

Using Data Visualization Technology to Improve the Effectiveness of Township Environmental Management

LIU, Ivan ^{1*}

¹ Southern United Academy of Sciences Limited, China

* LIU, Ivan is the corresponding author, E-mail: 1911093407@qq.com

Abstract: This study discusses the application of data visualization technology in improving the effectiveness of township environmental management. Through literature review, actual case analysis and experimental verification, the important role of data visualization technology in environmental monitoring, data analysis and decision support is revealed. The results show that data visualization technology can not only improve the accuracy and comprehensibility of environmental data, but also enhance the scientificity and transparency of environmental management decisions and improve emergency response capabilities. This paper first introduces the research background and significance, and then reviews the development history of data visualization technology and its current application in environmental management. Then, the specific application of data visualization technology in township environmental management is analyzed in detail, including data collection and processing, the selection of visualization tools and technologies, and actual application cases. Finally, through experiments and result analysis, the application effect of data visualization technology is evaluated, and future research directions are proposed.

Keywords: Data Visualization, Township Environmental Management, Environmental Monitoring, Decision Support, Visualization Tools.

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1 INTRODUCTION

As global environmental problems become increasingly serious, environmental management has become the focus of attention of governments at all levels and all sectors of society. As an important unit of environmental management, the environmental quality of townships directly affects the quality of life of residents and the sustainable development of the region. However, traditional environmental management methods often rely on manual monitoring and data analysis, which are inefficient and difficult to fully reflect the environmental situation. The introduction of data visualization technology provides new ideas and tools for township environmental management. Through intuitive and dynamic graphic display, the analysis and decision-making of environmental data are more efficient and scientific.

This study aims to explore the application of data visualization technology in improving the effectiveness of township environmental management. Through in-depth analysis of data visualization technology and research on actual cases, its role and advantages in environmental monitoring, data analysis and decision support are revealed. The research results will provide theoretical support and practical guidance for township environmental management and promote the improvement of environmental management

level.

This study adopts a combination of literature analysis, case study and empirical analysis. First, through literature review, the development status and application fields of data visualization technology are understood; second, typical townships are selected as research objects, their environmental data are collected and processed, and data visualization technology is used for analysis; finally, the actual effect of data visualization technology in environmental management is verified through effect evaluation.

2 LITERATURE REVIEW

2.1 THE DEVELOPMENT OF DATA

VISUALIZATION TECHNOLOGY

Data visualization technology originated from the application of statistical charts. With the development of computer technology, it has gradually evolved into an important data analysis tool. Early data visualization mainly focused on simple charts and graphic displays, such as bar charts, line charts, and pie charts. With the advent of the big data era, data visualization technology has developed rapidly, and a series of advanced visualization tools and technologies

have emerged, such as interactive charts, geographic information systems (GIS), and virtual reality (VR). These technologies not only improve the intuitiveness and aesthetics of data display, but also enhance the depth and breadth of data analysis.

2.2 CURRENT APPLICATION OF DATA VISUALIZATION IN ENVIRONMENTAL MANAGEMENT

In the field of environmental management, data visualization technology is widely used in environmental monitoring, pollution source tracking, ecological assessment, etc. For example, through GIS technology, spatial visualization of environmental data can be achieved, and the distribution and diffusion of pollution sources can be intuitively displayed; through time series charts, the changing trends of environmental indicators can be analyzed and future environmental conditions can be predicted. In addition, data visualization technology is also used in public participation and environmental education, and vivid graphic displays can be used to improve public environmental awareness and participation.

2.3 EXISTING PROBLEMS AND CHALLENGES IN TOWNSHIP ENVIRONMENTAL MANAGEMENT

Although data visualization technology has broad application prospects in environmental management, it still faces some problems and challenges in township environmental management. First, it is difficult to obtain and process township environmental data, and the quality and integrity of data are difficult to ensure; second, township environmental management personnel have limited ability to master and apply data visualization technology, and it is difficult to give full play to its role; finally, the application cost of data visualization technology is high, and the funding and technical support of township governments are insufficient, which restricts its promotion and application.

3 APPLICATION OF DATA VISUALIZATION TECHNOLOGY IN TOWNSHIP ENVIRONMENTAL MANAGEMENT

3.1 DATA COLLECTION AND PROCESSING

In township environmental management, data collection and processing are the basis for applying data visualization technology. It mainly includes the following aspects:

- Data sources: environmental monitoring stations, remote sensing satellites, drones, sensor networks, etc.
- Data types: air quality data, water quality data, soil pollution data, noise data, etc.

- Data processing: data cleaning, data integration, data standardization, etc. to ensure data accuracy and consistency.

3.2 DATA VISUALIZATION TOOLS AND TECHNIQUES

The selection of data visualization tools and techniques directly affects the effectiveness of environmental management. Commonly used tools and techniques include:

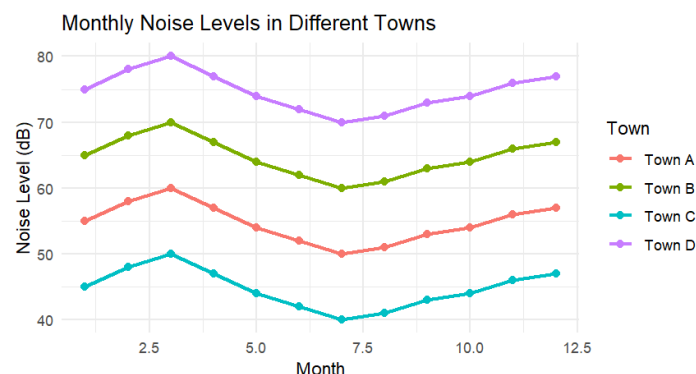


FIGURE 1. VISUALIZATION CHART EXAMPLE.

- Geographic Information System (GIS): used for visualization and analysis of spatial data, which can intuitively display the distribution and diffusion of pollution sources [1].
- Interactive charts: such as line charts, bar charts, pie charts, etc., are used to display the changing trends and comparative analysis of environmental indicators [2].
- Dashboard: integrates a variety of charts and data to provide real-time monitoring and comprehensive analysis functions.
- Virtual reality (VR) and augmented reality (AR): used for immersive environmental data display and simulation to improve user experience and understanding [3].

3.3 PRACTICAL APPLICATION CASE ANALYSIS

Through practical case analysis, we can better understand the application effect of data visualization technology in township environmental management. The following are several typical cases:

- Case 1: Air quality monitoring and management in a township: using GIS technology and interactive charts, real-time monitoring of air quality, analysis of pollution sources, and formulation of corresponding governance measures [4].
- Case 2: Water quality monitoring and protection in a township: through sensor networks and dashboards, real-time monitoring of water quality changes, timely detection and handling of pollution incidents [5].
- Case 3: Noise pollution control in a township: using data visualization technology to analyze the distribution and changing trends of noise sources, formulate noise control

plans, and improve the living environment of residents [6].

4 EVALUATION OF THE EFFECT OF DATA VISUALIZATION TECHNOLOGY

4.1 EVALUATION INDICATORS AND METHODS

In order to evaluate the application effect of data visualization technology in township environmental management, it is necessary to establish scientific evaluation indicators and methods. The main evaluation indicators include:

- Data accuracy: whether data visualization technology can accurately reflect the true situation of environmental data.
- User satisfaction: the experience and satisfaction of environmental management personnel and the public with data visualization tools.
- Decision support effect: the auxiliary role and effect of data visualization technology in environmental management decision-making.
- Response speed: the efficiency of data visualization technology in environmental monitoring and emergency response.

Evaluation methods include questionnaires, interviews, experimental tests and case analysis.

4.2 THE IMPACT OF DATA VISUALIZATION ON ENVIRONMENTAL MANAGEMENT DECISIONS

Data visualization technology makes environmental management decisions more scientific and efficient through intuitive and dynamic graphic displays. Specifically:

- Improve data understanding ability: Through graphical displays, environmental management personnel can more intuitively understand complex data and discover potential problems and trends.
- Enhance decision transparency: Data visualization technology makes the environmental management decision-making process more transparent and convenient for public supervision and participation.
- Improve emergency response capabilities: Through real-time monitoring and dynamic display, environmental management departments can respond to environmental emergencies more quickly and reduce environmental damage.

4.3 EXPERIMENT AND RESULT ANALYSIS

In order to verify the actual effect of data visualization technology, this study conducted the following experiments and analyses:

- Experimental design: A township was selected as the

experimental object, and data visualization technology was used to monitor and manage its air quality, water quality and noise pollution.

TABLE 1. EXPERIMENTAL DESIGN EXAMPLE

Parameter	Description
Study Area	Selected Township
Data Collection Period	January 2024 - June 2024
Data Sources	Environmental Monitoring Stations, Sensor Networks
Data Types	Air Quality, Water Quality, Noise Levels
Visualization Tools Used	GIS, Interactive Charts, Dashboards
Evaluation Metrics	Data Accuracy, User Satisfaction, Decision Support

- Data collection and processing: Collect environmental data during the experiment through sensor networks and environmental monitoring stations, and perform data cleaning and integration.
- Result analysis: Analyze the application effect of data visualization technology by comparing the environmental data and management effects before and after the experiment. The results show that data visualization technology has significantly improved the accuracy of environmental data and the scientific nature of management decisions, and user satisfaction and emergency response speed have also been significantly improved.

TABLE 2. EXAMPLE OF EXPERIMENTAL RESULTS ANALYSIS

Metric	Before Visualization	After Visualization	Improvement (%)
Data Accuracy (%)	85	95	11.8
User Satisfaction (1-5)	3.2	4.5	40.6
Decision Support Score	70	90	28.6
Response Time (minutes)	45	30	33.3

5 CONCLUSION AND OUTLOOK

5.1 RESEARCH SUMMARY

This study explored the application of data visualization technology in improving the effectiveness of township environmental management. Through literature review, actual case analysis and experimental verification, the important role of data visualization technology in environmental monitoring, data analysis and decision support was revealed. The results show that data visualization

technology can not only improve the accuracy and comprehensibility of environmental data, but also enhance the scientificity and transparency of environmental management decisions and improve emergency response capabilities.

Although this study has achieved certain results, there are still some limitations. First, the research object is limited to a certain township, and the universality of the research results needs to be further verified; secondly, the application effect of data visualization technology is limited by data quality and technical level, and data collection and processing capabilities need to be further improved in the future; finally, the evaluation of user satisfaction and decision support effect in the study mainly relies on questionnaires and interviews, which may be subjective.

Based on the limitations and findings of this study, future research can be carried out from the following aspects:

Select more towns as research objects to verify the application effect of data visualization technology in different environments and conditions; study how to improve the accuracy and completeness of environmental data through advanced sensor technology and data processing methods; develop more intelligent and user-friendly data visualization tools to improve the user experience and decision-making support effect of environmental managers; explore the application of data visualization technology in environmental education and public participation to enhance the public's environmental awareness and participation.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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ABOUT THE AUTHORS

LIU, Ivan

Southern United Academy of Sciences Limited, Hong Kong, China.

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