Cropland Area Dataset of the Russian Empire/ Union of Soviet Socialist Republics during the Past Millennium (1000–2000)

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Abstract: Reconstruction of historical land use/cover change is the core task of land use/cover change research at regional and global scales. In this study, we reconstructed cropland areas of the Russian Empire/Union of Soviet Socialist Republics over the period of 1000–2000 using historical data, including cropland area, population, grain yield, and town. The dataset included 5 sets of spatial data and 3 sets of tabular data. Spatial data include the boundary data of the European part of the Russian Empire in 1000, 1533, and 1900, the boundary data of the European section of the Union of Soviet Socialist Republics in 1958, and the boundary data of Siberia. The tabular data include (1) sheet-1: cropland area data of the Russian Empire/Union of Soviet Socialist Republics over the period of 1000–2000; (2) sheet-2: cropland area data of the European part of the Russian Empire/Union of Soviet Socialist Republics over the period of 1000–2000; and (3) sheet-3: cropland area data of Siberia over the period of 1590–2000. The dataset is archived in .shp and .xlsx formats and consists of 41 files with a data size of 2.18 MB (compressed to 1 file, 1.11 MB).

Keywords: land use/cover change; cropland area; past millennium; Eastern Europe; Union of Soviet Socialist Republics

1 Introduction

As a human-induced global environmental change, land use and cover change (LUCC) has dramatically modified the Earth's surface[1–3] and significantly influenced global and regional climate change and the carbon cycle through biogeochemical and biogeophysical mechanisms[4–7]. Therefore, LUCC has historically been the core task of international global

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[2] Zhao, Z. L., Li, J., Fang, X. Q., *et al.* Retrieval dataset of historical cropland area in Russia (1000–2000) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2021. https://doi.org/10.3974/geodb.2022.01.05.V1. https://cstr.escience.org.cn/CSTR:20146.11.2022.01.05.V1.

change research[8–11].

The origin and development of agriculture was a major event in the Holocene[12]. Since the emergence of agricultural civilization in the Neolithic Age, especially since the Industrial Revolution, LUCC caused by agricultural development has affected many aspects of the global environment[13]. Cropland is one of the most representative types of land use in human agricultural activities[13,14]. Reconstructing historical cropland cover change could not only improve our understanding of the anthropogenic roles of historical land cover changes and climate changes[15] but also help us cope with the challenges of environmental problems created by land cover conversion, promote the development of global change research and provide a reference for promoting the sustainable development of human society[16–18].

Since the 1990s, a number of international research projects, such as the Land Use/Cover Change Project, the BIOME300, the Global Land Programme and the LandCover 6k, have been implemented to promote historical LUCC reconstruction. Several representative global datasets on historical land cover have been developed, for example, the History Database of the Global Environment (HYDE)[14], Global Land Use Database of the Center for Sustainability and the Global Environment (SAGE)[19], KK10 dataset[20], and PJ dataset[21]. However, it has been noted that many uncertainties of the global datasets existed due to the defects of the original data at the regional scales by many regional scale reconstructions, which are more likely to represent the real historical LUCC[22–24]. At present, with abundant historical materials, LUCC reconstruction on regional scales is often conducted around the major agricultural regions of the world[25–27].

The history of agricultural reclamation in Russia originated in the period of 5000 B.C.–6000 B.C.[28]. During the past millennium, Russia acted as a vital agricultural country in the world, with a long history of exporting grain to other countries within Europe[28]. The cropland area in modern Russia accounted for 8.11% of the total arable land area in 2015 worldwide[14]. According to historical documents, a number of studies have reconstructed historical cropland data on regional scales, such as Vladimir, Yaroslavl, Nizhni Novgorod and Chernigov[29–33], and have covered the period since the 1870s. However, a longer-term reconstruction of cropland data and a broader spatial scale in Russia requires accelerated research.

We have mined some historical data related to cropland use and cover, such as population, cropland area, grain yield, and town in Russia, during the past millennium from historical materials. Based on the experience of relevant scholars in the reconstruction of cropland data in Russia, the cropland area dataset of the Russian Empire/Union of Soviet Socialist Republics during the past millennium was constructed in this study. The results of this study could provide relevant references for reconstructions of historical LUCC.

2 Metadata of the Dataset

The metadata of the Cropland area dataset of Russian Empire/Union of Soviet Socialist Republics during the past millennium (1000–2000)[34] are summarized in Table 1, including name, authors, geographical region, year of the dataset, data files, data publisher, and data sharing policy, etc.

3 Methods

3.1 Data Collection

The reconstruction period of this dataset covered five historical periods of Russia, including the Kievan Rus, the Grand Duchy of Moscow, the Russian Empire, the Union of Soviet Socialist Republics, and the Russian Federation. Before Yermark's eastward expedition to Si-

beria in 1581, the territory of the Russian regime was mainly distributed in Europe[35]. Considering that the boundaries of the Russian regime changed frequently in different historical periods, the spatial scopes of cropland area reconstruction in this dataset should correspond to the territories of the Russian regime in the historical periods. At the same time, because the territory of Russia can be divided into the European part and Siberian part, we also conducted the cropland area reconstruction of the above two parts in this study, and the data we used are shown in Table 2. Furthermore, the boundary data of the Russian regime are listed in Table 2. However, due to the acquirability of historical materials, we only listed the boundary data of the European part of the Russian regime and Siberia in several historical periods in Table 2.

3.2 Methods for Reconstructing Cropland Area

In this study, except that the cropland area data in some historical periods were sourced from the literature, the cropland area in other periods was calculated by the following formula.

(1) To calculate cropland area by per capita cropland area and population

$$\bar{A}_{ci} = A_{ci} / P_i \tag{1}$$

where $\bar{A}_{ci}$ denotes the per capita cropland area in year i (km^2), A_{ci} denotes the cropland area in year i (km^2), and P_i denotes the population in year i (people). Equation (1) was used to reconstruct the cropland area of Siberia in 1590 and 1700.

However, there were only population records and no records of the per capita cropland area in the materials of some historical periods, such as 1719. In the reconstruction of cropland area, we assumed that the change in per capita cropland area before and after 1719 was approximately linear[26]. The cropland area in 1719 was calculated using Equation (2).

$$A_{ci} = P_i \times \left[\frac{A_{cj}}{P_j} + (i-j) \times \frac{\frac{A_{ch}}{P_h} - \frac{A_{cj}}{P_j}}{h-j} \right] (j<i<h) \tag{2}$$

where A_{ci} denotes the cropland area in the year i (km^2), A_{ch} denotes the cropland area in the year h (km^2), the year h after the year i, A_{cj} denotes the cropland area in the year j (km^2), the year j before the year i. P_i denotes the population in year i (people), P_h denotes the population in year h (people), and P_j denotes the population in year j (people). Equation (2) was used to reconstruct the cropland area of the European part of the Russian Empire in 1719.

(2) Interconversion between cropland area and fractional cropland area

$$F_i = A_{ci} / A_{li} \tag{3}$$

where A_{ci} denotes the cropland area in year i (km^2), A_{li} denotes the land area in year i (km^2), and F_i denotes the fractional cropland area in year i (%). Equation (3) was used to reconstruct the cropland area of the European part of the Russian Empire in 1887 and 1914.

(3) To calculate cropland area by grain yield and grain yield per unit area

$$A_{ci} = C_i / C_{ai} \tag{4}$$

where A_{ci} denotes the cropland area in year i (km^2), C_i denotes the grain yield in year i (kg), and C_{ai} denotes the grain yield per unit area in year i (kg/km^2). Equation (4) was used to reconstruct the cropland area of Siberia in 1913.

Table 1 Metadata summary of the Cropland area dataset of Russian Empire/Union of Soviet Socialist Republics during the past millennium (1000–2000)

Items	Description
Dataset full name	Cropland area dataset of Russian Empire/Union of Soviet Socialist Republics during the past millennium (1000–2000)
Dataset short name	CroplandChangewRussia_1000–2000
Authors	Zhao, Z. L. ABH-1134-2021, Beijing Normal University, zhaozhilong@bnu.edu.cn Li, J., Beijing Normal University, 201931051018@mail.bnu.edu.cn Fand, X. Q., Beijing Normal University, xfang@bnu.edu.cn Ye, Y., Beijing Normal University, yeyuleaffish@bnu.edu.cn
Geographical region	the European part of Russian Empire/Union of Soviet Socialist Republics, and Siberia
Year	1000–2000
Data format	.shp, .xlsx
Data size	1.11 MB（after compression）
Data files	(1) Spatial data includes: the boundary data of the European part of Russian Empire in 1000, 1533, and 1900; the boundary data of the European part of Union of Soviet Socialist Republics in 1958; and the boundary data of Siberia (2) The tabular data includes: Sheet-1: cropland area data of Russian Empire/Union of Soviet Socialist Republics over the periods of 1000–2000; (2) Sheet-2: cropland area data of the European part of Russian Empire/Union of Soviet Socialist Republics over the periods of 1000–2000; (3) Sheet-3: cropland area data of Siberia over the periods of 1590–2000
Foundation	Ministry of Science and Technology of the People's Republic of China (2017YFA0603304)
Data computing environment	Microsoft Excel 2019; ArcGIS
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[36]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

(4) To calculate cropland area inferred from the number of towns

$$A_{ci} = 9842.8e^{0.0281N_i} \tag{5}$$

where A_{ci} denotes the cropland area in year i (Units: km^2), and N_i denotes the number of towns in year i (Units: pcs). Using the data in Table 2 and Equations (2) and (3), we can reconstruct the cropland area of the European region of Russia from 1500 to 2000 in this study. We found that there was a correlation between the cropland area and the number of towns during this period, that is, Equation (5) (R^2=0.92, p<0.01). Since it was difficult to mine the cropland area data of Russia before 1500, we used Equation (5) and the number of towns in Table 2 to reconstruct the cropland area of the European part of the Russian Empire from 1000 to 1400 in this study.

(5) Interpolation of cropland area

According to the data in Table 2 and the above equations, we can reconstruct two cropland area series, including the cropland area of the European part of Russia from 1000 to 2000 and the cropland area of Siberia from 1590 to 2000. However, the time sections corresponding to the two cropland area series were inconsistent. To explore the changes in the two cropland area series in each century, it was proposed to reconstruct the cropland area

data of 13 time periods, including 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1850, 1900, 1950 and 2000. In the two reconstructed cropland area series for the European

Table 2 Data sources for the dataset development

Time	Type of data	Coverage area	Data Sources
1000–2000	The number of towns	The European part of Russian Empire	Euratlas Shop: Georeferenced Historical Vector Data 1500[1]
1000	Boundary data	The European part of Russian Empire	The Routledge Atlas of Russian History [37]
1500, 1540, 1585	Cropland area	The European part of Russian Empire	The agriculture of Grand Duchy of Moscow in the 16th century[38]
1533	Boundary data	The European part of Russian Empire	The Routledge Atlas of Russian History [37]
1590	Per capita cropland area, population	Siberia	Review and Prospect of the development of the eastern region of the Union of Soviet Socialist Republics—four hundred years of the development of Siberia[39] Comparative development history[40] The history of Siberia[41]
1700	Per capita cropland area, population	Siberia	The history of Siberia: From Russian conquest to Revolution[42] Siberia: A history of the people[43]
1696, 1725, 1763, 1796, 1856	Cropland area, population	The European part of Russian Empire	Life History of the Tsarist Russia Age[44]
1719	Population	The European part of Russian Empire	Life History of the Tsarist Russia Age[44]
1858	Cropland area	Siberia	Commonalities and characteristics of Siberian agricultural development from the second half of the 19th century to the beginning of the 20th century[45]
1887, 1914	Fractional cropland area, land area	The European part of Russian Empire	Life History of the Tsarist Russia Age[44]
1900	Boundary data	The European part of Russian Empire	Life History of the Tsarist Russia Age[44]
1913	Grain yield, grain yield per unit area	Siberia	Stalin, Siberia and the crisis of The New Economic Policy[46]
1937,1954	Cropland area	Siberia	The history of Siberia[41]
1958	Boundary data	The European part of Union of Soviet Socialist Republics, Siberia	http://www.gadm.org/
1958, 2000	Cropland area	The European part of Union of Soviet Socialist Republics/Russian Federation, Siberia	Statistical yearbook of national economy of the Union of Soviet Socialist Republics in 1959 [47], Russian Statistical Yearbook 2003[48]
1983	Cropland area	Siberia	Agriculture in Siberia and the Far East of the Union of Soviet Socialist Republics[49]

part of Russia and Siberia, if there were no data at the 13 time sections, it was necessary to adopt the method of the annual average growth rate for the interpolation of cropland area at these time sections with no data[50]. Then, by adding the cropland area of the European part of Russia and Siberia, we can obtain the reconstruction data of cropland area in the Russian Empire/Unions of the Soviet Socialist Republics during the past millennium.

4 Data Results and Validation

4.1 Dataset Composition

The metadata of the Cropland area dataset of Russian Empire/Union of Soviet Socialist Republics during the past millennium (1000–2000) included 5 sets of spatial data and 3 sets of

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[1] https://www.euratlas.net/shop/maps_gis/gis_1500.html.

tabular data, as follows. Spatial data included the boundary data of the European part of the Russian Empire in 1000, 1533, and 1900; the boundary data of the European part of the Union of Soviet Socialist Republics in 1958; and the boundary data of Siberia. The tabular data included cropland area data of the Russian Empire/Union of Soviet Socialist Republics over the period of 1000–2000; cropland area data of the European part of the Russian Empire/Union of Soviet Socialist Republics over the period of 1000–2000; and cropland area data of Siberia over the period of 1590–2000.

4.2 Data Results and Validation

The cropland area change of the Russian Empire/Union of Soviet Socialist Republics during the past millennium is shown in Figure 1. From 1000–2000, the total cropland area of the study area increased from $3.69×10^4$ km^2 to $166.27×10^4$ km^2 (Figure 1). From 1000 to 1500, the total cropland area was small, and it increased from $3.69×10^4$ km^2 to $4.26×10^4$ km^2 and remained no more than $5×10^4$ km^2. From 1600 to 1950, the total cropland area increased continuously, from $11.38×10^4$ km^2 to $166.85×10^4$ km^2. From 1950 to 2000, the total cropland area showed a slight declining trend, decreasing from $166.85×10^4$ km^2 to $166.27×10^4$ km^2.

Figure 1 Cropland area change in the Russian Empire or Union of Soviet Socialist Republics during the past millennium

In 1581, Yermark made an eastward expedition to Siberia. In 1586, after entering Siberia, Russia established the first city, Tyumen, which is located next to the Tuul river. Then, Russia continued to advance eastward and completed its control of Siberia in 1860[42,43]. Before 1586, the territory of the Russian regime was mainly distributed in Europe. Therefore, the cropland area of the European part of the Russian Empire should be equal to that of the Russian Empire in the periods before 1586. From 1000 to 1585, the cropland area of the European part of the Russian Empire increased from $3.69×10^4$ km^2 to $8.02×10^4$ km^2. From 1585 to 1914, the cropland area of the European part of the Russian Empire increased continuously, from $8.02×10^4$ km^2 to $147.40×10^4$ km^2. Then, the cropland area of the European part of the Russian regime continued to decline, and it decreased to $130.12×10^4$ km^2 in 2000 (Figure 1).

In this study, we reconstructed the cropland area of Siberia over the period of 1590–2000. During this period, the cropland area of Siberia increased from $0.01×10^4$ km^2 to $36.15×10^4$ km^2. From 1590 to 1913, the cropland area of Siberia did not exceed $10×10^4$ km^2. The cropland area of Siberia increased continuously in the period of 1937–2000, from $11.96×10^4$ km^2 to $36.15×10^4$ km^2.

To evaluate the credibility of the reconstructed results in this study, we compared them with the available values in other published literature. The differences in cropland area were less than 10%. This means that the results in this study are credible[51].

5 Discussion and Conclusion

This dataset reconstructed the cropland area of the Russian Empire/Union of Soviet Socialist Republics from 1000 to 2000 based on historical documents. In this study, it can be seen that the total cropland area of the Russian Empire/Union of Soviet Socialist Republics increased from $3.69×10^4$ km^2 to $166.27×10^4$ km^2 during 1000–2000, with the phasic characteristics of slow increase (1000–1600)–continuous increase (1600–1950)–slight decrease (1950–2000). Analysing the regularity of cropland change can provide a data and scientific basis for
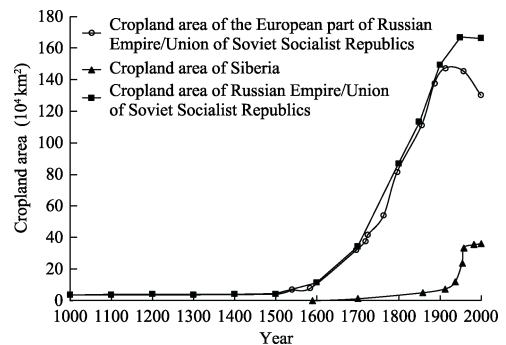
LUCC and related agricultural research in Russia for historical periods. Furthermore, this dataset can provide a reference for relevant research on cropland reconstruction in historical periods all over the world.

Author Contributions
Fang, X. Q. and Ye, Y. designed the study; Li, J. and Zhao, Z. L. completed the data processing and analysis; Zhao, Z. L. drafted the paper.

Conflicts of Interest
The authors declare no conflicts of interest.

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