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Combating Desertification through the Wine Industry in Hongsibu, Ningxia

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Abstract: Land desertification is a global environmental problem, leading to the deterioration of the ecological environment and is an issue that threatens humans. Hongsibu, located in Ningxia, northwest China, is a semi-desert area with the largest domestic single-site ecological resettlement area for poverty alleviation based on the wine industry. Here, we quantified the value of the ecosystem services of the wine industry in Hongsibu and used the analytic hierarchy process (AHP) to quantitatively evaluate the comprehensive benefits of the wine industry for resolving desertification. We found that winegrapes significantly increase vegetation cover, while significantly decreasing blowing sand and generating a total annual value of ecosystem services of 6.13×10^8 RMB. The evaluation score of the comprehensive benefits is 81.85%, with grape growers and chateaus obtaining large economic benefits from the wine industry. In conclusion, the wine industry's development not only enhances the economic level of grape growers but significantly resolves desertification in impoverished areas—thus alleviating poverty and land degradation, contributing to sustainable development. Therefore, this may be an effective strategy for sustainable development in other parts of the world.

Keywords: wine industry; desertification; ecosystem services; economic benefits; sustainable development

1. Introduction

Land desertification is a global environmental problem that causes land degradation and ecological environment deterioration, and threatens humans. In China, desertified land areas extend over 2.61×10^6 km^2, accounting for 1/4 of its total land area. Nearly 40% of China's relatively poor counties and nearly 25% of the poor population are located in the desert area of northwest China. The Ningxia region is located in the eastern part of northwest China, at the upper and middle reaches of the Yellow River. Most of this region is arid and semi-arid, making it one of the most severely desertified northwest Chinese provinces. The desertified area extends for 2.9×10^6 ha—accounting for 55.8% of the total land area of Ningxia [1–3]. Poor people are directly affected by land desertification in Ningxia—raising serious concerns regarding how the people who live in these ecologically fragile areas can be fed, even while the goal of achieving a reduction in desertification is not prioritized [4].

Desertification has become a serious problem in the arid and semi-arid regions of northwest China [5–7]. Inadequate land management measures, especially overgrazing, remain the main cause of desertification in arid regions [8]. Several studies have determined the causes of land degradation and proposed governance measures [9]. Most of

the government projects, such as the Three-North Shelterbelt System Project (since 1978) and the Ningxia Food Project 2605 (1980–present), aim to promote effective measures for desertification control, including the prohibition of grazing in fenced grasslands. Moreover, sustainable water management is the main measure for combating desertification in northwest China [10]. Desertification can also be resolved through economic development [11]. However, desertification is increasing at an alarming rate [8]; as such, residents in the affected areas cannot live while also protecting or improving the ecological environment [12]. The ineffectiveness of anti-desertification measures can be attributed to inadequate scientific involvement in decision-making, neglect of the human dimension, and a lack of a well-organized desertification monitoring system [13].

Hongsibu is a district of the Wuzhong Municipality, Ningxia, extending over an area of 2767 km^2, and was a deserted area with an extremely undesirable ecological environment before the Hongsibu Development Zone was established in 1999. Land desertification has seriously affected the local ecological environment, socioeconomic development, and the quality of life here. To address this situation, large-scale desertification prevention works have been carried out in Hongsibu. Here, the key projects aim at returning farmlands to forests and at implementing economic forest construction [14]. Grapevines, as a type of economic forest, are typically representative of Hongsibu's characteristic economic forest industry. The vines can not only improve the local ecological environment but also address the problems of the area residents' income and poverty, achieving a win–win situation in terms of economic and ecological benefits.

In Hongsibu, farmers have been growing grapevines since 2007, leading to the development of the wine industry. The frequency of winegrape planting has increased, and investments in the construction of chateaus have achieved initial results after three years of initial development. In 2018, viticulture spanned over an area of 7067 ha in Hongsibu, with a preservation rate of >70%. So far, 30 registered enterprises have provided an important development platform for the wine industry here. The wine industry is based on wine grape cultivation and wine production and sale. Thus far, research on the wine industry has focused on wine grape cultivars [15], wine quality [16,17], anthocyanin [18], polymeric polyphenols [19], irrigation technology [20,21], fertilization management and soil types [22], biological control of crop pests [23], and wine regions [24]. At present, research into the sustainable development of the wine industry is focused on improving the grape production ecosystem—an extremely simplified ecological viticulture technology system, with grapevines shape control, comprehensive grassing, in-row canes coverage, and winter hanging canes [25]. However, research on the value of the wine industry, especially its ecological value, remains scant. The study of the ecological value of the wine industry can not only entail direct benefits to the industry itself, but also contribute to the achievement of ecological benefits.

This research aims, then, to understand the economic and ecological value of the wine industry. Based on this, we propose three hypotheses: (1) The Hongsibu's wine industry has great ecosystem services value. (2) This wine industry also has significant economic and social benefits. (3) The use of the analytic hierarchy process (AHP) to quantitatively analyze that the wine industry demonstrates considerable and comprehensive benefits of desertification control. Based on our results, we also propose important programs for similar areas in other parts of the world, which are currently encountering the dual pressure of poverty and environmental degradation. Our results are of great significance and can help comprehensively achieve the sustainable development of the wine industry as well as to provide a theoretical basis for desertification control and poverty alleviation and sustainable development of ecological resettlement areas.

2. Materials and Methods

2.1. Study Region

This study was performed in Hongsibu (Figure 1)—the largest wine subarea in the eastern part of the Helan Mountains in China; this region belongs to the Ningxia Au-

tonomous Region, which is one of the wine regions with nationally protected geographical indications. Before the development of the wine industry, this area was deserted [26]. Located between the Daluo, Yantong, and the Niushou Mountains, Hongsibu is a mountain basin, with an area of 2767 km^2 and an altitude of 1240–1450 m, and has a typical temperate continental climate, which is dry and rainless throughout the year. There is also a large diurnal temperature difference, with an average annual precipitation of 251 mm, an average annual evaporation of 2387 mm, an average annual temperature of 8.7 °C, a daily temperature difference of 13.7 °C, a sum of accumulated effective temperatures ($\geq$10 °C) of >3200 °C, a total of annual sunshine hours of 2900–3550 h, and an average annual wind speed of 2.9–3.7 m/s. There are four types of soil in this region: lime calcareous soil, new accumulative soil, eolian sandy soil, and saline soil.
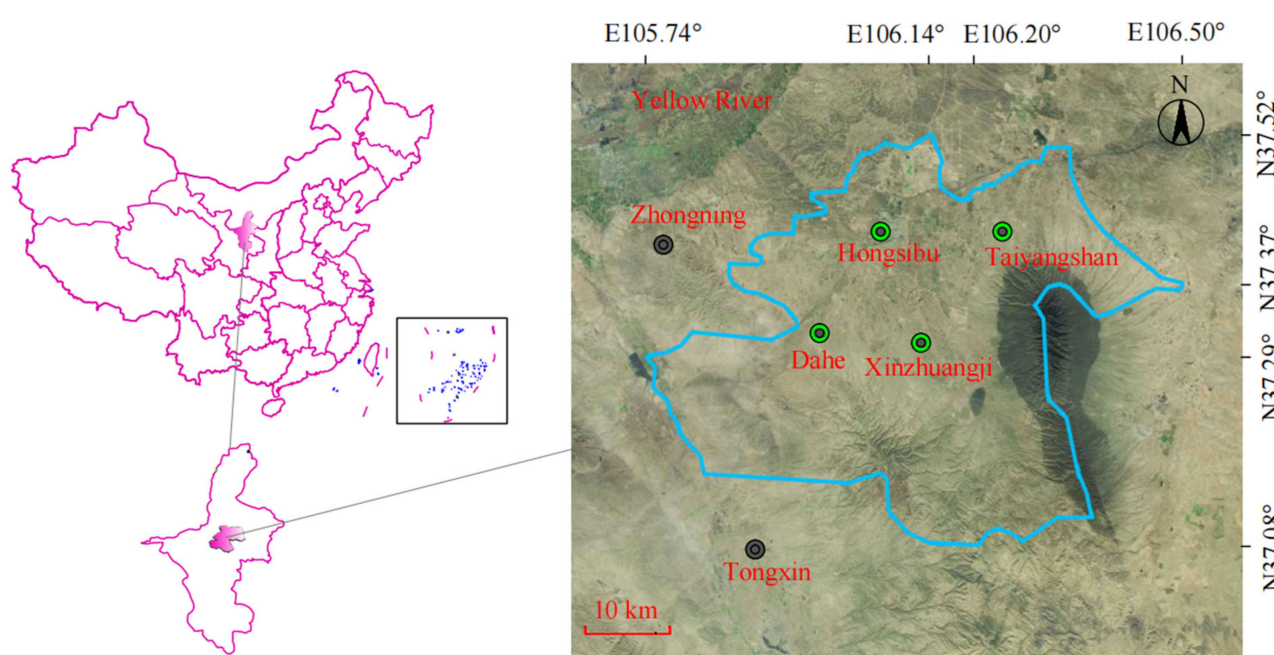

Figure 1. The study area: Hongsibu. The blue line represents the borders of Hongsibu. The survey sites selected for this study are marked in green (Grape growers Surveys, 2019 [n = 108] and Chateaus Surveys, 2019 [n = 10]).

2.2. Hongsibu's Wine Industry for Combating Desertification

The effect of the wine industry on desertification demonstrates the wine industry's value (i.e., ecological, economic, and social) as well as the comprehensive benefits of the wine industry against desertification (Figure 2). In March 2019, a one-week survey was conducted to obtain source data in Hongsibu. First, we studied the value of the wine industry by using the statistical methods for analyzing the original data. We then calculated the ecosystem services of the region (i.e., eastern foot of Helan Mountain, Ningxia, China) and Hongsibu. The ecosystem services, namely food production, carbon fixation, oxygen release, atmosphere purification, soil conservation, water conservation, water-saving and efficiency-enhancing, ecotourism, and ecological poverty alleviation [27], have been quantified using the method we used here [28–31]. The calculation formulas and the methods used for each value are shown in Table S1, see Supplementary Materials. Accordingly, we studied the comprehensive benefits of the wine industry for combating desertification.
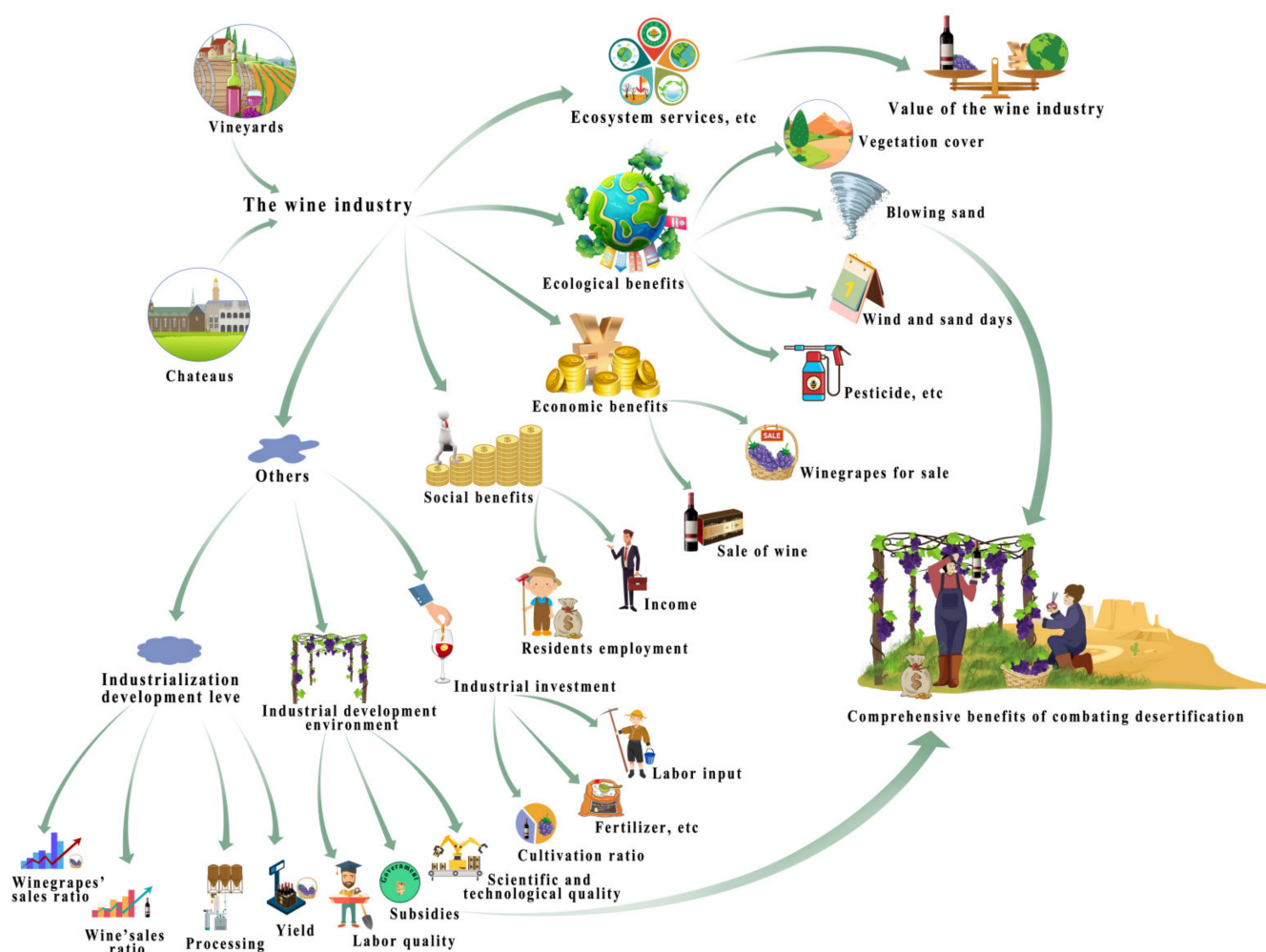
Figure 2. The wine industry's value and its comprehensive desertification control benefits.

2.3. Evaluation of the Comprehensive Benefits

Considering that the level of a technology can be considered a guarantee, economic, social, and ecological benefits can be classified as outputs. According to previous studies [32,33], the comprehensive benefits of the wine industry for combating desertification should rely on stable farmers' investment levels and on a strong industrial development platform (depending on the winery)—taking the road of industrialization to realize economic, social, and ecological benefits synergistic.

2.3.1. Construction of an Indicator System of the Comprehensive Benefits

Only a few studies have developed an evaluation indicator system of the comprehensive benefits of the wine industry to combat desertification. By combining this with agricultural industry's evaluation indicator system for sustainable development [34,35], we constructed a framework of a system covering all aspects of the wine industry's first-level evaluation indicators: industrial investment, industrial development environment, industrialization development level, economic benefits, social benefits, and ecological benefits.

2.3.2. Indicator Selection and Refinement

As shown in Table 1, the various evaluation indicators of the framework were refined to form second-level indicators of evaluation indicator system for the comprehensive benefits of the wine industry to combat desertification. This refinement drew upon previous studies [36–39] and combined the wine industry's particularities.

Table 1. Evaluation indicator system of comprehensive benefits of the wine industry to combat desertification.

First-Level Indicators	Second-Level Indicators	Investigation Object	Formula	Unit of Measurement
A Industrial investment	A1 Labor input of unit area	Grape growers	A1 = labor input/wine grapes area	number of people/ha
	A2 Amount of fertilizer per unit area	Grape growers	A2 = fertilizing amount/wine grapes area	RMB/ha
	A3 Planting ratio	Grape growers	A3 = wine grapes area/total cultivated area	%
B Industrial development environment	B1 Scientific and technological quality	Grape growers	B1 = scientific and technological input/cost of investment	%
	B2 Subsidies	Grape growers	B2 = government subsidies/cost of investment	%
	B3 Labor quality	Grape growers	B3 = number of labor of middle school or above/total labor	%
C Industrialization development level	C1 Yield per unit area	Grape growers	C1 = wine grapes yield/wine grapes area	t/ha
	C2 Wine grapes' sales rate	Grape growers	C2 = amount of wine grapes sales/wine grapes yield	%
	C3 Enterprise processing rate	Chateaus	C3 = amount of wine grapes processing/wine grapes yield of chateau	%
	C4 Enterprise sales ratio	Chateaus	C4 = wine sales/total amount of wine	%
D Social benefits	D1 Employment proportion	Grape growers	D1 = number of wine grapes practitioners/agricultural population	%
	D2 Poverty alleviation ratio	Grape growers	D2 = number of poor people/number of wine grapes practitioners	%
E Economic benefits	E1 Winegrapes contributes to income	Grape growers	E1 = wine grapes' income/farmer income	%
	E2 Winegrapes' expected contribution to income	Grape growers	E2 = wine grapes' income at expected maximum fruiting/farmer income	%
	E3 Wine contributes to chateau' income	Chateaus	E3 = wine income/investment cost	%
F Ecological benefits	F1 The proportion of farm manure used	Grape growers	F1 = farm manure usage/total amount of fertilizer	%
	F2 Reduction rate of desertified land	Chateaus	F2 = wine growing area/land area of chateau	%
	F3 Reduction rate of windy and sandy days	Chateaus	F3 = reduced windy and sandy days/total windy and sandy days before the wine industry	%
	F4 Amount of pesticide used per unit area	Grape growers	F4 = amount of pesticide used/wine grapes area	RMB/ha

2.3.3. Determination of the Relative Weight of Indicators

The evaluation indicator system comprises multiple evaluation indicators. The determination of the weight of the indicators is a key issue. Considering science and operability, and based on five experts' opinions, we determined the weight of each indicator [40]. We constructed a hierarchical structure model and used expert opinions and judgment matrices to compare indicators in pairs and determine their relative importance. Then, the indicators' relative weight was determined using MeshAHP software.

2.3.4. Data Standardization Processing

By using the sampling survey method, we randomly selected 108 grape growers and 10 chateaus to obtain source data on evaluation indicators of the comprehensive benefits. The actual value of each indicator was then calculated using the formulas listed in Table 1. Because there were differences in data dimensions in the evaluation indicator system, the standard value method was used to standardize the indicators' actual values [36]. The treatment method employed is as follows: we conducted interviews with five experts, who were asked to evaluate each indicator, such that an appropriate standard value could be determined. We assumed the actual value (Av) of the individual indicator and the standard value (Sv) and calculated the standardized score of indicators: $S = (Av/Sv) \times 100\%$. Among the ecological benefits, the indicator of the amount of pesticide used per unit area is the inverse indicator. It was thus processed as Sv/Av. The standardized score value of each indicators were multiplied by the weight coefficient, which were then summed to calculate the comprehensive benefit for desertification control.

3. Results

3.1. Changes in the Ecological Environment after the Wine Industry Development

We can observe that wine industry development enabled the reduction of the desertified area. Before this development in 2007, Hongsibu was characterized by sparse vegetation, a forest cover of <5%, an extension of 2767 km^2 of sand dunes, and a fragile ecological environment (Figure 3a). Since the development of the wine industry in 2007, viticulture area has been increasing so as to stop the expansion of deserts. Through wine industry development, special economic forests, such as grapevines, have been planted, with an extension of 11,733 ha being reached; this extension corresponded to an increase in the cover rate from <5% to 10.35% of the total area. The ecological construction of the wine industry made significant results in Hongsibu, and the local ecological environment has undergone significant changes (Figure 3b).

Figure 3. Ecological environment at the foot of Luoshan Mountain in Hongsibu (**a**) before and (**b**) after wine industry development.

Because of increases in the economic forest area with grapevines, significant changes were noted in several aspects including an adjusted atmospheric climate and in reduced number of sandstorm and dusty days—from 35 days per year before the development of the wine industry to 10 days in 2013. After the wine industry development resolved desertification, the ecological environment underwent changes such as shrinkage of the sandy desertified land, the formation of a better microclimate environment, and the control of sand storm hazards.

3.2. Ecosystem Services of the Wine Industry

Wine grapes in the eastern foot of Helan Mountain have a large ecosystem services value, and the proportion of each function is similar to that of Hongsibu. Our results showed that the value of the ecosystem services of the wine industry in Hongsibu, from the highest to the lowest, was as follows: food production > ecological poverty alleviation > ecotourism > atmospheric purification > carbon sequestration and oxygen release > water-saving and efficiency-enhancing > soil conservation > water resources conservation. In detail, the value of food production is 3.46×10^8 RMB, accounting for up to 54.96% of the total value; it is followed by the value of ecological poverty alleviation (1.67×10^8 RMB, accounting for 26.53% of the total value) and ecotourism (6.36×10^7 RMB, accounting for 10.10% of the total value; Table 2).

Table 2. Value of the ecosystem services of the wine industry.

Ecological Function	Formulas	Value of the Eastern Foot of Helan Mountain (RMB/Year)	Proportion of Each Function (%)	Value of Hongsibu (RMB/Year)	Proportion of Each Function (%)
Food production	$W_f = P \cdot A$	1.86×10^9	56.42	3.46×10^8	54.96
Carbon sequestration and oxygen release	$CV = P_c \cdot N \cdot A \cdot a$	2.51×10^7	3.52	4.67×10^6	3.43
	$OV = P_o \cdot N \cdot A \cdot b$	9.10×10^7		1.69×10^7	
Atmospheric purification	$U_{SO2} = K_{SO2} \cdot Q_{SO2} \cdot A$	2.05×10^6	1.83	3.82×10^5	4.45
	$U_{NOx} = K_{NOx} \cdot Q_{NOx} \cdot A$	2.74×10^4		5.09×10^3	
	$U_{HF} = K_{HF} \cdot Q_{HF} \cdot A$	1.82×10^4		3.39×10^3	
	$U_S = K_S \cdot Q_S \cdot A$	5.81×10^7		1.08×10^7	
Soil conservation	$W_s = (A-L) \cdot C \cdot P$	5.65×10^6	0.17	1.05×10^6	0.17
Water resources conservation	$W_w = (R-E) \cdot A \cdot P$	4.07×10^6	0.12	7.58×10^5	0.12
Water-saving and efficiency-enhancing	$Q = (X-x) \cdot A \cdot P$	8.40×10^6	0.25	1.56×10^6	0.25
Ecotourism	$V = P \cdot N \cdot Y$	3.42×10^8	10.37	6.36×10^7	10.10
Ecological poverty alleviation	$PA = P \cdot N$	9.00×10^8	27.30	1.67×10^8	26.53

The total value of ecosystem services of Hongsibu's the wine industry is 6.13×10^8 RMB. Among atmospheric purification, the value of dust and sand blocking is 1.08×10^7 RMB (Table 2)—indicating that the wine industry has an important ecological value and plays an important role in atmospheric purification of ecological environment.

3.3. Economic Benefits of the Wine Industry

After 2010, as wine grapes entered the fruit-bearing period, both the yields and the planting income of farmers began increasing annually. The scale of viticulture expanded continuously in Hongsibu, from 5800 ha in 2014 to 7067 ha in 2018 (Table 3). Wine grapes yields, including the perunit and total yields, also increased annually. Resident income from winegrapes also increased annually—with the income per unit area increasing from 10,821.76 RMB/ha in 2014 to 14,824.39 RMB/ha in 2018, and the agricultural per capita net income increasing from 1008.60 RMB in 2014 to 1399.80 RMB in 2018. During the same period, the proportion of wine grapes in per capita net income increased steadily, from 49.58% in 2014 to 68.50% in 2018 (Table 3). The wine industry depends on chateaus, and our analysis revealed the grape growers gained significant benefits from the sales of wine grapes, with a grape grower's average annual income being 40,000 RMB and the highest income of a single household being 200,000 RMB. The highest income exceeded

105,000 RMB/ha—equivalent to 7–8 times that with corn. Our results thus indicated that winegrapes have a significant economic value with regard to the growers' income.

Table 3. Changes in production, sales, and income of wine grapes over 2014–2018.

Year	Cultivated Area (ha)	Fruit Area (ha)	Per Unit Yield (kg/ha)	Total Yield (t)	Income Per Unit Area (RMB/ha)	Agricultural Per Capita Net Income (RMB)	Proportion of Wine Grapes in per Capita Net Income (%)
2014	5800	2578	3091.93	7971.00	10,821.76	1008.60	49.58
2015	5934	2680	3638.36	9750.80	11,642.75	1093.20	58.54
2016	6500	3300	3866.06	12,758.00	12,758.00	1185.50	60.46
2017	7067	3265	3982.45	13,002.70	13,938.58	1286.70	65.78
2018	7067	4150	4235.54	17,577.49	14,824.39	1399.80	68.50

Sources: Hongsibu District Natural and Resources Bureau of Wuzhong Municipality, and Hongsibu District Agriculture and Rural Affairs Bureau of Wuzhong Municipality.

The wine production and sales also increased annually, from 3200 t in 2014 to 9100 t in 2018 and from 1000 t in 2014 to 4500 t in 2018, respectively (Figure 4a). Moreover, the value of wine sales increased annually, from 1.7×10^8 RMB in 2014 to 3.5×10^8 RMB in 2018. During the same period, the profits from wine sales increased annually, from 9.0×10^7 RMB in 2014 to 2.1×10^8 RMB in 2018 (Figure 4b). Thus, a strong and significant economic benefit of the wine industry was observed.
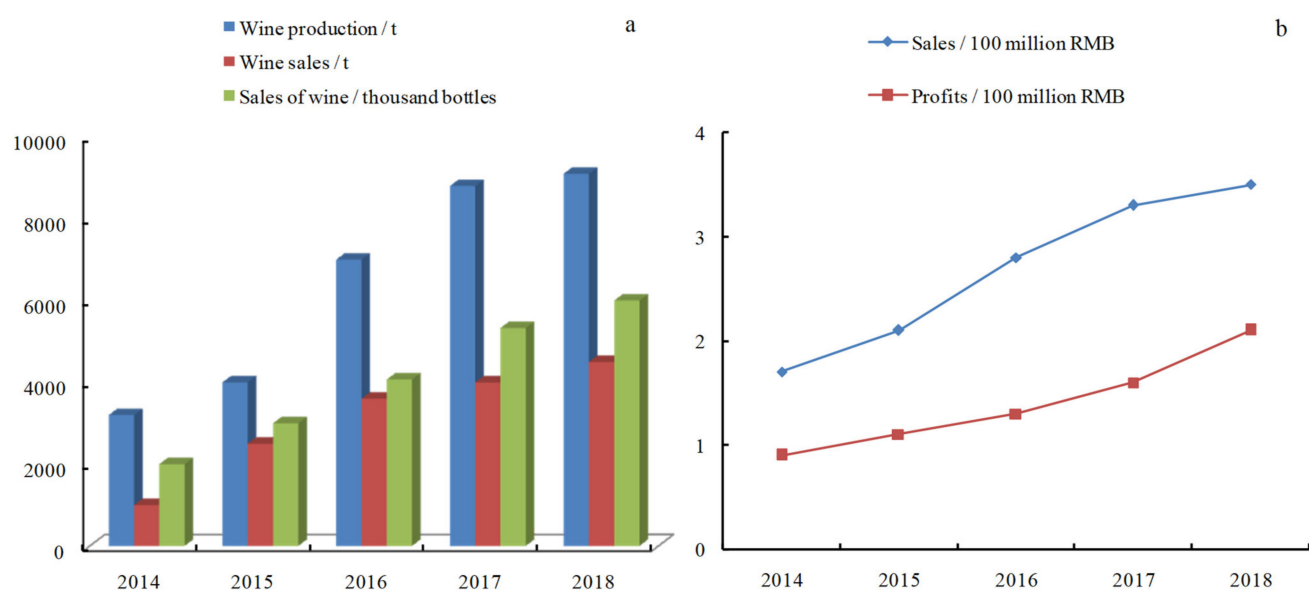

Figure 4. Changes in (**a**) wine production and sales and (**b**) wine sale and profits over 2014–2018. Data source: Hongsibu District Natural and Resources Bureau of Wuzhong Municipality, and Hongsibu District Agriculture and Rural Affairs Bureau of Wuzhong Municipality).

3.4. Comprehensive Benefits of Wine Industry Development

By comparing the first-level indicators, we constructed an evaluation matrix, determined the relative weights of the indicators (Figure 5a), and tested the matrix's consistency. Here, we obtained a consistency ratio (CR) of 0.065 (<0.1), indicating that the evaluation matrix had a satisfactory consistency. The highest weight of the first-level indicators was economic benefits, followed by ecological benefits (Figure 5a).

We then compared the second-level indicators by constructing an evaluation matrix, determining the relative weights (Figure 5b), and testing its consistency. The CR here was also <0.1, indicating that the evaluation matrix had a satisfactory consistency. The secondary indicators with the highest and lowest weights were wine contributes to chateau's income and subsidies of industrial development environment, respectively (Figure 5b).
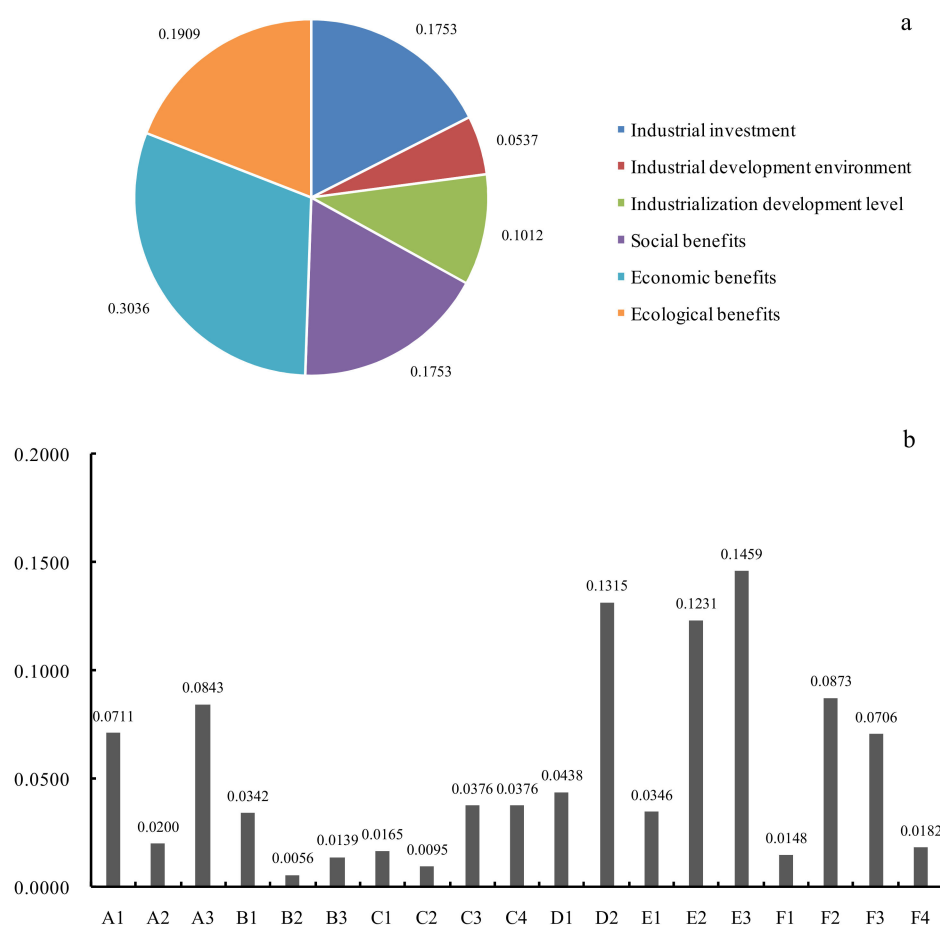
Figure 5. Weights of (**a**) first-level and (**b**) second-level indicators.

Comprehensive benefits of the wine industry for desertification control reached 81.85%; thus, the wine industry has an important role in combating desertification. The results of the investment analysis demonstrated that the overall investment of the wine industry is large. Specifically, the industrial investment was better than the industrial development environment. The standardized score of the labor input per unit area, that of the amount of fertilizer per unit area, and that of the planting rate were 79.58%, 92.42%, and 81.30%, respectively (Table 4). In addition to government subsidies, the scores of industrial development environment were relatively low. Despite the efforts lavished by the government, the technical level of ordinary villagers remained very poor. The score of scientific and technological quality and that of labor quality were only 57.42% and 55.36%, respectively. The scores of the industrialization development level were generally higher, with an enterprise processing rate of 86.21% and an enterprise sales ratio of 86.68% (Table 4).

From the perspective of social benefits, the development of the wine industry could drive 81.92% of local farmers to work and the poverty alleviation ratio reached 78.64%. The social benefits of the wine industry were remarkable. The expected contribution of maximum fruiting reached 93.39% of grape growers' income and 83.51% of wine contributed to chateaus' income—indicating that the wine industry has an important role in local economic development. The reduction rates of desertified land and of windy and sandy days were 79.66% and 86.80%, respectively. Thus, the wine industry has a significant and positive effect on desertification control (Table 4).

Table 4. Actual and standard values and standardized score of each indicators.

Secondary Indicators	Actual Value (Av)			Standard Value (Sv)			Standardized Score
	Sample Size	Average Value	Standard Deviation	Number of Interviews	Average Value	Standard Deviation	
A1	108	1.96	1.43	5	2.46	0.38	79.58%
A2	108	4565.64	194.51	5	4940.00	135.65	92.42%
A3	108	0.91	0.20	5	1.12	0.12	81.30%
B1	108	0.47	0.10	5	0.82	0.09	57.42%
B2	108	0.03	0.01	5	0.04	0.01	64.52%
B3	108	0.70	0.28	5	1.27	0.45	55.36%
C1	108	10.22	3.60	5	11.32	0.75	90.24%
C2	108	0.92	0.22	5	1.18	0.42	78.08%
C3	10	1.00	0.00	5	1.16	0.10	86.21%
C4	10	0.83	0.15	5	0.96	0.04	86.68%
D1	108	0.78	0.25	5	0.95	0.04	81.92%
D2	108	0.66	0.47	5	0.84	0.05	78.64%
E1	108	0.67	0.21	5	0.87	0.04	76.60%
E2	108	0.86	0.34	5	0.92	0.04	93.39%
E3	10	0.04	0.02	5	0.05	0.01	83.51%
F1	108	0.46	0.10	5	0.60	0.13	75.93%
F2	10	0.74	0.08	5	0.93	0.06	79.66%
F3	10	0.71	0.07	5	0.82	0.06	86.80%
F4	108	745.33	67.00	5	492.00	39.19	66.01%

Note: The data are based on a survey of the study region in 2019 (Source: Grape growers Surveys, 2019 [n = 108] and Chateaus Surveys, 2019 [n = 10]).

4. Discussion

Over the last 10 years, wine industry development has been prioritized in Hongsibu, China, and the related development model has been optimized. The wine industry (referred to as vineyards) provide important ecosystem services [41]—an inference consistent with ours. Our results showed that the economic and social benefits of the wine industry are significant; moreover, this substantially increases the resident income. At the same time, the wine industry can effectively prevent desertification in poor areas, by increasing vegetation cover, reducing the number of windy and sandy days, and blocking dust and sand. Our results align with those of a study that showed that the branches of grapes cut in winter and continuously hung on wires form wind barriers, and this contributes to the wind and sand resistance of buried soil during the cold period [42].

Desertification management aims at restoring fragile ecological environments, improving people's living standards, and increasing resource use efficiency [43]. Viticulture makes full use of the mountain wasteland resources, and chateaus' greening and shelter forest construction greatly improves the economic forest cover. Wine industry development has thus played a positive role in improving the local ecological environment (Figure 3) and economic growth and in effectively controlling desertification—thus supporting our hypotheses.

4.1. Ecological Value of the Wine Industry for Desertification Prevention

The wine industry demonstrated a very large ecological value [44], possibly because of the following results: first, 13 winegrape varieties were employed, with a proportion of 4:1 between red and white cultivars; the varieties included *Vitis vinifera* 'Cabernet Sauvignon', *V. vinifera* 'Cabernet Franc', and *V. Vinifera* 'Chardonnay'. Second, the supporting role of the industrial development platform was significant, leading to remarkable results. In fact, the 30 wineries put into production >40 wine brands including Qianhongyu, Geruihong, and Zhonghe, and 87 wines won 139 awards in international and domestic wine competitions, such as the World Selection of Brussels and the International Wine Awards of Helan Mountains East.

The total value of the ecosystem services of the wine industry was 6.13×10^8 RMB (Table 2), indicating that the wine industry has an important ecological value. The reason is that vines are not only an economic forest, which produces fruits, but can also a characteristic green forest, which is conducive to the improvement of the ecological environment, mainly through carbon fixation and oxygen release [30], water conservation and water-saving and efficiency-enhancing [45], as well as atmospheric purification [30]. We found that food production is of great value because the region is an area conducive for growing wine grapes. It has sufficient sunshine, abundant heat, and a large daily temperature difference; these characteristics are conducive to the accumulation of sugar and very beneficial to the full development and maturity of the fruit. These superior conditions significantly improve food production [46,47].

In China's arid and semi-arid regions, vegetation and crop growth and survival are severely restricted by water resource availability [48]. This reduces water resource use and maximizes water use efficiency. Our current results demonstrated that vines have significant water-saving and synergistic values (Table 2). This is because the water resource use efficiency of wine grapes is higher than that of food and vegetable crops but their water consumption is lower: wine grapes require 3900 t/ha of water, whereas wolfberry requires 4200 t/ha and corn, wheat, and daylily require 5400 t/ha. Moreover, when planting wine grapes, water can be saved through regulated deficit irrigation [49–51]. Therefore, we can infer that wine grapes are suitable for improving the ecological environment of arid regions.

4.2. Economic and Social Benefits for Combating Desertification

In northwest China, some residents cannot live normally in protecting the ecological environment [12]. Therefore, the management plan in this area is particularly focused on achieving economic benefits via desertification control. Here, we found that the wine industry has great economic value (Figure 4). Farmers sold wine grapes to increase income, whereas wine companies sold wines—thereby contributing to the sustainable development of the local society.

The wine industry generates significant economic benefits for desertification management. This is because the wine industry makes large investments and has a significant scale and economic value. Here, we found that the winegrape-growing area was continuously increasing. The fruit yield per unit area, the total fruit yield, and the planting income per unit area increased annually. This is consistent with the findings of other studies [52–54]. However, we also found that the output of wine grapes was relatively low (<4500 kg/ha; Table 3). This is mainly because >1980 ha of the existing planted and preserved areas were added after 2010, and they are current not yet in the fruit-producing period. As such, the average yield was low in this study because the production potential was not realized fully. Furthermore, nearly 600 ha of old orchards had insufficient water and fertilizer input and low management level, and thus, the fruit yield did not meet the expected target. We may have, therefore, underestimated the economic value of the wine industry. The economic benefits of wineries and enterprises are relatively higher because of the enterprises management and low operating costs of chateaus. Those with a low efficiency have insufficient management systems and are affected by the wine market not being developed fully [55]. Here, wine sales and profits increased annually between 2014–2018 (Figure 4). This is because the technical problems of wine industry production were essentially resolved, the wine quality was generally recognized by the industry, and the wine consumption market expanded further. In other words, the large economic value of the wine industry provides an effective guarantee for desertification control.

The wine industry also generates significant social benefits for desertification management. The wine industry contributes to wealth generation and poverty alleviation, which can effectively address the employment of the poor population [56]: it has been reported to provide 60,000 jobs for ecological immigrants, with a total annual wage of nearly 2.0×10^8 RMB. As such, the wine industry is becoming a core industry to overcome

migrant poverty—a conclusion that is consistent with the other studies [30]. Grape growers and chateaus have developed vine cultivations over a 7067-ha area. Assuming that one worker is required per 0.7 ha, the wine industry can generate a stable employment for 10,000 migrant workers with an annual per capita income of 15,000 RMB, thereby increasing of farmers' the annual income of 1.5×10^8 RMB in this region.

4.3. Comprehensive Benefits of the Wine Industry for Desertification Control

Desertification control projects involve ecological, economic, and social aspects. During the entire governance process, attention should be paid to the coordinated development of economy, society, and ecology as well as the enhancement of comprehensive benefits. The quantitative analysis demonstrates that the wine industry generates positive, comprehensive benefits for desertification control (Table 4)—consistent with the previous results [37,39]. Therefore, the model of the comprehensive benefits of the wine industry on desertification control established in the current study can be used by other researchers.

An important factor that limits the comprehensive benefits of the wine industry for desertification control is the industrial development environment, such as low scientific and technological quality, which contributes to only a 57.42% value (Table 4). Here, we found that the wine production area needs to soil-bury the vines to ensure their safe wintering. However, the soil-burying process increases the cost of production, making it difficult to realize mechanized production [57,58]—which leads to low technology levels. Another important factor restricting the industrial development environment is practitioners' education levels. More than 90% of the surveyed profit-making farmers had a high school or higher education level, whereas the loss-making farmers were mainly from illiterate groups or were elderly people or women. Accelerating the popularization of high-yield, high-quality, and efficient cultivation techniques for wine grapes is an important technical approach to improve the wine industry that has positive effect on desertification control.

Our study showed that the wine industry is characterized by large investments; a weak industrial development environment; a high industrialization level; and significant social, economic, and ecological benefits (Table 4). Our indicator system—established to assess the comprehensive benefits of the wine industry for desertification control—can reflect scientifically and comprehensively the objective reality and is applicable.

Through more than 40 years of desertification control, relatively stable ecological, economic, and social benefits have been achieved in Ningxia, and this has laid a good foundation for sustainable development [1,2,59]. Desertification management of the wine industry has generally been high (Table 4). This is because the policy orientation of the local government has helped the development of the wine industry and of the local economy, which in turn has played an important role in desertification control. Based on the results of the quantitative analysis, we propose the following recommendations to ensure strong desertification control: first, the government should provide as many technologies as possible to farmers through a combination of lectures as well as other means and increase the household registration rate of science and technology. Second, it the industrialization of the wine industry, the mode of operation of the enterprises and farmers, should be promoted to improve the comprehensive benefits of desertification control. Third, desertification control should be considered a systematic project involving the government, scientists, and farmers [11]. When constructing the project, various perfect guarantee systems should be established to coordinate the interests of all parties, so that economic, social, and ecological benefits is achieved in a comprehensive and balanced manner, with the coupling of the ecological and economic systems enhanced.

5. Conclusions

The development plan of Hongsibu's wine industry was established on the premise of "small winery and big industry" [60], which is in line with the development model of the wine industry. In summary, the wine industry (i.e., vineyards) has important ecosystem service functions. The wine industry has the attributes of an economical industry, with the

ability to provide income increase and poverty alleviation to the growers and solve the livelihood problem of the poor residents in sandy areas. The wine industry is of a great value to combating desertification, especially for increasing the coverage of local economic forests and effectively changing the harsh natural environment of desertification areas. The development of the wine industry can be an effective approach for the government's ecological management department to formulate policies. Generally, the development of local specialty industries can help combat desertification in impoverished areas effectively, thus providing solutions to the dual pressures of poverty and environmental degradation, as well as providing a method of sustainable development worldwide.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su13105654/s1, Table S1: The calculation formulas and methods of ecosystem services.

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