sustainability

MDPI

Article

Stream Flow Changes and the Sustainability of Cruise Tourism on the Lijiang River, China

Yuefeng Yao [1,*] and Azim Mallik [2,*]

1 Guangxi Key Laboratory of Plant Conservation and Restoration Ecology in Karst Terrain, Guangxi Institute of Botany, Guangxi Zhuang Autonomous Region and Chinese Academy of Sciences, Guilin 541006, China
2 Department of Biology, Lakehead University, Thunder Bay, ON P7B 5E1, Canada
* Correspondence: yf.yao@gxib.cn (Y.Y.); amallik@lakeheadu.ca (A.M.)

Received: 24 August 2020; Accepted: 15 September 2020; Published: 18 September 2020

check for updates

Abstract: Water resources play a critical role in the sustainable development of river-based tourism. Reduced stream flow on the Lijiang River, south China, may negatively impact the development of cruise tourism. We explored the effects of stream flow changes on cruise tourism by determining (1) cruise tourism development indicators, (2) stream flow regime characteristics and their impacts on cruise tourism development indicators, and (3) climate variability and socio-economic factors effecting stream flow. Cruise tourism on the river has experienced rapid growth in recent decades. Stream flow regimes displayed no significant changes between 1960 and 2016, although dry season stream flow was significantly lower than in other seasons. We found that stream flow changes did not have a significant impact on the development of cruise tourism. As precipitation has not changed significantly, policies, including regulated stream flow from hydroelectric reservoirs, are assumed to mitigate reduced stream flow. However, increased irrigation and economic development, combined with future climate change, may increase challenges to cruise tourism. Future reservoir operations should prepare for climate change-related increases in temperature and insignificant changes in precipitation, and adopt adaptive measures, such as rationing water use in various sectors, to mitigate water shortages for supporting sustainable tourism development.

Keywords: river-based tourism; reservoir regulation; water availability; climate variability; land use change

---

1. Introduction

Water is a foundational natural and economic resource that plays a critical role in sustainable development [1]. However, with economic expansion and population growth, the demand for water across multiple sectors has increased the stress on regional water availability, particularly in China [2–4]. While the demand for water continues to grow, water availability is declining in many regions, threatening regional sustainable development, particularly in river-based areas where tourism and economic development are reliant on adequate water availability. Furthermore, the expansion of river-based tourism can create additional water stress in areas where water availability is already limited in meeting the increasing demands of economic growth [5]. Therefore, the relationship between water resources and tourism has received particular attention from UNWTO (United Nations World Tourism Organization), UNEP (United Nations Environment Program), OECD (Organization for Economic Co-operation and Development) and related organizations and researchers [6,7].

Since the 1960s, the rapid growth in river-based tourism, and especially cruise tourism ("a socio-economic system generated by the interaction between human, organizational and geographical entities, aimed at producing maritime-transportation-enable leisure experiences" [8]), has led to increasing concern regarding the environmental impacts of this tourism sector [9,10]. The boom in cruise tourism has brought about substantial local and regional economic benefits, including increased employment, infrastructure development and the expansion of urbanization [11]. The consequence of these developments can have serious negative impacts on water resources and the natural environment [12,13]. Most research into the relationship between cruise tourism and water resources focuses on water pollution and other environmental issues [12,14], while the effects of stream flow changes on cruise tourism remains underexplored. The Lijiang River, one of 13 state-level key protected rivers in China, is located in the Guilin region, in the northeast Guangxi Zhuang Autonomous Region. River cruise tourism from Guilin to Yangshuo takes place along an 83 km meandering waterway that runs through the largest and the most spectacular karst tourist attraction of the world (Figure 1). River cruise tourism along the Lijiang River officially commenced in 1973 with five cruise boats with a total capacity of 440 passengers. In 1982, the Lijiang River scenic zone was listed as one of 44 national scenic spots in China. The Lijiang River scenic zone received a 4A national ranking in 2001 and a 5A ranking in 2007. In 2012, there were 234 three- and four-star level cruise boats on the river with a passenger capacity of 18,802 [15]. According to the government report, the carrying capacity for Lijiang River cruise tourism is 19,000 passengers per day [16]. As a corridor, the Lijiang River connects downtown Guilin and Yangshuo County with more than 18 scenic spots in the middle and lower reaches of the river with 3A or higher rankings. As such, it represents the core area of socio-economic growth in the Guilin region [17]. Because of this, cruise tourism from Guilin to Yangshuo plays a critical role in the Guilin–Lijiang River–Yangshuo tourism destination system and in regional economic growth [18]. Tourism development has been booming based on the distribution of tourism resources and accelerating the economic growth in the Guilin region [17,18]. Downtown Guilin is the core zone of a cluster of tourism resources and tourist services. The Merryland Resort in Xing'an County and Longji Terraced Rice Fields in Longsheng County represent the northern core areas of tourism in the Guilin region. Yangshuo County is the southern core areas of tourism, and it contains a number of historic and cultural heritage sites, and karst landscape scenic spots.

However, in an era of rapid tourism and economic growth, the Lijiang River now experiences water shortages, especially during the dry season [19,20]. What was once a year-round 83 km-long waterway has been shortened to 10 km during the dry season, due to a reduction in stream flow. When water discharge is less than 30 m^3/s, cruise boats are unable to navigate the Lijiang River, and a discharge of less than 8 m^3/s imperils the river's riparian ecosystems [21–23]. Given the almost 50 years history of cruise tourism as an economic activity on the Lijiang River, a reconsideration of current approaches to water resource management to support sustainable cruise tourism is required. Few studies have explicitly analyzed the effects of stream flow changes on cruise tourism on the Lijiang River. This has resulted in a major gap in the understanding needed for sustainable tourism development in the Guilin region.

We used the Lijiang River as a demonstration site to determine the effect of stream flow changes on cruise tourism development between 1979 and 2016, based on selected stream flow parameters and cruise tourism indicators. We also explored the effect of climate variability (precipitation, in this case) and socio-economic factors (reservoir operation, land use change, and river engineering) that might affect stream flow and, in turn, cruise tourism. The theoretical findings of this study form the basis of water resource management recommendations that can facilitate the development of sustainable cruise tourism on the Lijiang River.

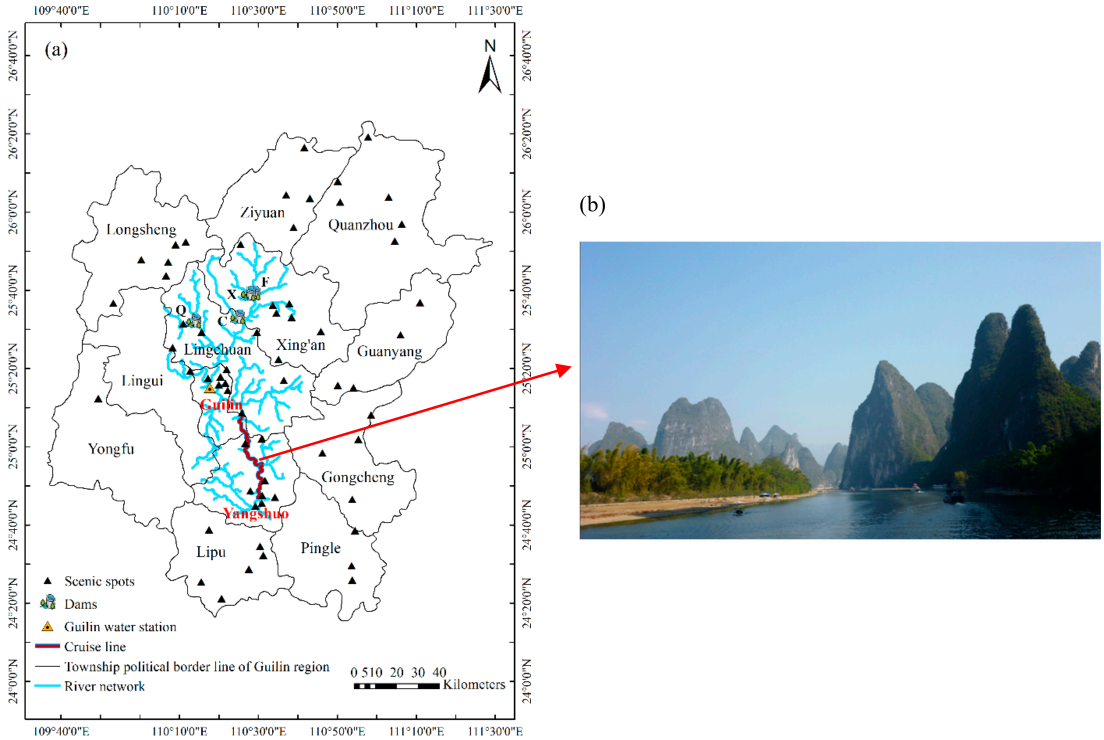

Figure 1. (**a**) The Lijiang River scenic zone, located in the Guilin region, Northeast Guangxi Zhuang Autonomous Region, China. Q, Qingshitan reservoir; C, Chuanjiang reservoir; X, Xiaorongjiang reservoir; F, Fuzikou reservoir; (**b**) Yellow Cloth Shoal, one of the essential scenic spots of the Lijiang River (photographed by Yuefeng Yao).

2. Materials and Methods

2.1. Study Area

The Lijiang River originates at Mao'er Shan Nature Reserve and flows 164 km to Yangshuo County. The cruise line from Guilin to Yangshuo, known as the Gold Waterway of the Guilin region, covers an 83 km stretch of river on a four- to five-hour journey through spectacular karst landscapes (Figure 1). The annual temperature in the Lijiang River area ranges from 17 °C to 20 °C, and annual precipitation ranges from 1400 mm to 2000 mm. Precipitation during the rainy season, from March to August, accounts for approximately 80% of total annual precipitation, while dry season precipitation, from September to February, accounts for the remaining 20%.

The Lijiang River, as one of China's most important scenic and historic sites, is the largest and the most spectacular karst tourist attraction of the world. Both the state and the local government have created a series of programs to preserve and develop the area. To meet the water demands of cruise tourism during the dry season, several additional hydroelectric dams have been constructed in the upper reaches of the Lijiang River [24]. In order to enhance water availability, the local government has implemented the national Grain for Green policy by converting cropland to forest or grassland since the early 2000s [17]. In 2011, the regional government issued the Lijiang River Eco-environmental Protection law, which focuses on the protection and conservation of riparian vegetation, water resources and landscapes [25]. Furthermore, based on the Lijiang River scenic zone, an outline plan (2012–2020) for the development of Guilin into an international tourist attraction was approved by the National Development and Reform Commission in November 2012 [26]. In the past few years, the local government has created bonus policies to promote tourism development and plan to introduce relevant policies to foster high-quality tourism development in the future [27].

2.2. Methods

We used linear regression to analyze recent trends in cruise tourism development and stream flow change, and applied the Pearson correlation analysis and the Granger causality test to evaluate the effects of stream flow changes on cruise tourism, based on selected stream flow parameters and cruise tourism indicators. We then explored the effects of climate variability (in this case, precipitation) and socio-economic factors (in this case, reservoir operation, land use change, and river engineering) on stream flow and, therefore, cruise tourism development. Figure 2 is a simplified flow chart of this study.

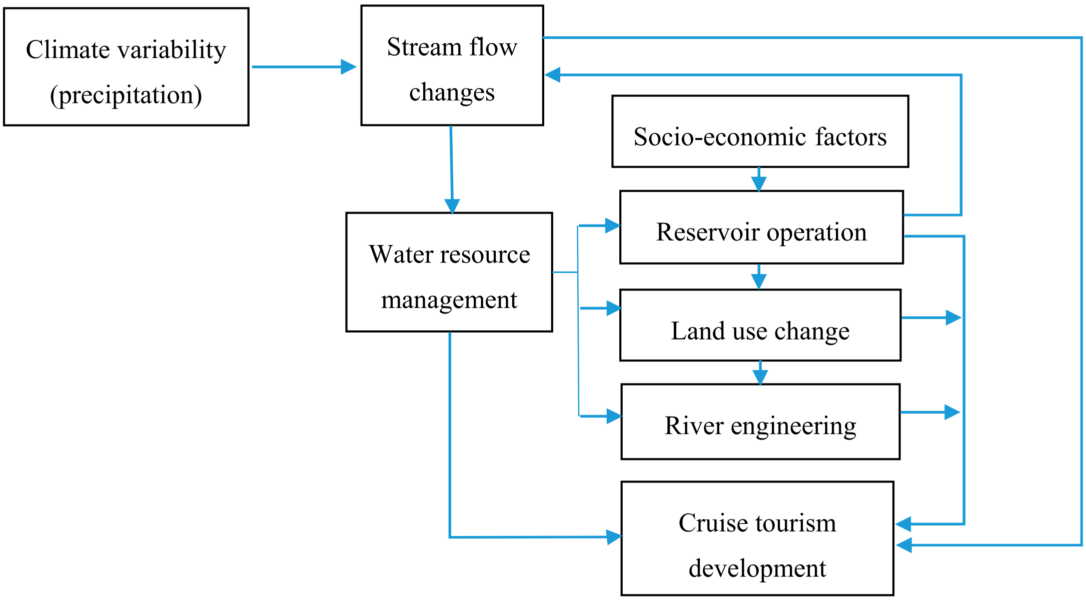

Figure 2. Simplified flow diagram illustrating the framework of this study.

2.2.1. Data Sources

To determine the development of regional cruise tourism we obtained economic data from the Guilin Lijiang Zhi [28] in 2004 and the Guilin Economic and Social Statistical Yearbook [29] from 1990 to 2016. These data included cruise passenger numbers and ticket prices per passenger on cruise boats from Guilin to Yangshuo, total number of tourists and tourism income for the Guilin region, and regional GDP for the Guilin region from 1979 to 2016. Since cruise tourism on the Lijiang River is dependent on the regulation of stream flow based on the water regimes at the Guilin water station during the dry season, we collected daily water discharge data from the Annual Hydrological Report of the Guilin water station from 1960 to 2016. Historical precipitation data from 1960 to 2016 were obtained from the China Meteorological Data Service Center (https://data.cma.cn). A dataset of future averages of annual precipitation, precipitation anomalies, air temperature, and air temperature anomalies for four representation concentration pathways (RCPs) for the 20 year period between 2020 and 2039 was downloaded from the GIS Program and Climate Changes Scenarios of the National Center for Atmospheric Research (https://gisclimatechange.ucar.edu/).

2.2.2. Handling Missing Data

Missing data for total number of tourists and tourism income in the Guilin region from 1979 to 1998 were interpolated using regression analysis based on tourist and tourism income data from 1999 to 2016. To compensate for missing cruise passenger number data for 2010, 2013, and 2014, we interpolated from average data from the preceding and succeeding years. Further, we replaced missing cruise ticket prices from 1979 to 1983 with prices from 1984.

2.2.3. Cruise Tourism Development Indicators and Stream Flow Parameters

The number of cruise passengers, the cruise passenger index (ratio of the number of cruise passengers to the total number of tourists of the Guilin region), cruise ticket revenues (number of cruise passengers multiplied by the ticket price per passenger, from Guilin to Yangshuo), and the cruise ticket revenue index (ratio of cruise ticket revenue to total tourism income for the Guilin region) were used to represent the cruise tourism development trend, and to analyze the effects of stream flow changes on the development of cruise tourism on the Lijiang River. Based on the Indicators of Hydrologic Alteration method [30], we employed twenty-five hydrological parameters to explore changes in stream flow and the impact of those changes on cruise tourism development. These were (1) annual stream flow, (2–13) annual monthly stream flow (from January to December), (14–18) minimum flow (1-, 3-, 7-, 30- and 90-day minimum flow), (19–23) maximum flow (1-, 3-, 7-, 30- and 90-day maximum flow), (24) base flow index, and (25) annual dry season flow (total monthly stream flow from September to February).

2.2.4. Linear Regression

Linear regression analysis was conducted to detect time series data trends, and to interpolate missing data based on recorded data. The trend slope was calculated using the least squares method [31]:

$$Slope = \frac{n \times \sum_{i=1}^{n}(i \times y_i) - \sum_{i=1}^{n} i \times \sum_{i=1}^{n} y_i}{n \times \sum_{i=1}^{n} i^2 - \left(\sum_{i=1}^{n} i\right)^2} \tag{1}$$

where y is a variable such as stream flow parameters, precipitation, and cruise tourism indicators; i is the time/year within the study period; n is the number of years within the study period. A positive slope value means an increasing trend, while a negative value indicates a decreasing trend, and zero signifies no change.

An F test with a confidence level of 95% was used to detect the significant trend of the time series data.

2.2.5. Detecting Abrupt Change of the Time Series Data

An abrupt change of stream flow or cruise tourism time series was detected using the Mann–Kendall test, and the Pettitt test was also applied to verify the abrupt change with the R program [32]. For a time series of stream flow or cruise tourism, the Mann–Kendall test statistic was calculated as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn\left(X_j - X_k\right) \tag{2}$$

where $sgn\left(X_j - X_k\right) = \begin{cases} 1 \ X_k < X_j \\ 0 \ X_k = X_j \\ -1 \ X_k > X_j \end{cases}$.

The null hypothesis (H_0) is that the stream flow or cruise tourism time series is identically distributed, while the alternative hypothesis (H_A) is that the stream flow or cruise tourism time series displays a monotonic trend.

The Pettitt test is defined as:

$$K_T = \max\left|U_{t,T}\right| \tag{3}$$

where

$$U_{t,T} = \sum_{i=1}^{t} \sum_{j=t+1}^{T} sgn\left(X_i - X_j\right) \tag{4}$$

Details of the Mann–Kendall test and Pettitt test can be obtained from the relevant sources [33–35].

2.2.6. Correlation Analysis and Granger Causality Test

Pearson correlation analysis [36] was employed to calculate the correlation coefficient between the stream flow parameter (x) and cruise tourism indicator (y):

$$\rho(x,\ y) = \frac{E(xy)}{\sigma_x \sigma_y} \tag{5}$$

where $E(xy)$ is the cross-correlation between x and y, and σ_x and σ_y are the variances of x and y, respectively. If $\rho(x,\ y)^2$ is closer to 1, the stronger the correlation between x and y. If $\rho(x,\ y)^2$ is equal to 0, x and y are independent.

Lasso analysis shrinks some of the variable coefficients, sets others to zero, and selects the best variables for enhancing the accuracy of predictions [37,38]. We employed Lasso analysis to select the related variables from the 25 stream flow parameters to determine which stream flow parameter has the most significant impact on cruise tourism development.

Granger [29] initially proposed his causality test as a statistical method in economics to explore whether one variable or time series can cause others (known as Granger-cause) (Equation (4)). The test has been applied widely in the fields of economics, biology, and environmental sciences to describe causality and feedback [39–41]. We assumed that stream flow Granger-caused the development of cruise tourism on the Lijiang River, and used the Granger causality test to verify this hypothesis.

$$\begin{aligned} X_t &= \textstyle\sum_{j=1}^{m} a_j X_{t-j} + \sum_{j=1}^{m} b_j Y_{t-j} + \varepsilon_t' \\ Y_t &= \textstyle\sum_{j=1}^{m} c_j X_{t-j} + \sum_{j=1}^{m} d_j Y_{t-j} + \varepsilon_t'' \end{aligned} \tag{6}$$

where m is the maximum number of lagged observation; a_j, b_j, c_j, and d_j are the coefficients; ε' and ε'' are residual for X_t and Y_t time series, respectively.

2.2.7. Future Climate Change Scenario Analysis

We analyzed temperature and precipitation changes for the next 20 years (2020–2039) under RCP2.6, RCP4.5, RCP6.0, and RCP8.5 scenarios using CCSM4.0 (Community Climate System Model). The CCSM is a geographic information system (GIS) Global Climate Model (GCM), and is one of the coupled climate models (CCM) used to simulate a series of emission scenario experiments in the fifth phase of the Coupled Model Intercomparison Project (CMIP5) [42]. It uses present day (1986–2005) climate datasets as the baseline to analyze future climate anomalies under four RCPs. RCP2.6 is a low forcing level which predicts that radiative forcing will rise to about 3 W/m^2 before 2100 and will then decrease. RCP4.5 and RCP6.0 are two stabilization levels in which radiative forcing will stabilize at approximately 4.5 and 6.0 W/m^2, respectively, after 2100. The radiative forcing level of RCP8.5 will reach more than 8.5 W/m^2 by 2100 [43]. The difference in temperature/precipitation over the Lijiang River basin between the next 20 years and the 1986 to 2006 average was interpolated using inverse distance weighting (IDW).

2.2.8. Effect of Reservoir Operation on Stream Flow

The Qingshitan reservoir has regulated downstream water supply during the dry season since 1987. Therefore, we compared monthly stream flow between 1960 and 1986 and between 1987 and 2016 to estimate the effect of reservoir regulation on monthly stream flow.

The deviation degree [44] was calculated to determine the effects of reservoir operation on stream flow:

$$D = \frac{x_t - x_0}{x_0} \times 100\% \tag{7}$$

where x_0 and x_t are the mean values of stream flow during the pre-regulation (1960 to 1986) and regulation period (1987 to 2016), respectively.

A positive D means an increase in stream flow during the regulation period compared to the pre-regulation period, while a negative D indicates a decrease.

3. Results

3.1. Trend Analysis of Cruise Tourism Development from Guilin to Yangshuo

The number of cruise passengers showed a fluctuated increase from 1979 to 2016, with an abrupt increase in 2000 ($p = 4.79 \times 10^{-5}$) (Figure 3). Prior to 1980, there were only 0.16 million cruise passengers annually, followed by a sharp increase from 0.19 million in 1980 to 1.44 million in 1987. Between 1987 and 2000, the number fluctuated, with a peak value of 1.74 million in 1992. However, following 2000, the number of cruise passengers increased to 2.18 million in 2006 with a dip in 2003. There was a slight decrease in 2007 and a sharp decrease in 2008, followed by relative stability until 2012. This may have been the result of a drastic decline in the cruise passenger index while the total number of tourists of the Guilin region increased sharply after 2006. Since 2006, the State Ministry of Culture and Tourism has implemented the Guiding Opinions on Promoting the Development of Rural Tourism. This includes the creation of a series of activities to promote rural tourism development, such as the China Rural Tourism Year 2006 [45]. As a result of this promotion of tourism development, the total number of tourists in Yangshuo, Xing'an, Longsheng, Gongcheng, Lipu, and Ziyuan Counties increased by 67%, 45%, 95%, 47%, 17%, and 130%, respectively, in 2006 compared to the previous year [46]. The number of cruise passengers increased rapidly again from 2012 to 2016.

Compared to the number of cruise passenger tourists, the total number of tourists in the Guilin region remained relatively stable prior to 1998, followed by an abrupt increase after 1998 ($p = 2.01 \times 10^{-6}$), peaking at 53.83 million in 2016.

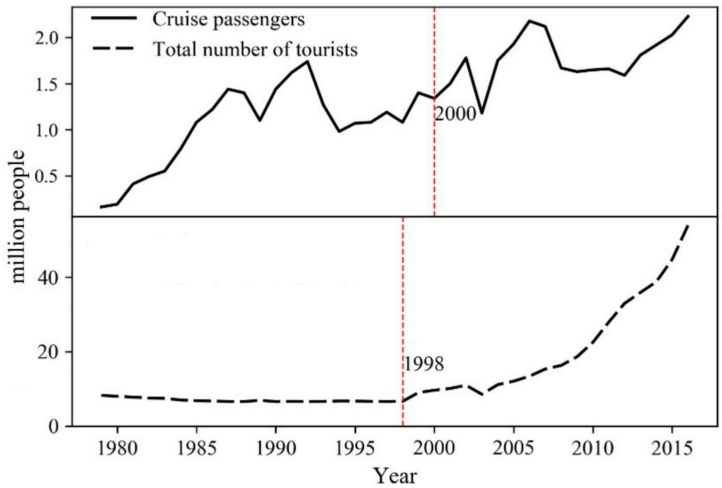

Figure 3. Temporal trends in the number of cruise passengers and total number of tourists from 1979 to 2016. The number of cruise passengers showed a tendency to increase on the whole, while the total number of tourists significantly and abruptly increased after 1998.

All cruise ticket revenue, total tourism income, and GDP for the Guilin region increased slowly before 1990 (Figure 4). From 1990 onwards, cruise ticket revenues increased rapidly until 2006, with an abrupt increase in 1997 ($p = 8.96 \times 10^{-6}$) and a decrease in 2003. This was followed by a sharp decrease in 2008, with revenues remaining relatively stable from 2008 to 2012 due to the drastic decline in cruise passenger numbers from 2006 to 2012. Cruise ticket revenue increased again from 2012 to 2016, with the highest value of 0.47 million yuan in 2016. Total tourism income increased slowly from 1990 to 2006, though it had an abrupt increase in 1994 ($p = 1.87 \times 10^{-6}$), and a peak value of 63.73 billion yuan in 2016. The GDP of the Guilin region increased gradually after 1990, with an abrupt increase in 1997 ($p = 1.86 \times 10^{-6}$), and attained a peak value of 205.48 billion yuan in 2016.

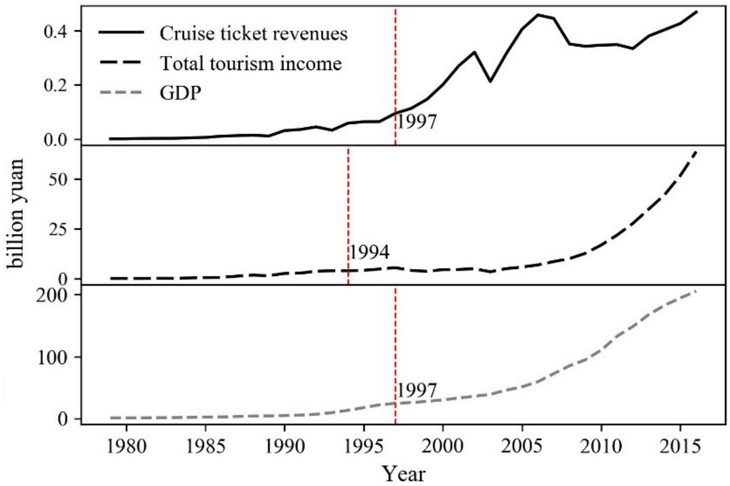

Figure 4. Temporal trends of cruise ticket revenues, total tourism income and GDP for the Guilin region, from 1979 to 2016. All cruise ticket revenues, total tourism income, and GDP increased slowly before 1990. Following 1990, cruise ticket revenues underwent a fluctuated increase until 2016. Both total tourism income and GDP for the Guilin region showed a similar gradually increasing trend prior to 2005, and then a sharp increase until 2016.

Recently, both cruise ticket revenue and cruise passenger indices have displayed a decreasing trend, particularly after 2006 (Figure 5). The cruise ticket revenue index fluctuated from 1979 to 1996, followed by a sharp increase from 1.35% in 1996 to 6.99% in 2005, with a small decrease in 2003 and 2004. A decreasing trend after 2006 was followed by an abrupt decrease in 2008 ($p = 0.02$), indicating a shrinking in the contribution of cruise ticket revenue to total tourism income. The cruise passenger index increased rapidly from 1.95% in 1979 to 26.49% in 1992, with a drastic decrease in 1989. Following 1992, there were sharp decreases in 1993 and 1994, followed by a fluctuating decrease from 1995 to 2006, and then an abrupt decrease after 2006 ($p = 0.03$).

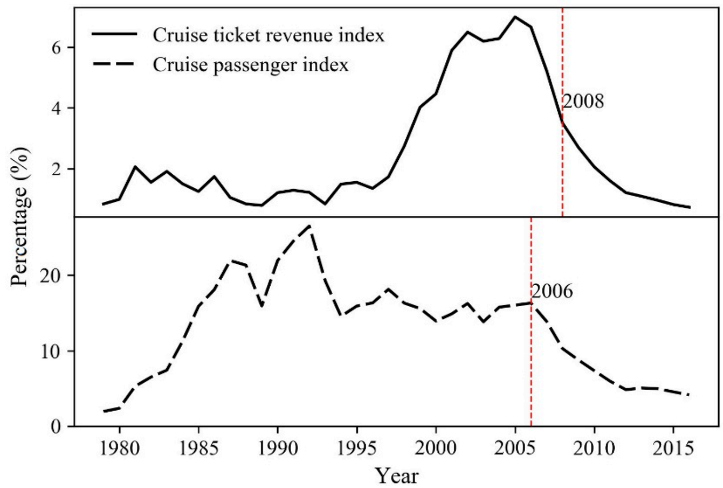

Figure 5. Temporal trends of cruise ticket revenue and cruise passenger indices from 1979 to 2016. Both cruise ticket revenue and cruise passenger indices decreased significantly after 2006.

3.2. Characteristics of Annual Stream Flow in the Lijiang River

From 1960 to 2016, the Lijiang River experienced large interannual variability in annual stream outflow (814.70 to 2219.31 mm, with a mean value of 1442.35 mm) (Figure 6). Annual stream outflow showed an overall rising trend with an increase ratio of 2.80 mm per year from 1960 to 2016. The annual dry season outflow also showed an overall upward trend. However, neither the annual stream outflow nor dry season outflow increased significantly (p value is 0.23 and 0.12, respectively) over the entire study period. The highest annual dry season outflow, in 2015, (855.62 mm) was due to heavy rain in November of that year, resulting in a November stream outflow (393.21 mm) that accounted for more than 45% of the total dry season outflow. If the annual dry season outflow for 2015 is excluded, there is no significant change during the study period ($p = 0.61$).

With the exception of April, the annual minimum flow (1 day, 3 day, 7 day, 30 day, and 90 day minimum flow), maximum flow (1 day, 3 day, 7 day, 30 day, and 90 day maximum flow), and annual monthly stream flow did not exhibit significant change. The annual April stream flow decreased significantly, with an abrupt decrease in 1982 ($p = 0.03$), suggesting that other sectors, such as agricultural irrigation, have increased water demand for spring crop growth, resulting in decreased stream flow in April.

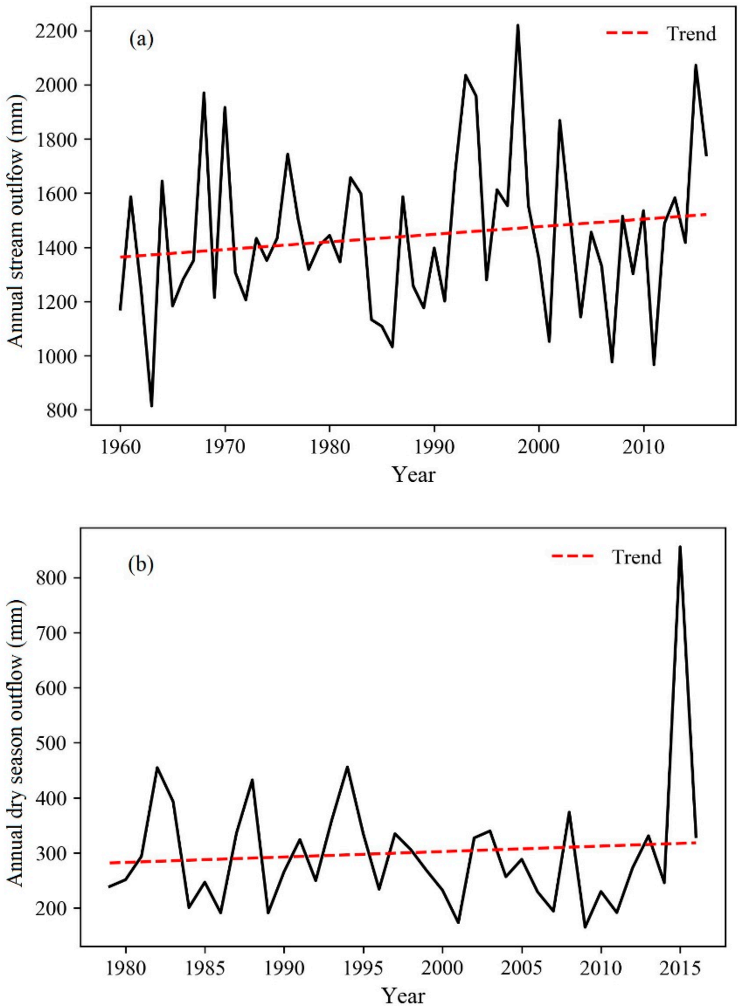

Figure 6. Trends in (**a**) annual stream outflow and (**b**) dry season outflow from 1960 to 2016. Neither annual stream outflow nor dry season outflow increased significantly, with p values of 0.23 and 0.63, respectively.

3.3. Effects of Stream Flow Changes on Cruise Tourism from Guilin to Yangshuo

Stream flow did not have a significant impact on the development of cruise tourism from 1979 to 2016, according to the Pearson's correlation matrix of cruise tourism indicators (number of cruise passengers and cruise ticket revenue) and stream flow parameters (Table 1). Stream flow in January, November, and December had a large positive correlation coefficient with the number of cruise passengers (0.18, 0.13, and 0.17, respectively) and cruise ticket revenue (0.15, 0.18, and 0.21, respectively).

Table 1. Pearson's correlation coefficients for cruise tourism indicators and stream flow.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Cruise passengers	0.18	−0.15	−0.08	−0.24	−0.10	0.04	0.10	−0.29	−0.11	−0.20	0.13	0.17	
Cruise ticket revenue	0.15	−0.23	−0.23	−0.07	0.02	0.13	−0.07	−0.23	−0.13	−0.18	0.18	0.21	
	1 day min [a]	3 day min	7 day min	30 day min	90 day min	1 day max [b]	3 day max	7 day max	30 day max	90 day max	base flow	annual flow	dry season flow
Cruise passengers	−0.14	0.02	0.02	0.12	−0.28	−0.07	−0.09	−0.11	−0.07	−0.01	0.05	−0.01	0.04
Cruise ticket revenue	−0.21	0.01	0.01	0.01	−0.21	−0.04	−0.07	−0.09	−0.09	0.02	−0.01	0.01	0.04

Note: [a] min, minimum flow; [b] max, maximum flow.

According to the variable selection criterion of lasso analysis, the monthly stream flow in January, February, March, April, May, June, August, and December, the 90 day minimum flow, the 1, 7, and 90 day maximum flow, annual flow, and dry season flow could be selected as the variables that have potential impacts on the number of cruise passengers (Table 2). Further, the monthly stream flow in February, March, June, August, and November, and the 7 and 30 day maximum flows could be selected as variables for exploring the effects of stream flow changes on cruise ticket revenue.

Table 2. Related coefficients of cruise tourism indicators and stream flow parameters calculated with lasso analysis.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Cruise passengers	0.0032	−0.0017	−0.0010	−0.0021	−0.0018	0.0003	0.0000	−0.0042	0.0000	0.0000	0.0000	0.0022	
Cruise ticket revenue	0.0000	−0.0004	−0.0004	0.0000	0.0000	0.0005	0.0000	−0.0002	0.0000	0.0000	0.0001	0.0000	
	1 day min [a]	3 day min	7 day min	30 day min	90 day min	1 day max [b]	3 day max	7 day max	30 day max	90 day max	base flow	annual flow	dry season flow
Cruise passengers	0.0000	0.0000	0.0000	0.0000	−0.0014	−0.0002	0.0002	−0.0002	0.0000	0.0012	0.0000	0.0005	0.0001
Cruise ticket revenue	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	−0.0002	−0.0001	0.0000	0.0000	0.0000	0.0000

Note: [a] min, minimum flow; [b] max, maximum flow.

In general, stream flow changes did not have a significant impact on the development of cruise tourism on the Lijiang River from 1979 to 2016. Within the 5% confidence level, only the January stream flow had the significant p value that could Granger-cause the development of cruise tourism (Table 3); an increase in January stream flow could increase the number of cruise passengers. However, the January stream flow did not increase significantly from 1960 to 2016 ($p = 0.18$), which suggests that this could not Granger-cause the development of cruise tourism on the Lijiang River.

Table 3. Effects of stream flow changes on the development of cruise tourism using the Granger causality test with p value.

	Jan.	June	Nov.	Dec.	90-Day Max [a]	Annual Flow	Dry Season Flow
Cruise passengers	0.01	0.74		0.40	0.41	0.45	0.96
Cruise ticket revenue		0.60	0.36				

Note: [a] max, maximum flow.

3.4. Climate Variability and Socio-Economic Factors Affecting Stream Flow and Cruise Tourism

3.4.1. Climate Variability (Precipitation)

The Lijiang River experienced a large interannual variability in annual precipitation from 1960 to 2016, ranging from 1254 mm to 3012 mm, with a mean value of 1894 mm. Annual precipitation displayed an overall upward trend, with an increase ratio of 2.81 mm per year, indicating that climate change has had a positive impact on stream flow. However, annual precipitation did not increase significantly during the study period (p = 0.51), suggesting that changes in stream flow primarily occurred due to reservoir operation and other anthropogenic factors.

The temperature is projected to increase by more than 0.8 °C in the Lijiang River area over the next 20 years (2020–2039) compared to the 1986–2005 average. It is estimated to rise by 0.80 °C and 1.06 °C under the RCP2.6 and RCP8.5 scenarios, respectively. At the same time, precipitation is projected to decrease from 0.58 to 1.00% under RCP2.6, compared to the 1986–2005 average. Furthermore, precipitation is forecasted to decrease by approximately 0.26% in the upstream reaches of the Lijiang River, under RCP8.5. In contrast, precipitation is projected to increase from 2.32 to 3.18% under RCP4.5, and from 0.90 to 1.79% under RCP6.0, over the next 20 years. However, these increases/decreases in projected precipitation are relatively small compared to the 1986–2005 average, suggesting that future precipitation levels will not change significantly in the Lijiang River area.

3.4.2. Socio-Economic Factors

Reservoir Operation

The monthly stream flow at the Guilin water station, which is the stream flow monitoring station for cruise tourism on the Lijiang River, increased from the 1960–1986 period to the 1987–2016 period, except for the months of April, May, and August (Figure 7). The most significant increase in monthly stream flow occurred in June (277.40 to 368.20 m^3/s), which resulted in the highest monthly stream flow shifting from May to June during the 1987–2016 period in contrast to the 1960–1986 period. The monthly stream flow during the dry season, from September to February, increased from the 1960–1986 period to the 1987–2016 period, especially in January (30.77 to 39.91 m^3/s), with a deviation degree of 29.70%. This indicates that regulation of the downstream water supply was beneficial during the dry season.

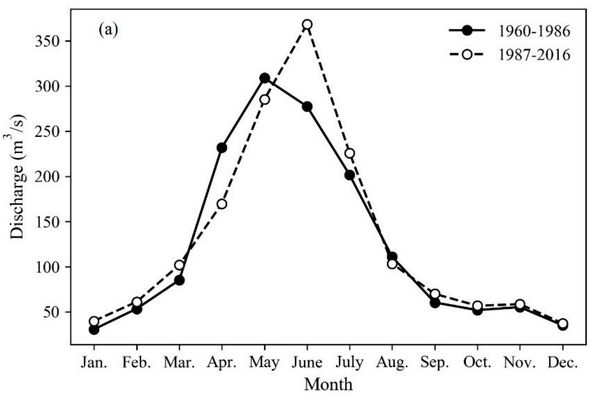

Figure 7. *Cont.*

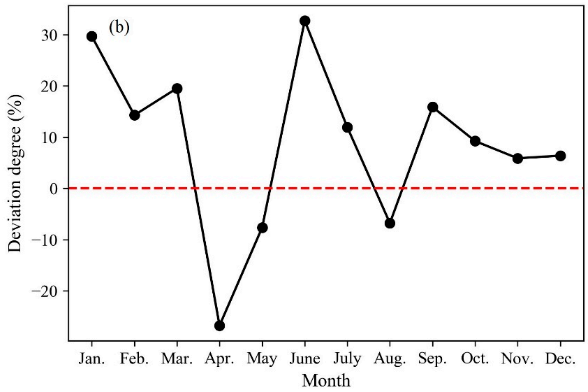

Figure 7. (**a**) Monthly stream flow changes and (**b**) their degrees of deviation during the period from 1987 to 2016 compared to the period from 1960 to 1986. Monthly stream flow in April, May, and August decreased during the period from 1987 to 2016 compared to the period from 1960 to 1986. The red line in (**b**) represents the zero deviation.

Land Use Change

A buffer zone of approximately 106.57 km^2 around the cruise line with a radius of 1 km was used to explore the impact of land use policy (Conversion of Cropland to Forest Program, also known as Grain for Green) on local land use changes. Land use change and its distribution patterns in the buffer zone showed that the area of forest increased from 55 km^2 in 2000 to 74 km^2 in 2015, and the water area increased from 8 km^2 in 2000 to 16 km^2 in 2015 (Figure 8). In contrast, the farmland area decreased from 10 km^2 in 2000 to 1 km^2 in 2015, indicating that the Conversion of Cropland to Forest Program implemented in the Guilin region at the beginning of the 2000s increased forest and water areas. Besides land use policy, other actions, such as sediment regulation, were adapted to improve stream flow in the Lijiang River. River bed excavation has been considerably higher in recent years compared to 1961. In 2013, sand excavation from the Lijiang River was 46,979 m^3, almost 10 times that of 1961 (4800 m^3).

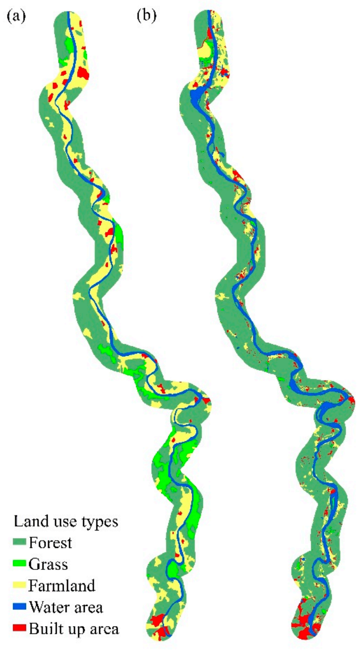

Figure 8. Spatial distribution of land use types in the buffer zone around the cruise line: (**a**) 2000 and (**b**) 2015.

4. Discussion

Cruise tourism from Guilin to Yangshuo plays a critical role in the Guilin–Lijiang River–Yangshuo tourism destination system and regional economic development. Tourism-related businesses generated almost one third of the GDP of the Guilin region in 2016. However, the cruise passenger index (ratio of the number of cruise passengers to total number of tourists in the Guilin region) and the cruise ticket revenue index (ratio of cruise ticket revenues to total tourism income for the Guilin region) displayed a decreasing trend after 2006. The cruise ticket revenue index is dependent on cruise ticket prices, number of cruise passengers, and total tourism income for the Guilin region. Since the cruise ticket price from Guilin to Yangshuo remained stable from 2006 to 2016 [46,47], a drastic decline in the number of cruise passengers resulted in a decrease in cruise ticket revenue. Furthermore, an increase in total tourism income accelerated the declining trend of the cruise ticket revenue index. The cruise passenger index strongly depends on the total number of cruise passengers, stream flow regimes of the Lijiang River, weather conditions, holiday periods, and other socioecological and political factors. Nevertheless, we found that stream flow did not decrease, particularly during the dry season from September to February. Therefore, stream flow changes did not have a significant negative impact on cruise tourism. This is likely because the total number of tourists and the total tourism income for the Guilin region increased sharply after 2006, while that of the number of cruise passengers and cruise ticket revenues remained stable or decreased. The number of cruise passengers and cruise ticket revenue have indeed shown a decreasing trend after 2006. Meanwhile, tourism opportunities in the region have been diversified, with the proliferation of new tourist destinations from 2006 to 2010 [18,48]. A series of rural tourism promoting activities created by the State Ministry of Culture and Tourism, such as the Guiding Opinions on Promoting the Sustainable Development of Rural Tourism in 2006 and 2018 [49], have effectively promoted the development of rural tourism. Rural tourism has, in turn, increased revenue and promoted employment [50]. With the development of tourist destinations within the Guilin region, the overall number of tourists and total tourism income set a new record in 2018 with, approximately 109 million people and 139 billion yuan, respectively [51].

Although we could not detect any significant impact of reduced stream flow on cruise tourism, this form of tourism is a highly important sector that is dependent on adequate water availability in the Lijiang River, particularly during the dry season, and the effects of climate change, combined with the intensification of water use, will further reduce water availability. Our projected results indicate that precipitation will not change significantly over the next 20 years (2020–2039) compared to the 1986–2005 average. However, the temperature is projected to increase from between 0.80 °C to 1.06 °C. Without a concomitant increase in precipitation, increasing temperature will likely reduce both summer and autumn stream flow [52]. Therefore, water shortages will likely worsen along the river, thus impeding regional economic development, including tourism. The effects of potential climate variability and reservoir regulation on stream flow must be carefully examined to ensure sustainable water resource management that will support viable cruise tourism.

Human activities, such as reservoir regulation, river-based tourism, and irrigation, combined with climate change, are likely to increase the stress on water availability in the Lijiang River, which will subsequently affect tourism and the aquatic ecosystem. Previous research suggests that current water discharge regulation by the Qingshitan reservoir alone cannot meet the water requirements of cruise tourism on the river as the primary function of this reservoir is the supply of water for irrigation and domestic consumption [22]. To meet the increasing water demands of economic expansion, and to support cruise tourism, particularly during the dry season, the Guilin government and the State Council have constructed several additional hydroelectric dams in the upper reaches of the Lijiang River [24]. Qingshitan reservoir, constructed in 1960, has regulated water supply downstream during the dry season since 1987. The Chuanjiang, Xiaorongjiang, and Fuzikou reservoirs were constructed in 2014, 2015, and 2018, respectively. Reservoir operation has caused significant changes in the downstream flow, improved some fish habitats on the river, especially by increasing water supply during the dry season, and also benefited human interests [22,53,54]. However, maintaining an ecological or quasi-natural flow must be ensured to conserve the river ecosystem [54]. Therefore, reservoir operation should be regulated to ensure optimal functioning of the river system, both ecologically and economically. When all of the reservoirs are fully operational and when water discharge is optimized, stream flow on the Lijiang River is expected to rise to 60 m^3/s during the dry season [55]. This will benefit both the river environment and human interests. Meanwhile, future research should consider the impact of the operation of multiple reservoirs on the Lijiang River under different climate change scenarios.

Tourism development, as well as economic growth, is associated with high water demand, and a large number of tourists may significantly exacerbate water shortage problems. The water consumption rate ranges from 84 to 2000 L per tourist per day [5]. The value of water use per tourist will increase if other amenities, such as swimming pools and golf courses, are included in the tourism area. With expanding tourism, water demands from the Lijiang River remain consistently high [21]. Meanwhile, local agricultural development may also lead to decreased stream flow. A previous study indicated that 80% of surface water (the largest quantity of regional water resources) is allocated to agriculture in the Guilin region [56]. This may explain why the monthly stream flow for the peak tourism months of April, May, and August decreased during the 1987 to 2016 period compared to the 1960 to 1986 period. Therefore, viable strategies for water regulation and irrigation planning are urgently required to avoid further adverse effects of stream flow on regional river-based tourism.

5. Conclusions

As water resources are the foundation of economic resources and critical for sustainable development, we assumed that decreases in stream flow would have negative impacts on the development of cruise tourism on the Lijiang River. However, we did not find that stream flow changes had a significant impact on the development of cruise tourism on the river from 1979 to 2016. Given that climate variability (in this case, precipitation) has experienced no significant change in previous decades, socio-economic factors, such as reservoir operation, land use policy, and river engineering, might have significant impacts on water availability. Current reservoir regulations have improved water availability in the Lijiang River, particularly during the dry season from September to February. Furthermore, additional reservoirs have been constructed to meet the increasing water demands of tourism, agriculture, and economic development. Considering that without a concomitant increase in precipitation, increases in temperature over the next 20 years (2020–2039) will likely reduce both rainy and dry season stream flow, the operation of multiple reservoirs in the Lijiang River should be conducted under conditions of (1) increasing reservoir capacities in heavy rain periods and adjusting flow regulation to support tourism during the dry season, and (2) preparing for climate change-related increases in temperature, insignificant changes in precipitation, and water shortages through adaptive measures, such as rationing water supply for cruise tourism, agriculture, domestic and municipal use.

Author Contributions: A.M. and Y.Y. conceived the idea. Y.Y. gathered and analyzed the data and wrote the first draft. A.M. provided critical feedbacks and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This study was financially supported by National Natural Science Foundation of China (grant number 41401211), National Key Research and Development Program of China (grant number 2012BAC16B01), West Light Foundation of Chinese Academy of Sciences (2014), the Foundation of the Guangxi Key Laboratory of Plant Conservation and Restoration Ecology in Karst Terrain (16-A-02-03), and the Foundation of Chinese Scholarship Council (CSC, 201808450049). A sabbatical leave awarded to A.M. from Lakehead University tenured at Guangxi Institute of Botany, Guangxi Zhuang Autonomous Region and Chinese Academy of Sciences enabled him to participate in this research.

Acknowledgments: We thank LetPub (www.letpub.com) for its linguistic assistance and scientific consultation during the preparation of this manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Li, J.; Qiao, Y.; Lei, X.; Kang, A.; Wang, M.; Liao, W.; Wang, H.; Ma, Y. A two-stage water allocation strategy for developing regional economic-environment sustainability. *J. Environ. Manag.* **2019**, *244*, 189–198. [CrossRef] [PubMed]
2. Gössling, S. Global environmental consequences of tourism. *Glob. Environ. Chang.* **2002**, *12*, 283–302. [CrossRef]
3. Valizadeh, N.; Mirzaei, M.; Allawi, M.F.; Afan, H.A.; Mohd, N.S.; Hussain, A.; El-Shafie, A. Artificial intelligence and geo-statistical models for stream-flow forecasting in ungauged stations: State of the art. *Nat. Hazards* **2017**, *86*, 1377–1392. [CrossRef]
4. Yang, W.; Liu, J. Water sustainability for China and beyond. *Science* **2012**, *337*, 649–650. [CrossRef]
5. Gössling, S.; Peeters, P.; Hall, C.M.; Ceron, J.P.; Dubois, G.; Lehmann, L.V.; Scott, D. Tourism and water use: Supply, demand, and security. An international review. *Tour. Manag.* **2012**, *33*, 1–15. [CrossRef]
6. Gössling, S. New performance indicators for water management in tourism. *Tour. Manag.* **2015**, *46*, 233–244. [CrossRef]
7. Paiano, A.; Crovella, T.; Lagioia, G. Managing sustainable practices in cruise tourism: The assessment of carbon footprint and waste of water and beverage packaging. *Tour. Manag.* **2020**, *77*, 104016. [CrossRef]
8. Papathanassis, A.; Beckmann, I. Assessing the "poverty of cruise theory" hypothesis. *Ann. Tour. Res.* **2011**, *38*, 153–174. [CrossRef]
9. Carić, H.; Mackelworth, P. Cruise tourism environmental impacts—The perspective from the Adriatic Sea. *Ocean Coast. Manag.* **2014**, *102*, 350–363. [CrossRef]
10. Lau, Y.; Sun, X. An Investigation into the Responsibility of Cruise Tourism in China. In *Maritime Transportation and Regional Sustainability*; Ng, A.K.Y., Monios, J., Jiang, C., Eds.; Elsevier Inc.: Amsterdam, The Netherlands, 2020; pp. 239–249. ISBN 9780128191347.
11. MacNeill, T.; Wozniak, D. The economic, social, and environmental impacts of cruise tourism. *Tour. Manag.* **2018**, *66*, 387–404. [CrossRef]
12. Johnson, D. Environmentally sustainable cruise tourism: A reality check. *Mar. Policy* **2002**, *26*, 261–270. [CrossRef]
13. Wang, H. *Report on the Development of Cruise Industry in China (2019)*; Wang, H., Ed.; Springer: Berlin/Heidelberg, Germany, 2020; ISBN 978-981-15-4660-0.
14. Brida, J.G.; Zapata, S. Cruise tourism: Economic, socio-cultural and environmental impacts. *Int. J. Leis. Tour. Mark.* **2010**, *1*, 205–226. [CrossRef]
15. Wang, Y. Lijiang River cruise tourism development issues and stratiges. *Econ. Reserch Guid.* **2015**, 254–256. [CrossRef]
16. Carrying Capacity for 5A Scenic Zone in China. Available online: http://www.gov.cn/xinwen/2015-07/17/content_2898961.htm (accessed on 11 August 2020).
17. Mao, X.; Meng, J.; Wang, Q. Modeling the effects of tourism and land regulation on land-use change in tourist regions: A case study of the Lijiang River Basin in Guilin, China. *Land Use Policy* **2014**, *41*, 368–377. [CrossRef]
18. Lu, L.; Bao, J.; Ling, S.; Zeng, Q.; Yu, H. The evolution progress and mechanism of Guilin-Lijiang River-Yangshuo tourism destination system. *Sci. Geogr. Sin.* **2012**, *32*, 1066–1074. [CrossRef]
19. Miao, Z. Water replenishment and tourism shipping in Lijiang River. *Site Investig. Sci. Technol.* **2000**, 36–40. [CrossRef]
20. Xu, J.; Dai, J. Variation characteristics of runoff in upper reaches of Lijiang River basin. *Yangtze River* **2018**, *49*, 41–46. [CrossRef]
21. Li, R.; Chen, Q.; Ye, F. Modelling the impacts of reservoir operations on the downstream riparian vegetation and fish habitats in the Lijiang River. *J. Hydroinformatics* **2011**, *13*, 229. [CrossRef]
22. Li, R.; Chen, Q.; Tonina, D.; Cai, D. Effects of upstream reservoir regulation on the hydrological regime and fish habitats of the Lijiang River, China. *Ecol. Eng.* **2015**, *76*, 75–83. [CrossRef]
23. Ye, F.; Chen, Q.; Li, R. Modelling the riparian vegetation evolution due to flow regulation of Lijiang River by unstructured cellular automata. *Ecol. Inform.* **2010**, *5*, 108–114. [CrossRef]
24. Yang, Y. Discussion on ecological and environmental water supplement target flow of Lijiang River. *GX Water Resour. Hydropower Eng.* **2012**, *3*, 7–10.

25. Lijiang River Eco-environmental Protection Law. 2011. Available online: http://www.gxzf.gov.cn/zwgk/flfg/dfxfg/t955429.shtml (accessed on 19 August 2020).
26. Outline Plan (2012–2020) for the Development of Guilin into an International Tourist Attraction. Available online: http://www.gov.cn/gzdt/2012-11/30/content_2278843.htm (accessed on 11 August 2020).
27. Guilin Forges Ahead in Tourism Upgrading. Available online: http://en.gxzf.gov.cn/2019-05/20/c_376274.htm (accessed on 11 August 2020).
28. Guilin Lijiang Zhi Editorial Committee. *Guilin Lijiang Zhi*; Guilin Lijiang Zhi Editorial Committee, Ed.; Guangxi People's Publishing House: Nanning, China, 2004; ISBN 7-219-05073-9/K987.
29. Guilin Economic and Social Statistical Yearbook Editorial Committee. *Guilin Economic and Social Statistical Yearbook*; Guilin Economic and Social Statistical Yearbook Editorial Committee, Ed.; China Statistics Press: Beijing, China, 2016; ISBN 9787503779817.
30. Richter, B.D.; Baumgartner, J.V.; Powell, J.; Braun, D.P. A method for assessing hydrologic alteration within ecosystems. *Conserv. Biol.* **1996**, *10*, 1163–1174. [CrossRef]
31. Guan, Q.; Yang, L.; Pan, N.; Lin, J.; Xu, C.; Wang, F.; Liu, Z. Greening and browning of the Hexi Corridor in northwest China: Spatial patterns and responses to climatic variability and anthropogenic drivers. *Remote Sens.* **2018**, *10*, 1270. [CrossRef]
32. Pohlert, T. Non-Parametric Trend Tests and Change-Point Detection. 2020. Available online: https://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwizspPJ1PHrAhUIMd4KHSLCDoYQFjAAegQIBRAB&url=https%3A%2F%2Fcran.r-project.org%2Fweb%2Fpackages%2Ftrend%2Fvignettes%2Ftrend.pdf&usg=AOvVaw2pWef-HxDUtvHEURSwCfMp (accessed on 20 August 2020).
33. Mann, H.B. Nonparametric tests against trend. *Econometrica* **1945**, *13*, 245–259. [CrossRef]
34. Hamed, K.H. Trend detection in hydrologic data: The Mann-Kendall trend test under the scaling hypothesis. *J. Hydrol.* **2008**, *349*, 350–363. [CrossRef]
35. Pettitt, A.N. A non-parametric approach to the change-point problem. *Appl. Stat.* **1979**, *28*, 126–135. [CrossRef]
36. Benesty, J.; Chen, J.; Huang, Y.; Cohen, I. *Noise Reduction in Speech Processing*; Springer: Berlin/Heidelberg, Germany, 2009; ISBN 9783540786115.
37. Tibshirani, R. Regression shrinkage and selection via the lasso: A retrospective. *J. R. Stat. Soc. Ser. B* **2011**, *73*, 273–282. [CrossRef]
38. Tibshirani, R. Regression shrinkage and selection via the lasso. *J. R. Stat. Soc. Ser. B* **1996**, *58*, 267–288. [CrossRef]
39. Granger, C.W.J. Testing for causality: A personal viewpoint. *J. Econ. Dyn. Control* **1980**, *2*, 329–352. [CrossRef]
40. Kamiński, M.; Ding, M.; Truccolo, W.A.; Bressler, S.L. Evaluating causal relations in neural systems: Granger causality, directed transfer function and statistical assessment of significance. *Biol. Cybern.* **2001**, *85*, 145–157. [CrossRef]
41. Mehdi, B.J.; Slim, B.Y. The role of renewable energy and agriculture in reducing CO_2 emissions: Evidence for North Africa countries. *Ecol. Indic.* **2017**, *74*, 295–301. [CrossRef]
42. Gent, P.R.; Danabasoglu, G.; Donner, L.J.; Holland, M.M.; Hunke, E.C.; Jayne, S.R.; Lawrence, D.M.; Neale, R.B.; Rasch, P.J.; Vertenstein, M.; et al. The community climate system model version 4. *J. Clim.* **2011**, *24*, 4973–4991. [CrossRef]
43. van Vuuren, D.P.; Edmonds, J.; Kainuma, M.; Riahi, K.; Thomson, A.; Hibbard, K.; Hurtt, G.C.; Kram, T.; Krey, V.; Lamarque, J.F.; et al. The representative concentration pathways: An overview. *Clim. Chang.* **2011**, *109*, 5–31. [CrossRef]
44. Xue, L.; Zhang, H.; Yang, C.; Zhang, L.; Sun, C. Quantitative assessment of hydrological alteration caused by irrigation projects in the Tarim River basin, China. *Sci. Rep.* **2017**, *7*, 1–13. [CrossRef] [PubMed]
45. Guiding Opinions on Promoting the Development of Rural Tourism. Available online: http://www.gov.cn/govweb/jrzg/2006-08/23/content_368032.htm (accessed on 20 August 2020).
46. Guilin Local Chronicies Editorial Committee. *Guilin Yearbook (2007)*; Guilin Local Chronicies Editorial Committee, Ed.; China Local Records Publishing Press: Beijing, China, 2007; ISBN 978-7-80238-175-9.
47. Guilin Local Chronicies Editorial Committee. *Guilin Nianjian (2017)*; Guilin Local Chronicies Editorial Committee, Ed.; Guangxi Normal University Press: Guilin, China, 2017; ISBN 9787559804105.

48. Feng, L.; You, H. Research on the Construction Index System of China Guilin Tourism Distribution Center. In Proceedings of the 2nd International Conference on Management, Education and Social Science (ICMESS2018), Qingdao, China, 23–24 June 2018; Atlantis Press: Beijing, China, 2018; Volume 176, pp. 1143–1146.
49. Guiding Opinions on Promoting the Sustainable Development of Rural Tourism. Available online: http://zwgk.mct.gov.cn/auto255/201812/t20181211_836468.html?keywords= (accessed on 13 August 2020).
50. Wang, L.E.; Cheng, S.K.; Zhong, L.S.; Mu, S.L.; Dhruba, B.G.C.; Ren, G.Z. Rural tourism development in China: Principles, models and the future. *J. Mt. Sci.* **2013**, *10*, 116–129. [CrossRef]
51. Guilin Local Chronicies Editorial Committee. *Guilin NianJian (2019)*; Guilin Local Chronicles Editorial Committee, Ed.; Thread-Binding Books Publishing House: Beijing, China, 2019; ISBN 9787512038479.
52. Barnett, T.P.; Adam, J.C.; Lettenmaier, D.P. Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* **2005**, *438*, 303–309. [CrossRef]
53. Li, W.; Han, R.; Chen, Q.; Qu, S.; Cheng, Z. Individual-based modelling of fish population dynamics in the river downstream under flow regulation. *Ecol. Inform.* **2010**, *5*, 115–123. [CrossRef]
54. Chen, Q.; Chen, D.; Han, R.; Li, R.; Ma, J.; Blanckaert, K. Optimizing the operation of the Qingshitan Reservoir in the Lijiang River for multiple human interests and quasi-natural flow maintenance. *J. Environ. Sci.* **2012**, *24*, 1923–1928. [CrossRef]
55. Chen, Q.; Yang, Q.; Li, R.; Ma, J. Spring micro-distribution of macroinvertebrate in relation to hydro-environmental factors in the Lijiang River, China. *J. Hydro-Environ. Res.* **2013**, *7*, 103–212. [CrossRef]
56. Jiang, Y.; Chen, Y.; Yan, Z. Water Utilization and Water Problems in Guilin City. Proceeding of the International Symposium on Water Resources and the Urban Environment, Wuhan, China, 9–10 November 2003; China Environmental Science Press: Wuhan, China, 2003; pp. 390–393.