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Ecological Service Value Harm on Biodiversity and Protection Countermeasures of Lishui river watershed

Xi Chen[1], Zhimin Tang[2,3,*], Yiyan Zhang[4], Hongbin Li[5], Yuan Li[6]
[1]School of Tourism and Aviation Management, Hunan Women's University, Changsha 410004, Hunan, China
[2]Chenzhou Institute of Agricultural Science, Chenzhou 423000, Hunan, China
[3]Chenzhou Branch, Hunan Academy of Agricultural Sciences, Chenzhou 423000, Hunan, China
[4]Institute of Nuclear Agriculture Sciences and Chinese Herbal Medicines, Changsha 410125, Hunan, China
[5]Hunan Maoshun Ecological Technology Co., Ltd., Changsha 410205, Hunan, China
[6]School of Social Development, Hunan Women's University, Changsha 410004, Hunan, China

Corresponding authors: (e-mail: 18867422061@163.com).

Abstract Landscape data were interpreted from Landsat MSS and TM satellite imagery, DEM data, and average grain yield records of the Lishui River watershed for the years 1980, 2000, and 2010. Using ENVI 4.7, ArcGIS 9.0, and Fragstats 3.3 software, landscape type maps for the Li River region in 1980, 2000, and 2010 were extracted, and the ecosystem service values for each landscape type were calculated for these three periods. The results show that between 1980 and 2010, the significant reduction in paddy field and woodland areas led to a continuous decline in ecosystem service value. Over the decade following 2000, the rate of decline was faster than in the previous twenty years. This trend poses serious resource and environmental challenges for the Lishui River watershed, including overharvesting of commercial timber, increased endangered species risk, degradation of aquatic vegetation, water pollution, and other ecological problems. To address these issues, it is necessary to strengthen policy support, establish sound legal frameworks, and implement strict management measures. Strategies should include developing eco-tourism to promote local economic growth, protecting biodiversity in key areas, conserving critical species resources, enhancing wetland and forest protection, and cultivating crops with lower water demand and higher water conservation capacity. These measures will help promote the sustainable economic, social, and ecological protection of the Lishui River watershed.

Index Terms ecological service value, biodiversity, protection countermeasures, Lishui river watershed

I. Introduction

The study of ecosystem service functions is a key component of ecological research. In recent years, landscape ecologists have increasingly focused on landscape patterns [1]–[3], which has led to growing attention on the valuation of ecosystem services. Monetizing the ecological services of natural ecosystems and quantifying their value not only provides the government with a scientific basis for ecosystem management decisions, but also offers the public clear and accessible data. This, in turn, enhances public awareness of the ecological functions and services provided by natural ecosystems, thereby promoting their protection [4].

The monetary valuation method has been widely applied in China. For example, Guan Wenbin et al. (2002) applied market value, shadow pricing, and opportunity cost methods to evaluate the ecological and economic value of forest services in the Gongga Mountain area, including water conservation, soil conservation, carbon dioxide fixation, and air purification [5]. Wang Shoubing et al. (2003) assessed the value of the Suzhou River landscape services in Shanghai using the willingness-to-pay method [6]. Yang Zhaohui (2010) developed a parameter table for ecosystem service value and applied it to evaluate ecosystem services under changing environmental conditions in the Haihe River Basin [7]. In recent years, watershed-scale assessments of ecosystem service value have received increasing research attention.

The Lishui River watershed, one of the four main tributaries of the Dongting Lake watershed, has the highest runoff modulus in the province and is known for its rapid flood fluctuations. It is an important production base for grain, cotton, livestock, and other agricultural commodities in both Hunan Province and China as a whole. Under the combined influence of climate change and human activities, the ecosystem service value of the Lishui River watershed has undergone significant changes [8]. These changes in the basin's ecological environment have important implications for the overall ecological security of the Dongting Lake watershed.

Alterations in the landscape pattern of the Lishui River watershed directly affect the sustainable development of both its ecological environment and the broader economy of the Dongting Lake watershed. However, despite its importance, research on the Lishui River watershed—particularly on the valuation of its ecosystem services—remains limited.

In this study, landscape data were interpreted from Landsat MSS and TM satellite imagery and DEM data for Hunan Province from 1980, 2000, and 2010. Using ENVI 4.7, ArcGIS 9.0, and Fragstats 3.3 software, and applying the monetary valuation method, we analyzed changes in the ecosystem service value of the Lishui River watershed between 1980 and 2010. The findings aim to provide guidance for ecological protection, flood forecasting, industrial structure planning and adjustment, resource utilization, and sustainable development in the region.

II. Research Area and Research Methods

II. A. General Description of the Research Area

The Lishui River, located in northwestern Hunan Province, flows through both Hunan and Hubei provinces, between latitudes 29°30′–30°12′N and longitudes 109°30′–112°00′E. The watershed has three main sources: the northern source is dominant, while the central and southern sources contribute smaller flows. The three stems join at Sangzhi County after merging with springs and tributaries near Xiaozibay Bridge and Dirty Rock, then flow eastward. The river receives water from tributaries such as Loushui, Dieshui, Daoshui, and Censhui before entering Dongting Lake at Li County's Xiaodu Ferry.

The Lishui River watershed has an average annual runoff of 13.12 billion cubic meters, covering an area of 18,496 km^2, of which 15,736 km^2 lie within Hunan Province. Annual precipitation across most of the basin is around 1,600 mm. The Sanjiangkou station reports an average annual runoff volume of 13.12 billion cubic meters [9], [10].

Within the Dongting Lake watershed, the Lishui River is the smallest of the four major rivers in Hunan Province, with a length less than half that of the Xiangjiang River and a drainage area of only one-fifth its size. Due to the influence of terrain, the upstream Three Gorges area experiences the same storm systems, often producing cyclones and frontal rainfall. Sangzhi and Cili counties form one of Hunan's three major storm zones, receiving especially high precipitation. The Lishui River has the highest runoff modulus in the province and is well known for rapid flood fluctuations, making it a key area for storm and flood analysis.

II. B. Data Sources

As shown in Figure 1, the data used in this study are primarily from the National Science Data Sharing Project — Earth System Science Data Sharing Platform. We also referenced land use type maps of Hunan Province from 1980, 2000, and 2010 (scale: 1:10,000,000; COVERAGE format ARC/INFO) and DEM data (scale: 1:2,500,000; grid size: 100 m × 100 m; GRID format).

Following the standard land use classification system [11] and adapting it to local conditions, the land use categories were divided into seven landscape types: paddy field, dry land, woodland, grassland, water, construction land, and unused land. In particular, paddy fields and dry land were separated from the general arable land category due to significant observed changes.

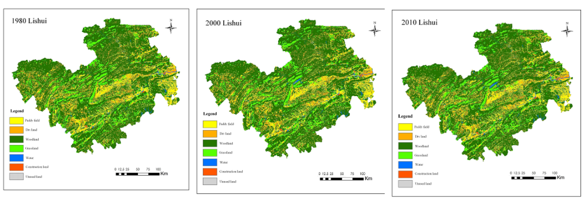

Figure 1: Distribution of the landscape components of the Lishui River watershed in 1980, 2000, and 2010.

II. C. Ecosystem Service Value Assessment

The concept of the *ecosystem* was first introduced by British ecologist Tansley in 1935, referring to a functional unit consisting of biological and abiotic components that interact and depend on each other through material cycling and energy flows [12], [13]. Ecosystems represent an integrated whole in which biological and non-biological elements are interdependent [14].

Ecosystem services can be quantified using various methods, such as the value assessment method, hedonic pricing method, energy analysis method, and replacement cost method, to reflect their ecological and economic importance [15].

The total value of ecosystem services in the Lishui River watershed was calculated as follows:

$$P = \sum V_i \times A_i$$

where P is the total value of ecosystem services (million RMB/year), V_i is the per-unit value of ecosystem services for land use type i (thousand RMB/(km^2·year)), and A_i is the area of land use type i (km^2).

The V_i values were derived from the equivalent factor table of ecosystem service values for China developed by Xie Gaodi et al. [16], adjusted by the natural food production value of farmland in the watershed.

Between 2001 and 2010, the Lishui River watershed had an average annual grain yield of 563,380 kg/km^{-2} [17]. Using a market price of 3.5 RMB/kg and considering that the natural ecosystem's contribution (without human input) accounts for one-seventh of the total farmland yield value, the natural food production value for farmland in the Lishui River watershed was calculated as 281,690 RMB/(km^2·year).

Based on these calculations, the per-unit ecological service values for different landscape types are shown in Table 1.

Table 1: Ecological service value per unit area of different landscape types in the Lishui River watershed (thousand RMB·km^{-2}·a^{-1}).

Landscape type	Value equivalent	Ecological service value
Paddy field	6.91	1946.48
Dry land	6.91	1946.48
Woodland	21.85	6154.93
Grassland	7.24	2039.44
Water	45.97	12949.29
Construction land	–	–
Unused land	0.42	118.31

III. Results and Analysis

III. A. Changes in Landscape Area and Mutual Transformation

Using ArcGIS 9.3, the 1980, 2000, and 2010 remote sensing interpretation maps were analyzed to calculate the area of each landscape type and the changes over time in the Lishui River watershed (Figure 2). As shown in Table 2, the largest changes occurred in woodland and dry land areas. Over the 30-year period, woodland area declined from 8,957 km^2 to 8,903 km^2, a decrease of 55 km^2, while dry land increased by 38 km^2.

Grassland, construction land, and water areas showed smaller changes. From 1980 to 2010, construction land and water increased by 21 km^2 and 19 km^2, respectively. These increases can be attributed to government initiatives aimed at protecting the Yangtze River's water environment, such as converting farmland to lakes and constructing water conservancy facilities, which expanded water areas in the watershed [19], [20].

Table 2: Area and changes in different landscape types of the Lishui River watershed (km^2).

Landscape Type	1980	2000	2010	1980–2000 Change	2000–2010 Change	1980–2010 Change
Paddy field	1642	1633	1635	-9	2	-7
Dry land	1453	1450	1492	-3	42	38
Woodland	8957	8956	8903	-2	-53	-55
Grassland	1277	1273	1261	-4	-12	-16
Construction land	128	140	149	12	9	21
Water	45	52	64	6	12	19
Unused land	0.15	0.15	0.20	0.00	0.05	0.05
Total	13503	13503	13503	0.00	0.00	0.00

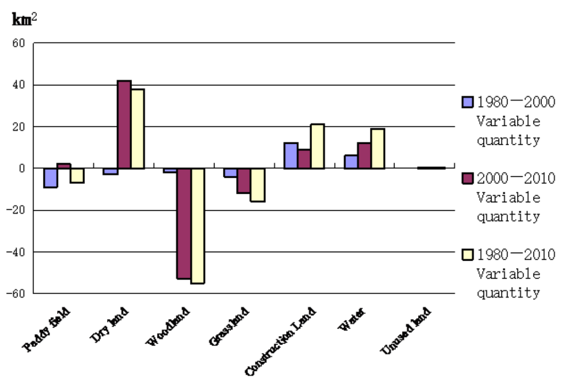

Figure 2: Net change in area of different landscape types in the Lishui River watershed (km^2).

III. B. Ecosystem Service Values

Based on the areas of each landscape type and their corresponding per-unit ecosystem service values, the total ecosystem service values for the Lishui River watershed were calculated for 1980, 2000, and 2010 (Table 3). The totals were 65.42, 65.53, and 65.38 billion RMB/year, respectively.

Between 1980 and 2000, the total value increased slightly by 0.17%. From 2000 to 2010, it decreased by 0.23%, resulting in an overall 0.06% decline over the 30 years. These results suggest that human activities have exerted a negative influence on the watershed's ecological systems.

Woodland contributed the highest proportion to total ecosystem service values—84.3%, 84.1%, and 83.8% in 1980, 2000, and 2010, respectively—although its absolute value decreased. Water areas and unused land showed the largest percentage increases in value over the 30 years, rising by 16.2% and 33.3%, respectively. Other land types experienced only minor changes, indicating relatively low human interference [23].

Table 3: Ecosystem service values of different landscape types in the Lishui River watershed (thousand RMB/year).

Landscape Type	1980	2000	2010	1980–2000		2000–2010		1980–2010	
				Change	%	Change	%	Change	%
Paddy field	3196097.2	3178092.3	3182569.2	-18004.9	-0.56	4476.9	0.14	-13528.0	-0.42
Dry land	2828738.5	2822334.6	2903308.0	-6403.9	-0.23	80973.5	2.87	74569.6	2.64
Woodland	55132200.2	55122906.2	54795771.9	-9293.9	-0.02	-327134.3	-0.59	-336428.3	-0.61
Grassland	2603951.4	2595304.2	2571034.9	-8647.2	-0.33	-24269.3	-0.94	-32916.5	-1.26
Water	1659321.9	1815749.3	1928149.2	156427.4	9.43	112399.8	6.19	268827.2	16.20
Unused land	17.7	17.7	23.7	0.0	0.00	5.9	33.33	5.9	33.33
Total	65420327.0	65534404.4	65380856.9	114077.4	0.17	-153547.5	-0.23	-39470.1	-0.06

IV. Harm to Biodiversity

Using 3S technology, we analyzed quantitative indices of the landscape spatial pattern in the Lishui River watershed. The total area of the watershed is approximately 1.35 million hm^2. In 2010, the total ecosystem service value was estimated at 65.38 billion RMB/year, with woodland contributing the largest share. The annual value of woodland ecosystem services reached 0.34 billion RMB/year. From 1980 to 2010, grassland ecosystem service value steadily declined, while water and unused land values increased—the most significant change being in water ecosystems, which grew by 16.2%.

Overall, the total ecosystem service value showed a downward trend over the 30-year period. From 1980 to 2000, ecosystem service function slightly increased, but between 2000 and 2010 it declined, with the rate of decline in the latter decade exceeding that of the previous two decades. This reflects a gradual intensification of human activity in the watershed, which poses increasing resource and environmental challenges [24], [25].

The decline in ecosystem service value is accompanied by degradation of the ecological environment, wild forests, and biological resources. Common threats include forest fires, over-harvesting of commercial timber, species poaching, and illegal trade. Collaborative research and effective utilization of biodiversity, ecosystem services, and biological resources remain limited and must be strengthened. Wetland ecosystems face shortened or disrupted food chains, threatening endemic and endangered species and creating conditions for possible extinction.

Reclamation of land from lakes and fisheries has significantly impacted aquatic biodiversity. Over recent decades, water conservancy projects, reclamation, and overfishing have reduced the number and area of lakes, increased endangered species counts, and shrunk rare fish habitats and spawning grounds. Fish populations have become smaller, aquatic vegetation has degraded, and water pollution has increased. Dam construction has fragmented continuous river ecosystems, obstructing breeding migrations and affecting fish reproduction.

Iconic plant species such as *Metasequoia glyptostroboides*, *Cathaya argyrophylla*, and *Davidia involucrata* have been affected. While flooding has not yet caused the extinction of most species, population sizes and genetic diversity are decreasing, accelerating the risk of extinction for certain species.

V. Biodiversity Conservation Strategies

a. **Strengthen policy support and legal management.** Enforce strict management measures to protect natural vegetation and biodiversity. Formulate region-specific policies and regulations for the conservation and sustainable use of biological resources. Maintain a biodiversity catalog, identify key biodiversity hotspots and species, and establish early warning and monitoring systems for threatened and economically significant species.

b. **Leverage eco-tourism for sustainable development.** The upper reaches of the Lishui River watershed are inhabited by Tujia, Bai, and Miao ethnic groups, with minority populations exceeding 50% in several counties (e.g., Sangzhi: 92.1%, Shimen: 51.3%, Cili: 49%). Economic development in the watershed lags behind other basins in Hunan Province [9]. Given the unique ecological and biodiversity resources, especially in Zhangjiajie City, eco-tourism can be developed to promote local economic growth, alleviate poverty, and encourage environmental stewardship. Expanding forest cover can also help absorb pollutants and maintain environmental quality.

c. **Protect key ecosystems and flagship species.** Areas with high biodiversity, such as Shimen County, Sangzhi County, and the Wuling Mountains, should receive targeted protection efforts. This includes investment in conservation, public awareness campaigns, and focused protection of flagship and endangered species.

VI. Conclusion

Among all landscape types, wetlands have the highest ecological service value (Table 1). The interaction of soil, water, plants, and animals in wetlands provides essential ecological functions [18], [19]. Where feasible, land of low ecological value (e.g., degraded grassland) should be restored or converted to high-value types (e.g., forests, wetlands) to rebalance the ecosystem and support both economic development and environmental protection.

Water bodies and woodlands represent the largest contributors to ecosystem service value in the watershed. Enhancing and protecting these resources is essential to reduce ecological damage, maintain ecosystem balance, and improve resilience against disasters such as floods and droughts. In urbanizing areas, particularly upstream, water-efficient crops should be planted, and natural precipitation should be effectively utilized to sustain downstream water supplies [8].

Sustained policy support, improved legal frameworks, and eco-tourism development—alongside the protection of key areas, ecosystems, and species—are crucial for safeguarding biodiversity in the Lishui River Basin [7], [20].

Data Availability

The experimental data supporting this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest regarding this work.

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References

[1] Zhang, Y., Min, Q., Bai, Y., & Li, X. (2018). Practices of cooperation for eco-environmental conservation (CEC) in China and theoretic framework of CEC: A new perspective. *Journal of Cleaner Production*, **179**, 515–526.
[2] Zhang, H., Wu, S., Yu, Y., & Lei, L. (2021). Effects of payments for watershed services policy on economic growth: A case study based on the synthetic control method. *Environment, Development and Sustainability*, **23**(2), 2739–2761.
[3] Li, J., Yin, H., Chang, J., Lu, C., & Zhou, H. (2009). Sedimentation effects of the Dongting Lake area. *Journal of Geographical Sciences*, **19**(3), 287–298.
[4] Yang, G., Dong, Z., Feng, S., Li, B., Sun, Y., & Chen, M. (2021). Early warning of water resource carrying status in Nanjing City based on coordinated development index. *Journal of Cleaner Production*, **284**, 124696.
[5] Wang, H., Zhu, Y., Zha, H., & Guo, W. (2021). Quantitative assessment of water level regime alterations during 1959–2016 caused by Three Gorges Reservoir in the Dongting Lake, China. *Water Supply*, **21**(3), 1188–1201.
[6] Zhang, M., Shi, L., Ma, X., Zhao, Y., & Gao, L. (2021). Study on comprehensive assessment of environmental impact of air pollution. *Sustainability*, **13**(2), 476.
[7] Jiang, Z., Kaji, K., & Ping, X. (2016). The tale of two deer: Management of Père David’s deer and sika deer in anthropogenic landscape of eastern Asia. *Animal Production Science*, **56**(6), 953–961.
[8] Zhao, Y., Yang, H., & Wei, F. (2010). Soil moisture retrieval with remote sensing images for debris flow forecast in humid regions. *Monitoring, Simulation, Prevention and Remediation of Dense and Debris Flows III*, **67**, 11189.
[9] Chen, M., Liu, C., He, X., Pei, E., Yuan, X., & Zhang, E. (2016). The efforts to re-establish the Chinese water deer population in Shanghai, China. *Animal Production Science*, **56**(6), 941–945.
[10] Nugent, G., McShea, W. J., Parkes, J., Woodley, S., Waithaka, J., Moro, J., & Smith-Flueck, J. M. (2011). Policies and management of overabundant deer (native or exotic) in protected areas. *Animal Production Science*, **51**(4), 384–389.
[11] Honda, T., Miyagawa, Y., Suzuki, Y., & Yamasaki, S. (2010). Possibility of agronomical techniques for reducing crop damage by sika deer. *Mammal Study*, **35**(2), 119–124.
[12] Ohashi, H., Yoshikawa, M., Oono, K., Tanaka, N., Hatase, Y., & Murakami, Y. (2014). The impact of sika deer on vegetation in Japan: Setting management priorities on a national scale. *Environmental Management*, **54**(3), 631–640.
[13] Takada, M., Suzuki, M., Ochiai, K., Asada, M., & Miyashita, T. (2010). Analysis of factors affecting rice-crop damage by sika deer in a landscape context and construction of a risk map in the Boso Peninsula, central Japan. *Japanese Journal of Conservation Ecology*, **15**(2), 203–210.
[14] Tsukada, H., Fukasawa, M., & Kosako, T. (2008). Is cattle grazing an effective deterrent against sika deer (*Cervus nippon*) intrusion into pastures? *Grassland Science*, **54**(1), 45–51.

[15] Takatsuki, S. (2009). Effects of sika deer on vegetation in Japan: A review. *Biological Conservation*, **142**(9), 1922–1929.

[16] Pérez-Espona, S., Pemberton, J. M., & Putman, R. (2009). Red and sika deer in the British Isles: Current management issues and management policy. *Mammalian Biology*, **74**(4), 247–262.

[17] Warren, R. J. (2011). Deer overabundance in the USA: Recent advances in population control. *Animal Production Science*, **51**(4), 259–266.

[18] Simon, M., & Din, S. M. (2025). Performance evaluation of self-organizing features in wireless sensor networks. *TK Techforum Journal (ThyssenKrupp Techforum)*, **2025**(1), 12–19.

[19] Kumar, J. A., Muthuvel, S., Pandian, R. S., Velmurugan, K., Di Bona, G., Kumar, S. B., Kumar, T. D., & Kumar, V. A. (2025). Curing of novel geopolymer brick using phase change material (paraffin wax) in passive solar dryer and comparison of properties with conventional geopolymer brick. *TK Techforum Journal (ThyssenKrupp Techforum)*, **2025**(1), 1–11.

[20] Tallat, R., & Chandra, N. (2024). Synthesis and fabrication of high-performance p-type silicon nanowire transistors. *TK Techforum Journal (ThyssenKrupp Techforum)*, **2024**(2), 32–39.

[21] Xu, Q., Zhang, M., & Lu, B. (2000). Study on the status of red deer population in Heilongjiang province. *Journal of Economic Animal*, **4**(1), 57–62.

[22] Sakata, H., Hamasaki, S., Kishimoto, M., Mitsuhashi, H., Mitsuhashi, A., Yokoyama, M., & Mitani, M. (2001). The relationships between sika deer density, hunting pressure and damage to agriculture in Hyogo Prefecture. *Humans and Nature*, **12**, 63–72.

[23] Uno, H., Ueno, M., Inatomi, Y., Osa, Y., Akashi, N., Unno, A., & Minamino, K. (2017). Estimation of population density for sika deer (*Cervus nippon*) using distance sampling in the forested habitats of Hokkaido, Japan. *Mammal Study*, **42**(1), 57–64.

[24] Ohashi, H., Kominami, Y., Higa, M., Koide, D., Nakao, K., Tsuyama, I., et al. (2016). Land abandonment and changes in snow cover period accelerate range expansions of sika deer. *Ecology and Evolution*, **6**(21), 7763–7775.

[25] Igota, H., & Suzuki, M. (2008). Community-based wildlife management: A case study of sika deer in Japan. *Human Dimensions of Wildlife*, **13**(6), 416–428.