Response to referee comments

We thank the two reviewers and the editor for the precious and constructive suggestions to improve our manuscript. We carefully revised our manuscript and addressed the comments of each of the two reviewers. Please find our point-by-point response below.

Referee #2

The authors developed a dataset to document cropland area over the past 1000 years in the North China. By using historical records and recent datasets, the manuscript particularly looked at the spatial changes and possible improvement to the accuracy of the regional dataset. I have a few concerns and suggestions for the authors to consider if they decide to revise the manuscript.

Response: Thank you very much for your constructive comments on our manuscript. We appreciate the time you spent reviewing our manuscript. Please find our point-by-point response below.

1. The novelty of this manuscript is not clearly presented. The authors have already published a few similar papers in the past few years, and even one for the Northeast China region. The only difference is the time period covered here. Land use change, especially for such long history with spatial coverage, is deemed important in understanding carbon budget, land emissions, and many other studies. This is what the authors also emphasized in the Introduction. However, this particular study presented only a few snapshots (i.e., 28), and just one relatively small area in China (not the ones with rich ancient history like capitals or the areas along the rivers/Yellow River that nurtured Chinese agriculture). Why is this study so unique and important? This can be made clearer in the Introduction.

Response: Thank you for your helpful suggestion, and we apologize if this was unclear. We reorganized the introduction to make it more coherent (Please see “Introduction section”, Line 25-82.), and also describe the novelty and the uniqueness of this study. Please see Line 73-82.

***Line 73-82*:** The dataset in this study presents a critical update and extension of the former historical cropland cover change in the three provinces of Northeast China over the past 300 years (Ye et al., 2009). Throughout the prolonged agricultural development, the natural vegetation landscape in the Northeast China has undergone notable transformations. In this study, we used the improved historical cropland reconstruction methods to reconstruct 28 time-points cropland area by assimilating multiple data sources in Northeast China from 1000 to 2020. The mainly new features of this dataset include: (1) Extended the reconstruction period to 1000~2020, aligning with the standard time-points of internationally established global historical LUCC datasets; (2) the reconstruction included the entire East of Inner Mongolia, which area accounts for approximately 45% of the Northeast China. (3) the smallest administrative divisions for the reconstructed cropland are at the provincial-level from 1000 to 1600, and at the county-level from 1700 to 2020. Our main objective is to provide a long-term time series of cropland area change dataset in Northeast China that is close to the historical "truth value" under a unified standard.

2. Also, please note that the current Introduction is quite similar to what's included in the Jia 2023 paper published at Regional Environmental Change, both the structure and argument of novelty. Quite a few sentences from the 2023 paper are used here again. This is not acceptable.

Response: Thank you for your helpful suggestion, and we apologize if this was confusing. We revised the structure and argument, and we also reorganized the introduction to make it more coherent. Please see "Introduction section", Line 25-82.

3. Next, in terms of the methods used here compared with others published by the same group of authors including the 2023 one, any significant difference besides data/records used? Any improvement to the methods? Could we expect any improvement of methods from an additional paper? HYDE have already developed global scale LUC data, with even longer history and higher resolution, and this study has always compared their results with HYDE. From what angle can we justify that this dataset has "higher reliability" or can "improve the accuracy and reliability"? Comparing a regional study with global work, or filling a few missing data (aim 1) do not make this a better paper. The authors need to better clarify the intention, methods, and even the comparison in

the discussion.

Response: Thank you for your insightful suggestion, and we apologize if this was confusing. Compare to 1000-1200, we developed cropland calculation indicators for 1300-1600 corresponding to different population categories (Please see Table 1, Line 632-654), and the algorithm to reconstruct the cropland by population is different (Please see the supplement material).

Table 1: The index of cropland area reconstruction from 1000 to 1600

Period	**Population type**	**Population (10^4)**	**Proportion of household registration**	**Corresponding cropland area**	**Total cropland area (km^2)**
1000, 1100	Agricultural population	371(1000); 612(1100)	Average household size: 6.5 people, 2.08 of whom were Man	Average annual cropland area per Man is 14 *Mu* (0.93 hm^2)	5513(1000); 9078(1100)
	Non-agricultural population	140(1000); 231(1100)		Average cropland area per household is 2 *Mu* (0.13 hm^2)	
1200	Agricultural population	587	Average household size: 5.96 people, 2 of whom were Man	Average annual cropland area per Man is 14 *Mu* (0.93 hm^2)	16949
	Non-agricultural population	338	Average household size: 10.59 people	Average cropland area per household is 45.3 *Mu* (3.02 hm^2)	
1300	Garrison soldiers	0.8	Each soldier represents a household	Average per garrison soldier is 100.1 Mu (6.67 hm^2)	4350
	Agricultural population	111	Average household size: 5 people, 1.67 of whom were Man	Average annual cropland area per Man is 14 *Mu* (0.93 hm^2)	
	Non-agricultural population (Minority ethnic household)	137		Average cropland area per household is 2 *Mu* (0.13 hm^2)	
1400	Soldiers and their dependents	70	Approximately 30% of garrison soldiers; Soldiers : dependents = 1 : 2	Average per garrison soldier is 46 *Mu* (3.07 hm^2)	2790
	Agricultural population (ordinary households/aborigines)	10	Average household size: 6 people, 2.25 of whom were Man	Average annual cropland area per Man is 14 *Mu* (0.93 hm^2)	
	Non-agricultural population (Minority ethnic household, Mongol household)	40	Average minority ethnic household size: 6 people, 2 of whom were Man; Mongol household size: 5, 1.67 of whom were Man	Average cropland area per household is 2 *Mu* (0.13 hm^2)	
1500, 1600	Soldiers and their dependents	25(1500); 12(1600)	Approximately 30% of garrison soldiers; Soldiers : Dependents = 1 : 2	Average per garrison soldier is 46 *Mu* (3.07 hm^2); Regular soldiers and one-third of their dependents is 14 *Mu* (0.93 hm^2)	4875(1500); 5868(1600)

	Agricultural population (ordinary households/aborigines/ refugees/migrants)	83(1500); 137(1600)	Average household size: 6 people, 2.25 of whom were Man	Average annual cropland area per Man is 14 *Mu* (0.93 hm^2)	
	Non-agricultural population (Minority ethnic household, Mongol household)	68(1500); 81(1600)	Same as 1400	Average cropland area per household is 2 *Mu* (0.13 hm^2)	

Line 632-654**:** (3) The two proxy indicators of 14 *Mu* (0.93 hm^2, the average annual potential cropland area per Man of the agricultural population) and 2 *Mu* (0.13 hm^2, the average cropland area per household in the nonagricultural population) from 1000 to 1600 may lead to inaccuracies in cropland estimation. The reasons for using population to reconstruct cropland during this period have been detailed in the previous section, necessitating further analysis and clarification of the corresponding cropland-related indicators.

Firstly, the conclusion of 14 *Mu* per Man for agricultural population during the Liao and Jin Dynasties (1000~1200) is primarily derived from historical records in the Jin Dynasty (1200) and the relationship between population and cropland in the early Qing Dynasty (1661~1680) (Jia et al., 2023). There are two reasons why 14 *Mu* was used in the Yuan and Ming Dynasties (1300~1600): one reason is the agricultural household size and the ratios of Man in agricultural household in Northeast China during the Yuan and Ming Dynasties (1300~1600) are closer to those of the Liao and Jin Dynasties (1000~1200) (Table 1). And the per capita cropland area owned by agricultural population in the Liao-Jin-Yuan-Ming periods (1000~1600) consistently ranged between 4 and 5 *Mu* (0.27~0.33 hm^2), slightly higher than the subsistence level of 3 *Mu* per capita in previous studies for the same historical period in this region (Ye et al., 2009; Fang et al., 2006; Shi, 1990), which is relatively reasonable. The second reason is that there were no significant changes in agricultural production technology in Northeast China during the Liao-Jin-Yuan-Ming periods (1000~1600), and the population declined significantly compared with the Liao and Jin Dynasties (1000~1200) due to factors such as warfare. However, considering the social stability at standard time-points during the Yuan and Ming Dynasties (1300~1600), the strong willingness of the agricultural population towards cultivation, and the limitations of individual cultivation capabilities, the cropland from the Liao and Jin Dynasties could be relatively easily inherited and reclaimed by descendants.

Secondly, Similar to the agricultural population, considering the non-agricultural household size, stable agricultural production technology, the historical inheritance of most ethnic groups, this study continues to use 2 *Mu* as the calculation indicator of non-agricultural population in the Yuan and Ming Dynasties (1300~1600) (Cong, 1993a; Cong, 1993b; Wu and Ge, 2005a; Cao and Ge, 2005b; Liu et al., 2016).

In this study, we used the improved historical cropland reconstruction methods to reconstruct 28 time-points cropland area by assimilating multiple data sources. Reconstruction of cropland area from 1000 to 1600 primarily relies on historical documents, population data. Furthermore, we used the most authoritative historical population data in China: "*History of Population of China*" and the cropland calculation indicators during this period corresponding to different population categories (Please see Table 1, Line 632-654 and the supplement material). We also attempt to analyze the rationality of our dataset based on the population changes, settlements changes, warfare, and land policies that may have influenced land cultivation in Northeast China during the Liao, Jin, Yuan, and Ming periods (1000-1600) (Please Line 453-495, Fig. S2).

Line 453-495**: 4.1.2 Rationality assessment**

Due to the unavailability of actual historical land cover data, we used the actual historical agricultural development of Northeast China as a reference standard for rationality assessment. As one of the cases evaluating the distribution rationality of the HYDE3.2 cropland cover in Northeast China over the past millennium, Fang et al. (2020) analyzed changes in the northern boundary and spatial distribution of settlement relics in the Liao, Jin, Yuan, and Ming periods (916~1644), as well as changes in the cumulative number of towns and spatial distribution of towns in the three provinces of Northeast China during the Qing Dynasty (1644~1911). The unique development history of the Northeast China shown in this case is basically consistent with the process of increase or decrease and spatial distribution of the total cropland area during the same period reconstructed by this study, which reflects the rationality of this dataset.

In addition, this study attempts to briefly summarize the population changes, settlements changes (the settlement relics and the administrative division points derived from Jia et al. (2018) and the

Historical Atlas of China (Tan, 1982a; Tan, 1982b)) (Fig. S2), warfare, and land policies that may have influenced land cultivation in Northeast China during the Liao, Jin, Yuan, and Ming periods (1000~1600). The population and settlements in Northeast China from 1000 to 1600 exhibited phase changes of expansion-reduction-expansion, with possible reasons including the Liao and Northern Song Dynasties signed the "*Chanyuan Alliance* (澶渊之盟)" in 1004 after war, the Jin and Southern Song Dynasties signed the "*Shaoxing Peace Treaty* (绍兴和议)" in 1141 after war, the Jin and Southern Song Dynasties signed the "*Longxing Peace Treaty* (隆兴和议)" in 1164 after war. During the three treaties and related wars, both the Liao and Jin dynasties in the north benefited significantly. They not only received reparations but also resettled large numbers of captives to the present-day Northeast China to engage in agricultural and other productive activities. Historical records also indicate that the rulers of the Liao and Jin dynasties during this period both attached much importance to agricultural production (Wu and Ge, 2022; Han, 1999; Toqto'A, 1974; Toqto'A, 1975).

From 1211, when Genghis Khan personally led the Mongol army to attack the Jin Dynasty, until 1233, the Mongols had essentially gained control over the entire Northeast China. Using this region as a base, they also conducted war against Goryeo (present-day Korean Peninsula), which lasted until 1259. From 1259 to 1287, the Mongols made several attempts to establish governing institutions in Northeast China, but faced continuous rebellions. It wasn't until the Yuan Dynasty subdued the rebellions and established the Liaoyang Province in 1287 that effective governance began in the Northeast China. However, during this period, the region suffered from continuous warfare, significant population loss, and severe disruptions to agricultural production (Xue, 2006, 2012). According to the Dynastic History of Yuan Dynasty, from 1294 to 1345, the Yuan government provided relief to Liaoyang Province 40 times. Additionally, rebellions in the Northeast China persisted from 1343 onwards, only being effectively subdued the rebellions by 1362, just six years before the collapse of the Yuan Dynasty in 1368 (Song, 1976; Xue, 2006, 2012).

In 1368, the Ming Dynasty was established, and remnants of the Yuan Dynasty retreated to the northern grassland, known as the Northern Yuan Dynasty (Tatar), which partly within our study area. It wasn't until 1389 that the Ming Dynasty established the "*Uriyangqa three Commanderies* (兀良哈三卫)" in the region from present-day Qiqihar city to Baicheng city, gaining certain practical control over the region. However, from 1399 to 1402, the Ming Dynasty faced the internal strife of the "*Jingnan Campaign* (靖难之役)" weakening its influence over the Northeast China, allowing some ethnic minorities to further occupy territories to the south. In 1409, the Ming Dynasty established the Dusi of Nuergan, reflecting their policy of appeasement and assimilation towards ethnic minorities in the Northeast China. In 1449, the Ming Dynasty experienced the "*Tumu Crisis* (土木之变)", prompting substantial efforts to fortify defensive structures. This also greatly strengthened the defensive capabilities of the Ming Great Wall in the Northeast China and confined the major agricultural population and agricultural areas of the Northeast China within the Dusi of Eastern Liao (south of the Ming Great Wall in the Northeast China). This situation persisted until the Ming Dynasty's collapse in 1644 (Cao and Ge, 2022; Fan, 2015; Cao and Ge, 2005; Zhang, 1974). All these pieces of evidence contribute to the validation of the rationality of our dataset to a certain degree.

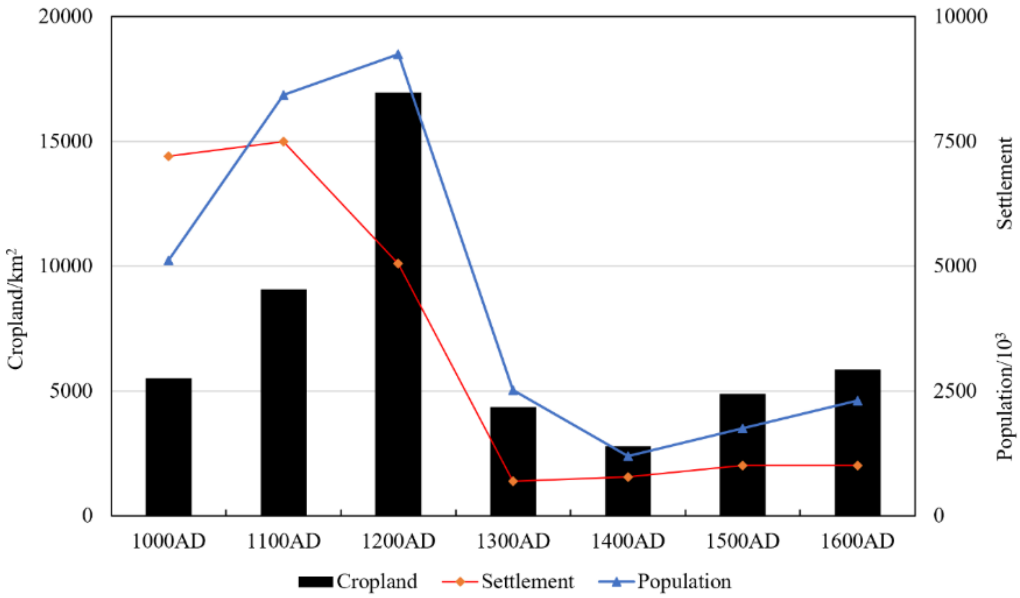

Figure S2. Graphs showing change in the cropland area, population and settlements of Northeast China from 1000 to 1600. The settlement relics and the administrative division points derived from Jia et al. (2018) and the Historical Atlas of China (Tan, 1982a; Tan, 1982b). The population data was revised and derived from the History of Population in China (Wu and Ge, 2005a; Cao and Ge, 2005b).

Overall, we reorganized supplemented some content attempt to better describe the intention (Please see "Introduction section", Line 25-82), methods (Line 219-269), and the comparison in the discussion (Please see "Discussion section", Line 427-678) and the supplement material.

***Line 219-269*:** (3) Linear interpolation and polynomial curve fitting to obtain the cropland area: Previous studies have used the linear interpolation and polynomial curve fitting to reconstruct cropland areas (He et al., 2017; Jin et al., 2015; Ramankutty and Foley, 1999; Wei et al., 2016; Wei et al., 2021; Ye et al., 2015; Yu, 2019; Fang et al., 2021), and the interpolated data did not reduce the credibility of their datasets. In addition, previous studies have shown that in the process of reclamation in the Northeast China over the past 300 years, 1860 was a dividing point between slow growth and rapid growth, mainly due to the implementation of the immigration and reclamation policy by the Qing government (Fang et al., 2020; Ye et al., 2009; Fang et al., 2005; Kong and Feng, 1989). Therefore, this study selected the CNEC data (Ye et al., 2009) in 1683, 1735, 1780, 1908 and 1914 for linear interpolation and polynomial curve fitting of cropland area data for each county or district in the three provinces of the Northeast China, obtaining data for 1700, 1750, 1800, 1850 and 1900. In addition, this study selected the data from Tian (Tian, 2005) in 1724, 1782, 1868, and 1911; the CNEC data (Ye et al., 2009) in 1735; the data from Ye (Ye and Fang, 2012) in 1916 for linear interpolation and polynomial curve fitting to obtain cropland area data for 1700, 1750, 1800, 1850, and 1900 in the Eastern of Inner Mongolia. The problems that may be encountered during the operation and the corresponding solutions are as follows:

①Linear interpolation and determination of zero values. The time points involved in this issue include 1700 and 1750 for the three provinces of Northeast China; 1750, 1800, and 1850 for East of Inner Mongolia. For instance, in Northeast China, the cropland area in each county in 1700 is interpolated based on records from 1683 and 1735. At 1700, there are no negative values, but there may be zero values. Specifically, the cropland value in 1683 is 0, while there is definite value in 1735. Our solution involves consulted contemporary county gazetteers to verify the history of land reclamation in 1700. If so, a polynomial curve fitting trend extrapolation was applied to obtain the proportional relationship at the provincial level for adjacent points on the extrapolated trend. Then this proportion was multiplied by the cropland area of the county at the adjacent time-point to obtain the cropland area at that time-point. If the land was not reclaimed, the value at that time point was considered as zero. Similarly, other counties involved in interpolation adopt the same solution when encountering this situation.

②Polynomial curve fitting and correction of negative values. Besides the previously mentioned linear interpolation, polynomial curve fitting based on the least squares method may encounter problems with data points resulting in negative values. First of all, the main reason for this issue is our historical determination that 1860 was a dividing point between slow and rapid growth. Therefore, we use 1860 as a breakpoint and separate interpolated the data for Ye (Ye et al., 2009, Ye and Fang, 2012) and Tian (Tian,

2005) before and after this period. Second, for time points that cannot be directly obtained through linear interpolation, cropland need to be calculated by polynomial fitting backwards (1800 and 1850 in the three provinces of Northeast China; 1900 in East of Inner Mongolia). For instance, in Northeast China, cropland area in each county in 1800 and 1850 are derived from data in 1683, 1735, and 1780 using polynomial curve fitting method. Some counties may show a decline in cropland, potentially resulting in negative values in the extrapolation results. Our solution involves using the proportion of provincial administrative level to multiply by the cropland area in 1780 for correction in the counties' cropland area in 1800 and 1850. Third, for time points that cannot be directly obtained through linear interpolation, cropland need to be calculated by polynomial fitting forwards (1900 in the three provinces of Northeast China; 1700, 1910 in East of Inner Mongolia). For instance, in Northeast China, cropland area in each county in 1900 is derived from data in 1908 and 1914 using polynomial curve fitting method. Due to rapid growth of cropland in some counties from 1908 to 1914, the extrapolation for 1900 may result in negative values. Our solution involves using the proportion of provincial administrative level to multiply by the cropland area in 1908 for correction in the counties' cropland area in 1900.

It should be noted that, considering the historical development process of Northeast China during the Qing Dynasty, war factors, and the encouraging land reclamation policies implemented by the Qing government after 1860, we determined that the cropland area in each county of Northeast China in 1900 would not significantly exceed that of 1908. During this period, in Northeast China, the total cropland area was gradually increasing and was not significantly affected by events such as the Second World War, which led to a notable decrease in cropland area in 1950 compared to 1930 and 1940. Therefore, when the extrapolated value for a county in 1900 exceeds that of 1908, the proportion of provincial administrative level is used to multiply by the cropland area in 1908 for correction in the county's cropland area in 1900.

③The determination of initial cultivation occurred between 1780 and 1908. Few counties in Northeast China where cropland was zero in 1683, 1735, and 1780, but had cropland in 1908. Our solution involves consulted contemporary county gazetteers to verify the history of land reclamation between 1800 and 1900. If local gazetteers indicate the initial cultivation occurred before 1860, this study applies the same method as described in "①Linear interpolation and determination of zero values". If the initial cultivation began after 1860, this study applies the same method as described in "②Polynomial curve fitting and correction of negative values". All the counties where this situation occurs can be found in Table S2.

4. L24: again, the Introduction is quite similar to Jia 2023, this has to be revised to be acceptable anywhere?

Response: Thank you again for your helpful suggestion, and we apologize if this was confusing. We reorganized the introduction to make it more coherent. Please see "Introduction section", Line 25-82.

5. L52: aims not aim.

Response: Thank you for your suggestion. We reorganized the aims to make it more coherent. Please see Line 81-82.

Line 81-82**:** Our main objective is to provide a long-term time series of cropland area change dataset in Northeast China that is close to the historical "truth value" under a unified standard.

6. L55-57: how many aims do you have exactly? Two or four? These do not seem to be complete sentences.

Response: Thank you for your suggestion, and we apologize if this was confusing. We reorganized the aims to make it more coherent. Please see Line 73-82.

Line 73-82**:** The dataset in this study presents a critical update and extension of the former historical cropland cover change in the three provinces of Northeast China over the past 300 years (Ye et al., 2009). Throughout the prolonged agricultural development, the natural vegetation landscape in the Northeast China has undergone notable transformations. In this study, we used the improved historical cropland reconstruction methods to reconstruct 28 time-points cropland area by assimilating multiple data sources in Northeast China from 1000 to 2020. The mainly new features of this dataset include: (1) Extended the reconstruction period to 1000~2020, aligning with the standard time-points of internationally established global historical LUCC datasets; (2) the reconstruction included the entire East of Inner Mongolia, which area accounts for approximately 45% of the Northeast China. (3) the smallest administrative divisions for the reconstructed cropland are at the provincial-level from 1000 to 1600, and at the county-level from 1700 to 2020. Our main objective is to provide a long-term time series of cropland area change dataset in Northeast China that is close to the historical "truth value" under a unified standard.

7. L113: this seem to be quite large for per person, can this value be used for the whole region?

Response: Thank you for your helpful suggestion, and we apologize if this was confusing. The definition of the Man is the adult labor force of a household (a male between the ages of 15 and 50 years in the Liao Dynasty; a male between the ages of 17 and 59 years in the Jin Dynasty; a male between the ages of 15 and 59 years in the Yuan Dynasty; a male between the ages of 16 and 60 years in the Ming Dynasty). The conclusion of 14 *Mu* per Man for agricultural population during this period (1000~1600) is primarily derived from historical records in the Jin Dynasty (1200) and the relationship between population and cropland in the early Qing Dynasty (1661~1680) (Jia et al., 2023). And we also discussed the uncertainty of this value. Please see Line 123 (a male between the ages of 15 and 50 years in the Liao Dynasty), 129 (a male between the ages of 17 and 59 years in the Jin Dynasty), 151 (a male between the ages of 15 and 59 years in the Yuan Dynasty), 172-173 (a male between the ages of 16 and 60 years in the Ming Dynasty), 632-654.

***Line 632-654*:** (3) The two proxy indicators of 14 *Mu* (0.93 hm^2, the average annual potential cropland area per Man of the agricultural population) and 2 *Mu* (0.13 hm^2, the average cropland area per household in the nonagricultural population) from 1000 to 1600 may lead to inaccuracies in cropland estimation. The reasons for using population to reconstruct cropland during this period have been detailed in the previous section, necessitating further analysis and clarification of the corresponding cropland-related indicators.

Firstly, the conclusion of 14 *Mu* per Man for agricultural population during the Liao and Jin Dynasties (1000~1200) is primarily derived from historical records in the Jin Dynasty (1200) and the relationship between population and cropland in the early Qing Dynasty (1661~1680) (Jia et al., 2023). There are two reasons why 14 *Mu* was used in the Yuan and Ming Dynasties (1300~1600): one reason is the agricultural household size and the ratios of Man in agricultural household in Northeast China during the Yuan and Ming Dynasties (1300~1600) are closer to those of the Liao and Jin Dynasties (1000~1200) (Table 1). And the per capita cropland area owned by agricultural population in the Liao-Jin-Yuan-Ming periods (1000~1600) consistently ranged between 4 and 5 *Mu* (0.27~0.33 hm^2), slightly higher than the subsistence level of 3 *Mu* per capita in previous studies for the same historical period in this region (Ye et al., 2009; Fang et al., 2006; Shi, 1990), which is relatively reasonable. The second reason is that there were no significant changes in agricultural production technology in Northeast China during the Liao-Jin-Yuan-Ming periods (1000~1600), and the population declined significantly compared with the Liao and Jin Dynasties (1000~1200) due to factors such as warfare. However, considering the social stability at standard time-points during the Yuan and Ming Dynasties (1300~1600), the strong willingness of the agricultural population towards cultivation, and the limitations of individual cultivation capabilities, the cropland from the Liao and Jin Dynasties could be relatively easily inherited and reclaimed by descendants.

Secondly, Similar to the agricultural population, considering the non-agricultural household size, stable agricultural production technology, the historical inheritance of most ethnic groups, this study continues to use 2 *Mu* as the calculation indicator of non-agricultural population in the Yuan and Ming Dynasties (1300~1600) (Cong, 1993a; Cong, 1993b; Wu and Ge, 2005a; Cao and Ge, 2005b; Liu et al., 2016).

References:

Jia, R., Fang, X., and Ye, Y.: Gridded reconstruction of cropland cover changes in Northeast China from ad 1000 to 1200, Reg. Envir. Chang., 23, 128, https://doi.org/10.1007/s10113-023-02118-y, 2023.

8. L384: The method is done by now, but how did you compute the spatial distribution of cropland across time? The previous methods mainly focused on total area numbers, but should the spatial pattern change with time, as the factors influencing cropland distribution change? For the area records, would the administrative region boundary change over time, which affect the statistics? Fig. 5 is an example that may be impacted by boundary changes.

Response: Thank you for your insightful suggestion.

From 1000 to 1600, the provincial-level administrative districts were derived from the Historical Atlas of China (Tan, 1982a; Tan, 1982b), and the cropland area during this period was reconstruction primarily relies on the population data in different provincial-level administrative districts.

The unified administration boundaries may affect the correct records of cropland. When we unified administration boundaries from 1700 to 1980, we referred to similar studies and adopted the similar method (Wei et al., 2019). Moreover, we performed this operation first at the time points with data records. After obtained all the cropland area at the modern administrative divisions of all time points, we performed linear interpolation and polynomial curve fitting to obtain the cropland area at standard time points, which had relatively less impact on cropland records. Please see Line 211-269.

***Line 211-269*:** (2) Unified administration boundaries: The CNEC data (Ye et al., 2009) in 1683, 1735, and 1780 corresponds to historical Qing Dynasty administrative districts, and the administrative districts used in 1908, 1914, 1931, 1940, 1950, and 1980 also differed from that of this study. The approach taken in this study involves unifying the cropland fraction within each county or district. The modern county-level administrative vector map used in this study is overlaid with Ye's county-level cropland fraction map. Then we calculated the area of overlap between each county or district in this study and Ye's corresponding county or district and then calculates the cropland area based on the proportional statistics. Similarly, for the Tian's data (Tian, 2005) used in this study for cropland fraction in 1724, 1782, 1868, 1911, and 1933, the same method is applied to unify them onto the modern map used in this study.

(3) Linear interpolation and polynomial curve fitting to obtain the cropland area: Previous studies have used the linear interpolation and polynomial curve fitting to reconstruct cropland areas (He et al., 2017; Jin et al., 2015; Ramankutty and Foley, 1999; Wei et al., 2016; Wei et al., 2021; Ye et al., 2015; Yu, 2019; Fang et al., 2021), and the interpolated data did not reduce the credibility of their datasets. In addition, previous studies have shown that in the process of reclamation in the Northeast China over the past 300 years, 1860 was a dividing point between slow growth and rapid growth, mainly due to the implementation of the immigration and reclamation policy by the Qing government (Fang et al., 2020; Ye et al., 2009; Fang et al., 2005; Kong and Feng, 1989). Therefore, this study selected the CNEC data (Ye et al., 2009) in 1683, 1735, 1780, 1908 and 1914 for linear interpolation and polynomial curve fitting of cropland area data for each county or district in the three provinces of the Northeast China, obtaining data for 1700, 1750, 1800, 1850 and 1900. In addition, this study selected the data from Tian (Tian, 2005) in 1724, 1782, 1868, and 1911; the CNEC data (Ye et al., 2009) in 1735; the data from Ye (Ye and Fang, 2012) in 1916 for linear interpolation and polynomial curve fitting to obtain cropland area data for 1700,

1750, 1800, 1850, and 1900 in the Eastern of Inner Mongolia. The problems that may be encountered during the operation and the corresponding solutions are as follows:

①Linear interpolation and determination of zero values. The time points involved in this issue include 1700 and 1750 for the three provinces of Northeast China; 1750, 1800, and 1850 for East of Inner Mongolia. For instance, in Northeast China, the cropland area in each county in 1700 is interpolated based on records from 1683 and 1735. At 1700, there are no negative values, but there may be zero values. Specifically, the cropland value in 1683 is 0, while there is definite value in 1735. Our solution involves consulted contemporary county gazetteers to verify the history of land reclamation in 1700. If so, a polynomial curve fitting trend extrapolation was applied to obtain the proportional relationship at the provincial level for adjacent points on the extrapolated trend. Then this proportion was multiplied by the cropland area of the county at the adjacent time-point to obtain the cropland area at that time-point. If the land was not reclaimed, the value at that time point was considered as zero. Similarly, other counties involved in interpolation adopt the same solution when encountering this situation.

②Polynomial curve fitting and correction of negative values. Besides the previously mentioned linear interpolation, polynomial curve fitting based on the least squares method may encounter problems with data points resulting in negative values. First of all, the main reason for this issue is our historical determination that 1860 was a dividing point between slow and rapid growth. Therefore, we use 1860 as a breakpoint and separate interpolated the data for Ye (Ye et al., 2009, Ye and Fang, 2012) and Tian (Tian, 2005) before and after this period. Second, for time points that cannot be directly obtained through linear interpolation, cropland need to be calculated by polynomial fitting backwards (1800 and 1850 in the three provinces of Northeast China; 1900 in East of Inner Mongolia). For instance, in Northeast China, cropland area in each county in 1800 and 1850 are derived from data in 1683, 1735, and 1780 using polynomial curve fitting method. Some counties may show a decline in cropland, potentially resulting in negative values in the extrapolation results. Our solution involves using the proportion of provincial administrative level to multiply by the cropland area in 1780 for correction in the counties' cropland area in 1800 and 1850. Third, for time points that cannot be directly obtained through linear interpolation, cropland need to be calculated by polynomial fitting forwards (1900 in the three provinces of Northeast China; 1700, 1910 in East of Inner Mongolia). For instance, in Northeast China, cropland area in each county in 1900 is derived from data in 1908 and 1914 using polynomial curve fitting method. Due to rapid growth of cropland in some counties from 1908 to 1914, the extrapolation for 1900 may result in negative values. Our solution involves using the proportion of provincial administrative level to multiply by the cropland area in 1908 for correction in the counties' cropland area in 1900.

It should be noted that, considering the historical development process of Northeast China during the Qing Dynasty, war factors, and the encouraging land reclamation policies implemented by the Qing government after 1860, we determined that the cropland area in each county of Northeast China in 1900 would not significantly exceed that of 1908. During this period, in Northeast China, the total cropland area was gradually increasing and was not significantly affected by events such as the Second World War, which led to a notable decrease in cropland area in 1950 compared to 1930 and 1940. Therefore, when the extrapolated value for a county in 1900 exceeds that of 1908, the proportion of provincial administrative level is used to multiply by the cropland area in 1908 for correction in the county's cropland area in 1900.

③The determination of initial cultivation occurred between 1780 and 1908. Few counties in Northeast China where cropland was zero in 1683, 1735, and 1780, but had cropland in 1908. Our solution involves consulted contemporary county gazetteers to verify the history of land reclamation between 1800 and 1900. If local gazetteers indicate the initial cultivation occurred before 1860, this study applies the same method as described in "①Linear interpolation and determination of zero values". If the initial cultivation began after 1860, this study applies the same method as described in "②Polynomial curve fitting and correction of negative values". All the counties where this situation occurs can be found in Table S2.

In addition, a study has indicated that the county-level administrative divisions are the most stable administrative division level in Chinese history (Zhao et al., 2024). Even so, the cropland area of each county estimated by this method in this study is still uncertain, and we have further described the uncertainty in Uncertainty analysis section. Please see Line 660-665.

Line 660-665**:** (2) From 1700 to 1980, the county-level administrative boundaries in the published data used in this study differ from the modern county-level administrative boundaries used in this study. Especially in the CNEC data (Ye et al., 2009) in 1683, 1735 and 1780, there is county-level in Liaoning province, Assistant Governorate Jurisdiction (prefecture-level) in Heilongjiang and Jilin province. This would result in counties belonging to different Assistant Governorate Jurisdictions in present-day having the same cropland fraction. This problem is difficult to correct further because the lowest administrative level in Northeast China available in historical data during this period is Assistant Governorate Jurisdiction (prefecture-level).

References:

Tan, Q.: The Historical Atlas of China, Volume 7, SinoMaps Press, Beijing, China, 1982a (in Chinese).

Tan, Q.: The Historical Atlas of China, Volume 6, SinoMaps Press, Beijing, China, 1982b (in Chinese).

Wei, X., Ye, Y., Zhang, Q., Li, B., and Wei, Z.: Reconstruction of cropland change in North China plain area over the past 300 years., Global & Planetary Change, 60-70, 2019.

Zhao, Y., Wang, K., Zhao, B., and Wang, F.: Spatio-temporal process and pattern of the establishment of county-level administrative divisions in China in the past 2200 years, Acta Geographica Sinica, 79, 890-908, https://doi.org/10.11821/dlxb202404005, 2024.

9. L455: there are several comparisons here, how do you justify that your estimates are better than others? Or do you suggest that as long as you have more data records then it should be more accurate?

Response: Thank you for your helpful suggestion, and we apologize if this was confusing. Our dataset assimilated multiple data sources (e.g.: historical documents, population data, garrison reclamation data, revised published results, statistical data, land survey data and RS data) and based on the improved historical cropland reconstruction methods (e.g.: cropland calculation indicators for different historical periods corresponding to different population categories), and the trend of increase and decrease of cropland area consistent with historical facts.

In addition, we acknowledge that the current paper's reliability, accuracy, or uncertainties assessments are not yet sufficiently comprehensive. We have made every effort to supplement the relevant assessments and uncertainty analysis as much as possible. And we deleted some description of the spatiotemporal variation characteristics of cropland area. Please see Line 428-495; 619-678, new Fig. 6, new Fig. 7 and Table S3.

***Line 428-495*: 4.1 Credibility assessment**

Based on the study of Fang et al. (2020), three methods including accuracy assessment, rationality assessment, and likelihood assessment, can be used to assess the credibility of historical LUCC dataset. Regarding the likelihood assessment, in reconstructing cropland area from 1985 to 2020, we selected eight RS products to assess the consistency. Based on the control of cropland survey data, this study identified high-consistency and high-priority pixels as cropland pixels for this dataset and evaluated and validated the accuracy of the integration results. Theoretically, compared with any single RS products used in this study during this period, the total amount of cropland area in this study is relatively more accurate and the spatial distribution is relatively more reasonable.

4.1.1 Accuracy assessment

The cropland data at lower spatial scales can be used to evaluate the accuracy of reconstructed cropland area. Due to the availability of county-level cropland survey data, we selected the county-level first general land investigation at 1985 and the county-level data from the third national land survey at 2020 for comparison. As shown in Fig. 6, the determination coefficients between the cropland area from this study and the cropland area from the survey data for 1985 and 2020 are 0.9582 and 0.9892 respectively. This indicated that the overall accuracy of the reconstructed cropland area at county-level was relatively high, and our constrained integration method that combines multisource cropland cover products with survey data can well match the spatial distribution of cropland cover in Northeast China.

In addition, from 1985 to 2020, the identified high-consistency and high-priority pixels as cropland pixels based on constrained integration method may lead to errors with survey data (Table S3). The relative errors between the cropland area of this study and the cropland survey data for the period 1985 to 2020 as -1.35%, 4.02%, 5.17%, 1.10%, 0.21%, -1.93%, 0.25% and 0.67%, respectively. The vast majority of errors are around 1%, with the larger errors are 4.02% and 5.17%, which indicates that the reconstructed cropland area in this study is relatively accurate from 1985 to 2020.

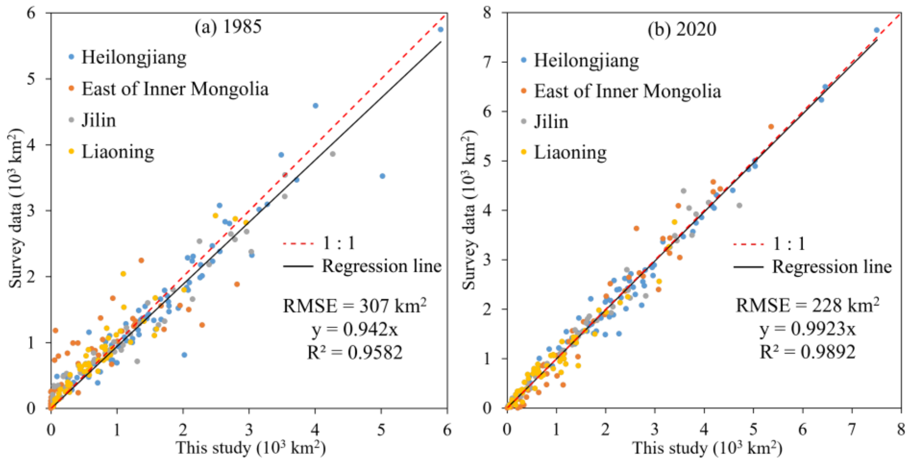

Figure 6: Correlation between the cropland data of this study and survey cropland data at county-level in the Northeast China in 1985 and 2020.

4.1.2 Rationality assessment

Due to the unavailability of actual historical land cover data, we used the actual historical agricultural development of Northeast China as a reference standard for rationality assessment. As one of the cases evaluating the distribution rationality of the HYDE3.2 cropland cover in Northeast China over the past millennium, Fang et al. (2020) analyzed changes in the northern boundary and spatial distribution of settlement relics in the Liao, Jin, Yuan, and Ming periods (916~1644), as well as changes in the cumulative number of towns and spatial distribution of towns in the three provinces of Northeast China during the Qing Dynasty (1644~1911). The unique development history of the Northeast China shown in this case is basically consistent with the process of increase or decrease and spatial distribution of the total cropland area during the same period reconstructed by this study, which reflects the rationality of this dataset.

In addition, this study attempts to briefly summarize the population changes, settlements changes (the settlement relics and the administrative division points derived from Jia et al. (2018) and the Historical Atlas of China (Tan, 1982a; Tan, 1982b)) (Fig. S2), warfare, and land policies that may have influenced land cultivation in Northeast China during the Liao, Jin, Yuan, and Ming periods (1000~1600). The population and settlements in Northeast China from 1000 to 1600 exhibited phase changes of expansion-reduction-expansion, with possible reasons including the Liao and Northern Song Dynasties signed the "*Chanyuan Alliance* (澶渊之盟)" in 1004 after war, the Jin and Southern Song Dynasties signed the "*Shaoxing Peace Treaty* (绍兴和议)" in 1141 after war, the Jin and Southern Song Dynasties signed the "*Longxing Peace Treaty* (隆兴和议)" in 1164 after war. During the three treaties and related wars, both the Liao and Jin dynasties in the north benefited significantly. They not only received reparations but also resettled large numbers of captives to the present-day Northeast China to engage in agricultural and other productive activities. Historical records also indicate that the rulers of the Liao and Jin dynasties during this period both attached much importance to agricultural production (Wu and Ge, 2022; Han, 1999; Toqto'A, 1974; Toqto'A, 1975).

From 1211, when Genghis Khan personally led the Mongol army to attack the Jin Dynasty, until 1233, the Mongols had essentially gained control over the entire Northeast China. Using this region as a base, they also conducted war against Goryeo (present-day Korean Peninsula), which lasted until 1259. From 1259 to 1287, the Mongols made several attempts to establish governing institutions in Northeast China, but faced continuous rebellions. It wasn't until the Yuan Dynasty subdued the rebellions and established the Liaoyang Province in 1287 that effective governance began in the Northeast China. However, during this period, the region suffered from continuous warfare, significant population loss, and severe disruptions to agricultural production (Xue, 2006, 2012). According to the Dynastic History of Yuan Dynasty, from 1294 to 1345, the Yuan government provided relief to Liaoyang Province 40 times. Additionally, rebellions in the Northeast China persisted from 1343 onwards, only being effectively subdued the rebellions by 1362, just six years before the collapse of the Yuan Dynasty in 1368 (Song, 1976; Xue, 2006, 2012).

In 1368, the Ming Dynasty was established, and remnants of the Yuan Dynasty retreated to the northern grassland, known as the Northern Yuan Dynasty (Tatar), which partly within our study area. It wasn't until 1389 that the Ming Dynasty established the "*Uriyangqa three Commanderies* (兀良哈三卫)" in the region from present-day Qiqihar city to Baicheng city, gaining certain practical control over the region. However, from 1399 to 1402, the Ming Dynasty faced the internal strife of the "*Jingnan Campaign* (靖难之役)" weakening its influence over the Northeast China, allowing some ethnic minorities to further occupy territories to the south. In 1409, the Ming Dynasty established the Dusi of Nuergan, reflecting their policy of appeasement and assimilation towards ethnic minorities in the Northeast China. In 1449, the Ming Dynasty experienced the "*Tumu Crisis* (土木之变)", prompting substantial efforts to fortify defensive structures. This also greatly strengthened the defensive capabilities of the Ming Great Wall in the Northeast China and confined the major agricultural population and agricultural areas of the Northeast China within the Dusi of Eastern Liao (south of the Ming Great Wall in the Northeast China). This situation persisted until the Ming Dynasty's collapse in 1644 (Cao and Ge, 2022; Fan, 2015; Cao and Ge, 2005; Zhang, 1974). All these pieces of evidence contribute to the validation of the rationality of our dataset to a certain degree.

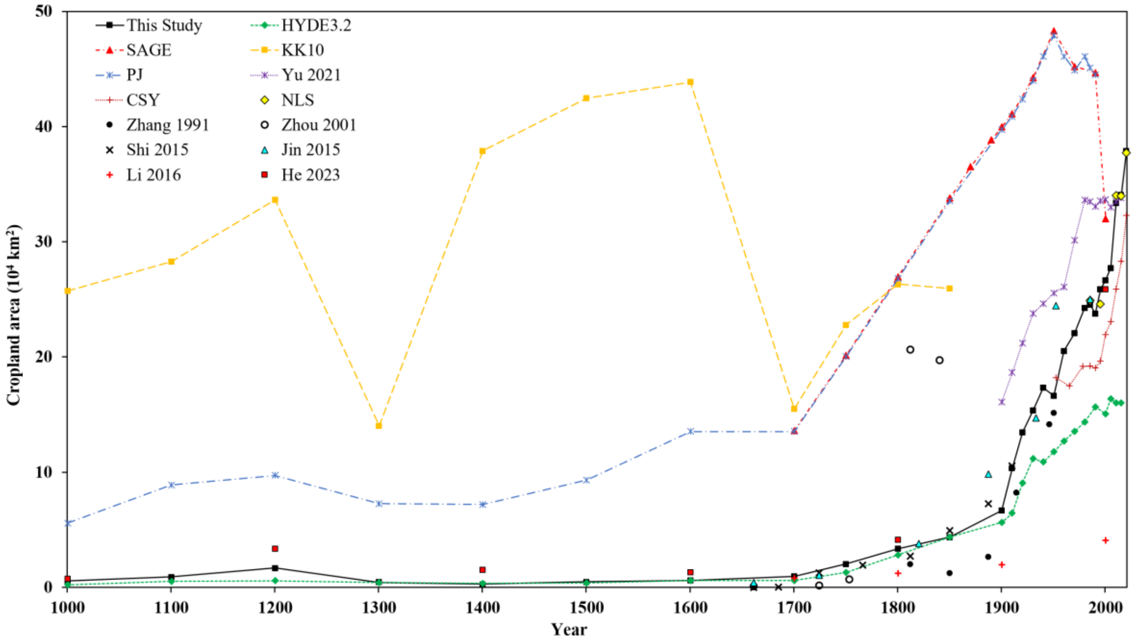

Figure 7: Comparison of total cropland area from global historical LUCC datasets, previous studies and this study in the Northeast China. The abbreviations used in the figure are as follows: HYDE3.2 refers to Goldewijk et al. (2017); SAGE refers to Ramankutty et al. (2008) and Ramankutty and Foley. (1999); KK10 refers to Kaplan et al. (2011); PJ refers to Pongratz et al. (2008); Yu 2021 refers to Yu et al. (2021); CSY denotes the Chinese Statistical Yearbook (refer to provincial and prefectural statistical yearbook); NLS denotes the National Land Survey (1985 refer to the first general land investigation; 1995 refers to the first national land survey; 2010 and 2015 refer to the second national land survey; 2020 refers to the third national land survey); Zhang 1991 refers to Zhang (1991); Zhou 2001 refers to Zhou (2001); Shi 2015 refers to Shi (2015); Jin 2015 refers to Jin et al. (2015); Li 2016 refers to Li et al. (2016); He 2023 refers to He et al. (2023).

***Line 619-678*: 4.4 Uncertainty analysis**

In this study, the uncertainty mainly consisted in two aspects: the definition and selection of data, the application of methods. Regarding the data aspect: (1) In this study, the definition of cropland before 1950 is: the sum of arable land and land under permanent crops, and the temporary changes in land use and fallow land during historical periods were not considered. The cropland area for 1950 and later are basically consistent with the identification rules in the National Land Survey. Although the temporary changes in land use and fallow land during historical periods, this may still result in our reconstruction slightly less cropland than actual historical period.

(2) Due to the completeness of historical documents, the reconstruction results of cropland for seven time points from 1000 to 1600 in this study are at the provincial-level, which may not finely reflect the spatiotemporal characteristics of cropland. Especially between 1000 and 1300, the results may lead readers to mistakenly believe that cropland were evenly distributed across the entire Northeast China. However, based on the distribution of settlement relics during this period, cropland may mainly distribute on the Liaohe Plain and on the southern part of the Songnen Plain, then reduced southward into Liaoning Province.

(3) The two proxy indicators of 14 *Mu* (0.93 hm^2, the average annual potential cropland area per Man of the agricultural population) and 2 *Mu* (0.13 hm^2, the average cropland area per household in the nonagricultural population) from 1000 to 1600 may lead to inaccuracies in cropland estimation. The reasons for using population to reconstruct cropland during this period have been detailed in the previous section, necessitating further analysis and clarification of the corresponding cropland-related indicators.

Firstly, the conclusion of 14 *Mu* per Man for agricultural population during the Liao and Jin Dynasties (1000~1200) is primarily derived from historical records in the Jin Dynasty (1200) and the relationship between population and cropland in the early Qing Dynasty (1661~1680) (Jia et al., 2023). There are two reasons why 14 *Mu* was used in the Yuan and Ming Dynasties (1300~1600): one reason is the agricultural household size and the ratios of Man in agricultural household in Northeast China during the Yuan and Ming Dynasties (1300~1600) are closer to those of the Liao and Jin Dynasties (1000~1200) (Table 1). And the per capita cropland area owned by agricultural population in the Liao-Jin-Yuan-Ming periods (1000~1600) consistently ranged between 4 and 5 *Mu* (0.27~0.33 hm^2), slightly higher than the subsistence level of 3 *Mu* per capita in previous studies for the same historical period in this region (Ye et al., 2009; Fang et al., 2006; Shi, 1990), which is relatively reasonable. The second reason is that there were no significant changes in agricultural production technology in Northeast China during the Liao-Jin-Yuan-Ming periods (1000~1600), and the population declined significantly compared with the Liao and Jin Dynasties (1000~1200) due to factors such as warfare. However, considering the social stability at standard time-points during the Yuan and Ming Dynasties (1300~1600), the strong willingness of the agricultural population towards cultivation, and the limitations of individual cultivation capabilities, the cropland from the Liao and Jin Dynasties could be relatively easily inherited and reclaimed by descendants.

Secondly, Similar to the agricultural population, considering the non-agricultural household size, stable agricultural production technology, the historical inheritance of most ethnic groups, this study continues to use 2 *Mu* as the calculation indicator of non-agricultural population in the Yuan and Ming Dynasties (1300~1600) (Cong, 1993a; Cong, 1993b; Wu and Ge, 2005a; Cao and Ge, 2005b; Liu et al., 2016).

Regarding the method aspect: (1) From 1700 to 1980, cropland areas at multiple time points in this study were derived through linear interpolation and polynomial curve fitting. Although we have fully considered historical facts and other research conclusions (Fang et al., 2020; Ye et al., 2009; Fang et al., 2005) when selecting the interpolation time points, 1860 was chosen as the dividing point between slow growth and rapid growth. This method, compared to data recorded at each specific historical point, may affect the accuracy of the value at those standard time points.

(2) From 1700 to 1980, the county-level administrative boundaries in the published data used in this study differ from the modern county-level administrative boundaries used in this study. Especially in the CNEC data (Ye et al., 2009) in 1683, 1735 and 1780, there is county-level in Liaoning province, Assistant Governorate Jurisdiction (prefecture-level) in Heilongjiang and Jilin province. This would result in counties belonging to different Assistant Governorate Jurisdictions in present-day having the same cropland fraction. This problem is difficult to correct further because the lowest administrative level in Northeast China available in historical data during this period is Assistant Governorate Jurisdiction (prefecture-level).

(3) From 1985 to 2020, the land survey data utilized in this dataset might exhibit uncertainties in early cropland data due to backward technology and other factors. Additionally, the use of a uniform correlation coefficient to correct the cropland statistics data for the entire Northeast China may affect the accuracy of the cropland area in localized areas, this may lead to a lower cropland area at previous time-points. To mitigate the impact of these uncertainties on our dataset during this period, this study mainly adopts two methods: Firstly, this study mainly selects the standard time-points data after the nationwide surveys, avoiding the use of annual land change survey data. For instance, the cropland area in 1985 in this dataset is based on the first general land investigation around 1985; the cropland area in 1995 is based on the first NLS's standard time-point data on October 31, 1996; the cropland area in 2010 is based on the second NLS's standard time-point data on December 31, 2009; and the cropland area in 2020 is based on the third NLS's standard time-point data on December 31, 2019. Secondly, this study uses

correlation coefficients to correct the statistical data by category and time point. For instance, the average correlation coefficient of the second and third NLSs with corresponding statistical data is used to correct the statistical data for the 1990, 2000, and 2005; the correlation coefficient of the 1985 first general land investigation with corresponding statistical data is used to correct the statistical data for the 1950~1980.

Table S3. Supplementary information showing the total cropland area of global LUCC datasets, previous representative published studies and our dataset in Northeast China from 1000 to 2020 (10^4 km^2).

Period	1000	1100	1200	1300	1400	1500	1600	1661	1685	1700	1724	1750	1753	1766	1800	1812	1820	1840	1850	1870	1887	1890	1900
This Study	0.55	0.91	1.69	0.44	0.28	0.49	0.59			0.96		2.04			3.33				4.36				6.66
HYDE3.2	0.23	0.53	0.57	0.42	0.34	0.37	0.59			0.59		1.29			2.81				4.36				5.63
SAGE										13.61		20.16			26.97				33.80	36.52		38.85	39.97
KK10	25.72	28.26	33.65	14.00	37.90	42.48	43.85			15.49		22.79			26.32				25.93				
PJ	5.58	8.88	9.72	7.27	7.19	9.30	13.53			13.53		20.04			26.80				33.57				39.74
Yu 2021																							16.07
CSY																							
NLS																							
Zhang 1991																2.02			1.21		2.66		
Zhou 2001								0.09			0.16		0.68			20.64		19.71					
Shi 2015								0.00	0.02		1.25			1.95		2.70			4.94		7.27		
Jin 2015								0.43			1.05						3.80				9.82		
Li 2016										0.78					1.23								1.98
He 2023	0.77		3.35		1.51		1.31								4.14								

Period	1910	1914	1920	1930	1933	1940	1946	1950	1952	1960	1965	1970	1978	1980	1985	1990	1995	2000	2005	2010	2015	2020
This Study	10.33		13.44	15.37		17.31		16.63		20.53		22.07		24.28	24.56	23.76	25.87	26.64	27.74	33.37	34.08	37.90
HYDE3.2	6.44		9.08	11.19		10.88		11.76		12.71		13.53		14.37		15.66		15.06	16.38	16.00	16.00	
SAGE	41.11			44.24				48.30				45.21				44.67		31.99				
KK10																						
PJ	40.87		42.37	44.02		46.08		47.92		46.09		44.90		46.08	45.12	44.49						
Yu 2021	18.64		21.21	23.78		24.63		25.56		26.09		30.13		33.61	33.49	33.05	33.55	33.68	32.99	33.50	33.79	
CSY									18.22		17.49		19.18		19.21	19.04	19.66	21.96	23.07	25.79	27.97	32.06
NLS															24.89		24.60			34.03	33.99	37.64
Zhang 1991		8.23					14.17	15.17														
Zhou 2001																						
Shi 2015	10.55																					
Jin 2015					14.71				24.46						25.01							
Li 2016																		4.09				
He 2023																		25.89				

The abbreviations used in the table are as follows: HYDE3.2 refers to Goldewijk et al. (2017); SAGE refers to Ramankutty et al. (2008) and Ramankutty and Foley. (1999); KK10 refers to Kaplan et al. (2011); PJ refers to Pongratz et al. (2008); Yu 2021 refers to Yu et al. (2021); CSY denotes the Chinese Statistical Yearbook (refer to provincial and prefectural statistical yearbook); NLS denotes the National Land Survey (1985 refer to the first general land investigation (Committee of Integrative Survey of Natural Resources and Committee of National Planning of Chinese Academy of Sciences, 1989); 1995 refers to the first national land survey (Li, 2000); 2010 and 2015 refer to the second national land survey; 2020 refers to the third national land survey (https://gtdc.mnr.gov.cn/Share#/)); Zhang 1991 refers to Zhang (1991); Zhou 2001 refers to Zhou (2001); Shi 2015 refers to Shi (2015); Jin 2015 refers to Jin et al. (2015); Li 2016 refers to Li et al. (2016); He 2023 refers to He et al. (2023).

10. L514: this is NOT "uncertainty analysis", there is no "analysis" at all. Just some random discussions.

Response: Thank you for your helpful suggestion, and we apologize if this was confusing. We have reorganized the structure of the "Uncertainty analysis section", and added more specific and detailed description to analyze uncertainty. Please see "Uncertainty analysis section", Line 619-678.

11. L533: don't you think the conclusion is a bit too long?

Response: Thank you for your helpful suggestion. We have reorganized the "Conclusion section". Please see "Conclusion section", Line 684-703.

Once again, thank you very much for your constructive comments, which has greatly improved this manuscript.