Sustainability **2014**, *6*, 4632-4644; doi:10.3390/su6074632

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

Research on Scenic Spot's Sustainable Development Based on a SD Model: A Case Study of the Jiuzhai Valley

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Received: 26 April 2014; in revised form: 10 July 2014 / Accepted: 11 July 2014 / Published: 23 July 2014

Abstract: In the field of tourism, the development of tourist attractions is playing an increasingly crucial role in tourism economy, regional economy and national economy. However, the eco-environment has been damaged while tourism industry develops rapidly. Thus, to solve the contradiction between tourism development and eco-environment protection is the key to achieving sustainable development of tourism. This paper builds a SD model, which is based on the analysis of the economic subsystem and environment subsystem, to promote sustainable development. In order to show the effectiveness of the model, Jiuzhai Valley is taken as the research object and a decisive basis is provided for the path adjustment of sustainable development in tourist scenic.

Keywords: tourist scenic system; sustainable development; system dynamics; Jiuzhai Valley

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1. Introduction

Tourism, which has become prosperous in the past few decades, has benefited transportation, accommodation, catering, entertainment and retailing sectors [1]. UNWTO predicts that international tourism demands will double by 2020 to 1.6 billion visitors and it will generate nearly $2 trillion dollars in economic activities [2]. China's tourism industry develops faster than other countries as Chinese people's living standards improve significantly along with the rapid development of the national economy [3]. However, the expansion of the tourism industry and the growing number of tourists have contributed to congestion and environmental damages in scenic spots, as more garbage, sewage and carbon emissions are brought about by the increasing tourists [4]. Tourism is prosperous all over the world, especially in western China [5], therefore, the realization of sustainable development in the tourism industry has caught the eyes of many scenic spot managers and scholars.

Sustainable development of tourism mainly focuses on tourism environmental capacity, indicators and policies of sustainable development, tourist destinations' life cycle, as well as community participation [6,7]. Tosun (1999) and Logar (2010) analyzed policy's impact on tourism development and put forward several recommendations to the scenic spot managers and government [8,9]. Some scholars thought the evaluation index of the sustainable development in tourism was the key to relevant research [10,11]. Cevat Tosun (2001), Briassoulis (2002), Northcote and Macbeth (2006), and Northcote (2006) gave a detailed evaluation index on sustainable development in scenic spots [10,11] and then studied the evaluation index of the sustainable development on the basis of the index. Castellani and Sala (2010), and Castellani (2010) did empirical research to verify its scientificity and effectiveness [12,13]. Briassoulis (2002) examined the factors which threatening the sustainable development of tourism, and pointed out that economic recession, environmental degradation, social contradictions and tourists' satisfaction reduction were the factors to constrain the sustainable development of tourism [14]. Miller (2010), by studying the public's understanding of sustainable development and the influence of visitors' behaviors on the sustainable development of tourism industry, pointed out that it was necessary to request that visitors behave themselves [15]. Based on the system theory, Hilal (2010) set up a collaborative network organization and environment management to promote the sustainable development of tourism [16]. As research on sustainable development go deeper, tourism products' life cycle theory has been applied to tourist destinations, and the life cycle changes of tourist destinations. Besides, the analysis of life cycle's characteristics in different stages is conducive to spot possible problems in different stages of the life cycle, thus corresponsive approaches could be initiated timely to solve them. In the end, the life cycle can be prolonged and the sustainable development of tourism will be achieved.

Through analyzing relevant researches, it can be found that qualitative analysis is frequently adopted, mainly in studies such as ecological footprint, environmental capacity, PSR method and system simulation. However, quantitative study is rarely employed, only in studies on sustainable development of tourist destinations [17–20].

This paper proposes a system dynamics (SD) model, which combines quantitative and qualitative methods to research sustainable development in tourism. As the contradiction lies in economic development and environment damages, the relationship between the economic subsystem and the environmental subsystem will be highlighted. In addition, we will come up with some suggestions about sustainable development in tourism by running the SD model to simulate a real situation.

This paper is organized logically as follows: Section 2 analyzes the scenic spot system, including the economic subsystem and the environmental subsystem. On the basis of dynamic system with the two subsystems, the system dynamics equations of sustainable development of scenic spots are created to conduct a quantitative study and systematic analysis. Then the system dynamics model of sustainable development is built; Section 3 runs the SD model and analyzes its results; Section 4 concludes the situation of sustainable development and discusses necessary further research.

2. Model

2.1. Methodology

System dynamics is a technique that combines qualitative and quantitative methods to analyze system operating mechanism. The methodology process is described in detail as follows:

Step 1: Observe the system carefully and identify its objectives;

Step 2: Use system approaches to analyze the system and select proper variables to represent the objectives;

Step 3: Develop causal loops to represent system operating mechanism and then transform them into stock and flow diagrams.

Step 4: Based on the stock and flow diagrams, simulation equations are formed to describe the system quantitatively.

Step 5: Use SD software such as VENSIME to set up a dynamic model and run the model to simulate the system's real state.

2.2. System Analysis

Sustainable development of tourism includes two subsystems, namely the economic subsystem and the environmental subsystem.

In the economic subsystem, profit is the key variable as scenic spot manager's economic objective is to maximize revenue. Investment in garbage disposal, sewage treatment promotion and infrastructure are related to the key variable, therefore, all these variables will be included in economic subsystem. On one hand, the tourist number grows hand in hand with the incremental promotion investment as well as the increasing investments in garbage disposal and sewage treatment, which will undoubtedly improve the environment of a scenic spot. As for investment in infrastructure, it will enhance tourists' satisfaction which in the end will attract more tourists. On the other hand, although more tourists means more revenue, the investments in garbage disposal, sewage treatment promotion and infrastructure will soar as well. The causal relationships in Figure 1 are presented to show their chains combined with economic subsystem: Tourist quantity → Scenic profit → Promotion investment → Tourist quantity, Tourist quantity → Scenic profit → Garbage's handling investment → Tourist quantity, Tourist quantity → Scenic profit → Sewage's handling investment → Tourist quantity, Tourist quantity → Scenic profit → Infrastructure investment → Tourist quantity.

In the environmental subsystem, the environment quality index measured by garbage load ratio, water environment pollution level and air pollution level is the key variable, as scenic spot manager's environmental objective is to maximize the environment quality. Garbage quantity, sewage quantity and carbon emission are major variables which impact the environment quality, as a result, they are considered in environment subsystem. On one hand, a higher environment quality index will bring in more tourists. On the other hand, more tourists mean more garbage, sewage and carbon emission which will deteriorate the environment. The causal relationships in Figure 2 are presented to show their chains combined with environment subsystem: Environment quality index → Tourist quantity → Garbage quantity → Garbage load ratio → Environment quality index, Environment quality index →

Tourist quantity → Sewage quantity → Water environment pollution level → Environment quality index, Environment quality index → Tourist quantity → Carbon emission → Air pollution level → Environment quality index.

Figure 1. Economic subsystem' causal relationship.

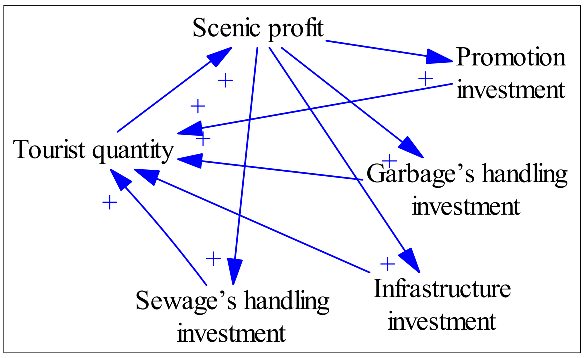
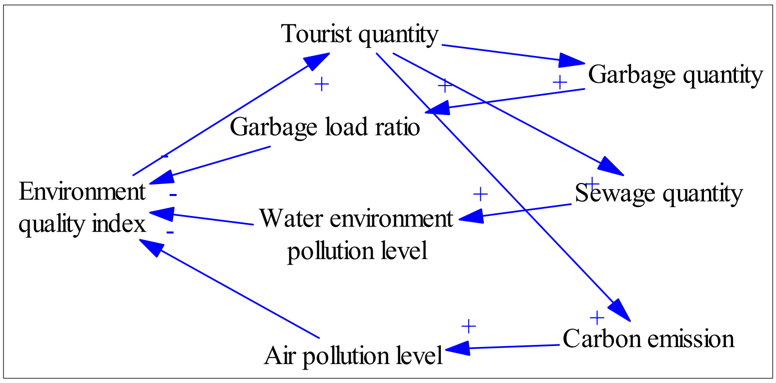
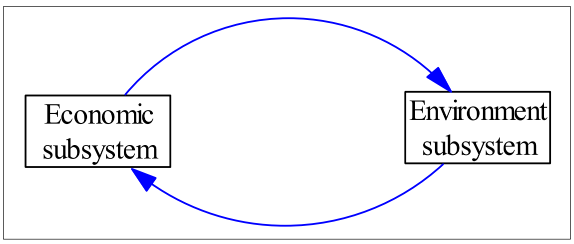


Figure 2. Environment subsystem' causal relationship.



After analyzing the above two subsystems, we conduct a quality analysis of the relationship between economic subsystem and environment subsystem (Seeing Figure 3). In Figure 3, we find that economic subsystem has both positive and negative impacts on environment subsystem and vice versa. That means in some cases positive impact is predominant while in some other cases negative impact will be more salient.

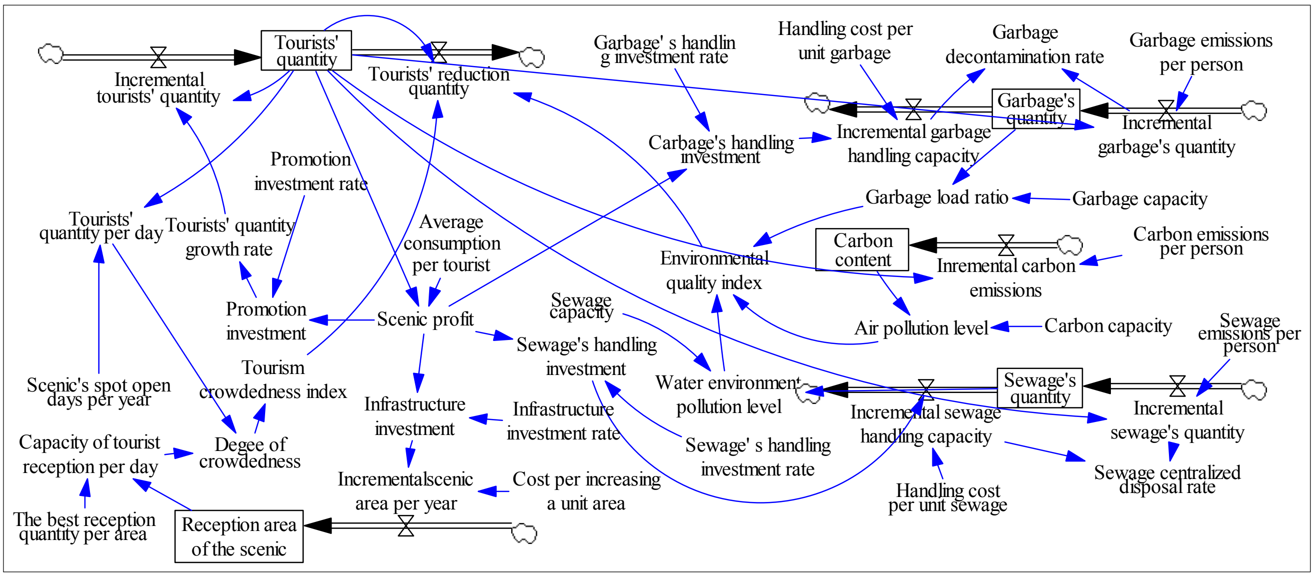
Figure 3. Relationship between economic subsystem and environment subsystem.



2.3. SD Model

According to the system structure and analysis on causal feedback relations between the two subsystems, the system flow diagram of SD model is seen as Figure 4.

Figure 4. SD model.



According to the cause-effect relationships between the two subsystems, major research-level variables of each subsystem are as follows: Tourist quantity, Garbage quantity, Sewage quantity, Carbon content, and reception area of the scenic spot. Major researched flow rate variables are as follows: Incremental garbage handling capacity, Incremental garbage quantity, Incremental sewage handling capacity, Incremental sewage quantity, Incremental tourist quantity, quantity of reduced tourists, Incremental carbon emissions and Incremental scenic spot area per year. In addition, major researched auxiliary variables are as follows: Handling cost per unit garbage, garbage decontamination rate, garbage emissions per person, garbage capacity, garbage load ratio, handling cost per unit sewage, sewage emissions per person, sewage centralized disposal rate, sewage capacity, water pollution level, carbon emissions per person, carbon capacity, air pollution level, environmental quality index, garbage handling investment rate, sewage handling investment rate, promotion investment rate, garbage handling investment, sewage handling investment, promotion investment, average consumption per tourist, profit of the scenic spot, scenic spot's operation days per year, tourist quantity per day, average consumption per tourist, degree of crowdedness, capacity of tourist reception per day, reception capacity per area, infrastructure investment rate, infrastructure investment and cost per increased unit area.

The relationships among the variables take on complex and dynamic features. Thanks to the clarified cause-effect relationships among the variables or key elements, it is possible to simulate the system and then create system equations to lay a solid groundwork for a quantitative analysis on this system.

3. Simulation

3.1. Model Equations

Specific performances of the system dynamics model are a series of mathematical equations, which can be created by the formula editor that VENSIM provides [21–23]. Combined with the system flow diagram and operation method of the tourist destination, the system dynamics equations for sustainable development based on SD model can be created.

Economic subsystem: Tourists' quantity. K = Tourists' quantity. J + Incremental tourists' quantity. JK, Incremental tourists' quantity. KL = Tourists' quantity growth rate. K * Tourists' quantity. K, Tourists' quantity reduction rate. K = Environment influence coefficient. K * Environmental quality index. K + Tourist crowdedness indices. K * Tourist crowdedness influence coefficient. K, Tourists' quantity growth rate. K = Promotion investment. K * Promotion investment influence rate. K.

Environmental subsystem: Garbage's quantity. K = Garbage's quantity. J + Incremental garbage's quantity. JK – Garbage handling capacity. JK, Incremental garbage's quantity. KL = Garbage discharge per tourist. K * Tourists' quantity. K, Garbage handling capacity. KL = Garbage's quantity. K * Garbage handling rate. K, Sewage's quantity. K = Sewage's quantity. J + Incremental Sewage's quantity. JK – Sewage handling capacity. JK, Incremental Sewage's quantity. KL = Sewage emissions per tourist. K * Tourists' quantity. K, Sewage handling capacity. KL = Sewage's quantity. K * Sewage handling rate. K, Carbon emissions. K = Carbon emissions. J + Incremental carbon emissions. JK, Incremental carbon emissions. KL = Carbon emissions per touritst. K * Tourists' quantity. K, Environmental quality index. K = (1/exp(Garbage load ratio) + 1/exp(Sewage load ratio) + 1/exp(Carbon emissions load ratio))/3.

3.2. Model Parameters

We collect the model parameters from the related literatures [5] and Jiuzhai Valley Scenic Spot Management Bureau and the results are shown in Table 1.

Table 1. Parameter value.

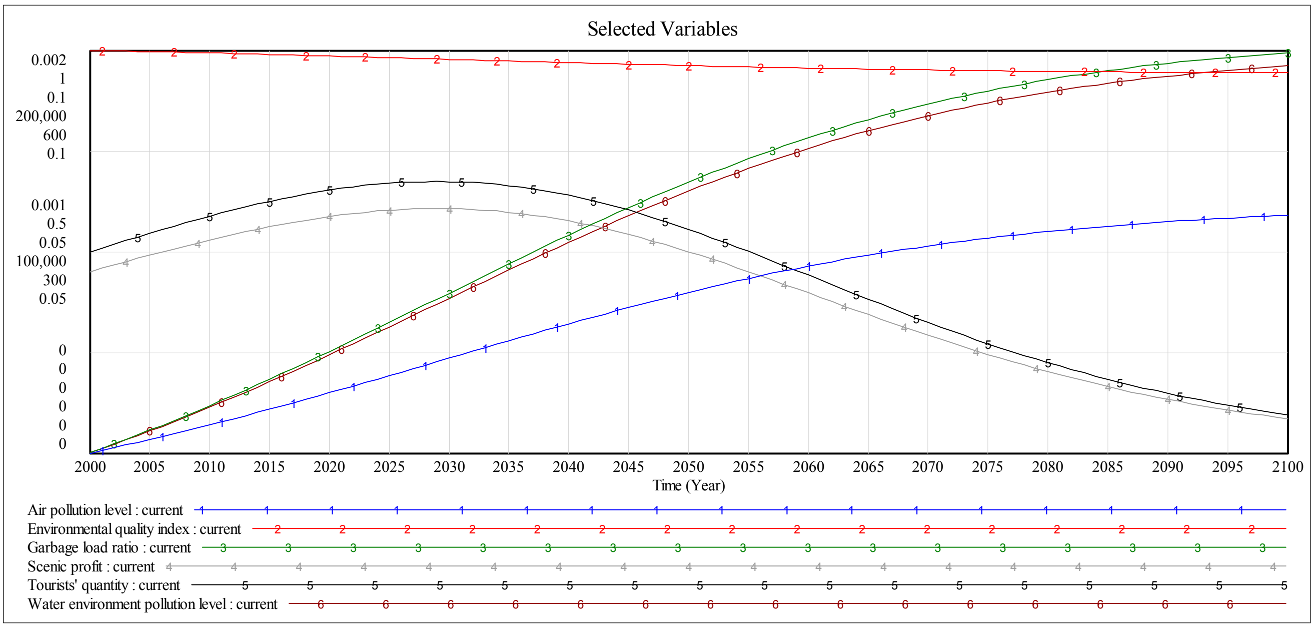
Parameter name	Value	Unit	Sources
Environment influence coefficient	0.403	Non-dimension	Field Research and review of literatures
Tourist crowdedness influence coefficient	0.612	Non-dimension	Field Research and review of literatures
Promotion investment influence rate	0.003	Non-dimension	Jiuzhai Valley Scenic Spot Management Bureau
Average consumption per tourist	290	Yuan	Jiuzhai Valley Scenic Spot Management Bureau
Garbage emission per tourist	1.112	Kilogram	Jiuzhai Valley Scenic Spot Management Bureau
Sewage emission per tourist	1.1	Kilogram	Jiuzhai Valley Scenic Spot Management Bureau
Carbon emissions per tourist	0.0042963	Kilogram	Jiuzhai Valley Scenic Spot Management Bureau
Garbage handling investment rate	0.5%	Non-dimension	Jiuzhai Valley Scenic Spot Management Bureau
Sewage handling investment rate	0.5%	Non-dimension	Jiuzhai Valley Scenic Spot Management Bureau
Infrastructure investment rate	5%	Non-dimension	Jiuzhai Valley Scenic Spot Management Bureau
Promotion investment rate	0.5%	Non-dimension	Jiuzhai Valley Scenic Spot Management Bureau

The first two parameters are obtained from literature [5] and the others are mean values by statistical data collected from Jiuzhai Valley Scenic Spot Management Bureau. For example, carbon emissions per tourist are estimated within the scenic area in this paper. Taking the actual data searched from Jiuzhai Valley into account, carbon emissions per tourist are mainly calculated from carbon dioxide emission factor generated by different energy consumption of sightseeing vehicles from 2002 to 2012 and the respiration of tourists in Jiuzhai Valley. Then the mean value is taken as value of carbon emissions per tourist.

3.3. Simulation Results

Running the simulation model, its results are shown in Figure 5, which contains states of tourist quantity, garbage load ratio, water environment pollution level, air pollution level, environmental quality index and the scenic spot's profits from the 2000 to 2030. As to the state of tourist quantity shown in Figure 5, driven by tourism development, which will be boosted by a fine ecological environment, it will maintain a linear growing trend. However, when tourist quantity reaches the capacity limitation of Jiuzhai Valley, its growth trend will slow down and finally stop in 2030. So after 2030, the best way to increase tourist quantity is to enhance the tourist reception capacity of Jiuzhai Valley.

Figure 5. Simulation results.



The third line in Figure 5 shows the changes of garbage load ratios every ten years. We find that before 2030, the growth rate of garbage load ratio is increasing, but after 2030, it will slow down because tourist quantity will reach the maximum reception capacity in 2030. The growth rate of garbage load ratio increases together with tourist quantity before 2030, and it will decrease along with tourist quantity after 2030.

The sixth line in Figure 5 shows the changes of water environment pollution level every ten years. We can find that before 2030, the growth rate of water environment pollution level is increasing, it will slow down after 2030 because tourist quantity will reach the maximum reception capacity in 2030. The growth rate of water environment pollution level increases together with tourist quantity before 2030, and it will decrease along with tourist quantity after 2030.

The first line in Figure 5 shows the changes of air pollution level every ten years. We find that the growth rate of air pollution level will increase before 2030 and it will slow down after 2030, because tourist quantity will reach the maximum reception capacity in 2030. The growth rate of air pollution level increases together with tourist quantity before 2030 and it will decrease along with tourist quantity after 2030.

The second line in Figure 5 shows the changes of environment quality level every ten years. From Figure 9, we can find that environment quality index will decrease when garbage load ratio, water quality and air pollution level increase, that's because those factors will harm the environment more as tourism grows rapidly.

The fourth line in Figure 5 shows the yearly changes of the scenic spot's profit. From Figure 10, we can find that the profit is increasing as tourism develops soundly before 2030, but it will decrease together with environment quality level after 2030. It indicates that the major impact of environment quality level is positive and when environment deteriorates, it will bring negative rather than positive results.

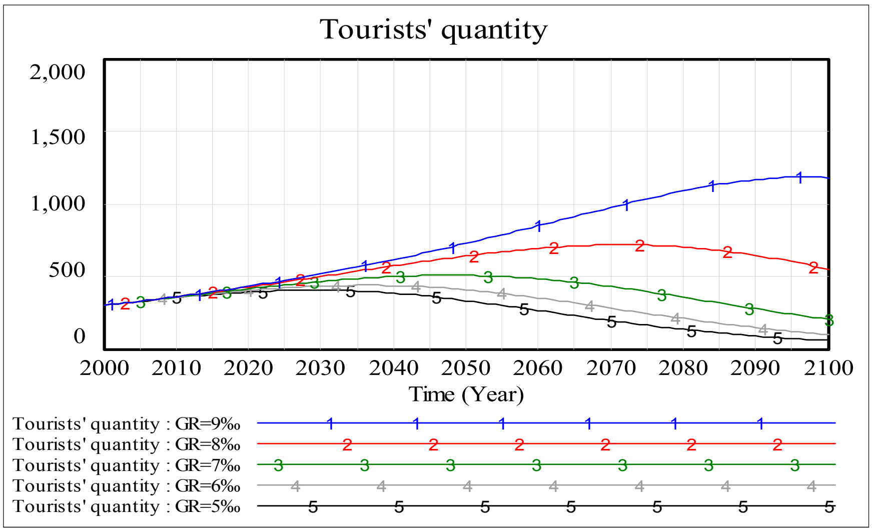
3.4. Sensitivity Analysis

From the analysis above, it can be found that environment could determine the development of Jiuzhai Valley. Thus, it is necessary to analyze the impact of environmental quality control change on tourism industry, including garbage investment rate and sewage investment rate (there is no measure controlling carbon emission in Jiuzhai Valley).

3.4.1. Sensitivity Analysis of Garbage Investment Rate

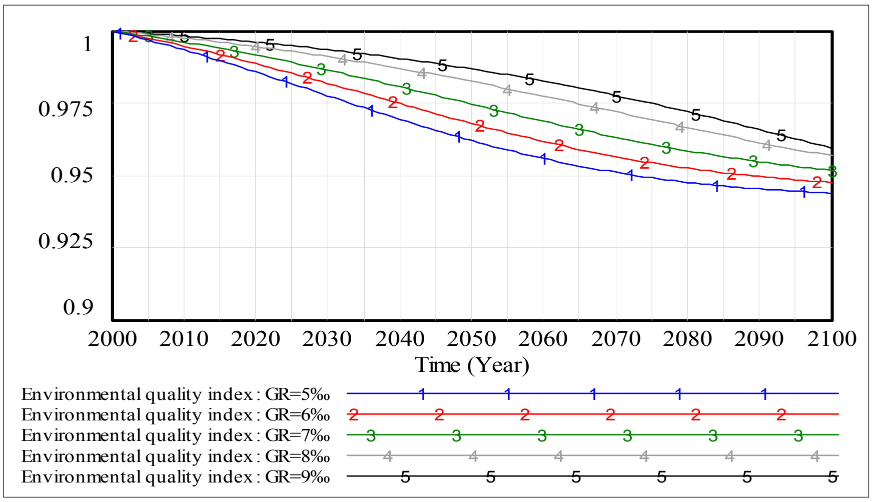
In order to show the impact of the garbage investment rate, we set its value at 0.6%, 0.7%, 0.8%, 0.9% by increasing 0.1% respectively. In addition, by combining it with the current garbage investment rate in Jiuzhai Valley, which is 0.5%, we obtain the results of sensitivity analysis as presented in Figures 6–8.

Figure 6. Results of sensitivity analysis on tourist quantity.



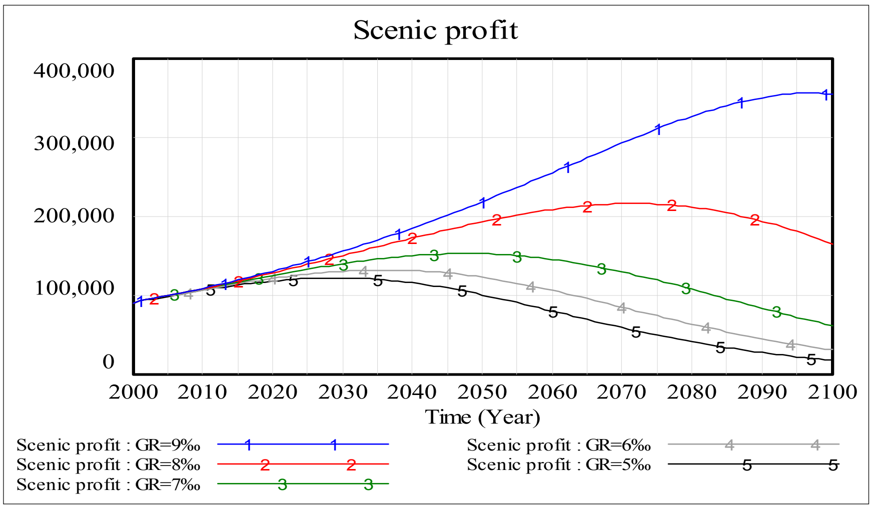
From Figure 6 we can find that when garbage investment rate increases, tourist quantity and its growth rate increases as well. That means garbage investment has a great impact on tourism development, and it can postpone the fall of the scenic spot.

Figure 7. Results of sensitivity analysis on environmental quality.



From Figure 7 we can find that when garbage investment rate increases, the environmental quality index and its growth rate increases as well. That means garbage investment has a great impact on tourism development and a better environment is the essential reason for tourism advancement. So the reason why garbage investment can promote tourism is that the environment is improved.

Figure 8. Results of sensitivity analysis on scenic spot's profit.

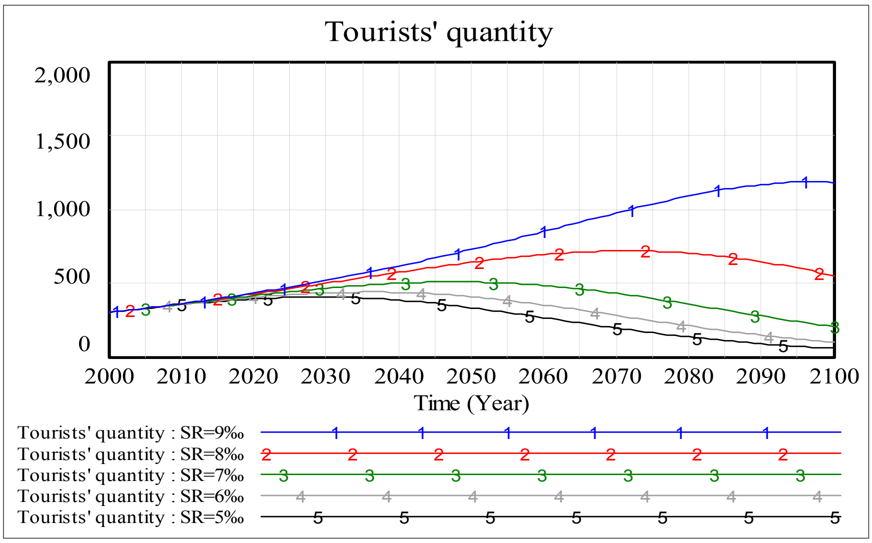


From Figure 8 we find that when the garbage investment rate increases, the scenic spot's profit and its growth rate increases as well. It is obvious that the increase of garbage investment rate contributes to a better environment, which in the end brings more profit to the scenic spot. That means the increase of garbage investment rate can enhance the environment's positive impact on tourism.

3.4.2. Sensitivity Analysis of Sewage Investment Rate

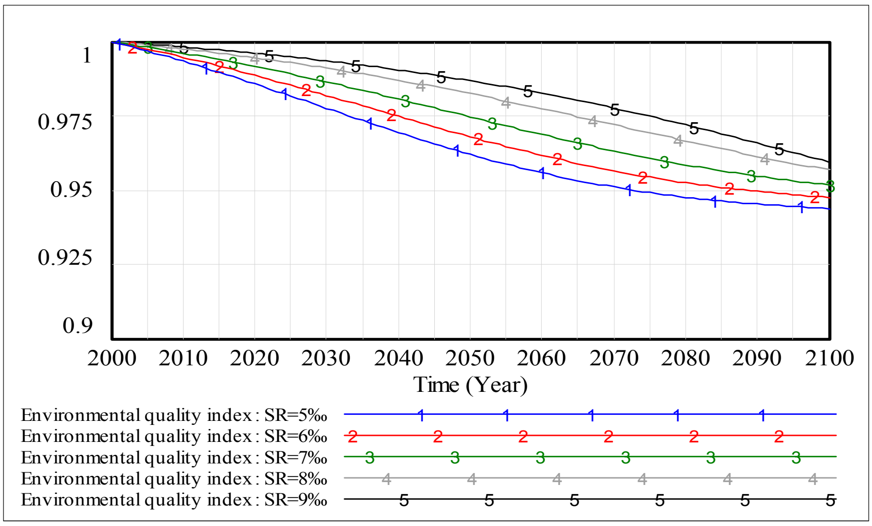
In order to show the impact of sewage investment rate, we set its value at 0.6%, 0.7%, 0.8%, 0.9% by increasing 0.1% respectively. In addition, by combining it with the current sewage investment rate in Jiuzhai Valley, which is 0.5%, we obtain the results of sensitivity analysis as presented in Figures 9–11.

Figure 9. Results of sensitivity analysis on tourist quantity.



In Figure 9 we find that when the sewage investment rate increases, tourist quantity and its growth rate increases as well. That means sewage investment has a great impact on tourism development, and it can postpone the fall of the scenic spot.

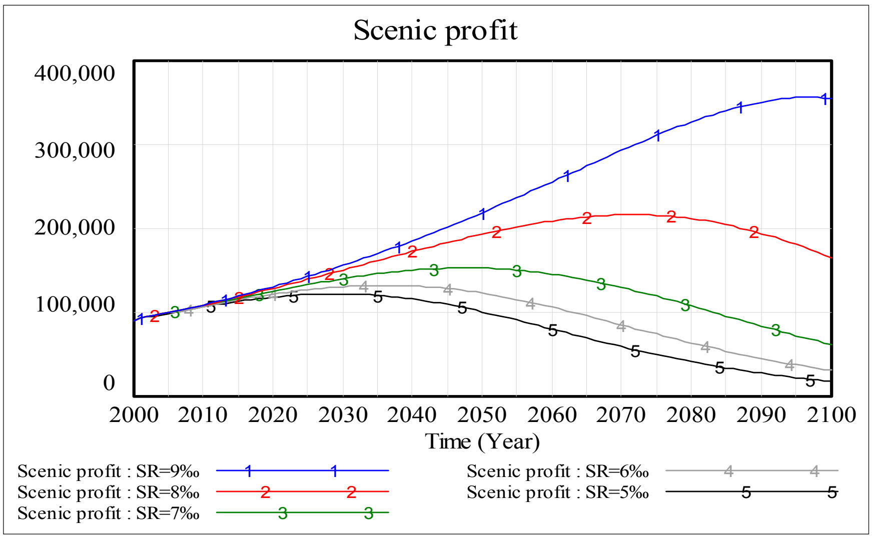
Figure 10. Results of sensitivity analysis on environmental quality.



In Figure 10 we find that when the sewage investment rate increases, environment quality index and its growth rate increases as well. That means sewage investment has a great impact on tourism development and a better environment is the essential reason for tourism advancement. So the reason why sewage investment can promote tourism is that the environment is improved.

In Figure 11 we find that when the sewage investment rate increases, the scenic spot's profit and its growth rate increases as well. It is obvious that the increase of sewage investment rate contributes to a better environment which in the end brings more profits for the scenic spot. That means the increase of sewage investment rate can enhance the environment's positive impact on tourism.

Figure 11. Sensitivity analysis's results of scenic profit.



4. Conclusions

This paper aims to use a system dynamic model to reveal the development situation and characteristics of a tourism system at a tourist destination. The two interrelated subsystems proposed in this paper are integrated into a complex system of a tourism system. According to the simulation of Jiuzhai Valley from the perspectives of the economic subsystem and the environmental subsystem, we find that the environment subsystem has both positive and negative impacts on the economic subsystem and vice versa. In order to analyze the impact of the environment subsystem on the economic subsystem, we have done sensitivity analysis on garbage investment rate and sewage investment rate respectively. From the sensitivity analysis, we conclude that the increase in the garbage investment rate and the sewage investment rate facilitate sustainable development in a scenic spot because they can improve the environment quality index, which enhances the environment's positive impacts on the economic subsystem. Therefore, for a scenic spot manager, to increase investment in handling garbage and sewage turns out to be a good way to promote sustainable development.

In the future, we will analyze the thresholds of investment rate for garbage and sewage respectively, which are also key aspects to efficiently promote sustainable development.

Acknowledgments

This work was supported by the Major International Joint Research Program of the National Natural Science Foundation of China (Grant no. 71020107027), the National High Technology Research and Development Major Program of China (863 Program) (Grant no. 2008AA04A107), the National Natural Science Foundation of China (Grant no. 71001075), the National Natural Science Foundation of China (Grant no. 71371130), the China Postdoctoral Science Foundation (Grant no. 2012M521704), Doctoral Fund of Ministry of Education of China (20110181110034), 985, 211 Projects of Sichuan University and Central University Fund of Sichuan University.

Author Contributions

The study was designed by Zhixue Liao in collaboration with all co-authors. Data was collected by Zhixue Liao and Yuyan Luo. The first and final drafts were written by Zhixue Liao and Yuyan Luo. The draft questions were critiqued by Maozhu Jin and Peiyu Ren. The results were analyzed by Maozhu Jin and Zhixue Liao. The project and key elements of the research were reviewed by Peiyu Ren. The writing work of corresponding parts and the major revisions of this paper were completed by Maozhu Jin and Zhixue Liao.

Conflicts of Interest

The authors declare no conflict of interest.

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