Research on Application Status of 3S Technology in Wetland

Ping He, Zifei Mao, Yue Zou, Xueya Chen, and Yuanxing Cai

***Abstract*—This paper analyzes the research status of 3S technology in China's wetlands. The research of 3S technology in wetland landscape pattern and driving force analysis is increasing day by day. Most of the research uses 3S technology to calculate the landscape index, and reveals the change rule of wetland landscape pattern characteristics with natural and human factors from the type scale and landscape scale. The use of 3S technology for wetland information extraction and dynamic monitoring research is gradually increasing. In most studies, wetland information was extracted according to different classification criteria, and spatio-temporal characteristics of wetland were analyzed based on area change, spatial distribution and shape change. With the development, planning and protection of wetland resources, the advantages of 3S technology will become more prominent.**

***Index Terms*—Wetland, 3s technology, landscape index, resources.**

I. Introduction

Wetland is a unique ecosystem formed by the intersection of land and water. It has the characteristics of biodiversity and landscape diversity. It is one of the important living environments for human beings [1], [2].Wetlands have strong productivity and provide important habitats and growth environments for animals and plants [3]. Wetlands have strong productivity and provide important habitats and growth environments for animals and plants [3]. China's wetland area ranks first in Asia, accounting for about 3.8 percent of the total land area, with an area of 38.5×104km^2.It includes lake wetland, marsh wetland, river wetland and constructed wetland, with an area of 8.4×104km^2, 13.7×104km^2, 0.82×104km^2 and 0.23×104km^2 respectively. It is one of the rare countries with complete species and wide distribution in the world [4]-[6]. Lake wetlands are mainly in the middle and lower reaches of the Huaihe River, the Middle and lower reaches of the Yangtze River, the eastern part of the Grand Canal, the Yellow River and the lower reaches of the Haihe River, and also in the Qinghai-Tibet Plateau, Yunnan-Guizhou Plateau, Mongolia-Xinjiang Plateau and northeast China [7]. Marsh wetlands are mainly distributed in the Sanjiang Plain, the Great and small Hinggan Mountains and Changbai Mountains in northeast China, and the Zoige and Qinghai-Tibet Plateau in Sichuan Province. Due to the influence of topography and climate, the distribution of river wetlands in China is very uneven. Most rivers are distributed in the eastern monsoon region of China, while in the non-monsoon region of northwest inland region, the distribution of rivers is very rare due to the influence of precipitation [8]. Constructed wetlands are mainly distributed in the middle and upper reaches of the Yangtze River and Yellow River, northeast China and the middle and upper reaches of the Pearl River and other regions with developed hydraulic resources [9].

At present, the field of wetland scientific research expands, the content and methods of research increase, and it has become an important research field. Quantitative acquisition and analysis of wetland information in space and time is the key to wetland research. Quantitative acquisition and analysis of wetland information in space and time is the key to wetland research. The development of 3S technology provides new technical means and methods for wetland research. RS technology can obtain a wide range of data, rich information, fast access to information, short update cycle, less restricted access to information. GIS has powerful data management, spatial information processing, spatial statistical analysis and visualization application functions, so that we can obtain the required experience and knowledge from the original data. GNSS provides accurate positioning, assists field investigation, establishes accurate wetland interpretation markers, and makes information extraction more accurate. Thus, 3S technology has great advantages in wetland research.

II. Study on Wetland Landscape Pattern and Driving Force

Landscape pattern, generally referring to the spatial pattern of landscape, reflects the spatial distribution rules and landscape differences of landscape elements (patches) with different shapes, areas and properties. The purpose of landscape pattern analysis is to obtain landscape spatial pattern information through various landscape pattern indexes, and to find potentially valuable laws in seemingly disordered landscapes [10]. Guan ruihua established the geographic information System for Noel National Nature Reserve. In this system, ecological spatial analysis of landscape evolution is carried out on GIS platform, and digital management and dynamic monitoring are realized. This system provides reference for multi-scale research on landscape pattern of the reserve and provides data support and decision-making basis for the management department of the reserve [11]. Han Xingxing studied the temporal and

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spatial dynamic changes of land cover types in Poyang Lake in the past 40 years and their driving factors. Using meteorological data and measured hydrological data, he analyzed the possible causes of vegetation changes in lake wetlands, and preliminatively discussed the impact of water storage of the Three Gorges Project on vegetation growth in lake wetlands [12]. Taking Momoge Wetland as the research object, Liang Minxuan collected satellite remote sensing data of the research area for nearly 35 years, and revealed the change rule of wetland landscape pattern characteristics with natural and imaginary factors from the type scale and landscape scale by calculation of landscape index [13]. Gaozuqiao *et al.* Rule-based object-oriented classification method extracted the wetlands along the Yellow City belt of Ningxia from the three remote sensing images in 2000/2009/2018, and analyzed the characteristics and driving factors of wetland landscape pattern change [14].Ding Pengkai *et al.* obtained the spatial distribution of wetland landscape pattern in Ruoergai region by using remote sensing images of 5 periods as data sources, and analyzed the changes of plateau wetland landscape pattern in Ruoergai region by using landscape pattern index [15].Yang Li analyzed the temporal dynamic characteristics of wetland landscape pattern in Dongting Lake area before and after the operation of the THREE Gorges Project by using the model based on the data of six remote sensing images in the study area. The ecological health of dongting Lake wetland was evaluated at time scale. The influencing factors of wetland landscape pattern in Dongting Lake were summarized [16]. Using Lantsat7 as the data source, Tan Zhiqiang *et al.* quantitatively evaluated the evolution characteristics and differences of wetland landscape pattern of the two lakes before and after the operation of the Three Gorges Project through decision tree classification and Gaussian regression, providing scientific basis for wetland protection and reconstruction. Through research, it is found that drought stress of different degrees is the main reason for the differential evolution characteristics of wetland landscape pattern between the two lakes [17]. Zhang Ming Ming *et al.* selected remote sensing data from four phases of Caohai National Nature Reserve to analyze landscape pattern characteristics and change rules in different phases of the reserve, and proposed that in order to ensure the healthy development of the ecological environment of Caohai National Nature Reserve, regulating and coordinating the rational configuration of the reserve landscape is an important measure to be considered in the comprehensive management of Caohai [18]. Xu Jiren *et al.* studied the evolution and driving forces of wetland landscape pattern in Nansihu Lake from 1987 to 2010. It was found that the landscape pattern of Nansihu Wetland was influenced by natural and human driving forces, and human driving forces combined with population factors and economic development level factors had the greatest influence on landscape spatial pattern [19]. In conclusion, the analysis of landscape pattern of lake wetland generally reflects the composition and dynamic change of landscape structure by calculating the number of landscape patches, patch area, landscape fragmentation, diversity index, dominance index and evenness index.

III. Study on Wetland Information Extraction and Dynamic Monitoring

The identification and extraction of wetland information is the basis of wetland change analysis, and provides the basis for the classification, rational protection and scientific management of wetland ecosystem. Based on MODIS data, Liu Jingnan extracted the wetland distribution in the Sanjiangyuan Region in 2001, 2005, 2010 and 2014, analyzed its dynamic changes and summarized the factors affecting the changes in the region, providing a basis for the management and protection of the Sanjiangyuan region [20]. Taking Dongting Lake as the research object, Zhu Xiaorong explored efficient extraction methods for wetland information of Dongting Lake by utilizing spectral and texture features of remote sensing image data with different resolutions and combining with other auxiliary data, and revealed the evolution law of wetland [21]. Taking Poyang Lake as an example, Du Jing extracted and analyzed the wetland information of Poyang Lake in 2000, 2005, 2010 and 2015, analyzed the wetland change process, studied its change trend, explored the wetland change law, provided data support for wetland protection and restoration decisions, and put forward corresponding protection suggestions [22]. Tian Na used remote sensing data to extract river wetland, lake wetland, reservoir wetland, paddy field and tidal flat wetland in Shanghai, and analyzed the wetland landscape pattern and terrestrial ecological service changes in Shanghai from 1987 to 2007 [23]. Zhu Changming *et al.* took Tarim River as the research object, based on the year 2000 and combined with the observation data of groundwater level, made a comparative analysis of the dynamic change process of regional ecological environment before and after artificial ecological water diversion [24]. Zhao Zhilong carried out remote sensing information analysis on the wetland system of Qiangtang Plateau, a typical representative of the Tibetan Plateau wetland, with multi-stage Landsat data, and carried out remote sensing extraction analysis on the changes of lake area [25]. Taking Ebinhu Wetland National Nature Reserve as the research object, Wang Jingzhe analyzed the spatial structure change, transfer characteristics, spatio-temporal correlation pattern, landscape pattern and spatial connectivity of wetlands, and analyzed the situation of river wetland, lake wetland, constructed wetland, marsh wetland, salt marsh wetland and non-wetland [26]. Zhou Dan took Napahai Wetland as the research object and established a napahai wetland classification system based on satellite remote sensing images of 2000, 2007 and 2014 as data sources [27]. Lu Hui et al. took 7 images from 1986 to 2015 as data sources and used the improved normalized differential water index to extract the water area and wetland information of the middle reaches of the Heihe River in each year, and analyzed its spatio-temporal variation characteristics from the aspects of area change, spatial distribution and shape change [28]. Lu Hui et al. took 7 images from 1986 to 2015 as data sources and used the improved normalized differential water index to extract the water area and wetland information of the middle reaches of the Heihe River in each year, and analyzed its spatio-temporal variation characteristics from the aspects of area change, spatial distribution and shape change [28].Gong Yingbi extracted topographic map wetland data of 1955, 1972 and 1990 and wetland resource census data of 2007 in Changsha, and studied wetland landscape pattern change and driving mechanism in the process of urbanization from the perspective of time gradient and space gradient using qualitative and quantitative analysis methods [29].Taking Bitahai wetland, Dashanbao wetland, Lashihai Wetland and Napahai wetland as the research area, Kang Yingdong et al. extracted land cover data and analyzed the changes of wetland area in the study area by using Landsat satellite remote sensing images of five periods from 1977 to 2015 as remote sensing data sources. Three parameters, landscape index, dynamic attitude and human direct interference, were used to discuss the impact of human stress on wetland landscape change and wetland protection effect of international important wetlands in Yunnan-Guizhou Plateau [30]. Zeng Tao took the ecological tourism resources of Xingkai Lake National Wetland Nature Reserve as the research object. On the basis of comprehensive investigation and extensive collection of relevant data, he used investigation analysis method, analytic hierarchy process, tourism chart method, cluster analysis method, remote sensing technology and other research methods to study the evaluation, monitoring and development of the ecological tourism resources of Xingkai Lake National Wetland Nature Reserve. The classification standard of lake wetland ecotourism resources is established, and the dynamic change of wetland ecotourism resources in Xingkai Lake is monitored [31]. Taking the West Liaohe River Basin as the research area, Wu Menghong extracted the wetland distribution information in 1985, 2000 and 2015, and carried out the research on the wetland evolution law from the four aspects of wetland area change, wetland temporal and spatial change, transfer matrix analysis and landscape pattern analysis. From two aspects of natural environment and social economy were selected temperature, precipitation, evaporation, sunshine time, altitude, slope, population density, driving factors such as GDP, build the wetland change database driver, driving based on random forest mathematical statistical model is established, the quantitative analysis of the influence of each driving factor for the wetland evolution [32]. Zhu Gang *et al.* took Junggar as the research area, and the classification system and dynamic monitoring mentioned above have great reference significance. Through the selection of landscape diversity index, dominance index, fragmentation index, patch shape index and other spatial pattern index, the change of wetland landscape pattern in the inner flow region of Junggar in recent 34 years from 1975 to 2009 was studied [33].Using Landsat TM images of four periods from 1991 to 2007 as wood data, Zheng Zhongming analyzed the dynamic changes of wuhan wetland landscape during 17 years under the background of urbanization, studied the characteristics of wetland plant diversity, and analyzed the degradation mechanism of different types of wetland resources. This paper focuses on the protection and restoration strategies of wuhan wetland resources [34]. With the support of RS and GIS technology, Kong Chunfang *et al.* applied the principles and methods of landscape ecology to analyze and study the landscape pattern, process, change and driving mechanism of wuhan urban wetland, reveal its evolution characteristics and evolution rules, and explore the driving factors that cause its dynamic change, so as to contribute to the rational utilization and development of urban wetland resources and the improvement and governance of urban ecological environment. And provide scientific basis and information support for the sustainable development of ecological environment of “Lake City Wuhan” [35]. Wu Jing revealed from the Angle of landscape planning and driving mechanism in the evolution of the lakes in wuhan, according to the data analysis and statistical method of grid GIS to wuhan binhu region nature of land use change, species, habitat changes, humanities landscape, leisure landscape change and landscape elements such as visual landscape change are analyzed and put forward the corresponding Suggestions and comments, Expectation provides a theoretical basis for the comprehensive management, protection and development of urban lakes, and provides decision support for urban construction and management [36].Cui Hua selected tumen River Basin on the Chinese side as the research area and established a suitable wetland classification system according to the geographical characteristics of the region. Referring to previous studies, Based on the five Landsat remote sensing image data and collected statistical data, the object-oriented classification method combined with human-computer interaction was used to interpret the land use types and wetland types in Tumen River Basin in 2017. On the basis of ensuring high classification accuracy, the 2017 wetland interpretation data was taken as the reference. Inversion of temporal and spatial distribution characteristics and degradation of wetland degradation in the tumen River Basin in recent 40 years, and further analysis of the driving forces of wetland degradation [37]. With the support of RS and GIS technology, Liu Dongyun took the images of tianjin in 1999, 2003 and 2007 as the data source, extracted the wetland feature information, adopted the traditional visual interpretation classification method, combined with other non-remote sensing data and high-resolution images as auxiliary means, and obtained the basic information of Tianjin wetland. On this basis, tianjin wetland is divided into 2 categories and 12 sub-categories, and the changes of wetland area in three periods are analyzed by ARCMAP software, and the dynamic changes of wetland landscape pattern in Tianjin are obtained after Fragstats3.0 and Excel software processing [38]. Li Nana *et al.* used Landsat series remote sensing images to make remote sensing mapping of Wetlands in Sichuan province, and obtained the temporal and spatial database of wetland changes in two periods from 2000 to 2015 through GIS spatial superposition analysis, and selected average wind speed, rainfall, average temperature, average sunshine duration, average relative humidity, GDP, per capita GDP, agricultural GDP and The driving forces of wetland type change in Sichuan province were studied by using the canonical correlation analysis (CCA) method, providing reference for wetland protection and restoration in Sichuan Province [39]. The classification system and dynamic monitoring mentioned above have great reference significance.

IV. CONCLUSION

The classification system of lake wetland has not formed a unified standard, so it is very important to establish a unified wetland remote sensing classification system for the classification and extraction in the future.

In terms of the analysis of the driving forces of wetland landscape evolution, most of the social and economic data studied are not comprehensive enough, and the long-term factors of wetland landscape evolution in the study area need to be more scientifically analyzed.

The research on the response of lake wetland ecosystem from the perspectives of ecology, environment, hydrology, meteorology and geography needs to be strengthened.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Zifei Mao and Yue Zou have collated the data.Xueya Chen and Yuanxing Cai reviewed and revised the first draft.

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