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*Original Research*

# Research on Value Accounting and Realization Path of Eco-products of the Villages in Karst Desertification Control

**Fangli Feng, Kangning Xiong*, Yanghua Yu, Rong Zhao, Nana Yu**

School of Karst Science, State Engineering Technology Institute for Karst desertification Control, Guizhou Normal University, Guiyang 550001, China

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**Abstract**

Villages are important supply sites for eco-products, and karst desertification is an important factor restricting their socio-economic development. Using the Xie G.D. modified equivalent factor table method, the eco-product values of the village ecosystems of Shijiayakou and Luoshuidong in Salaxi, a potential-slight desertification area, the village ecosystems of Youqi and Wangjiazhai in Qingzhen, a mildly-moderately desertification area, and the village ecosystems of Chaeryan and Kongluojing in the moderately-intensely desertification area of Huajiang were accounted for. The results showed that: (1) the value of eco-products from high to low is Salaxi (17,810,600 yuan) > Qingzhen (13,497,500 yuan) > Huajiang (8,831,600 yuan); (2) the value of eco-products of different service types in descending order is as follows: regulating service (35,196,700 yuan) > material provisioning service (3,023,100 yuan) > cultural service (1,191,800 yuan); (3) the highest eco-product value of different land use types is forest land, followed by arable land, and the rest of the land use types have lower eco-product values; (4) the average density of eco-product values of watersheds, forest land, grassland, arable land, and unutilized land is 553,000 yuan/ha, 128,000 yuan/ha, 78,000 yuan/ha, 28,000 yuan/ha and 751 yuan/ha, and there are obvious differences between villages with different levels of karst desertification control, with spatial heterogeneity.

**Keywords:** ecosystem service value, eco-products value, land use, karst desertification, village

## Introduction

Ecosystem service value (ESV) refers to the benefits that humans directly or indirectly derive from the various service functions of ecosystems, which include the inputs of useful substances and energy to the economic and social systems and the resources such as clean air and clean water that are directly provided to members of the human society [1-3]. Costanza [4] and Daily [5] proposed the value of ecosystem services in 1997, deducting the cost of natural resources consumed and pollution damage in GDP accounting to assess the goods or services humans receive from natural ecosystems, making economic assessments more convincing and rational. As an important

*e-mail: xiongkn@gznu.edu.cn
Tel.: + 8613608547678

component of natural resource assets, the contribution of ecosystem service value to the well-being of human society is extremely important. It cannot be ignored, and quantifying the value of ecosystem services is an important way to analyze the contribution of ecosystems to human beings. However, the public goods attributes and externalities of ecosystem services have not been identified and analyzed deeply enough, leading to a biased understanding and evaluation of their value.

The United Nations issued the Framework for Economic and Environmental Ecosystem Accounting (SEEA-EA), which has led to a growing appreciation of the value of ecosystems, quantification, and a clear understanding of the value they create [6]. In 1977, Westman et al. conducted an early study to assess the value of natural ecosystem services [7]. Following this, the number of studies on the value of ecological services increased, particularly after the 1990s. In 1995, Gren L.M. et al. assessed the value of ecological services in the Danube River in Europe [8], while in 1996, Jakbosson assessed the value of endangered species in Victoria, Australia [9]. In 1997, Dixon assessed the value of soil and sediment retention in a UK watershed [10]. Cejudo E. et al. accounted for the water retention capacity and organic carbon content of the topsoil of the Quintana Roo Mexican wetland soils, thereby providing elements for regulating ecosystem services' ecological and economic valuation [11]. Goldscheider N used a holistic approach to assess groundwater protection and ecosystem services in karst areas [12]. Scholars assess the value of ecosystem services from different perspectives [13-17]; the equivalent value factors (EVFs) are mainly used in current ecosystem service valuation methods [18-21], alternative market approaches, etc. [22]. However, assessing the value of ecosystem services is a complex process that lacks uniform and effective assessment methods and standards. With the deepening of research on ecosystem services by scholars at home and abroad, domestic scholars Hong and Yang [23] proposed "eco-products" with Chinese characteristics based on ecosystem services in the light of China's actual situation, which triggered a large number of domestic scholars to conduct research on ecological products and their values. The value of ecosystem services and eco-products are closely related, with the value of ecosystem services providing a broader and more comprehensive perspective to assess the economic value of ecosystems, while the value of eco-products focuses more on the economic value of specific eco-products. Eeco-product value is an in-depth study of ecosystem service value [24], which is monetized ecosystem services. It is assessed for a specific eco-product using methods such as the corresponding market value or production cost, and to avoid double counting, the eco-product value does not account for the support services that provide the underlying conditions for other services [25]. Since the concept of eco-products was proposed in the National Main Functional Areas Planning issued by the State Council in 2010 and the Opinions on Establishing a Sound Mechanism for Realizing the Value of Eco-Products was issued in 2021, the importance of eco-products value has become more and more prominent. Pilot demonstration zones have been set up in China, such as in Fujian, Zhejiang, Qinghai, Guizhou, and Jiangxi. The scope of related research has gradually diversified, for example, for the province [26-28], city [29-31], county [32, 33], and village [34, 35]. These zones have facilitated a gradual diversification of the scope of relevant research, for example, for forest eco-products [36-38], water eco-products [39], marine eco-products [40], wetland eco-products [41], grassland eco-products [42], and glacier eco-products [43], as well as the value of different ecosystem eco-products and the connotations of eco-products [44-46], eco-product value realization and its accounting [47-50], realization mechanisms and pathways [51-52], influencing factors [53-55], and so on. Relative to the gross domestic product (GDP), the concept of sustainable development in which the value of eco-products transforms green mountains into golden mountains has obvious ecological and economic advantages. However, many studies have shown that the value of eco-products is difficult to measure, trade, and realize.

The fragile habitats of the karst region, the dichotomous structure above and below the ground, and the influence of human activities make the region prone to problems such as soil and water leakage [56], land desertification, and rock exposure, which are difficult to recover and are challenging for the growth and reproduction of living organisms and the economic development of the region. The development of karst desertification (KD) in Guizhou has resulted in five different levels of intensity: no KD, potential KD, mild KD, moderate KD, and intense KD [57]. Soil physicochemical properties, including soil water content and soil organic matter, have been demonstrated to have a clear correlation with KD grades [58]. The different grades of KD have been shown to affect plant growth and biological habitats, with the intensification of KD resulting in a decline in species richness and life-type composition [59]. The quantity and quality of eco-products produced by different grades of KD are different, and studying the value of eco-products in different grades of KD areas can provide an information basis for karst desertification control (KDC). A village ecosystem is a composite ecosystem that takes the village territory as a spatial carrier and puts the natural, economic, and social environments into action in the production and life of farmers through material circulation, energy flow, and information transfer [60]; village ecosystems supply ecological material products such as agriculture, forestry, animal husbandry, and fishery, while also providing ecosystem services such as soil conservation, water conservation, flood storage, air purification, water purification, climate regulation, carbon sequestration and oxygen release, landscape recreation, and other ecosystem services, which have important ecological, economic and cultural values, and are the best management units for KD. Current research on the value of eco-products in Guizhou mainly focuses on the mechanism of realization [61, 62], the path of realization [63-65], and synergistic development with the construction of ecological civilization and rural revitalization [66, 67], with less research on value accounting, and little attention has been paid to the village ecosystem as an important production site for eco-products. Using the equivalent factor method to account for the value of eco-products in villages with KDC is conducive to deepening the understanding of village eco-products, promoting the development of eco-products and their value realization in KDC villages, and giving full play to their economic and social benefits.

China's research into the value of eco-products is currently undergoing a period of rapid development, moving from theoretical to practical transformation. However, there are still a number of shortcomings: (1) Research into the value of eco-products is mainly concentrated in large-scale regions, with less research involving small-scale regions; (2) the mode of realization of the value of eco-products in KDC villages is single and inefficient; (3) the path of realization of the value of eco-products in KDC village ecosystems is not clear, and the mode of realization is unsustainable, resulting in low-value realization. As the production and living places of villagers, villages carry the unique history of farming civilization and are the accumulation of wealth developed by human beings over generations in rural settlements, with high cultural and historical value. As an important part of the ecological environment, the village ecosystem has various types of eco-products. The identification and value accounting of village eco-products are of great significance for promoting rural revitalization and sustainable development of villages.

In summary, the eco-products of KDC villages are rich in types and have high potential ecological and economic values, but the eco-products of villages have problems with low-value realization rates, single realization paths, and non-uniform accounting methods. Eco-products are the basis for the development of human society, and village ecosystems are important areas for eco-product supply. In the final analysis, accounting for the value of eco-products in villages with different levels of KDC is an assessment of the ability of sustainable economic and social development supported by village ecological resources and environment. Therefore, this study accounts for the value of eco-products of villages with different grades of KDC by using the equivalent factor method and analyses the spatial distribution pattern of their value land average density, which is conducive to deepening the understanding of the eco-products of villages, better grasping the achievements of KDC and the current stage of the current status quo of the village development, and providing a scientific management mode and scientific basis for the subsequent economic development of villages and the enhancement of the value of the eco-products of villages to give full play to their economic, social and economic development, promoting the sustainable development of the village. Karst landscapes are widely distributed and involve many countries and regions. By accounting for the value of eco-products in karst areas of KDC villages, it can provide a sustainable model for resource management in karst areas, promote the coordinated development of the local economy and environment; moreover, it can help human beings to better understand the positive roles of these areas in the maintenance of ecological balance and the conservation of biodiversity, and provide local data and cases for the comprehensive study of the ecological value of the In addition, it can help human beings better understand the positive role of these areas in maintaining ecological balance and biodiversity conservation, and provide local data and cases for the comprehensive study of the ecological value of other karst areas around the world, thus enriching the research results in this field.

## Materials and Methods

### Overview of the Study Area

The study area of this paper is located in the northwestern, southwestern, and central regions of the Guizhou Plateau (Fig. 1), where the development of karst landscapes is extensive and typical, basically representing the typical landscapes of plateau mountains, plateau basins, and plateau valleys of the karst plateau. Guanling-Zhenfeng Huajiang karst plateau canyon moderate-intensity KD area, Qingzhen Hongfenghu belongs to the karst plateau basin mild-moderate KD area, and Bijie Salaxi demonstration area belongs to the karst plateau mountain potential-mild KD area. The three study areas have significant regional differences in locational conditions, characteristics of the natural environment, and the level of socio-economic development, etc., and are able to reflect the evolution and development process of the karst region's desertification in a more complete way. They are typical representatives of KD areas in southwest China and even the whole country.

The three study areas are situated within the subtropical rocky desertification management area, which experiences heavy rainfall during the summer months. This, coupled with the influence of human activities, has resulted in serious soil erosion and surface water loss. The degradation of vegetation and land, decline in biodiversity, and serious ecological damage are all consequences. Furthermore, the restoration process is hindered by these factors. It is evident that there is a close relationship between rocky desertification and poverty. The backward economy and fewer employment opportunities have contributed to a significant exodus of young labor and an accelerated aging of villages.

The three study areas have diverse types of karst morphology, a wide distribution of carbonate rocks, and

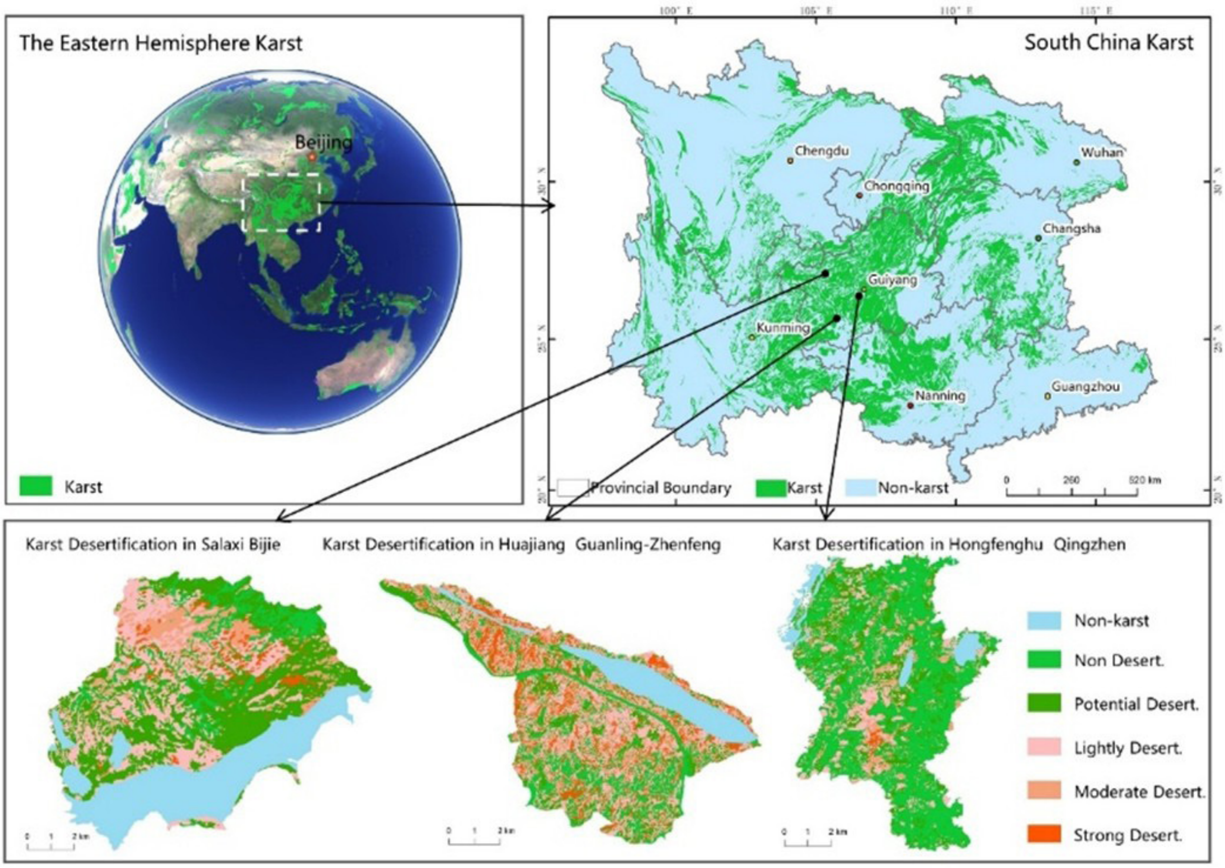



Fig. 1. Location map of the study area.

outstanding environmental effects of strongly developed karst and fragile karst. The types of KD cover many levels, such as none, potential, mild, moderate, and intense. The socio-economic profile, land use, and production mode of the study area are in line with the general level of karst areas in southern China. The representative KDC villages in the study area are shown in Table 1, and the distribution of village ecosystems is shown in Fig. 2.

## Data Sources

This study calculated the value of eco-products of villages with different levels of KDC in 2022. To conduct the study, socio-economic data such as land use data, unit price, production, cultivated area, and yields had to be obtained (Table 2).

The land use data of this study were obtained from the geospatial data cloud (http://www.gscloud.cn/) with an accuracy of 30 m. The elevation data were extracted from the DEM in the study area by downloading from the geospatial data cloud, and in order to use the remote sensing data, it is necessary to convert the original remote sensing data in various formats into a format that can be recognized by various remote sensing image processing software. According to the land resource classification standard, the land use type of the study area was reclassified into six types, namely arable land, forest land, grassland, water, construction land, and unused land, and the land use type map was obtained. The socio-economic data, such as crop unit price and yield, were obtained from the national compilation of information on the costs and benefits of agricultural products and the statistics published by the township and county governments. The obtained village socio-economic survey data were analyzed and processed using statistical analysis software such as SPSS22, Excel, Origin 2022, and other research methods such as statistics.

## Research Methodology

As proposed by Xie et al., the equivalence factor method is based on the principle of classifying ecosystem services and constructing equivalents of the value of various services provided by different types of ecosystems, with the value of each service being determined by quantifiable criteria. When combined with the ecosystems' distribution area, the method can assess the value of ecosystem services. The specific calculation formula is as follows: "service value = equivalent factor×modification factor×area of land type". The modification factor is determined based on factors such as the economic value and yield of the main crops grown in the study area. The method requires less

Table 1. Overview of villages with different levels of KDC.

| Desertification grade | Potential-mild KD villages | | Mild-moderate KD villages | | Medium-intensity KD villages | |
|---|---|---|---|---|---|---|
| Name of village | Shijiayakou (SJYK) | Luoshuidong (LSD) | Youqi (YQ) | Wangjiazhai (WJZ) | Chaeryan (CEY) | Kongluojing (KLJ) |
| Agricultural acreage ($hm^2$) | 142.94 | 112.33 | 200.5 | 105.7 | 76.35 | 60.06 |
| Wooded area ($hm^2$) | 316.21 | 420.61 | 214.64 | 191.79 | 173.95 | 385.79 |
| Grassland area ($hm^2$) | 0 | 0.38 | 1.09 | 5.18 | 0.26 | 0 |
| Water areas ($hm^2$) | 0 | 0.23 | 6.75 | 1 | 0 | 0.17 |
| Unused land area ($hm^2$) | 0 | 0.54 | 0 | 0.24 | 0.44 | 2.7 |
| Subscriber number | 143 | 277 | 789 | 272 | 187 | 313 |
| Total population (people) | 538 | 1059 | 3156 | 1046 | 574 | 1046 |
| Population density (people /$hm^2$) | 1.15 | 1.94 | 6.89 | 3.18 | 2.15 | 2.23 |
| Main crops grown | Corn, potatoes, beans, vegetables, peppers | Corn, potatoes, beans, peppers, vegetables, walnuts | Rice, corn, potatoes, peppers, vegetables, rapeseed | Rice, corn, rapeseed, peppers, vegetables, tea | Corn, beans, peppers, walnuts, loquats | Beans, peppers, vegetables, loquats, oranges |
| Main farmed poultry | Pigs, cattle, sheep, chickens | Goose, pig, cattle, sheep, chicken | Pigs, chickens, ducks | Pigs, chickens, cattle | Chicken, dog, cattle | Pigs, chickens, cattle |

data, simplifies the assessment process, and renders the results more intuitive and easier to use.

In this study, based on the improved equivalence factor method of unit area value by Xie G. et al. [68], the land use types in the study area were classified into six categories: arable land, forest, grassland, watershed, unused land, and construction land, and the ecosystem services were classified into three categories: provisioning, regulating, and cultural services, and the parameters of the equivalence factor table were corrected according to the actual situation in Guiyang, Bijie, and Anshun. Based on the current situation of ecosystems in the study area, combined with the ecosystem classification of the Xie G. Equivalent Factor Table, the values of the equivalence factors in the study area are: arable land = (paddy field + dry land)/2, forest = (deciduous forest + shrub forest)/2, grassland = scrubland, water area = water system, and unused land = bare land. A table of equivalence factors adapted to the situation in the study area was obtained (Table 3), and the value of ecosystem services for 1 standard equivalence factor was calculated based on the area, unit volume, and unit price of the main crops grown in the study area. Among them, one standard unit of ecosystem service value equivalent was defined as 1/7 of the economic value of the average annual grain yield of 1 $hm^2$ of farmland [69-70]. According to the study area's specific situation, the farmland ecosystem's food production value was calculated based on three crops: maize, wheat, and soybean, and construction land was not calculated and expressed as 0. The calculation formula is:

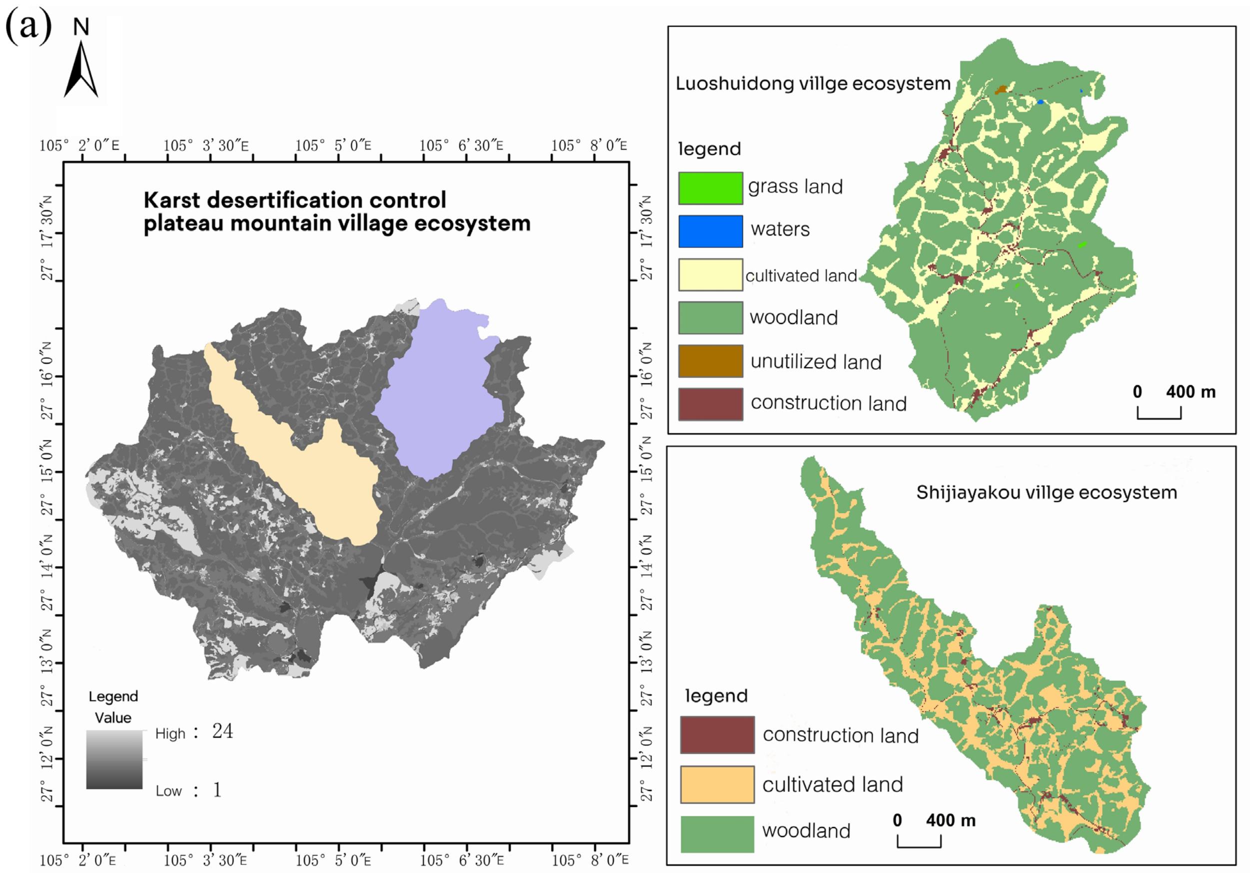
$$D = \frac{1}{7}\sum_{i=1}^{n}\frac{mi \times pi \times qi}{M} \tag{1}$$

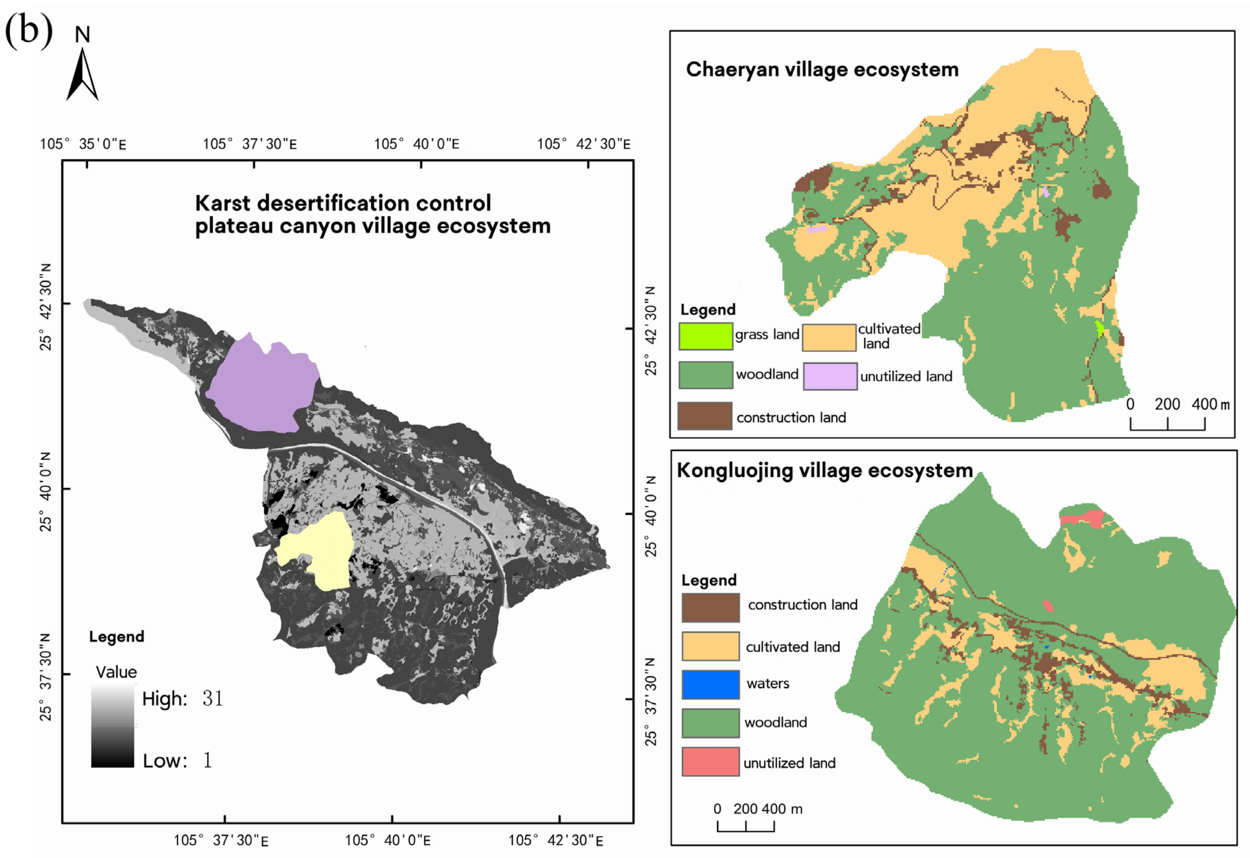
Among them, $D$ is the economic value of the food production service function provided by the farmland ecosystem per unit area, $i$ is the type, $pi$ is the national average price of crops, $qi$ is the yield per unit area of $i$ food crops, $mi$ is the area of $i$ food crops, and $M$ is the total area of $n$ food crops.

The economic value of food for a standard equivalence factor in Bijie, Qingzhen, and Anshun was calculated to be 1473.35 yuan/$hm^2$, 1204.93 yuan/$hm^2$, and 881.78 yuan/$hm^2$, respectively. By multiplying it with the corrected equivalence factor table of village ecosystems in Bijie, Qingzhen, and Anshun, respectively, the coefficient of the value of eco-products was obtained (Table 4), and the coefficients of value were put into the fishery network established.

$$GEP = \sum_{i=1}^{n}\frac{Si \times Qi}{10000} \tag{2}$$

Among them, $GEP$ is the total value of eco-product value (yuan), $Si$ is the area of each fishing net land use ($hm^2$), $Qi$ is the eco-product value coefficient of each land use type, $i$ = 1,2,3,4,5,6 represent cultivated land, forest land, grassland, water area, unused land, and construction land, respectively, and 10000 is the unit conversion coefficient.


(a)
N
Karst desertification control
plateau mountain village ecosystem
Legend
Value
High : 24
Low : 1
Luoshuidong villge ecosystem
legend
grass land
waters
cultivated land
woodland
unutilized land
construction land
0 400 m
Shijiayakou villge ecosystem
legend
construction land
cultivated land
woodland
0 400 m


(b)
N
Karst desertification control
plateau canyon village ecosystem
Legend
Value
High: 31
Low: 1
Chaeryan village ecosystem
Legend
grass land
cultivated land
woodland
unutilized land
construction land
0 200 400 m
Kongluojing village ecosystem
Legend
construction land
cultivated land
waters
woodland
unutilized land
0 200 400 m

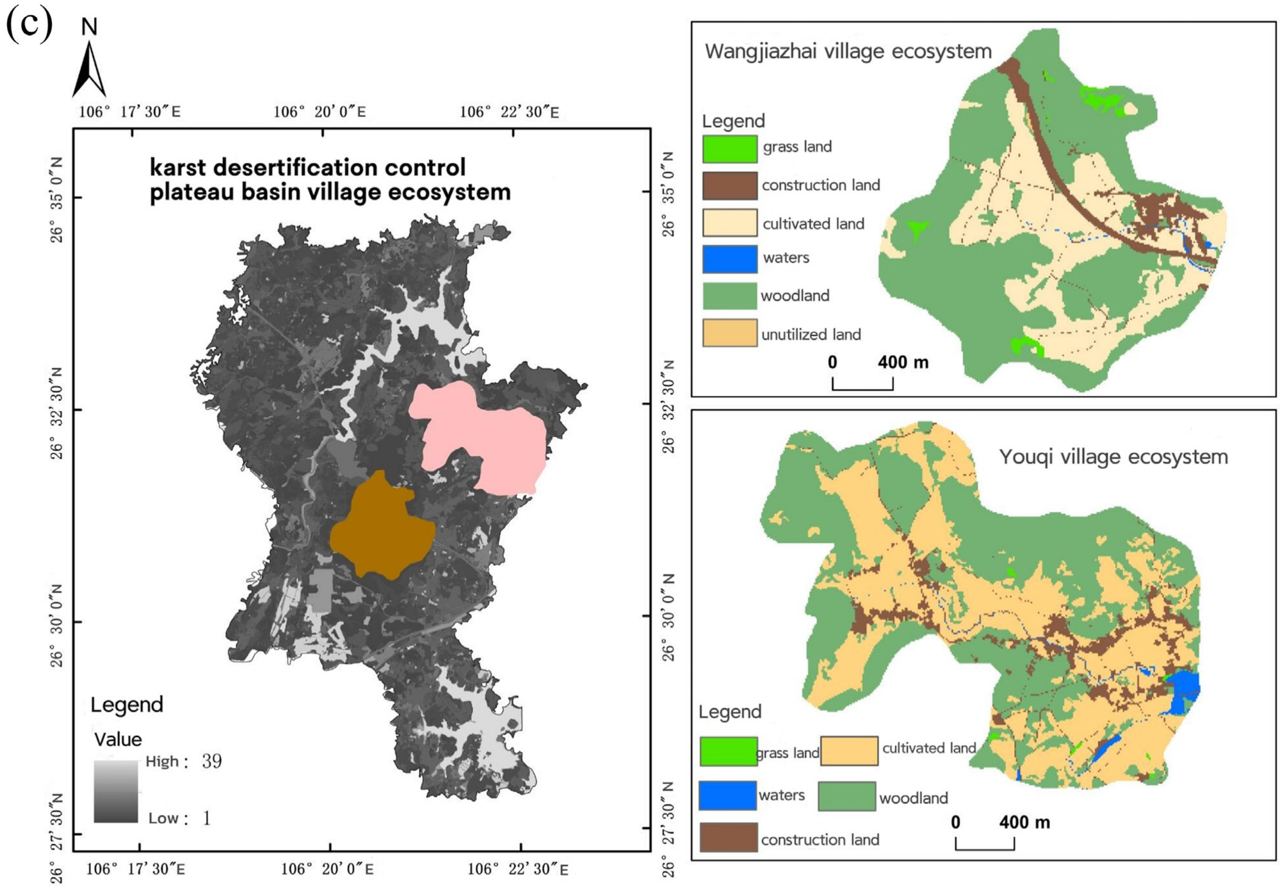



Fig. 2. (a) Salaxi potential-mild KDC village ecosystem, (b) Qingzhen mild-moderate KDC village ecosystem, (c) Huajiang moderate-intensity KDC village ecosystem.

Table 2. Data source and date of access.

| Data Type | Data Name | Data Sources | Date of visit |
|---|---|---|---|
| Land use | Land use data | http://www.gscloud.cn/ | Accessed on 12 April 2024 |
| Socio-economic data | National compendium of cost-benefit information on agricultural products | https://www.stats.gov.cn/ | Accessed on 20 April 2024 |
| | Statistical yearbook | https://www.anshun.gov.cn/ksh/tjnj/ , https://www.bijie.gov.cn/bm/bjstjj/zwgk/tjsj/tjnj/ , https://www.guiyang.gov.cn/ztzlsjtj/ztzlsjtjtjnj/ | Accessed on 22 April 2024 |
| | Statistical bulletin on national economic and social development | https://www.guiyang.gov.cn/zwgk/zfxxgks/fdzdgknr/tjxx/tjgb/https://www.gzqz.gov.cn/zwgk/zfxxgkzl/fdzdgknr/tjxx/, https://www.bijie.gov.cn/zwgk/zfsj/tjxx/tjgb/, https://www.anshun.gov.cn/ksh/tjgb/, http://www.guanling.gov.cn/web2022/zwgk/zdlyxxgk/jjgzlfz/sjtj/index.html, https://www.bjqixingguan.gov.cn/zfxxgk/fdzdgknr/tjxx_5620533/tjgb_5620535/ | Accessed on 26 April 2024 |

Table 3. Correction of Xie G. equivalent factor table for different grades of the villages in KDC.

| Name of study area | Ecological system classification | | | Supply services | | | Regulating services | | | | Cultural services | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | First classification | | Secondary classification | Food production | Production of material | Supply of water resources | Gas conditioning | Climate control | Clean-up operation | Hydrological regulation | Soil conservation | Esthetic landscape |
| Potential-mild KDC village ecosystem | SJYK | Cultivated land | Dry land | 0.85 | 0.40 | 0.02 | 0.67 | 0.36 | 0.10 | 0.27 | 1.03 | 0.06 |
| | | Forest land | Broad-leaved / shrubs | 0.24 | 0.55 | 0.28 | 1.79 | 5.37 | 1.61 | 4.05 | 2.19 | 0.88 |
| | | Grassland | Shrub grass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Waters | Water system | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Unused land | Bare ground | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LSD | Cultivated land | Dry land | 0.85 | 0.40 | 0.02 | 0.67 | 0.36 | 0.10 | 0.27 | 1.03 | 0.06 |
| | | Forest land | Broad-leaved / shrubs | 0.24 | 0.55 | 0.28 | 1.79 | 5.37 | 1.61 | 4.05 | 2.19 | 0.88 |
| | | Grassland | Shrub grass | 0.38 | 0.56 | 0.31 | 1.97 | 5.21 | 1.72 | 3.82 | 2.40 | 0.96 |
| | | Waters | Water system | 0.80 | 0.23 | 8.29 | 0.77 | 2.29 | 5.55 | 102.24 | 0.93 | 1.89 |
| | | Unused land | Bare ground | 0 | 0 | 0 | 0.02 | 0 | 0.10 | 0.03 | 0.02 | 0.01 |
| Mild-moderate KDC village ecosystem | YQ | Cultivated land | Paddy / drylands | 1.11 | 0.25 | -1.31 | 0.89 | 0.47 | 0.14 | 1.5 | 0.52 | 0.08 |
| | | Forest land | Broad-leaved / shrubs | 0.24 | 0.55 | 0.28 | 1.79 | 5.37 | 1.61 | 4.05 | 2.19 | 0.88 |
| | | Grassland | Shrub grass | 0.38 | 0.56 | 0.31 | 1.97 | 5.21 | 1.72 | 3.82 | 2.40 | 0.96 |
| | | Waters | Water system | 0.80 | 0.23 | 8.29 | 0.77 | 2.29 | 5.55 | 102.24 | 0.93 | 1.89 |
| | | Unused land | Bare ground | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | WJZ | Cultivated Land | Paddy / drylands | 1.53 | 0.45 | -1.3 | 1.23 | 0.65 | 0.19 | 1.63 | 1.04 | 0.11 |
| | | Forest land | Broad-leaved / shrubs | 0.39 | 0.88 | 0.45 | 2.88 | 8.62 | 2.57 | 6.42 | 3.51 | 1.41 |
| | | Grassland | Shrub grass | 0.38 | 0.56 | 0.31 | 1.97 | 5.21 | 1.72 | 3.82 | 2.40 | 0.96 |
| | | Waters | Water system | 0.80 | 0.23 | 8.29 | 0.77 | 2.29 | 5.55 | 102.24 | 0.93 | 1.89 |
| | | Unused land | Bare ground | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.10 | 0.03 | 0.02 | 0.01 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moderate-intensity KDC village ecosystem | CEY | Cultivated land | Dry land | 0.85 | 0.40 | 0.02 | 0.67 | 0.36 | 0.10 | 0.27 | 1.03 | 0.06 |
| | | Forest land | Broad-leaved / shrubs | 0.24 | 0.55 | 0.28 | 1.79 | 5.37 | 1.61 | 4.05 | 2.19 | 0.88 |
| | | Grassland | Shrub grass | 0.38 | 0.56 | 0.31 | 1.97 | 5.21 | 1.72 | 3.82 | 2.40 | 0.96 |
| | | Unused land | Bare ground | 0 | 0 | 0 | 0.02 | 0 | 0.10 | 0.03 | 0.02 | 0.01 |
| | KLJ | Cultivated land | Dry land | 0.85 | 0.40 | 0.02 | 0.67 | 0.36 | 0.10 | 0.27 | 1.03 | 0.06 |
| | | Forest land | Broad-leaved / shrubs | 0.24 | 0.55 | 0.28 | 1.79 | 5.37 | 1.61 | 4.05 | 2.19 | 0.88 |
| | | Waters | Shrub grass | 0.80 | 0.23 | 8.29 | 0.77 | 2.29 | 5.5`5 | 102.24 | 0.93 | 1.89 |
| | | Unused land | Bare ground | 0 | 0 | 0 | 0.02 | 0 | 0.10 | 0.03 | 0.02 | 0.01 |

## Results and Discussion

### The Value of Eco-Products in Villages with Varying Degrees of KDC

With regard to the various grades of KD, the total eco-product value of village ecosystems in potential-mild KDC areas was 1781.06 million yuan, while in light-moderate KDC areas, it was 1349.75 million yuan, and in moderate-intensity KDC areas, it was 883.16 million yuan. The eco-product value of village ecosystems in the three study areas was found to be highest in the villages designated for treatment of light KD, followed by those designated for treatment of light-moderate KD, and lowest in those designated for treatment of moderate-intensity KD. This indicates a negative correlation between the eco-product value and the grade of KD, whereby the higher the grade of KD, the lower the value of eco-products (Fig. 3). The land use types that have the greatest impact on the eco-product value of different KD grades are mainly forest land, arable land, and water. The low value of eco-products in Huajiang can be attributed to a number of factors, including the limited arable land area, low vegetation cover, and low eco-product yield. The village land-use areas are presented in Table 5.

The eco-product value of the potential-slight KD treatment villages in Bijie is estimated at 1781.06 million yuan, comprising 867.94 million yuan for SJYK and 913.13 million yuan for LSD. The eco-product value of Qingzhen's mildly-moderate KD treatment villages is 1349.75 million yuan, including 627.75 million yuan for YQ and 721.99 million yuan for WJZ. Additionally, the eco-product value of Zhenfeng Huahua River's moderate-intensity KDC village is 883.16 million yuan. The eco-product value of the ecosystem of CEY is 285.43 million yuan, while that of KLJ is 597.72 million yuan (Fig. 3). The findings indicate that the value of eco-products in villages undergoing KDC is inversely correlated with the extent of KD. This is largely attributed to the prevailing ecological conditions in these regions, which are characterized by poor biological growth and a restricted output and quality of eco-products. Additionally, the low vegetation cover in these areas impairs the regulating service function of eco-products.

### Value of Eco-Products of Different Service Types

From the perspective of the different ecosystem service types, the value of the eco-products was ranked as follows: regulating services > supplying services > cultural services. The value of eco-products from regulating services, material supply services, and cultural services was found to be in the following order: Bijie (1545.94 million yuan, 147.84 million yuan, and 87.28 million yuan) > Qingzhen (1202.56 million yuan, 86.45 million yuan, and 60.74 million yuan) > Anshun (771.18 million yuan, 68.01 million yuan, and 43.96

Table 4. Product value coefficient of land use type in different grades of the villages in KDC.

| Name of study area | | Cultivated land | Forest land | Grassland | Waters | Unused land |
|---|---|---|---|---|---|---|
| Qingzhen potential-mild KDC village ecosystem | YQ | 4818.81 | 22505.52 | 23037.25 | 163494.05 | — |
| | WJZ | 7317.95 | 36024.79 | 23037.25 | 163494.05 | 239.28 |
| Bijie mild-moderate KDC village ecosystem | SJYK | 5586.86 | 25155.71 | — | — | — |
| | LSD | 5586.86 | 25155.71 | 25750.06 | 182746.66 | 267.46 |
| Huajiang medium-intensity KDC village ecosystem | CEY | 4712.67 | 21219.55 | 21720.9 | — | 225.61 |
| | KLJ | 4712.67 | 21219.55 | — | 154151.98 | 225.61 |

million yuan) (Table 6). The ranking of the high and low values of eco-products of various types of regulating services differed between locations (Fig. 4). The values of eco-products in different KD areas were dominated by material supply products and regulating services. The village ecosystems provided abundant food resources for the residents and made significant contributions to regulating temperature and precipitation in the villages. However, the low vegetation coverage, exposed bedrock, and lack of surface water in the KDC villages result in an esthetic landscape value that is below average. Furthermore, the slow economic development of the villages, the imperfect infrastructure development, and the lack of service consciousness of the villagers contribute to the fact that their tourism value has yet to be developed; the value of their cultural services is low.

Among the various types of ecosystem services in Bijie potential-slight KDC of SJYK, the value of eco-products was ranked as regulating services (749.55 million yuan, 86.36%) > material provisioning services (76.37 million yuan, 8.8%) > cultural services (42.03 million yuan, 4.84%), and the value of eco-products of regulating services was highest among the regulating services, which was 257.53 million yuan, accounting for 34.36% of the regulating services. The value of eco-products in LSD is in the order of regulating services (7.9639 million yuan, 87.22%) > material supply services (71.48 million yuan, 7.83%) > cultural services (45.26 million yuan, 4.96%); among the regulating services, climate regulation is the highest, with 277.08 million yuan, accounting for 34.79% of the regulating services. The only three eco-products with a value of more than 100 million yuan are climate regulation, hydrological regulation, and soil conservation, of which the highest is climate regulation, indicating the importance of ecological environmental protection in regulating the microclimate of village ecosystems. The value of eco-products of forest land is much higher than that of other land-use types, mainly because forest land has a large land-use area and provides a large physical volume of material products and regulating services, which provides high economic value and ecological and environmental benefits for villages.

Among the various types of ecosystem services in Qingzhen mild-moderate KDC YQ, the value of eco-products was ranked as regulating services (565.27 million yuan, 90.05%) > material provisioning services (36.38 million yuan, 5.79%) > cultural services (26.11 million yuan, 4.16%); hydrological regulating services had the highest value of regulating services at 224.39 million yuan, which accounted for regulating services of 39.7%, and purification of the environment was the lowest. In the ecosystem services of the WJZ category, the value of eco-products was ranked as regulating services (637.28 million yuan, 88.27%) > material provisioning services (50.08 million yuan, 6.94%) > cultural services (34.63 million yuan, 4.8%); the value of eco-products of climatic regulation was the highest among the regulating services at 210.83 million yuan, which accounted for 33.08% of the regulating services. The value of eco-products for climate regulation is the highest, accounting for 33.08% of regulation services. Only climate regulation and hydrological regulation have an eco-product value of more than 100 million

Table 5. Village land use area ($hm^2$).

| | Village name | Farmland | Woodland | Grassland | Waters | Unused land | Total |
|---|---|---|---|---|---|---|---|
| Bijie | SJYK | 142.94 | 316.21 | 0 | 0 | 0 | 468.89 |
| | LSD | 112.33 | 420.61 | 0.38 | 0.23 | 0.54 | 545.3 |
| Qingzhen | YQ | 200.5 | 214.64 | 1.09 | 6.75 | 0 | 458.3 |
| | WJZ | 105.7 | 191.79 | 5.18 | 1 | 0.24 | 328.89 |
| Huajiang | CEY | 76.35 | 173.95 | 0.26 | 0 | 0.44 | 265.18 |
| | KLJ | 60.06 | 385.79 | 0 | 0.17 | 2.7 | 470.9 |

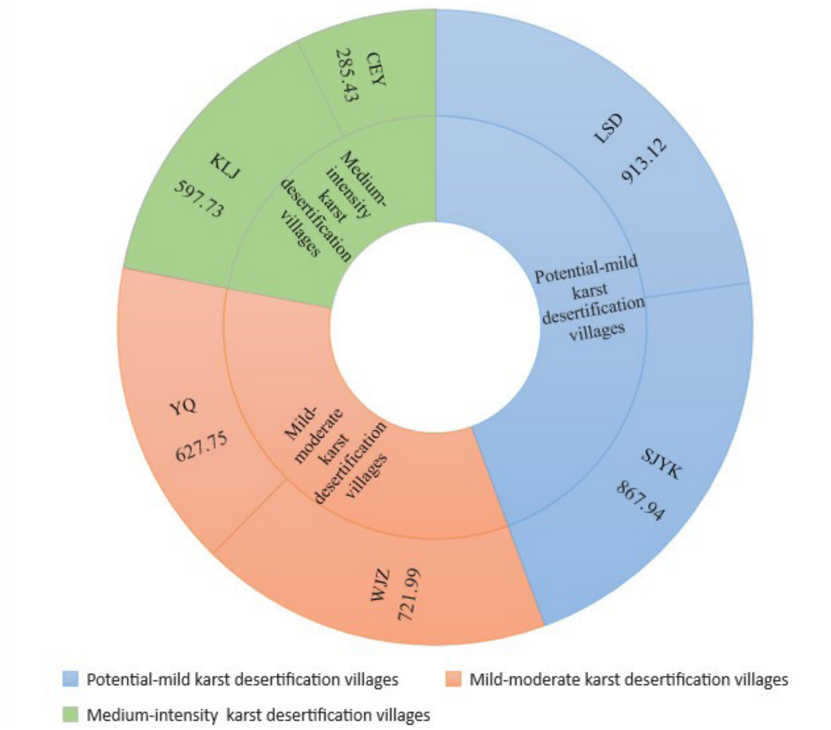



Fig. 3. The value of eco-products in different levels of the villages in KDC.

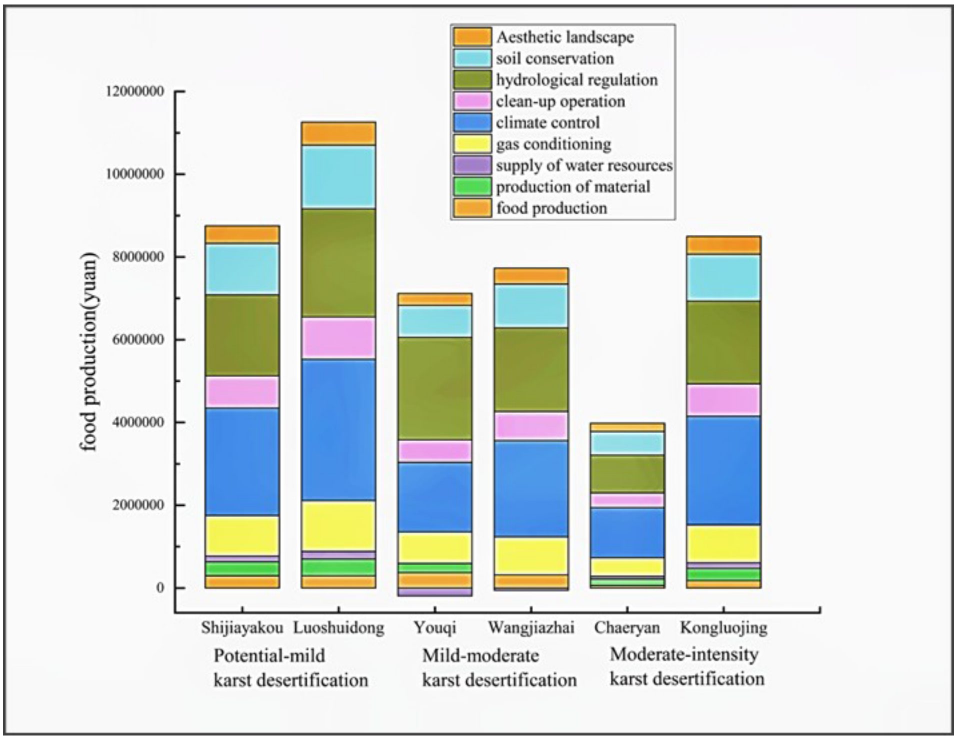



Fig. 4. The value of ecosystem services and eco-products.

yuan, and the higher water consumption of cultivated land leads to a negative eco-product value of water resource supply. The value of eco-products of forest land is much higher than that of other land use types, mainly due to the high value of water supply and regulation services provided by forest land, which provides villages with abundant forest resources and better ecological and environmental benefits.

Among the various types of ecosystem services in Huajiang moderate-intensity KDC CEY, the value of

Table. 6. The value of eco-products of different ecosystem services (yuan).

| | Village name | Supply service | Adjustment service | Cultural service | Total |
|---|---|---|---|---|---|
| Bijie | SJYK | 763637.99 | 7495464.21 | 420290.5 | 8679392.68 |
| | LSD | 714794.23 | 7963892.04 | 452543.7 | 9131229.98 |
| | Total | 1478432.22 | 15459356.25 | 872834.19 | 17810622.66 |
| Qingzhen | YQ | 363752.77 | 5652713.52 | 261052.2 | 6277518.51 |
| | WJZ | 500780.53 | 6372831.68 | 346326.1 | 7219938.27 |
| | Total | 864533.3 | 12025545.2 | 607378.3 | 13497456.78 |
| Huajiang | CEY | 249171.75 | 2466658.52 | 138491.5 | 2854321.73 |
| | KLJ | 430949.48 | 5245177.75 | 301143.8 | 5977270.99 |
| | Total | 680121.23 | 7711836.27 | 439635.2 | 8831592.72 |

eco-products was ranked as regulating services (246.67 million yuan, 86.42%) > material provisioning services (24.92 million yuan, 8.73%) > cultural services (13.85 million yuan, 4.85%); the value of eco-products of climate regulation among the regulating services was the highest at 84.84 million yuan, accounting for 34.4% of regulating services, and purifying the environment is the lowest. The value of eco-products in the village of KLJ is in the order of regulating services (524.51 million yuan, 87.75%) > material supply services (43.1 million yuan, 7.21%) > cultural services (29.8 million yuan, 5.04%); the value of eco-products of climate regulation in regulating services is the highest at 184.45 million yuan, accounting for 35.17% of the regulating services, and purifying the environment is the lowest. The value of eco-products above 100 million yuan is only the climate regulation and hydrological regulation of KLJ, and the area of woodland in CEY is only half of that of KLJ, which is an important contributor to the value of eco-products, and therefore the value of eco-products produced by it is low. The value of products from forest land is much higher than other land use types, mainly because of the high value of raw material production and regulation services provided by forest land, which provides villages with abundant forest products and improves the local ecological environment.

## The Value of Eco-Products of Different Land Use Types

In terms of different land uses, forest land has the highest contribution to the value of eco-products of village ecosystems in the three study areas, accounting for at least 60% of the total value of eco-products in each area, followed by arable land. This is mainly because forest land and arable land are not only larger in area but are also the most important source of living and production resources for villagers. In addition to land use types not found in village ecosystems, land use types such as grasslands and watersheds all provide lower values of eco-products, accounting for less than 1%, due to their smaller areas. The value of eco-products from unused land is the lowest (Fig. 5). In general, the eco-product values of the village ecosystems in Bijie are, in descending order: forest land > arable land > water > grassland > unused land; the village ecosystems in Qingzhen are, in descending order: forest land > arable land > grassland > water > unused land; the village ecosystems in Huajiang are, in descending order: forest land > arable land > water > grassland > unused land.

The eco-product value of the ecosystem in Bijie potential-slight KDC SJYK is the highest in forest land, amounting to 788.75 million yuan. This is followed by arable land, which has an estimated value of approximately 79.19 million yuan. This discrepancy can be attributed to the fact that forest land occupies a significantly larger area than arable land. Furthermore, the area of forest land (67%) is approximately twice that of arable land (33%), and the value of water resource provisioning and regulating services provided by forest land is also significantly larger than that of arable land. The highest eco-product value of the ecosystem in LSD was observed for forest land, which reached 858.02 million yuan, followed by arable land, with an estimated value of approximately 50.89 million yuan. In contrast, the lowest value was found for unused land, with an estimated value of only 117.12 yuan. Although the land area of unused land is larger than watersheds and grasslands, it does not provide material products, and its environmental benefits are low. Consequently, its eco-product value is considerably lower than that of grasslands and watersheds.

The eco-product value of forest land in the YQ of Qingzhen's mild-moderate KDC is the highest, at 437.85 million yuan, accounting for 69.75% of the total value, followed by watersheds at about 100.03 million yuan, accounting for 15.93%, cultivated land at 87.59 million yuan (13.95%), and grassland at the lowest, at only 2.28 million yuan (0.36%). The area of watersheds is much smaller than that of cultivated land, but the value of eco-products is higher than that of cultivated land, mainly because the value of the water supply of cultivated land

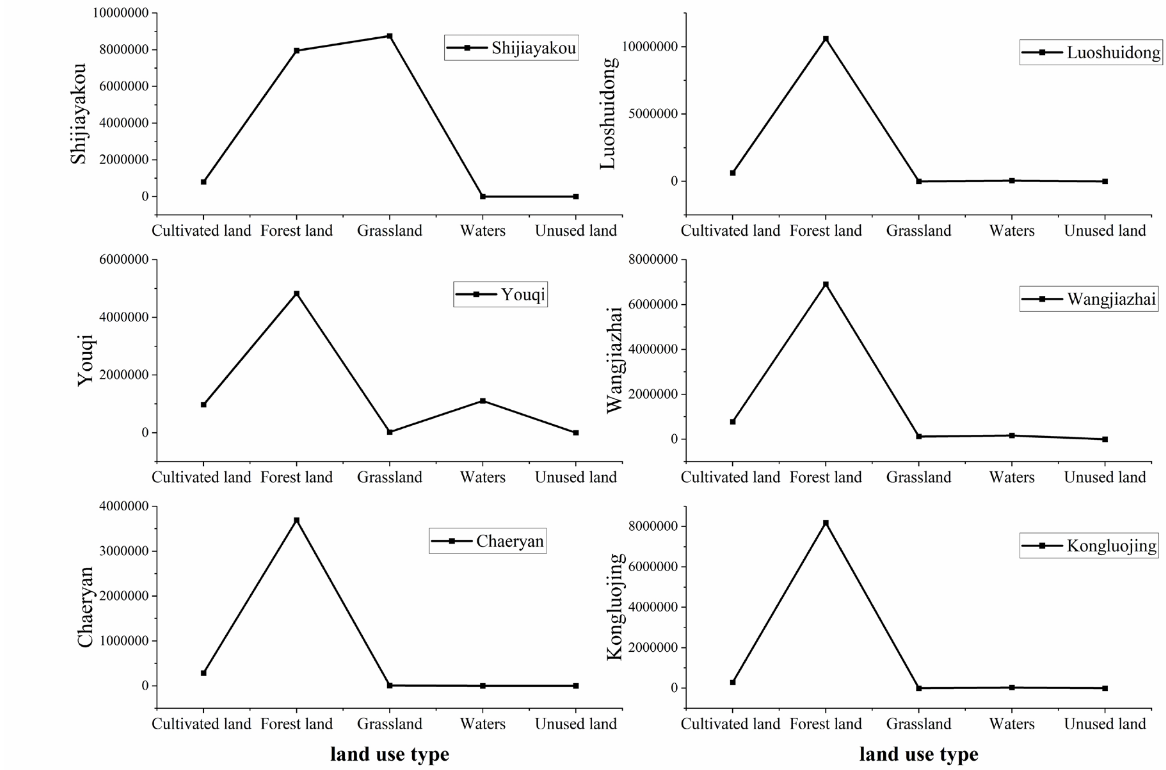



Fig. 5. The value of ecosystem services and eco-products of different grades of the villages in KDC.

is negative, and the value of the regulating services of watersheds is also higher than that of cultivated land. The eco-product value of forest land in WJZ was the highest at 626.26 million yuan, accounting for 86.74% of the total value, followed by arable land at 70.09 million yuan, accounting for 9.71%. The eco-product values of watersheds and meadows were less, at 14.82 million yuan (2.05%) and 10.82 million yuan (1.5%), respectively. The value of eco-products on unused land was the lowest, at only 52.05 yuan.

The eco-product value of the ecosystem of CEY in Huajiang moderate-intensity KDC is the highest in forest land, which is 259.71 million yuan, accounting for 90.99% of the total value, followed by cultivated land at 25.32 million yuan (8.87%), grassland at 0.4 million yuan (0.14%), and the least in unutilized land, which is only 96.84 yuan. The value of eco-products of forest land is 10 times higher than that of cultivated land. This is because the karst medium-intensity KD area has a low value of cultivated land due to the development of aboveground and belowground dichotomous structures and serious water and soil leakage, whereas the ecological regulating service value of forest land is higher, which widens the gap between the two. The eco-product t-value of forest land in KLJ is the highest, which is 575.93 million yuan, accounting for 96.35% of

Table 7. Value of eco-products from different land-use types (yuan).

| | Village name | Cultivated land | Forest land | Grassland | Waters | Unused land | Total |
|---|---|---|---|---|---|---|---|
| Bijie | SJYK | 791863.1 | 7887529.73 | 0 | 0 | 0 | 8679392.7 |
| | LSD | 508912.92 | 8580180.49 | 7934.91 | 117.12 | 9131229.98 | 9131229.98 |
| | Total | 1300776 | 16467710.22 | 7934.91 | 117.12 | 9131230 | 17810623 |
| Qingzhen | YQ | 875928.9 | 4378521.53 | 22760.66 | 1000307.32 | 0 | 6277518.49 |
| | WJZ | 700920.73 | 6262606.46 | 108165.36 | 148193.68 | 52.05 | 7219938.27 |
| | Total | 1576849.6 | 10641127.99 | 130926.02 | 1148501 | 52.05 | 13497457 |
| Huajiang | CEY | 253166.45 | 2597111.86 | 3973.57 | 0 | 69.84 | 2854321.7 |
| | KLJ | 199128.42 | 5759277.5 | 0 | 18436.51 | 428.54 | 5977271 |
| | Total | 452294.87 | 8356389.36 | 3973.57 | 18436.51 | 498.38 | 8831592.7 |

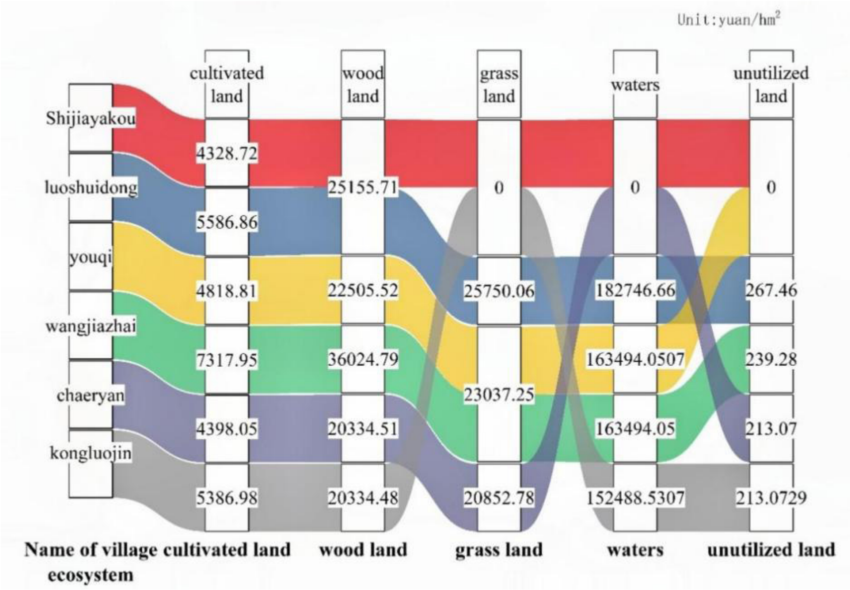



Fig. 6. The average density of the value of village eco-products (yuan/ha).

the total value. The total value of the rest of the land use types is less than 5%, and the area of forest land is six times more than that of the arable land, which is related to the serious KD in the locality and the small number of arable land resources. Due to serious soil erosion, land fragmentation, and low soil fertility, the value of its arable land is also low. (Table 7).

## Average Density of Eco-Products

With regard to the mean density of land per unit of eco-product t-value (land density) (Fig. 6), the highest land density was observed in the watershed, reaching 55.3 million yuan/ha, followed by 12.8 million yuan/ha in forest land, 18.64 million yuan/ha in grassland, 2.8 million yuan/ha in arable land, and the lowest land density was found in the unused land, at only 751 yuan/ha. In terms of ecosystem service types, the land mean density in all three study areas was found to be: regulating service > provisioning service > cultural service. Furthermore, the land mean density of regulating services was larger in terms of climate and hydrological regulation. The highest land density was observed in Qingzhen, at 3.75 million yuan/ha, followed by Salaxi with 3.52 million yuan/ha, and Huajiang with the lowest density of 2.41 million yuan/ha. The degree of KD in Qingzhen is greater than that observed in Salaxi. However, the land-averaged density of eco-product value is higher in Qingzhen, primarily due to the larger water area and the higher value of hydrological regulation.

### *Salaxi Potential-Mild KDC Area*

The highest land-averaged density of eco-product values in the potential-slight KD-treated villages in Salaxi was water (14.8 million yuan/ha), followed by forest land (4.5 million yuan/ha), grassland (2.1 million yuan/ha), cropland (1 million yuan/ha), and the unutilized land was only 216.9 yuan/ha. The magnitude of land-mean density among different ecosystem service types was as follows: regulating service (3.06 million yuan/ha) > provisioning service (0.29 million yuan/ha) > cultural service (0.17 million yuan/ha). The distribution of eco-product values within the SJYK and LSD ecosystems was found to be uneven (Fig. 7). Furthermore, a correlation was identified between the high and low eco-product values and the distribution characteristics of the land use types. The spatial distribution of eco-product values in SJYK is relatively uniform and concentrated in specific locations. The value of a single grid unit of forest land is within the range of 5234 to 6236 yuan, while the value of a single grid unit of water is within the range of 4305 to 5234 yuan. The value of the eco-products associated with a single grid unit of grassland is within the range of 3351 to 4305 yuan. The value of a single grid unit of cultivated land is within the range of 2279 to 3351 yuan. Finally, the value of a single grid unit of unused land is within the range of 157 to 2279 yuan. The distribution of high and low values in the falling water hole is characterized by a contiguous pattern. The value of one grid of forest land is within the range of 9328-15129 yuan, while the value of one grid of water is within the range of 6131-9328 yuan. The value of the eco-products of the grassland grid is within the range of 4178-6131 yuan, the value of cultivated land is within the range of 2698-4178 yuan, and the value of the unused land grid is within the range of 34-2698 yuan.

### *Hongfenghu Mild-Moderate KDC Area*

The highest land-averaged density of eco-product value in Qingzhen mild-moderate KDC villages was that of water, which was valued at 29.6 million yuan per

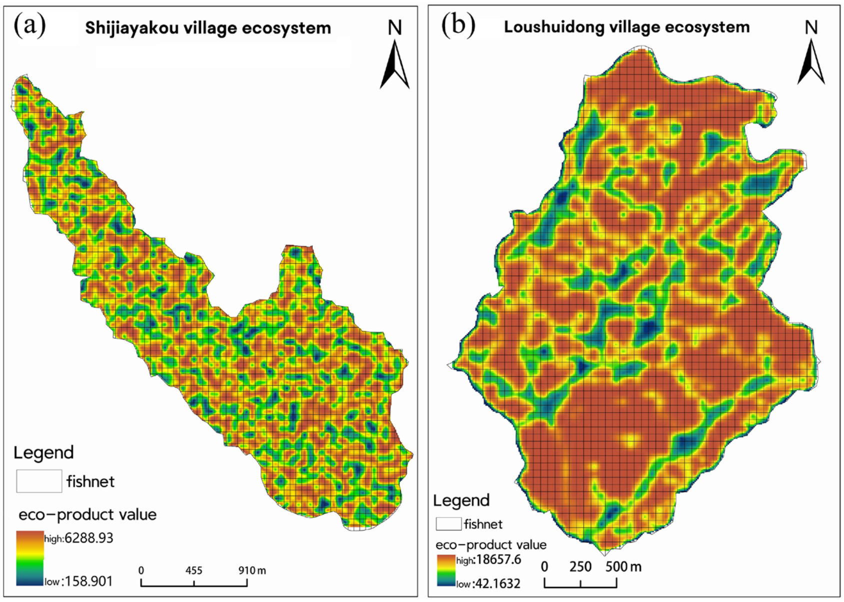



Fig. 7. Spatial distribution map of ecological product value of potential-mild karst desertification control villages in Bijie (a. Shijiayakou b. Luoshuidong).

hectare. This was followed by forest land, which was valued at 5.3 million yuan per hectare. The highest land-averaged density of eco-product value was observed in the grassland category, with an estimated value of 4.1 million yuan/ha. This was followed by arable land, with an estimated value of 1.1 million yuan/ha, and then by unutilized land, which had an estimated value of only 216 yuan/ha. The magnitude of land-mean density among different ecosystem service types was as follows: regulating services (3.3 million yuan/ha) > provisioning services (0.24 million yuan/ha) > cultural services (0.17 million yuan/ha). There is a notable discrepancy in the spatial distribution of the eco-product value of the ecosystems in YQ and WJZ (Fig. 8). A discernible correlation exists between the high and low eco-product value and the distribution characteristics of the land use types. When considered alongside the land use map presented in the preceding section, it becomes evident that the eco-product value of the forested land is considerable. The areas with a high value of eco-products in YQ are more dispersed, with a point-like distribution in the village's eastern, central, and southwestern areas. Conversely, the values of fishing grids in the southern and northwestern areas of YQ are lower. The value of one grid of forest land ranges from 18983 to 35300 yuan, while the value of one grid of water is approximately 11377 to 18983 yuan. The value of the grid of grassland's eco-products falls within the value of cultivated land, ranging from 2804 to 5984 yuan, while the value of unused land ranges from 38 to 2804 yuan. The distribution of eco-product values in WJZ is notably disparate, exhibiting a gradual transition from low to high values. The eastern and central regions are characterized by relatively low eco-product values,

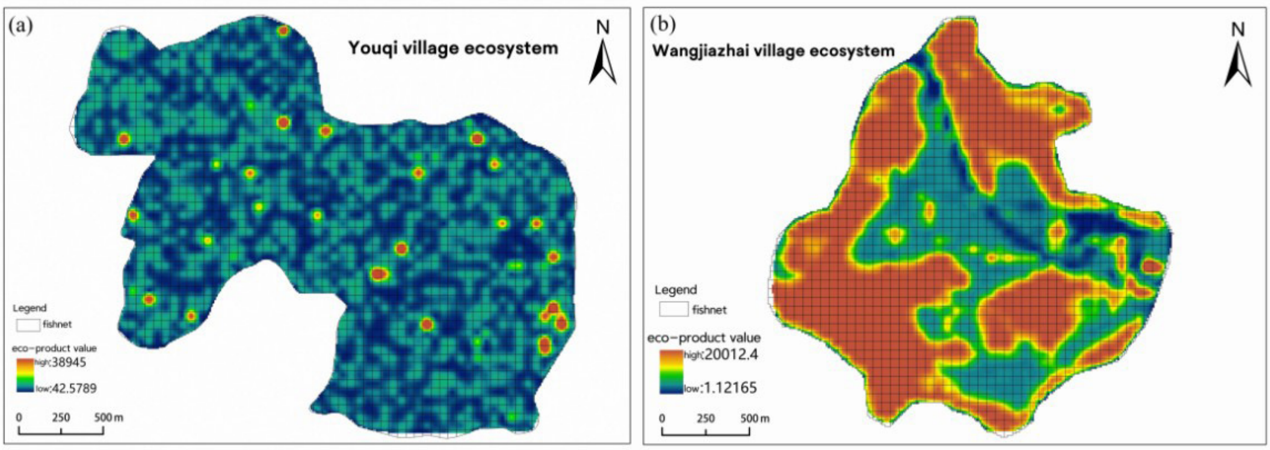



Fig. 8. Qingzhen mild-moderate karst desertification control village ecological product value spatial distribution map (a. Youqi b. Wangjiazhai).

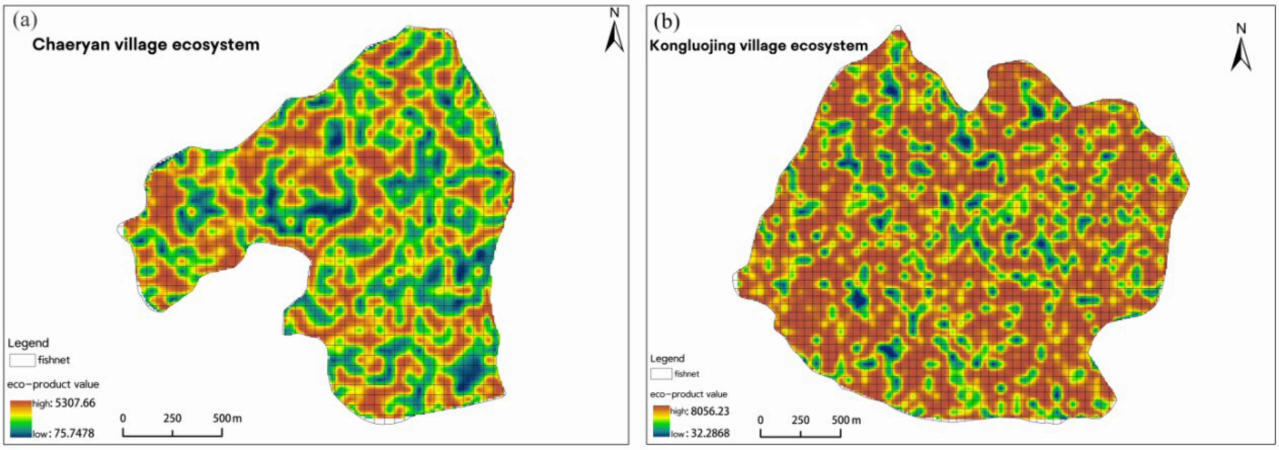



Fig. 9. Spatial distribution map of ecological product value of villages in Zhenfeng Huajiang moderate-to-strong karst desertification control village (a. Chaeryan b. Kongluojing).

while the western and northeastern regions display considerably higher values. The value of one grid of forest land ranges from 10457 to 18139 yuan, while the value of one grid of water is approximately 6892 to 10457 yuan; grassland grid eco-product values range from about 4695 to 6892 yuan, cropland from 2561 to 4695 yuan, and unused land grid values range from 1 to 2561 yuan.

*Huajiang Moderate-Intensity KDC Area*

The highest land-averaged density of eco-product value in Huajiang moderate-intensity KDC villages was grassland (12.4 million yuan/ha), followed by water (10.8 million yuan/ha), forest land (3 million yuan/ha), arable land (0.7 million yuan/ha), and unused land was only 317.5 yuan/ha. The size of the average density of land in different ecosystem service types was regulation service (21,000 yuan/ha) > provisioning service (0.19 million yuan/ha) > cultural service (0.12 million yuan/ha). The eco-product t-values in CEY and KLJ ecosystems were unevenly distributed in the spatial distribution (Fig. 9). The areas with a high value of eco-products in CEY were relatively contiguous and distributed in blocks across the villages, and the high and low value of fishing nets were distributed in a staggered manner. The high and low values of eco-products have a certain correlation with the distribution characteristics of land use types. Combined with the land use map in the previous section, the eco-product value of woodland is high; the value of 1 grid of woodland is in the range of 2500-3128 yuan, the value of 1 grid of water is in the range of 3128-3750 yuan, the value of eco-products of the grid of grassland is in the range of 1872-2500 yuan, the value of arable land is in the range of 1208-1872 yuan, and the value of the unused land grid is in the range of 53-1208 yuan. The boundaries between high and low eco-product values in KLJ are relatively obvious and are distributed in a point-like manner. The value of 1 grid of forest land is in the range of 3354-3750 yuan, the value of 1 grid of water is in the range of 2845-3354 yuan, the value of eco-products of the grassland grid is in the range of 2248-2854 yuan, the value of cultivated land is in the range of 1535-2248 yuan, and the value of the unutilized land grid is in the range of 22-1535 yuan.

## Discussion

In recent years, in the background of investing a large amount of capital and manpower, the management of KD has achieved certain results; the ecological environment of KD areas has been improved, and farmers have gotten rid of poverty [71]. The construction and development of many villages have been very rapid, and a series of village-characteristic eco-products and ecological industries have been developed, such as the rural low-carbon logistics industry [72], rural tourism [73], and village-characteristic eco-products. However, the identification and value realization of eco-products suffer from unclear identification and low utilization. The value accounting object of this study is small-scale villages, which distinguishes it from the large- and medium-scale regions that are the main focus of current value accounting and enriches the research on the value realization of eco-products. Differences in eco-product values of KDC villages are affected by many factors, and there are obvious differences between KDC villages of different levels with spatial heterogeneity. The value of eco-products in the three study areas is affected by various natural conditions such as local soil thickness, soil fertility, water status, topography, and geomorphology.

KD represents a significant ecological issue in karst regions. Accurately assessing and quantifying the value of eco-products affected by KD is crucial for effective management in these areas. This study evaluates the total value of eco-products in Bijie (potential-mild KD), Qingzhen (mild-moderate KD), and Huajiang (moderate-strong KD). The findings reveal key areas for

KDC within village ecosystems and highlight Guizhou Province's commitment to ecological civilization. The study also underscores the substantial benefits provided by the ecosystem and offers a data foundation for advancing the "two mountains" concept. This, in turn, supports the development of additional ecological civilization demonstration areas in KD regions. It was found that forest land was the most dominant land use type in the study area, providing a large number of forestry products and regulating service products. Saraxi had the lowest KD level, the highest vegetation cover, the largest area of forest land, and the value of eco-products of forest land was the highest among the three study areas. The eco-product value of water and cultivated land is highest in Qingzhen. In addition to its larger area, Qingzhen has a flat topography; soil and water resources lost from the surrounding mountains are pooled in the basin, and the land is in good fertility conditions; coupled with the higher level of production management technology in Qingzhen, the land output has a high density per land area, and the value of eco-products is high. Hua Jiang has the worst natural environment, with high KD levels, land fragmentation, serious soil erosion, low eco-product output, a low value of regulating services, and a low land average density. The accounting results show that the value of eco-products is inversely proportional to the KD grade; the higher the KD grade, the lower the value of eco-products. Based on the accounting results, the study provides an in-depth analysis of the value of village eco-products across different levels of KD and suggests strategies for realizing this value in various grades of KDC. This study proposes the following ways to realize the value of eco-products in villages with different levels of KDC:

*Potential-Mild KDC Villages*

Salaxi, as a potential-slight KDC area, has a relatively light degree of KD and a more continuous distribution of soil. However, the local community has traditionally relied on agricultural practices that have resulted in low land utilization, limited economic benefits, and a low output value of eco-products. These practices have primarily involved the cultivation of crops such as corn, potatoes, and vegetables. In recent years, the villagers of Saraxi have diversified their agricultural practices, planting crops such as roasted tobacco, walnut, prickly pear, plum, and other species characteristic of forestry. This has enabled them to retain water and soil through the use of vegetation while also increasing their economic income through the sale of forest products. Additionally, they have employed barren hills and fodder grain to develop cattle, sheep, and other livestock. Nevertheless, the village's economic development model remains at the stage of primary eco-product planting and harvesting, with a retail sales approach that lacks market competitiveness. Therefore, it is recommended that potential-light desertification management villages should fully use the advantages of the local natural environment, developing and implementing an integrated economic model based on local conditions. This could include the development of tourism, camping, forestry, an under-forest economy, and the promotion of activities such as under-forest chicken and bee breeding and ecological animal husbandry. In addition, it would be beneficial to improve the infrastructure and attract talented individuals who have left the area. Infrastructural improvements should be made, talented individuals should be encouraged to return, and the integrated development mode of "production-processing-sales" should be adopted gradually in order to extend the industrial chain, increase the added value of eco-products, reduce the damage to the land, and increase economic income.

*Mild-Moderate KDC Villages*

The terrain of Qingzhen belongs to the plateau basin and is relatively flat, but KD is more serious. The primary agricultural products are rice, corn, chili peppers, and vegetables. Secondary agricultural products include nurseries, grapes, watermelons, and flowers. Qingzhen is situated in close proximity to the provincial capital, Guiyang, and serves as a primary supplier of agricultural and ancillary products to the urban population. The villagers demonstrate a comprehensive understanding of eco-products and a pronounced awareness of environmental protection. Nevertheless, the low price and restricted distribution channels impede the realization of the intrinsic value of eco-products. To this end, the principle of 'rice is suitable for rice, and vegetables are suitable for vegetables' should be adhered to in order to develop "rice + fish", "nursery + tea", "Solidago decurrens Lour + Rosa roxbunghii", and other modes. This will fully exploit the advantages of the provincial capital city's "vegetable basket". Those areas experiencing mild-to-moderate KD should develop land use plans that align with the specific circumstances of the villages. This entails rational use of land resources, increasing crop growing with short growth cycles, high yields, and high economic value while reducing crops growing with long growth periods and high costs. Furthermore, the utilization of the Internet and other modern technologies should be maximized, emphasizing publicity and expanding sales channels. This will facilitate the increased production of eco-products and the creation of distinctive landmark products.

*Moderate-Intensity KDC Villages*

The Huajiang region is situated within a highland canyon area, characterized by a rugged landscape, significant KD, a fragmented land structure, shallow soil with low fertility, and a high incidence of soil erosion. The principal cash crops are dragon fruit, pepper, and loquat. The ecological environment in areas experiencing moderate-intensity KD is notably poor, frequently resulting in diminished crop yields. Consequently, it is imperative to enhance the resilience of the ecosystem, reinforce ecological protection and restoration, and augment the production capacity of eco-products through strategies such as afforestation and soil and water conservation. Furthermore, it is essential to adjust the industrial structure, invest in research and development of advanced green production technologies, and encourage enterprises to transition to environmentally conscious, low-carbon operations. This will facilitate industrial upgrading, capitalize on the distinctive local topography and landscape, and develop tertiary industries such as eco-tourism, thereby enhancing the village economy's capacity for sustainable development. Furthermore, enhancing public awareness of ecological protection and education on the subject will assist in increasing the market demand for eco-products.

## Conclusions

The value of eco-products in karst desertification control refers to the total worth of various products and services resulting from restoring and protecting ecological environments in karst desertification areas. This valuation process involves quantifying eco-products value in monetary terms using mathematical models, thereby making the ecosystem's benefits more tangible. Using the equivalent factor method for eco-product value accounting, this study assesses the value of eco-products in villages with varying levels of KDC in Guizhou Province and draws the following conclusions:

(1) Value comparison by area: The eco-product value across the three study areas is as follows: Salaxi potential-mild KDC villages (1781.06 million yuan) > Qingzhen mild-moderate KDC villages (1349.75 million yuan) > Huajiang moderate-intensity KDC villages (863.25 million yuan).

(2) Value by land use type: In terms of land use, forest ecosystems contribute the highest value to the village ecosystem, accounting for at least 60% of the total eco-product value in each region. This is followed by cultivated land, while unused land contributes the least.

(3) Value by ecosystem service type: The value of eco-products ranked by service type is as follows: regulation service > supply service > cultural service. Specifically, the values are: Bijie (1545.94 million yuan, 147.84 million yuan, 87.28 million yuan) > Qingzhen (1202.56 million yuan, 86.45 million yuan, 60.74 million yuan) > Anshun (758.32 million yuan, 61.29 million yuan, 43.65 million yuan).

(4) Average density of eco-product value: The average density of eco-product value per hectare for different land types, including water areas, forest land, grassland, cultivated land, and unused land, is 55.3 million yuan/ha, 12.8 million yuan/ha, 7.8 million yuan/ha, 2.8 million yuan/ha, and 751 yuan/ha, respectively.

In this study, the eco-product value of different levels of the villages in KDC was calculated, and the eco-product value and average density of different land use types were analyzed. The results were basically consistent with the actual situation of the village, which confirmed the scientific nature of the accounting methods and indicators. In the future, it can provide an information basis for KDC and village eco-product development. Due to the small scale of the village, the data collection has objective limitations, and the value of cultivated land and forest land eco-products has not been refined to the secondary classification. It is hoped that this will be further improved in future research. At present, accounting for the value of village eco-products still faces many difficulties and shortcomings. For example, only representative agricultural products are selected for material products, and the characteristic agricultural products in different regions, such as pepper and vegetables, are not considered. Cultural services only account for esthetic landscape indicators, and other cultural service functions are not fully considered. There are certain limitations. It is necessary to further improve the indicators of village eco-product value accounting in subsequent research. The basic data on the eco-products of the village are mainly derived from the relevant statistical yearbooks. There are still deficiencies in collecting multi-source spatio-temporal data and identifying spatial elements of eco-products. This paper only selects the cross-sectional data of 2022 to conduct a preliminary accounting of the value of eco-products in the study area. Therefore, how to quantitatively evaluate the value of village eco-products from the two dimensions of time and space is an important part of future research.

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## Conflict of Interest

The authors declare no conflict of interest.

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