in various counties and cities was generally low, particularly in Laifeng County, where rainfall decreased by 90%, and by half in counties like Hefeng and Xuan'en. The drought resulted in mild to moderate drought across most of the basin, with severe drought in some areas. Large and medium-sized reservoirs played a crucial role, with a total water storage of 4.747 billion cubic meters, although this was 24.6% less than the previous year, but still above the dead water level, ensuring water supply. The flow of major rivers in some urban areas significantly decreased, exacerbating the drought [5]. In summary, the basin suffered severe drought from July to August 2022.

2.2.2. Analysis of the Causes of Water Shortages

After an in-depth comprehensive analysis, the water shortage problem in the Yuanjiang-Lishui River Basin primarily stems from the following three factors:

(1) Climate Change Instability

The instability brought about by climate change has had a severe impact on the basin. The current trend of global warming has significantly altered the rainfall patterns in China, leading to a noticeable decrease in precipitation in some regions. This situation has adversely affected the runoff in the Yuanjiang-Lishui River Basin in the Enshi area, making the basin's water resources face even more severe challenges.

(2) Overexploitation of Water Resources

Overexploitation of water resources is also a critical issue. With the continued growth of the basin's population and rapid economic development, the demand for water resources has been increasing. This increasing demand has inevitably led to the excessive extraction of groundwater and surface water resources, far exceeding the natural environment's capacity for self-recovery.

(3) Inefficient Utilization of Water Resources

The inefficient utilization of water resources is also a significant factor contributing to the water shortage in the basin. In various water use sectors, including agricultural irrigation, industrial production, and urban residential life, there are issues with improper water usage in the basin. This inefficient use not only leads to severe waste of water resources but also further exacerbates the water shortage problem in the basin. Therefore, it is imperative to take effective measures to change these inefficient water use practices, thereby achieving the rational use and sustainable development of water resources.

(4) Ecological Environment Destruction

Ecological destruction is an aspect of the basin's water resource issues that cannot be ignored. With the intensification of human activities, the ecological environment of the basin has suffered severe damage. Activities such as deforestation, excessive land reclamation, and wetland destruction have led to a decrease in vegetation cover and an increase in soil erosion, which in turn have affected the hydrological cycle and water resource conditions in the basin. In the Yuanjiang-Lishui River Basin, the problem of ecological destruction is particularly prominent. Large areas of wetlands have been filled in or reclaimed, leading to a reduction in wetland area and degradation of wetland functions. Wetlands are vital ecological barriers and water conservation areas in the basin; their reduction and degradation directly impact the basin's water resource conditions and water quality safety.

2.3. Water Pollution

2.3.1. Current Water Quality Status

According to the detailed report titled "Enshi Water Environmental Quality Status," in 2021, the water quality in the Loushui area was rated as Class V, indicating a certain degree of pollution. However, time has not brought a complete positive change. By 2023, although the water quality in the Youshui River area had improved, it remained in the Class IV category, indicating ongoing pollution issues and that the water quality had not yet met the established standards.

From a broader perspective, from 2021 to 2023, there has been an overall improvement in water quality, advancing from the original Class III to a cleaner Class II. Nevertheless, the government must remain vigilant, as even with improvements, pollution issues cannot be ignored and require ongoing efforts and measures to ensure continued improvement and compliance with standards.

With the acceleration of industrialization and increased levels of urbanization, a significant amount of industrial wastewater and untreated or inadequately treated domestic sewage is directly discharged into rivers, leading to severe declines in water quality. This pollution phenomenon is particularly prominent in the Yuanjiang-Lishui River Basin. Industrial wastewater contains heavy metals, toxic and harmful substances, and a large amount of organic pollutants, causing substantial damage to river ecosystems. Meanwhile, domestic sewage contains high levels of nitrogen, phosphorus, and other nutrients, which accumulate excessively in rivers, leading to eutrophication and triggering explosive growth of aquatic organisms like blue algae, further exacerbating the deterioration of water quality.

2.3.2. Discussion of Water Pollution Causes

The issue of water pollution in the Yuanjiang-Lishui River Basin in Enshi has become increasingly severe, with the core cause being the excessive use of pesticides and fertilizers, which directly leads to intensified agricultural non-point source pollution. Currently, the treatment rate of rural domestic sewage in the basin is only 23%, significantly lagging behind the provincial average of 32.4%, highlighting the urgency and importance of rural sewage treatment [1]. Additionally, there are many deficiencies in the collection and harmless treatment of rural solid waste, with common practices such as random open burning and dumping into ditches, which further exacerbate environmental degradation.

In 2022, the use of plastic film increased by 83.58 tons compared to 2021, putting even greater pressure on the environment [1]. However, the current recycling network and regeneration system for solid waste such as used agricultural films and pesticide bottles are still underdeveloped, limiting effective resource recovery and recycling.

In agricultural production, there is a significant lack of organic integration between crop cultivation and animal husbandry. This deficiency results in direct discharge of manure and the application of more organic matter than the soil can bear, severely impacting both soil and water quality. In particular, in Laifeng County within the basin, rural environmental pollution and ecological destruction issues have become increasingly prominent. Long-term use of pesticides and fertilizers has led to soil compaction and deterioration, with agricultural runoff carrying harmful substances into water bodies, exacerbating water pollution. Moreover, the rapid development of rural animal husbandry and aquaculture has also intensified water pollution, making the water quality of aquaculture areas a serious concern [6].

3. Conclusion

The Yuanjiang-Lishui River Basin, located in the southwestern part of Hubei Province, is a secondary region of the Qingjiang River Basin with a total area of 5,320 square kilometers. The basin faces environmental challenges such as flood disasters, sharp conflicts in water resource supply and demand, and water quality pollution. In terms of flood disasters, factors including abundant precipitation, complex and variable climate, topography and landforms, human activities, and inadequate flood control engineering contribute to the severity of floods. Regarding water resource conflicts, factors such as unstable climate change, over-exploitation of water resources, and unreasonable use of water resources lead to shortages. For water quality, excessive use of pesticides and fertilizers has intensified agricultural non-point source pollution. Additionally, inadequate treatment of rural domestic sewage and waste, an underdeveloped solid waste recycling network and recycling system, and insufficient integration between crop cultivation and animal husbandry further exacerbate water pollution.

To address these severe environmental challenges, a series of comprehensive management measures are needed for the Yuanjiang-Lishui River Basin.

Firstly, to address flood disasters, it is necessary to strengthen monitoring and early warning of climate change, improve flood control infrastructure, and enhance flood prevention capabilities. Additionally, land use planning should be strengthened to reduce human activities' impact on the natural environment. Especially in flood-prone areas, development activities should be restricted to protect the natural ecological environment.

Regarding the conflict between water resource supply and demand, a reasonable water resource management mechanism should be established to strengthen water conservation and protection. Promoting water-saving technologies and equipment, encouraging residents and businesses to conserve water, and reducing water consumption are essential. Moreover, supervision of water resource development and utilization should be increased, and over-exploitation should be strictly controlled to ensure sustainable use of water resources.

To address water quality pollution, strict environmental protection regulations and standards should be established, with a focus on controlling agricultural non-point source pollution. Promote ecological agriculture and green planting technologies to reduce the use of pesticides and fertilizers. Enhance the construction and efficiency of rural domestic sewage and waste treatment facilities. Develop a comprehensive solid waste recycling network and recycling system to reduce environmental pollution

from solid waste. Additionally, strengthen the organic integration of crop cultivation and animal husbandry to achieve resource utilization of agricultural waste and minimize negative environmental impacts.

In addition to the above measures, there is a need to strengthen ecological protection and restoration efforts in the Yuanjiang-Lishui River Basin. This includes enhancing vegetation protection and restoration to improve forest coverage and vegetation quality. It is also crucial to strengthen soil and water conservation efforts to prevent soil erosion and water loss. Furthermore, ecological monitoring and assessment should be improved to keep track of environmental conditions and provide scientific support for ecological protection.

In summary, environmental management of the Yuanjiang-Lishui River Basin requires collective effort and participation from society as a whole. Only by implementing comprehensive management measures can we effectively address issues such as flood disasters, water resource supply-demand imbalances, and water quality pollution, and achieve sustainable development in the Yuanjiang-Lishui River Basin.

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