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Exploring Multi-Scenario Simulation of Ecosystem Service Value of Wetland in Yinchuan, China

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Abstract
Wetlands have an important function in supporting urban biodiversity, regulating climatic patterns, and enhancing resilience against natural disasters. Wetland conservation in rural parts of western China is a matter of concern due to the presence of water scarcity, fragile ecosystems, and insufficient resilience to natural disasters. The objective of this project is to examine existing strategies or methods for conserving wetlands, investigate the most effective approaches to wetland conservation, and improve a simulation model that may be used to highlight the importance of wetland ecosystem services. This study aims to provide a theoretical framework to support the wetland conservation strategy, catering to the needs of both participants and policymakers involved in the process.
Keywords: Wetland Conservation, Scenario Simulation, ESV

Introduction
Wetlands are widely acknowledged as very critical ecosystems at a worldwide level due to their essential contributions in supporting ecological service functions (Kovács et al., 2022). According to Xu et al (2023), they play a significant role in enhancing the overall value of ecosystem services, representing roughly 23% on a worldwide scale. Furthermore, these entities inhabit approximately 9% of terrestrial regions. Wetland ecosystems provide substantial social advantages, including regulatory activities such as flood control and water purification, as well as provisioning services like as habitat provision and nutrient accumulation (Zhang et al., 2021). There are several methodologies available for assessing the value of wetland ecosystem services, including functional value, equivalent factor, and energy theory. Among the various methodologies, value evaluation stands out for its high level of accessibility and widespread support among the general population. The worldwide ecosystem services are predicted to have an annual economic value of 33.3 trillion dollars, with wetland ecosystems playing a substantial role by contributing 4.9 trillion dollars. From

1700 to 2020, there has been a notable decline in the global extent of wetland areas, resulting in an overall loss of around 21% (with a confidence interval spanning from 16% to 23%). The reduction in wetland extent has predominantly transpired in geographical areas like Europe, the United States, and China. The conservation of the extant wetland ecosystems and the adoption of wetland restoration strategies are of utmost significance and necessitate prompt consideration.

According to Zhang et al (2013), the annual service values of ecosystems in China, specifically land ecosystems and wetland ecosystems, are estimated to be 5.6 trillion yuan and 2.7 trillion yuan, respectively. Additionally, the overall annual service value of ecosystems in China is calculated to be 7.8 trillion yuan. The wetland ecosystem located in the Yellow River Delta exhibits an estimated annual ecosystem services value ranging from 3.28 × 109 to 4.53 × 109, with regulating services being the predominant function (Zhang et al., 2021). According to Li et al. (2018), the wetlands located within the National Wetland Parks possess an ecosystem service value estimated at roughly US $28.2 million. Additionally, these wetlands exhibit an intermediate service value of $35,614.03 million, with the most crucial service being their ability to regulate the atmosphere and mitigate flood events through diversion and storage mechanisms. Nevertheless, it is noteworthy that the ecological service value of wetlands in China is primarily concentrated in the eastern region, constituting approximately 75% of the overall wetland area. In contrast, the western region exhibits a considerably lower proportion, accounting for merely 25% of the total wetland coverage (An et al., 2007; Nasreen et al., 2020). Yinchuan, a prominent provincial capital city in the western region, has consistently faced many issues about water resources, the preservation of wetland ecological equilibrium, and the mitigation of climate change (Tian et al., 2021).

The conservation and judicious utilisation of wetlands have garnered growing global attention due to their provision of many ecosystem services. China possesses a considerable abundance of wetland ecosystems, which have gained recognition as prominent areas of high ecological variety (An et al., 2020). China has undergone a significant decline in wetland areas due to the rapid processes of urbanisation, population expansion, and industrial development (Liu et al., 2021). Ying et al (2021) identified several noteworthy perils and obstacles that pose a considerable risk to wetlands, including the degradation of their habitats, the decline in biodiversity, and deficiencies in their preservation and management. Nevertheless, the spatial distribution of wetlands in China exhibits significant disparities, as approximately 75% of the nation's wetland resources are concentrated in the southeastern region, while the remaining 25% are found in the northwest (Lu et al., 1996; Bian et al., 2020). The Yinchuan Wetlands play a crucial role as a migration route and breeding habitat for avian species in western China and East Asia-Australasia. These wetlands are notable for their exceptional characteristics, including a high density of wetlands, a wide distribution range, and a substantial number of wetland areas. These features are particularly uncommon in the arid regions of western China. Based on the already accessible data, the Yinchuan Lake wetland ecosystem is estimated to yield an annual value of 1.303 billion yuan in terms of services rendered.

The wetlands in Yinchuan are confronted with the challenges posed by climate change and the potential threats associated with the reduction of wetland areas as a result of human activities. Wetlands are subject to the impacts of soil salinization, the reduction in size of lake wetlands, and the salinization of groundwater. Surface water resources are characterised by a reasonably high abundance, however, the presence of permanent water bodies is limited in terms of proportion. The replenishment of water supplies mostly depends on precipitation and the Yellow River, leading to variable water coverage. The difficulties at hand are greatly influenced by the processes of overdevelopment and land degradation (Wang et al., 2019). According to Zhong et al (2019), the Yinchuan wetland water bodies exhibit a significant elevation in the levels of polycyclic aromatic hydrocarbons, which consequently give rise to potential ecological hazards. The occurrence of extreme weather events, such as floods and droughts, has witnessed an escalation due to the impact of global climate change. Simultaneously, the capacity to endure and mitigate the effects of natural catastrophes has experienced a decline. The functionality and advantages of wetland ecosystems are experiencing a decline. The wetlands in Yinchuan have several issues related to land utilisation, water contamination, and ecological deterioration (Li et al., 2018; Mi et al., 2020). These challenges will result in ecological problems, impacting the quality of water resources, biodiversity, and ecological degradation. Wetland protection regulations have been instituted in the region of Ningxia inside China; yet, the issue of wetland degradation persists as a significant concern. The recognition of the significance of ecosystem services in tackling wetland management and policy concerns is acknowledged by the Chinese government. Chinese scientists have undertaken experimentation with many methodologies to enhance the field of ecosystem services for wetland conservation. However, it is important to acknowledge that substantial obstacles persist in this endeavor. A recommended framework has been developed to enhance wetland policy in China by monitoring and assessing the value of ecosystem services provided by wetlands. The mitigation of water body degradation in the wetlands of Yinchuan has been effectively restrained. Nevertheless, the occurrence of wetland ecological concerns and the decline of natural wetlands persist as a result of climate effects and insufficient strategic responses. Currently, Yinchuan is confronted with the following challenges

i. Water resources shortage. The water supply of the Yinchuan Wetland mainly depends on the Yellow River, whereby the water resources are scarce, the proportion of permanent water bodies is small, and the water coverage area fluctuates violently.
ii. Fragile ecosystem. Affected by natural conditions and human activities, the water production ecological services' natural supply and regulation capacity is weak.
iii. Low ability to resist natural disasters. Climate change stresses wetland ecosystems, with increased extreme weather events such as droughts, floods, heavy rainfall, and lower resilience to natural disasters.

Thus, it is imperative to conduct simulations of various scenarios to assess the possible effects of future land use changes on wetland ecosystems. Additionally, it is crucial to examine the ecological value of wetlands in terms of the services they provide. This analysis should aim to identify critical points and sensitive areas that may be particularly vulnerable to these land use changes. Ultimately, the findings of such research should inform the development of scientifically grounded policies for the conservation of wetland ecosystems in the future.

Literature Review

The literature reviews have been conducted based on the sub-themes that were included in the main research question construct. The sub-themes of the research question construct will be presented in Table 1.

Table 1.0
Sub Themes of the RQ Construct

RQ CONSTRUCT	Research Question	Research Objective
Wetland	Sub RQ1:What are the current strategies or app roaches for wetland conservation?	Sub RO1:To review current wetland conservation strategies or approaches.
Ecosystem Service Value(ESV)	Sub RQ2:What is the most effective conservatio n method for wetland conservation currently av ailable?	Sub RO2:To determine the most effective methods for current wetland conservation.
Scenario Simulation s Integrating ESV	SubRQ3:How Scenario Simulations Integrating E cological Service Values Can Promote Wetland Conservation?	Sub RO3:To prove and detail Scenario Simulations Integrating ESV to promote wetland conservation.
scientific strategy f or wetland conserv ation	Sub RQ4:How to formulate the best scientific strategies for wetland conservati on?	Sub RO4:To formulate the best scientific strategy for wetland conservation.

Overview of Wetland

According to Byamukama et al (2019), wetland habitats are widely recognized as the most varied and productive ecosystems on Earth. Wetlands, as per the definitions provided by Virginia (1986); Meng et al (2017), encompass both permanent and seasonal waterlogged areas characterized by the absence of trees and the presence of open herbaceous plants. This classification includes several types of wetlands such as marshes, lakes, rivers, floodplains, estuary deltas, ponds, rice paddies, and marine waters up to a depth of 6 meters during low tide. Wetlands play a crucial role in providing various services to creatures, encompassing water conservation, food provision, cultural significance, biodiversity hotspots, and pollution mitigation. Specifically, wetlands serve a vital role in the prevention of floods, filtering of water, and provision of habitat for many plant and animal species.

Nevertheless, the wetlands are currently confronting the imminent threat of degradation as a result of urbanisation, alterations in land use patterns, the impacts of climate change, and pollution. Among these factors, the modification of land use cover stands out as a primary contributor to the pollution and decrease observed in wetland ecosystems. Wetland conservation strategies encompass a range of approaches and methodologies. An effective method involves the formulation of regional restoration strategies that employ a prioritization framework, taking into account previous losses, future projections, and available management alternatives. As exemplified by Lu (2019), the implementation of restoration measures that consider historical losses, future forecasts, and management alternatives facilitates the formulation of strategies for wetland area restoration. Furthermore, the achievement of sustainable preservation of wetland ecosystems necessitates the identification of fundamental concerns, the undertaking of comprehensive research, and the execution of conservation and development tactics. The utilisation of remote sensing techniques for the monitoring of vegetation cover has been recognized as a valuable approach in wetland conservation endeavors (Robert et al., 2018). Figure 1 will show the Wetland Conservation Events in China.

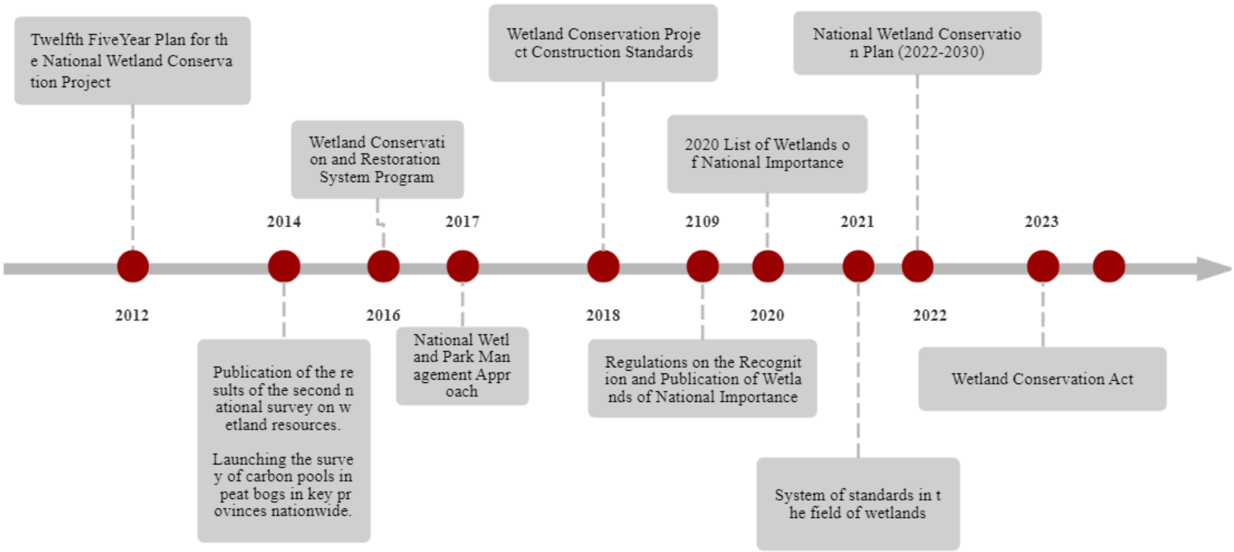

Figure 1.0: Wetland Conservation Events in China

Ecosystem Service Value（ESV）
Wetlands have a crucial role in providing a range of ecosystem services, encompassing provisioning, regulating, habitat, and cultural services. According to Srikanta et al. (2019), these services have a significant role in enhancing human well-being, promoting biodiversity, and contributing to the general sustainability of the planet. Nevertheless, wetlands are confronted with substantial challenges, as approximately 50% of wetland areas worldwide have been lost, and the remaining wetlands are experiencing a decline (Dolf et al., 2018). The assessment of the significance of wetland ecosystem services holds great importance in providing information for decision-making processes and conservation initiatives. Numerous studies have evaluated the ecological benefits provided by wetlands through the utilisation of diverse methodologies and variables. Li et al (2018) conducted an assessment of the value of wetland ecosystem services in the Yellow River Delta, taking into account several factors such as hydrology, meteorology, society, economy, resources, environment, and culture. Tang (2019) conducted a study that employed emergy theory to evaluate the service values of the Liaohe estuary wetland ecosystem. The findings emphasized the significance of its role in controlling the atmosphere and mitigating flood events through diversion and storage mechanisms.

Furthermore, the study utilized a dynamic integrated methodology to evaluate the monetary worth of the wetland ecosystem services in the Nanjing Jiangbei New Area. The findings revealed a deterioration in ecological conditions, highlighting the imperative for sustainable utilisation and conservation efforts (Edward, 2019). Hence, the assessment of the value of wetland ecosystem services enables the quantification of the diverse ecological benefits offered by wetlands. This process furnishes policymakers and conservation practitioners with the necessary quantitative data to facilitate evidence-based decision-making and scientific advancements in the realm of environmental preservation. The Value of Ecosystem Services Provided by Wetlands The relevant studies will be depicted in Figure 2.

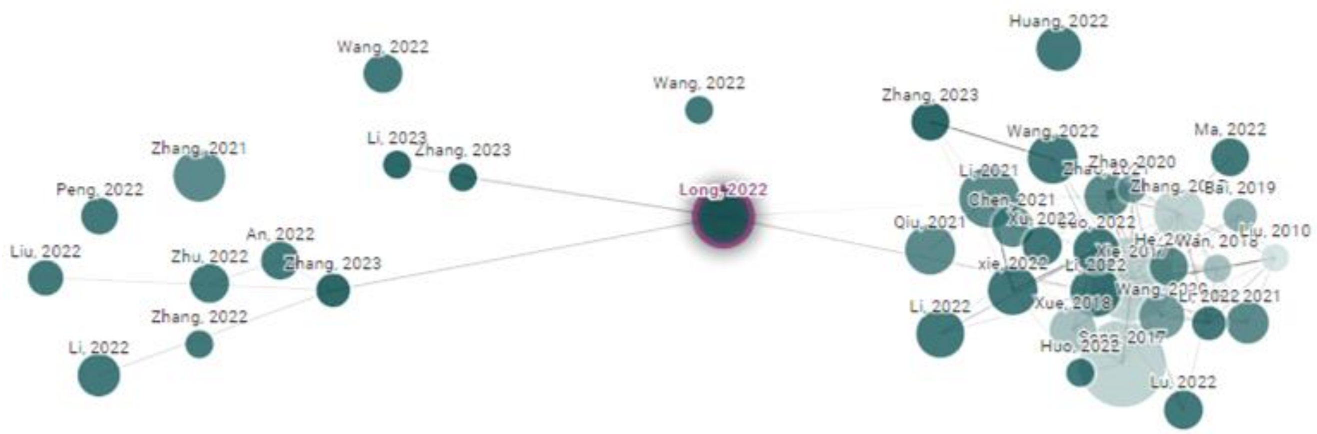

Figure 2.0: Wetland Ecosystem Service Value Related studies

Scenario Simulation of ESV

The utilisation of scenario simulation model was employed to evaluate the ramifications of urban expansion on wetland habitats and the ecological services they provide. According to Stoeckl et al (2021), the research indicates that the expansion of urban areas has a detrimental impact on the patterns of wetland landscapes and the provision of ecosystem services. These services encompass water conservation, habitat quality, and water quality purification. The present study aims to conduct a scenario simulation of the Earth System Model Version (ESV) to investigate its performance and evaluate its suitability for predicting future climate changes. The ESV is a comprehensive model that The relevant studies will be included in Table 2.

Table 2.0
Scenario Simulation of ESV Related studies

Title	First Author	Year	Cations
Urban land use change simulation and spatial responses of ecosystem service value under multiple scenarios: A case study of Wuhan, China Xuesong Zhang	Xuesong Zhang	2022	13
Simulation of future land use/cover change (LUCC) in typical watersheds of arid regions under multiple scenarios.	Qingzheng Wang	2023	4
Response of Ecosystem Service Value to Landscape Pattern Changes under Low-Carbon Scenario: A Case Study of Fujian Coastal Areas.	Guo Cai	2022	2
Patterns and controls of ecosystem service values under different land-use change scenarios in a mining-dominated basin of northern China.	Yingqing Su	2023	2
Coupling an Ecological Network with Multi-Scenario Land Use Simulation: An Ecological Spatial Constraint Approach.	Wenbin Nie	2022	2
Combining LSTM and PLUS Models to Predict Future Urban Land Use and Land Cover Change: A Case in Dongying City, China.	Xin Zhao	2023	1
Soil Water Erosion and Its Hydrodynamic Characteristics in Degraded Bald Patches of Alpine Meadows in the Yellow River Source Area, Western China.	Shengchun Tong	2023	0
Dynamic Evolution and Scenario Simulation of Ecosystem Services under the Impact of Land-Use Change in an Arid Inland River Basin in Xinjiang, China.	Zulipiya Kulaixi	2023	0
Multi-scenario simulation analysis of cultivated land based on PLUS model—a Haikou, China case study.	Xiaofu Lin	2023	0

However, it is possible to alleviate the adverse consequences by imposing limitations on urban growth inside wetland areas and adopting efficient strategies to conserve wetlands in regions experiencing fast urbanisation (David, 2020). A separate investigation was conducted to determine the most advantageous positioning of rehabilitated wetlands to optimize specific ecosystem functions. The research employed a combination of multi-criteria analysis and scenario testing methodologies to ascertain appropriate locations for wetland rebuilding. This determination was made by considering many variables, including but not limited to recreational potential, biodiversity, nitrogen mitigation potential, land rent, and flash-flood danger. According to Huang et al (2019), the findings of the study indicate that the existing restored wetlands were not located in catchments characterized by high biodiversity or low land rent. This suggests that a more systematic approach is required to optimize the benefits derived from ecosystem services. Hence, the utilisation of scenario simulation in assessing the value of wetland ecosystem services can facilitate a comprehensive comprehension of the repercussions of urban growth on wetlands, thereby furnishing a scholarly foundation for their conservation and administration. Through the implementation of suitable policies and initiatives aimed at constraining the expansion of urban areas into wetland regions, as well as facilitating the restoration and rejuvenation of wetlands, it is possible to effectively alleviate adverse consequences and optimize the potential benefits derived from the ecosystem services offered by wetlands.

Scenario Simulation of ESV for Wetland Conservation

Numerous research have been conducted with a primary emphasis on wetland conservation and management. According to John et al (2008), the investigation revealed notable disparities between the present hydrological state of the wetland and its original conditions. Specifically, the observed patterns of surface-water movement deviated considerably from the simulated unaltered conditions. In a study conducted by Ma (2012), a dynamic simulation modeling approach was employed to examine the optimal equilibrium between economic development and wetland conservation in Tianjin, China. The researchers recommended three sustainable policies for the sensible utilization and protection of wetlands: population control, advancement of wetland restoration technology, and modification of industry structure. In his study, James (2004) devised a Decision Support System (DSS) that effectively merged Expert Systems (ES) with a hydrologic model. The purpose of this system was to formulate a wetlands enhancement plan specifically aimed at controlling the export of atrazine. The simulation conducted showed a notable decrease of 46% in the export of atrazine when considering the suggested expansion of marsh acreage. The simulations demonstrated that the implementation of wetlands and water and sediment control basins (WASCOBs) can effectively mitigate flood peaks within watersheds. In the study conducted by Lee (2002), a dynamic simulation model known as WETLAND was established to optimize the control of non-point source pollution in artificial wetlands. The calibration and validation of the model were conducted using data obtained from a wetland located in Kentucky. Subsequently, the model was employed to facilitate the design of a hypothetical man-made wetland situated in Virginia.

In contemporary times, the protection and management of wetlands have been facilitated via the utilisation of diverse models and methodologies for simulation and analysis. The InVEST model, as described by Leila et al (2020), offers a means of quantifying and forecasting the provision of water and the quality of habitat in wetland ecosystems. Previous research conducted by Douglas et al (2018) has demonstrated that implementing conservation measures targeted at waterfowl, such as water level manipulation and cow exclusion, can have positive outcomes for various other wildlife species. The use of conservation practices, such as the utilisation of nutrient removal wetlands and water and sediment control basins (WASCOBs), has the potential to effectively retain water, reduce nutrient loads, and alleviate flooding within watersheds. The utilisation of machine learning methodologies, in conjunction with forthcoming NISAR data, presents a promising approach for the effective categorization and cartographic representation of wetland classifications (Sarina et al., 2021). The comprehension of temporal patterns and accessibility of water within wetland ecosystems has significant importance in the context of conservation planning, particularly about the migratory seasons of avian species reliant on aquatic habitats (Sarina et al., 2021). The synchronization of wetland flooding with species migration has the potential to enhance conservation methods and optimize efficiency. Hence, the utilisation of scenario modelling in researching the worth of wetland services has yielded significant backing for the preservation of wetlands. The utilisation of modeling and analysis tools enhances the scientific rigor, precision, and sustainability of wetland conservation decisions, hence facilitating the attainment of robust and sustainable development of wetland ecosystems.

Conceptual Framework

The conceptual framework encompasses a series of phases that involve predicting the capacity of ecological services under various scenarios, conducting land use analysis, optimizing strategies for wetland ecological protection, and validating the optimal contribution of wetland ecological service value. The placement of the Conceptual Framework will be depicted in Figure 3.

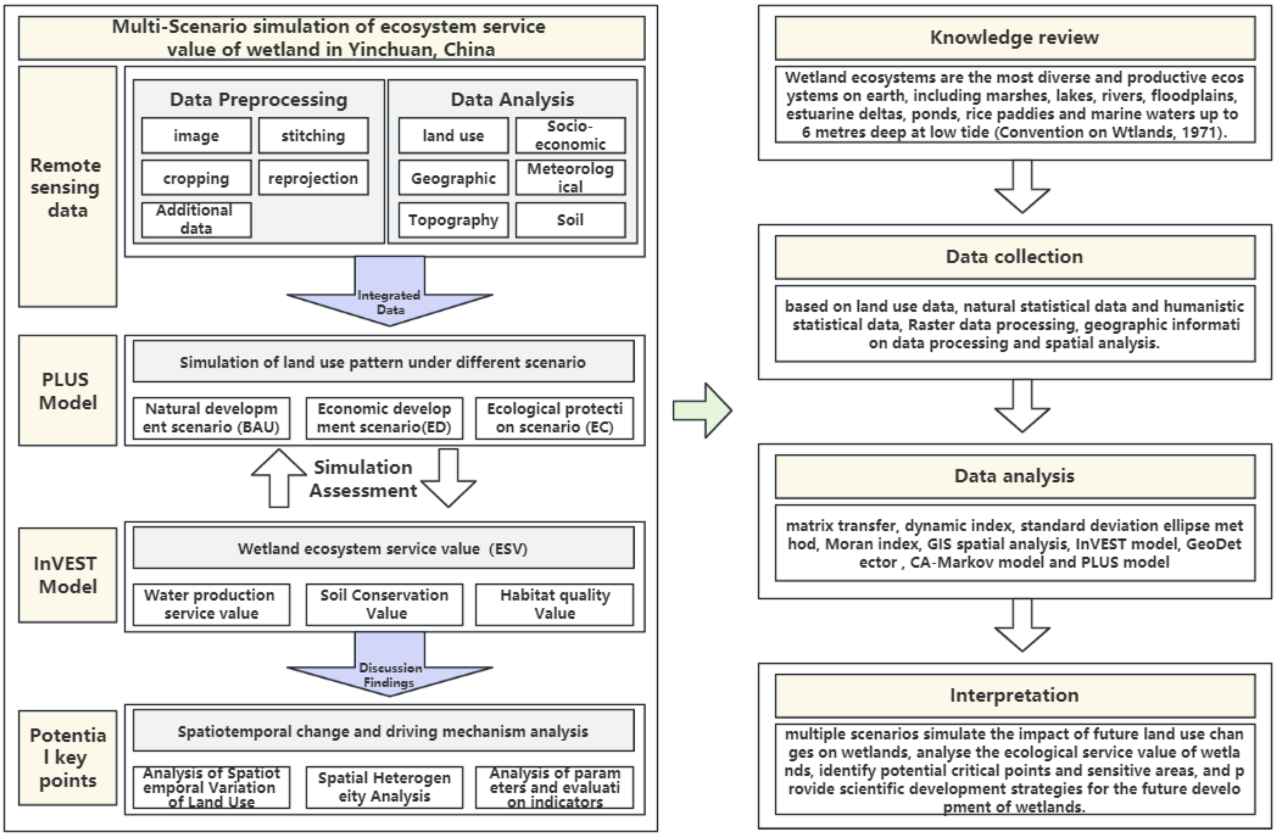

Figure 3.0: Conceptual Framework

Based on prior research, the present investigation necessitates a sequential process comprising four stages: literature review, data acquisition, analysis, and interpretation. The initial phase of this study involves doing a comprehensive literature analysis to explore the contextual background and rationale for identifying the research gap. Subsequently, the study will formulate the research question and establish the research objective. The data utilized in this study were obtained from many sources, including the China Yearbook, Ningxia Yearbook, Yinchuan Yearbook, geographic information, and remote sensing data. In addition, this study incorporates statistical analysis techniques, including Microsoft Access to quantify raw data collected over multiple years. Envi tools are utilized for the manipulation of remote sensing data, including splicing, cropping, and coordinating corrections. Furthermore, GIS and other specialized statistical tools are employed for spatial analytic purposes. The subsequent examination pertains to the analysis results' map and report interpretation, with a focus on discussing the advantages, problems in application, and potential enhancements of scenario-based wetland ecosystem service values. Conclusions are the outcomes derived from the research objectives. This study has the potential to serve as a focal point for future discussions and the establishment of priorities. The study has several limitations that should be acknowledged. Firstly, it primarily focuses on wetland conservation within landscaped gardens. Secondly, it specifically examines urban wetland conservation, thus limiting the generalizability of the findings to other contexts. Lastly, the study does not extensively explore strategic considerations about the experiences of landscape practitioners.

This study encompasses the utilisation of multiple sources of data. The content encompasses the processes of acquiring, selecting, and harmonizing data from multiple sources. The necessary data for the research are shown in Table 1. The use of ArcGIS for spatial data processing, spatial analysis, and mapping is employed. Additionally, the concepts underlying the PLUS and InVEST models are considered. The extraction of parameters, as well as the operation and analysis of the model findings, are also conducted. The study comprises the following steps:

i. Future land use projections under multiple scenario models based on historical land use data.
ii. Using the InVEST model to quantify and evaluate ecosystem quantification and evaluation of system service functions.
iii. Spatial data and temporal change prediction and analysis.
iv. Attribution analysis of spatial heterogeneity of ecosystem services

Conclusion

In conclusion, the main objective of this study is to determine the most efficient approach for evaluating the effects of urban land use change on the values of wetland ecosystem services. Additionally, this research seeks to investigate the potential trade-offs and synergies in ecosystem service values that may arise from different land use scenarios in the future. The findings of the study indicate that the process of urbanisation in Yinchuan has resulted in significant alterations to the land use patterns, hence exerting an impact on the structural and functional aspects of the wetland environment. In the context of future land use planning, it has been observed that the modeling of ecosystem service values for future wetlands across various scenarios can serve as a viable approach for the conservation of wetland areas.

This study has discovered three significant deficiencies in the current body of research and literature. Firstly, the existing body of research exhibits a noticeable inadequacy in research techniques, since past studies predominantly rely on qualitative arguments and lack a problem-oriented awareness. To effectively address this matter, the present study employs a more rigorous and quantitative methodology to bolster the strength and reliability of its conclusions. Furthermore, the present study has identified a notable empirical deficiency within the existing body of literature. Prior investigations predominantly concentrated on wetland functions, management, and governance, although were lacking in substantive research findings. This work aims to address the aforementioned research vacuum by presenting empirical findings that demonstrate the substantial impact of fast urbanisation on land use patterns, leading to considerable modifications in the structure and functioning of wetland ecosystems. Through the establishment of this empirical foundation, the study provides useful insights for both policymakers and stakeholders. Furthermore, previous studies primarily focused on wetlands in southeast China when discussing the concept of "multi-scenario simulation," resulting in a lack of research on remote western regions. Acknowledging the significance of this methodology, the present study expands its application to Yinchuan, a geographical area situated in the western part of China, to address this existing vacuum in knowledge. The utilisation of multi-scenario simulation techniques boosts the pertinence and practicality of the study's prognostications for the particular geographic area under investigation.

The findings of the study underscore the considerable influence of fast urbanisation on alterations in land use, resulting in notable transformations in the structure and functioning of wetland ecosystems. As a result, these modifications have an impact on the delivery of essential ecosystem services. The study underscores the significance of integrating the benefits associated with wetland ecosystem services into forthcoming urban land planning scenarios, in order to effectively pursue sustainable development.

However, it is important to note that the study does recognise a number of limitations that need to be addressed to enhance the reliability and validity of future research. The limitations encompass several aspects such as data reliability, assumptions made by the model, regional variations, elements that were not taken into account, uncertainty associated with future projections, and the intricacy arising from the use of multiple models. In order to address these problems, it is recommended that future research exert increased vigilance during the process of data collecting and model creation, with a particular focus on verifying the completeness and correctness of the data. Furthermore, the integration of several components and the examination of streamlined and efficient models can contribute to the reduction of complexity in the study, hence augmenting its dependability.

In its entirety, this study provides significant contributions to our understanding of the intricate connections between land use patterns and the provision of ecological services by wetlands. Nevertheless, it is crucial to acknowledge and confront the aforementioned constraints. To enhance the advancement of sustainable development, it is imperative that future research places emphasis on enhancing the quality of data and the accuracy of modelling. Additionally, researchers should take into account integrative aspects to generate research outputs that are more comprehensive and reliable. In addition, the incorporation of wetland ecosystem service value evaluation into urban land planning will offer decision-makers significant guidance in developing effective policies that promote the harmonious advancement of ecological preservation and urban expansion in Yinchuan.

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References

Kovacs, G. M., Horion, S., & Fensholt, R. (2022). Characterizing ecosystem change in wetlands using dense earth observation time series. *Remote Sensing of Environment*, 281, 113267. https://doi.org/10.1016/j.rse.2022.113267

Xu, Y., Xie, Y., Wu, X., Xie, Y., Zhang, T., Zou, Z., Zhang, R., & Zhang, Z. (2023). Evaluating temporal-spatial variations of wetland ecosystem service value in China during 1990–2020 from the donor side based on cosmic exergy. *Journal of Cleaner Production*, 414, 137485. https://doi.org/10.1016/j.jclepro.2023.137485

Zhang, X., He, S., & Yang, Y.(2021). Evaluation of wetland ecosystem services value of the Yellow River Delta. *Environmental Monitoring and Assessment*, 193, 353. https://doi.org/10.1007/S10661-021-09130-X

Zhang, R., Zhang, X., Yang, J., & Yuan, H. (2013). Wetland ecosystem stability evaluation by using Analytical Hierarchy Process (AHP) approach in Yinchuan Plain, China. *Mathematical and Computer Modelling*, 57(3–4), 366–374. https://doi.org/10.1016/j.mcm.2012.06.014

Li, L., Su, F., Mark, T., Brown., Liu, H., & Wang, T. (2018). Assessment of Ecosystem Service Value of the Liaohe Estuarine Wetland. *Applied Sciences*, 8(12), 2561-. https://doi.org/10.3390/APP8122561

An, S., Li, H., Guan, B., Zhou, C., Wang, Z., Deng, Z., Zhi, Y., Liu, Y., Xu, C., Fang, S., Jiang, J., & Li, H. (2007). China's Natural Wetlands: Past Problems, Current Status, and Future Challenges. *AMBIO: A Journal of the Human Environment*, 36(4), 335–342. https://doi.org/10.1579/0044-7447(2007)36[335:CNWPPC]2.0.CO;2

Nasreen, J., Wen, Y., Lu, X., Hai, L., & S, An. (2020). Ecosystem threats and management strategies for wetlands in China. *Marine and Freshwater Research*, 71(12), 1557-1563. https://doi.org/10.1071/MF19366

Tian, D., Dang, L., DING, R., Cai, Q., Zhang, P., Wang, L., & Yang, H. (2019). Distribution, Sources, and Ecological Risk Assessment of Polycyclic Aromatic Hydrocarbons in the Surface Waters of the Yinchuan. *Wetlands*. 40(7), 3068-3077. https://doi.org/10.13227/J.HJKX.201812096

An, S., C., & Max, F. (2020). Further wetland research in China. *Marine and Freshwater Research*, 71(12) https://doi.org/10.1071/MFV71N12_ED1

Liu, Y., Jin, R., & Zhu, W. (2021). Conversion of Natural Wetland to Farmland in the Tumen River Basin: Human and Environmental Factors. *Remote Sensing,* 13(17), 3498-. https://doi.org/10.3390/RS13173498

Ying, Y., Lyle, D., Vorsatz., Christelle., & Stefano, C. (2021). Landward zones of mangroves are sinks for both land and water borne anthropogenic debris. *Science of The Total Environment*, 151809-. https://doi.org/10.1016/J.SCITOTENV.2021.151809

Lu, X., Liu, H., & Hu, J. (1996). Wetland resource protection and rational utilization in China. *Chinese Geographical Science,* 6(4), 313-320. https://doi.org/10.1007/S11769-996-0052-Z

Bian, H., Li, W., Li , Y., Ren, B., Niu, Y., & Zeng, Z. (2020). Driving forces of changes in China's wetland area from the first (1999–2001) to second (2009–2011) National Inventory of Wetland Resources. *Global Ecology and Conservation*, 21. https://doi.org/10.1016/J.GECCO.2019.E00867

Wang, Y., Zhang, W., & Wang, W. (2019). Practical exploration of " Internet+ healthcare" in Yinchuan City. *Chinese Journal of Hospital Administration*, 35(8), 623-626. https://doi.org/10.3760/CMA.J.ISSN.1000-6672.2019.08.003

Zhong, C.H., Yang, Q., Ma, H., Bian, J., Zhang, S., & Lu, X. (2019). Application of environmental isotopes to identify recharge source, age, and renewability of phreatic water in Yinchuan Basin. *Hydrological Processes*, 33(16), 2166-2173. https://doi.org/10.1002/HYP.13468

Li, B., & Wang, W. (2018). Trade-offs and synergies in ecosystem services for the Yinchuan Basin in China. *Ecological Indicators*, 84, 837-846. https://doi.org/10.1016/J.ECOLIND.2017.10.001

Mi, L., Tian, J., Si, J., Chen, Y., Li, Y., & Wang, X. (2020). Evolution of Groundwater in Yinchuan Oasis at the Upper Reaches of the Yellow River after Water-Saving Transformation and Its Driving Factors. *International Journal of Environmental Research and Public Health*, 17(4), 1304. https://doi.org/10.3390/IJERPH17041304

Byamukama, W., Salihu, A, K., & Ommega, I. (2019). Sustainable Management and Conservation of Wetland Resources in Uganda: A Review. *Resources, Conservation and Recycling*, 5(1), 47-51. https://doi.org/ 10.15436/2378-6841.19.2479

Virginia, C. (1986). An overview of the hydrologic concerns related to wetlands in the United States. *Botany*, 64(2), 364-374. https://doi.org/10.1139/B86-053

Guo, M., Li, J., Sheng, C., Xu, J., & Wu, Li. (2017). A Review of Wetland Remote Sensing. *Sensors*, 17(4), 777-. https://doi.org/10.3390/S17040777

Arya, S. R., Elizabeth, & K, S. (2018). Wetlands: The living waters-A review. *Agricultural Reviews*, 39(2), 122-129. https://doi.org/10.18805/AG.R-1717

Gregg, A., Alan, T., Herlihy., & Philip, R, K. (2019). Quantifying the extent of human disturbance activities and anthropogenic stressors in wetlands across the conterminous United States: results from the National Wetland Condition Assessment. *Environmental Monitoring and Assessment,* 191(1), 324-324. https://doi.org/10.1007/S10661-019-7314-6

Lu, X. (2019). Application of environmental isotopes to identify recharge source, age, and renewability of phreatic water in Yinchuan Basin. *Hydrological Processes,* 33(16), 2166-2173. https://doi.org/10.1002/HYP.13468

Robert, C., Rudolph, d, G., Paul, C., Paul, C., Sutton., Sander, v, d, P., Sharolyn, A., Ida, K., Stephen, F., & K, T. (2014). Changes in the global value of ecosystem services. *Global Environmental Change-human and Policy Dimensions*, 26(26), 152-158. https://doi.org/10.1016/J.GLOENVCHA.2014.04.002

Srikanta, S., Suman, C., Pawan, K, J., Saskia, K., Saskia, K., Somnath, S., Saikat, K, P., Urs, P., Kreuter., Paul, C., Sutton., Shouvik, J., Kinh, B, D., & Kinh, B, D. (2019). Ecosystem Service Value assessment of a natural reserve region for strengthening protection and conservation. *Journal of Environmental Management*, 244, 208-227. https://doi.org/10.1016/J.JENVMAN.2019.04.095

Dolf, D. G., Luke, B., C., Max, F. C., & Max, F. (2018). Wetland ecosystem services. *The Wetland Book,* 323-333. https://doi.org/10.1007/978-90-481-9659-3_66

Tang, S. (2019). Valuation of wetland ecosystem services in rapidly urbanizing region: a case study of the Nanjing Jiangbei new area, china. *Applied Ecology and Environmental Research*, 17(5). https://doi.org/10.15666/AEER/1705_1090910927

Edward, B., & Barbier. (2019). The Value of Coastal Wetland Ecosystem Services. *Coastal Wetlands* 947-964. https://doi.org/10.1016/B978-0-444-63893-9.00027-7

Stoeckl, N., Condie, S., & Anthony, K. (2021). Assessing changes to ecosystem service values at large geographic scale: A case study for Australia's Great Barrier Reef. *Ecosystem Services*, *51*, 101352. https://doi.org/10.1016

David, M., Mushet., & Cali, L. (2020). Modeling the Supporting Ecosystem Services of Depressional Wetlands in Agricultural Landscapes. *Wetlands*, 40(5), 1061-1069. https://doi.org/10.1007/S13157-020-01297-2.

Huang, Q., Zhao, X., He, C., Yin, D., & Meng, S. (2019). Impacts of urban expansion on wetland ecosystem services in the context of hosting the Winter Olympics: a scenario simulation in the Guanting Reservoir Basin, China. *Regional Environmental Change*, 19(8), 2365-2379. https://doi.org/10.1007/S10113-019-01552-1.

John, S., Sanderson., Natasha, B., David, A., Steingraeber., & Claudia, B. (2008). Simulated natural hydrologic regime of an intermountain playa conservation site. *Wetlands*, 28(2), 363-377. https://doi.org/10.1672/07-76.1

Ma, C., Zhang, G., Zhang, X., Zhou, B., & Mao, T. (2012). Simulation modeling for wetland utilization and protection based on system dynamic model in a coastal city, China. *Procedia environmental sciences*, 13, 202-213. https://doi.org/10.1016/J.PROENV.2012.01.019

James, N., Carleton., Pallavi, P., Monica, L., Hubert, J., Montas. (2004). Combining GIS, AI and Modeling to Analyze Wetland Functions in Maryland Watersheds. American Society of Agricultural and Biological Engineers, 042012. https://doi.org/10.13031/2013.17071

Erik, R., Lee., Saied, M., & Theresa, M. (2002). A model to enhance wetland design and optimize non-point source pollution control. *Journal of The American Water Resources Association*, 38(1), 17-32. https://doi.org/10.1111/J.1752-1688.2002.TB01531.X

Leila, R., Bahram, M., & Ahmad, R, Y. (2020). Assessing and Modeling the Impacts of Wetland Land Cover Changes on Water Provision and Habitat Quality Ecosystem Services. *Natural resources research*, 29(6), 3701-3718. https://doi.org/10.1007/S11053-020-09667-7

Douglas, C. T., Owen, S., & Mark, L. (2018). Multi-species benefits of wetland conservation for marsh birds, frogs, and species at risk. *Journal of Environmental Management*, 212, 160-168. https://doi.org/10.1016/J.JENVMAN.2018.01.055