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The Spatial–Temporal Evolution and Impact Mechanism of Cultivated Land Use in the Mountainous Areas of Southwest Hubei Province, China

Zhengxiang Wu [1,2,3,4], Qingbin Fan [1], Wen Li [1] and Yong Zhou [3,*]

1. Key Laboratory of Natural Disaster and Remote Sensing of Henan Province, Nanyang Normal University, Nanyang 473061, China; 20131138@nynu.edu.cn (Z.W.); fanqingbin@lzb.ac.cn (Q.F.); 22551340428@nynu.edu.cn (W.L.)
2. Rural Revitalization Institute, Nanyang Normal University, Nanyang 473061, China
3. Hubei Provincial Key Laboratory of Geographical Process Analysis and Simulation, Central China Normal University, Wuhan 430079, China
4. Nanyang Development Strategy Institute, Nanyang Normal University, Nanyang 473061, China

* Correspondence: yzhou@mail.ccnu.edu.cn

Abstract: Changes in cultivated land use significantly impact food production capacity, which in turn affects food security. Therefore, accurately understanding the spatial and temporal variations in cultivated land use is critical for strategic decision-making regarding national food security. Since the second national soil survey was conducted in around 1980, China has implemented major efforts, such as a nationwide soil testing and fertilization project in around 2005 and the establishment of the *National Standards for Cultivated Land Quality Grading* in 2016. However, limited research has focused on how cultivated land use has changed during these periods and the mechanisms driving these changes. This study, using Enshi Prefecture in the mountainous region of southwestern Hubei Province as a case study, examines the spatiotemporal changes in cultivated land use during 1980–2018. Land use data from 1980, 2005, and 2018 were combined with statistical yearbook data from Enshi Prefecture, and remote sensing and GIS technology were applied. Indicators such as the dynamic degree of cultivated land use, the relative rate of change in cultivated land use, and a Geoscience Information Atlas model were used to explore these changes. Additionally, principal component analysis was employed to examine the mechanisms influencing these changes. The results show that (1) the area of cultivated land in Enshi Prefecture increased slightly from 1980 to 2005, while from 2005 to 2018, it significantly decreased; compared with the earlier period, the transformation of land use types during 2005–2018 was more intense; (2) the increase in cultivated land area from 1980 to 2005 was mainly due to deforestation, the creation of farmland from lakes, and the reclamation of wasteland, while the decrease in land area was primarily attributed to the conversion of farmland back to forests and grassland. From 2005 to 2018, the main drivers for the increase in cultivated land were deforestation and the reclamation of wasteland, while the return of farmland to forests remained the primary reason for the decrease in land area; (3) from 1980 to 2005, the dynamic degree of cultivated land use in each county and city of Enshi Prefecture was generally low. However, between 2005 and 2018, the dynamic degree increased in most counties and cities except Enshi City and Xianfeng County; (4) there were significant variations in the relative rate of change in cultivated land utilization across counties and cities from 1980 to 2005. However, from 2005 to 2018, the relative rate of change decreased in all counties and cities compared to the previous period; (5) since 1980, nearly 50% of the cultivated land in Enshi Prefecture has undergone land classification conversion, with frequent shifts between different land classes; and (6) economic development, population growth, capital investment, food production, and production efficiency are the dominant socioeconomic factors driving changes in cultivated land use in Enshi Prefecture. The results of this study can provide a scientific basis for the protection and optimization of cultivated land resources in the mountainous regions of southwestern Hubei Province.

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1. Introduction

Cultivated land is an important material resource and the foundation of human survival and development [1]. It serves multiple functions, such as agricultural production, spatial-carrying capacity, and environmental protection [2]. It is not only responsible for providing food security for humans but is also related to national food security and sustainable economic and social development [3]. China's mountainous areas account for nearly 70% of the country's total land area, and there is a shortage of cultivated land resources. With the acceleration of China's socioeconomic development and urbanization in recent years, problems such as decreases in the quantity, quality, spatial fragmentation, and ecological environment of cultivated land have become increasingly prominent [4]. The contradiction between the limited cultivated land resources and the expansion of urban construction land and ecological land has also been exacerbated [5]. In addition, the phenomena of occupying superior cultivated land to compensate for inferior cultivated land and of occupying plain cultivated land to compensate for mountainous cultivated land frequently occur. The reserve resources of cultivated land continue to decrease, and the incentive and constraint mechanisms for the protection of cultivated land are not yet well-established. China's rational utilization and protection of cultivated land, and the balance between occupation and compensation, are facing multiple pressures [6,7]. In particular, in mountainous areas with complex terrain conditions, the problems of fragmented cultivated land, small quantities, poor quality, and the contradiction between the people and land are more prominent. Thus, the protection and efficient utilization of cultivated land resources in mountainous areas are particularly important. Therefore, against the background of the construction of an ecological civilization and high-quality economic development, it is of great significance to study the spatiotemporal evolution of cultivated land use in mountainous areas and clarify its impact mechanism. This is crucial for the sustainable use of cultivated land in mountainous areas, as well as in ensuring food security and protecting the ecological environment.

At present, domestic and foreign scholars' research on cultivated land utilization mainly focus on its spatiotemporal evolution [8,9], the evaluation of its utilization [10,11], the transformation of its utilization [12–14], its utilization and food security [15,16], the evaluation of the efficiency of its utilization [17,18], regional differences in its utilization [19,20], the multifunctional utilization of cultivated land [21,22], the productivity of cultivated land [23,24], aspects of its utilization and surface source pollution [25], and the ecological restoration of cultivated land [9,26,27]. Among these research foci, due to the frequent and complex transformations occurring between cultivated land and other land types, the spatiotemporal evolution of cultivated land use has become a major topic in recent years. The research areas considered cover the global [28], national [15,16], provincial [12,13], municipal [29,30], county [6], and even micro scales [31], while some studies are based on terrain units [21,32,33]. Yao et al. [28] analyzed the spatiotemporal characteristics of cultivated land resources at both global and local scales. They found that, across all continents, cultivated land showed a tendency for expansion towards higher-latitude regions. Most countries have shown the expansion of newly added cultivated land and a decrease in existing cultivated land. Wang et al. [34] analyzed the spatiotemporal differentiation and impact mechanism of cultivated land use in the Beijing–Tianjin–Hebei region. They found that the influence of socioeconomic and policy factors on cultivated land use is increasing, while the influence of natural factors is declining. Li Dan et al. [35] explored the spatiotemporal changes and driving factors of cultivated land use in Heilongjiang Province and found that the population size, policy factors, GDP, and urbanization level are the main driving forces in the spatiotemporal evolution of cultivated land. Liang et al. [32] used cultivated land in the southwestern mountainous areas of China as an example, and they found that the terrain and local policies are the main factors affecting the evolution of such cultivated land in these areas. In his study on the evolution of cultivated land in Luoyang City, China, Hua [29] found that both the altitude and industrial output had a significant impact on the amount of cultivated land. The study by Li et al. [36] on the changes in cultivated land and their driving factors in the Dongting Lake Basin showed that the impact of human activities is gradually increasing, while the impact of natural factors is gradually decreasing. Overall, the existing research mostly analyzes the spatiotemporal evolution of cultivated land and its influencing factors from the perspectives of the characteristics, mechanisms, and causes.

In approximately 1980, China started to conduct the second national soil survey in its history. This comprehensively identified the types, quantities, distributions, and basic characteristics of the soil resources in China. At this time, because of the prominent contradiction between the people and the land, the problem of the indiscriminate occupation and misuse of cultivated land emerged. Thus, China implemented a policy for cultivated land use based on the "protection of the quantity of cultivated land" [37]. With the continuous process of reform and opening up, as well as urbanization, the occupation of cultivated land occurs frequently, and the phenomenon of cultivated land occupying superior land to compensate for inferior land under the system for the balanced occupation and compensation of cultivated land has also emerged [38]. In 2005, the central government's No. 1 document clearly proposed the following: we should make efforts to carry out scientific fertilizer applications, carry out the "fertile soil project", promote soil testing and formula fertilization, and increase soil organic matter. At this time, China's cultivated land protection policy changed, focusing on the dual protection of cultivated land, namely "cultivated land quantity + quality" [39]. In 2012, the 18th National Congress of the Communist Party of China (CPC) announced the prelude to the construction of China's ecological civilization, which helped to further strengthen China's cultivated land protection policy [40]. At the end of 2016, the Ministry of Agriculture and Rural Development (MArD) issued the national standard for Cultivated Land Quality Evaluation (GB/T 33469-2016) [41], and a new round of the National Cultivated Land Quality Evaluation (NCCLQE) was conducted in 2017. At this time, China's cultivated land utilization and protection policy had entered the stage known as "cultivated land quantity + quality + ecology", focusing on three aspects [42]. Changes in cultivated land use can have an important impact on its food production capacity, which in turn affects food security [43]. In the current context of the continuous increase in the world's population, the decrease in per capita cultivated land holdings, and great challenges to food security [44], it is necessary to identify the changes in China's cultivated land use during the period between China's second national soil survey and the implementation of soil testing and fertilizer application technology. After the implementation of soil testing and fertilization technology, and with the introduction of the national standard for Cultivated Land Quality Rating (GB/T 33469-2016), which started a new round of national cultivated land quality evaluation, how did the cultivated land utilization change and how were the results compared? These questions require scientific and in-depth investigation; however, there is a lack of relevant research results.

The southwestern mountainous area of Hubei is a typical mountainous agricultural region in China, with a long history of cultivation. In recent years, the encroachment of construction land on cultivated land and the implementation of ecological protection projects brought about by urbanization have led to a reduction in the cultivated land use area. However, the changes in the spatial distribution and evolution of cultivated land use changes are still unclear. Understanding the changes in the utilization of cultivated land is the foundation for the protection and rational utilization of cultivated land resources. In order to comprehensively understand the current situation and identify the changing trends of farmland use in the mountainous areas of southwestern Hubei, this study adopts remote sensing data and takes Enshi Prefecture as a case study. It uses several methods and models, such as the cultivated land dynamics, the relative change rate of cultivated land,

and geographic information maps, and the changes in farmland use in the region during 1980–2005 and 2005–2018 are analyzed. Moreover, the impact mechanism associated with farmland changes is explored using principal component analysis. The purpose of this study is to determine the main factors leading to changes in cultivated land use in the mountainous areas of southwest Hubei Province and to explain their causes, mechanisms, and processes. It seeks to provide a reference for the rational utilization of cultivated land resources, the protection of such resources, and sustainable socioeconomic development in this region.

2. Materials and Methods

2.1. Overview of the Study Area

Enshi Prefecture is located in the southwest of Hubei Province (108°23′12″–110°38′08″ E, 29°07′10″–31°24′13″ N) (Figure 1), at the intersection of Hubei, Hunan, and Chongqing. The prefecture is 220 km wide from east to west and 260 km long from north to south, with an area of 24,000 km^2. The vast majority of the territory is mountainous, with higher terrain to the west and north, lower terrain to the east, and an average altitude of >1000 m. Overall, the terrain is complex and differs markedly, with different types of terrain being staggered; this configuration is commonly known as "eight mountains and half water and half fields". The region has a humid subtropical monsoon mountain climate, with a warm, rainy, and humid climate across the whole state. It is characterized by an average annual precipitation of 1600 mm, which is affected by the terrain, exhibiting obvious vertical regional differences in climate. The main soil types are paddy, red, yellow, and yellow-brown. The cultivated land is divided into two categories: paddy fields and dryland, accounting for 29.46 and 70.54% of the total cultivated land area, respectively. The cultivated land is mainly distributed in river valleys and low-altitude areas, with limited areas of extensive contiguity and obvious fragmentation. The main food crop is corn, followed by rice, wheat, and potatoes, with tobacco, tea, and alpine vegetables also being prevalent.

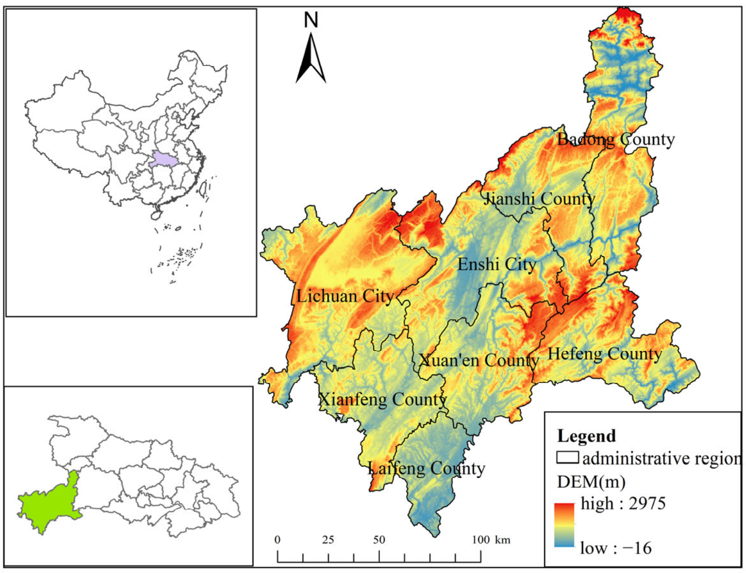

Figure 1. Study area location and elevation distribution.

2.2. Data Sources

The boundary data of the administrative divisions of Enshi Prefecture and its counties and cities, along with the land use data of Enshi Prefecture at three time points: 1980, 2005, and 2018, were derived from the China Resource and Environmental Science and Data Center (http://www.resdc.cn/, accessed on 16 March 2024). The spatial resolution of the land use data was 30 m × 30 m. The driving factor data regarding the dynamic evolution of cultivated land were derived from the Hubei Provincial National Economic Statistical

Yearbook (Agriculture) 1980 [45], the Western Hubei Statistical Yearbook 1985 [46], and the Enshi Prefecture Statistical Yearbook [47].

2.3. Modeling the Cultivated Land Utilization Dynamics

The dynamic degree of cultivated land use can be used to quantitatively describe the quantitative change in the utilization of certain types of cultivated land within a specific period of time, and it has a positive effect in predicting the changes and trends in cultivated land use. The formula for the calculation of cultivated land dynamics is as follows [48,49]:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\%, \tag{1}$$

where K is the dynamic degree of cultivated land; U_a and U_b are the cultivated land areas at the beginning and end of the study period, respectively; and T is the length of the study. $K > 0$ indicates that the cultivated land dynamics have changed positively and increased overall, whereas $K < 0$ indicates a negative change, i.e., an overall decrease. The greater the absolute value of K, the faster the rate of land change.

2.4. Modeling the Relative Rate of Change in Cultivated Land Use

The relative rate of change in cultivated land use reflects the ratio of the intensity of the change in the cultivated land area in each county and city in the study area to the change degree of the total cultivated land area in the area. The primary advantage of this method is that it avoids interference from the size of the administrative districts or cultivated land during the horizontal comparison of administrative divisions, and it can accurately reflect the activity of cultivated land changes in various counties and cities. The formula is as follows [50]:

$$R = \frac{|U_b - U_a| \times C_a}{U_a \times |C_b - C_a|}, \tag{2}$$

where R represents the relative rate of change in the cultivated land area in a county in the region, U_b and U_a are the cultivated land areas at the beginning and end of the study in the county, respectively, and C_b and C_a are the total cultivated land areas at the beginning and end of the study in the entire study area (i.e., Enshi Prefecture), respectively. $R > 1$ indicates that the change in the cultivated land area in the county is relatively higher than that in Enshi Prefecture. $R = 1.0$ indicates that the change rate of the cultivated land quantity in the county is equal to that in Enshi Prefecture. $R < 1.0$ indicates that the change rate of the cultivated land quantity in the county is less than that of Enshi Prefecture.

2.5. Geoscience Information Atlas

2.5.1. Algebraic Operations Regarding the Land Use Change Atlas

In this study, the national remote sensing detection land use/cover classification system was adopted to conduct algebraic operations on the land use change maps. The types of land use included 6 primary types, namely cultivated land, forestland, grassland, water, residential land, and unused land, as well as 25 secondary types. Based on the land use data of Enshi Phase 3, the spatial unit of the selected map was a grid unit of 30 m × 30 m; the map algebraic overlay operation of the raster data was performed using ArcGIS 10.7 software to realize the fusion of the land use type spatial information. The code of the land use type in the two periods before and after Enshi Phase 3 was calculated according to Equation (3).

The algebraic formula for the land use change map is [51,52]

$$M = 100A + B, \tag{3}$$

where A is the code of the previous land use type; B is the code of the subsequent land use type; and M is the code for the type of land use change during the study period. The local categories were coded as follows: 10—cultivated land, 11—paddy field, 12—dry land, 20—forestland, 30—grassland, 40—water area, 50—construction land, and 60—unused land. For example, code 1112 indicates the type of land converted from paddy fields to dryland, and code 1220 represents the type of land converted from dryland to woodland. Finally, the land use change maps of Enshi Prefecture from 1980 to 2005 and 2005 to 2018 were synthesized.

2.5.2. Atlas Analysis of Land Use Change Patterns

Using the map algebraic overlay operation in the ArcGIS 10.7 software, the land use type maps for the three time periods (1980, 2005, and 2018) were intersected sequentially, new fields were added to the attribute table, and algebraic operations were performed as follows [51,52]:

$$N = 10{,}000A + 100B + C \quad (4)$$

where N is the map unit code of the land use change pattern in the study, and A, B, and C are the land use type codes for 1980, 2005, and 2018, respectively. For example, the code 201030 in Table 1 indicates that the land change process consisted of forestland–cultivated land–grassland. The land use change patterns were then determined based on the new map cell codes.

Table 1. Changes in cultivated land use in Enshi Prefecture from 1980 to 2018.

Code	Change Mode	Meaning	Example
I	Full-term cultivated land type	No change in the type of cultivated land use in 1980–2018	101010
II	Intermittent cultivated type	Non-cultivated land in 1980, cultivated land in 2005, and non-cultivated land in 2018	201030
III	Repeated cultivation type	Cultivated land in 1980, non-cultivated land in 2005, and cultivated land in 2018	103010
IV	Conversion to the cultivated type	Non-cultivated land in 1980, cultivated or non-cultivated land in 2005, and cultivated land in 2018	201010
V	Shift from cultivated land type	Cultivated land in 1980, cultivated or non-cultivated land in 2005, and non-cultivated land in 2018	103020

2.6. Principal Component Analysis

Principal component analysis is a method of dimensionality reduction and processing. It allows multiple variables to be grouped into a few main composite indicators while retaining most of the information about the original multiple variables; their relationships with the dependent variable can then be explored through the analysis of the composite indicators [53]. In this study, based on the results from the specific analysis of the changes in cultivated land use in Enshi, we explored the driving mechanism behind cultivated land use changes by combining the collected and collated socioeconomic statistical indicators with principal component analysis using the SPSS.25 software (IBM, Armonk, NY, USA).

3. Results

3.1. Changes in the Quantitative Structure of Cultivated Land Use

The spatial evolution of the distribution of cultivated land use is strongly influenced by natural and human factors. Driven by a combination of various factors, different land use types are constantly transformed spatially, resulting in the dynamic evolution of cultivated land use. To explore the transformation characteristics of cropland use in detail between 1980 and 2018 in Enshi Prefecture, we used ArcGIS 10.7 to establish land use transfer matrices for the periods of 1980 to 2005 and 2005 to 2018 and extracted transfer maps involving cropland categories to analyze the spatial transfer of cropland use during these time periods (Tables 2 and 3). Overall, the land use structure of Enshi Prefecture is dominated by forestland, accounting for approximately 77% of the total area, followed by cropland (12.83%) and grassland (9.10%), with smaller areas of construction land, water, and unused land.

Table 2. Land use transfer matrix of Enshi Prefecture, 1980–2005 (km^2).

1980	2005									
	Paddy Field	**Dryland**	**Forest Land**	**Grassland**	**Water Area**	**Construction Land**	**Unused Land**	**Increase in Area**	**Reduction in Area**	**Net Increase in Area**
Paddy field	935.54	1.31	19.70	1.73	1.33	6.99	0.00	33.81	31.06	2.75
Dryland	1.21	2089.37	81.90	15.85	3.39	4.30	1.00	106.55	107.65	−1.1
Forest land	24.45	96.38	18,448.41	40.22	14.87	7.88	0.07	127.65	183.87	−56.22
Grassland	2.44	8.28	23.54	2178.29	0.90	0.29	0.10	58.99	35.55	23.44
Water area	5.58	0.27	0.73	0.29	22.48	0.04	0.00	20.78	6.91	13.87
Construction Land	0.09	0.05	0.23	0.01	0.29	18.20	0.00	19.5	0.67	18.83
Unused land	0.04	0.26	1.55	0.89	0.00	0.00	0.03	1.17	2.74	−1.57

Table 3. Land use transfer matrix of Enshi Prefecture, 2005–2018 (km^2).

2005	2018									
	Paddy Field	**Dryland**	**Forest Land**	**Grassland**	**Water Area**	**Construction Land**	**Unused Land**	**Increase in Area**	**Reduction in Area**	**Net Increase in Area**
Paddy field	616.93	29.88	273.06	26.31	3.85	19.26	0.00	292.69	352.36	−59.67
Dryland	18.73	1427.04	662.44	73.87	3.32	10.27	0.00	750.78	768.63	−17.85
Forest land	249.04	644.69	17,261.60	267.43	87.97	60.71	0.13	1260.52	1309.97	−49.45
Grassland	22.39	73.21	311.54	1819.97	1.77	7.12	0.07	1819.97	416.1	1403.87
Water area	0.45	1.40	8.42	0.83	31.50	0.56	0.05	97.45	11.71	85.74
Construction land	2.08	1.55	5.00	0.35	0.54	28.16	0.00	97.92	9.52	88.4
Unused land	0.00	0.05	0.06	0.01	0.00	0.00	0.07	0.25	0.12	0.13

Table 2 shows that, between 1980 and 2005, the areas of all of the different land use types changed, with cultivated land (paddy fields and dryland) showing the greatest increase (140.36 km^2), followed by forestland (127.65 km^2), whereas unused land increased the least (1.17 km^2). The largest decrease in area was found for forestland (183.87 km^2), followed by cultivated land (138.71 km^2); construction land showed the smallest decrease in area (0.67 km^2). In terms of the net increase in area, grassland exhibited the largest increase (23.44 km^2), followed by construction land (18.83 km^2) and grassland (13.87 km^2). Forestland exhibited the largest change in its net area, decreasing by 56.22 km^2; other land types experienced a smaller net change.

From 2005 to 2018, grassland showed the largest increase in area (1819.97 km^2), followed by forestland (1260.52 km^2) and cultivated land (1043.47 km^2), and unused land showed the smallest increase in area (0.25 km^2) (Table 3). In addition, forestland exhibited the largest decrease in area during this period (1309.97 km^2), followed by cultivated land (1120.99 km^2) and grassland (416.1 km^2); unused land showed the smallest decrease in area (0.12 km^2). In terms of the net increase in area, grassland had the largest net increase (1403.87 km^2), followed by construction land (88.40 km^2) and water areas (85.74 km^2). Conversely, cultivated land exhibited a net decrease in area (77.52 km^2), whereas the area of forestland decreased by 49.45 km^2. Unused land showed the smallest change, with a net area increase of 0.13 km^2.

3.2. Analysis of the Geographic Information Atlas of Cultivated Land

3.2.1. Atlas Analysis, 1980–2005

To explore the transformation characteristics of cultivated land use in different stages, we used ArcGIS 10.7 to establish a land use transfer matrix, from which we extracted the transfer map of cultivated land types in order to analyze the spatial transfer of cultivated land from 1980 to 2005 (Tables 4 and 5).

Table 4. Main sources of new cultivated land in Enshi Prefecture, 1980–2005.

Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage (%)	Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage (%)
1211	Dryland → paddy fields	1.21	3.58	1112	Paddy fields → dry land	1.31	1.23
2011	Woodland → paddy fields	24.45	72.32	2012	Woodland → dryland	96.38	90.46
3011	Meadows → paddy fields	2.44	7.22	3012	Grassland → dry land	8.28	7.77
4011	Waters → paddy fields	5.58	16.50	4012	Waters → drylands	0.27	0.25
5011	Construction land → paddy fields	0.09	0.27	5012	Construction land → dry land	0.05	0.05
6011	Unused land → paddy fields	0.04	0.12	6012	Unused land → dry land	0.26	0.24
subtotal		33.81	100	subtotal		106.55	100

Table 5. Main destinations for reduced cultivated land area in Enshi Prefecture, 1980–2005.

Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage (%)	Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage (%)
1112	Paddy fields → dry land	1.31	4.22	1211	Dryland → paddy fields	1.21	1.12
1120	Paddy fields → woodlands	19.70	63.43	1220	Dryland → woodland	81.90	76.08
1130	Paddy fields → meadows	1.73	5.57	1230	Dryland → meadows	15.85	14.72
1140	Paddy fields → waters	1.33	4.28	1240	Dryland → waters	3.39	3.15
1150	Paddy fields → construction land	6.99	22.50	1250	Dryland → construction land	4.30	3.99
1160	Paddy fields → unused land	0.00	0.00			1.00	0.93
subtotal		31.06	100	subtotal		107.65	100

Table 4 shows that, from 1980 to 2005, among the types of newly cultivated land in Enshi Prefecture, the area of paddy fields increased by 33.81 km^2; this was primarily derived from forestland (24.45 km^2), accounting for 72.32% of the total increase in the area of paddy fields, followed by water areas (5.58 km^2) and grassland (2.44 km^2), accounting for 16.50 and 7.22% of the total area of paddy fields, respectively. The newly increased dryland area (106.55 km^2) was mainly derived from forestland (96.38 km^2) followed by grassland (8.28 km^2), accounting for 90.46 and 7.77% of the total dryland source area, respectively; other land types were converted to dryland over smaller areas. These results suggested that deforestation and land reclamation constituted the main mechanisms underlying the increase in the cultivated land area during this period, followed by water and grassland reclamation, whereas the exchange between paddy fields and dryland was limited. The areas of construction land and unused land flowing into cultivated land were relatively small.

In the study area, from 1980 to 2005, the overall decrease in the area of paddy fields amounted to 31.06 km^2, among which the area converted from paddy fields to forestland was the largest (19.70 km^2), followed by construction land (6.99 km^2), accounting for 63.43 and 22.50% of the total area lost from paddy fields, respectively. The areas and proportions of transfer to grassland, dryland, and water areas were relatively small (Table 5). During this period, the total outflow of dryland amounted to 107.55 km^2, of which 81.90 km^2 was converted to forestland and 15.85 km^2 was converted to grassland, accounting for 76.08 and 14.72% of the total area lost from dryland, respectively. The areas and proportions of transfer to paddy fields, water areas, and construction land were small. The main reason for the reduction in dryland was also conversion to forestland. From these findings, it can be seen that the return of cultivated land to forests and grasslands was the main reason for the loss of cultivated land during this period, followed by the occupation of construction land.

These results show that, from 1980 to 2005, the return of cultivated land to forests was the main reason for the decline in cultivated land, followed by the return of cultivated land to grassland and the occupation of cultivated land for construction. The increase in area mainly arose from deforestation and land reclamation, followed by grassland reclamation and water reclamation. The transfer of construction land and unused land to cultivated land was not significant. However, overall, the difference between the cultivated land use area transferred out and that transferred in was small, and the total cultivated land area in the study region was relatively stable during this period.

3.2.2. Atlas Analysis, 2005–2018

From 2005 to 2018, within the newly increased cultivated land area of Enshi Prefecture, the proportion of paddy fields increased by 292.69 km^2 (Table 6). Forestland was the main source for the increase in paddy fields (249.04 km^2), followed by grassland (22.39 km^2) and dryland (18.73 km^2), accounting for 85.09, 7.65, and 6.40% of the total inflow area, respectively. Meanwhile, the conversion area of construction land (2.08 km^2) accounted for only 0.71% of the increase in the area of paddy fields and the area transferred from unused land was negligible. On the other hand, from 2005 to 2018, the dryland area in Enshi Prefecture increased by a total of 750.78 km^2, primarily through transfer from forestland (644.69 km^2) and grassland (73.21 km^2), accounting for 85.87 and 9.75% of the new dryland area, respectively. Construction land reclamation contributed 1.55 km^2, accounting for 0.21%, whereas unused land exhibited the smallest area transferred to dryland (0.05 km^2), with a change rate approaching 0.

Table 6. Main sources of new cultivated land in Enshi Prefecture from 2005 to 2018.

Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage/%	Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage/%
1211	Dryland → paddy fields	18.73	6.40	1112	Paddy fields → dry land	29.88	3.98
2011	Woodland → paddy fields	249.04	85.09	2012	Woodland → dryland	644.69	85.87
3011	Meadows → paddy fields	22.39	7.65	3012	Grassland → dry land	73.21	9.75
4011	Waters → paddy fields	0.45	0.15	4012	Waters → drylands	1.40	0.19
5011	Construction land → paddy fields	2.08	0.71	5012	Construction land → dry land	1.55	0.21
6011	Unused land → paddy fields	0.00	0.00	6012	Unused land → dry land	0.05	0.01
subtotal		292.69	100.00	subtotal		750.78	100.00

Table 7 shows the direction of the outflow of cultivated land in the study area from 2005 to 2018. The total outflow amount from paddy fields was 352.36 km^2, of which the area converted from paddy fields to dryland was 29.88 km^2, accounting for 8.48% (i.e., within-cultivated land-type transfer). The conversion area of paddy fields to forestland amounted to an area of 273.06 km^2, accounting for 77.49% of the paddy field outflow; grassland (26.31 km^2), construction land (19.26 km^2), and wetlands (3.85 km^2) accounted for 7.47, 5.47, and 1.093% of the outflow, respectively (Table 7). The total outflow from dryland was 768.63 km^2, of which the area converted to paddy fields amounted to 18.73 km^2, accounting for 2.44% of the outflow. The area converted to forestland (662.44 km^2) accounted for the majority (86.18%) of the outflow, whereas the area converted to grassland (73.87 km^2) and construction land (10.27 km^2) accounted for 9.61 and 1.34%, respectively.

Table 7. Main destinations for reduced cultivated land area in Enshi Prefecture, 2005–2018.

Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage/%	Encode	Land Use Map Change Unit	Transfer Area/km^2	Percentage/%
1112	Paddy fields → dry land	29.88	8.48	1211	Dryland → paddy fields	18.73	2.44
1120	Paddy fields → woodlands	273.06	77.49	1220	Dryland → woodland	662.44	86.18
1130	Paddy fields → meadows	26.31	7.47	1230	Dryland → meadows	73.87	9.61
1140	Paddy fields → waters	3.85	1.09	1240	Drylands → waters	3.32	0.43
1150	Paddy fields → construction land	19.26	5.47	1250	Dryland → construction land	10.27	1.34
1160	Paddy fields → unused land	0.00	0.00				0.00
subtotal		352.36	100.00	subtotal		768.63	100.00

The results show that, from 2005 to 2018, the return of farmland to forests was the main mechanism underlying the decline in cultivated land, followed by the return of farmland to grassland and the occupation of cultivated land for construction. The increase in area was mainly due to deforestation and land reclamation, followed by grassland reclamation and construction land reclamation.

3.3. Analysis of Changes in Cultivated Land Use

To further determine the patterns of cultivated land dynamics in different periods, we introduced the cultivated land use dynamics model and the cultivated land use relative change rate model, and we calculated the cultivated land use dynamics index and the cultivated land use relative change rate for each period (Table 8).

Table 8. Changes in cultivated land by county and city in Enshi Prefecture, 1980–2018.

District	1980–2005			2005–2018		
	Area Changes/km^2	**Dynamics /%·a^{-1}**	**Relative Rate of Change/%**	**Area Changes/km^2**	**Dynamics /%·a^{-1}**	**Relative Rate of Change/%**
Enshi City	−1.62	−0.01	2.55	−0.88	−0.01	0.08
Lichuan City	4.81	0.03	5.80	3.83	0.04	0.22
Jianshi County	6.68	0.08	16.58	−9.56	−0.22	1.16
Badang County	3.63	0.04	8.21	−8.11	−0.18	0.92
Xuan'en County	3.15	0.03	6.55	−5.24	−0.11	0.55
Xianfeng County	−5.60	−0.06	11.42	−1.81	−0.04	0.21
Laifeng County	3.24	0.05	9.35	−3.31	−0.09	0.49
Hefeng County	−10.32	−0.16	31.19	−53.27	−1.61	8.41

3.3.1. Cultivated Land Use Dynamics

From 1980 to 2005, the inflow and transfer of cultivated land in Enshi Prefecture as a whole were relatively balanced, the total cultivated land area showed minimal change, and the degree of change in cultivated land was negligible (Table 8). The absolute amount of cultivated land in various regions of Enshi Prefecture varied from 1980 to 2005, with increases and decreases in different counties and cities. The cultivated land areas in Enshi City, Xianfeng County, and Hefeng County decreased, with the change in cultivated land characterized primarily by outward transfer. Alternatively, the areas in Lichuan City, Jianshi County, Badong County, Xuan'en County, and Laifeng County increased, with inward transfer characterizing this change.

The area in Enshi Prefecture with the highest level of activity in terms of cultivated land change from 1980 to 2005 was found in Hefeng County in the southeast. The areas with moderate activity were located in Xianfeng County and Laifeng County in the southwest of Enshi Prefecture, as well as Jianshi County in the northeast. The areas with low activity were mainly distributed in Enshi City, Xuanen County, and Lichuan City in the central and western parts of the study area, as well as in Badong County in the northeast.

From 2005 to 2018, the inflow of cultivated land in Enshi Prefecture was smaller than the outflow, resulting in a large change in the overall amount of cultivated land. Within Enshi Prefecture, the area of cultivated land increased slightly only in Lichuan City, whereas in other counties and cities, it decreased. In addition, from 2005 to 2018, the degree of cultivated land dynamics in Enshi Prefecture increased substantially, with the largest degree occurring in Hefeng County in the southeast of Enshi Prefecture, followed by Jianshi County and Badong County in the northeast. Conversely, the degree of cultivated land dynamics in other areas was relatively low.

3.3.2. Relative Rate of Change in Cultivated Land Use

Table 8 shows that between 1980 and 2005, Hefeng County, located in the southeast of the study area, experienced a relatively high change rate in cultivated land (31.19) among the evaluated regions, followed by Xianfeng County in the southwest and Jianshi County in the northeast (both between 9.39 and 16.58). On the other hand, those of the other counties were relatively small. Similarly, from 2005 to 2018, Hefeng County exhibited the largest change rate (8.41), followed by Jianshi County and Badong County in the northeast of the study area (both between 0.55 and 1.17), whereas the other counties and cities showed smaller change rates.

Together, these results highlight that, from 1980 to 2005, the degree of cultivated land dynamics and the relative change rate of cultivated land use in Hefeng County were greater than those of other counties and cities. The dynamics and change rates of Xianfeng County in the southwest and Jianshi County in the northeast of the study area were also relatively large. In comparison, the cultivated land dynamics in Laifeng County were relatively large, but the relative change rate was small, whereas both measures in the other counties and cities were relatively small. Hefeng County also exhibited the highest metrics from 2005 to 2018. Those of Badong County and Jianshi County, located in the northeast of the study area, were moderate, whereas those of other counties and cities were small. Overall, the degree of cultivated land dynamics and the relative change rate of cultivated land utilization in all counties and cities in the study area were relatively consistent.

3.4. Atlas Structure of Land Use Change Patterns

We next reconstructed the data on the land use status in the study area during 1980, 2005, and 2018 to obtain the pattern of cultivated land use change over the past 40 years (Figure 2). This was divided into five major change patterns according to the characteristics of phased change (Table 9). From 1980 to 2018, the fully cultivated land model occupied a major position, accounting for 50.18% of the total area. Intermittently cultivated land was mainly distributed in Lichuan City, Enshi City, and Jianshi County, accounting for 1.88% of the total area and primarily composed of "cultivated land–forestland–forestland". This was followed by "cultivated land–grassland–cultivated land", which accounted for 87.53 and 8.55% of the total area of this type, respectively. The repeatedly cultivated land type was mainly distributed in Lichuan City, Enshi City, and Xianfeng County, accounting for only 0.94% of the total area, being composed of mainly "cultivated land–forestland–cultivated land", followed by "cultivated land–grassland–cultivated land", accounting for 87.53 and 8.55% of the total area of this type, respectively. Areas of conversion to the arable type of cultivated land were mainly distributed in Lichuan City, Enshi City, Jianshi County, and Badong County, accounting for 22.61% of the total area, among which "forestland–forestland–cultivated land", "grassland–grassland–cultivated land", and "forestland–cultivated land–cultivated land" accounted for 84.43, 8.72, and 5.68% of the total area of this type, respectively. Finally, the outward transfer of the cultivated land type was mainly distributed in Lichuan City, followed by Enshi City and Jianshi County, accounting for 24.39% of the total area. It was primarily composed of "cultivated land–cultivated land–forestland", "cultivated land–cultivated land–grassland", and "cultivated land–forestland–forestland", accounting for 78.84%, 8.30%, and 6.34% of the outward transfer type, respectively.

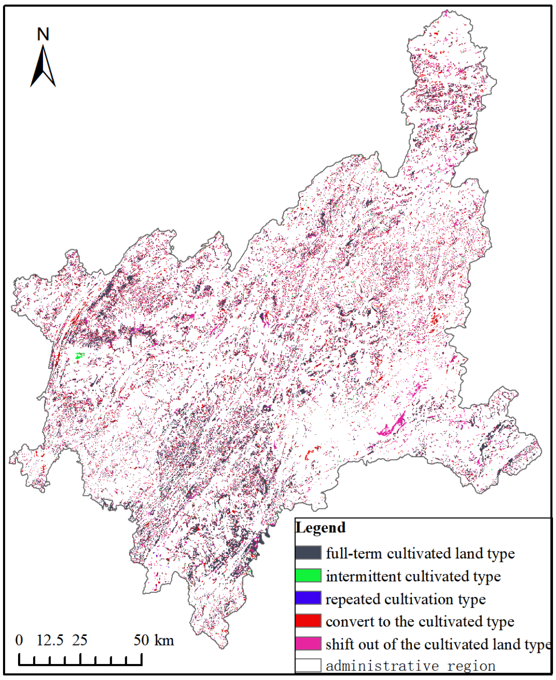

Figure 2. Atlas of cultivated land use change patterns in Enshi Prefecture from 1980 to 2018.

Table 9. Main map units of cultivated land use change from 1980 to 2018.

District	Change Mode				
	Full-Term Cultivated Land Type (km^2)	Intermittent Cultivated Type (km^2)	Repeated Cultivation Type (km^2)	Converted to the Arable Type (km^2)	Shift Out of the Cultivated Land Type (km^2)
Enshi	338.14	12.69	6.81	160.79	163.50
Lichuan	445.82	20.43	9.17	215.97	207.50
Jianshi	186.73	11.88	4.83	127.77	130.42
Badong	196.27	9.72	4.07	148.12	152.60
Xuan'en	282.62	7.62	4.23	95.13	97.13
Xianfeng	282.09	7.22	6.30	95.84	103.36
Laifeng	219.03	4.49	2.08	55.17	55.36
Hefeng	151.07	4.59	1.75	48.19	111.56
total	2101.77	78.64	39.24	946.96	1021.43
Percentage	50.18	1.88	0.94	22.61	24.39

Overall, our results indicate that nearly 50% of the cultivated land in Enshi Prefecture has been converted from another land type over the past 40 years, and the conversion between land types is relatively severe.

3.5. Driving Mechanisms

The study of driving mechanisms has been a primary focus in cultivated land use change research, with the aim of identifying the main factors leading to cultivated land-use change and explaining its causes, mechanisms, and processes. Previous research has demonstrated that the spatiotemporal evolution of cultivated land use is often influenced by natural factors, as well as economic, social, and policy factors [54–56]. In particular, the influence of natural factors on land use change within a short period of time is relatively slow and limited [36]; meanwhile, socioeconomic factors often play a decisive role in land use change in the short term, and they constitute the primary factors affecting cultivated land use change [57]. Policy factors guide the direction of land use change, often causing major adjustments in land use patterns, and have a significant impact on land use.

3.5.1. Natural Factors

Field investigations indicate that the vast majority of Enshi Prefecture is mountainous, with large altitude differences. Enshi Prefecture has a large area of sloping farmland, and there is farmland utilization at different altitudes. The elevation and slope affect the climate, soil erosion, and cultivation methods in the region, which are important factors determining farmland utilization. Therefore, there are significant differences in the soil, crop types, cultivation systems, and yield levels in areas with different altitudes [36].

An analysis of the proportion of cultivated land at different altitudes and slopes in the research area shows that from 1980 to 2018, the proportion of cultivated land at different altitude ranges did not change substantially. The largest change amounted to 0.6%, occurring in the >1600 m altitude range, whereas the smallest (0.08%) was observed in the range of 600 to 800 m (Table 10). Cultivated land use was mainly distributed in the ranges of 600 to 800, 800 to 1000, and 1000 to 1200 m. According to the "Technical Regulations for the Investigation of Land Use Status", published by the China Agricultural Regional Planning Commission in 1984, the slope of cultivated land can be divided into five levels, and the proportion of the cultivated land area in the three assessment years was recorded according to the slope, as shown in Table 11. The proportion of cultivated land between 6° and 15° accounted for the largest proportion, followed by 15°–25°. The cultivated land area along steep slopes (>25°) approached 20% of the total cultivated land, whereas that at slopes $\geq$6° amounted to approximately 85%.

Table 10. Distribution of cultivated land at different altitudes.

	Altitude Classification (m)	≤600	600–800	800–1000	1000–1200	1200–1400	1400–1600	>1600
Percentage (%)	1980	12.70	19.61	21.37	22.38	12.06	7.22	4.65
	2005	12.59	19.57	21.31	22.22	12.06	7.45	4.81
	2018	12.50	19.65	21.44	21.70	12.20	7.27	5.25
Variety range (%)	1980–2018	0.20	0.08	0.13	0.68	0.14	0.23	0.60

Table 11. Distribution of cultivated land with different slopes.

	Slope Grading	≤2°	2°–6°	6°–15°	15°–25°	>25°
Percentage (%)	1980	2.48	13.66	36.11	29.40	18.35
	2005	2.49	13.77	36.39	29.27	18.07
	2018	2.36	13.22	36.11	29.74	18.58
Change (%)	1980–2018	0.13	0.55	0.28	0.47	0.51

The above analysis indicates that the proportion of cultivated land at different height ranges and slope levels in the study area exhibited minor changes between 1980 and 2018. In the past 40 years, the crust, temperature, and precipitation in Enshi Prefecture have been relatively stable [36,57,58], indicating that natural factors have a relatively weak impact on the spatiotemporal changes in cultivated land use and are not the main factors affecting such changes. Wang Quanxi et al. found that the influence of the elevation and slope on the changes in cultivated land patterns in typical areas of the Lower Liaohe Plain from 1980 to 2018 was relatively small [58]. Li Huidan et al.'s study on the spatiotemporal distribution characteristics of sloping cultivated land in Chongqing showed that natural factors such as altitude and rainfall had a relatively weak impact on the changes in sloping farmland, while socioeconomic factors such as economic development, policy regulation, farmers' incomes, and urban expansion were the main driving factors of changes in sloping cultivated land [59].

3.5.2. Socioeconomic Factors

Based on previous studies [54–56], we selected 15 socioeconomic indicators and analyzed the principal components. X1–X15 represented the following factors: X1 was the total population at the end of year X1 (10,000 people); X2 was the rural population (10,000 people); X3 was the per capita GDP (CNY); X4 was the total value of primary industry (ten thousand CNY); X5 was the total value of secondary industry (ten thousand CNY); X6 was the industrial total value (ten thousand CNY); X7 was the total value of tertiary industry (ten thousand CNY); X8 was the regional fiscal revenue (ten thousand CNY); X9 was the total power of agricultural machinery (kilowatts); X10 was the effective irrigation area (thousand hm^2); X11 was the fertilizer application rate (purified) (t); X12 was the total grain output (t); X13 was the per capita grain volume (kg); X14 was the total output value of agriculture, forestry, animal husbandry, and fishery (ten thousand CNY), and X15 was the per capita net income of rural residents (CNY). Table 12 shows that the cumulative contribution rate of the first and second principal components reached 93.378%, and the characteristic values were >1. These results indicate that the first and second principal components can fully reflect the driving force of the dynamic evolution of cultivated land use in Enshi Prefecture from 1980 to 2018.

Table 12. Eigenvalues and principal component contribution rates.

Principal Component	Eigenvalue	Contribution Rate/%	Cumulative Contribution Rate/%
PC1	11.968	79.79	79.79
PC2	2.038	13.588	93.378

From the rotating principal component load matrix (Table 13), it can be seen that the primary principal component had strong positive correlations with 11 factors: the per capita gross regional product; total value of primary industry; total value of secondary industry, total industrial value; total value of tertiary industry; regional fiscal revenue; total output value of agriculture, forestry, animal husbandry, and fishery; per capita net income of rural residents; total power of agricultural machinery; effective irrigation area; and fertilizer application rate (purification). These factors reflect economic growth, agricultural production, and capital input; thus, the first principal component can be considered representative of economic growth, production efficiency, and capital investment. The second principal component had a significant positive correlation with demographic conditions and food production. Overall, the evaluation of these indicators suggests that the socioeconomic driving forces affecting the changes in cultivated land and soil use in Enshi Prefecture can be classified as economic development, population growth, capital input, grain production, and production efficiency.

Table 13. Principal component load matrix after rotation.

Secondary Indicators	Indicator Code	Principal Components	
		PC1	PC2
Total population at the end of the year	X1	0.641	0.725
Rural population	X2	−0.472	0.738
GDP per capita	X3	0.975	0.207
Gross value of primary industry	X4	0.891	0.442
Gross value of secondary industry	X5	0.984	0.161
Gross Industrial Value	X6	0.983	0.171
Gross value of tertiary industry	X7	0.977	0.161
Region-wide fiscal revenue	X8	0.987	0.137
Total power of agricultural machinery	X9	0.909	0.383
Effective irrigation area	X10	0.842	0.285
Fertilizer application amount (purified)	X11	0.709	0.691
Total food production	X12	0.279	0.873
Food production per capita	X13	0.552	0.700
The total output value of agriculture, forestry, animal husbandry, and fishery	X14	0.921	0.374
Per capita net income of rural residents	X15	0.980	0.173

Demographic Factors

From 1980 to 2018, the total population of Enshi Prefecture increased from 3.1736 million to 4.017 million, with a total population increase of 8.434×10^4. The rural population increased from 2.9903 million to 3.1982 million, with an increase of 2.079×10^5. During this period, the cultivated land use area in the study region decreased from 3.163×10^3 hectares to 3.088×10^7 hectares, with a total decrease of 74.64 hectares (Figure 3). Moreover, the urbanization rate increased from 7.71% in 1980 to 44.86% in 2018. On the one hand, with an increase in the population, the demand for food also increases, requiring more cultivated land to meet the needs of the growing population. On the other hand, with the continuous growth of the population and the increasing urbanization rate, the expansion of rural settlements and urban areas, and the construction of public infrastructure, it is inevitable that more agricultural land (including cultivated land) will be occupied. The reduction in cultivated land has exacerbated the contradiction between the people and land.

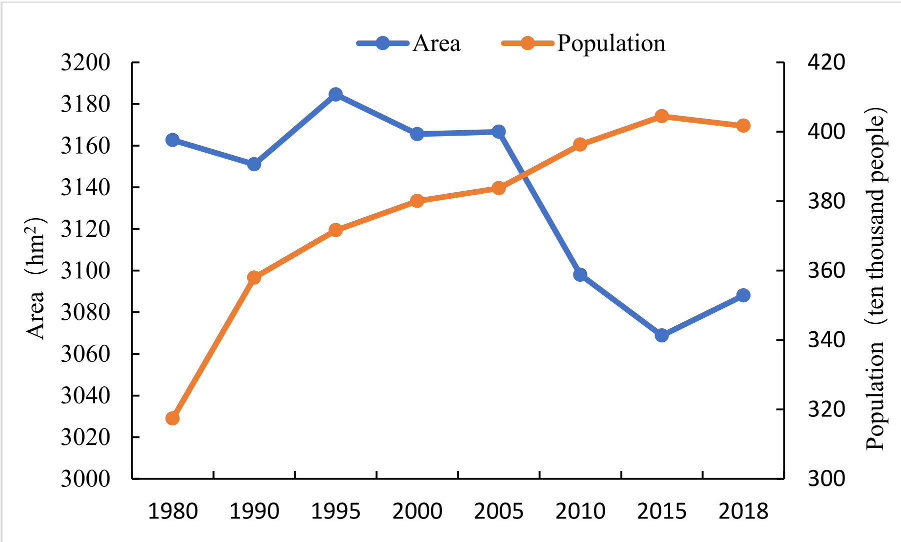

Figure 3. Changes in Population and Cultivated Land in Enshi Prefecture from 1980 to 2018.

Economic Factors

As shown in Figure 4, from 1980 to 2018, the value of primary industry in Enshi Prefecture increased from CNY 4.33 $\times$ 10^8 to CNY 1.66 $\times$ 10^{10}, the value of secondary industry increased from CNY 1.19 $\times$ 10^8 to CNY 2.96 $\times$ 10^{10}, the industrial output value increased from CNY 9.02 $\times$ 10^7 to CNY 2.42 $\times$ 10^{10}, and the value of tertiary industry increased fromCNY 1.49 $\times$ 10^8 to CNY 4.09 $\times$ 10^{11}. The per capita regional GDP increased from CNY 221 to CNY 25,848 and the district's fiscal revenue increased from CNY 6.283 $\times$ 10^7 to CNY 1.71 $\times$ 10^{11}. However, during this period, the cultivated land area decreased by 74.64 hectares.

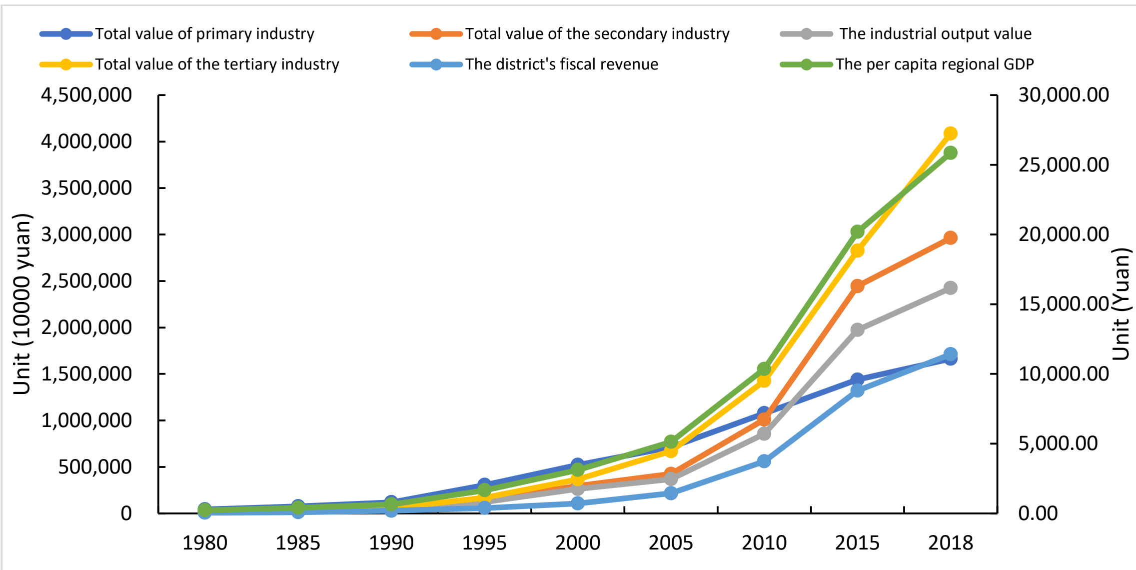

Figure 4. Economic Development and Changes in Enshi Prefecture from 1980 to 2018.

It can be seen that the development of the economy has driven the process of urbanization, and the degree of industrialization is constantly increasing, with a large amount of high-quality cultivated land being occupied by construction land. In addition, with economic development and the rising level of consumption, there will inevitably be a demand for a higher quality of life, which will further increase the requirements related to road traffic, accommodation conditions, and urban infrastructure, thus accelerating reductions in the cultivated land area.

China first proposed the policy of linking the occupation of cultivated land with development and reclamation in 1997 and included the "balance of cultivated land occupation and compensation" in the Land Management Law in 1998. Balancing the occupation and compensation of cultivated land is a basic strategy for cultivated land protection. However, due to the lack of an effective cultivated land quality supervision system and effective administrative law enforcement measures, it is difficult to achieve a balance between "quantity and quality" at the same time. The phenomenon of "occupying superior land and compensating for inferior land" is common, leading to the increasing pressure on cultivated land.

Capital Investment and Grain Production

Improving the yield per unit of grain is an important guarantee in ensuring food security. Technological progress is an important condition for improving the grain yield per unit area. With the continuous development of the economy and society in Enshi Prefecture, the level of agricultural technology and equipment has also been significantly improved. As shown in Table 14, from 1980 to 2108, with the continuous increase in population and the decrease in the cultivated land area in Enshi Prefecture, in order to improve grain production, the total power input of agricultural machinery in Enshi Prefecture increased from 165,119 kilowatts to 2,405,290 kilowatts, the effective irrigation area increased from 63.46 thousand hectares to 66.39 thousand hectares, and the amount of fertilizer applied increased from 27,830 tons to 258,534 tons. Overall, capital investment in agricultural production increased significantly, and the total grain output increased from 931,000 tons to 1.4669 million tons. The per capita grain volume also increased from 293.36 kg to 434.24 kg, demonstrating that technological progress has driven the investment of agricultural production capital, thereby promoting an increase in the grain yield per unit area. The continuously decreasing cultivated land area and the increasing population have greatly increased the total grain output and per capita grain output; improved the productivity of unit cultivated land; greatly alleviated the contradiction between population growth, economic development, and reductions in the cultivated land area; eased the pressure of the population on cultivated land; and provided a strong guarantee for food security.

Table 14. Changes in Agricultural Production Input from 1980 to 2018.

Time	Total Power Input of Agricultural Machinery (kW)	Effective Irrigation Area (1000 hm^2)	Amount of Fertilizer Applied (ton)	Total Grain Output (Ten Thousand tons)	per Capita Grain (kg)
1980	165,119	63.46	27,830	93.10	293.36
1985	160,854	56.26	44,985	126.82	378.32
1990	283,107	50.85	73,373	121.06	338.19
1995	339,997	48.00	147,816	136.88	368.35
2000	475,761	50.12	163,375	170.05	447.45
2005	814,930	55.82	185,452	153.58	400.24
2010	1,755,583	66.09	250,767	167.18	493.06
2015	2,642,613	71.61	283,981	167.41	503.88
2018	2,405,290	66.39	258,534	146.69	434.24

Agricultural Production Efficiency

In order to promote social and economic growth, Enshi Prefecture exploits its local conditions to adjust its agricultural structure. It has developed various agricultural management methods according to the local conditions and promoted the diversification of its agriculture. Thus far, it has formed four leading agricultural industries, consisting of tobacco, tea, vegetables, and forest fruits. As shown in Figure 5, the total output value of agriculture, forestry, animal husbandry, and fishery increased from CNY 603.78 million in 1980 to CNY 3028.338 million in 2018. The adjustment of the agricultural structure has led to the occupation of some cultivated land. In addition, with the rapid development of the economy, in order to pursue higher economic benefits, farmers are no longer solely planting grain crops, but are shifting towards planting more profitable cash crops such as tobacco leaves, tea gardens, and vegetables. In 1980, the per capita net income of farmers in Enshi Prefecture was CNY 172, and this increased to CNY 10,524 in 2018. In the past 40 years, the per capita net income has grown more than 60 times larger. The adjustment of the agricultural production structure has also led to a reduction in the cultivated land area.

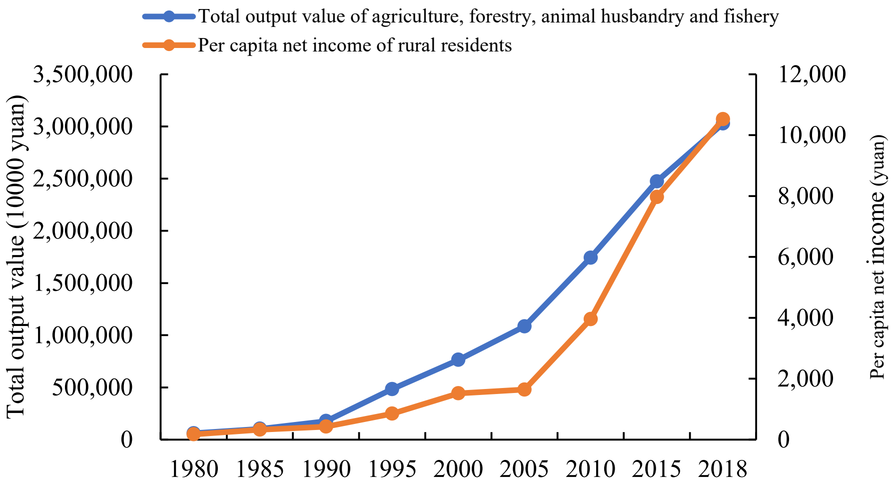

Figure 5. Changes in the total output value of agriculture, forestry, animal husbandry, and fishery in Enshi Prefecture and the income of farmers and residents from 1980 to 2018.

3.5.3. Policy Factors

Government policy has a guiding and restraining effect on the evolution of cultivated land use, and it constitutes the primary external force driving this process [58]. The project of returning farmland to forests and grassland, which began in 1999, has important effects on the spatial distribution of cultivated land use [55]. Enshi Prefecture is a typical mountainous agricultural area with a large area of sloped, cultivated land. Returning farmland to forests and grassland on steep slopes is an important measure for the construction of ecological environments and for soil and water conservation. According to the 2010 Enshi Prefecture Forestry Bureau's "Investigation Report on Returning Farmland to Forest in Enshi Prefecture" [59], published in 2010, the project of returning farmland to forest in Enshi Prefecture spanned the period of 2000 to 2009, and a total of 1.318 $\times$ 10^5 hm^2 of farmland has been returned to forestland, among which 0.576 $\times$ 10^5 hm^2 of sloped cultivated land was afforested. To consolidate the achievements of this project of returning farmland to forestland and grassland, Central Document No. 1, published in 2014, proposed to continue to implement major forestry projects such as returning farmland to forestland and grassland and strengthening ecological protection construction. In 2020, during national-level inspections preceding a new round of returning farmland to forests, Enshi Prefecture reported that a total of 0.471 $\times$ 10^5 hm^2 of farmland had been converted to forestland since the implementation of the 2014 round of returning farmland to forestland. According to the statistics of land use data in 2018, Enshi Prefecture contained 0.573 $\times$ 10^5 hm^2 of cultivated land with slopes >25°; in practice, 25° is generally used as the slope limit for land cultivation. In addition, in approximately 2000, responding to a country-wide wave of economic construction, many localities vigorously promoted the construction of industrial and high-tech parks, leading to the occupation of a large amount of cultivated land. Overall, these observations indicate that policy factors play a substantial role in promoting the changes in cultivated land use.

4. Discussion

4.1. Major Findings

The mountainous area in southwestern Hubei is an integral part of the Wuling Mountains in China, characterized by a unique geographical location and a complex ecological environment. This region plays a crucial role in soil and water conservation, water source preservation for the Three Gorges Reservoir, and biodiversity protection in the Wuling Mountains [60]. Enshi Prefecture, as the core of the mountainous area of southwestern Hubei, has a long agricultural history, with the local government prioritizing land use and ecological protection and implementing effective measures such as reforestation and soil conservation, achieving remarkable results. Selecting Enshi Prefecture as the study area not only reveals significant patterns in mountainous farmland utilization but also provides valuable insights into ecological conservation strategies and regional agricultural sustainability. Thus, Enshi Prefecture serves as a typical and representative study area.

According to China's Soil and Water Conservation Law, cultivation on slopes steeper than 25° is strictly prohibited [61]. The 2014 "Central Document No. 1", referring to the first policy document issued each year by China's central government, reaffirmed the policy of converting farmland on steep slopes, heavily desertified land, and key water sources back to forests and grasslands and approved the implementation of the General Plan for the New Round of Conversion of Farmland to Forest and Grassland [62]. Since 1980, the proportion of sloped farmland exceeding 25° in Enshi Prefecture has remained at no less than 18%. Chen et al. [61], in their analysis of sloped farmland in Yunnan, found that the area of farmland above 25° accounted for 13.83% of the region, while Xu et al. [63] highlighted that eastern China primarily uses farmland with slopes less than 15°, with farmland above 15° being rare; however, sloped farmland in southwestern China reaches as high as 74.68%. This indicates that Enshi Prefecture's high proportion of sloped farmland is not isolated within China, contradicting China's Soil and Water Conservation Law and posing challenges to ecological development. Continued reforestation, grassland restoration, and the integrated management of sloped farmland are necessary to achieve land management and ecological protection goals in the region.

This study, based on the utilization of paddy fields and dry land, examines changes in land use types and spatial distribution, extending the dimensions of studies on land use. The 1980–2005 period saw increases in the area of paddy fields, mainly sourced from forest land followed by water bodies and dry land and possibly influenced by national policies promoting agricultural production, such as enhancing food self-sufficiency and increasing rice cultivation. The increase in dry land area, primarily sourced from forests and grasslands, might be related to adjustments in local agricultural structure, such as developing specialty agriculture to improve economic efficiency, while reductions were mainly due to reforestation and grassland restoration, consistent with Xiong and Tian et al. [64,65]. This reflects the balance between ecological protection and agricultural production during that period at the policy level—ensuring food security while also protecting and restoring the environment [39]. Between 2005 and 2018, increases in the areas of paddy fields and dry land mainly came from forest and grassland, while reductions primarily converted land back to forest, likely due to accelerated urbanization, adjustments in the structure of the agricultural industry, and strengthened ecological protection policies [42]. Between 1980 and 2018, dry land showed more intense conversion than paddy fields, likely due to the relative vulnerability of dry land to human activities [66]. Studies by Dai et al. [67] in Tongren City and Zhu et al. [68] in Zhangjiajie City, both in the Wuling Mountains, reveal similar trends—forest and grassland as major sources of new farmland, with conversion back to forest driving land reductions. This study found that, from 1980 to 2018 in southwestern Hubei, forest land provided most of the newly converted farmland, followed by grassland, while farmland reduction was mainly due to reforestation, consistent with the findings mentioned above in the Wuling Mountains region.

Over the past 40 years, Enshi Prefecture has exhibited characteristics of both stability and intensity in farmland use changes. Nearly half of its farmland experienced land type conversion, likely reflecting the region's efforts to balance economic development, social transformation, and ecological protection. However, frequent land type conversions might adversely affect soil quality, the ecological environment, and agricultural productivity.

4.2. Policy Implications

Based on the study results and the current development status of Enshi Prefecture, the following policy implications are proposed by this study: (1) Agricultural zoning. Promote the gradual conversion of farmland on slopes greater than 25° back to forests and grasslands to prevent soil erosion and land degradation. For slopes below 25°, implement soil and water conservation measures such as terracing, slope water system management, and soil and water retention farming. (2) Develop specialty agriculture. As the largest producing area of selenium-rich tea in China, Enshi Prefecture could capitalize on its mountainous advantages by promoting the tea industry as a green, ecological, and specialty industry, advancing high-quality economic development. (3) Strengthen farmland balance supervision. With urbanization and industrialization accelerating, significant amounts of high-quality farmland are being used for urban construction. Due to incomplete regulatory frameworks, the phenomenon of replacing high-quality land with lower-quality land persists, leading to declining farmland quality and threatening regional food security.

4.3. Limitations and Outlooks

The limitations of this study are twofold. First, given the extensive area of sloped farmland in the study region, analyzing the spatiotemporal conversion patterns between sloped farmland and other land types since China's second national soil survey would be valuable for soil and ecological environment management, especially under the influence of national policies and ecological civilization initiatives. Second, due to the challenges in quantifying policy factors and the limited short-term changes in natural factors, this study could not quantitatively analyze the combined impact of natural, socioeconomic, and policy factors on land use in Enshi Prefecture. Therefore, only qualitative interpretations of natural and policy factors were provided. Future research could adopt more detailed indicators representing natural and policy factors to offer more comprehensive quantitative insights.

5. Conclusions

(1) The land use structure in Enshi Prefecture is dominated by forestland, followed by cultivated land and grassland. During the period of 1980–2005, the area of paddy fields increased by a net value of 2.75 km^2, the area of dryland decreased by a net value of 1.1 km^2, and the area of forestland conversion was the largest, followed by that of dryland. During the period of 2005–2018, the area of paddy fields decreased by a net value of 59.67 km^2, the area of dryland decreased by a net value of 17.85 km^2, and the area of forestland conversion was the largest, followed by that of grassland and dryland. Comparing the two time periods, the transformation of land use types was more severe in 2005–2018.

(2) During the period of 1980–2005, the area of paddy fields increased, and the land was derived mainly from forestland, followed by water and dryland; the increase in the area of dryland was mainly due to conversions from forestland, followed by grassland; and the decrease in the area of paddy fields was mainly due to its conversion into forestland, followed by construction land. The decrease in the dryland area was mainly due to conversion to forestland, followed by grassland. The main reasons for the increase in the area of cultivated land at this stage were deforestation, the creation of fields around lakes, and the reclamation of wasteland, while the main reason for the decrease in the area of cultivated land was the return of farmland to forests and grassland. During the period of 2005–2018, the increase in the area of paddy fields and dryland mainly originated from forestland, followed by grassland. The decrease in the area of paddy fields and dryland was mainly due to their conversion to forestland,

and the outflow area of cultivated land was larger than the inflow area during this period, resulting in a decrease in the area of cultivated land. The increase in the area of cultivated land utilized in this period was mainly due to deforestation and the reclamation of wasteland, and the decrease in the area of cultivated land was mainly due to the return of farmland to forests. Since 1980, in terms of the change in the area of cultivated land, the conversion between dryland and other land categories has been more severe than the conversion of paddy fields.

(3) During the period of 1980–2005, the dynamic degree of cultivated land use was generally small in all counties and cities in Enshi Prefecture. During the period of 2005–2018, with the exception of Enshi City, where there was no change in the dynamic degree of cultivated land use, and Xianfeng County, where the dynamic degree of cultivated land use decreased slightly, all counties and cities exhibited an increase, albeit to varying degrees. In both time periods, the dynamic degree of cultivated land use was the largest in Hefeng County.

(4) During the period of 1980–2005, the relative rate of change in cultivated land use in Hefeng County was the largest, followed by that in Jianshi County and Xianfeng County, while the corresponding values for all other counties and cities were smaller. The overall relative rate of change in cultivated land use in the counties and cities in Enshi Prefecture varied greatly. During the period of 2005–2018, the relative rate of change in cultivated land use in all counties and cities was reduced compared to the previous period. The relative rate of change in cultivated land use in Hefeng County was larger during this period, while the relative rate of change in other counties and cities was smaller.

(5) In the atlas of cultivated land use change patterns during the period of 1980–2018, the full-term cultivated land type pattern dominated, accounting for 50.18% of the total area. The intermittent cultivated land type accounted for 1.88% of the total area, the repeated cultivated land type only accounted for 0.94% of the total area, conversion to the cultivated type accounted for 22.61% of the total area, and the shift from the cultivated land type accounted for 24.39% of the total area. This indicates that nearly 50% of the cultivated land in Enshi Prefecture has been converted in the past 40 years, and the conversion between land types is relatively severe.

(6) The spatial–temporal evolution of cultivated land use in Enshi Prefecture is influenced by natural factors, socioeconomic factors, and policy factors. Natural factors are less influential due to their stability over a short period of time. Meanwhile, socioeconomic factors play a dominant role in the spatial–temporal variation in cultivated land use in Enshi Prefecture, among which economic development, population growth, capital investment, food production, and production efficiency are the predominant factors that contribute to this variation. Among the policy factors, the return of farmland to forests and grassland plays a large role in promoting change in the cultivated land use area.

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