Abstract: An in-depth understanding of the associations between variations in the wetland area and socio-economic driving forces is essential owing to rapid urbanization. However, to date, no study has performed a quantitative study on the relationships between spatio-temporal patterns for wetland area variations and socio-economic driving factors in Yunnan Province. Based on Statistical Yearbook data, we found that during 10 years, different types of wetlands exhibited different change rates, with obvious spatial heterogeneity. The overall increase in wetland area in Yunnan Province was 13.35%, of which the increases in river, lake, and swamp wetland areas were 46.39%, −3.12%, and 295.56%, respectively. At the city level, the maximum decrease and increase in total wetland area were noted in Xishuangbanna (−84.30%) and Diqing (+185.22%), respectively. A total of 9 of 24 factors which were further selected according to collinearity diagnostics might help interpret changes in the wetland area of Yunnan Province according to the regression analysis results ($R^2 = 0.749$, $p < 0.01$). Moreover, in different city development periods, the key socio-economic factors were different, which should be considered separately when formulating policies. Our results may clarify the socio-economic influencing factors for wetland spatio-temporal changes and help to guide policymakers.

Keywords: wetland type; Yunnan province; dynamic change; driving forces

1. Introduction

Wetlands have multiple functions and offer various ecosystem services that are essential for biodiversity, ecological security, and human well-being [1]. They also provide some essential ecological, economic, and social commodities, including groundwater recharge, flood storage, water quality amelioration and enhancement, carbon storage, wildlife habitat, organic waste recovery, fisheries, and ecotourism, thereby serving as cultural, recreational, and educational resources [2–5]. With the rapid urbanization accompanying economic and demographic growth, the area of wetlands has changed remarkably [6]. The growth and decline of wetlands are closely related to ecological balance, as well as to human survival and sustainable economic and social development.

As per the estimates, wetlands make up 12.8 million square kilometers (km$^2$) on a global scale, accounting for 8.5% of total land area. Wetland areas have been reduced and their functions degraded in numerous places across the globe [7–9]. During the past
150 years, over half of the world’s wetlands have changed or experienced degradation because of the activities of mankind [10]. From 1970 to 2008, the ratio of global natural wetlands was reduced by around 30% on average [11]. The Ramsar Convention on Wetlands (2018) also pointed out that global wetlands were degraded and destroyed at a faster rate compared with other natural ecosystems. As much as 35% of global wetlands quickly vanished in 1970 to 2015, and the annual destruction rate has continued to accelerate after 2000 [12].

It is estimated that the wetland area is 451,084 ± 2014 km$^2$ in China, including 70.5% inland wetlands [13]. The ecological sustainability of China is under serious threat, and wetlands are among the most adversely affected ecosystems because of rapid urbanization [14]. China’s total area of wetlands over 1 km$^2$ has decreased from 384.8 × 10$^3$ km$^2$, as reported by the first (1999–2001) National Inventory of Wetland, to 350.8 × 10$^3$ km$^2$, as reported in the second (2009–2011) National Inventory of Wetland. The area of natural wetlands, such as swamps, rivers, and lakes, as well as coastal wetlands, was reduced by 33.8 × 10$^3$ km$^2$ in the research period, accounting for 99.4% of reduced wetland area [15]. In the Yellow River Delta, the total natural wetland area decreased from 2565.6 km$^2$ in 1986 to 1574.5 km$^2$ in 2008 [16]. A study indicated that the increase in agricultural land (paddy fields) reduced wetland area by 67% in the Sangjiang Plain, China, between 1975 and 2004 [17]. Niu et al. [18] pointed out that massive agricultural development resulted in the destruction of almost all natural wetlands in China’s eastern plains, and the losses were especially severe in the early 1980s.

Yunnan Province has complex geographical conditions and diverse wetland types, such as river, lake, and swamp wetlands. The spatial distribution of precipitation is extremely uneven in this region owing to the presence of special terrains such as high mountains and deep valleys. Therefore, the hydrological distribution rules of river wetlands are relatively complex, that is, generally more in the south and west, and less in the north and east. Although a large number of lakes exist in Yunnan Province, these lakes cover a small and scattered area, and most of these lakes are semi-closed plateau fresh water lakes located at an altitude of 1280–3226 m [19,20]. Owing to the characteristics of wide distribution and the presence of numerous freshwater lake wetlands in the plateau, Yunnan Province contains the largest number of freshwater lake wetlands in southwest China. A total of 36 lakes (including 24 permanent and 12 seasonal), covering an area of more than 1 km$^2$, exist in the province, which this total has been divided based on the number of lakes into four groups, namely, central Yunnan, western Yunnan, southern Yunnan, and eastern Yunnan. The province has four types of swamp wetlands, namely, forest swamp, herbaceous swamp, meadow swamp, and shrub swamp, which are mainly distributed in the northwest alpine and subalpine areas [21].

In general, the factors affecting wetland distribution and areas can be divided into natural and human factors. Natural factors include soil properties, water chemistry, and the type of biota residing in the wetlands [22], whereas human factors encompass infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overharvesting and overexploitation, and invasive species introduction [23]. Research has shown that for the major threats to wetland ecosystems, water pollution, biological invasion by exotic species, human activity development, and the socio-economic development context are the major factors that affect wetland ecosystems [24]. Previous research has mostly concentrated on a single effect factor, including climate change [25,26], soil [27], topography [28], or human disturbances [29] at the regional scale [30]. Wetland ecosystems can be affected by numerous factors which simultaneously influence them to varying degrees [31]. So far, researchers have relied on correlation, regression, principal component, and sensitivity analyses to investigate the response of wetland areas to specific factors on different temporal and spatial scales, and various in-depth studies have investigated the driving forces and driving mechanism for wetland changes at different spatio-temporal scales [32–34]. Wetland degradation may be induced by many drivers, including site-based
ones, and regional or global ones. Thus, ensuring the protection of wetlands on the basis of the stable development of social economy has become the key concern.

Considering the lack of research on a comprehensive analysis of various factors and time series variation in the socio-economic driving factors, this research aims at clarifying the spatio-temporal characteristics of wetland area changes in Yunnan Province from 2008 to 2017. In addition, the study determined the dominant socio-economic driving factors for wetland area changes. The results of this study provide in-depth and comprehensive knowledge of wetland area changes, as well as useful suggestions for wetland resource management and sustainable development.

2. Materials and Methods

2.1. Study Area

Yunnan Province (Figure 1), located in China’s southwestern region (97°31′39″~106°11′47″ E, 21°8′32″~29°15′8″ N), covers a total area of 380,454.36 km², out of which 84% is mountainous, 10% area is plateau, and 6% area is basin. The terrain in the province tilts from northwest to southeast, in a ladder-like distribution pattern from north to south. The average temperature during summer is approximately 19~22 °C. The average temperature in the coldest month of winter exceeds 6~8 °C. The annual temperature difference is often 10~15 °C, whereas the temperature is low during rainy days [35]. The complex topography forms plentiful wetland resources, which exhibit diversity, particularity, and significance.

Figure 1. The location and topography of Yunnan Province.

2.2. Data Sources and Selection

All data for the case study were obtained from the Statistical Yearbook in Yunnan Province from 2008 to 2017. The underlying impact factors involved in the research were chosen based on former driving factor analyses of the wetland area change. Data standardization was performed after the collection of all the data. A total of 24 indicators (Table 1) were selected following the principle of data availability, factors’ spatial diversity, and synthesis of previous research results to determine the relationship between the area change of the three wetland types and the influencing factors. The indicators were further specified as demographic factors (X1–X3), economic factors (X4–X12), city construction factors (X13–X14), water pollution factors (X15–X18), tourism development factors...
(X19–X21), and scientific research factors (X22–X24). Figure 2 represents the flowchart of the analysis of socio-economic factors influencing the wetland area change.

Figure 2. Flowchart of the analysis of socio-economic factors influencing the wetland area change.
Table 1. The comprehensive evaluation index system for wetland area changes.

| Number | Index Name               | Units       | Subsystem                  |
|--------|--------------------------|-------------|----------------------------|
| X1     | Urban population         | 10^4 person | Demographic factor         |
| X2     | Rural population         | 10^4 person | Demographic factor         |
| X3     | Population density       | Person/km²  | Demographic factor         |
| X4     | Gross domestic product   | 10^4 Yuan   | Economic factor            |
| X5     | Percentage of primary industry | %         | Economic factor            |
| X6     | Percentage of secondary industry | %       | Economic factor            |
| X7     | Percentage of tertiary industry | %     | Economic factor            |
| X8     | GDP per person           | Yuan/person | Economic factor            |
| X9     | Beef                     | Ton         | City construction factor   |
| X10    | Milk                     | Ton         | City construction factor   |
| X11    | Mutton                   | Ton         | City construction factor   |
| X12    | Sheep wool               | Ton         | City construction factor   |
| X13    | Urban area               | Km²         | City construction factor   |
| X14    | Park green land per capita | m²/person | Water pollution factor     |
| X15    | Urban sewage emission    | 10^4 m³     | Water pollution factor     |
| X16    | Urban sewage treatment   | %           | Water pollution factor     |
| X17    | Industrial water consumption | 10^4 tons | Water pollution factor     |
| X18    | Industrial waste water emission | 10^4 tons | Water pollution factor     |
| X19    | Total tourism revenue    | 100 million yuan | Tourism development factor |
| X20    | Domestic tourists        | 10^4 person | Tourism development factor |
| X21    | Overseas tourists        | Person      | Tourism development factor |
| X22    | Natural science research institutions | / | Scientific research factor |
| X23    | Natural science researchers | Person | Scientific research factor |
| X24    | Scientific and technical personnel | Person | Scientific research factor |

2.3. Correlation Analysis

The wetland area change map was used to determine the change in the area of three types of wetlands (river, lake, and swamp) in different cities from 2008 to 2017. This map was considered to be a dependent variable, whereas the different socio-economic driving factors were considered independent variables, and multiple linear regression grounded on the ordinary least squares (OLS) model was adopted [36]. The least square method was employed for obtaining partial regression coefficients of each variable and indicating the contribution degree of each independent variable to the dependent variables. Regarding the dependent variable (the variation in wetland area between 2008 and 2017) as \( y \), and \( k \) independent variables related to socio-economic factors as \( x_1, x_2, \ldots, \) and \( x_n \), the OLS model is given by:

\[
y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ni} + \epsilon_i
\]

where \( \beta_0, \beta_1, \beta_2, \ldots \) and \( \beta_k \) are unknown parameters, \( \epsilon \) denotes error item, \( k \) represents the number of independent variables, and \( n \) suggests the number of samples. The least square method was employed for calculating the regression parameter matrix.

\[
\hat{\beta} = \left( X^T X \right)^{-1} X^T Y
\]

where \( X \) and \( Y \) signify the matrix of independent variables and the column vector of dependent variables, respectively, and \( X^T \) indicates the column vector of the unknown parameter. In order to eliminate the problem of the collinearity of independent variables, we performed collinearity diagnostics of the independent variables, then the selected indicators (Variance inflation factor < 10) were used for the multiple linear regression model analysis.

Furthermore, a redundancy analysis (RDA) [37] was performed using the Canoco software (version 5.0) to examine the manner in which socio-economic factors caused changes in the wetland area of different types at the city scale; this method was also
used for identifying significant explanatory variables and determining the correlation of socio-economic factors and wetland area changes.

3. Results

3.1. Overall Changes in Wetland Areas of Yunnan Province

During the 10-year period (from 2008 to 2017), the total wetland area in Yunnan Province increased by 45.9 thousand hectares, making up 0.8% of the total land area, which increased gradually, reached a maximum of 1.54% in 2016, and finally decreased to 1.02% in 2017. Among the three wetlands, the areas of the river and swamp wetlands increased by 7.4 thousand hectares and 26.6 thousand hectares, respectively, in 10 years. Unlike the increasing trend of river wetland and swamp wetland areas, the area of lake wetland decreased by 54.7 thousand hectares. To summarize, during 2007–2018, the overall increase in wetland area in Yunnan Province was 13.35%, wherein the river, lake, and swamp wetland areas changed by 46.39%, −3.12%, and 295.56% during the 10-year period, respectively. The largest change percentage was observed for the swamp wetland area.

3.2. Variations in Wetland Areas of Different Cities

Regarding the variation trend of all the wetlands across cities of Yunnan Province, variation in areas ranging from −66.7 to 3.8 thousand hectares was observed in a total of five cities, namely, Xishuangbanna, Yuxi, Kunming, Chuxiong, and Dali (Figure 3a). The greatest reduction in the total wetland area was observed in Xishuangbanna; the area in this region decreased from 79.0 thousand hectares in 2008 to 12.4 thousand hectares in 2017, accounting for a total reduction of 84.30%. The total wetland area of the other cities increased, with the maximum increase being in Diqing (i.e., from 11.5 thousand hectares in 2008 to 32.8 thousand hectares in 2017, accounting a the total increase proportion of 185.22%). In addition, the increase in the wetland area in Zhaotong was the smallest (i.e., 0.90%) during the decade.

The variations in the river wetland area (Figure 3b) in different cities changed from −84.43% to 980% during the ten years. The areas with reduced river wetland areas were Xishuangbanna, Yuxi, and Zhaotong, wherein the area decreased by −66.7, −0.5, and −0.3 thousand hectares, respectively. The area of the river wetland in the other 13 cities increased, and the largest increase in area was observed in Baoshan (from 1.0 ten thousand hectares in 2008 to 10.8 thousand hectares in 2017). The other two cities with a considerable increase in the area were Wenshan and Kunming, wherein the increase proportions were 165.00% and 300.00%, respectively.

The variation trend in the lake wetland area in Yunnan Province is shown in Figure 3c. The degradation of lake wetlands was found to be severe, and the area of these wetlands changed from −13.4 to 0.6 thousand hectares during the decade. In 2007, 12 cities had lake wetlands, and their area decreased from −98.94% to −16.07%. Among the cities, Kunming exhibited the largest variation, whereas Baoshan exhibited the smallest variation. Puer and Dehong had no lake wetland records in 2008. However, the wetland area in these regions increased to 0.1 and 0.6 thousand hectares in 2017, respectively.

The area of swamp wetlands (Figure 3d) in Yunnan Province changed from −0.1 to 17.3 thousand hectares during the 10-year period. Among all cities, the swamp wetland area in only Qujing decreased by 0.1 thousand hectares, with a change proportion of 20.00%. According to the Statistical Yearbook data of 2008, the area of six cities had swamp wetland records, including Dehong, Zhaotong, Nujiang, Dali, Lijiang, and Diqing, was found to increase in the range of 10.00–865.00%. The maximum increase was in Diqing, with an area of 17.3 thousand hectares. In the other nine cities, no swamp wetland was recorded in 2008. However, the swamp wetland area in these regions increased by 0.1–0.4 thousand hectares in 2017.
Figure 3. Variations in the (a) total wetland, (b) river wetland, (c) lake wetland, and (d) swamp wetland areas in Yunnan Province from 2008 to 2017. KM: Kunming; QJ: Qujing; YX: Yuxi; BS: Baoshan; ZT: Zhaotong; LJ: Lijiang; PE: Puer; LC: Lincang; CX: Chuxiong; HH: Honghe; WS: Wenshan; XS: Xishuangbanna; DL: Dali; DH: Dehong; NJ: Nujiang; DQ: Diqing.

3.3. Socio-Economic Driving Forces Analysis of Wetland Area Changes

In terms of total wetland area variations, the adjusted $R^2$ of the regression analysis was 0.749, which indicated that the nine selected variables (Table 2) explained 74.9% of the variation in total wetland area change at a significance level of 1% (Table 3). At a significance level of 5%, factors such as population density, percentage of secondary industry, gross domestic product (GDP) per person, milk, urban sewage treatment, overseas tourists, and natural science research institutions were found to have significant positive effects on the total wetland area change, whereas factors such as industrial water consumption and industrial waste water emission, were found to be significantly negatively correlated with the total wetland area change (Figure 4a). From the perspective of a province, the natural science research institutions exhibited the greatest impact on total wetland area change, with a standardized coefficient of 0.853, followed by the population density and milk production, and corresponding standardized regression coefficients were 0.615 and 0.506, respectively. Nevertheless, the contribution of the city construction factor was relatively small and nonsignificant.
Figure 4. Standard coefficients between the (a) total wetland, (b) river wetland, (c) lake wetland, and (d) swamp wetland areas and socio-economic driving forces. Red dots represent negative correlation and green dots represent positive correlation. *, **, *** represent significance less than 0.05, 0.01 and 0.001. UP, Urban population; RP, rural population; PD, population density; GDP, gross domestic product; PP, percentage of primary industry; PS, percentage of secondary industry; GDPP, GDP per person; SW, sheep wool; UA, urban area; PGA, per capita green area; USE, urban sewage emission; UST, urban sewage treatment; IWC, industrial water consumption; IWE, industrial waste water emission; TTR, total tourism revenue; DT, domestic tourists; OT, overseas tourists; NSI, natural science research institutions; NSR, natural science researchers; STP, scientific and technical personnel.
Table 2. Collinearity diagnostics of the independent variables.

| Factors                          | Variance Inflation Factor |
|----------------------------------|---------------------------|
| Gross domestic product           | 1.356                     |
| Percentage of secondary industry | 1.506                     |
| Milk                             | 1.549                     |
| Sheep wool                       | 1.285                     |
| Per capita green area            | 2.1                       |
| Urban sewage treatment           | 2.825                     |
| Industrial water consumption     | 1.647                     |
| Industrial waste water emission  | 1.817                     |
| Overseas tourists                | 1.555                     |

Table 3. Results of multiple linear regression analysis for changes in the area of different wetland types in Yunnan Province.

| Type                | Adjusted $R^2$ | $F$ Value | $p$ Value |
|---------------------|----------------|-----------|-----------|
| Total wetland       | 0.749          | 34.532    | <0.001    |
| River wetland       | 0.612          | 18.728    | <0.001    |
| Lake wetland        | 0.741          | 33.772    | <0.001    |
| Swamp wetland       | 0.427          | 7.761     | <0.001    |

For the river wetland area change, the adjusted $R^2$ in the regression analysis was 0.612, which indicated that the nine selected variables (Table 2) explained 61.2% of the variation in river wetland area at a significance level of 1% (Table 3). At a significance level of 5%, the factors identified as significantly positively correlated with the river wetland area change were rural population, sheep wool, urban sewage treatment, and natural science researchers, whereas those identified as negatively correlated with the river wetland area variations included the urban population, population density, GDP, industrial waste water emission, and overseas tourists (Figure 4b). From the perspective of a province, the natural science researchers had the most prominent effect on vegetation recovery, with a regression coefficient of 1.929, followed by the urban population and rural population, with regression coefficients of −1.362 and 1.198, respectively. Similar to that for the total wetland area change, the contribution of the city construction factor to the river wetland area change was relatively small and nonsignificant.

For the lake wetland area change, the adjusted $R^2$ in the regression analysis was 0.741, which indicated that the nine selected variables (Table 2) explained 74.1% of the variation in lake wetland area at a 1% significance level (Table 3). At a 5% significance level, the population density, GDP, percentage of secondary industry, milk and per capita green area were found to have significant positive effects on the lake wetland area variations, whereas rural population and industrial water consumption were found to be in a significantly negative correlation with the increased lake wetland area (Figure 4c). From the perspective of a province, the population density was found to have the most prominent effect on vegetation recovery, with a coefficient of 0.772, followed by the rural population and percentage of secondary industry, with regression coefficients of −0.766 and 0.541, respectively. The contribution of tourism development and scientific research factors towards the lake wetland area change were relatively small and nonsignificant.

For the swamp wetland area change, the adjusted $R^2$ in the regression analysis was 0.427, which indicated that the nine selected variables (Table 2) explained 42.7% of the variation in swamp wetland, and the associated $F$ value was 13.904. The equation was also tested at a 1% significance level (Table 3). At a 5% significance level, the rural population, GDP per person, and overseas tourists were found to have significant positive effects on the lake wetland area variations, whereas the percentage of primary industry, percentage of secondary industry, and total tourism revenue exhibited significant negative correlations with the swamp wetland area variations (Figure 4d). From the perspective of a province level, the rural population was found to have the most prominent effect on swamp wetland,
with the regression coefficient of 1.848, followed by the total tourism revenue and overseas tourists, with the regression coefficients of −0.89 and 0.778, respectively. However, the contribution of city construction factor, water pollution factor, and scientific research factor were found to be relatively small and nonsignificant.

3.4. Changes in the Explanatory Ability of Different Socio-Economic Driving Forces for Wetland Area Variation

The forward selection of RDA indicated that the key socio-economic driving forces influencing the wetland area change varied in different years (Table 4). In 2008, domestic tourists played a dominant role in explaining the wetland area variation of Yunnan Province, with a 48.7% explanatory ability (Figure 5a), followed by natural science research institutions, industrial water consumption, and GDP per person, with explanatory abilities of 21.2%, 16.1%, and 3.1%, respectively. However, in 2017 (Figure 5b), overseas tourists, milk, total tourism revenue, and industrial waste water emission exerted a significant influence on the wetland area variation of Yunnan Province, with explanatory abilities of 61.6%, 17.9%, 12.1%, and 6.4%, respectively. The other variables had weaker explanatory abilities. In general, these results indicate that different socio-economic factors play a crucial role in influencing wetland area variation. However, the explanatory factors for the wetland area were found to vary over the study period. In 2008, the tourism development factor, the scientific research factor, the water pollution factor, and the economic factor exerted important influences, whereas in 2017, the factors influencing the wetland area variation were tourism development, the economic factor, and water pollution.

![Figure 5](image-url)

Figure 5. RDA two-dimensional ordination diagram of the plots in 2008 and 2017. The relationship between socio-economic factors and wetland area changes in (a) 2008 and (b) 2017. DT, domestic tourists; NSI, natural science research institutions; IWC, industrial water consumption; UST, urban sewage treatment; SW, sheep wool; GDPP, GDP per person; PS, percentage of secondary industry; OT, overseas tourists; TTR, total tourism revenue; IWE, industrial waste water emission; GDP, gross domestic product; PT, percentage of tertiary industry; UST, urban sewage treatment; PS, percentage of secondary industry.
### Table 4. Explanatory ability of significant variables in 2008 and 2017.

| Variables                              | Explains % | p   |
|----------------------------------------|------------|-----|
| Domestic tourists                      | 48.7       | 0.006 |
| Natural science research institutions  | 21.2       | 0.048 |
| Industrial water consumption           | 16.1       | 0.022 |
| Urban sewage treatment                 | 6.3        | 0.07  |
| Sheep wool                             | 3.6        | 0.078 |
| GDP per person                         | 3.1        | 0.02  |
| Percentage of secondary industry       | 0.6        | 0.122 |
| Overseas tourists                      | 0.3        | 0.222 |
| Population density                     | <0.1       | 0.999 |
| Overseas tourists                      | 61.6       | 0.004 |
| Milk                                   | 17.9       | 0.05  |
| Total tourism revenue                  | 12.1       | 0.016 |
| Industrial waste water emission        | 6.4        | 0.004 |
| Gross domestic product                 | 0.9        | 0.178 |
| Percentage of tertiary industry        | 0.7        | 0.148 |
| Urban sewage treatment                 | 0.3        | 0.194 |
| Percentage of secondary industry       | <0.1       | 0.999 |

### 4. Discussion

#### 4.1. Yunnan Province Has Extensive Wetlands

The overall increase rate of the wetland area in Yunnan Province was 13.35% from 2008 to 2017, among which the areas of river, lake, and swamp wetlands changed by 46.39%, −3.12%, and 295.56%, respectively. The results indicate that Yunnan Province has extensive wetlands, although the area of lake wetlands has been slightly reduced. These positive results may be attributed to a series of implemented ecological restoration projects, particularly in recent decades, to control wetland degradation. Studies have reported that ecological conservation and restoration policies help promote the wetland ecosystem [38,39]. For preventing ecosystem degradation caused by rapid economic growth, the Chinese government began to make heavy investments in natural capital protection and restoration after 2000. China formulated the National Wetland Conservation Action Plan in 2000 and approved the 2002–2030 National Wetland Conservation Engineering Program (NWCEP) in 2003 [1] and the Wetland Protection and Restoration System Program in 2016 [40]. In accordance with the national top-level design on wetland protection and management, Yunnan Province issued the opinions of the general office of the People’s Government of Yunnan Province on implementing the wetland protection and restoration system scheme in December 2017 in terms of local conditions, which defined the objectives, tasks, and work measures of establishing and improving the wetland protection and restoration system. Liu et al. [41] also observed considerable improvements in wetland ecosystem health and increases in wetland area with the enforcement of wetland conservation and restoration policies in China.

In 2013, Yunnan Province issued regulations on wetland protection. Since the 13th five-year plan (2016–2020), Yunnan has acquired CNY 495 million of national wetland protection funds and is effectively promoting the protection of important wetlands and the restoration of degraded wetlands by focusing on nine plateau lakes and important wetlands, taking six major water systems as the main line, complementing swamp wetland protection and small and micro wetland construction, combining point, line and area, and systematic treatment. At the city level, Xishuangbanna exhibited the largest reduction of 84.30% in the total wetland area. The largest increase in the total wetland area (+185.22%) was observed in Diqing (Figure 3). However, obvious spatial heterogeneity was observed among different wetland types. Wetland Park design is aimed at protecting and restoring wetland ecosystems with scientific methods, and the final achievements of this design have been remarkable. The Qinghua Wetland of Baoshan, Yunnan Province, is a good example [42]. Our results also indicate that Baoshan experienced the largest increase in
4.2. The Main Driving Factors for Wetland Area Variation

The 9 of 24 factors further selected by the research displayed a strong explanatory power for wetland area change in Yunnan Province ($R^2 = 0.749, p < 0.05$) (Table 2). Studies have proposed a positive correlation between river wetland area changes and changes in forest areas, mean annual temperature, and extreme minimum temperature, while reservoir wetland area changes were in a positive regression relation with changes in city construction areas and mean annual temperature [15]. Undue land reclamation accompanied by rapid population growth caused a shrinkage in the water surface area of Dongting Lake (formerly the largest freshwater lake in China) by 49.2% from 1930 to 1998 [43]. In accordance with the National Wetland Inventory of 1981–1982, around 40% of the 233 wetlands in America have been destroyed by human activities [44]. The socio-economic indicators for the wetland area variation included the population factor and economic factors. The finding agrees with the results from numerous studies indicating that population and the economy play a crucial role in wetland degradation [45,46], which in turn may lead to urban sprawl and the shrinking of inland and coastal wetlands. However, depending on how human activities alter the man–nature relation, wetland degradation can be either accelerated or prevented by these activities [47].

The main influencing factors exhibited both similarities and differences across different wetland types. Specifically, the total wetlands and river wetlands have been influenced by factors such as population, economy, water pollution, tourism development, and scientific research, whereas the lake wetlands have been mainly influenced by the water pollution factor, the economic factor, the city construction factor, and the water pollution factor. Likewise, the swamp wetlands have been mainly influenced by the population factor, the economic factor, and the tourism development factor. Thus, exploring changes in different wetland types from the perspective of diverse socio-economic forces is essential for identifying the key nodes for adapting to human activities and ensuring the sustainable development of wetland ecosystems.

4.3. The Driving Factors for Wetland Area Variations over Time

We also found variations in the driving factors for wetland area change with time, which may be attributed to human social progress and development. In 2008, the main influencing factors were tourism development, scientific research, water pollution, and economic, whereas in 2017, the tourism development factor and the economic factor played a major role. Our results can clarify the key socio-economic influencing factors for wetland area changes, thereby providing guidance to policymakers. The main drivers for vegetation coverage vary with time and variables in coastal wetlands in China [32]. Therefore, assessment methods for a comprehensive assessment of these systems should be developed, which can help in characterizing human interference and determining the main interference drivers for the formulation of management strategies [48].

In a word, as people gradually deepen their understanding of the importance of wetland protection, wetland resources in Yunnan Province have been managed and protected to a certain extent. By analyzing the impact of different socio-economic factors on changes in wetland areas in Yunnan, we concluded that socio-economic factors such as scientific research, water pollution, tourism development, and economic factors play important roles in wetland variation. Moreover, in different development stages and different cities, the influencing factors are not quite the same. Therefore, with the development of Yunnan’s economy, wetland protection in Yunnan is facing more severe challenges. We should always be alert to new impact factors and take effective measures in time.
temperatures, rising sea levels, significant increases in extreme climate and natural disasters, and loss of biodiversity have threatened the wetland ecosystem, especially the plateau wetland ecosystem in Yunnan. Coping with and resisting the negative impact of climate change present significant challenges at present. In future studies, human socio-economic and natural climate change factors should be comprehensively considered to effectively protect wetlands, actively restore the wetland ecosystem, and build a solid ecological barrier for the sustainable development of the social economy.

5. Conclusions

The study results indicate that the total wetland area of Yunnan Province increased by 13.35% during 2008–2017. Among different wetlands, the river, lake, and swamp wetland areas exhibited change rates of 46.39%, −3.12%, and 295.56%, respectively. The main influencing factors for different types of wetlands varied; therefore, different management and protection measures should be implemented in different areas. RDA results illustrated that the tourism development factor, the water pollution factor, and the economic factor had significant lasting influences on the wetland area change. Our findings highlight variations in the major drivers for wetlands with time and across different wetland types. Thus, wetland management should consider the complicated influences of socio-economic factors on wetlands, and efficient protection measures including tourism development, economic development, and water pollution control in cities may help in achieving long-term conservation goals. Furthermore, global climate change has threatened the wetland ecosystem, especially the plateau wetland ecosystem in Yunnan. It is very significant to study both socio-economic factors and climate change in ecological protection and restoration in Yunnan Province in the future.

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