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Assessment of Sustainable Livelihood and Geographic Detection of Settlement Sites in Ethnically Contiguous Poverty-Stricken Areas in the Aba Prefecture, China

Yanguo Liu [1,2,*], Chengmin Huang [1], Qing Wang [2], Junwei Luan [3] and Mingtao Ding [2]

1 College of Architecture and Environment, Sichuan University, Chengdu 610065, China; huangchengmin@126.com
2 School of Environment and Resource, Southwest University of Science and Technology, Mianyang 621010, China; qingw@imde.ac.cn (Q.W.); mingtaoding@163.com (M.D.)
3 International Centre for Bamboo and Rattan, Beijing 100102, China; junweiluan@126.com
* Correspondence: liuyg2008@126.com

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Abstract: The Chinese government aims to deal with poverty by 2020 for people living in ethnic and rural regions, including mountainous ethnic regions with the highest concentration of poverty and chronic poverty. Based on a sustainable livelihood Framework, five capitals and 33 evaluation indices of livelihood were built, and 13 counties' resources of the Aba Tibetan and Qiang Autonomous Prefecture were compared in order to calculate the degree of poverty. Topographic factors index of settlement sites (TFIS) were constructed by eight topographic factors, and diagnoses of the dominant factors of differentiation of 2699 settlements were calculated by using the geographical detector model to establish the poverty alleviation policies and models for different regions. The results showed that the livelihood capital evaluation indices were different (0.56–1.88), and natural capitals (mean value 1.56) had obvious advantages, but physical (mean value 0.56), financial (mean value 0.78), and human capital were lower (mean value 0.93), limiting the rate of transforming the ecological resources advantage into the economy. In the TFIS, the settlement points indicate topographic factors of natural breakpoint classification superposition, including elevation, slope, relief amplitude, surface incision, variance coefficient in elevation, surface roughness, distance to roads, and distance to rivers. These are within the 8–34 range, and their power determinant value to TFIS are 0.02, 0.70, 0.77, 0.76, 0.51, 0.66, 0.06, and 0.09. Livelihood capital evaluation indices and TFIS classification one (8–14) are positively correlated, and negative correlation (22–26 and 27–34) is at the 0.05 level. The county's poverty alleviation measures and development under different livelihood indices and TFIS indicate that the ecotourism industry has become the inevitable choice for promoting rapid and coordinated development of economy, society, and the environment in ethnic regions.

Keywords: sustainable livelihoods assessment; entropy method; geographical detector; ethnic contiguous poverty-stricken area; China

1. Introduction

Poverty is both a worldwide problem that hinders human survival and development, and a spatially heterogeneous phenomenon, i.e., poor people tend to be clustered in specific places [1–3], which is particularly evident in minority regions of China compared with their important geographical positions [4,5]. The eradication of poverty and the realization of common prosperity is a major task for China to build a well-off society successfully. Being an important component of China's economic and social development, ethnic regions are responsible not only for ecological safety (such as supplying

natural resources, and conserving soil and water), but also for ensuring national security and ethnic unity [6]. However, the development of minorities and their regions was relatively hysteretic because of geographical, and cultural factors in the vicious circle of long-term poverty [4,7,8]. Special living conditions, habits of locals, and regional characteristics in economic and social development greatly differ between cities and developed areas under the influence of national poverty development and public administration [8,9]. Assessment of sustainable livelihood is a crucial prerequisite for targeting interventions [8]. Due to differences in nature, economy, culture, and other aspects of studies in various countries, there will be some differences when various types of livelihood capital are specifically quantified [9–14]. Based on the central government's policies toward ethnic groups, religions, and poverty alleviation strategies in China, making informed scientific development strategies of ethnic regions and taking targeted measures in poverty alleviation for inclusive, green, and sustainable living, may be the most likely way out of poverty [5,9]. The Sustainable Livelihoods Framework revealed the essence of the concept of "livelihood" from the perspective of the system, pointing out that poverty is caused by multiple factors. Potential opportunities for poverty eradication, as well as how to use the capital and livelihood strategy to pursue the desired result, were also identified [8,9,13–19]. This framework connected the right tools to household assets and livelihood activities, resulting in many other socio-economic components being revealed and becoming the quantitative analysis framework of the current situation in impoverished areas [3,5,8]. We use this access to "resource background and capabilities" framework in understanding a county's livelihood. Therefore, the quantification of livelihood can provide a solid evidence-base for decision-making and can assist with development strategies [15]. Based on local poverty, special ecological environments, resource advantages, and the internal connection between development and poverty alleviation, the evaluation index system of livelihood capital was built in minority contiguous poverty-stricken areas from the perspective of evaluating sustainable livelihood. The livelihood capitals of 13 counties of the Aba Tibetan and Qiang Autonomous Prefecture were calculated according to the natural, human, social, physical, and financial capitals. All five capitals and 33 evaluation indices are based on references and relevant study achievements. These evaluation indices were used for comparative purposes between the poverty degree and the development potential in order to provide the basis of strategies for poverty reduction and economic development.

After more than four decades of implementation of the state's poverty alleviation program, a series of significant achievements have been made in fields such as living conditions, natural ecological landscapes, infrastructure, and public services [20]. The minority contiguous areas are still existing in poverty. In addition to the five capitals, what is the other cause of poverty and what are the influences of other factors? There are geographically linked factors strongly affecting people's livelihood [15]. In many countries strong codependency exists between livelihood and the environment, which can severely impact the level of poverty [15]. The complex topography provides opportunities for a variety of capital management techniques [3,12]. Villages (settlement sites) are units of culture and social organization and are seen to have a certain moral validity which is firmly embedded in local cultural norms, social practices, and structures [14]. The geographical detector method is used to analyze factors which influence poverty, and the determinant value to analyze the topographic factors of settlement sites (TFIS). The digital elevation model (DEM) provides another reference for effective implementation of a precision poverty alleviation strategy.

2. Materials

2.1. Study Area

Aba Tibetan and Qiang Autonomous Prefecture within 100°31′~104°27′ E, 30°35′~34°19′ N is located in the northwest Sichuan Basin. The southeast margin of Qinghai-Tibet Plateau features complex geological structures and fault developments as the typical landscape of the mountains and canyons of the region. Middle and high mountains compose the main geomorphologic form here,

covering an area of approximately 84,200 km^2. This area is not only an important source of water conservation in the upper reaches of the Yangtze and Yellow Rivers, but also an important part of the forest and biodiversity conservation of the Sichuan and Yunnan Provinces. It is the ecological barrier of the Qinghai Tibet Plateau. This region has the second-most Tibetan and the foremost Qiang residential areas, with 80% ethnic minorities, a 75% rural population, and a total population of 920,000. This includes the 13 counties of Maerkang, Jinchuan, Xiaojin, Aba County, Ruoergai, Hongyuan, Rangtang, Wenchuan, Li County, Mao County, Songpan, Jiuzhaigou, and Heishui (Figure 1) (Statistics Bureau of Sichuan Provence 2014; Aba Tibetan and Qiang Autonomous Prefecture 2014). A contiguous poverty-stricken area and "5·12" Wenchuan earthquake zone, there are many famous natural world heritage sites here, such as the Jiuzhaigou Nature Reserve, the Huanglong Nature Reserve, the Wolong Nature Reserve for Giant Pandas Habitat, and the Ruoergai Wetland (one of the three largest wetlands in China).

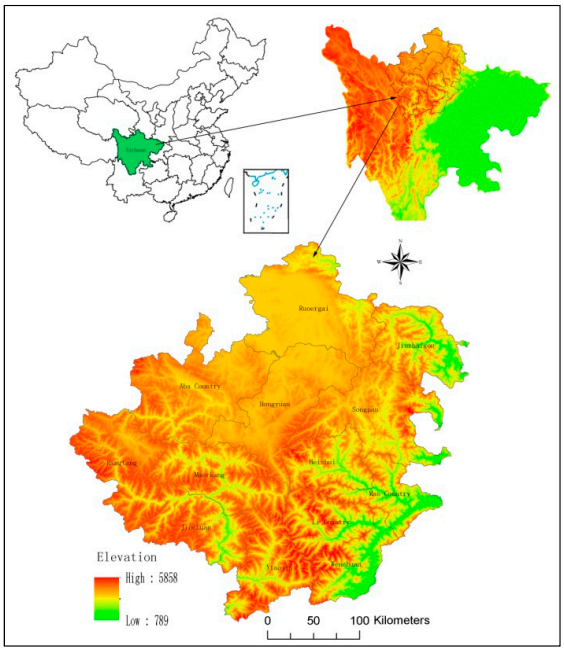

Figure 1. Location of Aba Prefecture.

2.2. Materials

The data used in this study is divided into three parts: social economic data, spatial data, and peasant household data.

(1) Social economic data, which includes the 2014 Statistical Bulletin of the National Economic and Social Development, 2014 Yearbook, and the Construction Scheme of Ecological Protection and Construction Demonstration Area (2015–2020) of the Aba Tibetan and Qiang Autonomous Prefecture. All the data was announced on government websites.

(2) Spatial data, which includes Digital Elevation Model (DEM)-ASTER GDEM 30 m (The data set is provided by the Geospatial Data Cloud site, Computer Network Information Center, Chinese Academy of Sciences [21], and the Administrative Map of Sichuan Province. Remote sensing data is the secondary data we use. With the help of ArcGIS, a Digital Elevation Model map, eight topographic factors were created.

(3) Household data, includes participant-based information gathered in different counties using household interviews to determine income structure. Average expenditure structure data was derived from the poverty monitoring report of rural China compiled by the Department of Household Surveys in the National Bureau of Statistics of China.

3. Methods

3.1. Construction of Evolution Indices

The Sustainable Livelihoods Framework (SLF) is a conceptual approach aimed at improving our understanding of the livelihood of poor people by considering the inherent complexities of poverty and assessing the different factors, constraints, and opportunities which shape people's livelihood strategies [8,20]. The question of who defines "development" is an important one in the scholarly inquiry of developing countries [19]. Settlement sites (villages) are the most basic units of culture and social organization, and the county is the direct unit to implement national policy, indeed it is the lowest level unit of policy making and execution in ethnic minority areas of China. There is much literature about villages or large regions as research units [4–10,13,15,22], we selected the county as the research unit which can provide an effective bridge between the micro and macro environments [23]. This paper focuses on quantitative analysis methods supported by the research results of domestic and foreign scholars on livelihood [1,2,8–10,13–20,22–25], based on the connotation and relationship of multidimensional poverty and sustainable development. We combine indicators which reflect the ethnic minority area's ecological environment, poverty reduction, and regional development through an evaluation index system of livelihood capital in minority mountain areas. The evaluation index contains five (natural-human-social-physical-financial) aspects and 33 specific indicators to quantitatively evaluate the livelihood capital and compare poverty degrees of the 13 counties, all of which are critical to providing the future of poverty alleviation policies.

3.2. Index Clarification

Assessment of sustainable livelihood as the crucial prerequisite for targeting interventions [8] in each country showed that increased investment in extractives has occurred in a context in which the state, though not strong, demonstrates some capacity for planning and regulating economic activity [26]. This situation was especially obvious in the poor and backward minority areas of China. One of the major challenges for assessment remains that both measuring the livelihood category and its mapping are data intensive [1]. In this paper, we argue that the livelihood capitals from the government's perspective might offer a robust means of understanding the interplay between poverty alleviation and county development.

(1) Index selection of natural capital

Because of the function of ecological defense and the environmental vulnerability of this region, inclusive, green, and sustainable modes may be the only way of out of poverty. Therefore, based on the major function oriented zoning in China, Assessment Index for Ecotourism in Natural Reserves, and the ecological function of Aba in the Sichuan Province [27], we selected four indices to assess natural capital: the coverage of forest (C11), the area of the nature reserve (C12), the natural wetland protection rate (C13), and the crop sown area per capita (C14).

(2) Index selection of human capital

Being the only dynamic one among the five capitals, human capital determines the capacity and scope of other capitals being in accordance with its quantity and quality. A total of eight indices were selected (Table 1).

(3) Index selection of social capital

The assessment of social capital was achieved by reviewing the human network structure and the activities within this structure. To demonstrate the perspectives of government and personal households, nine indices were chosen (Table 1).

(4) Index selection of physical capital

Physical capital consists of two parts: the public and the personal. A total of five indices were selected (Table 1).

(5) Index selection of financial capital

This paper selected six indices (Table 1) from three aspects of the regional and personal capital: disposable cash, savings, and credit.

Table 1. Livelihoods capitals evolution indexes in Aba Prefecture.

Goal Layer	Criteria Layer	Indicator Layer	Reference Value	Basis
Livelihoods evaluation indexes A	Natural B1	Coverage of forest (%) C11	35.75	National average
		Area rate of nature reserve (%) C12	12.89	National average
		Natural wetland protection rate (%) C13	6.00	Aba ecological construction planning
		Crop sown area of per capita (m^2) C14	824.23	National average
	Human B2	Population density (people/km^2) C21	51.30	National average
		Natural growth rate of population (%) C22	5.21	National average
		Proportion of Agriculture and animal husbandry (%) C23	45.23	National average
		Ratio of compulsory education %) C24	10.11	National average
		Teacher quantity per 10,000 people owning C25	97.30	National average
		Public health technical persons quantity per 10,000 people (%) C26	54.03	National average
		Per capita consumption (yuan) C27	14,491.00	National average
		Total consumption growth rate (%) C28	9.60	National average
	Social B3	Per capita GDP (yuan) C31	46,531.20	National average
		GDP growth rate (%) C32	7.40	National average
		Participation rate of rural cooperative medical system (%) C33	100.00	Extrapolated ideal value
		Participation rate of endowment insurance C34	61.58	National average
		Registered urban unemployment rate (%) C35	4.09	National average
		Ratio of minimum living guarantees (%) C36	5.49	National average
		Growth rate of tourism income (%) C37	15.40	National average
		Contribution rate of tourism revenue to GDP (%) C38	15.14	National average
		Tourist density C39	6.63	Average of Sichuan Provence
	Physical B4	Urbanization rate (%) C41	50.00	National average
		Fixed assets investment (a hundred million yuan) C42	60.59	National average
		Rate of the 2nd and 3rd industry (%) C43	90.00	National average
		Per capita food production (kg) C44	443.84	National average
		Per capita meat production (kg) C45	63.66	National average
		Traffic line density (%) C46	46.00	National average
	Financial B5	Per capita loan (yuan) C51	59,700.00	National average
		Per capita of resident deposit (yuan) C52	37,058.24	National average
		Per capita disposable income of urban residents (yuan) C53	28,844.00	National average
		Growth rate of per capita disposable income of urban residents (%) C54	9.00	National average
		Net income of farmers and herdsmen (yuan) C55	9892.00	National average
		Growth rate of net income of farmers and herdsmen (%) C56	11.20	National average

3.3. Calculation of Livelihood Capitals

(1) Determination of index weight

Although there are 13 counties and 33 indicators, the connotation and criteria of sustainable livelihood is tremendously divergent based on different social-economic conditions and spatial temporal scales [8]. Because of this, we use the grey systems theory—a methodology for studying

problems of uncertainty, in which there is limited information and small samples. In the real world, there are many problems of this type, allowing a broad range of applicability of the theory of grey systems to assessment livelihood [28]. The entropy-weight method is used to calculate objective weights of criteria. If there is a large difference between the objects for a determined criterion, this criterion can be regarded as an important factor for the analysis of alternatives [28]. In this paper, the entropy method calculates the comprehensive index by evaluating the amount of information provided by the indicators, and the weight of these indicators are determined by the judgment matrix of the evaluation indicators [7,8,27,28]. As the evaluation system contains positive and negative indicators, the sample matrix should be carried out by non-dimensional disposal. If the study area has m evaluation objects, containing n evaluation indicators, X is defined as the comprehensive evaluation index sample matrix, and expressed as:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{11} & \cdots & x_{1n} \end{pmatrix}, X = \{x_{ij}\}_{m \times n} (0 \le i \le m, 0 \le j \le n) \quad (1)$$

As the dimension of each indicator is not uniform, the range-based method is used to standardize the indicator coefficients. The evaluation indicators are divided into positive indicators and negative indicators. The positive indicator refers to that which is better if its value is larger, while the negative indicator refers to that which is better if its value is smaller. The method to standardize is:

$$y_{ij}^{p} = (X_{ij} - \min x_j)/(\max x_j - \min x_j) \quad (2)$$

$$y_{ij}^{n} = (\max x_j - X_{ij})/(\max x_j - \min x_j) \quad (3)$$

In which, $\min x_j$ refers to the minimum value of the evaluation samples of Indicator j, and $\max x_j$ refers to the maximum value.

The calculation method of transforming Matrix X to Matrix Y is:

$$Y = (y_{ij})_{m \times n} \text{ (in which, } y_{ij} \in [0,1]) \quad (4)$$

In information theory, greater entropy means a smaller value difference of the evaluation indicator, and this indicator has lesser weight. Alternately, if the value difference of an indicator is larger, its entropy is smaller, and this indicator has greater weight. In the matrix Y, f_{ij} is the proportion of evaluation Target i under Indicator j, calculated by:

$$f_{ij} = y_{ij} / \sum_{i=1}^{m} y_{ij} \text{ (in which, } [j] = 1, 2, ..., [n]) \quad (5)$$

H_j is the entropy value of Indicator j, calculated by:

$$H_j = -k \sum_{i=1}^{m} f_{ij} \ln f_{ij} \text{ (in which, } [k = 1/\ln m], \text{ when } [f_{ij} = 0], [f_{ij} \ln f_{ij} = 0]) \quad (6)$$

w_j is the entropy weight of Indicator j, calculated by:

$$w_j = (1 - H_j) / \sum_{j=1}^{n} (1 - H_j) \text{ (in which, } [w_j \in [0,1], \sum_{j=1}^{n} w_j = 1]) \quad (7)$$

The results of weight calculation are listed in Table 2.

Table 2. Results of weight.

Index	Goal	Weight	Criteria	Weight
Coverage of forest (%) C11	Livelihoods A	0.019	Natural B1	0.159
Area rate of nature reserve (%) C12		0.032		0.264
Natural wetland protection rate (%) C13		0.059		0.485
Crop sown area of per capita (m^2) C14		0.011		0.091
Population density (people/km^2) C21		0.035	Human B2	0.159
Natural growth rate of population (%) C22		0.024		0.106
Proportion of agriculture and animal husbandry (%) C23		0.020		0.091
Ratio of compulsory education (%) C24		0.028		0.125
Teacher quantity per 10,000 people owning C25		0.013		0.061
Public health technical persons quantity per 10,000 people (%) C26		0.041		0.187
Per capita consumption (yuan) C27		0.038		0.169
Total consumption growth rate (%) C28		0.023		0.102
Per capita GDP (yuan) C31		0.026	Social B3	0.081
GDP growth rate (%) C32		0.021		0.067
Participation rate of rural cooperative medical system (%) C33		0.040		0.127
Participation rate of endowment insurance C34		0.015		0.046
Registered urban unemployment rate (%) C35		0.035		0.111
Ratio of minimum living guarantees (%) C36		0.009		0.028
Growth rate of tourism income (%) C37		0.050		0.158
Contribution rate of tourism revenue to GDP (%) C38		0.075		0.235
Tourist density C39		0.046		0.146
Urbanization rate (%) C41		0.013	Physical B4	0.081
Fixed assets investment (a hundred million yuan) C42		0.030		0.191
Rate of the 2nd and 3rd industry (%) C43		0.023		0.147
Per capita food production (kg) C44		0.025		0.161
Per capita meat production (kg) C45		0.027		0.173
Traffic line density (%) C46		0.039		0.246
Per capita loan (yuan) C51		0.029	Financial B5	0.158
Per capita of resident deposit (yuan) C52		0.036		0.198
Per capita disposable income of urban residents (yuan) C53		0.033		0.182
Growth rate of per capita disposable income of urban residents (%) C54		0.029		0.157
Net income of farmers and herdsmen (yuan) C55		0.014		0.076
Growth rate of net income of farmers and herdsmen (%) C56		0.042		0.228

The weight of contribution rate of tourism revenue to GDP (C38), natural wetland protection rate (C13), growth rate of tourism income (C37), and the growth rate of net income of farmers and herdsmen (C56) is in the front rank (Table 2), Thus, tourism revenue and natural resources play an important role in regional livelihood capital, and the net income of farmers and herdsmen is the most intuitive index for household livelihood and poverty alleviation. The weight of the urbanization rate (C41), crop sown area per capita (C14), ratio of minimum living guarantees (C36) is at the end of the spectrum, which indicates that promoting non-farming activities is an important pathway out of poverty in contiguous poverty stricken areas. The minimum living guarantee is an important basic guarantee for the elderly and disabled people, and has a small impact on the regional livelihood assessment.

The natural wetland protection rate (C13) among the natural capital, public health technical quantity per 10,000 people (C26) among the human capital, contribution rate of tourism revenue to GDP (C38) among the social capital, traffic line density (C46) among the physical capital, and the

growth rate of the net income of farmers and herdsmen (C56) among the financial capital are the maximum weight values in the five capitals. The area of crop sown per capita (C14) among the natural capital, ratio of compulsory education (C24) among the human capital, ratio of minimum living guarantees (C36) among the social capital, urbanization rate (C41) among the physical capital, and the net income of farmers and herdsmen (C55) among the financial capital are minimum weight values in the five capitals. We argue that the improvement of regional livelihood capital may be considered from the index of maximum weight, and providing the most basic livelihood resources to reduce poverty may be considered from the index of minimum weight.

(2) Calculation model

The positive and negative indicators are:

$$Z_i = 1 - \frac{S_i - C_i}{S_i - S_{\min}}, Z_i = 1 - \frac{C_i - S_i}{S_{\max} - S_i} \tag{8}$$

in which, Z_i is the value of the index, C_i is the actual value, and S_i is the reference value of this indicator; $S_{\max}$ refers to the maximum value of the evaluation samples of indicator, and $S_{\min}$ refers to the minimum value.

A multi objective linear weighting function evaluation model is used to calculate the value of a comprehensive development index R_i as:

$$R_i = \sum_{j=1}^{n} w_j \times z_{ij} \tag{9}$$

3.4. Geographical Detector Method

Looking at a few core, truly irreducible dimensions, and investigating the properties of their joint distribution over the population, by means of both dominance analysis and a plurality of well thought-out indices, is likely to generate real insights concerning poverty, and perhaps contribute to the design and targeting of policy actions to reduce it [2]. Topographic factors of settlement sites (villages) are the truly irreducible dimensions. With the help of ArcGIS software and the settlement site's database, eight topographic factors of 2699 settlement points were extracted, and each one of eight topographic factors of 2699 settlements points were divided into five levels with a natural breakpoint method. The first level is marked 1, second marked 2, and so on. TIFS of the settlement points are the sum of marks (Figure 2, Table 3). The current set of the TIFS map a snapshot of the levels of regional environment and assets.

This method was used by Wang Jinfeng et al. during their study on disease risks [29]. In recent years, as an essential method for detecting the spatial pattern and mechanism for certain elements, the geographical detector method has been extensively applied in social, economic, and natural sectors. Among the above, the detector is used to inspect whether certain geological factors are the cause for the formation of the spatial distribution deviation of certain indicators [30–32]. The working theory is to compare the total variance of these indicators at different types of partitions, and that of the total research area. The formula is as below [29]:

$$P_{D,H} = 1 - \frac{1}{n{\sigma_H}^2} \sum_{i=1}^{m} n_{D,i} {\sigma_{H_{D,i}}}^2 \tag{10}$$

In above formula, D is the influential factor; H Topographic factors index of settlement sites; $P_{D,H}$ is the explanatory power from D to H; n and σ^2 are the number of samples and variance from the whole region; m is the number of sub-regions; $n_{D,i}$ is the number of samples of indicator D at category i. Value range for $P_{D,H}$ is [0,1]. And the larger the value is, the greater the influence will be exerted from the factor to the settlement changes.

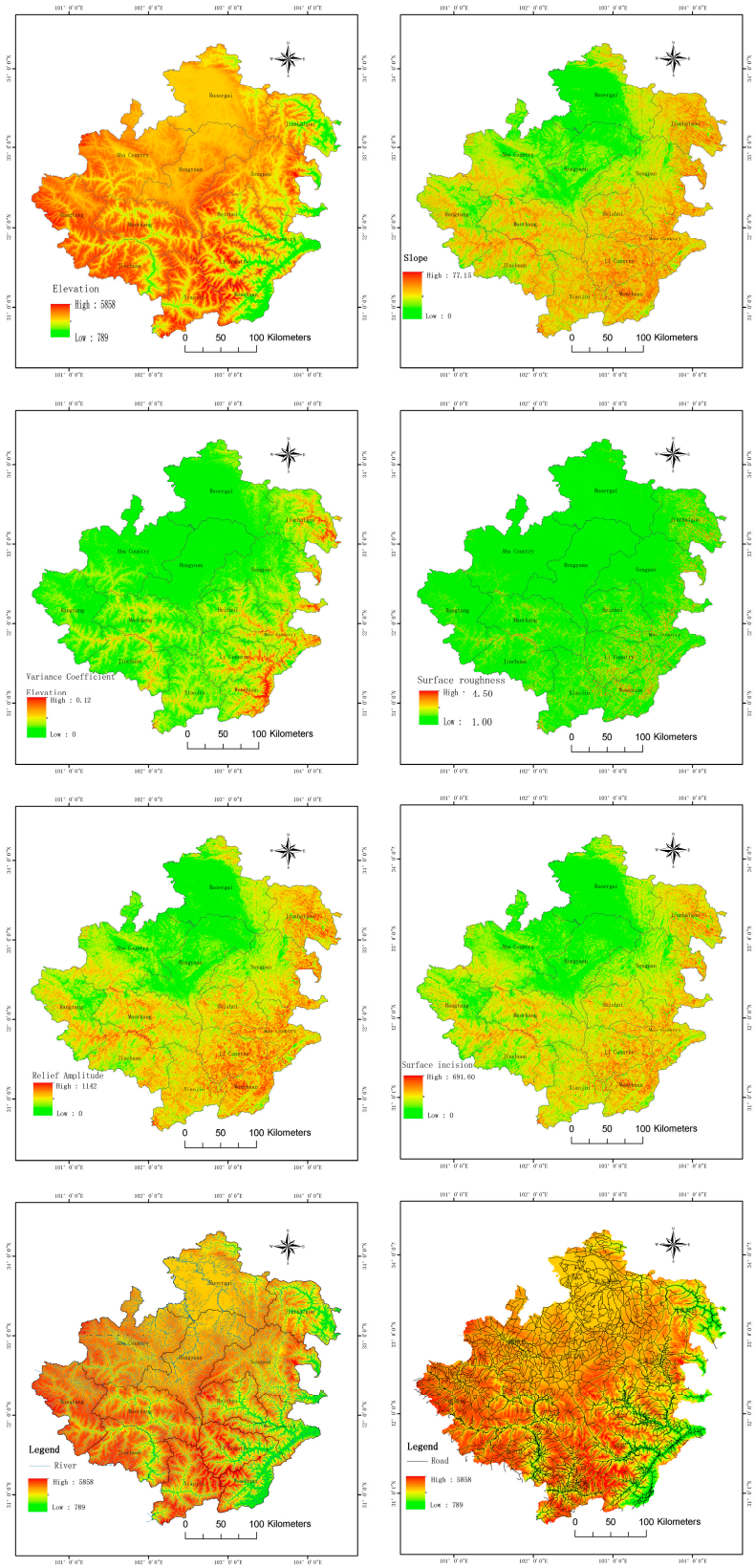

Figure 2. Eight topographic factors.

Table 3. Geographic detected power of influencing factors for TIFS.

Indictor	Classification (natural breaks) First (1) Second (2) Third (3) Fourth (4) Fifth (5)					P
Elevation	≤1638.00	>1638.00~2436.00	>2436.00~3036.00	>3036.00~3585.00	>3585.00~4543.00	0.02
Slop	≤10.34	>10.34~19.66	>19.66~27.74	>27.74~36.18	>36.18~56.95	0.70
RA	≤99.00	>99.00~178.00	>178.00~245.00	>245.00~324.00	>324.00~635.00	0.77
SI	≤43.36	>43.36~82.96	>82.96~122.36	>122.36~167.60	>167.60~377.36	0.76
VCE	≤0.012	>0.012~0.021	>0.021~0.031	>0.031~0.049	>0.049~0.104	0.51
SR	≤1.06	>1.06~1.14	>1.14~1.23	>1.23~1.37	>1.37~1.84	0.66
DRD	≤171.43	>171.43~518.32	>518.32~1134.61	>1134.61~2113.26	>2113.26~4133.40	0.06
DR	≤363.03	>363.03~739.15	>739.15~1305.47	>1305.47~2736.25	>2736.25~7064.42	0.09

4. Results

4.1. Evaluation of Livelihood Capitals

Through the above computational processes, the comprehensive index value and that of natural, human, social, physical, and financial capitals of the thirteen counties in 2014 were obtained (Table 4).

(1) There are complex geomorphic types in this study area: high mountain and steep gorge areas in the southeast, an upland plain in the middle, and a plateau district in the northwest. These include complex and diverse ecosystems, such as forest, grassland, wetland, high mountainous lakes, and swamp ecosystems. Because of the region's spatial and landscape characteristics, the values of natural capitals reflected large differences among the 13 counties. The maximum value of the natural capital was in Ruoergai County (4.26). The Ruoergai Wetland is one of the three largest wetlands of China (Sanjiang Plain Wetland, Heilongjiang Province; Lalu Wetland, Tibet), and 30% of the water of the upper reaches of the Yellow River is from the wetland. The Mao County received the lowest score (0.29), because it is located in the arid valleys of the upper reaches of the Min River, which has lower vegetation coverage and a fragileenvironment. With the advent of a tourism boom, ecotourism areas and natural reserves present enormous attractions, while natural resources become one of the most important factors promoting the development of the county's tourism. For instance, the Jiuzhaigou Nature Reserve attracted 5.81 million visitors with 7.4 billion yuan (RMB) in 2014; the Huanglong Nature Reserve in Songpan County, the Wolong Nature Reserve in Wenchuan County, and the ethnic villages in Li County followed. In terms of the social capital rating, especially considering the two factors of the growth rate of tourist income and contribution of tourism revenue to GDP, Jiuzhaigou received the highest score (3.56), and Rangtang County the lowest owing to its alpine climate and landscapes.

(2) Aba Prefecture is one of the contiguous poverty-stricken areas in China, combining old liberated, ethnic, and distant areas; This was consistent with the evaluation results of the physical, financial, and human capitals. The average evolutional score of its physical capital was only 0.56, far below the national average (1.0), especially in the three aspects of traffic line density, rate of the 2nd and 3rd industry, and per capita food production. This showed that the poor infrastructure conditions, irrational industrial structure, and insufficient food self-sufficiency restricted the capacity of natural resources transforming into effective ecological assets [33]. Although the scores of the human and financial capitals were not high, the basic education, ecological construction, and, especially, the social service in this region, have shown great improvement under the drive of some policies. These include a western development strategy, national and provincial poverty alleviation policy, the grain for green project, and the construction of a national ecological function area.

Table 4. The evaluation indexes of livelihoods in county scale.

County	Livelihoods Index	Natural Capital Index	Human Capital Index	Social Capital Index	Physical Capital Index	Financial Capital Index
Ruoergai	1.51	4.62	1.48	0.85	0.65	1.37
Aba County	1.09	2.18	0.80	1.49	0.33	0.66
Rangtang	0.58	1.93	0.71	0.11	0.37	0.51
Jiuzhaigou	1.88	1.76	1.31	3.56	0.54	0.89
Hongyuan	0.90	1.51	1.51	0.67	0.46	0.51
Maerkang	0.79	0.38	1.25	0.59	0.77	0.86
Jinchuan	0.56	0.48	0.35	0.64	0.69	0.61
Songpan	1.59	1.31	1.01	3.13	0.61	0.66
Heishui	1.62	1.40	0.89	3.33	0.51	0.63
Li county	1.41	1.37	0.64	2.79	0.52	0.74
Xiaojin	0.70	0.80	0.61	0.49	0.57	1.25
Mao County	0.76	0.29	0.64	1.09	0.72	0.67
Wenchuan	1.33	2.22	0.95	1.99	0.55	0.75
Average	1.13	1.56	0.93	1.59	0.56	0.78

(3) The livelihood capital evaluation indices were evidently different, as follows: Jiuzhaigou (1.88) > Heishui (1.62) > Songpan (1.59) >Ruoergai (1.51) > Li County (1.41) > Wenchuan (1.33) > Aba County (1.09) > Hongyuan (0.90) > Maerkang (0.79) > Mao County (0.76) > Xiaojin (0.70) > Rangtang (0.58) > Jinchuan (0.56). This order was consistent with the popularity of natural reserves and the variety of ecotourism resources. Even though there were large differences in natural resources—and the opportunities, strategies, and effects in developing ecotourism also differed significantly among the 13 counties studied—inclusive, green, and sustainable modes of development, were, practically by consensus, identified as the only methods for development out of poverty. Within the regions, differentiated development models should be made based on the livelihood developing complementary relationships, and achieving complementary developments of regional ecotourism.

The five counties (Songpan, Heishui, Mao County, Li County, and Wenchuan) in the upper reaches of Min River were a beneficial reference. These rely on the Jiuzhaigou Natural Reserve Tourism Link, the Huanglong Natural Reserve of Songpan, the Dagu Glacier scenic area of Heishui, the ethnic villages of Li County, and the Wolong Giant Panda Nature Reserve as different ecotourism resources in order to fully utilize their respective advantages. Gradually, they formed a trend of coordinated development; consequently, the five counties are all at the top of the evaluation of the livelihoods capital rankings.

The result of the evaluation of livelihoods based on the 33 indicators coincided with the results of the national-level poverty-stricken county of Rangtang and Xiaojin counties. However, the state county of Heishui was inconsistent with the livelihood evaluation primarily because the standards for national-level impoverishment are determined by per capita income, per capita GDP, and per capita local fiscal revenue. In this paper, we thought that it would be difficult for limited indicators and standards to fully reflect the overall situation, and, according to the livelihood capital assessment status and realities, Jinchuan County's situation is not optimistic.

4.2. Analyses on a County Scale

In the 13 counties of Aba Prefecture there were great differences among the five capitals.

(1) Jinchuan and Rangtang counties reflected the lowest score of the comprehensive index of livelihood capital, especially Jinchuan, yet the five capital's evaluation values were all below the standard 1.0. Even the values of the natural and human capitals were below 0.5, therefore, the overall level of economic and social development of Jinchuan was inevitably low because of its limitations in resources and circumstances. The value of the natural capital of Rangtang was greater than 1.0, but the values of human and physical capitals were all below 0.5; the financial capitals were only 0.51, so the social and economic developments were also relatively backward.

(2) The scores of comprehensive indices of livelihood capital of Xiaojin, Mao County, Hongyuan, and Maerkang counties were all below the standard 1.0. Xiaojin was the only county with a value

of financial capitals above 1.0, but in the two aspects of growth rate of per capita disposable income of urban residents and the growth rate of net income of farmers and herdsmen, it was at the top of the 13 counties. Mao County scored the lowest value of natural capital, though its reliance on its geographically advantageous location on the Jiuzhaigou Tourism Link led to its tourism revenue growth being faster, though the most significant characteristic was its natural resource constraints. For Maerkang, the administrative center of Aba Prefecture, the only value above 1.0 was human capital. In Hongyuan, although the values of natural and human capital were above 1.0, the values of physical and financial capitals were lower, and its industrial structure was irrational, so the growth rates of urban residents, farmers, and herdsmen were slower.

(3) Scores of comprehensive indices of livelihood capital of Aba County, Wenchuan, and Li counties were in the range of 1.0–1.5. The value of natural capital of Aba County was higher because of the Manzhatang Wetland being the most important part of the Ruoergai Wetland, and because of its famous tourist attraction, the largest Langyi Bonismo Temple. The growth rate of Aba Counties tourism revenue has reached about seventy percent. On account of the minimum density of traffic lines and large proportion of primary industry, its value for physical capital was the lowest of the 13 counties.

(4) The comprehensive indices of livelihood capital of Ruoergai, Songpan, Heishui and Jiuzhaigou counties were all above 1.5. Ruoergai County had obvious advantages in its two aspects of natural and financial capital because of the Ruoergai Wetland and its growth in ecotourism. Ruoergai County had the highest values of per capita disposable income, growth rate of urban residents, net income, and the growth rate of farmers and herdsmen. Relying on the Jiuzhaigou Natural Reserve Tourism Link, Songpan, Heishui, Li County, Wechuan and Jiuzhaigou counties gradually formed a trend of coordinated development.

4.3. Topographic Factors Index of Settlement Sites

The proportion of settlements in the first and second zone is within 50%, Heihui, Li County, and Xiaojin are 3.45%, 4.41%, and 6.61%, the smallest proportion in the first zone. Li County, Xiaojin, Heishui, Wenchuan, Jinchuan, and Maerkang are 81.86%, 77.81%, 77.15%, 68.24%, 65.46%, and 63.89% in the third zone and above, the topographic conditions in these areas cause regional poverty as they are unsuitable for human habitation and farming. Hongyuan, Ruoergai, and Aba County are 2.33%, 16.38%, and 28.44% in the third zone and above, yet remain in poverty because of the alpine pastoral area (Figures 3 and 4). The correlation between the livelihood capital evaluation indices and TFIS classification is calculated with the first zone (8~14) being positively correlated and the negative correlation (22–26 and 27–34) at the 0.05 level.

Topographic factors of elevation, slope, relief amplitude, surface incision, variance coefficient in elevation, surface roughness, distance to roads and distance to rivers affect settlement site differentiation. Their power determinant value to TFIS are 0.02, 0.70, 0.77, 0.76, 0.51, 0.66, 0.06, and 0.09 (Table 3). The relief amplitude and surface incision have a leading role in the distribution and location of the current settlement, followed by slope. These factors affect the occurrence of poverty, which are also the fundamental reason why poverty is difficult to eliminate.

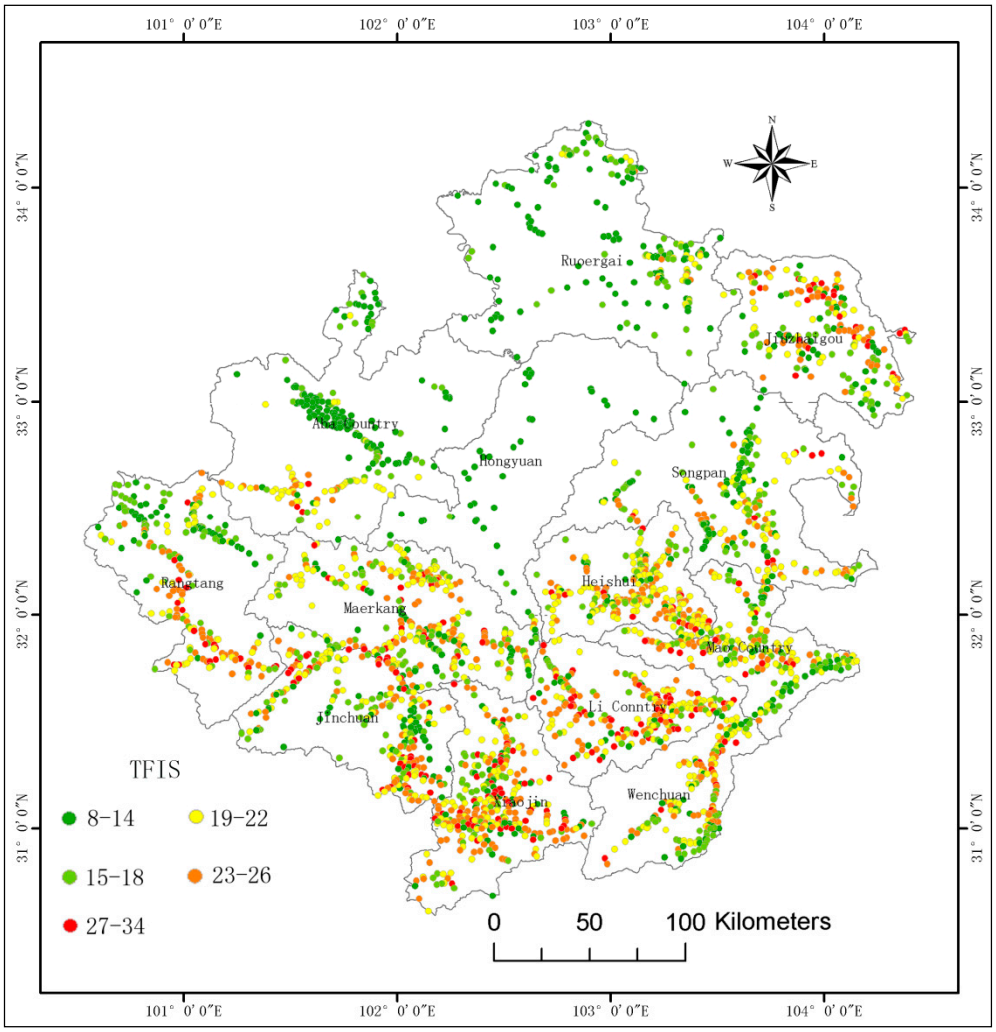

Figure 3. Topographic factors index of settlement sites.

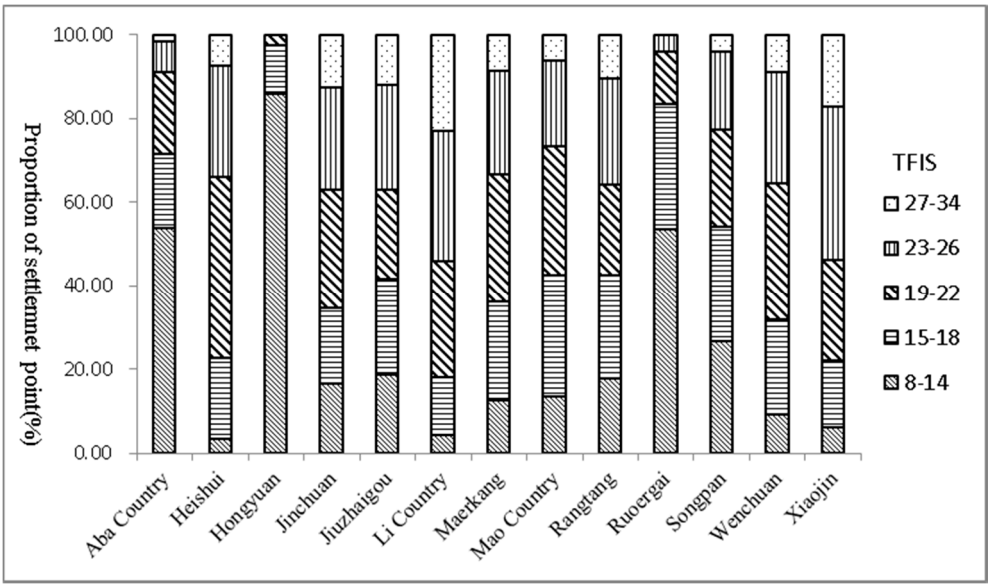

Figure 4. Proportion of settlement points on county scale.

4.4. Development Analysis

Through analysis, the region with the higher score of livelihood capital evaluation has the highest ecotourism revenue, as it relies on the superiority of natural resources and minority cultural resources. Rural tourism is one of the most important and valuable factors which can contribute to maintaining economic growth in these areas and it is a vital element which can provide local residents with many direct benefits [10]. According to the World Wildlife Fund for Nature, 20% of tourism revenue in developing countries originates from ecotourism [34], and ecotourism has become one of the fastest growing segments within the travel and tourism industry [35]. By comparing ecotourism and sustainable livelihood (Table 5), there is a lot of consistency identified in benefits, core stakeholders, guidance, participants, and management methods. These five aspects are consistent with the poverty alleviation mechanism based on their own conditions to achieve independent development.

Ecotourism improvements in many developing countries and regions have proven that the comprehensive benefits of the ecotourism industry will cause a multiplier effect [35–37]. Therefore, ecotourism is a "power industry" which can completely improve and promote regional society, economy, culture, and ecosystem development in the modern social economy, especially in a region which a large proportion of settlements in the third zone and above. Due to environmental protection and the benefit to communities—two major features of the ecotourism industry—a series of guided measures for tourism development have been issued at national, provincial, and municipal levels [38–40]. Ecotourism has become a key and inevitable choice for promoting rapid and coordinated development of the economy, society, and environment in ethnic regions. In previous studies around the world, tourism has been shown to be an additional source of income for local households as a nonagricultural activity [12], though a large proportion of total tourist revenue can be consequently lost from the local area due to leakage [11]. In a post-industrial era, mountainous areas with greater natural resources will be sure to escape poverty, instead becoming economic highlands.

The five counties in the upper reaches of Min River proved beneficial to our research, and the Ruoergai wetland is currently aiming to build its ecotourism into an important business sector to generate profits making the county financially sustainable. The complex and comprehensive nature of regional strategy requires an effective integration of the socioeconomic needs of farmers and herdsmen with environmental policies in order to promote sustainable social-ecological systems in the Aba Prefecture. The vision of tourism as a conservation tool is widely practiced today [11].

Table 5. Comparison of ecotourism and sustainable livelihoods.

Comparison Items	Ecotourism	Sustainable Livelihoods
Background	Environmental damage caused by Mass tourism	Poverty of rural residents
Concerned benefit	The environment was protected and communities benefit from tourism activities	Maintain/strengthen the benefit of our own assets and capabilities under the precondition of not destroying the resources
Core stakeholder	community of tourism destination; tourist	Community residents
Main guidance	Government	Government
Main participant	Community residents	Community residents
Management method	democratic decision-making and decentralized management	Organization, leadership and hierarchy management

5. Conclusions and Discussion

Development and progress are both common desires and requirements. However, historically, there have always been gaps and imbalances, and poverty is one reflection of such gaps and imbalances. Poverty in minority ethnic regions is not only closely related with geography, history, and humanity, but also often with complex religious, political, and social stability issues. As such, these regions are

always China's focus for poverty alleviation and economic development, relying on local conditions, guiding the region to select the appropriate industry to achieve independent development and to be effective in eliminating poverty. Based on local situations, special ecological environments, resource advantages, and the internal connection between development and poverty, the evaluation index system of livelihood capital was built in minority contiguous poverty-stricken areas for the purpose of sustainable livelihood evaluation, and to compare the degree of poverty and development potential. The livelihood capitals of 13 counties of Aba Tibetan and Qiang Autonomous Prefecture were analyzed, according to the natural, human, social, physical, and financial capital; all five capitals and thirty-three evaluation indices were based on references and relevant study achievements. Topographic factors index of settlement sites (TFIS) were constructed by eight topographic factors, diagnosing the dominant factors of differentiation of 2699 settlements by using the geodetector model, and putting forward the poverty alleviation policies and models for different regions. The results showed that:

(1) The livelihood capital evaluation indices were obviously different, and the order is as follows: Jiuzhaigou (1.88) > Heishui (1.62) > Songpan (1.59) > Ruoergai (1.51) > Li County (1.41) > Wenchuan (1.33) > Aba County (1.09) > Hongyuan (0.90) > Maerkang (0.79) > Mao County (0.76) > Xiaojin (0.70) > Rangtang (0.58) > Jinchuan (0.56), showing that the major difference was in economic development of the overall level, natural resource endowment, county infrastructure, social security, and the measures and effect of developing ecotourism.

(2) Natural capital values were higher and the average was 1.56, as there were excellent ecological resources with potential advantages for these counties, but there were great differences due to the special conditions of natural geography, and unique topographic features. The values of physical, financial, and human capital were lower, and this limited the rate of transformation of the ecological resource advantage into the economy. However, great improvement was seen because of infrastructure construction, ecological conservation, the income of farmers and herdsmen, and, especially, the primary education and health services with the support of Great West Development Strategy in China, anti-property policies in Sichuan Provence, policies of conversion of cropland to forest and grassland, and the construction of the National Ecology Function zone.

(3) The order of proportion of settlements in the third zone and above is: Li County (81.86) > Xiaojin (77.81) > Heishui (77.15) > Wenchuan (68.24) > Jinchuan (65.46) > Maerkang (63.89) > Jinchuan (58.33) > MaoCounty (57.50) > Rangtang (57.28) > Songpan (45.93) > AbaCounty (28.44) > Ruoergai (16.38) > Hongyuan (2.33). The correlation between the livelihood capital evaluation indices and TFIS classification is calculated with the first zone (8~14) being positively correlated, and negative correlation (22~26 and 27~34) at the 0.05 level. Topographic factors of elevation, slope, relief amplitude, surface incision, variance coefficient in elevation, surface roughness, distance to roads and distance to rivers affect settlement site differentiation, and their power determinant value to TFIS are 0.02, 0.70, 0.77, 0.76, 0.51, 0.66, 0.06, and 0.09. The relief amplitude and surface incision have a leading role in the distribution and location of the current settlement, followed by slope.

(4) The comparison of ecotourism and sustainable livelihood shows there is a lot of consistency in concerned benefit, core stakeholders, main guidance, main participant, and management methods. These are consistent with the poverty alleviation mechanism based on their own conditions to achieve independent development. Because of the TFIS the ecotourism industry has become the inevitable choice for promoting rapid and coordinated development of the economy, society, and environment in ethnic regions.

Whether natural or cultural heritage landscapes, and regardless of their location or focus of development, minority regions have been under pressure from tourism. With the tourism boom, minority regions quickly became hot areas for ecotourism development due to their unique natural and cultural resources; these regions not only have ecological importance for safely supplying natural resources, and conserving soil and water, but they also play an important role in national security and unity. Therefore, tourism development requires systematic planning and design on the regional and national scale, ensuring tourism is a way to protect, rather than destroy, social and

cultural resources. Because of ecological barriers and environmental fragility, combined with the sustainable livelihood assessment and evaluation results, the ecotourism industry is an inclusive, green, sustainable development, and it is the only choice for the contiguous poor areas to speed up their development. Furthermore, combining the three characteristics of natural geography, humanity, and long-term poverty, a new system for poverty alleviation should be established. This should include a strategic poverty alleviation policy for mountainous areas to make widespread plans in whole contiguous destitute areas, and also include different concrete poverty alleviation policies, like industrial, education, social security, and social management policies. Developing ecological tourism to promote economic development is vital—after all, economic development is the foundation and fundamental way to eliminate poverty.

This paper contributes to the livelihood development discussion in remote and ethnic minority areas of China, a very important as well as very complex and multilayered issue. Accurate assessment of livelihood in some special areas (such as environmentally fragile areas, poverty-stricken areas, and disaster stricken areas) is crucial for understanding the problems of sustainability, and implementing poverty alleviation programs [8]. In this paper we tried to tackle and analyze this complexity by applying a large number of livelihood indices and topographic factors of settlements sites (villages), the truly irreducible dimensions in the county scale. The established evaluation indices of livelihood objectively reflects the practical conditions of the research area which can be used not only in southwest China, but could also be widely applied to other rural mountainous regions in China. The hill and mountain areas in China occupy close to 69% of China's total land area and are home to 45% of its population. The mountainous areas are an essential component of regional development, but are lagging behind the country [33]. Economic growth leads to more income for people, which in turn reduces poverty and improves standards of living [41]. In short, the economic situation in the region is very important. The healthy development and growth of the economy must be maintained in order to provide quality employment opportunities for low-income groups and the poor. In particular, many poorly educated and skilled families should be given extra training and assistance, increasing their employment opportunities and income channels.

Supplementary Materials: The following are available online at www.mdpi.com/2220-9964/7/1/16/s1. Table S1: Indicator layers of 13 counties, Table S2: Survey of consumption structure, Table S3: Survey on per capita net income of farmers and herdsmen.

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