Recent Spatiotemporal Changes in Cropland and Analysis of Cropland Quantity for Food Security in the Loess Plateau: A Postprint

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Abstract

Based on remote sensing survey datasets, we quantitatively analyzed the spatiotemporal variation characteristics of farmland and the quantitative changes in the minimum farmland area required for absolute grain security in China' s Loess Plateau region from 1990 to 2015. The results indicate that: the farmland area in the Loess Plateau decreased from 192,529.65 km² in 1990 to 182,688.50 km² in 2015, with a net reduction of 9,841.14 km², representing a magnitude of 5.11%, among which the period 2000–2010 witnessed the largest decrease, with a net reduction of 8,483.00 km²; larger dynamic change patches of farmland were mainly distributed in the central and western regions, while fragmented change patches were widely distributed; the area of farmland converted out of cultivation (31,875.82 km²) exceeded the area converted into farmland (21,815.25 km²). The increase in farmland area primarily originated from the conversion of grassland and forest, mainly distributed in irrigated agricultural zones and southeastern plain areas, whereas the decreased farmland was mainly converted into grassland and forest, primarily distributed in the rain-fed agricultural zones of the central gully region. Furthermore, during this period, the area of farmland converted into artificial surfaces such as built-up land and transportation land gradually increased, mainly distributed in the low-altitude plain areas of the southeast; the minimum farmland area required for absolute grain security in the Loess Plateau exhibited a significant decreasing trend (from 70,913.37 km² in 1990 to 33,981.64 km² in 2015), and its proportion of the total farmland area in the region showed a clear contraction (from 36.83% in 1990 to 18.60% in 2015). The current net decrease in total farmland area has not significantly impacted the quantity of farmland required for absolute grain security.

Full Text

Spatial and Temporal Changes of Cultivated Land and Quantitative Analysis of Grain Safety Cultivated Land on the Loess Plateau in Recent Years

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Abstract

Based on land cover maps and survey data, this paper quantitatively analyzed the spatial and temporal characteristics of cultivated land on the Loess Plateau in northwestern China from 1990 to 2015, and evaluated changes in the minimum cultivated land area required for grain safety. The results showed that the area of cultivated land decreased from 192,529.65 km² in 1990 to 182,688.50 km² in 2015 (a decrease of 5.11%), with the period 2000–2010 witnessing the largest change rate, showing a net decrease of 8,483.00 km². The largest decrease in cultivated land was mainly distributed in the central and western areas of the Loess Plateau, and the finely-changed pixels were widely scattered. The area converted from croplands (31,875.82 km²) was larger than that converted to cultivated lands (21,815.25 km²) during the period 1990–2015. The increased cultivated lands were mainly converted from grasslands and woodlands, which primarily occurred in the irrigated agricultural areas and southeastern plains of the Loess Plateau; while the decreased cultivated lands were mostly converted to grasslands and woodlands, and this was concentrated in the middle rain-fed farm areas of the Loess Plateau. In addition, the area of cultivated land converted to built-up land gradually increased during this period, and was mainly distributed in the low-altitude plains in the southeast of the Loess Plateau. The minimum cultivated land area for grain safety decreased from 70,913.37 km² in 1990 to 33,981.64 km² in 2015, and the corresponding percentage (accounted for total cultivated land) decreased from 36.83% to 18.60%. However, the decrease of cultivated land has negligible impact on grain safety on the Loess Plateau.

Keywords: cultivated land; minimum area of cultivated land demanded; variation characteristics; Loess Plateau

2. Results and Analysis

2.1 Data Sources and Processing The study utilized land cover data derived from remote sensing imagery and statistical surveys. ArcGIS and Matlab software were employed for spatial analysis and data processing. Four time periods were analyzed: 1990, 2000, 2010, and 2015. The study area spans 103°–114°E and 34°–40°N, covering approximately 640,000 km², which represents about 6.67% of China' s total land area and one-tenth of its cultivated land resources.

The Loess Plateau exhibits significant spatial heterogeneity in climate, with precipitation ranging from 600–800 mm in the southeastern region to 100–200 mm in the northwestern area. The region comprises diverse landforms including gully slopes, broken plateaus, sand-covered areas, and earth-rock mountainous regions, making it representative of transitional zones between arid and semi-arid environments.

2.2 Temporal Changes in Cultivated Land Area From 1990 to 2015, the total cultivated land area on the Loess Plateau decreased by 9,841.14 km², representing a 5.11% decline. The most dramatic reduction occurred during the 2000–2010 period, when the area decreased by 8,483.00 km². The spatial distribution of cultivated land showed distinct patterns across different time intervals.

During 1990–2000, the cultivated land area decreased from 192,529.65 km² to 192,941.21 km², with a net increase of 411.56 km² in some regions and a decrease of 7,867.62 km² in others, resulting in a net change of -7,456.06 km². The period 2000–2010 saw the most significant reduction, with cultivated land decreasing to 184,662.03 km². From 2010–2015, the trend continued, with the area further declining to 182,688.50 km².

2.3 Spatial Distribution and Conversion Patterns The spatial analysis revealed that cultivated land conversion followed distinct regional patterns. The increased cultivated lands were primarily converted from grasslands and woodlands, concentrated in irrigated agricultural zones and the southeastern plains. Conversely, decreased cultivated lands were mainly transformed into grasslands and woodlands, particularly concentrated in the middle rain-fed farming areas.

Built-up land expansion onto cultivated land showed a gradual increase throughout the study period, predominantly occurring in low-altitude plains in the southeastern Loess Plateau. The conversion patterns varied significantly across the three sub-periods: 1990–2000, 2000–2010, and 2010–2015, reflecting different policy implementations and socioeconomic drivers.

2.4 Grain Safety Cultivated Land Assessment The minimum cultivated land area required for grain safety was calculated based on per capita grain demand, crop yields, and population data. The results demonstrated a substantial decrease in the required area from 70,913.37 km² in 1990 to 33,981.64 km² in 2015. This reduction was driven by improvements in agricultural productivity and changes in dietary structure.

The proportion of grain safety land to total cultivated land decreased from 36.83% in 1990 to 18.60% in 2015, indicating that despite the overall reduction in cultivated land area, the region' s grain security situation improved. The calculations accounted for variations in grain yield per unit area across different ecological zones, with higher yields in irrigated areas compared to rain-fed regions.

The analysis shows that the Loess Plateau maintained adequate grain production capacity throughout the study period, with the actual cultivated land area consistently exceeding the minimum requirement for grain safety. The largest safety margin occurred in 2015, when the actual cultivated land area was approximately 148,706.86 km² greater than the minimum required area.

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Note: Figure translations are in progress. See original paper for figures.