DOI: 10.23977/pree.2024.050108
ISSN 2616-2253 Vol. 5 Num. 1

"3S" Technology in Land Resource Management

Haoqi Chang[1,2,a], Taoqian Xie[3,b,*]

[1]College of Urban and Environmental Sciences, Central China Normal University, Wuhan, Hubei, 430000, China
[2]Warner College of Natural Resources, Colorado State University, Fort Collins, CO 80523, USA
[3]School of Public Administration, Central China Normal University, Wuhan, Hubei, 430000, China
[a]changhaoqi66@163.com, [b]xtq0406@ccnu.edu.cn
[*]Corresponding author

Keywords: Remote Sensing, Geographic Information Systems, Global Positioning System, Land Resource Management

Abstract: Land resources are an important foundation for the survival and development of human society, but the development and utilization of land require scientific planning and management to achieve sustainable development. "3S" technology, namely remote sensing (Remote Sensing), Geographic Information System (GIS), and Global Positioning System (GPS), has advantages such as wide data coverage, high data acquisition accuracy, and fast analysis speed, and has important application value in land resource management (LRM). This article takes land as the research area, uses remote sensing and GIS technology to obtain high-resolution remote sensing image data and related GIS data of the land, generates a high-precision map of the land, and then uses GIS tools to classify land use types, calculate land area and characteristics. At the same time, soil quality and terrain elevation of the land can be analyzed, and spatial variation patterns can be recorded. Finally, this article applies "3S" technology for sustainable land use planning and management of the land, achieving scientific regulation of land resources. The research results indicate that "3S" technology has outstanding value in the process of land resource management. Under its management, the highest land yield can reach 5499 kilograms, the lowest land use efficiency can reach 80%, and the highest environmental impact index can reach 9. Therefore, "3S" technology can play an important role in sustainable land use planning and land resource management.

1. Introduction

Land resource management is a crucial field and a fundamental project. However, its role in achieving sustainable development, protecting the environment, and improving social well-being is irreplaceable. If land resources are not managed properly, it can lead to a series of serious problems. However, traditional land management methods may face some limitations when facing increasingly severe land use pressures and environmental challenges. Therefore, finding new technologies and methods to improve the effectiveness of land resource management has become crucial.

The main research objective of this article is to explore the application of "3S" technology in land resource management, and to evaluate its potential in terms of land use efficiency, land output, and environmental impact. Through a comparative experiment of the effectiveness of traditional land management methods and "3S" technology, and analyzing and summarizing its experimental results, this article reveals the advantages of "3S" technology in improving the effectiveness of land resource management compared to traditional technologies, and provides scientific basis and decision support for decision-makers.

This article first introduces the methods used in the experimental comparison process, including data collection, analysis, and selection of evaluation indicators. After introducing the research methods, it further delves into the background and principles of "3S" technology, as well as its potential application in land resource management, indicating its application prospects. Next, the evaluation results were presented, including a comparative analysis of land use efficiency, land output, and environmental impact. Finally, through the discussion and summary of the results, the application prospects and suggestions of "3S" technology in land resource management are drawn.

2. Related Work

The management of land resources is of utmost importance for social development, and many researchers have conducted in-depth research on land resource management. Based on the non renewable nature of land resources, efficient, scientific, and standardized utilization of land resources is the key to maximizing their value, and has become the future development direction of land resource utilization management according to Luo Yu. Focusing on land use transformation and LRM, he analyzed the implementation points of related work from a practical perspective, in order to provide reference for practical optimization [1]. Zhang Guoman conducted research on measures to strengthen LRM and achieve efficient and intensive land use. Firstly, he analyzed the connotations of land conservation and intensive use, and then provided a detailed overview of land resource utilization. Finally, he elaborated on measures to strengthen LRM and achieve efficient and intensive land use by proposing a series of methods [2]. Yang Song elaborated on the content of LRM, analyzed the problems existing in LRM, and explored the integration of LRM and land use planning in the new era. He proposed comprehensive land use planning strategies to achieve scientific management of land resources, improve the utilization rate of land resources and space, and promote stable social and economic development in China [3]. In the face of the increasingly serious shortage of land resources, Xiangzhi mainly analyzes the transformation of land use and LRM in the new era in order to better ensure the rational use of land resources. It is hoped to provide reference for the development of related work [4]. Chen Hong utilizes modern technology to develop and utilize existing land resources in a reasonable manner, recognizing and grasping the magnitude and spatial characteristics of their changes in real time, in order to maintain the overall dynamic balance of cultivated land and achieve sustainable utilization [5]. Mugambiwa S S explored climate governance based on the Indigenous Knowledge System (IKS) in water and LRM in resource scarce areas of Zimbabwe. Research has found that strengthening and accepting IKS is crucial for incorporating local strategies into development processes, particularly in climate governance for water and LRM, and in resource scarce communities [6]. Beillouin D conducted a meta-analysis to investigate a limited number of land management measures, mainly mineral fertilization, organic additives, and cultivation. He discussed the mismatch between increasing research and the need for more local, reusable, and diversified knowledge on how to protect high organic carbon reserves or restore depleted organic carbon reserves [7]. Mesfin S poses a threat to Ethiopia's current and future agricultural production due to soil organic carbon depletion. He investigated the impact of land management and climate change on soil organic carbon to promote climate change mitigation practices [8]. Hurley P aims to explain why, in the context of jointly designing new environmental land management methods in England, some land managers (mainly farmers) may have difficulty accessing agricultural environmental plans [9]. Nziguheba G proposed using agricultural practices to indirectly quantify priority indicators (crop productivity, soil organic carbon, acidification, erosion, nutrient balance), providing an opportunity to determine the practices needed to reverse land degradation [10]. Although these experts and scholars have conducted in-depth research and practice on LRM and utilization, they have put forward many beneficial suggestions and measures. However, there are also problems such as incomplete plans, lack of systematicity and integration. This study overcomes the shortcomings of previous researchers, comprehensively applies modern technological means and management techniques, designs more comprehensive and detailed plans, and through practical testing and improvement, better realizes the efficient utilization and sustainable development of land resources.

3. Method

3.1 Acquisition and Preprocessing of Land Resource Data

In LRM, obtaining and preprocessing land resource data is a very important step [11-12]. Data acquisition involves many methods, including remote sensing data, land survey, open data sources and Internet data. Remote sensing data can obtain surface information through remote sensing platforms such as satellites, aviation, or drones, such as satellite images, LiDAR data, etc. Land survey requires on-site investigation and sampling, collecting data on land attributes, soil samples, etc. [13-14]. Public data sources can utilize public data provided by government agencies, research institutions, or other organizations, such as geographic data, land use data, climate data, etc. In addition, social media and Internet data can also provide information related to land resources, such as geographical location information and comments published by users.

After data acquisition, it is necessary to preprocess the data. The purpose of data preprocessing is to ensure the quality and applicability of data. The preprocessing steps include data cleaning, data integration, data filtering and sampling, data correction and calibration, data interpolation and filling, as well as data conversion and projection. Data cleaning is to remove errors, omissions, or outliers to ensure the accuracy and consistency of data. Data integration is the process of integrating and formatting data from different sources for subsequent processing and analysis. Data filtering and sampling select regions and attributes for analysis based on the research purpose to ensure the representativeness of the data. Data correction and calibration is the process of atmospheric correction, geometric correction, etc., on remote sensing data to improve the accuracy and consistency of the data. Data interpolation and filling are used to fill or speculate on missing or incomplete data, ensuring the integrity and continuity of the data. Data conversion and projection convert data into a projection coordinate system suitable for analysis and display, and perform unit conversion and other operations. Table 1 shows the preprocessed land data:

Table 1: Land data after data preprocessing

Land-use type	Area in 2020 (km2)	Area in 2010 (km2)	Change (km2)
Farmland	5000	4800	200
Forest	3000	3200	-200
Urban Area	2000	1800	200
Water Bodies	1000	1000	0
Grassland	1500	1600	-100
Desert	400	300	100
Wetland	800	900	-100
Mining Area	300	200	100

Through appropriate data acquisition and preprocessing, high-quality, consistent, and reliable land resource data can be obtained, providing a reliable foundation for subsequent analysis, modeling, and decision-making.

3.2 "3S" Technology

"3S" technology refers to the comprehensive application of three technologies: Remote Sensing, Geographic Information System (GIS), and Global Positioning System (GPS).

Remote sensing technology can provide large-scale and high-resolution surface information by obtaining remote sensing data on the Earth's surface, such as satellite images and LiDAR data. In land classification, remote sensing technology can identify and classify different land types, such as farmland, forests, wetlands, etc. By analyzing the spatial distribution and characteristics of different land types, it can help formulate land use planning and decision-making [15-16]. In land change monitoring, remote sensing technology can monitor and analyze changes in land use and land cover, providing information on land change trends, speeds, and impacts for decision-making support in LRM, environmental protection, and sustainable development.

GIS is a popular technology tool in the market, and it is one of the most important tools for land resource management, which can be used for data management and analysis. In land resource management, it can integrate and analyze land data from different sources, such as remote sensing images, terrain data, soil data, etc., and through spatial analysis and model construction, reveal the spatial distribution, correlation, and other potential problems of land resources [17-18].

GPS is a satellite navigation system that can provide precise positioning and navigation information, and this precise positioning and navigation information can be global. In land survey and measurement, GPS can be used to obtain accurate coordinates and location information of locations. With the help of GPS, land surveyors and surveyors can improve the accuracy and efficiency of land surveys and measurements.

In land resource management, "3S" technology has important application value. Remote sensing technology can be used for land classification and change monitoring, GIS can be used for land resource management and decision support, and GPS can be used for land survey and measurement. The comprehensive application of these technologies not only helps to provide comprehensive and accurate land resource information for land resource management, but also has a positive impact on supporting land planning, management, and sustainable development decisions.

3.3 Integration and Comprehensive Application of "3s" Technology

The integration and comprehensive application of "3S" technology can provide comprehensive, accurate, and insightful basic land resource information for land resource management [19-20]. This comprehensive application method includes data integration and fusion, spatial analysis and model construction, decision support and visualization, and on-site data collection, which plays a significant role in promoting the in-depth development of land resource management.

Data integration and fusion is the process of integrating data from different sources into a unified dataset, and using technical means to maintain consistent data formats. It involves field mapping and data merging operations, which can provide a comprehensive data foundation for subsequent analysis.

Spatial analysis and model construction are conducted using GIS platforms to explore the spatial distribution of land resources, as well as the relationships and potential development or security issues between land resources. Based on remote sensing data and other geographic data, land use classification models and change monitoring models can be constructed to identify and monitor changes in different land types [21].

Decision support and visualization utilize the analysis and visualization tools provided by GIS to display and analyze the integrated land resource data. Integrating the integrated data with decision support systems or land resource management systems can provide decision-makers with real-time and accurate land resource information.

The combination of mobile devices and GPS technology in on-site data collection makes land surveys and data collection possible. The collected data can be directly synchronized with the GIS platform to achieve real-time data updates and data quality control.

By integrating and comprehensively applying "3S" technology, comprehensive, accurate, and multidimensional analysis of land resource information can be achieved, thereby supporting land resource management, planning, and decision-making, and improving the efficiency and sustainability of land use.

4. Results and Discussion

Land resource management plays a significant role that cannot be ignored in the development and stability of social economy and environment. To evaluate the performance of different land management methods, using multiple evaluation indicators can provide comprehensive analysis and comparison. In this study, the effectiveness of using "3S" technology for land resource management can be evaluated and compared with the effectiveness of using traditional methods. This study can focus on indicators such as land output, land use efficiency, and environmental impact to comprehensively understand the potential of "3S" technology in land resource management.

4.1 Comparison of Land Output

One of the greatest functions of land resource management is to increase land output, therefore land output is one of the important indicators for evaluating the effectiveness of land resource management. This study adopts a comparative experimental method to verify the impact of "3S" technology on land yield and determine the magnitude of the impact. At the beginning of the experiment, two methods were used to manage 8 different plots of land, and the final comparison of experimental data was collected to reveal the differences between using "3S" technology and traditional methods for land management. The final result is shown in Figure 1.

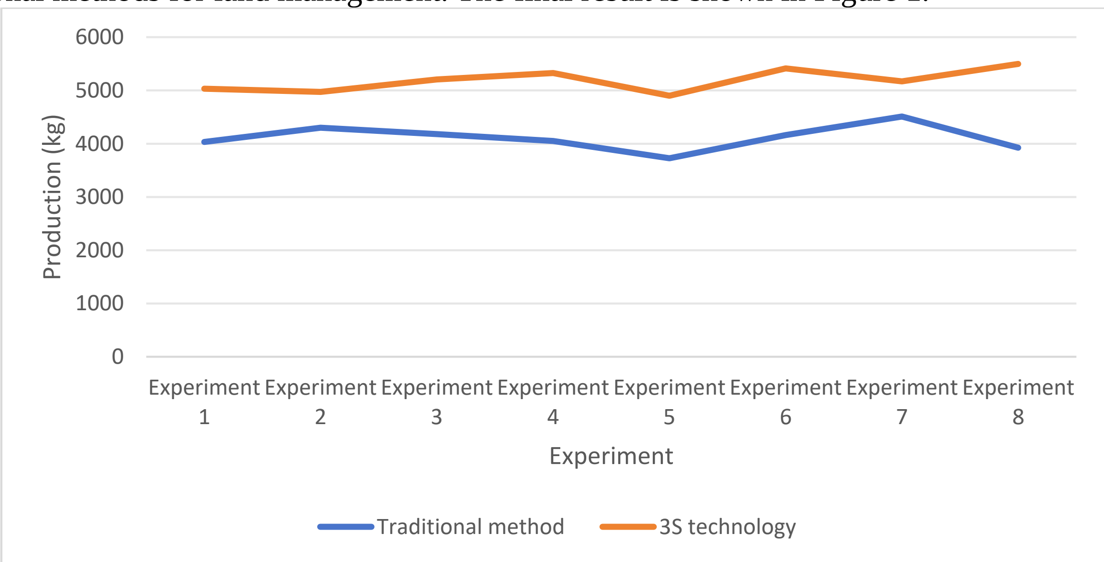

Figure 1: Comparison of Land Output

From Figure 1, it can be seen that in Experiment 1, the yield of the same piece of land under traditional management was 4033 kilograms, but under the "3S" technology management, its land yield reached 5034 kilograms, an increase of 1001 kilograms. In other experiments, the yield under "3S" technology management was higher than that under traditional method management. These data help to understand the potential of "3S" technology in improving land output and provide scientific basis for future LRM decisions.

4.2 Land Use Efficiency

Comparing the improvement of land use efficiency by different technologies is an important way to understand the development and utilization of land resources and the performance of technologies. By comparing the utilization efficiency of different land resources, the social and economic development level and natural resource development and utilization capacity can be effectively evaluated, as shown in Figure 2.

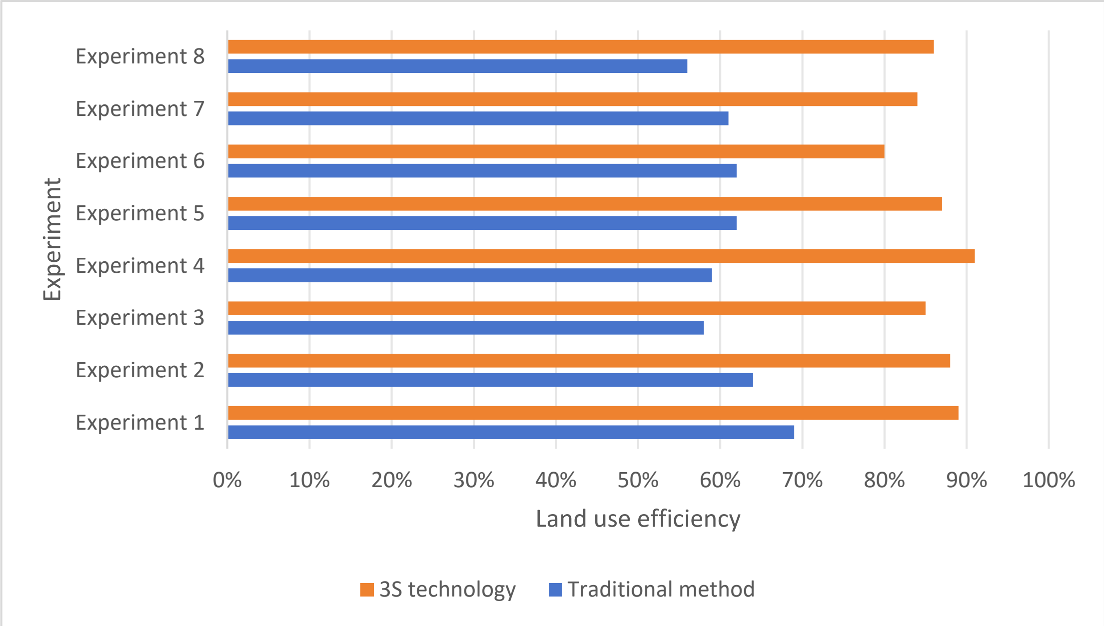

Figure 2: Comparison of Land Use Efficiency

From Figure 2, it can be seen that in Experiment 1, the same piece of land was managed using "3S" technology, and its land use efficiency could reach 89%. However, under traditional technology management, the land use efficiency could only reach 69%. Similarly, the land use efficiency of other lands under the use of "3S" technology management is always greater than that under traditional technology management, which also confirms the significant role of "3S" technology in LRM.

4.3 Environmental Impact Index

The Environmental Impact Index is usually obtained through weight allocation and comprehensive evaluation of various environmental impact factors. These factors may include water quality, water resource utilization, soil quality, biodiversity, carbon emissions, etc.

By comprehensively evaluating the performance of traditional methods and "3S" technology on environmental impact index, the final results are compared as shown in Figure 3:

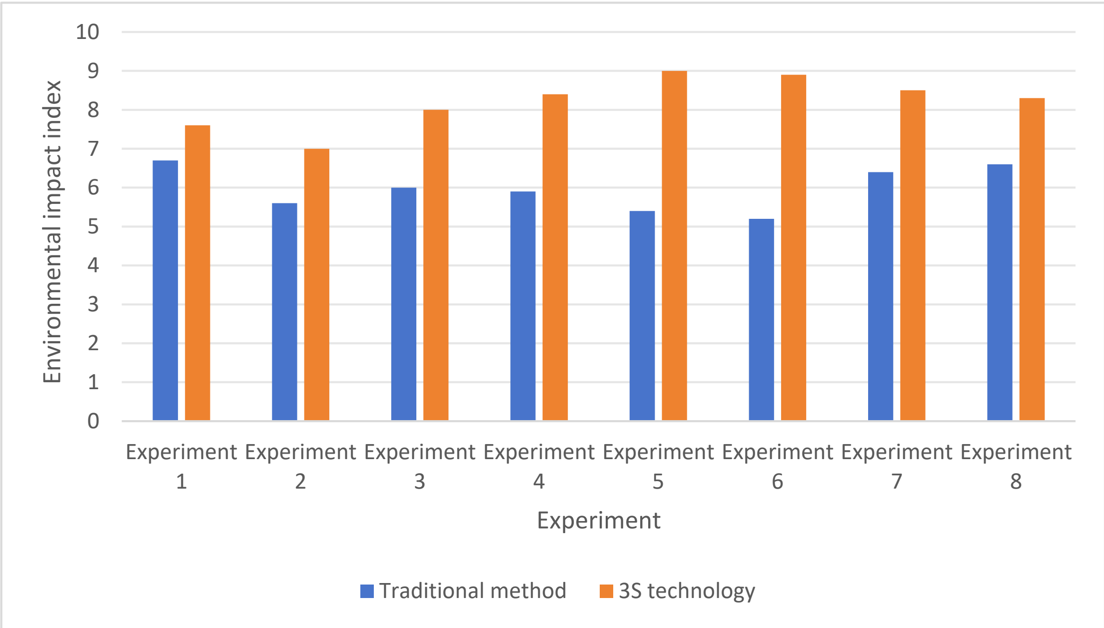

Figure 3: Comparison of Environmental Impact Index

From Figure 3, it can be seen that when land resources are managed through "3S" technology, their environmental impact index remains above 7, with the highest even reaching 9. The highest environmental impact index under traditional technological management is only 6.7, and the lowest is 5.2. This indicates the enormous potential of "3S" technology in LRM.

5. Conclusions

The main purpose of this study is to explore the application of "3S" technology in land resource management and its effectiveness, and to evaluate its potential for land use efficiency, land output, and environmental impact. This study reveals the advantages of "3S" technology in improving the effectiveness of land resource management by comparing the output of land under traditional land management methods and "3S" technology, the land use efficiency under different technologies, and the final environmental impact index effect. The research method adopted by this institute is to use remote sensing technology to obtain high-resolution surface information, and then combine GIS and GPS for spatial analysis and decision support. Finally, through three sets of comparative experiments with different performance, the final conclusion was drawn that "3S" technology has important application value in land resource management. Firstly, it provides high-resolution surface information to help this study gain a more comprehensive understanding of the current situation and changes in land resources. Secondly, "3S" technology provides accurate geographic positioning and spatial analysis tools, which can help decision-makers better plan land use and improve land use efficiency.

References

[1] Luo Yu. Analysis of land use transformation and land resource management .Low carbon World, 2023, 13(9): 121-123

[2] Zhang Guoman. Suggestions for measures to strengthen land resource management and realize the conservation of intensive land use .Smart Agriculture Guide, 2023, 3(14):60-63

[3] Yang Song. Comprehensive planning of land resource management and land use in the new period .China Kitchen and Bathroom, 2023, 22(5):110-112

[4] Xiang Zhi. Analysis on land use transformation and land resource management in the new period. Nonferrous

Metals, 2023, 46(4):109-110
[5] Chen Hong.Research and design of county-level land resource management system based on WebGIS .Information and computers, 2023, 35(9):114-117
[6] Mugambiwa S S, Makhubele J C. Indigenous knowledge systems based climate governance in water and land resource management in rural Zimbabwe. Journal of Water and Climate Change, 2021, 12(5): 2045-2054.
[7] Beillouin D, Cardinael R, Berre D, et al. A global overview of studies about land management, land-use change, and climate change effects on soil organic carbon. Global change biology, 2022, 28(4): 1690-1702.
[8] Mesfin S, Gebresamuel G, Haile M, et al. Modelling spatial and temporal soil organic carbon dynamics under climate and land management change scenarios, northern Ethiopia. European Journal of Soil Science, 2021, 72(3): 1298-1311.
[9] Hurley P, Lyon J, Hall J, et al. Co-designing the environmental land management scheme in England: The why, who and how of engaging 'harder to reach' stakeholders. *People and Nature, 2022, 4(3): 744-757.*
[10] Nziguheba G, Adewopo J, Masso C, et al. Assessment of sustainable land use: linking land management practices to sustainable land use indicators. International Journal of Agricultural Sustainability, 2022, 20(3): 265-288.
[11] Duffy C, Prudhomme R, Duffy B, et al. Randomized national land management strategies for net-zero emissions. Nature Sustainability, 2022, 5(11): 973-980.
[12] DeFries R, Ahuja R, Friedman J, et al. Land management can contribute to net zero. Science, 2022, 376(6598): 1163-1165.
[13] Mikha M M, Johnson J M F, et al. Land management effects on wet aggregate stability and carbon content. Soil Science Society of America Journal, 2021, 85(6): 2149-2168.
[14] Bagwan W A, Gavali R S, Maity A. Quantifying soil organic carbon (SOC) density and stock in the Urmodi River watershed of Maharashtra, India: implications for sustainable land management. Journal of Umm Al-Qura University for Applied Sciences, 2023, 9(4): 548-564.
[15] Biswal D. Nematodes as ghosts of land use past: elucidating the roles of soil nematode community studies as indicators of soil health and land management practices. Applied Biochemistry and Biotechnology, 2022, 194(5): 2357-2417.
[16] Ibrahim A S, Akanbang B A A, Laube W. Sustaining decentralized collaborative governance arrangements in Africa: A case study of land management committees in the Upper West Region, Ghana. GeoJournal, 2022, 87(2): 641-660.
[17] Dzurume T, Dube T, Thamaga K H, et al. Use of multispectral satellite data to assess impacts of land management practices on wetlands in the Limpopo Transfrontier River Basin, South Africa. South African Geographical Journal, 2022, 104(2): 193-212.
[18] Mansergh I M, Cheal D C, Burch J W, et al. Something went missing: cessation of Traditional Owner land management and rapid mammalian population collapses in the semi-arid region of the Murray–Darling Basin, southeastern Australia. Proceedings of the Royal Society of Victoria, 2022, 134(1): 45-84.
[19] Chen W, Zhu K, Wu Q, et al. Adaptability evaluation of human settlements in Chengdu based on 3S technology. Environmental Science and Pollution Research, 2022, 29(4): 5988-5999.
[20] Chen T, Guo R, Yan Q, et al. Land management contributes significantly to observed vegetation browning in Syria during 2001–2018. Biogeosciences, 2022, 19(5): 1515-1525.
[21] Fawanz Almunlihi. Water Quality Monitoring and Early Warning Technology of Zebrafish Behavior Based on 3s Technology. Academic Journal of Environmental Biology, 2021, 2(3): 39-46.