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# A Study of the Spatial Relevance between Economic Development and Water Resources Utilization in the Upper Reaches of Minjiang River Basin

**Chunlei Song, Bing Zhao***

Southwest Minzu University, Chengdu, China
Email: 790264116@qq.com, *zhaobin_swun@sina.com

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## Abstract

By adopting the methods of GIS and Spatial Correlation Analysis, from the perspective of the spatial scale, the author analyzed the spatial relevance between all the counties' GDP and their water resources utilization in the upper reaches of Minjiang River Basin. The research shows that, firstly, their GDP and water resources utilization distribute disproportionally. Secondly, their GDP of secondary industry has definite correlation in spatial distribution and certain degree of spatial aggregation, at the same time, which is positively related to water consumption in spatial correlation. After analyzing the correlation of GDP and water resources utilization, it is found that the total water consumption and water consumption of the secondary industry are positively correlated with GDP spatially, while the GDP of the primary industry and the tertiary industry are negatively correlated with water consumption. The scarcity of available water resources is a key restricting factor for the economic development of western China. Due to the limitations of data collection, there may be some deviations in the final data analysis.

## Keywords

Water Resources, Spatial Correlation, Moran Index, Water Consumption

## 1. Introduction

Rational exploitation and utilization of water resources and rational optimal allocation of resources are the prerequisites for achieving the goal of sustainable development in economy and environment. In some Arid Valley Areas of the upper reaches of Minjiang River, the irreplaceability and uneven spatial and

temporal distribution of water resources are the main restrictive factors that limit the economic and social development' speed and degree in Arid Valley Area [1]. It is conducive to the rational development and utilization of water resources and their optimal allocation for studying the spatial distribution of water resources and its corresponding relationship with regional economic development.

The water resources development, utilization and optimal allocation are aimed at sustainable development of social economy and ecological environment. In the study of the relationship between regional economic development and water resources, Zhang Liming and others used Grey Correlation Analysis Method to quantitatively analyze the correlation between urban economic development and water resources utilization structure, and concluded that per capita GDP exerts a greater impact on the change of water resources utilization structure. Zhang Zhenlong and others used VAR model to analyze the long-run equilibrium relationship between water consuming industry ecosystem and economic growth in the upper reaches of Minjiang River, and found that economic development has a negative impact on water consumption [2].

Spatial Statistical Analysis is an important approach to study spatial distribution and correlation [3]. Ran Zeze analyzed the economic growth and spatial correlation of the Core Node Cities in Northwest China of the Silk Road Economic Belt, taking Moran Index to figure out the correlation of spatial distribution of economic development. Zhang Xuebin and others applied Spatial Analysis and Statistical Analysis Methods to explore the spatial & temporal pattern and spatial action relation of economic differences in the basin [4]. Liu Na and others have studied the spatial variation and correlation of population and economy in Gansu Province, and analyzed the corresponding relationship between population and economy both from the time and spatial scales. There are still many related studies, and the Spatial Statistical Analysis Method is more thorough [5].

This paper analyzed the spatial correlation between regional economic development and water resources utilization in the upper reaches of Minjiang River, and thus more intuitively illustrated the role of water resources utilization in its economic development, and also provided a reference for this areas' more scientific and sustainable development in economy and ecological environment.

## 2. Definitions and Methods of the Research

The upper reaches of Minjiang River Basin refer to the eastern part of Qinghai-Tibet Plateau, northwest of Sichuan Basin and east of Tibetan Qiang Autonomous Prefecture of Ngawa. It's situated in the triangular land mass between the Qinling zonal tectonic belt, the Longmenshan North-North-East tectonic belt and the Barkam North-West tectonic belt. Its longitude ranges from 102˚33'46-104˚15'36, and its latitude ranges from 30˚45'37"-33˚69'35". this area has abundant water resources because of interlaced rivers and vast lakes, etc. The per capita water resources is top-ranked nationwide. However, the unavailable

glacier reserves account for a large part, and most of this area is arid valley so that water resource is a little bit scarce. As for the spatial scale, the distribution of water resources is uneven in the upper reaches of Minjiang river, which has prominent constraint on regional economic development.

In this study, those spatial vector data are selected from the county-level shape-file format data in the upper reaches of Minjiang River Basin. The statistical data include population, GDP, water resources and its consumption of all the counties in the upper reaches of Minjiang River Basin in 2016 [6] [7] [8].

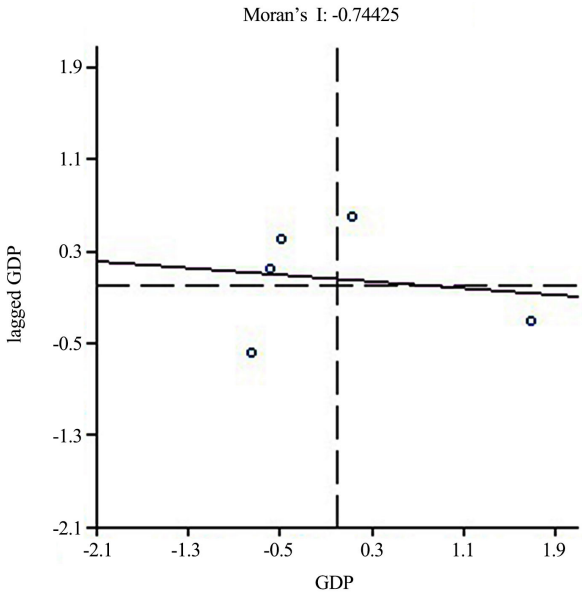
The spatial weight matrix can express the spatial topology and adjacency among different spatial objects. Firstly, a spatial weight matrix is given to represent the adjacent relationship of N spatial regions and further to indicate the relationship among different regions [9] [10]. For the former research, the adjacency relation weight matrix is often adopted. Considering that the area of the counties in the upper reaches of Minjiang River is not all close and has wide span, so the author adopted the distance weight matrix. First, the ArcGIS is used for the centroid computation of the vector data of the counties, and the average value of the adjacent distance is used as the distance weight. It can effectively avoid the imbalance of the spatial proximity. Moran index can reflect the similarity of the spatial adjacent region or its cell attribute values. After normalization of variance, the value of Moran index I will be normalized to −1.0 - 1.0. The value greater than 0 indicates positive spatial correlation, and the larger the value, the more obvious the spatial correlation; Less than 0 indicates negative spatial correlation, and the smaller the value, the greater the spatial difference. When it's equal to 0, the spatial correlation is random. The results of spatial correlation are illustrated by Moran scatter graph, which is used to describe local spatial instability. The four quadrants of Moran scatter graph correspond to four types of local spatial correlation between the regional unit and its neighbors, respectively. Combining Moran scatter diagram with LISA significance level, Moran significance level graph can come into being.

## 3. Results and Analysis of the Research

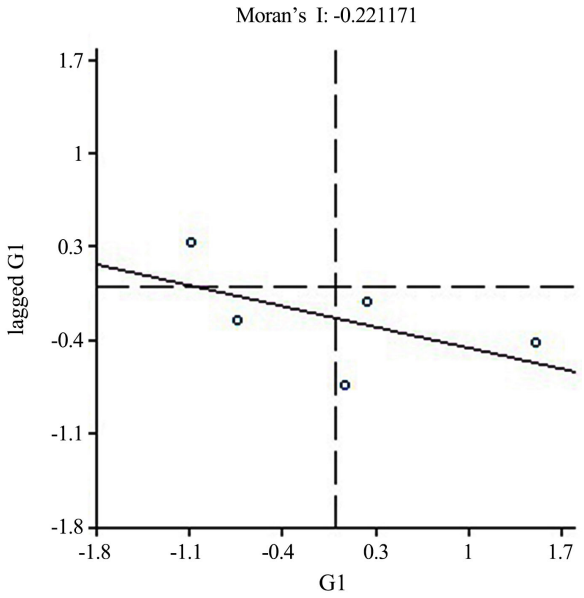
### 3.1. Spatial Distribution Characteristics of Economic Development in the Upper Reaches of Minjiang River Basin

In 2016, the GDP of the upper reaches of Minjiang River Area reached 1537.76 million yuan. Based on the global spatial self-correlation analysis of the GDP of this area's counties, the Moran's I index of the overall GDP of the counties is calculated (**Figure 1(a)**). The GDP of the counties is negatively correlated spatially. From the scatter graph, we can see that the landing points are relatively balanced and the quadrants are not far apart, which shows that it's not so obvious for the regional aggregation trend of economic development. The GDP value of Wenchuan County is higher. The Moran's I index of the second industry GDP (G2) of the counties is 0.0392942 (**Figure 1(c)**). The output value of Wenchuan and Maoxian counties is higher, but their spatial distribution of aggregation degree is not high. The Moran's I index of primary industry GDP (G1)

is −0.221171 (Figure 1(b)) and the index of tertiary industry GDP (G3) is −0.493041 (Figure 1(d)), which shows that the spatial heterogeneity of primary and tertiary industry GDP is significant in each county, and their spatial correlation is not strong. What's more, their agricultural development's types and patterns are different, and the resource output is the main constraint factor for them. However, the first and tertiary industry GDP of each county has a certain correlation, most of the data points dotted in the second and fourth quadrants, in a nutshell, it is a "low-high" trend in space. The data of total GDP and secondary industry GDP of each county are similar, that is to say, three industries plays a decisive role in market economy, and industries accounts for the largest proportion of economic development in the upper reaches of Minjiang River.




(a)




(b)

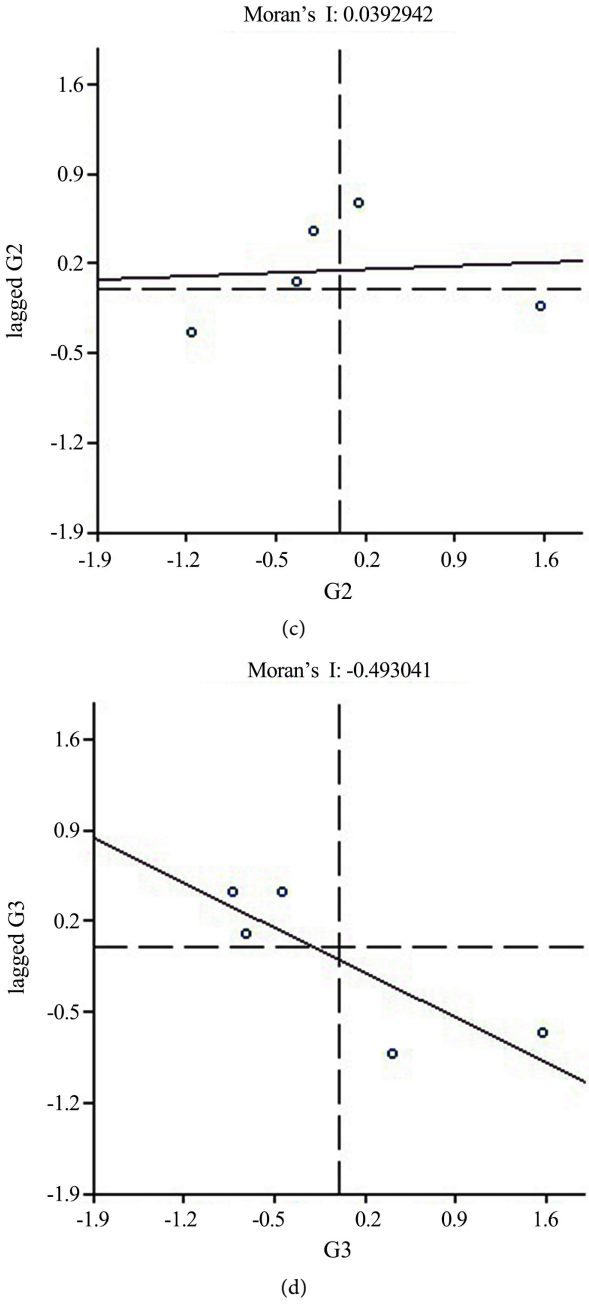
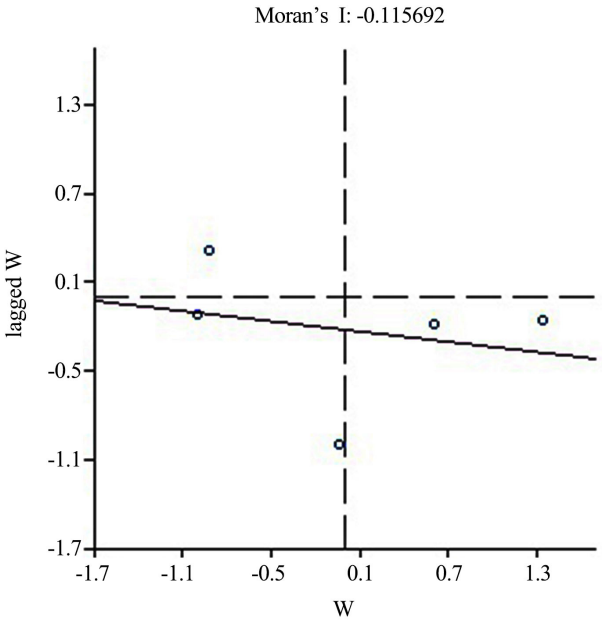



**Figure 1.** (a) GDP; (b) Primary industry GDP; (c) Second industry GDP (d) Tertiary industry GDP of Moran scatter plot.

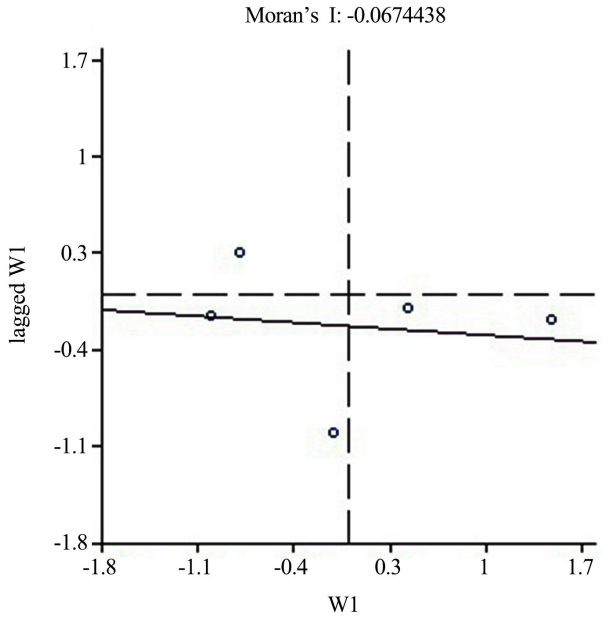
### 3.2. Spatial Correlation of Water Resources Utilization in the Upper Reaches of Minjiang River

The total amount of water consumption in the upper reaches of Minjiang River is 97.98 million cubic meters, of which 78.02 million cubic meters are used for production, accounting for 79.63% of the total amount of water. 530,000 cubic meters for ecological environment, 0.54% of the total amount of water and per capita water consumption is 251 cubic meters. The Moran's I index of total water consumption is −0.115692 (**Figure 2(a)**) and its distribution is negatively

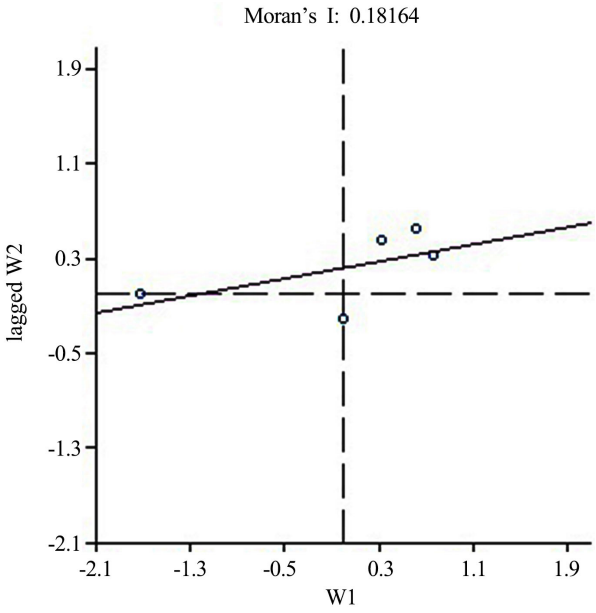
correlated in space, with definite spatial differentiation. Primary industry water consumption (Figure 2(b)) accounts for a large proportion of the total water consumption, but Moran scatter plot shows that primary industry water consumption has a negative spatial correlation. The index of secondary industry (Figure 2(c)) is 0.18164, which has a positive spatial correlation. The water consumption of tertiary industry (Figure 2(d)) shows negative spatial correlation. Maoxian county's primary industry ranks first in the whole basin, while Wenchuan county's secondary industry water consumption ranks first, and is higher than other counties in the basin.



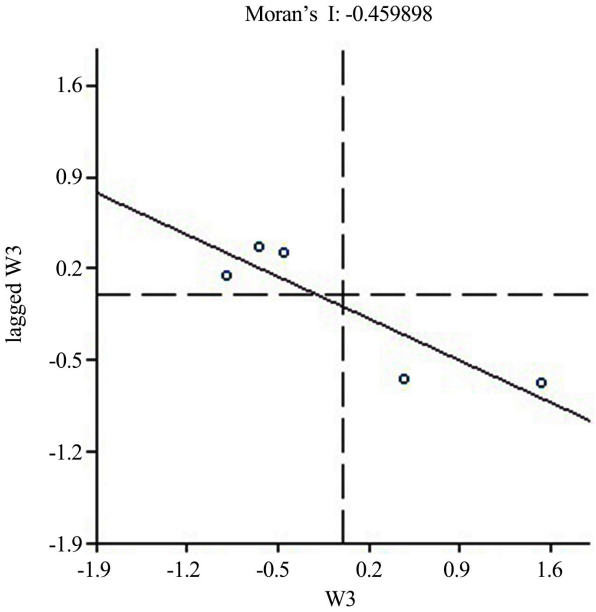

(a)




(b)




(c)




(d)

**Figure 2.** (a) Total water resources; (b) Total water consumption inprimary industry; (c) Total water consumption in second industry; (d) Moran scatter plot of total water consumption in tertiary industry.

### 3.3. Spatial Relevance Analysis of Water Resources Utilization and Economic Development in the Upper Reaches of Minjiang River Basin

**1) The Water Resources and the Spatial Distribution of per Capita GDP in the Upper Reaches of Minjiang River Basin**

Due to the special spatial and geographical location, the economic development of the upper reaches of Minjiang River takes big differences. It can be seen

from the per capita GDP plot of the basin (Figure 3), the per capita GDP value is divided into five levels. Lixian County has the highest per capita water consumption, Wenchuan County with higher per capita GDP has a lower per capita water consumption, Songpan County has a lower proportion of production water consumption, and the spatial correlation between per capita water consumption and per capita GDP is not so obvious. Wenchuan County is at a relatively high level of economic development, and the per capita GDP is low in other regions, and has a certain aggregation correlation. Per capita water consumption is relatively low in some counties with lower per capita GDP, indicating that water resources are an prominent constraint factor for economic development in the upper reaches of Minjiang River.

**2) Spatial Correlation between GDP and Water Resources Utilization in the Upper Reaches of Minjiang River**

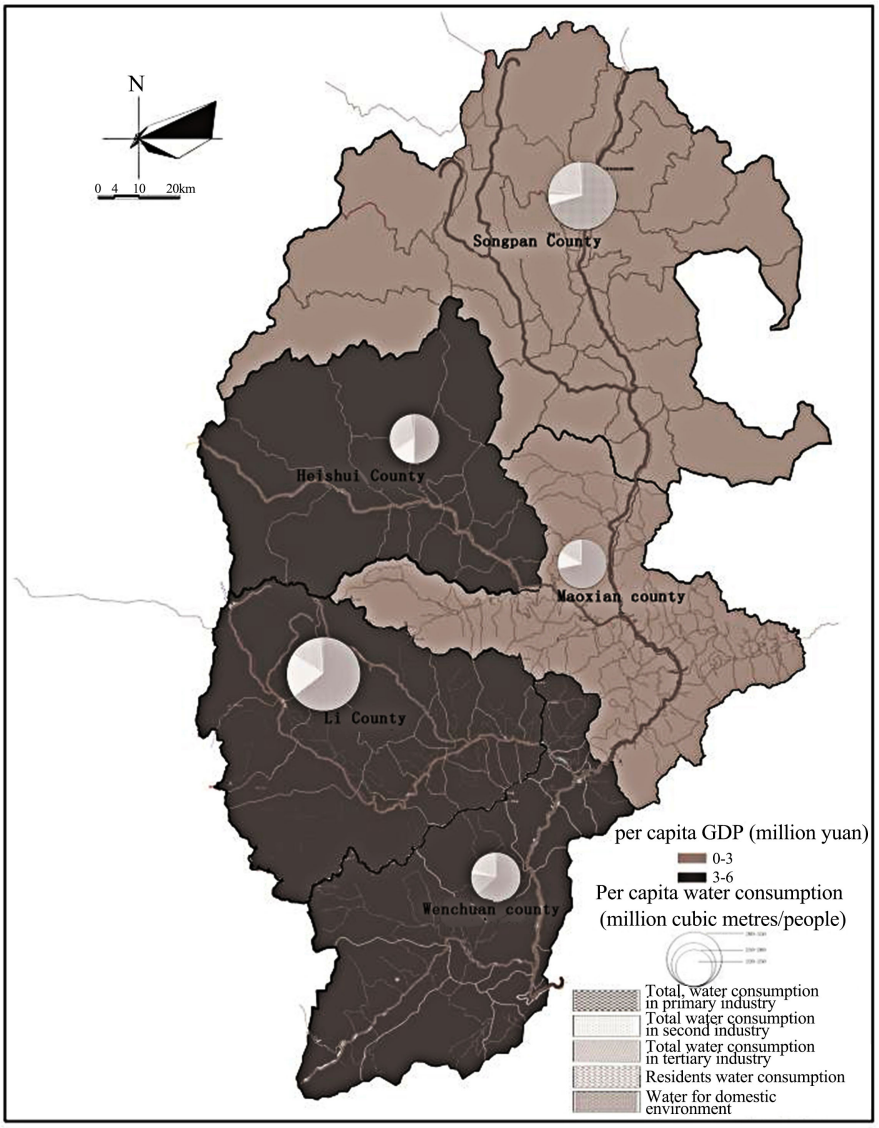
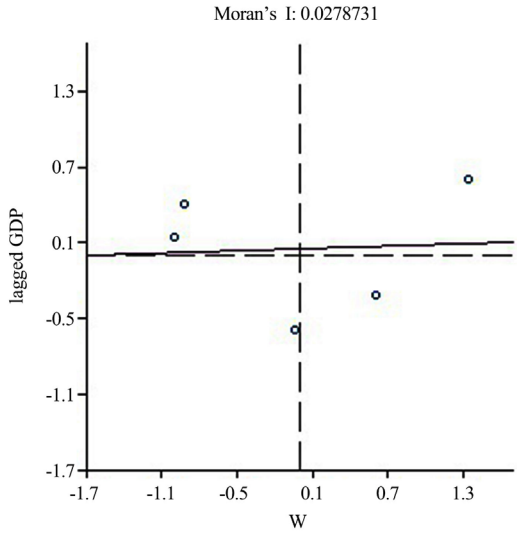



Figure 3. The spatial distribution box plot of the per capita GDP and water consumption.

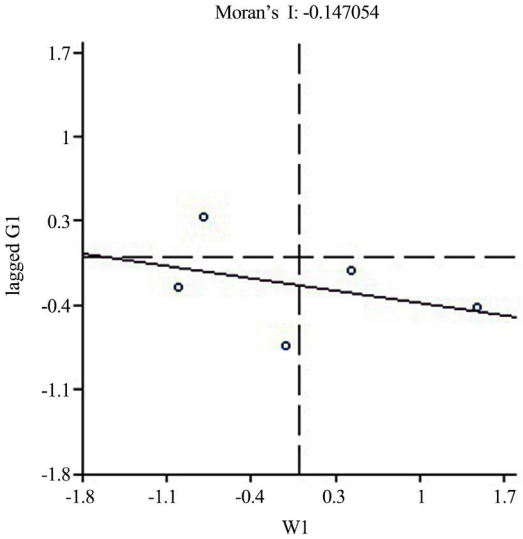
In order to further analyze the spatial correlation between GDP and water resources utilization in the upper reaches of Minjiang River, the bivariatespatial auto-correlation analysis method was used to study the spatial correlation between total water consumption and GDP, primary industry GDP and water consumption, secondary industry GDP and water consumption, tertiary industry GDP and water consumption, and explore the spatial correlation between industrial water consumption and industrial GDP. From the figure, we can see that GDP and total water consumption shows a positive correlation trend, Moran's I index is 0.0278731 (**Figure 4(a)**), which shows that GDP and water resources have a strong spatial correlation. In the spatial correlation between industrial GDP and water consumption, primary industry GDP is negatively correlated with water consumption (**Figure 4(b)**. Secondary industry GDP is positively correlated with water consumption, and its Moran's I index is 0.261119 (**Figure 4(c)**. The tertiary industry GDP is negatively correlated with water consumption (**Figure 4(d)**). The main reasons are as follows: first, the upper reaches of Minjiang River Basin are vast in territory and rich in resources, but it has a rough and steep terrain that restricts the development of primary industry, and there is unreasonable allocation of water consumption and low water use efficiency, so it has a greater impact on the local auto-correlation index. Second, with the support of production and construction in the upper reaches of Minjiang River Basin, the basic industry has developed rapidly, showing the aggregation tendency of the second industry GDP and water consumption in the first and the fourth quadrant; In addition, with the rise of tourism and service industry, the tertiary industry's dependence on water resources is weakened. Therefore, the GDP of some counties with high water consumption of tertiary industry remains lower, while that of some counties with low water consumption of tertiary industry keeps higher.

## 4. Conclusions and Discussion

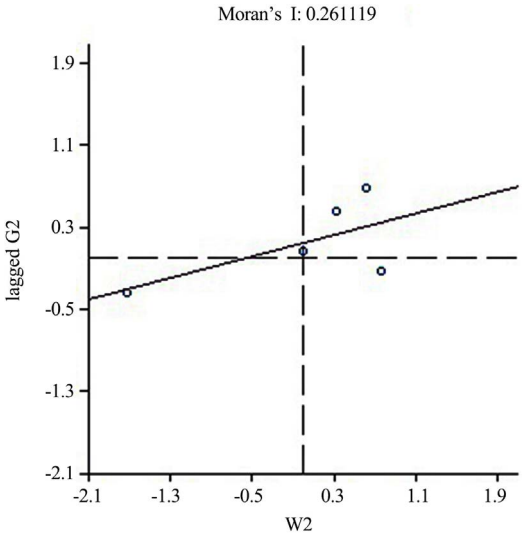
This article takes 2016 as the time node after the "one belt and one road initiative", so the author takes the year 2016 as the research time node, and the spatial correlation analysis was carried out on the basis of the GDP data and water resource utilization data of all the counties in the upper reaches of Minjiang River Basin. From the perspective of the spatial auto-correlation analysis of GDP and industrial GDP of each county, this area's spatial gap of economic development is wide. The GNP, primary industry and tertiary industry all show a negative spatial correlation trend. The spatial distribution of economic development in the upper reaches of Minjiang River by and large shows an unbalanced dot distribution. From the spatial auto-correlation analysis of water resources utilization, it is concluded that only the secondary industry water consumption is positively correlated in spatial correlation and has certain spatial aggregation, while the total water consumption, the primary industry water consumption and the tertiary industry water consumption are all negatively correlated in spatial correlation and have strong spatial heterogeneity.


Moran's I: 0.0278731
lagged GDP
W
1.3
0.7
0.1
-0.5
-1.1
-1.7
-1.7
-1.1
-0.5
0.1
0.7
1.3

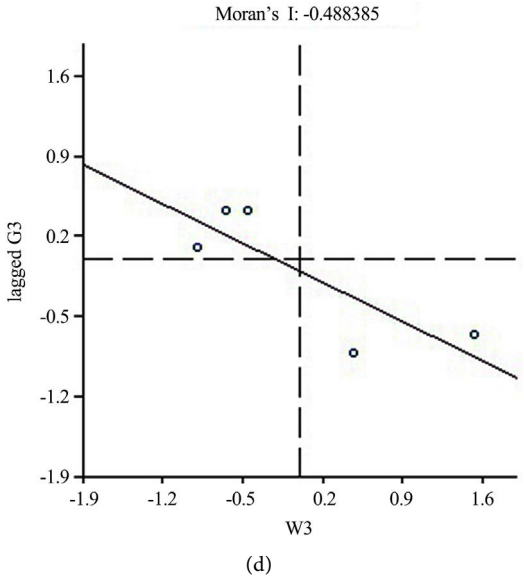
(a)


Moran's I: -0.147054
lagged G1
W1
1.7
1
0.3
-0.4
-1.1
-1.8
-1.8
-1.1
-0.4
0.3
1
1.7

(b)


Moran's I: 0.261119
lagged G2
W2
1.9
1.1
0.3
-0.5
-1.3
-2.1
-2.1
-1.3
-0.5
0.3
1.1
1.9

(c)




(d)

**Figure 4.** (a) Total water resources and GDP; (b) Total water consumption in primary industry and primary industry GDP; (c) Total water consumption in second industry and second industry GDP; (d) The correlation between the total water consumption of the tertiary industry and the GDP of the tertiary industry.

This paper linked a correlation between GDP of each industry and the spatial distribution of water resources utilization for understanding whether the spatial distribution structure of water resources utilization directly affects the spatial distribution of industrial GDP. The research shows that the total water consumption and the secondary industry water consumption have a positive spatial correlation with GDP, but the correlation index is small and the correlation is not obvious. There is a negative spatial correlation between GDP and water consumption in the primary and tertiary industries, which indicates that the water resources utilization has a certain impact on economic development in spatial distribution, but the planning and transformation of water resources break the constraint of water resources on regional industry development.

This paper analyzed the spatial correlation between GDP and water resources in the upper reaches of Minjiang River Basin from the perspective of spatial visualization. It is concise, intuitive and can operate easily and fast. Of course, there are still many shortcomings, because the size of each county is different. The factor of land use is included in the factor analysis to make the spatial statistical analysis more reasonable. In addition, the development of regional economy is also affected by various factors such as ecological environment. It is important how to promote the benign interaction between regional economy and ecological environment, and apply it to the fine spatial management of macro-economic growth in the upper reaches of Minjiang River, rationally allocate production, living and ecological water use, which promote the coordinated development of socio-economic and ecological environment of the counties in the upper reaches of Minjiang River, and achieve the long-term sustainable development of space utilization adapting to regional economy.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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