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Reconstruction Dataset of Cropland Change in Five Central Asian Countries over the Last Millennium

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Abstract: Reconstructing land use and cover change (LUCC) is an important task for global change research. As one of the important ways to use land, cropland is the focus for the reconstruction of historical land cover datasets. This study reconstructed the total cropland area of five Central Asian countries over the last millennium based on historical documents and used a gridded allocation algorithm to develop gridded cropland fraction data with a spatial resolution of 5′×5′. The main conclusions are as follows: (1) the change in cropland area in five Central Asian countries between 1000 A.D. and 2000 A.D. had three phases of "steady with fluctuations - growth - decline". (2) The cropland is mainly distributed in oases along rivers, with a tendency to expand outward over time. (3) After 1850 A.D., the increase in cropland area mainly occurred in the northern part of Kazakhstan. This dataset includes tables of total cropland area in five Central Asian countries for the last millennium archived in.xlsx data format and preserved 5′×5′ gridded cropland fractions of five Central Asian countries over the last millennium archived in.img data format with a data size of 8.61 MB (compressed into one single file with 422 KB).

Keywords: land use/cover change; cropland area; gridded allocation; five Central Asian countries

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The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.04.10.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.04.10.V1.

1 Introduction

Land use/cover change (LUCC) has affected natural terrestrial ecosystems and biodiversity as well as has altered the albedo and radiative forcing on the land surface, which consequently changed global biogeochemical cycles (carbon cycle, nitrogen cycle, etc.), resulting

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in far-reaching implications for global climate change[1–5]. As one of the land use types with the most influential and far-reaching impact on the original land cover, cropland has been the focus of research regarding historical land use/cover change. The six existing global-scale historical land cover datasets (HH[6], SAGE[7], HYDE3.2[8], PJ[9], LUH[10], KK10[11]) all contain reconstructions of cropland data.

Reconstruction of relatively accurate historical cropland cover change based on regional history is one of the fundamental ways to improve the accuracy of global land cover data[12]. Existing regional reconstructions of historical cropland cover change are mostly concentrated in traditional farming regions, such as China[13–16], Germany[17–19], France[20,21], and America[22], while few studies have been conducted on nonmajor farming regions.

The five Central Asian countries include Kazakhstan, Tajikistan, Uzbekistan, Kyrgyzstan and Turkmenistan. Because the five Central Asian countries are landlocked and water resources are scarce, the majority of this region has been historically dominated by pastoralism, with only a small amount of cropland in oases around the Syr Darya and Amu Darya[23]. However, since Tsarist Russia invaded the five Central Asian countries in the mid-19th century, Kazakhstan's agriculture has grown at an astonishing rate in just over 100 years, and Kazakhstan is now the largest food producer in Central Asia and a major global food exporter[24]. Therefore, reconstructing the cropland cover change over the last millennium in five Central Asian countries can not only help to characterize the spatial and temporal changes in cropland cover in nonmajor farming regions but also help to understand the impact of physiogeographic factors associated with human production patterns as well as determine how humans surpass the limits of physical conditions to exploit land.

This dataset reconstructed the cropland cover change in five Central Asian countries over the last millennium based on historical documents. It includes total cropland area in five Central Asian countries for 25 time sections during 1000–2000 A.D. and 5′×5′ gridded cropland cover data for 8 time sections during 1000–2000 A.D. The overall goal is for this study to provide a reference for historical cropland cover reconstruction in nonmajor farming regions.

2 Metadata of the Dataset

The metadata of the Reconstruction dataset of cropland change in five Central Asian countries over the last millennium (1000–2000)[25] are summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods

The development of this dataset consists of the following two main elements: (1) Reconstruction of cropland area; (2) Gridded allocation. The data sources and references are shown in Table 2 and Table 3.

3.1 Methods for Reconstructing Cropland Area

The cropland area for the 13 time sections in this study between 1954 A.D. and 2000 A.D. was obtained directly from the data sources listed in Table 2, and no direct data sources were available for each time section prior to 1954 A.D. In these time sections for which no direct data are available, the cropland area in 1928 A.D. was obtained from statistical yearbooks and historical documents that combined with the 1954–2000 A.D. cropland area. The cropland area for the 11 time sections between 1000 A.D. and 1850 A.D. were derived from historical documents and extrapolated back from the 1928 A.D. reconstruction results.

Table 1 Metadata summary of the Reconstruction dataset of cropland change in five Central Asian countries over the last millennium (1000–2000)

Items	Description
Dataset full name	Reconstruction dataset of cropland change in five Central Asian countries over the last millennium (1000–2000)
Dataset short name	CroplandCentralAsia_1000-2000
Authors	Jiang, C. AEN-4274-2022, Beijing Normal University, jayciejiang@mail.bnu.edu.cn Ye, Y., Beijing Normal University, yeyuleaffish@bnu.edu.cn Fang, X. Q., Beijing Normal University, xfang@bnu.edu.cn Zhang, C. P., Beijing Normal University, cpzhang01@163.com Zhang, D. Y., Beijing Normal University, zdy2014@mail.bnu.edu.cn
Geographical region	(Under modern frontiers) Kazakhstan, Tajikistan, Uzbekistan, Kyrgyzstan and Turkmenistan
Year	1000–2000A.D.
Spatial resolution	5′×5′
Data format	.xlsx, .img
Data size	8.61 MB (422 KB after compression)
Data files	(1) Data archived in .xlsx data format includes two tables: Table 1. Total cropland area of five Central Asian countries during 1000–2000 Table 2. Cropland area of each five Central Asian country during 1928–2000 (2) Data archived in .img data format includes 8 time sections (1000 A.D., 1200 A.D., 1400 A.D., 1500 A.D., 1750 A.D., 1850 A.D., 1928 A.D., 2000 A.D.) of gridded cropland fraction in five Central Asian countries
Foundation	Ministry of Science and Technology of P. R. China (2017YFA0603304)
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 (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free 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 per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[26]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

Table 2 Data sources and references for the reconstruction of cropland area

Type of data	Data sources and references	Time
Cropland area	FAO[27]	2000
	Compilation of Economic Statistics of the Five Soviet Central Asian Republics[28] Statistical Yearbook of the National Economy of the USSR 1956[29] Compilation of Soviet Agricultural Statistics[30] Sixty Years of Soviet National Economy[31]	1928, 1954, 1955, 1958, 1959, 1962, 1968, 1975, 1976, 1978, 1980, 1983
Population	Atlas of World Population History[32]	1000–1850
	Study of Population Issues in Central Asia[33]	1750, 1850
Qualitative description of agricultural historical facts	Outline of Central Asia History[34] Outline History of Five Central Asian Countries[35] General History of Central Asia[36,37] History of Central Asia[38–40] History of Civilizations of Central Asia[41] History of the Conquest of Central Asia[42]	1000–2000
	A History of the Tsarist Russia Conquest of Central Asia[43] Soviet Exploitation of Central Asia and Kazakhstan[44] Study of the Policy of Russian Rule in Central Asia[45]	1750, 1850, 1928
	Brief History of Central Asia[46] History of the World Conquer[47] Turkestan Down to the Mongol Invasion[48] The Empire of the Steppes[49] Turkic Lineage[50]	1219, 1229, 1260, 1370, 1400, 1405

Table 3 The data sources of gridded allocation

Type of data	Data sources
Cultivatable land suitability dataset	Zhang's study[51]
Cropland fraction data approximately 2000 C.E.	Zhang's study[52]
Bare land, water bodies, artificial surfaces	http://globallandcover.com/home.html?type=data

(1) Cropland area in 1928 A.D.

The five Central Asian countries had data on both cropland area and sown area in the various statistical yearbooks of the USSR before 1954 A.D., whereas in 1928 A.D., only data on sown area were available. In terms of the history of agricultural development in the five Central Asian countries[42–45], the pattern of cropland cover in the four Central Asian countries except Kazakhstan has not changed much in the 20th century. Therefore, the average of the ratio of cropland area to sown area in 1954–2000 A.D. can be used instead of the ratio of cropland area to sown area in 1928 A.D. in these four countries. Equation 1 shows the process of calculating the cropland area in 1928 A.D. for these four countries using Uzbekistan as an example.

$$C_{\mathrm{UZB1928}}=\frac{1}{11}\sum_{t}^{11}\frac{C_t}{SA_t}\times SA_{\mathrm{UZB1928}} \tag{1}$$

where C_{UZB1928} refers to the cropland area in Uzbekistan in 1928 A.D.; $C_{\mathrm{UZB}t}$ refers to the cropland area in Uzbekistan under time section t from 1954 A.D. to 2000 A.D., and there are 11 time sections of cropland from 1954 A.D. to 2000 A.D. in this study; $SA_{\mathrm{UZB}t}$ refers to the sown area in Uzbekistan under time section t from 1954 A.D. to 2000 A.D.; and SA_{UZB1928} refers to the sown area in Uzbekistan in 1928 A.D.

Kazakhstan experienced rapid large-scale agricultural reclamation in the 20th century that was extensive and deep, and the ratio of cropland area to sown area in 1928 A.D. cannot be replaced by the average of the ratio of cultivated area to sown area for the period from 1954 AD to 2000 A.D., as in the other four countries. Therefore, the cropland area in Kazakhstan in 1928 A.D. was reconstructed according to historical sources[53], which stated that "after the October Revolution, cropland in Kazakhstan increased by an average of 154,000 hectares (converted into 1540 km^2) per year".

$$C_{\mathrm{KAZ1928}}=C_{\mathrm{KAZ1954}}-1540\times(1954-1928) \tag{2}$$

where C_{KAZ1928} refers to the cropland area in Kazakhstan in 1928 A.D. and C_{KAZ1954} refers to the cropland area in Kazakhstan in 1954 A.D.

(2) Cropland area in 1850 A.D.

The agricultural history of Kazakhstan began with the large-scale agricultural migration from Tsarist Russia to Kazakhstan in the second half of the 19th century[44] at the point when Russian migration policy towards Central Asia shifted from a military based policy to a predominantly agricultural one around the 1860s[45], which showed a spatial progression from north to south.

Before 1850 A.D., agriculture in Kazakhstan was mainly located in the Syr Darya basin in southern Kazakhstan and near the Zhetysu region in southeastern Kazakhstan. Nomadic herders predominantly populated the steppes of northern Kazakhstan, with a negligible cropland fraction, and from 1850 A.D. onwards, the steppes of northern Kazakhstan experienced large-scale reclamation for cultivation. The growth of cropland in southern Kazakhstan and the other four countries of Central Asia during this period is difficult to estimate because of the difficulty of obtaining population ratios in northern and southern Kazakhstan from 1850 A.D. to 1928 A.D. and the increased uncertainty created by the demographic changes brought about by mass migration and changes in population density resulting from the shift of the nomadic population to the settled population. However, the cropland fraction in southern Kazakhstan and the other four countries of Central Asia, although increasing slightly in line with population growth, is negligible compared to the unprecedentedly large increase in northern Kazakhstan. Therefore, this study concluded that the increase in cropland in the five Central Asian countries after 1850 A.D. occurred mainly in northern Kazakhstan, with the southern part of the five Central Asian countries reaching the maximum area that could be reached in 1850 A.D. in the context of this study. This north–south divide in Kazakhstan is derived from An Historical Atlas of Central Asia[54]. The total cropland area of the five Central Asian countries in 1850 A.D. was calculated by Equation 3.

$$C_{\mathrm{CA1850}} = C_{\mathrm{CA1928}} - C_{\mathrm{KN1928}} \quad (3)$$

where C_{CA1850} and C_{CA1928} refer to the total cropland area in the five Central Asian countries in 1850 A.D. and 1928 A.D., respectively, and C_{KN1928} is the cropland area of northern Kazakhstan in 1928 A.D.

(3) Cropland area in 1750 A.D.

The rapid development of irrigation programs in the five Central Asian countries occurred after 1750 A.D.[40]. A large proportion of the nomadic population was converted to a settled population and started to engage in farming[35], which led to the rapid development of cropland area during this period. The main idea for reconstructing cropland area in 1750 A.D. is shown by Equation 4.

$$C_{\mathrm{CA1750}} = \frac{C_{\mathrm{CA1850}}}{P_{\mathrm{CA1850C}}} \times P_{\mathrm{CA1750C}} \quad (4)$$

where C_{CA1750} refers to the total cropland area of five Central Asian countries in 1750 A.D., P_{CA1850C} refers to the number of people engaged in farming in 1850 A.D., and P_{CA1750C} refers to the number of people engaged in farming in 1750 A.D.

The population engaged in farming in 1850 A.D. was made up of two components: the population engaged in farming in 1750 A.D. increased by the way of natural growth, and the number of people who switched from pastoralism to farming between 1750 A.D. and 1850 A.D. We consider the former rate of growth to be equal to the growth rate of the total population of the region between 1750 A.D. and 1850 A.D. and the latter that the conversion occurred mainly among the Uzbeks and Turkmens[35, 40]. P_{CA1750C} was calculated by Equation 5.

$$P_{\mathrm{CA1850C}} = \left(1 + \frac{P_{\mathrm{R1850}} - P_{\mathrm{R1750}}}{P_{\mathrm{CA1750}}}\right) \times P_{\mathrm{CA1750C}} + \left(\alpha_{\mathrm{UZB}} + \alpha_{\mathrm{TKM}}\right) \times P_{\mathrm{CA1850C}} \quad (5)$$

where P_{R1850} and P_{R1750} refer to the total population of the region in 1850 A.D. and 1750 A.D., respectively, and α_{UZB} and α_{TKM} refer to the number of Uzbeks and Turkmens who have switched from pastoralism to farming, respectively, as a percentage of the total population.

The total population was derived from the Atlas of World Population History[32]. The number of the farming population was converted from the total population combined with the descriptions in historical sources[34, 35, 55], and the discounted proportion of the farming population in 1850 A.D. was 60%. The α_{UZB} and α_{TKM} are determined from the qualitative descriptions in references[33, 35, 41–43, 55, 56], with α_{UZB} at 30% and α_{TKM} at 8.75%.

(4) Cropland area in 1000 A.D., 1200 A.D., and 1500 A.D.

The period of rapid cropland development in Central Asia occurred mainly after 1750 A.D., before which the total amount of cropland area was small and the development trend was not positive and tended to be stable[36–41]. The cropland area fluctuated only when subject to war or invasion[46–49], and such fluctuations are reflected in the reconstruction of cropland area in 1219–1260 A.D. and 1370–1405 A.D. This study assumed that the per capita cropland area in the five Central Asian countries during the period 1000–1500 A.D., except for fluctuating time periods, remained the same as in 1750 A.D. and that the cropland area increased with population growth (Equation 6).

$$C_{\text{CA}t}=\frac{C_{\text{CA1750}}}{P_{\text{CA1750}}}\times P_{\text{CA}t} \tag{6}$$

where $C_{\text{CA}t}$ refers to the total cropland area in the five Central Asian countries under time section t that was not affected by external disturbances during the period 1000–1500 A.D. and $P_{\text{CA}t}$ refers to the total population of the five Central Asian countries under time section t that is not affected by external disturbances during the period 1000–1500 A.D.

(5) Cropland area in 1219 A.D., 1229 A.D. and 1260 A.D.

In the year 1219 A.D., Genghis Khan led an invasion of Central Asia, and the arrival of nomads resulted in a large amount of damage to the cropland in five Central Asian countries[36]. It was not until 1229 A.D. that agriculture began to recover when the cities and cropland of the region were taken over by Yalavachi[39, 57], and it recovered to its original level in 1260 A.D.[47]. Therefore, it can be assumed that the year 1219 A.D. was the start of the disturbance and 1260 A.D. was the end of the disturbance, the cropland area in these two time sections was unaffected by the disturbance, and the cropland area was reconstructed in the same way as in Equation 6. The year 1229 A.D. can be considered the period when the disturbance had its greatest impact and the cropland area fell to its lowest value during the disturbance, which can be calculated by Equation 7.

$$C_{\text{CA1229}}=\beta\times\frac{C_{\text{CA1750}}}{P_{\text{CA1750}}}\times P_{\text{CA1229}} \tag{7}$$

where C_{CA1229} refers to the total cropland area in the five Central Asian countries in 1229 A.D. and β is the percentage of conversion.

The Mongol invasion of Central Asia resulted in the mass murder of its inhabitants. As there is a positive correlation between population and cropland area, β can be determined by the proportion of the population reduced in that period. According to the Empire of the Steppes, approximately four-fifths of the population was killed, leaving the affairs of the surviving one-fifth of the population to be managed by Darugachi[49]. Therefore, β is taken as 1/5.

(6) Cropland area in 1370 A.D., 1400 A.D. and 1405 A.D.

In 1370 A.D., Timur began his wars of expansion, which had a large impact on agriculture in five Central Asian countries, similar to the conquest of Genghis Khan. However, after, and even during, the war of conquest in 1400 A.D., Timur had already started to recover the economy. Until Timur's death in 1405 A.D., prosperity was restored in Central Asia[39]. Therefore, 1370 A.D. was the start of the disturbance, and 1405 A.D. was the end of the disturbance. The cropland area in these two time sections was unaffected by the disturbance, and the cropland area was reconstructed in the same way as in Equation 6. The year 1400 A.D. can be considered the period when the disturbance had its greatest impact and the cropland area fell to its lowest value during the disturbance, which can be calculated by Equation 8.

$$C_{\text{CA1400}}=\gamma\times\frac{C_{\text{CA1750}}}{P_{\text{CA1750}}}\times P_{\text{CA1400}} \tag{8}$$

where C_{CA1400} refers to the total cropland area in the five Central Asian countries in 1400 A.D. and γ is the percentage of conversion.

The Timurid leaders continued the Mongol nomadism of Genghis Khan's time and their systematic means of destruction[49], with the intention of emulating their ancestors. Therefore, this study concludes that the damage to the cropland of five Central Asian countries during the Timurid period is comparable to that of the Genghis Khan period, which means that γ has the same value as β and is also taken as 1/5.

3.2 Methods for Allocating Historical Cropland Area into Grid Cells

In the gridded allocation of cropland area in the five Central Asian countries, country-specific data are available for the cropland area in 1928 A.D. and 2000 A.D., so the "study units" used for the distribution of these two sections are for each of the five Central Asian countries (which means there are five study units). The total cropland area for the 1850 A.D. and earlier sections is only available for the five Central Asian countries as a whole, so the "study unit" used for these sections is the five Central Asian countries as a whole (which means there is only one study unit).

In this study, based on the gridded cultivatable land suitability data calculated by Zhang *et al*.[51], the gridded allocation of cropland was completed through the following steps.

(1) Creating 5′×5′ resolution grids covering five Central Asian countries. The cropland fraction in 2000 A.D. calculated by Zhang *et al*.[52] was summed with the fraction of "Artificial Surface" in the GlobeLand30 dataset in 2000 A.D. on a 5′×5′ grid as the potential cropland fraction of the grids in 2000 A.D. (Equation 9). The grids were ranked in order of potential cropland fraction from higher to lower and then divided into 10 equal parts in the number of grids covering the study units from higher to lower fraction.

$$PotenFrac(i)_{2000} = CropFrac(i)_{2000} + ArtfFrac(i)_{2000} \quad (9)$$

where $PotenFrac(i)_{2000}$ refers to the potential cropland fraction in the i^{th} grid cell; $CropFrac(i)_{2000}$ is the cropland fraction in the i^{th} grid cell in 2000 A.D.; and $ArtfFrac(i)_{2000}$ is the fraction of the artificial surface in the i^{th} grid cell.

(2) The area of a grid with a resolution of 5′×5′ varies with latitude, so grids with the same cropland fraction may actually have different cropland areas. To eliminate the error introduced by this problem, the area of the grids in the study units needed to be corrected by Equation 10.

$$\xi(i) = \frac{GridArea(i)}{GridArea_{max}} \quad (10)$$

where $\xi(i)$ refers to the grid area correction factor in the i^{th} grid cell; $GridArea(i)$ refers to the grid area in the i^{th} grid cell; and $GridArea_{max}$ refers to the largest grid area in the study unit to which the i^{th} grid cell belongs.

(3) In this study, the percentage of cultivable land for a 5′×5′ resolution grid cell was assumed to be 90%. Allocated the cropland area in the first decile grids according to Equation 11 and set the percentage of cultivable land of the first decile grids at 9%.

$$CropArea(i,x) = CropArea \times \frac{Suit(i,x) \times \xi(i)}{\sum_{i=1}^{i} Suit(i,x) \times \xi(i)} \quad (11)$$

where $CropArea(i,x)$ refers to the cropland area that has been allocated in the i^{th} grid cell in allocation unit x; $CropArea$ is the total area of cropland in the study unit; $Suit(i,x)$ refers to the gridded cultivatable land suitability data in the i^{th} grid cell in allocation unit x; and $\xi(i)$ refers to the grid area correction factor in the i^{th} grid cell.

(4) If at the end of the allocation for the first decile girds there was still a surplus of cropland area, the allocation for the second decile grids began in accordance with Equation 11 with the percentage of cultivable land at 9%, and at the same time the allocation for the first decile girds continued in accordance with Equation 11 with the percentage of cultivable land at 18%. Following the above rules, the cropland could be allocated to all deciles by iteration. If all the cropland area of the study unit was allocated, the allocation stopped, and if there was still a surplus of cropland area in the study unit at the end of the allocation in the

10th decile girds, the remaining cropland area was allocated throughout the study units in accordance with Equation 11.

(5) Cropland fraction calculation (Equation 12).

$$CropFrac(i) = \frac{CropArea(i)}{GridArea(i)} \times 100\% \tag{12}$$

where *CropFrac*(*i*) refers to the cropland fraction of the i^{th} grid; *CropArea*(*i*) is the cropland area of the i^{th} grid; and *GridArea*(i) is the area of the i^{th} grid.

(6) Correction of oversaturated grids.

1) This study considered water bodies and bare land to be noncultivable land, whereas the extent of modern nascent water (mostly reservoirs) could be regarded as historically cultivable land; therefore, the arable land fraction in the grid could be calculated by Equation 13.

$$ArabFrac(i) = \frac{GridArea(i) - \left[BlArea(i) + WaArea(i) - NERsArea(i)\right]}{GridArea(i)} 5 \tag{13}$$

where *ArabFrac*(*i*) refers to the arable land fraction in the i^{th} grid; *GridArea*(*i*) refers to the area of the i^{th} grid, *BlArea*(*i*) refers to the bare land area in the i^{th} grid, *WaArea*(*i*) refers to the water body area in the i^{th} grid and *NERsArea*(*i*) refers to the modern nascent water area in the i^{th} grid obtained from natural earth data.

2) Combining the percentage of cultivable land for a 5′×5′ resolution grid cell (90% in this study) and the arable land fraction in the grid (Equation 13), the maximum cropland fraction in the grids could be calculated by Equation 14.

$$CropFrac_{max}(i) = \begin{cases} ArabFrac(i) & \left(ArabFrac(i) < 90\%\right) \\ 90\% & \left(ArabFrac(i) \geq 90\%\right) \end{cases} \tag{14}$$

where $CropFrac_{max}$(i) refers to the maximum cropland fraction in the i^{th} grid and *ArabFrac*(*i*) refers to the arable land fraction in the i^{th} grid.

For the grids where *CropFrac*(*i*) exceeded $CropFrac_{max}(i)$, $CropFrac_{max}(i)$ was directly assigned as their *CropFrac*(*i*) and summed up all the excess grids' cropland area and reallocated them to the grids that did not reach their $CropFrac_{max}$(i) according to Equation 11. This step was repeated several times until all grids' *CropFrac*(*i*) values were lower than $CropFrac_{max}(i)$, and the correction ended.

4 Data Results and Validation

4.1 Data Composition

The reconstruction dataset of cropland change in Five Central Asian countries over the Last Millennium (1000–2000) contains the total cropland area of five Central Asian countries during 1000–2000 A.D. and the 5′×5′ gridded cropland fraction of five Central Asian countries during 1000–2000 A.D. The cropland area for 25 time sections include 2 tables of the total cropland area of five Central Asian countries during 1000–2000 and the cropland area of each of the five Central Asian countries during 1928–2000, which are archived in.xlsx data formats. The gridded cropland fraction with a spatial resolution of 5′×5′ includes 8 time sections (1000 A.D., 1200 A.D., 1400 A.D., 1500 A.D., 1750 A.D., 1850 A.D., 1928 A.D., 2000 A.D.), which are archived in .img data formats.

4.2 Data Products

Changes in total cropland area in five Central Asian countries during 1000–2000 A.D. are shown in Figure 1. The change in cropland area over the last millennium in the five Central Asian countries can be divided into three phases: a smooth phase with fluctuations from

1000 A.D. to 1750 A.D., a rapid increase from 1750 A.D. to 1992 A.D., and a decline from 1992 A.D. to 2000 A.D.

The total cropland area in the five Central Asian countries was 9,617.46 km^2 in 1750 A.D., before which the total cropland area did not change much, and the cropland area increased slowly with population growth. However, there were fluctuations in cropland area caused by warfare in the early 13th and late 14th centuries, causing the cropland area to fall to 1,229.57 km^2 in 1400 A.D. and to 1,137.98 km^2 in 1229 A.D.

Cropland in Central Asia grew rapidly between 1750 A.D. and 1992 A.D. In particular, the cropland area increased from 41,329.87 km^2 to 439,780 km^2 between 1850 A.D. and 1992 A.D., which represented a nearly tenfold increase over more than 100 years. This was the result of Tsarist Russia's large-scale land reclamation in Central Asia, especially in Kazakhstan.

Between 1992 A.D. and 2000 A.D., the cropland area decreased significantly from 439,780 km^2 in 1992 A.D. to 394,323 km^2 in 2000 A.D. This is due to the destruction of agriculture as a result of the change in policy regimes in five Central Asian countries after the dissolution of the Soviet Union[58]. Particularly in Kazakhstan, the loss of a large number of farmers and capital from the countryside has led to large-scale abandonment of cropland.

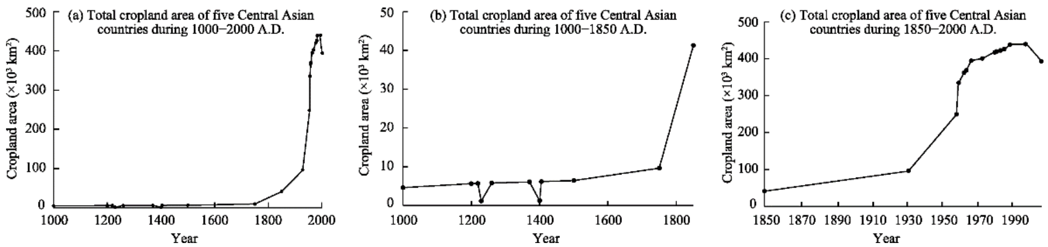

Figure 1 Total cropland area of five Central Asian countries during 1000–2000 A.D.

The 5′×5′ gridded cropland fraction in Central Asia during 1000–2000 A.D. is shown in Figure 2. The cropland was mainly distributed in oases around the Amu Darya and Syr Darya in southern Central Asia, such as the Khorezm Oasis, Fergana basin in Transoxiana, Zeravshan River valley oases, which nourish Samarkand and Bukhara, and Merv Oasis and Akhal Oasis in Turkmenistan. Cropland was also distributed in the Talas River basin, the Chu River basin, and the Zhetysu region. One of the distinctive features of the distribution of cropland in Central Asia was the distribution along rivers. This is due to the aridity and lack of rainfall in Central Asia, where rivers are an important source of irrigation water. In Central Asia, agriculture can be developed only when water sources and irrigation systems are available.

Over time, there has been a tendency for cropland to expand outwards from the oasis. Especially since 1750 A.D., there has been a rapid increase in cropland area and a marked increase in the extent of expansion. Selecting 1850 A.D. as a turning point, the distribution of cropland in Kazakhstan changed significantly. With the invasion of Tsarist Russia, large-scale migration and reclamation activities in northern Kazakhstan led to a rapid expansion of the cropland from north to south. Kazakhstan was transformed from a pastoralist country to an agricultural power in just 100 years, and it finally became the breadbasket of the Soviet Union.

5 Discussion and Conclusion

This study reconstructed the total cropland area and 5′×5′ gridded cropland fraction in five Central Asian countries during 1000–2000 A.D. The main conclusions are as follows: (1) The change in cropland area in five Central Asian countries between 1000 A.D. and 2000

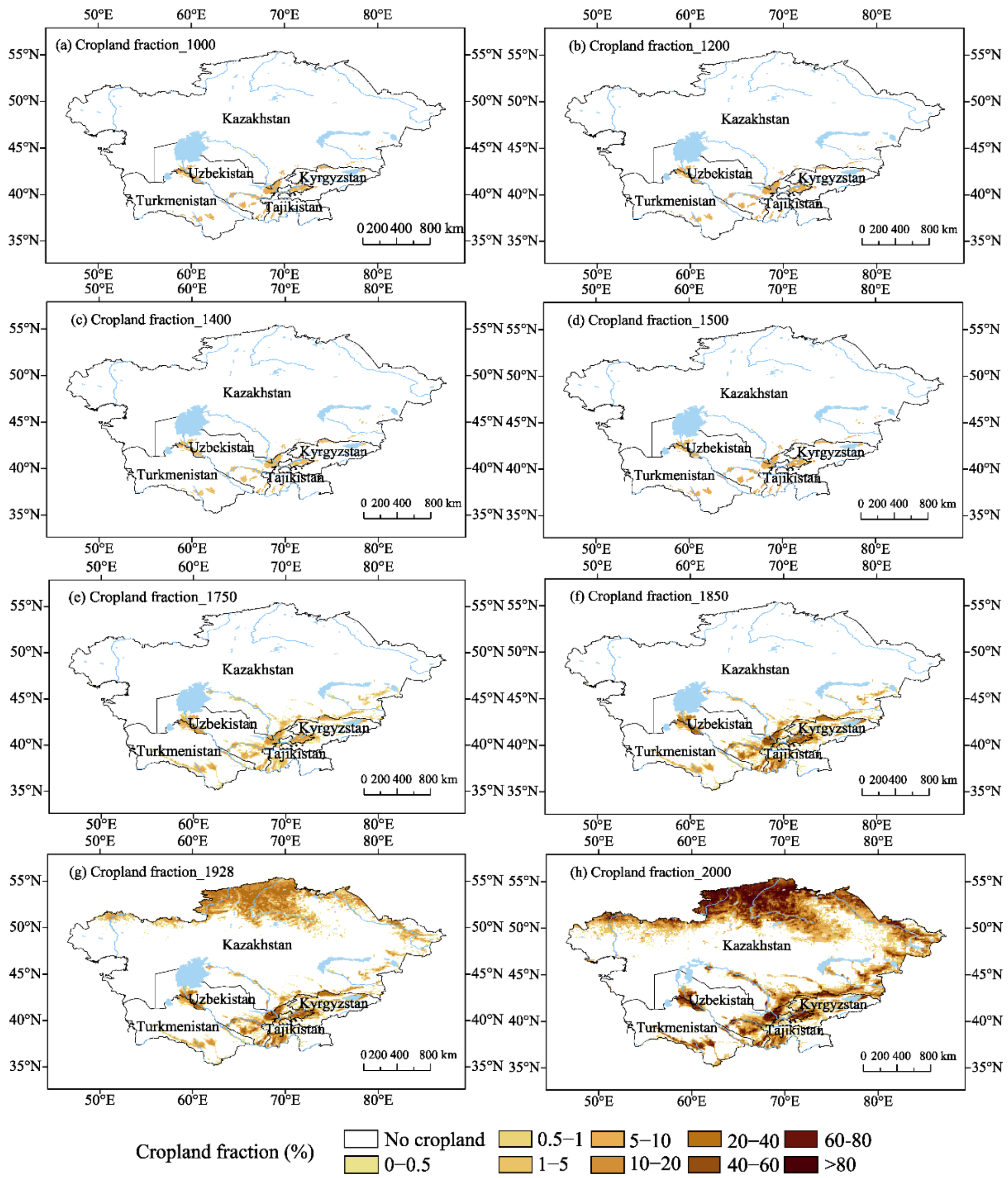

Figure 2 The 5′×5′ gridded cropland fraction in Central Asia during 1000–2000 A.D.

A.D. had three phases of "steady with fluctuations–growth–decline". (2) Cropland was mainly located in oases along the rivers and tends to expand outwards over time. After 1850 A.D., the increase in cropland area occurred mainly in the northern part of Kazakhstan. The reconstruction of cropland cover change in five Central Asian countries in the last millennium can provide ideas for the reconstruction in nonmajor farming regions where data sources are less available and help to compare the spatial and temporal characteristics of cropland development in major farming regions and the region else.

Author Contributions

Ye, Y. and Fang, X. Q. designed the algorithms of the dataset. Jiang C. contributed to the processing and analysis of the cropland area. Zhang C. P. designed the gridded allocation

algorithm. Zhang C. P. and Zhang, D. Y. provided guidance and advice on the gridded allocation algorithm. Jiang C. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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