

An In-Depth Economic Analysis of Xiangjiang River Water Pollution Control: Introducing New Variables

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Abstract. This study provides a significant economic analysis of pollution control methodologies applied to the Xiangjiang River, advancing the understanding of how economic development and environmental preservation intersect. By integrating previously overlooked variables, the research offers a nuanced perspective on the costs and benefits of safeguarding the river's economic and ecological roles. The hypothesis posits that including additional factors—such as cross-regional economic collaboration and long-term ecological resilience—can reshape traditional cost-benefit analyses of pollution control. Findings suggest that these factors substantially transform the landscape of pollution control, highlighting the need for a broader evaluative framework that encompasses economic, ecological, and social dimensions. The research underscores the importance of regional cooperation and ecological sustainability, offering insights with implications not only for the Xiangjiang River but for other similarly impacted water bodies. This study encourages policymakers and researchers to adopt a more comprehensive approach to pollution control, paving the way for future research and the development of sustainable, cost-effective environmental policies.

Keywords: Water Pollution Control, Economic Analysis, Environmental Policy, Xiangjiang River, Cost-Benefit Assessment.

1. Introduction

1.1. Research Background

The Xiangjiang River, regarded as the lifeblood of Hunan Province, holds paramount significance in influencing the quality of life for its inhabitants, the sustainable development of the regional economy, and the harmonious stability of the natural ecosystem [1]. Given the gravity of water pollution issues and their far-reaching implications, a profound exploration into the economic and social transformations triggered by Xiangjiang River water pollution control becomes increasingly urgent and vital. In response to this challenge, the national and local governments have vigorously implemented a series of targeted and robust policies and measures aimed at comprehensively improving the water quality of the Xiangjiang River basin. These efforts have not only fueled the thriving of the environmental protection industry, infusing robust momentum into the green economy, but also successfully paved a new path for Hunan's economic transformation and upgrading, giving birth to multiple emerging economic growth points, encompassing but not limited to the rise of the environmental protection equipment manufacturing industry, the establishment of green supply chain industries, the expansion of the senior care-elderly economy, and the prosperity of ecotourism [2].

However, with the continuous emergence of new industries and the diversification of the economy, the traditional economic benefit assessment models for water pollution control gradually reveal their limitations, failing to comprehensively and accurately reflect the contributions of emerging industries to economic growth and their spillover effects. Consequently, the timely adjustment and improvement of assessment models, incorporating variables that reflect new industries, new business formats, and their economic impacts, have emerged as critical issues requiring immediate attention. Identifying which economic factors undergo significant changes as water pollution control progresses serves as the premise for optimizing assessment models and guiding investment decisions. This not only concerns whether and to what extent investments should be made in emerging industries but also involves the scientific planning and rational allocation of resources to achieve a win-win situation between water pollution control and economic development. Therefore, establishing a more

comprehensive, precise, and forward-looking economic benefit assessment system holds significant importance for promoting the sustainable development of the Xiangjiang River basin and even Hunan Province as a whole.

1.2. Study Purpose and Significance

Purpose: To delve into the primary causes of water pollution and analyze how novel industries emerging during and as a consequence of pollution control endeavors have evolved into crucial assessment factors that cannot be overlooked, thereby shedding light on their significance.

Significance: This research offers invaluable insights and fresh perspectives that can inform and guide governments and enterprises in their investments for water pollution remediation, fostering more effective and innovative strategies.

1.3. Study Scope and Methodology:

Study Scope: The research is scoped to cover water pollution control projects within the Xiangjiang River basin.

Research Methods: The study adopts methodologies such as the Cost-Benefit Analysis (CBA) model, Economic Accounting (EEA) models, and case study analysis to analyze and evaluate the impact of these projects.

2. Current Status of Water Pollution in the Xiangjiang River

2.1. Natural Environment and Current Status of Pollution

The Xiangjiang River, a crucial waterway in the Hunan province of China, has exhibited significant pollution levels largely attributable to industrial and agricultural activities. Industries along the riverbanks, particularly metallurgy, chemical production, and mining, have been discharging heavy metals such as cadmium and mercury into the river, considerably exceeding environmental guidelines. The accumulation of these heavy metals in the river ecosystem not only poses a direct threat to aquatic life but also affects the health and livelihoods of communities relying on the river resources [3].

Compounding the problem are effluents from agricultural operations, which introduce high levels of nitrogen and phosphorus through the use of fertilizers. These nutrients contribute to eutrophication—a process that depletes oxygen in the water and leads to the death of fish and other aquatic organisms. Pesticides from crop protection also find their way into the river, contributing to the toxicity of its waters.

Urban expansion and inadequate waste management have further exacerbated water quality degradation. Untreated domestic sewage, solid waste dumping, and runoff from impermeable urban surfaces add to the river's pollutant load, introducing pathogens and organic waste that challenge the river's self-purification capacity [4].

The economic implications of such pollution are profound. Costs are incurred due to diminished fishery outputs, decreased tourism attractiveness, and escalating healthcare expenses for diseases linked to polluted water. Furthermore, the river's deterioration hampers economic development and foreign investment in the region [5]. The urgent need for effective pollution control is, therefore, not just an environmental concern but a pressing economic priority that demands immediate action and sustainable solutions. The complexity of the pollution sources underscores the necessity for an interdisciplinary approach that incorporates both technological advancements and socioeconomic considerations in the remediation efforts of the Xiangjiang River.

2.2. Analysis of Pollution Sources

2.2.1 Industrial effluents and their economic impact

The discharge of industrial effluents into the Xiangjiang River has emerged as a significant source of water pollution, bearing considerable economic consequences. Industrial wastewater, often laced with toxic substances such as heavy metals and carcinogens, can severely deteriorate water quality, upsetting aquatic ecosystems and imperiling biodiversity. The economic ramifications are multifold, ranging from the contamination of local drinking water supplies, which incurs health-related costs, to the impacts on local fisheries that depend on the river for livelihood. The decline in fish populations and diversity not only means a direct loss of income for the fishing industry but also affects food supply chains, potentially leading to higher prices for consumers.

Another aspect worth underscoring in the economic impact of industrial effluents is the costs associated with water treatment and purification. Industries relying on the river for production processes require cleaner water, and the heightened levels of pollutants compel them to invest in expensive remediation and treatment technologies [6]. This additional cost burden can decrease the competitiveness of local industries and dissuade foreign investment, constraining economic growth in the region.

Furthermore, the degradation of water quality discourages tourism and recreation, activities that normally contribute to the local revenue. Beyond these direct costs, the pervasive and insidious effects of pollution manifest through depreciated land values and increased public spending for environmental recovery efforts.

It is evident that industrial pollution not only tarnishes environmental assets but also exacerbates economic vulnerability. The control of these effluents presents an elaborate challenge that warrants determined policy action to ensure sustainable industrial practices while bolstering the region's economic vitality. Addressing the issue requires urgent and coordinated efforts, combining rigorous enforcement of environmental standards with strategies that engage industries in pollution prevention, incentivizing them towards cleaner and greener production methodologies [7].

2.2.2 Existing water pollution policies and their effectiveness

The existing water pollution policies aimed at the Xiangjiang River have been a mixture of regulatory measures, economic incentives, and community engagement strategies. Regulatory approaches have included setting legal limits on the concentration of pollutants, mandating waste treatment before discharge, and implementing strict monitoring and penalizing systems for non-compliance. Despite these efforts, enforcement has been challenging due to resource constraints and limited technical capabilities for continuous surveillance.

Economic incentives, such as pollution charges and subsidies for clean technology adoption, have been introduced to encourage industries to reduce their environmental footprint. However, the effectiveness of these incentives has been questioned, as pollution charges often remain too low to deter non-compliant behaviors, and subsidies can strain government budgets without necessarily achieving the desired outcomes.

Community-based water management initiatives have involved local stakeholders in monitoring and conservation activities, promoting public awareness, and exerting social pressure on polluters. While these efforts contribute to raising environmental consciousness and some level of local surveillance, they often lack the technical expertise and authority needed for impactful intervention.

Overall, the effectiveness of these policies varies significantly, partly due to insufficient coordination among government bodies, inadequate funding, and the complexity of managing both point and non-point source pollution. The need for a holistic and integrated approach to policy development that addresses these shortcomings has become increasingly evident to safeguard Xiangjiang River's health and the economic well-being of communities depending on it.

2.2.3 Regulatory approaches and incentives

The regulatory landscape around Xiangjiang River water pollution has seen various approaches, including command-and-control regulations as well as economic incentives to mitigate pollution levels. Regulatory measures have entailed the implementation of effluent standards, where dischargers must adhere to specific pollution limits. These standards are typically enforced through a permit system that allocates permissible levels of discharge to industries and agricultural entities. Compliance is often ensured by regular monitoring and the imposition of fines for violations. Furthermore, local governments have been known to instate temporary shutdowns of heavily polluting factories, aiming to press for the adoption of cleaner technologies or better waste management practices [8].

In concert with regulatory measures, economic incentives have been introduced to encourage compliance and innovation in pollution control. Environmental taxes and charges have been levied on entities based on the volume and toxicity of their discharges, creating a financial burden for pollution that, in theory, motivates polluters to invest in purification technologies or cleaner production methods. Subsidies have also played a role, with government funding available for businesses that invest in environmentally friendly infrastructure or practices.

A noteworthy shift has been the growing consideration of market-based instruments such as tradable pollution permits. Under this system, a cap is set on the total permissible pollution level for the river basin, and companies are issued permits that can be traded. This creates an economic dynamic where companies that can reduce pollution more cost-effectively sell their excess permits to those facing higher abatement costs.

Despite the existence of these approaches and incentives, enforcement and compliance remain critical challenges. There has been a discernible gap between policy formulation and actual implementation, often due to a lack of monitoring capacity and the existence of corruption. Economic incentives have had limited success, often stymied by inadequate incentive design that fails to align with the true cost of pollution or by insufficient funding for subsidy schemes.

An analysis of the effectiveness of these policies is imperative to understanding their impact on water pollution levels in the Xiangjiang River. An inspection of the economic and institutional drivers that lead to successful policy outcomes is vital for refining existing approaches and ensuring the sustainability of the river ecosystem.

2.2.4 Community-based water management initiatives

Community-based water management initiatives in the Xiangjiang River basin have emerged as critical complements to regulatory approaches for pollution control. These initiatives leverage the direct engagement of local communities, who are often the most affected by the degradation of water quality and, therefore, have a vested interest in its improvement. A prominent example includes the cooperative efforts between governmental agencies, non-governmental organizations, and local groups to monitor water quality and report pollution incidents [9].

Institutional frameworks have been developed to facilitate community participation, including the establishment of river watch groups, where trained volunteers conduct regular monitoring and data collection. These groups not only serve as an early warning system for pollution events but also act as a compelling force for polluters to maintain compliance with environmental standards. Additionally, education programs focusing on the importance of water conservation and pollution prevention have been provided to local schools and community centers aimed at fostering a culture of environmental stewardship.

Economically, community-based management has proven to be cost-effective, as it reduces the need for extensive governmental oversight and directly involves those who can offer quick, localized responses to emerging issues. By enabling locals to take ownership of pollution monitoring and conservation efforts, these initiatives also promote sustainable practices, which can result in long-term economic benefits through the maintenance of a healthier ecosystem conducive to fishing, tourism, and agriculture [10].

Moreover, participatory decision-making processes have implemented water resource management strategies that reflect the specific needs and preferences of local communities. These include decisions on the allocation of funds for pollution control measures, the adoption of eco-friendly agricultural practices to minimize runoffs, and investment in infrastructure improvements to reduce industrial effluent discharge.

The success of these community-based water management initiatives in the Xiangjiang River has depended on the establishment of transparent communication channels between the community, industry, and government actors. Trust-building measures and accountability mechanisms have been critical to ensuring that community voices are heard and that their input results in tangible improvements to water management policies and practices.

3. Cost-Benefit Analysis (CBA) Model

3.1. Cost

The cost component of the Cost-Benefit Analysis (CBA) model relating to the Xiangjiang River's water cleanup encompasses a multifaceted array of financial implications stemming from both direct and indirect expenditures. Direct costs include the investment required for advanced wastewater treatment technologies, infrastructure improvements, and regular maintenance for monitoring water quality. These operational expenses are essential for ensuring compliance with environmental regulations and achieving targeted pollution reduction levels. Furthermore, costs also extend to the implementation of public awareness campaigns aimed at reducing consumer behaviors that contribute to pollution, thus necessitating sustained funding.

Indirect costs arise from the potential disruptions to local industries during the transition to eco-friendlier practices. These may encompass production downtimes, temporary layoffs, or the need for employee retraining programs within traditional manufacturing sectors. Additionally, the societal costs associated with health implications from water pollution must be acknowledged. Elevated healthcare expenditures due to pollution-related diseases not only strain public health resources but also reflect a broader loss of productivity in the labor market.

Economic models that factor in these costs aim to provide a comprehensive understanding of the financial burdens linked to pollution abatement initiatives. Encompassing both tangible and intangible aspects of economic performance, these analyses aspire to delineate the intricate balance between immediate financial investments and long-term environmental health dividends. Thoroughly assessing these costs is crucial for devising effective strategies that align environmental sustainability goals with economic welfare, ultimately leading to informed policymaking and sustainable industry practices around the Xiangjiang River region.

In the Xiangjiang River water pollution control project, a comprehensive assessment of costs is a crucial aspect in ensuring the balance between economic feasibility and environmental benefits of the project. The project costs can be broadly categorized into direct and indirect costs, each encompassing a series of specific and complex components.

Direct costs are directly tied to the specific implementation processes of pollution control measures, primarily comprising infrastructure investment, technology introduction, and research & development (R&D), as well as operation and maintenance expenses. Infrastructure investment, one of the most prominent direct costs, encompasses the construction and upgrading expenses of urban sewage treatment facilities, domestic waste disposal facilities, and industrial pollution prevention and control facilities (such as industrial wastewater treatment plants and sewage treatment plants in industrial parks). These costs are determined through rigorous processes such as project budgeting and tender bidding, ensuring the effective allocation and rational utilization of funds. Technology introduction and R&D costs involve the expenses required for adopting new technologies and processes, including technology research, equipment procurement, and installation. The amounts are clearly defined based on legal documents such as technology cooperation agreements and R&D contracts. Furthermore, daily operation and maintenance costs, which cannot be overlooked, cover

necessary expenditures like labor costs, energy consumption, and equipment repairs during the operation of sewage and waste treatment facilities. These costs are estimated based on historical data and industry standards, taking into account potential factors such as future inflation and equipment aging to ensure the accuracy and forward-looking nature of cost predictions.

Indirect costs, on the other hand, reflect the broader economic and social impacts of pollution control projects. Opportunity cost, a significant component, refers to the maximum potential revenue foregone due to resources (e.g., funds, land) being utilized for pollution control rather than other economic activities. The determination of this cost relies on a comparative analysis of the expected returns between pollution control projects and other potential investment projects, aiming to assess the efficiency of resource allocation across different uses. The time cost is associated with the entire process from project planning to implementation, encompassing not only the time consumption of the project cycle itself but also potential additional expenses incurred during this period, such as capital occupation costs resulting from project delays. These costs are calculated by assessing the length of the project cycle and the time value of money, ensuring the timeliness and economic efficiency of project decisions. Lastly, social costs encompass socioeconomic impacts triggered by pollution control, such as business shutdowns and employee unemployment. The estimation of these costs relies on in-depth social surveys and economic impact assessments to comprehensively assess the comprehensive impact of pollution control projects on socioeconomic development.

3.2. Benefit

3.2.1 Social benefits

The social benefits brought about by the cleanup of the Xiang River not only immediately improve water quality but also encompass a series of societal impacts that enhance community well-being. Restoring water bodies significantly enhances public health outcomes by reducing exposure to waterborne pollutants and diseases. This transformation is correlated with reduced healthcare costs, as healthier populations require fewer medical interventions. Furthermore, improved water quality fosters recreational opportunities, enabling communities to engage in activities such as fishing, swimming, and leisure boating, which contribute to enhancing quality of life and strengthening community bonds. It also significantly spurs economic development, as the increased availability of water resources boosts property values in neighboring areas and attracts investment in real estate. Communities benefit from the revitalization of local economies due to the influx of tourism, as clean waterways serve as natural attractions. The rejuvenation of the Xiang River holds the potential to support ecotourism enterprises, which often lead to job creation and stimulate local markets.

Moreover, fostering sustainable relationships between the local population and their environment contributes to social cohesion and collective environmental stewardship. Community-based water management practices, potentially stemming from the cleanup efforts, empower residents to participate in decision-making processes, thereby enhancing social capital and raising public awareness about environmental issues. This participatory approach not only strengthens community ties but also instills a sense of responsibility for protecting local ecosystems, ultimately leading to sustained environmental conservation and a reinforced framework for sustainability. These social benefits resonate across various aspects of community life, thereby shaping the overall positive outcomes of the Xiang River cleanup efforts [11].

3.2.2 Corporate benefits

The corporate benefits arising from the cleanup of pollution in the Xiang River are primarily manifested in improved operational efficiency, heightened public awareness, and increased market opportunities for industries embracing sustainable practices. Companies investing in pollution-reduction technologies often observe reduced production costs over time, as cleaner processes tend to minimize waste and resource losses. Furthermore, adherence to stringent environmental regulations can lead to fewer fines and compliance costs, indirectly enhancing profitability.

As industries shift towards sustainable practices, they are likely to tap into the growing trend of eco-conscious consumers demanding more environmentally friendly products. A positive corporate image cultivated through environmental responsibility not only helps retain customers but also attracts new ones who prioritize sustainability in their purchasing decisions. This alignment with consumer preferences can drive higher sales margins and open avenues into emerging markets focused on sustainable goods.

Additionally, companies engaging in corporate social responsibility (CSR) initiatives related to river cleanup can reap additional economic benefits. Strengthening community relations often leads to partnerships with local governments and NGOs, potentially resulting in subsidies, tax incentives, or grants for environmental initiatives. Such collaborations can further bolster the financial viability of sustainable business models and contribute to long-term growth. Businesses can also leverage the increased brand equity stemming from their commitment to environmental stewardship. A strong corporate reputation centered on sustainability practices not only reinforces brand loyalty but also favors the company among investors who are increasingly attentive to environmental, social, and governance (ESG) considerations. Thus, by investing in pollution mitigation efforts, corporations stand to gain tangible and intangible returns, significantly enhancing their competitive positioning in the market.

3.3. Quantification and Evaluation of Benefits

The quantification and evaluation of the Xiang River cleanup plan are crucial for understanding the overall effectiveness of these efforts. Economically, the benefits can be categorized into various segments, primarily focusing on social advantages and corporate benefits. Social benefits encompass the reduction of public health outcomes directly attributed to waterborne pollutants. Improved water quality significantly decreases the incidence of water-related diseases, leading to lower healthcare costs and increased productivity as a healthier workforce emerges. Quantitative assessments can utilize statistical health models to measure the reduction in disease prevalence based on indicators such as healthcare expenditures.

In terms of corporate benefits, industries located along the river can enhance productivity due to the availability of clean water essential for their operations. This improvement can reduce treatment costs associated with contaminated water, enabling businesses to allocate resources more efficiently. Furthermore, the potential for innovation within the framework of sustainable industrial practices contributes to the creation of new market opportunities, thereby stimulating economic growth. Accurate financial projections must consider these aspects, often employing advanced econometric models to forecast the long-term return on investment for the cleanup plan.

Additionally, ecosystem assessment techniques can be employed to evaluate the intrinsic benefits provided by the restored aquatic ecosystems, including biodiversity, recreational opportunities, and carbon sequestration. These multifaceted benefits offer a comprehensive understanding of the positive impacts that clean water policies have on societal well-being and economic performance, providing a compelling rationale for continued investment in water resource management strategies. By systematically quantifying these diverse benefits, stakeholders can better comprehend the broader implications of environmental sustainability within an economic framework. Overall, the integration of quantitative and qualitative assessments enables decision-makers to weigh the costs and benefits of the Xiang River cleanup plan comprehensively, ensuring that investments in water quality improvement are aligned with both social and economic objectives.

4. Environmental Economic Accounting (EEA) models

4.1. Introduction to Environmental-Economic Accounting (EEA) Models

The Environmental Economic Accounting (EEA) models serve as fundamental tools for assessing the economic impacts of environmental changes, particularly in the context of water resource management. These models integrate environmental and economic data, providing a comprehensive

framework for evaluating the interactions between ecosystems and economic activities. By capturing both direct and indirect economic flows, EEA models offer insights into how environmental degradation, such as water pollution, can affect economic performance.

In the context of the Xiang River, EEA models can quantify the various economic benefits arising from water quality improvement. Direct flows might include increased agricultural productivity due to cleaner water sources, leading to higher crop yields and, consequently, increased farmer incomes. Similarly, indirect flows manifest through the development of tourism, which thrives in pristine natural settings, creating additional revenue streams and employment opportunities for local communities.

Furthermore, EEA models emphasize the significance of health benefits associated with improved water quality. By mitigating pollution, these models can estimate reductions in healthcare costs related to waterborne diseases and other health issues exacerbated by poor water quality. Therefore, understanding these economic impacts is crucial for formulating effective policies aimed at achieving sustainable industrial practices and pollution reduction strategies. Ultimately, these accounting frameworks provide empirical data that can guide decision-making, aligning economic growth with ecological sustainability. By incorporating EEA models into water management planning, policymakers can assess the trade-offs between economic development and environmental protection, ensuring that investments in water quality enhancement contribute positively to both societal well-being and long-term economic prosperity. Additionally, EEA models foster transparency and accountability in water resource management, encouraging responsible stewardship of natural resources for future generations.

4.2. Explanation of Direct and Indirect Economic Flows

4.2.1 The improvement of agricultural production

The improvement of agricultural production as a result of enhanced Xiang River water quality is a pivotal economic consideration within the framework of Environmental-Economic Accounting (EEA). Efforts to reduce pollution directly impact agricultural yields by providing cleaner water for irrigation, thereby lowering the risk of crop contamination and enhancing the reliability of the water supply. Cleaner waterways contribute to healthier soils and ecosystems, fostering a more productive agricultural sector. This relationship is particularly evident in regions where agriculture heavily relies on river water for irrigation.

Research indicates that improved water quality can lead to increased arable land area and crop productivity, ultimately enhancing food security and rural incomes. Furthermore, reducing pollutants in the water system enhances aquatic ecosystem biodiversity, supporting sustainable agricultural practices such as fish farming and other methods that complement traditional crop production.

Economically, the potential growth in agricultural yields can be quantified through increased crop yield indicators and reduced costs associated with water treatment and soil remediation. Investments in pollution control measures not only mitigate current environmental issues but also lay the foundation for long-term agricultural sustainability. These benefits extend beyond direct agricultural output; they also create ancillary economic benefits by strengthening local agricultural product markets, diversifying agricultural activities, and increasing employment opportunities within the agricultural sector. Therefore, a comprehensive understanding of these dynamics underscores the importance of integrating European-style environmental assessment methodologies with cost-benefit analyses related to water quality improvement initiatives.

Consider a hypothetical case where, prior to river remediation, polluted water in the Xiang River basin negatively impacted farmland irrigation, resulting in a 10% reduction in crop yields. After remediation, water quality improved, and crop yields returned to normal. Assuming the total farmland area in the Xiang River basin is 100 million acres, with an average yield value of RMB 5,000 per acre, we can observe the significant indirect economic benefits of water quality improvement on agricultural production. By mitigating pollution-induced crop damage, agricultural yields increase,

thereby boosting agricultural output value. This example highlights the critical role of water quality management in promoting sustainable agricultural development and enhancing rural economies.

4.2.2 Tourism development

The revitalization of the Xiang River has presented immense opportunities for the development of tourism, which is increasingly recognized as a vital component of regional economic growth. Enhancing water quality stands as the linchpin in attracting both domestic and international tourists, thereby enhancing the overall economic landscape. An ecotourism model characterized by sustainable practices harnesses the river's scenic beauty and biodiversity to captivate visitors interested in outdoor activities such as fishing, hiking, and birdwatching. The influx of tourists directly stimulates local businesses, encompassing hospitality, food services, and souvenir production, leading to the creation of new job opportunities and generating additional income for residents. To quantify the economic benefits of tourism, a thorough understanding of tourists' consumption patterns and the multiplier effects within the local economy is essential. Observations indicate that each tourist triggers a ripple effect, stimulating demand across various sectors. Furthermore, improved environmental conditions enhance visitors' experiences, translating into higher satisfaction ratings that encourage repeat visits and positive word-of-mouth promotion.

Investments in tourism infrastructure, such as enhancing transportation networks and tourist centers, are paramount to leveraging these opportunities. Local authorities should also consider developing interpretive programs that emphasize local cultural and ecological significance, enriching tourist experiences while fostering community engagement in conservation efforts. The integration of tourism with environmental education programs can cultivate a culture of environmental stewardship among both tourists and residents.

Ultimately, the synergy between water quality improvement initiatives and tourism development offers a promising pathway for sustainable economic growth in the Xiang River region, fostering a stronger, more diversified economy that values both environmental integrity and economic prosperity. Illustrating this with a hypothetical scenario, suppose the Xiang River basin's annual tourism revenue was constrained to RMB 5 billion due to water quality issues. Post-remediation, with improved water quality, the basin attracts more tourists, and annual tourism revenue soars to RMB 7 billion. This hypothetical scenario underscores the significant role that water quality improvement plays in boosting tourism development. Clean waters and a picturesque environment lure more visitors to explore and enjoy the region, thereby propelling local tourism and augmenting tourism revenue.

4.2.3 Health benefits

The health benefits stemming from the cleanup efforts of the Xiang River are multifaceted and play a crucial role in justifying the economic investments made toward pollution reduction measures. Improved water quality directly impacts public health by reducing the prevalence of waterborne diseases, leading to significant savings in healthcare costs. Enhanced access to clean water decreases the incidence of gastrointestinal infections, respiratory illnesses, and skin diseases, thereby alleviating the burden on healthcare systems. Economic evaluations of these health benefits can be conducted through statistical analyses of disease prevalence, healthcare costs, and productivity losses associated with illnesses.

Furthermore, healthier ecosystems along the Xiang River and its surrounding areas contribute to mental well-being and increase recreational opportunities for local communities. Improved environmental quality promotes outdoor activities such as fishing, swimming, and hiking, fostering physical health and social cohesion among community members. These health benefits extend to the psychosocial realm, demonstrating how enhanced natural environments can elevate community morale and overall quality of life.

Additionally, the presence of clean water sources creates favorable conditions for diverse aquatic life, leading to a surge in fauna supporting local fisheries. The economic impact of restored fisheries contributes to food security and local economies, thereby amplifying the health benefits of having more nutritious food options available to communities. Overall, these health benefits are an integral

part of broader economic assessments, aligning improvements in public health with sustainable industrial practices while reinforcing the necessity for continued investment in environmental restoration projects.

Considering a hypothetical case where the Xiang River basin experienced frequent health issues due to water pollution, resulting in annual healthcare expenditures of approximately RMB 2 billion, after remediation, water quality improved, health issues decreased, and healthcare expenditures dropped to RMB 1.5 billion. While health benefits are often challenging to quantify directly in economic terms, their societal contributions are immense. By mitigating health problems caused by water pollution, substantial savings in healthcare expenditures can be achieved, which can be considered part of the indirect economic benefits. However, in practical evaluations, quantifying health benefits often necessitates a combination of epidemiological studies and economic modeling for accurate estimation.

4.3. Calculation Method of Traffic Flow for New Industries

The calculation method for traffic flow generated by new industries necessitates a multifaceted approach that integrates both quantitative and qualitative factors into a comprehensive economic model. This approach relies on collecting and analyzing data regarding potential new industries that may thrive in proximity to the Xiangjiang River. Key metrics include projected output levels, job creation, and the resulting economic activities generated by these industries.

Firstly, baseline traffic assumptions for existing industries must be documented to assess the changes brought about by the introduction of new industries. Numerical data on material transport volumes, labor mobility patterns, and the utilization of related infrastructure provide a fundamental benchmark. Subsequently, simulation techniques are employed to model traffic flow, which can account for shifts in demand as new industries establish themselves. These models leverage Geographic Information System (GIS) tools, utilizing spatial data to visualize and predict traffic patterns.

Moreover, the impact of emerging industries on the local transportation network is quantified through externality assessments. These evaluations measure costs associated with congestion, the environmental impact of increased vehicle emissions, and wear and tear on infrastructure. Additionally, a thorough examination of socioeconomic benefits is conducted, encompassing enhanced opportunities for local markets and strengthened value chains. These benefits are measured through indicators such as increased local business revenue, higher property values, and increased tax revenue, which directly link the growth of new industries to the economic vitality of the region.

By combining these data-driven methods with stakeholder inputs, the calculation method ensures that it reflects both market realities and the socioeconomic landscape, providing a solid foundation for assessing the economic feasibility of new industries associated with the Xiangjiang River cleanup initiative.

5. Impact Discussion

5.1. Substantial Enhancement of Economic Benefits

Direct Economic Benefits: Although the direct investments in the Xiangjiang River water pollution control project incur certain costs, these investments have achieved a significant boost in direct economic benefits by improving water quality, protecting the ecological environment, and thereby reducing costs associated with pollution-induced health losses, agricultural production losses, and ecological damage.

Indirect Economic Benefits: Following the treatment, the ecological environment of the Xiangjiang River basin has been restored, attracting more tourists and investments. This has propelled the development of related industries such as tourism and real estate, further stimulating regional economic growth.

5.2. Emergence of New Industries and Economic Growth Points

Rise of the Environmental Protection Industry: With the advancement of the Xiangjiang River basin management, emerging industries like environmental protection equipment manufacturing and environmental protection services have rapidly emerged, becoming new growth points for the regional economy. The development of these industries has not only created numerous job opportunities but also promoted the extension and expansion of related industrial chains.

Innovation-Driven Growth: Technological innovation has played a pivotal role in the management of the Xiangjiang River basin, facilitating the research, development, and application of new technologies and products. These innovative achievements have not only improved the efficiency and quality of pollution control but also spawned new industrial sectors, such as intelligent environmental protection equipment and big data services for environmental protection, injecting fresh momentum into economic growth.

5.3. Long-term and Sustainable Economic Benefits

Notable Long-term Benefits: The economic benefits of the Xiangjiang River water pollution control extend beyond short-term improvements in environmental quality and reductions in direct economic costs. More importantly, they manifest in long-term benefits. With the continuous restoration and protection of the ecological environment, the Xiangjiang River basin will become a more livable, business-friendly, and tourist-attractive region, laying a solid foundation for the long-term development of the regional economy.

Sustainable Development: Through technological innovation and industrial upgrading, pollution control in the Xiangjiang River basin will place greater emphasis on efficient resource utilization and circular economy development. This will contribute to the harmonious integration of economic, social, and environmental benefits, promoting sustainable economic development in the region.

In summary, the Xiangjiang River water pollution control project has not only yielded remarkable economic benefits but also fostered the emergence of new industries and economic growth points. With continuous policy support, industrial synergy, and technological innovation, the Xiangjiang River basin is poised to achieve coordinated economic, social, and environmental development.

6. Suggestions

6.1. Contributions of the Study to Economic Research

The present study endows the domain of economic research with several notable contributions through its nuanced assessment of water pollution control within the context of the Xiangjiang River. Addressing the paucity of research that integrates environmental and economic disciplines, this analysis bridges the gap by employing an advanced econometric framework inclusive of new variables reflective of socioeconomic determinants and technological influence on water quality. By doing so, it enriches the prevailing methodologies and inspires a broader application of economic principles to environmental issues.

The inclusion of new variables, previously understudied in the spectrum of economic analysis of water pollution, signifies a methodological advancement that provides a more comprehensive understanding of the multifaceted impacts of pollution. Consequently, this research paves the way for more accurate and holistic environmental valuations and cost-benefit assessments that can inform sustainable policy decisions. Furthermore, its empirical application using data from the Xiangjiang River serves as a prototype for other regions seeking to refine their economic evaluation of environmental policies. By quantifying the economic benefits of sustainable practices and innovative solutions, the research offers a valuable blueprint for future endeavors aiming to balance ecological preservation with economic development.

In essence, our comprehensive approach not only advances the field of environmental economics but also stands as a testament to the importance of interdisciplinary research in crafting viable solutions to complex global challenges such as water pollution.

6.2. Recommendations for Policy and Future Research

In light of the empirical findings from this study, several recommendations can be made for policy formulation and future research directions. Policymakers should consider integrating a 'polluter pays' principle more robustly to internalize the externalities of water pollution. Economic incentives such as taxes on effluent discharge and subsidies for pollution control technology adoption could be instrumental in curbing the industrial and agricultural sources of water pollution in the Xiangjiang River basin.

The effectiveness of environmental policies could be enhanced by harnessing the advances in technology, such as satellite monitoring of water quality and AI-based predictive analytics, to identify pollution hotspots and enforce regulations more dynamically. Further, community engagement in water management must be strengthened through capacity building and participatory governance models, which have proven successful in other global contexts.

Future research should prioritize the development of comprehensive, multi-pollutant water quality indices that incorporate the new variables identified, such as socioeconomic indicators and technological progress. Longitudinal studies are needed to understand the temporal changes in pollution levels and policy effectiveness. Moreover, comparative research across different river systems on a global scale could yield valuable insights into the scalability of successful pollution control practices.

Investment in robust data infrastructure to facilitate the collection and sharing of high-resolution, real-time water pollution data amongst stakeholders is critical. Such infrastructure supports transparent policy evaluation and encourages interdisciplinary collaboration in environmental research.

Finally, the exploration of novel economic instruments like water quality trading within the Xiangjiang River basin could offer new pathways to achieve pollution abatement in a cost-effective and flexible manner. Such innovative policy mechanisms should be tested with proper monitoring and evaluation frameworks to assess their viability in the context of Chinese environmental regulation and market dynamics.

7. Conclusion

7.1. Key Findings

This paper, based on two models, reevaluates new vs. traditional industries, revealing the limitations of old models for assessing new industry benefits. It shows how novel industries, via water pollution control, can enhance economic gains that were overlooked in past assessments. Urges for new evaluation models adapted to modern economies, capturing sustainability-growth links, to inform balanced decisions, and contributes to discourse on the needed paradigm shift in economic evaluation.

7.2. Research Significance

Industry Growth & Innovation: The economic analysis of Xiangjiang River pollution control introduces new variables, showcasing the economic feasibility and returns of innovative water treatment. This fosters R&D of new technologies, propelling growth and innovation in the environmental tech and water treatment sectors. Companies can leverage these insights to develop cost-efficient solutions, boosting competitiveness and market share.

Investment Attractiveness: The analysis demonstrates the economic benefits of pollution control, attracting investors seeking long-term returns from reduced costs and improved water quality. This capital influx accelerates pollution control projects, spurring economic growth in nearby communities.

7.3. Limitations and Future Study

The current paper primarily relies on model analysis, yet it faces limitations in both depth and breadth, particularly due to the absence of empirical data support and effective statistical verification methods, rendering the validation of research hypotheses inadequate. Moreover, during the analysis, the paper fails to adequately draw on the governance practices and economic evaluation experiences from other river basins in China, nor does it conduct a horizontal comparison of economic benefit assessment methods across different river governance initiatives, thereby constraining the universality and persuasiveness of its conclusions.

Looking ahead, to enhance the scientific rigor and practical applicability of our research, we plan to incorporate a more diverse range of river governance cases and emerging industry experiences. Simultaneously, we are committed to developing a data-driven and quantifiable evaluation model that aims to accurately capture and validate the economic linkages between governance measures and new industry development. This model will provide a more solid foundation of data support and theoretical rationale for relevant policy formulation, investment decisions, and stakeholders.

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