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Spatial Pattern Dataset and Analysis of Land Use and Ecosystem Services in Yarkant River Basin (1978–2018)

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Abstract: Using Landsat images acquired in 1978, 1988, 1998, 2008, and 2018, we analyzed the land use and ecosystem services in the Yarkant River basin from 1978 to 2018. The results showed that: (1) Over the period 1978–2018, land use changed significantly. The area of cultivated land, forest land, and wetland increased by 338.9×10^3 hm^2, 8.23×10^3 hm^2, and 42.69×10^3 hm^2, respectively, while the area of grassland, water body, and unused land decreased by 59.2×103 hm^2, 103.21×103 hm^2, and 227.43×103 hm^2, respectively. (2) From 1978 to 2018, the value of ecosystem services in the Yarkant River basin exhibited a decreasing-increasing-decreasing trend, with an overall decrease. The total value of ecosystem services decreased from 425.86×10^8 Yuan in 1978 to 424.43×10^8 Yuan in 1988, then increased to 440.67×10^8 Yuan in 1998, before decreasing again to 417.00×10^8 Yuan in 2018. (3) The value of ecosystem services shows that the reduction in the value of regulatory functions outweighs the changes in the value of other functions, and the change in the value of regulatory services is synchronous and identical to the change in total ecosystem services. The ecosystem service function of the Yarkant River basin is essentially dominated by regulatory functions. (4) From 1978 to 2018, the sensitivity index of the ecosystem service value of each land type in the Yarkant River basin was less than 1, indicating that the value of ecosystem services in this region lacks elasticity. In conclusion, the land use changes in the Yarkant River basin coincide with socioeconomic construction activities in this region, providing some scientific basis and practical references for land use planning, ecological construction, and regional sustainable development.

Keywords: Yarkant River basin; land use/cover change (LUCC); ecosystem service value (ESV); sensitivity coefficient (CS)

1 Introduction

Land use/cover change (LUCC) is a hot topic in the field of global environmental changes and has a significant impact on the atmosphere, water, soil, biodiversity, and human activi-

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ties[1]. The study of LUCC enables the impact of land use changes on regional environmental variations to be assessed, and therefore provides scientific guidance for regional ecological construction and sustainable development[2]. LUCC influences the regional ecological process and causes changes in the soil, water, and atmosphere of the surrounding area[3]. Thus, LUCC studies not only identify the transformation of land use structures induced by human activities but also reflect the spatiotemporal dynamics of the regional landscape that result in structural and functional changes to ecosystems. Hence, studying the changes in regional ecosystem service value under the influences of LUCC is an important topic[4]. At present, the energy evaluation method, benefit conversion method, and valuation method are the main approaches for estimating the value of regional ecosystem services[5]. Of these, the valuation method is widely applied in calculating ecosystem service value, and the results are always converted into a monetary value. The valuation method is best suited to comparisons of different ecosystem service functions within a certain ecosystem but is also useful for comparing specific ecosystem service functions among diverse ecosystems[6]. The Tarim River is the longest inland river in China, and its upper reaches are made up of three headwaters: Aksu River, Hotan River, and Yarkant River[7]. Since 2001, the coordinated ecological protection and economic development of the Tarim River basin have seen the government invest significant funds (107×10^8 Yuan) in implementing an integrated management project for the Tarim River basin. Under this project, the ecological environment of the lower reaches of Tarim River has been improved to some extent, restoring the ecological corridor of this stretch of the river[8]. The Yarkant River is an important headwater of the Tarim River and is one of the main rivers in the Tarim Basin. In this study, based on remote sensing data collected in 1978, 1988, 1998, 2008, and 2018 from the Yarkant River basin, the influence of LUCC on the ecosystem service value is analyzed over the 41-year study period.

2 Metadata of the Dataset

This study examines the variations in the spatial structure of ecological land use and ecosystem service values in the Yarkant River basin from 1978 to 2018. The main metadata elements analyzed in this study[9] are presented in Table 1.

3 Research Area

The Yarkant River basin (35°50′N–40°31′N, 74°28′E–80°54′E) is located in the southwest of Xinjiang Uygur autonomous region (Figure 1)[11], at the western margin of the Tarim River basin. The Yarkant River basin enjoys rich light and heat resources. Because of the blocking effect of the Pamir Mountains, Karakoram Mountains, and

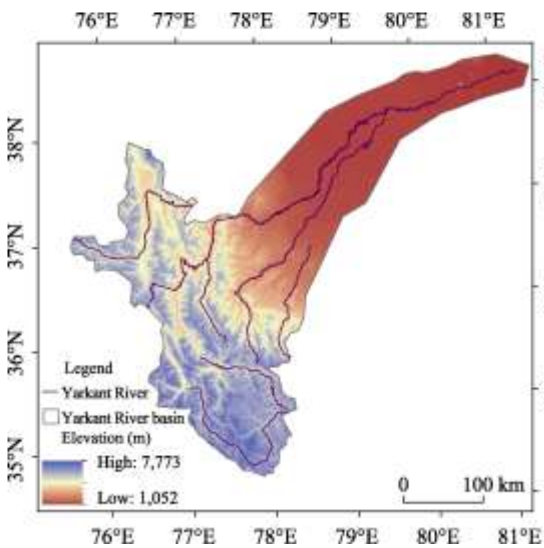

Figure 1 Topographic map of Yarkant River basin

southern Tianshan Mountains, the warm and moist air of the Atlantic and Indian oceans cannot reach the Yarkant River basin, resulting in perennial drought and dry conditions, with an average annual rainfall of only 30–60 mm and a typical continental climate[5]. The Yarkant River basin sees only a small annual temperature change but does have abundant solar-thermal resources. The average temperature range is 11.4–12.3 ℃ and the long frost-free period provides climatic conditions that are very helpful for regional agricultural production. The middle area of the Yarkant River basin is highly suited to the cultivation of long-staple cotton and melons as well as other fruits. Thus, this region is famous for cotton, dry fruits, and fruit production (walnuts, almonds, red jujube, and pomegranate)[12]. In the Yarkant

Table 1 Metadata summary of "Variation dataset of land use and its ecosystem service value in Yarkant River basin (1978–2018)"

Items	Description
Dataset full name	Variation dataset of land use and its ecosystem service value in Yarkant River basin (1978–2018)
Dataset short name	LU_EcoSerValue_Yarkant
Authors	Wang, J. P., Kashgar Satellite Data Receiving Station of Aerospace Information Research Institute, Chinese Academy of Sciences, wangjp@radi.ac.cn Mamat, A., Kashgar Satellite Data Receiving Station of Aerospace Information Research Institute, Chinese Academy of Science, ayinuer@radi.ac.cn Ma, Y. X., Key Laboratories of Digital Earth Sciences, Institute of Aerospace Information Research Institute, Chinese Academy of Sciences, mayx@radi.ac.cn
Geographical region	35°50'E–40°31′N, 74°28′E–80°54′E
Year	1978, 1988, 1998, 2008, 2018 Spatial resolution 30 m×30 m
Data format	.shp, Grid, .xlsx Data size 4.04 MB (after compression)
Data files	Dataset consists of two folders and one Excel file, mainly including the following: Folder 1 contains three sub-folders: (i) Research area .shp data, (ii) Yarkant River .shp data, (iii) Terrain data of the study area Folder 2 contains five remote sensing classified images showing the results for 1978 (MSS), 1988 (TM), 1998 (TM), 2008 (ETM+), and 2018 (OLI). These images were prepossessed using ENVI.5 and ArcGIS10.0 software and the land use types of the Yarkant River basin were divided into six land use types: cultivated land, forest land, grassland, water area, construction land, and unused land The Excel file contained five tables (Tables 3–7): Table 3 contains the ecosystem service equivalent values per unit area in the Yarkant River basin; Table 4 contains the values of ecosystem services per unit area in the Yarkant River basin; Table 5 contains the area ratios and change rates of different land use types in the Yarkant River basin, 1978–2018; Table 6 contains the ecosystem service values and their changes in the Yarkant River basin; Table 7 contains sensitivity coefficient changes of ESV for different land use types for 1978, 1988, 1998, 2008, and 2018 in the Yarkant River basin
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Data computing environment	ENVI 5.0 and ArcGIS10.0
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy include: (1) ***Data*** are openly available and can be freely downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten percent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be noted in suitable places in the new dataset[10]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

River basin, the pressures of economic development and ecological protection coexist. In the past few decades, with rapid regional changes in land use, the regional eco-environmental structure has changed dramatically. Therefore, the rational exploitation of natural resources and sustainable development of the eco-environment is essential in achieving societal goals. Understanding the current ecological and environmental changes has great significance in terms of coordinating the economic development, ecological protection, and sustainable development of this arid region.

4 Methods

4.1 Data Collection and Pre-possessing

The data used in this study include remote sensing data, topographic data (digital elevation model, DEM), and socioeconomic data. The remote sensing data were largely Landsat remote sensing data, such as the 1978 (MSS), 1988(TM), 1998 (TM), 2008 (ETM+), and 2018 (OLI) data obtained from the geospatial data cloud and data sharing website of the Institute of Aerospace Information Research Institute, Chinese Academy of Sciences. The remote sensing data analyzed in this study were collected from June to August because there are abundant water resources during this period and the natural vegetation cover flourishes in the Yarkant River basin. The DEM data are taken from the environmental data-sharing network of the Chinese Academy of Sciences. The socioeconomic data were mainly obtained from the "Xinjiang statistical yearbook" and "Kashgar statistical yearbook." In the process of image interpretation, this study adopts three-band combinations, 2, 3, and 4, and the geometric correction, registration, visual interpretation, and digital processing of remote sensing images for each period were carried out using ENVI.5 and ArcGIS10.0. According to China's current land use classification system, the Yarkant River basin land use types can be divided into six categories, namely cultivated land, forest land, grassland, waterbody, wetland, and unused land (Figure 2). An accuracy test indicated that the final classification was more than 80% correct, which satisfies the research requirements.

4.2 Analysis Method of Land Use/Cover Change

The land uses dynamic attitude (P) and land use total dynamic attitude (R) are key indicators in describing the rate of change of regional land use/cover. The land use dynamic attitude quantitatively reflects the spatial and temporal differences of land use changes[13], and is calculated as:

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

$$R = \frac{\sum_{k}^{n} \left(\frac{U_{bk} - U_{ak}}{U_{ak}} \right)}{T} \times 100\% \tag{2}$$

where P refers to the dynamic attitude of a certain land use type during the research period and R refers to the total dynamic attitude of regional land use change during the research period. k denotes the land use type, and U_a, U_b are the areas of a particular land use type during periods a and b. T is the study period.

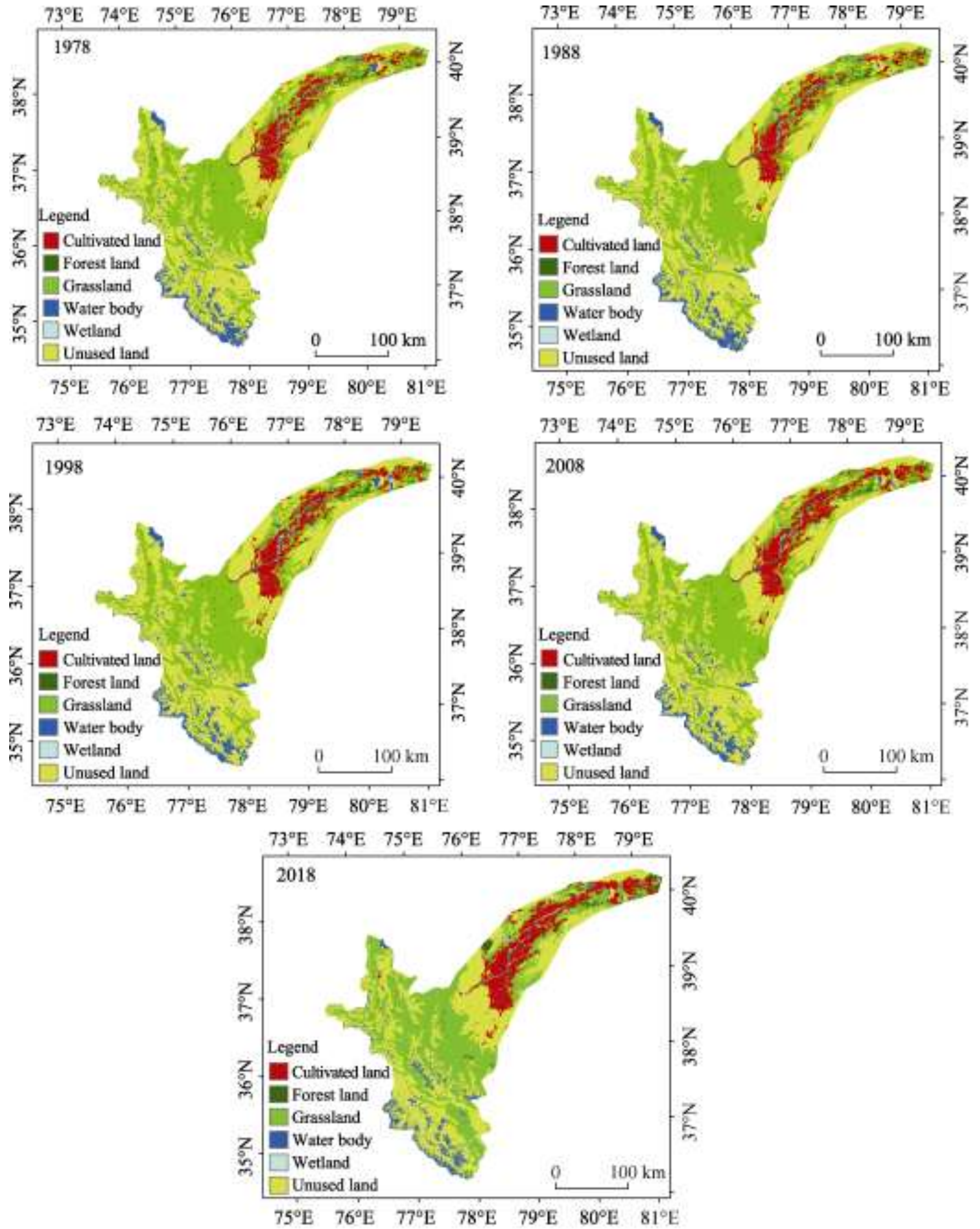

Figure 2 LUCC in the Yarkant River basin (1978–2018)

4.3 Evaluation of Ecosystem Service Value

4.3.1 Selection and Correction of Value Coefficient

The "World ecosystem service equivalent value"[14] and the "Chinese terrestrial ecosystem service equivalent value per unit area"[6, 15] are widely used to assess the ecosystem service value. The ecosystem equivalent value is calculated as follows[3] (Tables 2 and 3):

$$E_{ij} = e_{ij} E_a \tag{3}$$

where E_{ij} refers to the equivalent factor value of land use type *i* and ecological service function type *j*; e_{ij} refers to the correction coefficient of ecological service function type *j* for land use type *i*, and E_a refers to the ecosystem service equivalent value per unit area in China.

Table 2 Correction coefficients of different ecosystems in arid regions

Ecological system	Cultivated land	Forest land	Grassland	Water body	Wetland	Unused Land
Correction coefficient	0.37	0.422,2	0.333,4	0.61	0.69	0

Table 3 Ecosystem service equivalent value per unit area in Yarkant River basin

Service function		Cultivated land	Forest land	Grassland	Water body	Wetland	Unused land
Regulation Services	Gas regulation	0.19	1.48	0.27	0.00	1.24	0.00
	Climatic regulation	0.33	1.14	0.30	0.30	11.80	0.00
	Water regulation	0.22	1.35	0.27	13.54	10.70	0.03
	Waste treatment	0.61	1.64	0.44	11.82	12.54	0.01
Supporting Services	Soil formation	0.54	0.56	0.65	0.01	1.18	0.02
	Biodiversity protection	0.26	1.38	0.36	1.62	1.73	0.34
Production Services	Food production	0.37	0.05	0.10	0.06	0.21	0.01
	Raw material	0.04	1.10	0.02	0.01	0.05	0.00
Cultural Services	Recreation and culture	0.00	0.54	0.01	2.82	3.83	0.01
Total		2.56	9.24	2.42	30.17	43.27	0.42

4.3.2 Ecosystem Service Value Calculation

The total value of ecological services can be estimated using the valuation method and the ecosystem service equivalent value (Table 3). The ecosystem service value (ESV) is calculated as:

$$ESV = \sum_{i=1}^{n} S_i^V C_{kf} \tag{4}$$

where *ESV* refers to the total value of ecosystem services in the study area, S_i refers to the total area of land use type *i*, and VC_{kf} refers to the value coefficient of land use type *k* for ecological function *f*. VC_{kf} can be calculated as:

$$VC_{kf} = E_{ij}^V \tag{5}$$

where E_{ij} refers to the ecological service function equivalent value of revised land use *j* concerning original land use *i*, and *V* refers to the economic value of the food production service function per unit of the agri-ecosystem. *V* can be calculated according to:

$$V = \frac{1}{7} \sum_{i=1}^{n} \frac{m_i p_i q_i}{M} \tag{6}$$

where *n* is the crop type. The Yarkant River basin includes Yarkant County, Poskam County, Kargilik County, Makit County, and Maralbexi County. The main crops in these areas are wheat, rice, corn, padanmu, red dates, walnuts, and beans. P_i refers to the current price of grain crops (Yuan t^{-1}), *q* refers to the per unit area yield of grain type *i* (t hm^{-2}), and *m* refers to the area of grain crop *i* (hm^2). *M* denotes the total area of food crops (hm^2). According to the statistical yearbook, the average economic value of *V* in the study area for 1978, 1988, 1998, 2008, and 2018 is 1575.5 (Yuan hm^{-2} a^{-1}). Finally, using Equation (4), the ESV coefficients of the six land types in the Yarkant River basin can be calculated. The results are presented in Table 4.

Table 4 Value of ecosystem services per unit area in Yarkant River basin

Service function		Cultivated land	Forest land	Grassland	Water body	Wetland	Unused land
Regulation Services	Gas regulation	291.5	2,331.4	425.4	0.0	1,956.8	0.0
	Climatic regulation	518.8	1,798.9	472.7	468.5	18,589.3	0.0
	Water regulation	349.8	2,129.9	425.4	21,331.3	16,850.0	47.3
	Waste treatment	851.1	877.9	1,024.1	10.9	1,858.9	31.5
Supporting Services	Soil formation	956.0	2,590.5	693.2	18,618.6	19,763.4	15.8
	Biodiversity protection	413.9	2,173.1	567.2	2,549.3	2,717.7	535.7
Production Services	Food production	582.9	72.0	157.6	98.0	326.1	15.8
	Raw material	58.3	1,727.0	31.5	10.9	76.1	0.0
Cultural Services	Recreation and culture	5.8	849.1	15.8	4,444.9	6,033.4	15.8
Total		2.56	4,028.1	14,549.8	3,812.7	47,532.3	68,171.7

4.3.3 Sensitivity Analysis

The coefficient of sensitivity (CS) indicates the degree to which ESV depends on the value coefficient (VC) over time[16]. When CS<1, ESV is considered inelastic concerning the ecosystem VC. The greater the value of CS, the more critical the accuracy of the ecological VC when evaluating ESV. In this study, based on the ecological service value coefficients (Table 3), we calculated CS by Equation (7) by adjusting the ESV coefficients for each land use type by 50% and then calculating the corresponding change in ESV.

$$CS = \left| \frac{(ESV_j - ESV_i) / ESV_i}{(VC_{jk} - VC_{ik})} \right| \tag{7}$$

where *CS* refers to the sensitivity coefficient, *ESV* is the total ecological service value, VC_{ik} and VC_{jk} are the initial and adjusted value coefficients, respectively, and *k* is the land use type.

5 Data Results and Analysis

5.1 Dataset Composition

The dataset consists of two folders and one Excel file, as shown in Table 1. Folder 1 contains three sub-folders to describe the study area. Folder 2 contains five remote sensing classified images showing the results for 1978 (MSS), 1988 (TM), 1998 (TM), 2008 (ETM+), and 2018 (OLI). The Excel file contained five tables (Tables 3–7).

5.2 Results

5.2.1 Land Use/Cover Change

Changes in land use and land cover mainly occur in the oasis and desert ecotone areas of arid and semiarid regions. From the LUCC results for the Yarkant River basin, it is clear that very significant changes occurred during the study period (Table 5, Figure 2).

The Yarkant River basin has a total area of 7.46×10^6 hm^2, of which the largest proportion is unused land (44.71% in 1978, 45.05% in 1988, 44.47% in 1998, 44.45% in 2008, and 41.66% in 2018). The proportion of cultivated land has steadily increased (1.98% in 1978, 14.05% in 1988, 15.24% in 1998, 21.98% in 2008, and 63.51% in 2018). From 1978 to 2018, the total dynamic attitude of LUCC is 7.26%; from 1978 to 1988 it was 0.415%, from 1988 to 1998 it was 13.25%, from 1998 to 2008 it was 1.25%, and from 2008 to 2018 it was 10.82%.

Table 5 indicates that significant LUCC occurred in the study area over the 41 years considered here, especially after 2008, and the rate of change became significantly faster. From 1978 to 2018, the rate of increase in land use was most pronounced for wetland (249.13%), followed by cultivated land (63.51%), water body (20.35%), forest land (7.02%), unused land (6.82%), and grassland (2.01%). The proportion of cultivated land increased very obviously in this period, with an average annual increase of 8.5×10^3 hm^2. The other notable change in land use type concerns unused land, which decreased by 227.43×10^3 hm^2 during the 41 years. Moreover, the areas of a water body and grassland decreased by 103.2×10^3 hm^2 and 59.2×10^3 hm^2, respectively, while wetlands and woodland increased by 42.7×10^3 hm^2 and 8.2×10^3 hm^2, respectively.

Table 5 Area ratios and change rates of different land use types in Yarkant River basin (1978–2018) (%)

Land Use Type	1978	1988	1998	2008	2018	1988–1978	1998–1988	2008–1998	2018–2008	2018–1978
Cultivated land	7.15	7.30	8.32	9.59	11.70	0.20	1.41	1.52	2.20	1.59
Forest land	1.57	1.54	1.67	1.56	1.68	–0.23	0.89	–0.69	0.81	0.18
Grassland	39.53	39.11	38.22	37.49	38.74	–0.11	–0.23	–0.19	0.33	–0.05
Water body	6.80	6.80	6.85	6.51	5.42	0.00	0.08	–0.50	–1.68	–0.51
Wetland	0.23	0.22	0.47	0.41	0.80	–0.35	11.24	–1.40	9.79	6.23
Unused land	44.71	45.04	44.47	44.45	41.66	0.07	–0.13	0.00	–0.63	–0.17

5.2.2 Response of Ecological Service Value to Land Use Change

To estimate the ecological service value, the revised coefficients were applied to the corresponding formula and the ecosystem service value of the Yarkant River basin was calculated. The results are presented in Table 6. It can be seen that the total ecosystem services value of the Yarkant River basin has gradually decreased, although the whole process is not monotonic. From 1978 to 1988, the ecological service value decreased by 1.43×10^8 Yuan, before increasing from 1988 to 1998 by 16.24×10^8 Yuan and then decreasing again from 1998 to 2018 by 23.68×10^8 Yuan. Over the whole study period, there is a decreasing trend, resulting in a total ecosystem value loss of 8.87×10^8 Yuan. In 1978, 1988, 1998, 2008, and 2018, the production function of the study area was 41.55×10^8 Yuan, 41.12×10^8 Yuan, 45.39×10^8 Yuan, 44.19×10^8 Yuan, and 52.39×10^8 Yuan, respectively, and the value of the regulatory function was 346.47×10^8 Yuan, 345.57×10^8 Yuan, 355.54×10^8 Yuan, 342.99×10^8 Yuan, and 326.49×10^8 Yuan, respectively. The value of supporting functions was 12.25×10^8 Yuan, 12.21×10^8

Yuan, 12.84×10^8 Yuan, 13.14×10^8 Yuan, and 14.49×10^8 Yuan, respectively. The cultural functions had a value of 12.25×10^8 Yuan, 12.21×10^8 Yuan, 12.84×10^8 Yuan, 13.14×10^8 Yuan, and 14.49×10^8 Yuan, respectively.

Table 6 Ecosystem service value and its changes in Yarkant River basin

Service function		The total value of ecological services (10^8 Yuan)					Value change (10^8Yuan)				
		1978	1988	1998	2008	2018	1978–1988	1988–1998	1998–2008	2008–2018	1978–2018
Regulation services	Gas regulation	17.17	16.99	17.53	17.28	18.93	–0.18	0.54	–0.25	1.65	1.76
	Climatic regulation	24.38	24.13	27.86	26.91	33.46	–0.25	3.74	–0.95	6.54	9.08
	Water regulation	129.58	129.33	133.5	127.12	115.8	–0.25	4.13	–6.33	–11.37	–13.82
	Waste treatment	37.2	36.94	37.33	37.41	40.26	–0.26	0.39	0.08	2.85	3.06
Supporting services	Soil formation	126.94	126.63	131.6	126.15	119.2	–0.31	4.92	–5.4	–6.98	–7.77
	Biodiversity protection	52.75	52.67	53.2	52.31	51.3	–0.08	0.54	–0.89	–1.01	–1.44
Production services	Food production	8.92	8.93	9.34	9.76	10.81	0.01	0.41	0.42	1.05	1.89
	Raw material	3.33	3.28	3.5	3.38	3.68	–0.05	0.21	–0.12	0.3	0.34
Cultural services	Recreation and culture	25.6	25.54	26.9	25.4	23.63	–0.06	1.37	–1.5	–1.77	–1.97
	Total	425.86	424.43	440.7	425.72	417	–1.43	16.24	–14.95	–8.73	–8.87

5.2.3 Ecosystem Services Sensitivity Analysis

According to the sensitivity coefficients formula, the ecological value coefficients of various land use types were adjusted up or down by 50% and the sensitivity indexes were calculated for 1978, 1988, 1998, 2008, and 2018. The results are presented in Table 7.

Table 7 Sensitivity coefficient change of *ESV* for different land use types in 1978, 1988, 1998, 2008, and 2018 in Yarkant River basin

Value coefficient (VC ±50%)	1978(%)	CS	1988(%)	CS	1998(%)	CS	2008(%)	CS	2018(%)	CS
Cultivated land	2.524	0.05	2.582	0.052	2.837	0.057	3.384	0.068	4.214	0.084
Forest land	2.003	0.04	1.963	0.039	2.059	0.041	1.984	0.04	2.189	0.044
Grassland	13.201	0.264	13.105	0.262	12.333	0.247	12.524	0.25	13.211	0.264
Water body	28.309	0.566	28.402	0.568	27.562	0.551	27.11	0.542	23.029	0.461
Wetland	1.372	0.027	1.329	0.027	2.718	0.054	2.420	0.048	4.891	0.098
Unused land	2.591	0.052	2.619	0.052	2.491	0.050	2.577	0.052	2.466	0.049

The sensitivity coefficients of the six land use types in 1978, 1988, 1998, 2008, and 2018 varied from 0.027 to –0.568. These values are less than 1, indicating that ESV in the study area is inelastic for VC_{ik}, and the results are credible. Because water bodies and grassland have larger ecosystem service value coefficients, the sensitivity coefficients for these land use types are larger. Water bodies have the largest sensitivity coefficients (above 0.46 in all five periods), followed by grassland (above 0.247 in all five periods). Farmland, woodland, wetland, and unused land have similar sensitivity coefficients, all of which are below 0.01.

6 Discussion and Conclusion

In this study, based on the remote sensing image data from 1978, 1988, 1998, 2008, and 2018, the land use changes in the Yarkant River basin have been analyzed. The land use changes objectively reflect the relationship between human activities and the ecological environment.

In recent decades, the exploitation and utilization of water and soil resources in oasis areas have been rapidly increasing. Therefore, the fragile ecological environment has been placed under unprecedented pressure from human disturbances.

In terms of the interaction between land use changes and ecological services, the Yarkant River basin has experienced a large-scale expansion in cultivated land and a large-scale reduction in grassland and water bodies. At the same time, the structure of natural ecosystems has shifted from non-agricultural land to agricultural land, which is a significant characteristic of reduced ecosystem function. This situation indicates that there is a simultaneous development of oasis areas and enhanced desertification[17]. The ecological service's value of cultivated land gradually increased during these 41 years, but it failed to prevent the trend of the total ecosystem services value of the Yarkant River basin from decreasing. Cultivated land is converted from grassland, and the expansion of cultivated land does not contribute significantly to the ecosystem services value of Yarkant River Basin, which caused the value of natural capital in the area to continue decreasing[18].

The main findings of this study can be summarized as follows:

(1) From 1978 to 2018, the overall rate of LUCC in the Yarkant River basin was 7.26%. The change in land use over the 41-year period can be ordered as follows: wetland (249.13%) > cultivated land (63.51%) > water body (20.35%) > forest land (7.02%) > unused land (6.82%) > grassland (2.01%). Over the whole study period, the area of cultivated land increased rapidly, whereas water bodies, grassland, and unused land exhibited a continued decrease in area. This indicates ecological problems such as vegetation degradation and water area reduction in the Yarkant River basin.

(2) The estimated ecological service value of the Yarkant River basin in 1978, 1988, 1998, 2008, and 2018 was 425.86×10^8, 424.43×10^8, 440.67×10^8, 425.72×10^8, and 417.00×10^8 Yuan, respectively. From the relationship between changes in land use structure and ecological service value, the decreases in water bodies and grassland are the main reason for the decrease in ecological service value in the study area.

(3) The structure of ecosystem function services shows that the reduction in regulation services outweighs the changes in the value of other functions, and the change in regulation services is synchronized with the change in total ecological services. This shows that the ecosystem service function of the Yarkant River basin is dominated by the regulatory func-

tions.

(4) A sensitivity analysis showed that the sensitivity coefficients for all land use types were less than 1 and often close to 0, indicating that the estimated ESV of the study area is considerably inelastic concerning the value coefficients. This result is helpful in quantitatively analyzing the ecological effects of land use structure changes in the Yarkant River basin.

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