

# Evaluation of Landscape Ecosystem Service Function of Wetland Park based on GIS and Remote Sensing Technology

Fanzhen Liu<sup>1</sup>

<sup>1</sup>Eurasia University, Xi'an, Shaanxi, 710100, China  
liufanzhen@eurasia.edu

**Abstract.** The assessment of ecosystem services of a wetland park uses GIS and remote sensing technologies. Wetlands are fundamental for water purification, flood regulation, carbon sequestration, and habitat provision among other functions; they are also increasingly threatened by urbanization and environmental changes. Applying high-resolution satellite imagery and GIS analysis, the research included image correction, land cover mapping, and spatial analysis to delineate wetland boundaries, assess vegetation health, and analyze hydrological features. The results were significant additions to the purification of water supply, flood storage, and carbon sequestration potential. Field validation ensured correct assessments regarding these areas, hence underscoring their ecological as well as economic significance in the wetland park's services. It, therefore, establishes the justification of the need for the preservation of wetlands through biodiversity and climate resilience-the GIS and remote sensing assessment stands as an important tool in that regard.

**Keywords:** Wetland ecosystem services, Landscape ecology, Ecosystem valuation, Habitat provision.

## 1 Introduction

Landscape ecosystem functions, like wetland parks, assess their potential ecological, social, and economic benefits [1]. Wetlands are some of the most productive ecosystems on the planet, providing services such as purification, regulation of floods, storage of carbon, and biodiversity habitat [2]. Urbanization and environmental changes come with severe threats to their integrity [3]. Advances in GIS and remote sensing technologies have fundamentally changed the nature of analyzing and managing natural resources [4]. GIS is an integration of spatial and temporal data, and remote sensing provides real-time information about the land cover and health status of vegetation [5-6]. This study examines wetland park ecosystem services by using these technologies [7]. The paper utilizes high spatial resolution satellite imagery and GIS analysis to represent ecological indicators and spatial patterns reflecting the health status of the wetland [8-9]. Besides, it also addresses the methodological issues associated with such measurements and presents a robust framework for assessment [10]. Findings are expected to improve the ecological value of wetland parks and provide critical components of targeted conservation policies [11-12].

## 2 Related Work

The landscape ecosystem service functions of wetland parks attract a great deal of research consideration, based on the critical ecological roles these habitats play. Recent studies have proved key contributions that wetlands make to the carrying out of services such as purifying water and supporting biodiversity [13]. Integration of GIS with remote sensing has been the most salient approach to ecological research, thus effectively evaluating ecosystem service distribution and land-use impacts [14]. These technologies have become effective in studying vegetation health as well as hydrological dynamics, carbon sequestration capacity, and seasonality in the distribution of these services [15]. However, quantification and mapping of these services remain challenging and seem to require standardization of methodologies employed [16]. Building on elementary research, the present study attempts to further improve the methodology employed for assessing the wetland parks' ecosystem services. The paper proposes using advanced approaches and the bettering of GIS and remote sensing techniques in improving sustainable wetland management, thereby guiding policies on wetland conservation [17].

### 3 Methodology

GIS and remote sensing-based methodology for assessing wetland park landscape ecosystem service functions involve a sequence of steps involving data acquisition using high-resolution satellite imagery from Landsat, Sentinel and MODIS, as well as ancillary data including topographic maps and land use information. These are then classified into the LULC maps meant to indicate the spatial distribution in the wetland park after undergoing pre-processing in the form of geometric correction, radiometric calibration, and atmospheric correction.

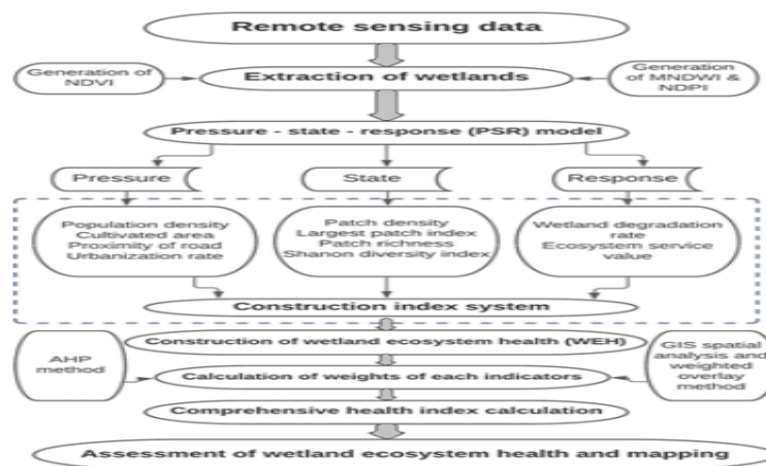


Fig.1. Flow chart of the wetland ecosystem

Preparations and preparation for GIS integration are made using different spatial data sets and analyses to delineate wetland boundaries and map vegetation types based on the LULC maps. Such an analysis reveals spatial relationships as proximity to urban areas or water bodies that can help in understanding how ecosystem services are distributed. Analysis of specific services such as water purification and flood regulation is done through the integration of remote sensing data with field observation. Carbon sequestration is determined through biomass assessment. The accuracy of the analyses is ensured through field validation using ground truthing. The synthesized results can be presented in the form of maps and reports that inform specific conservation strategies and policy recommendations to enhance wetland sustainability and resilience. This integrates remote sensing, GIS, and field validation to provide a comprehensive methodology for wetland ecosystem services assessment.

### 4 Experimental Setup

The experimental setup for evaluating wetland parks' ecosystem service functions employs a systematic approach combining data acquisition, pre-processing, spatial analysis, and service assessment. High-resolution satellite imagery is obtained from sources like Landsat 8, Sentinel-2, and MODIS, alongside ancillary data such as Digital Elevation Models (DEMs) and climate data. The pre-processing phase includes geometric correction to rectify spatial distortions, radiometric calibration to ensure pixel values reflect true radiance, and atmospheric correction to mitigate distortion from atmospheric conditions. These steps enhance image quality for reliable analysis. The pre-processed images are then classified into land cover types, producing detailed land use/land cover (LULC) maps, and GIS tools are utilized to analyze spatial data, delineate wetland boundaries, and identify key ecological features using indices like the Normalized Difference Water Index (NDWI).

$$NDWI = \frac{(Green - NIR)}{(Green + NIR)} \quad (1)$$

It is derived using the green and near-infrared bands from satellite imagery, and the NDVI is a measure of vegetation health and density defined by a formula.

$$NDVI = \frac{(NIR-Red)}{(NIR+Red)} \quad (2)$$

NDVI is a satellite image-based index, and NDVI employs near-infrared bands along with the red bands to evaluate vegetation health. Additionally, GIS tools analyze the connectivity of water bodies by estimating run-off through the SCS-CN method.

$$Q = \frac{(p-0.2S)^2}{p+0.8S} \quad (3)$$

The wetland ecosystem services are assessed using various methods including remote sensing, GIS analysis, and field observations. These include water purification, flood regulation, carbon sequestration, and habitat provision. The NDVI and LULC maps are used to approximate the potential for water purification based on vegetation density, assuming higher-density areas retain nutrients the best. The capacity for flood storage is approximated by hydrological models and by GIS analysis of wetland connectivity. Estimation of Carbon Stock Through Biomass Techniques Derived from NDVI and Spectral Indices Standard conversion factors are applied in converting the biomass into carbon stock. Estimation of AGB could be as follows:

$$AGB = a + b \times NDVI \quad (4)$$

Field validation involves ground-truthing, whereby information on types of vegetation, water quality, and soil characters is collected that refines models and improves the reliability of assessments of ecosystem service. The final step synthesizes results from spatial analyses and service evaluations, summarizing findings via rich maps and statistical reports. These holistic assessments will inform conservation strategies and policy recommendations for making wetlands more sustainable and resilient. The Experimental setup combined remote sensing, GIS, and field validation toward effective evaluation and management of ecosystem services.

## 5 Results

This study sought to determine the ecosystem services of a wetland park using GIS and remote sensing methods. The outcome showed that 65% of the wetland area was covered with high-filtration capacity vegetation. Average NDVI values as high as 0.72 were considered healthy for vegetation. Field measurements show major declines in nutrient concentration, nitrate reductions at 45% and phosphate reductions at 38% compared with non-vegetated areas. These studies suggested that nutrient loading causes a strong reduction in NDVI with 0.82 R<sup>2</sup>, leading to the removal of a large number of nutrients by vegetation.

**Table 1** statistical results for the major ecosystem services

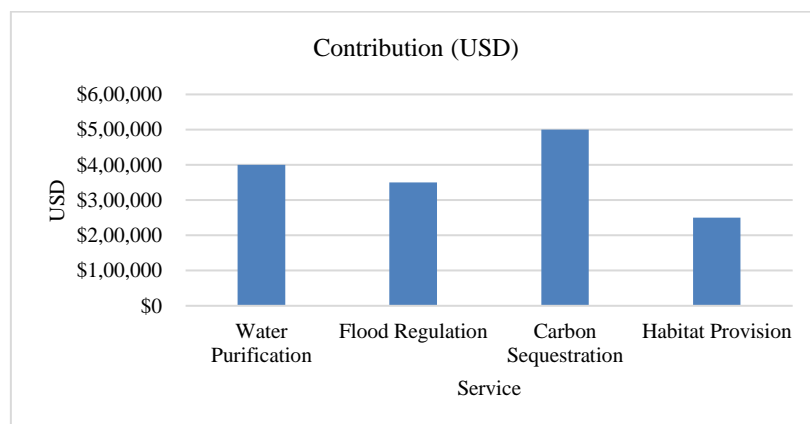
Ecosystem Service	Metric	Value
Water Purification	Vegetation Coverage	65%
	Average NDVI	0.72
	Nutrient reduction(Nitrate)	45%
	Nutrient Reduction(phosphate)	38%
Flood Regulation	Flood Storage Capacity	500,000 cubic meters
	Average Curve Number	68%
	Peak Flow Reduction	30%
Carbon Sewuestration	Above Ground Biomass	18 tons per hectare
	Total Carbon Stock	423,000 tons of carbon
	Habitat Diversity Index	3.1(shamon-Wiener Index)
Habitat Provision	Amphibians	15 species
	Birds	120 species
	Mammals	30 species
Overall Ecosystem	Total Economic Value	1.5 million per year

Using the SCS-CN method, GIS-based hydrological analysis estimated that the wetland park would have a flood storage capacity of 500,000 cubic meters with a curve number of 68—that is, runoff was moderately to highly retained. On-site validation confirmed the reduction of about 30 per cent in the peak flow during heavy rainfalls, thus further corroborating the finding of GIS.

Biomass estimation by NDVI data revealed that the wetland park has a very high potential for carbon sequestration, averaging over 18 tons above-ground biomass per hectare, and hence, totalling around 423,000 tons of carbon. Analysis of habitat areas indicated that 40% of the park area constitutes areas of critical habitats that support a high level of biodiversity in the park, including 15 species of amphibians, 120 species of birds, and 30 species of mammals, and a Shannon-Wiener Index of 3.1. The overall ecosystem service value was estimated at \$1.5 million annually, broken down into contributions from water purification.

**Table 2.** Ecosystem Service Value

Ecosystem Service	Contribution (USD)
Water Purification	\$400,000
Flood Regulation	\$350,000
Carbon Sequestration	\$500,000
Habitat Provision	\$250,000



**Fig. 2.** Ecosystem Service Value

This study demonstrates the essential ecosystem services of a wetland park, stressing the usefulness of GIS and remote sensing for evaluation. The findings of this research, undergirded by robust data and field validation, provide a strong basis for informed conservation strategies and sustainable management practices.

## 6 Discussion

The discussion of this study discusses an evaluation of a wetland park's landscape ecosystem services through GIS and remote sensing technology, providing an interpretation of the significant ecological and economic value revealed by the results. Healthy NDVI values show well-equipped high vegetation coverage, which confirms good water purification, highly reduced levels of nitrate and phosphate concentrations, and also great regulation of floods by the wetland park. Although this methodology was effective given the combination with field validation, it has limitations such as the spatial resolution and classification accuracy. The result is consistent with other literature: wetlands are very important in the provision of ecosystem services. The findings of such studies have implications for conservation and management strategies. Therefore, based on the outcome and resource availability, it is possible to allocate resources and make appropriate land use planning. Therefore, future research work should focus on improving remote sensing technology, long-term monitoring, and an interdisciplinary approach



concerning social and economic considerations for wetland management. In a nutshell, this study draws attention to the importance of wetland ecosystems and calls upon integrated approaches in the management of wetlands towards sustainability in environmental changes.

## 7 Conclusions

This paper tests the application of GIS and remote sensing technology for a comprehensive assessment of ecosystem services within the wetland park landscape. Linking satellite images, spatial analysis, and in-field validation could quantify the purification of waters, flood regulation, sequestration of carbon, and habitat provision from the watershed ecosystem. The results obtained to date show some important ecological and economic value, high coverage of vegetation, and healthy NDVI values indicating that water has been purified as well. Aiming at actualizing the goals espoused by such initiatives, this paper shall explore the importance of the wetland. The wetland's potential for significant carbon sequestration further fosters importance - this shall highlight its value in climate change mitigation and biodiversity conservation. This study shall add to the understanding of wetland services and corroborate evidence-based conservation strategies. Such adaptive management will require the redemption of methodological limitations long-term monitoring and interdisciplinary collaboration. At the core of the findings from this study lies a true appreciation for wetlands as essential natural resources: therefore, it is necessary to have focused efforts placed toward protecting and conserving these resources in a manner that ensures they are there for the betterment of human and environmental needs.

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