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Farmland Distribution Dataset of the Yarlung Zangbo–Lhasa–Nyangqu River Region of the Tibetan Plateau

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Abstract: A dataset of high spatial resolution farmland distribution can accurately reflect the spatial distribution of farmland, which is very important for understanding the decision-making of farmland resource utilization and guaranteeing national food security and sustainable development of the economy and society. Based on the 2-m Google Earth remote sensing image in 2020, this study interprets and constructs the farmland distribution dataset YLN-F2020 in the Yarlung Zangbo–Lhasa–Nyangqu River (YLN) region of the Tibetan Plateau, using a geostatistical analysis method to reveal the spatial distribution pattern of farmland in the research area. The results showed that: (1) the total area of farmland of the YLN-F2020 product was 2,356.15 km^2, and the overall accuracy was 95.2%. Compared with GLC2020 and LandUse2018, the accuracy of published farmland data of the Tibetan Plateau was found to be uncertain in terms of spatial distribution, which makes it difficult to meet research needs. (2) The farmland in this area was mainly distributed along rivers, with more farmland in the east than in the west, and more in the south than in the north. Farmland in the YLN region had obvious aggregation characteristics, and the spatial distribution was relatively concentrated in the southwest and east. There was a significant positive spatial correlation and spatial aggregation of farmland in the study area. This dataset can effectively solve the problem of insufficient resolution or missing farmland data of the YLN region of the Tibetan Plateau and provide a reference for rational farmland utilization and formulation of farmland protection policy.

Keywords: Tibetan Plateau; Yarlung Zangbo–Lhasa–Nyangqu River (YLN) region;; farmland spatial distribution

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[2] Sang, Y. M., Lu, Y. H., Wang, X., *et al*. Farmland distribution dataset in the Yaluzangbu River, Nianchu River and Lhasa River region of the Tibetan Plateau (2020) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2022. https://doi.org/10.3974/geodb.2022.10.04.V1. https://cstr.escience.org.cn/CSTR:20146.11.2022.10.04.V1.

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1 Introduction

Farmland is the basic resource which human society depends on for survival and development and is the basis for food production. Changes in the quantity and quality of farmland affect the stable supply of food, which in turn affects food security[1]. Food security is an important foundation for national security, and China has always prioritized safeguarding the bottom line of national food security and guaranteeing food production and supply of important agricultural products. Among them, the extraction of high-resolution spatial distribution information of farmland is prerequisite for accurately judging changes in the quantity of farmland, which can provide a data basis for the sustainable use of farmland and food security policy formulation. At present, many global land dataset products are available on the market[2–4]. But existing studies mostly use Spot 4 with 10-m, Landsat TM with 30-m, and MODIS remote sensing images with 250-m spatial resolutions as data sources for extracting farmland information[5], mapping the area range of farmland[6], developing land cover products[7], exploring the dynamic changes of farmland[8,9] and its spatial distribution pattern[10,11], and other studies; however, their data resolution and accuracy are generally low. The accuracy of farmland data of mountainous areas, especially plateau areas, which are influenced by the natural geographical environment, still needs improvement despite data processing such as multivariate data fusion and resampling before extracting information on farmland[12,13]. Some scholars have published higher-resolution data on the spatial distribution of agricultural facilities on the Tibetan Plateau[14], nonetheless, global or national high- and medium-resolution data in the plateau region are generally less accurate. Therefore, this study takes the heart of the Tibet autonomous region and an important food-producing region, the YLN region, as the research object, and obtains a high-spatial resolution farmland distribution dataset and analyses its spatial distribution characteristics by visually interpreting high-spatial resolution remote sensing images. This provides a comprehensive understanding of the distribution of farmland in the YLN region and provides a reference for scientific decisions on the use of farmland in the Tibetan Plateau.

2 Metadata of the Dataset

The metadata of the Farmland distribution dataset in the Yaluzangbu River, Nianchu River and Lhasa River region of the Tibetan Plateau (2020)[15] are shown in Table 1.

3 Data Source and Methods

3.1 Study Area

The Yarlung Zangbo–Lhasa–Nyangqu River (YLN) region of the Tibetan Plateau (87°00′E–92°35′E, 28°20′N–31°20′N) refers to the middle reaches of the Yarlung Zangbo–Lhasa–Nyangqu River basin, which include 18 counties (districts): Chengguanqu, Doilungdeqen,

Table 1 Metadata summary of the Farmland distribution dataset in the Yaluzangbu River, Nianchu River and Lhasa River region of the Tibetan Plateau

Items	Description
Dataset full name	Farmland distribution dataset in the Yaluzangbu River, Nianchu River and Lhasa River region of the Tibetan Plateau
Dataset short name	YLN-F2020
Authors	Sang, Y. M. HHZ-1737-2022, Institute of Geographic Sciences and Resources Research, Chinese Academy of Sciences, sangyiming0725@igsnrr.ac.cn Lu, Y. H. HHZ-2779-2022, Institute of Geographic Sciences and Resources Research, Chinese Academy of Sciences, luyh.20b@igsnrr.ac.cn Wang, X. 0000-0002-8158-9288, Institute of Geographic Sciences and Resources Research, Chinese Academy of Sciences, wangxue@igsnrr.ac.cn Xin, L. J. CJC-8123-2022, Institute of Geographic Sciences and Resources Research, Chinese Academy of Sciences, xinlj@igsnrr.ac.cn
Geographical region	The Yarlung Zangbo–Lhasa–Nyangqu River region of the Tibetan Plateau
Year	2020
Spatial resolution	2 m
Data format	.shp, .tif
Data size	568 MB (15.5 MB after compression)
Data files	The dataset consists of 30 data files in 4 data folders, which includes: (1) Scope geographic information system data in the YLN region; (2) spatial distribution vector data of farmland in the YLN region in 2020; (3) spatial distribution raster data of farmland in the YLN region in 2020; and (4) verification point data of farmland
Foundation(s)	Ministry of Science and Technology of P. R. China (2019QZKK0603)
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[16]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

Dagze, Lhunzhub, Nyemo, Quxu, and Maizhokunggar in Lhasa; Nedong, Chanang, Konggar, Sangri, and Qonggyai in Lhoka; and Samzhubze, Namling, Gyangze, Lhaze, Xaitongmoin, and Bainang in Xigazi (Figure 1). This region is located in the south-central part of the Tibetan Plateau and is the main part of the southern Tibetan valley. The landscape generally contains three types of mountains, hills, and plains, with altitudes ranging from 3,200–7,200 m. The overall terrain is high in the west, low in the east, high in the north and south, and low in the middle. The total land area is 6.67×10^4 km^2, of which farmland accounts for >60% of the total farmland area in the Tibet autonomous region[17]. The area is rich in water resources and has many rivers, making it suitable for the growth of many types of crops and has a well-developed animal husbandry, making it this hinterland of the Tibet autonomous region an important grain-producing region which enjoys the reputation of being the granary of Tibet. The economic development conditions of Lhasa, Xigazi, and Lhoka are better than those of the rest of Tibet, and the dense population and convenient transportation in the region make the YLN region a political, economic, transportation, and cultural center of Tibet[18].

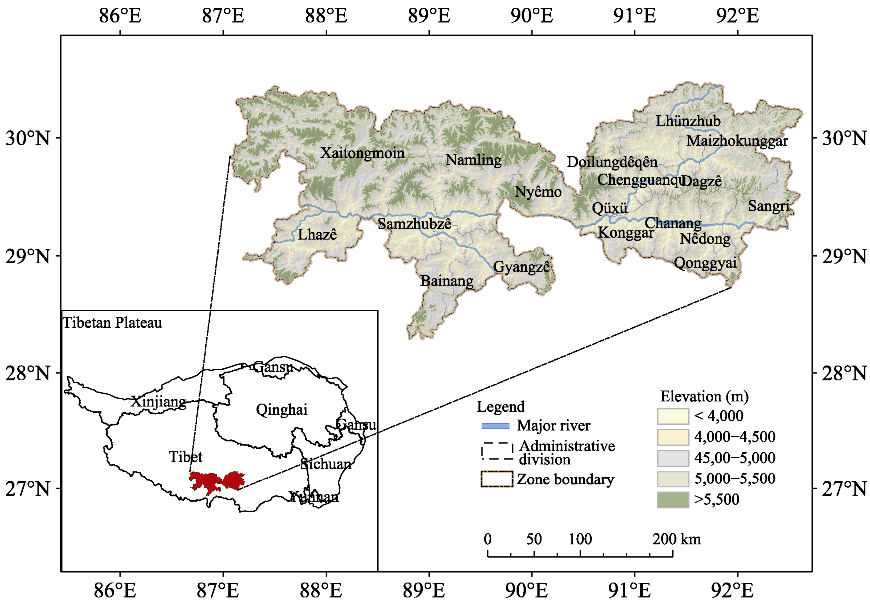


Figure 1 Location map of the research area

3.2 Data Source

In this study, the 2-m resolution remote sensing images of Google Earth in 2020 were selected as the main data source. Google Earth contains rich high-resolution satellite image data, and its satellite images have a resolution of up to submeter levels, which are widely used. The YLN-F2020 high spatial resolution data used Mercator projection with an image level of 16 and a spatial resolution of 2 m × 2 m. There were fewer clouds in the image, the image was clear, and its quality was better (Figure 2).

Figure 2 High resolution remote sensing images of YLN region

3.3 Extraction of Farmland Spatial Distribution Information

The YLN-F2020 data were obtained from high-spatial-resolution images, and the external contours of the features shown in the images were very clear. To ensure the accuracy of obtaining the farmland distribution dataset, this study used the administrative divisions of the YLN region as the boundary and identified and interpreted the farmland directly on the images through the method of visual interpretation, combining interpretation flags and a priori knowledge, and based on the physical characteristics of the farmland. ArcGIS 10.7

software was used to edit and outline the farmland, thus obtaining the farmland vector data shapefile and extracting the spatial distribution information of the farmland.

3.4 Spatial Accuracy Verification of Farmland

3.4.1 YLN-F2020 Data Product Accuracy Evaluation

To verify the accuracy of the dataset, this study used a field validation method to evaluate the accuracy of the YLN-F2020 product. In the outing expedition of the YLN region in the Tibetan Plateau, 351 standard sample plots were selected from different regions, altitudes, and soil conditions. The details of the sample plots, such as latitude and longitude locations, were recorded and vectorized in ArcGIS 10.7 software to obtain the sample point data used for validation, as shown in Figure 3.

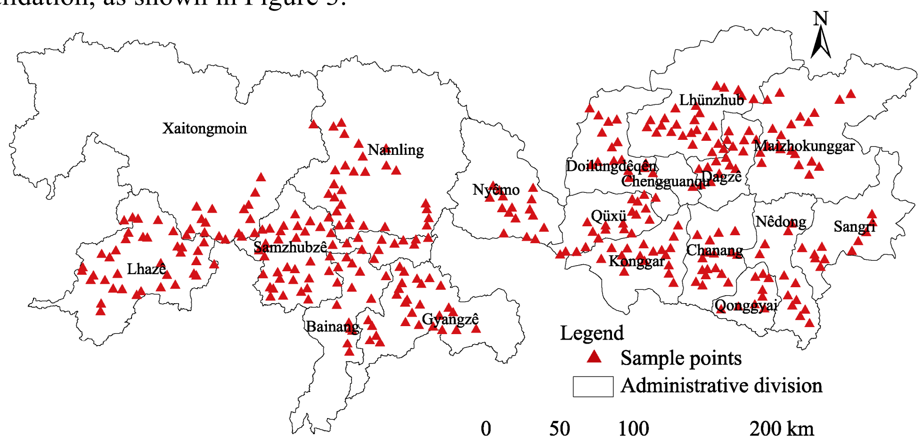


Figure 3 Sample points distribution map

3.4.2 Comparison of YLN-F2020 Data Product with Other Products

To better verify the accuracy and necessity of the extracted farmland distribution dataset, the extracted farmland data were compared with Global Land Cover30 and LandUse2018, which are publicly available with high accuracy, and the accuracy of the dataset results was evaluated. The Global Land Cover30 dataset is a global 30-m surface cover dataset led by the Ministry of Natural Resources, and has an overall classification accuracy of up to 85.72% and a Kappa coefficient of 0.82, which has given good classification results globally; however, its accuracy on the Tibetan Plateau has not yet been effectively validated.

The LandUse2018 dataset is a Chinese land-use dataset led by the Institute of Geographic Sciences and Resources of the Chinese Academy of Sciences, which mainly uses the human–computer interaction model and has been widely used in a wide area of China but has been relatively rarely used in the Tibetan Plateau. In this study, to remove the influence of the time factor, Global Land Cover30 V2020 and LandUse2018 were chosen for comparison with our YLN-F2020 dataset, as all datasets included similar time (between 2018–2020).

In terms of data processing, our data were at 2-m resolution and the spatial resolutions of Global Land Cover30 V2020 and LandUse2018 were 30- and 100-m, respectively. Therefore, in this study, the YLN-F2020 dataset was sampled up to 30- and 100-m, respectively, and to ensure that the sampling method matched the other two datasets, those with >50% of farmland area were considered farmland[19]. For data comparison, we used image-by-image comparison to count the misclassification and omission of farmland in YLN-F2020 as the standard and conducted zonal statistics.

4 Data Results and Validation

4.1 Data Products

The high spatial resolution farmland distribution dataset for the YLN region of the Tibetan Plateau contained four parts: research area extent data, farmland spatial distribution vector data, farmland spatial distribution raster data, and farmland validation points.

4.2 Data Validation

4.2.1 Accuracy Validation

The YLN-F2020 product and the field farmland sample points were verified to have the same spatial distribution characteristics. There were 351 actual available farmland sample points, of which 334 were correctly classified as farmland and 17 were omitted, with errors mainly concentrated in Namling, Chanang, and Konggar. The overall accuracy of the extracted farmland data was 95.2%, indicating that the data had high accuracy and reflected the spatial distribution of farmland in the research area.

4.2.2 Product Comparison Results

Comparing the results, GLC2020 and LandUse2018 had lower correct farmland rates, where the user's accuracy did not exceed 55%, with the highest being 53.97% for GLC2020, followed by 43.25% for LandUse2018. In terms of producer's accuracy, both products performed slightly better than user's accuracy, with the highest being 70.15% for GLC2020, followed by LandUse2018 at 53.77%. This indicates that there is still a large degree of uncertainty in the spatial distribution of publicly available farmland data on the Tibetan Plateau. Therefore, current farmland products can hardly meet the requirements of both macro-level studies on the spatial distribution of farmland and micro-level studies, such as the intensity of farmland use and its environmental effects.

From the district and county comparison perspective, the user's and producer's accuracies for both datasets did not exceed 80% in each district and county, except for the producer's accuracy of GLC2020 in Quxu county. The user's accuracy of the two products was higher in Bainang county (Figure 4), with accuracies of GLC2020 and LandUse2018 being 73.49% and 62.56%, respectively, whereas the user's accuracy in the remaining districts and counties did not exceed 60%. The producer's accuracy was highest in Quxu county, with accuracies of the two products being 83.44% and 77.86%, respectively, whereas the producer's accuracy in other districts and counties did not exceed 80%. The producer's accuracy of LandUse2018 was slightly lower, not exceeding 70%. Therefore, from the perspective of accuracy, the accuracy of GLC2020 was better than that of LandUse2018 in all districts and counties, but the two datasets were affected by the accuracy in farmland studies in districts and counties, and still have difficulties in meeting the relevant follow-up studies. From the perspective of the spatial distribution of errors (Figure 5), the misclassification was found to be mainly distributed in riverine and mountainous alluvial fan areas.

In terms of error analysis, the classification errors of GLC2020 and LandUse2018 were mainly concentrated in the land class aspect, mainly grassland, farmland, and rivers, and there were more cases of misclassification and omission. This may originate mainly from the following aspects: (1) insufficient training samples. According to the existing articles on GLC2020[20,21], the training sample points in the farmland classification algorithm were found to be mainly concentrated in plain areas with relatively flat terrain. There were fewer samples in the Tibetan Plateau, which makes it difficult to support the classification of farmland in the YLN region. (2) The image quality was poor. GLC2020 and LandUse2018 images are mainly based on Landsat and resource satellites with a spatial resolution of only 30-m and are easily affected by clouds and fog. The YLN region is mainly located in the

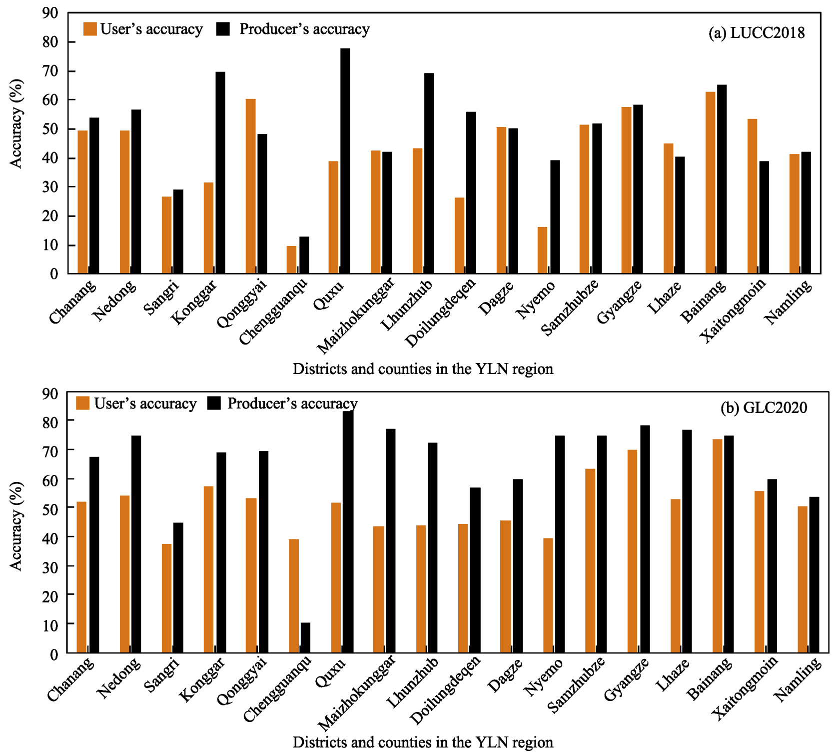


Figure 4 Comparison of GLC2020 and LandUse2018 product results based on districts and counties in the YLN region

river valley terraces where there are more clouds and fog, so it brings great challenges to the human–computer interaction of LandUse2018 and GLC2020, which mainly rely on classification algorithms. (3) Mixed image elements. A high degree of fragmentation was observed in the 30-m (approximately 0.9 ha) resolution images of farmland distribution in the YLN region. The mixed image elements are serious, and are a major source of error. (4) Limitations of classification algorithms. Currently, more classification algorithms are based on threshold methods, neural networks, and random forests. This algorithm has obvious advantages for the rapid classification and extraction of large areas. However, in many Chinese and global regional products, the Tibetan Plateau in the YLN region is often not the main focus of the product. Therefore, the limitations of these algorithms are progressively magnified in this region, making it difficult to effectively solve the "same spectrum with different objects" and "same objects with different spectrum" problems in this region, thus increasing the error rate of the product.

4.3 Data Results

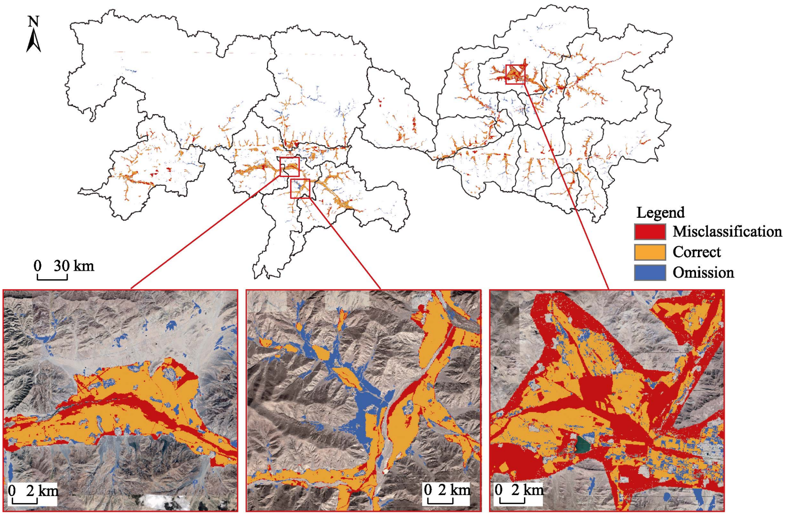
4.3.1 Regional Distribution Characteristics of Farmland in YLN Region

The total area of farmland in the YLN region was 2,356.15 km^2. As shown in the map of farmland distribution (Figure 6a), farmland was distributed along the main stream of the Yarlung Zangbo River, tributaries of the Lhasa and Nyangqu Rivers, and evenly distributed on both sides of the river, with good irrigation conditions. The farmland distribution characteristics were detected more in the east than in the west, and more in the south than in the north. The districts and counties with the most farmland in the entire region were the southwestern Samzhubze District and Lhaze county; central Gyangze, Bainang, Namling Counties; and northeastern Lhunzhub county, accounting for 58.49% of the farmland area in the entire YLN region. The largest area of farmland was in Samzhubze District, with 347.76

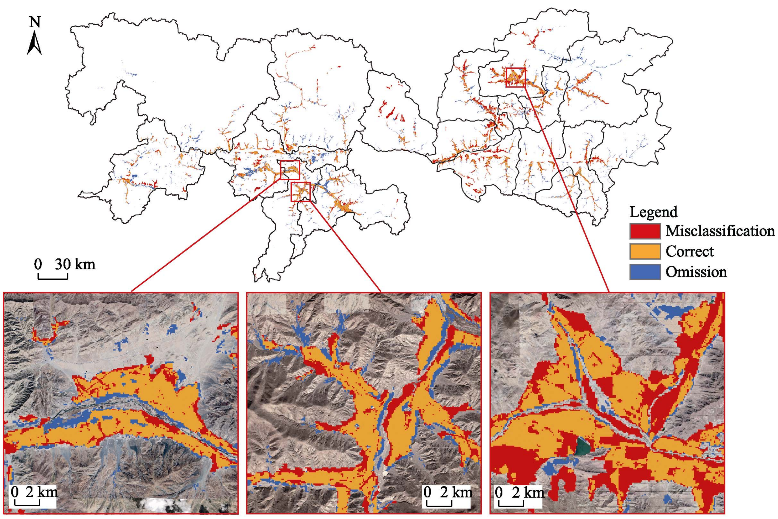
km^2 of farmland, accounting for 14.65%. This was followed by Gyangze and Lhunzhub, with farmland area of 253.47 and 248.53 km^2, accounting for 10.68% and 10.47% of all farmland, respectively. Chengguanqu had the smallest area of farmland with 11.63 km^2 accounting for only 0.49% of the total farmland in the region (Figure 6b).

4.3.2 Spatial Distribution of Farmland Density in the YLN Region

Based on the analysis of the characteristics of the regional farmland distribution, to further reflect the spatial density distribution of farmland in the YLN region, first, the farmland plots were converted to points in ArcGIS 10.7, and subsequently, the kernel density was estimated and farmland was divided into five classes using the natural breakpoint method (Figure 7). As shown in Figure 7, the spatial distribution of farmland in the YLN region showed evident differences due to topographical factors and irrigation conditions. Although the overall spatial distribution of farmland covered a wide area, regional aggregation characteristics were still visible, mainly in the southwestern and eastern density aggregation areas. The areas with higher farmland density were mainly concentrated in the flat terrain of

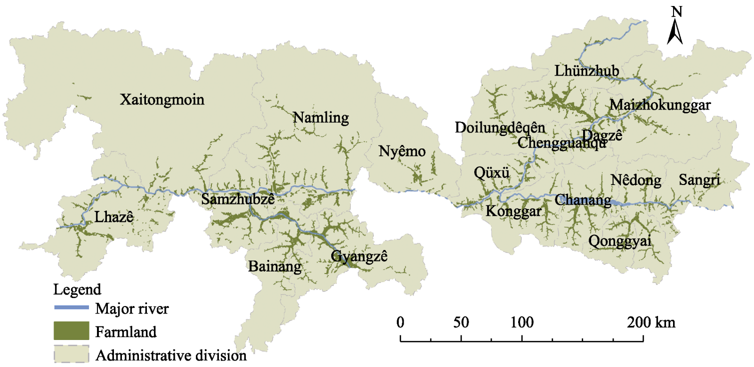


a. Farmland map produced by GLC2020 product

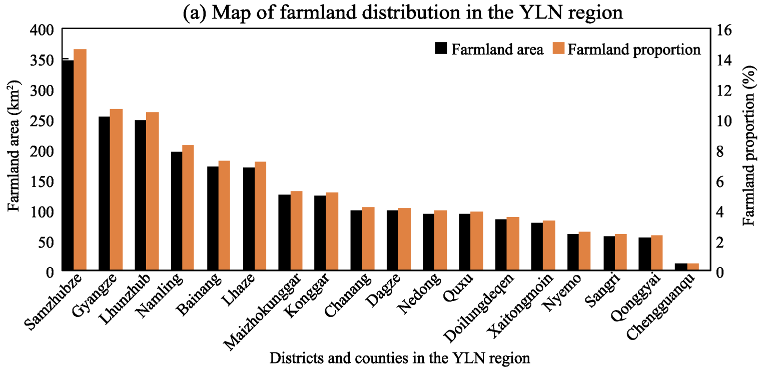


b. Farmland map produced by LandUse2018 product

Figure 5 Spatial distribution maps of farmland in the YLN region produced by GLC2020 and LandUse2018 products



(a) Map of farmland distribution in the YLN region



(b) Area and proportion of farmland in each district and county

Figure 6 Farmland distribution in YLN region

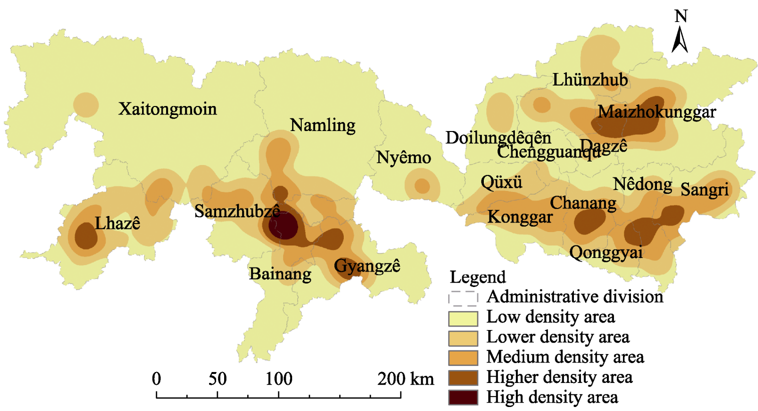


Figure 7 Kernel density estimation map of farmland

river valleys, including the southern part of Lhaze; northern parts of Bainang and Dagze; central parts of Gyangze, Chanang, and Nedong; and western part of Maizhokunggar. The areas with medium density were mainly distributed in the southern part of the research area, and the areas with low density were mainly located in the northern part of the research area.

4.3.3 Spatial Correlation Analysis of Farmland in the YLN Region

In this study, global and local autocorrelation were used to analyze the spatial correlation of farmland distribution in the research area. Township level was used as the next research scale to better reflect the spatial distribution of farmland, and the farmland occupation ratio was chosen as the attribute information to calculate global Moran's I and test its significance. The results showed that the global autocorrelation coefficient Moran's I of the research area was 0.57, which is greater than 0, indicating that farmland in the YLN region shows

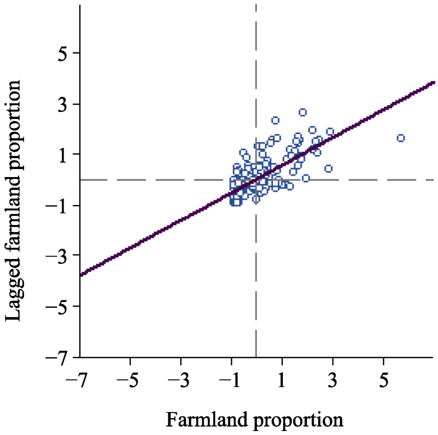


Figure 8 Moran's I scatter plot

significant spatial autocorrelation. The z-score was 14.80, which is greater than the critical value of 1.96, passing the test of significance level α=0.05, indicating that there is a clear spatial aggregation of farmland in the YLN region.

Based on global autocorrelation analysis, the local autocorrelation of the spatial distribution of farmland in the YLN region was analyzed. From the Moran's index scatter plot (Figure 8), the vast majority of areas in the YLN region seemed to be located in the first and third quadrants, indicating that the spatial distribution of farmland tends to be spatially positively correlated with high and low values of aggregation.

Furthermore, LISA agglomeration maps were used to characterize the homogeneous and heterogeneous distribution of farmland between townships and their neighbors in the YLN region. As shown in Figure 9, the LISA agglomeration map showed the following spatial association characteristics.

The "high-high" area. The townships belonging to this type were mainly located in the western part of Gyangze, northern part of Bainang, and southeastern part of Samzhubze, showing a larger area in the overall south–central agglomeration of the YLN region, with a scattered distribution in the northeast. Townships in the south–central area had a high proportion of farmland for themselves and their surrounding townships, and the topography was relatively flat with farmland distributed along the lower reaches of the river. By superimposing the slope data, the south–central and northeastern "high-high" agglomerations were found to be located near the lower reaches of the Nyangqu and Lhasa Rivers, respectively, where water resources are abundant and irrigation is convenient. The uneven slopes on both sides of the lower reaches of the Yarlung Zangbo River resulted in less farmland on the northern side and more on the southern side, hence, there was no "high-high" aggregation. Combined with population and economic development, the "high-high" area in the northeast is closer to the central city of Lhasa, which is densely populated and has better conditions for the development of the surrounding cities, so the scope of farmland gathering in the south–central part is much larger than that in the central part.

The "high-low" area. Townships belonging to this type were distributed east of Quxu. The farmland in this area was distributed along the Lhasa River, but the number of spatial units in this type of township was small, mainly represented by the high proportion of farmland in the townships but a low proportion in the surrounding townships. Although farmland was densely distributed under the influence of the river, the eastern part of Quxu was adjacent to the "low-low" aggregation area, and the distribution of farmland along the river gradually decreased and then increased, resulting in the phenomenon of "high-low" aggregation.

The "low-high" area. Townships of this type were located in Gyangze, Nedong, and Lhunzhub. The spatial relationships in this area showed clear heterogeneity, with the area showing a low proportion of farmland in the townships but a high proportion in the surrounding townships. By comparing the water distribution map, the townships in the "low-high" area were found to be affected by the water source, with the area near the river being densely distributed with farmland. The upstream water source was sufficient and the farmland was distributed in concentrated contiguous areas with large farmland areas, whereas the downstream river channel became narrower and the water source decreased sharply, resulting in a reduction in farmland area.

The "low-low" area. The townships were mainly distributed in the eastern part of Xaitongmoin, northern parts of Namling and Nyemo, and vicinity of Chengguanqu. The townships were roughly distributed in the northwest and east–central parts of the YLN region, showing a relatively good gathering trend. The northwest area of the YLN region is mountainous with high altitude and open terrain, but it is restricted by poor farming conditions, low soil organic matter content, cold and dry climate, and many other factors that are not conducive to the growth of crops. Therefore, little or no farmland was observed in this area. The main agricultural production mode in this area is animal husbandry, therefore, the proportion of farmland in townships and surrounding townships is relatively small. Chengguanqu, located in the east–central part of Lhasa, is the center of the city and has a higher level of economic development than other areas. Even though the Lhasa River passes through, farmland in this area and its surrounding areas is still less distributed.

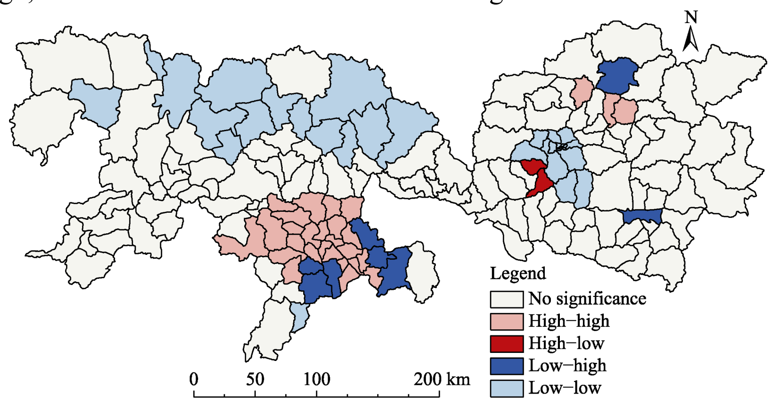


Figure 9 LISA aggregation map

5 Discussion and Conclusion

In this study, high-spatial-resolution remote sensing images were used to extract the distribution of farmland in the YLN region of the Tibetan Plateau and construct the YLN-F2020 dataset product, which was compared with other products, and its accuracy was evaluated. Moreover, the spatial distribution pattern of farmland in the research area was analyzed to reveal its spatial distribution characteristics. The overall accuracy of farmland extraction for the YLN-F2020 product was determined to be 95.2%, which is relatively high. Compared with GLC2020 and LandUse2018 products, the spatial distribution of farmland on the Tibetan Plateau was found to have large uncertainties, which could not meet research requirements. From the perspective of regional distribution, the farmland in the YLN region was mainly distributed along the rivers, showing spatial distribution characteristics of more in the east than in the west, more in the south than in the north. From the perspective of the distribution density of farmland, farmland showed characteristics of aggregation in the region, with southwest and east density aggregations. From the perspective of spatial correlation, farmland in the research area had an evident positive spatial correlation and a trend of spatial aggregation. Based on the continuous improvement and development of high-resolution remote sensing images, the research results can effectively solve the problem of insufficient resolution or missing farmland data in the YLN region of the Tibetan Plateau, and provide a data basis for the establishment of a nationwide farmland database. In addition, studying the spatial distribution pattern of farmland on the Tibetan Plateau can provide an understanding of the distribution characteristics of farmland resources in the region. In the process of social and economic development, scientific and effective knowledge of utilization of farmland resources on the Tibetan Plateau is beneficial.

Notably, the high-resolution remote sensing image used to analyze the distribution of farmland in this study only covers the data of 2020, and the data of previous years were not extracted for comparative analysis, so the dynamic change trend of farmland cannot be observed, lacking the combination of time and space. Moreover, there were a few clouds in the image; therefore, there may be some errors in visual interpretation, which may lead to the indistinct identification of ground objects. Therefore, the combination of space and time can be considered in subsequent studies of the spatial distribution of farmland, and other interpretation methods can further improve the efficiency of farmland extraction.

Author Contributions

Wang, X. and Xin, L. J. designed the algorithms of dataset. Lu, Y. H. performed data validation. Sang, Y. M. contributed to the data processing and analysis and wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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