RESEARCH ARTICLE

# The effects of agricultural land consolidation on carbon and ecosystem service value changes in Jiangxi Province, China

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**Based on the characteristics of agricultural production in Jiangxi Province, China, the changes of agricultural carbon emission and carbon fixation in various cities were estimated for the whole process of soil respiration, agricultural production, and crop output from 2010 to 2020. Then, a linear regression model was established based on the significant correlation between rice paddy planting and net agricultural carbon storage. By collecting and sorting out the geographic coordinate data of the agricultural land consolidation projects in Jiangxi Province, this study explored if the agricultural land consolidation could improve net agricultural carbon storage by increasing vegetation productivity, and ecosystem service value (ESV) by changing land use types. Also, relevant paths and evaluation methods were discussed, and a quantitative analysis was made. It could be concluded that, from 2010 to 2020, agriculture in Jiangxi Province realized net carbon sink, although there were ups and downs every year. In terms of land use types, cultivated land contributed the most to agricultural carbon sources and sinks in Jiangxi Province. As the key component of crop carbon storage in Jiangxi Province, rice paddy production accounted for 60% of the sown area, 90% of total crop output, and 93% of carbon storage among all the crops. Low-carbon rice farming was the best solution to the low-carbon development of agriculture in Jiangxi Province. By improving the cultivated land and plant production capacity, agricultural land consolidation projects in Jiangxi Province increased the net agricultural carbon storage by 709,600 tons of carbon (t C) per year, while increased the ESV by ¥230 million (CNY) per year through changing the land use types, such as converting the construction land into agricultural land.**

**Keywords:** carbon effect; ecosystem services value; land use type; agricultural land consolidation.

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## Introduction

At present, land use and global climate change have become common concerns in the world. The land consolidation, especially agricultural land consolidation, is an essential way for optimizing the large-scale land use in China. Both domestic and international researchers have performed various studies on agricultural land consolidation based on the impact of land use change on the ecological environment [1-4]. Currently, the goal of agricultural land consolidation in China is being gradually transformed from merely increasing cultivated land and higher productivity to ecological civilization and balanced development. Relevant studies mainly focus on the typical terrestrial ecosystem and regional land use, rather than the carbon effects of agricultural land consolidation, not to mention the specific land consolidation projects. Moreover, there are some pending issues such as unclear carbon source/sink function of the land consolidation projects and unclear carbon effects before and after consolidation. The carbon emission measurement methods and carbon emission reduction approaches are still to be studied in terms of land consolidation.

Focusing on individual or multiple projects from the perspective of energy consumption brought by land consolidation, most international studies dedicated to the estimation of the carbon effects or currency value brought by energy reduction through calculating the transportation cost saved from land consolidation projects [1-8], while the domestic studies focused on individual agricultural land consolidation projects [9, 10]. However, domestic studies are also gradually shifting to comprehensive study on the effects of land consolidation on energy consumption, crop growth, land use structure, and production modes [9, 11-16]. In addition to soil field sampling, the study methodology mainly consists of indirect assessments and measurements. The agricultural carbon emission mainly comes from the following seven sources including (1) the direct or indirect carbon emissions from agriculture in the production and use of agricultural inputs such as chemical fertilizers, pesticides, and agricultural films; (2) the direct or indirect consumption of fossil fuels from the use of agricultural machinery, which mainly refers to the carbon emissions from agricultural diesel; (3) the greenhouse gas emissions directly or indirectly caused by the destruction of soil organic carbon pool and the great loss of organic carbon into the air in the process of land plowing; (4) the carbon released from the indirect consumption of fossil fuels by electric energy in the process of irrigation; (5) methane emitted from the crop production (mainly rice paddy); (6) $CO_2$ released by soil respiration, especially the $CO_2$ released from cultivated land and garden soil including soil microbial respiration, living root respiration, soil animal respiration, and other abiotic process (chemical oxidation of carbonaceous substances); (7) nitrous oxide emitted from agricultural land including $N_2O$ emissions directly caused by the application of nitrogen fertilizer and manure and straw returning, and $N_2O$ indirectly emitted by atmospheric deposition and nitrogen runoff and leaching loss [4]. The agricultural carbon sink mainly comes from cultivated or orchard field and output of different crops.

Jiangxi Province is one of the most important rice paddy production areas in China. The perennial rice paddy accounts for about 85-90% of the food crops in Jiangxi Province, and the total rice output accounts for about 95% of the total grain output. Also, the area of double-cropping and triple-cropping rice paddy is constantly expanding. With the agricultural modernization, many inputs with large carbon emissions such as chemical fertilizers, pesticides, and agricultural films have been applied causing severe carbon emission in Jiangxi Province. Agriculture, as a sector with great significance in Jiangxi Province, demonstrates different production efficiencies in various regions. Hence, agricultural land consolidation, as an important means to improve agricultural production efficiency, was analyzed quantitatively in this study based on its impact on carbon budget and ecosystem service value in various regions of Jiangxi Province to provide the insights and references for formulating differentiated agricultural carbon reduction policies.

## Materials and methods

### Geographic information of the interested region

Jiangxi Province, China is located between 113°34′36″ to 118°28′58″ E and 24°29′14″ to 30°04′41″ N in the south of Yangtze River. The landforms are dominated by mountains and hills, which account for 36% of the province's area. Specifically, landform in Jiangxi Province is made up of 42% of hills, 12% of plains, and 10% of water area.

**Data resources**

The data involved in this study were retrived from the following resources.

**(1) Satellite image data:**

The data were obtained from the websites of Resource and Environment Science and Data Center of Chinese Academy of Sciences (https://www.resdc.cn) and the Normalized Difference Vegetation Index (NDVI) of MODIS13Q1 standard vegetation index product of Jiangxi Province from National Aeronautics and Space Administration (NASA) of the United States (https://www.nasa.gov), which mainly included the data of land use and cover type.

**(2) Meteorological data:**

The meteorological data in this study were mainly obtained from National Climatic Data Center of China Meteorological Administration (http://data.cma.cn/), which included the monthly temperature, precipitation, and sunshine hours from 25 meteorological stations in Jiangxi Province and 10 meteorological stations in neighboring Provinces.

**(3) Data of agricultural land consolidation projects:**

The data mainly came from relevant information systems of the land department. Various attributes were involved such as project name, approval date, area, location, investment, and spatial data such as coordinate of land consolidation projects, as well as the coordinate points, project red line map, some typical project area planning and design reports, planning and design drawings, and project budget tables. Grain production capacity data came from agricultural sector and field studies.

**(4) Data of land use status:**

The data were obtained from the survey statistics on resource of environment data cloud platform every year including the land use status maps, tables, and other information. The current land use data of each year during the study period and the previously processed delineations of agricultural land consolidation project were superimposed and examined to get the data of land use changes in the project area.

**(5) Socio-economic data:**

The data were obtained from the Statistical Yearbook of Jiangxi Province (http://www.jiangxi.gov.cn/col/col424/index.html) and agricultural sector (http://nync.jiangxi.gov.cn/col/col27869/index.html) including GDP, population density, urban construction land, food prices, output, and data of planting area over the years from 2010 to 2020.

**Data processing**

All acquired data were analyzed by using platform software including ArcGIS 10.7 (ESRI Inc, Redlands, California, USA) and ENVI 5.5 (Exelis Visual Information Solutions, Melbourne, FL, USA). The data of the agricultural land consolidation projects were divided into three groups. The first one was the vector data of agricultural land consolidation projects collected in the “rural land consolidation monitoring and supervision system”, which included not only spatial information such as the project coordinates, but also attribute information such as the project name, approval date, area, location, and financial investment. These data were saved on a project basis with one project one record. In fact, a project might include several projected subareas. Therefore, one project record might contain multiple separate delineations. In order to facilitate subsequent analysis, such projects were segmented, so that, each record corresponded to only one delineation. The other two groups of land consolidation data were collected from different departments. One was the text files of range coordinates of the project area, which were converted by Python script programming to vector graphics. Another one was the red line maps of the project area. Most of such maps were in CAD format and could be converted into vector format compatible with the first group of project data by GIS software. Since the last two groups of data only had project names after being converted into vector data and there was a shortage of other relevant attributes, it was necessary to perform the association operation on the attributes in the database software. In this study, the corresponding attribute databases were linked in SQL Server2008 R2 environment (Microsoft Corporation, Redmond, Washington, USA).

### Calculation of carbon budget of agricultural resources

Carbon emission/sink from agriculture was calculated by using the following formula:

$$E_t = \sum_{i=1}^{n} E_{ti} = \sum_{i=1}^{n} T_i \times \delta_i \tag{1}$$

where $E_t$ was the total carbon emission/sink of agriculture in the year $t$, $E_{ti}$ was the total carbon emission/sink of agricultural carbon category $i$ in the year $t$, $T_i$ was the amount of substance with agricultural carbon emission/sink source $i$ or the area of soil respiration land $i$ in the year $t$, $\delta_i$ was the carbon emission/sink coefficient of carbon category $i$, $i$ was the category of agricultural carbon emission/sink sources where carbon emission included soil respiration of cultivated land, soil respiration of orchard field, chemical fertilizer, pesticide, agricultural film, agricultural diesel, plowing, agricultural irrigation, and early and middle rice or late rice cultivation, carbon sink included soil respiration of cultivated land, soil respiration of orchard field, and output of crops. The carbon emission coefficients of various agricultural carbon sources and carbon absorption coefficients of various agricultural carbon sinks were obtained from relevant studies [17, 18].

### ESV measurement and calculation

With the references to the current ESV evaluation method [19, 20], the standard equivalent factor of ESV was considered to be equal to 1/7 of the economic value of food crops produced on 1 $hm^2$ farmland. Land use forms, which could be divided into forest, grassland, farmland, wetland, desert, river, and lake, had different ESV coefficients considering the differences of ecosystem types. ESV changes within the agricultural land consolidation delineation were quantified based on the sum of ESV calculated in each land use form.

## Results

### Agricultural carbon budget in Jiangxi Province

### (1) Change of annual agricultural carbon budget in Jiangxi Province

The total annual agricultural carbon emission in Jiangxi Province, China increased from 37.2901 million t C in 2010 to 39.3063 million t C in 2020, while the total annual agricultural carbon sink decreased from 45.6052 million t C in 2010 to 44.8378 million t C in 2012 and then increased year by year to 47.3764 million t C in 2020. The carbon sink/source ratio over the years was 117.80 – 122.30%. From 2010 to 2020, the net annual agricultural carbon storage fluctuated within the range of 6.8099 – 8.3151 million t C. The net annual agricultural carbon storage in 2010 reached 8.3151 million t C but was less in 2012 and 2016 (7 million t C). However, it rebounded to more than 8 million t C in 2018 and 2020, but still not reached the level of 2010 (Figure 1).

### (2) The trend of agricultural carbon budget in Jiangxi Province

For the different agricultural carbon sources in Jiangxi Province in 2020, the emission from soil respiration in cultivated land accounted for 68%, while the chemical fertilizer, late rice cultivation, rural electricity consumption, early rice cultivation, middle-season rice cultivation, and garden soil respiration took 7.59%, 6.09%, 5.99%, 5.12%, 2.61%, and 0.67%, respectively. The total carbon emission from agricultural film, pesticide, agricultural irrigation, and plowing accounted for 0.68%. For the mix of agricultural carbon sink, the carbon fixation in the cultivated land, crops, and garden land accounted for 51.68%, 47.60%, and 0.73%, respectively. Among the crops, rice contributed the most to carbon fixation, fluctuating in the range of 85.15 - 95.87% from 2010 to 2020 (Figure 2A), while its cultivation contributed to the whole agricultural carbon emission fluctuating in the range of 14.93 –

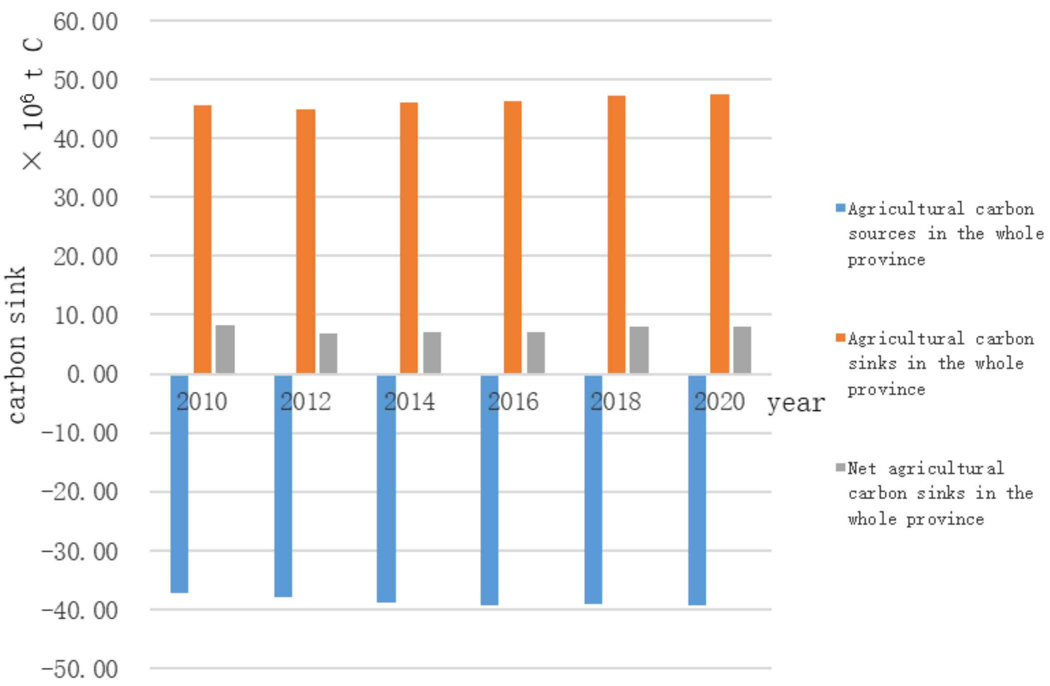

**Figure 1.** Agricultural carbon sources, carbon sinks, and net storage in Jiangxi Province, China.

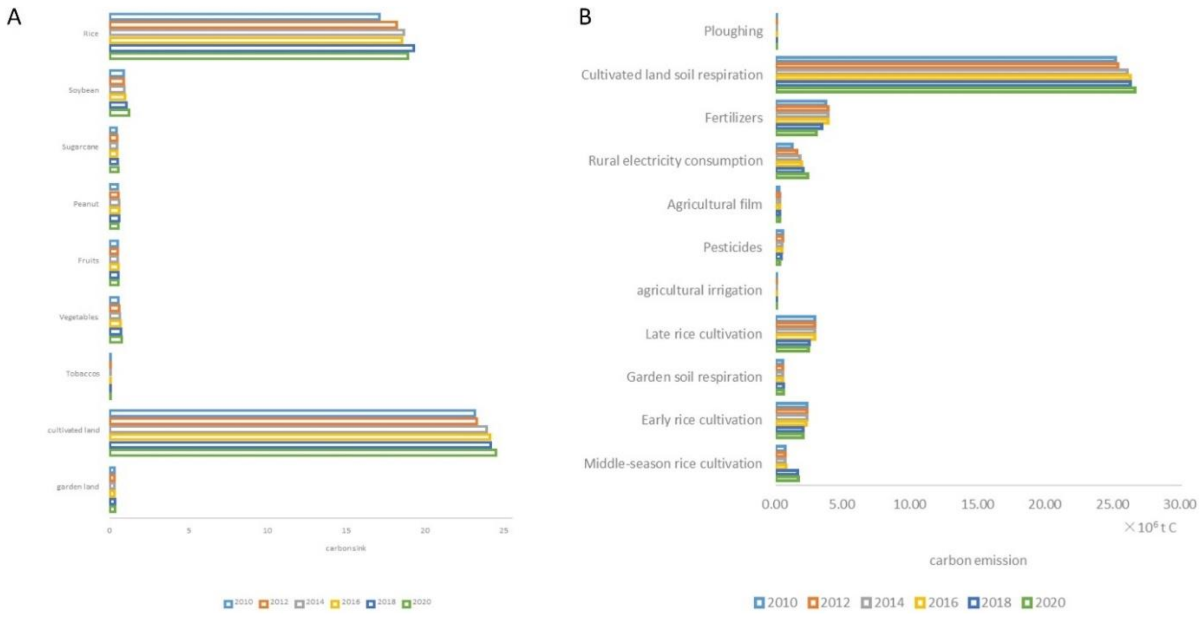

**Figure 2.** Sources of agricultural carbon fixation (A) and emission (B) in Jiangxi Province, China from 2010 to 2020.

15.74% from 2010 to 2020 (Figure 2B).

### (3) Relationship between net agricultural carbon storage and rice paddy yield in Jiangxi Province, China

Rice paddy production is the key component of crop carbon storage in Jiangxi Province, China. Rice paddy accounted for 60% of crop sown area with its production taking 90% of total crop production, and 93% of crop carbon storage.

**Table 1.** Linear models of net agricultural carbon storage (t C) and rice yield (t) in the cities of Jiangxi Province, China.

| City | Correlation coefficients | Linear regression coefficient based on the relationship between rice yield and net agricultural carbon storage ($B_i$) | Calculation base of net agricultural carbon storage (t C) ($c_i$) |
|---|---|---|---|
| **Nanchang** | 0.9160 | 1.3906 | -2,171,567.06 |
| **Jingdezhen** | 0.8653 | 1.2795 | -330,690.81 |
| **Pingxiang** | 0.8866 | 1.2017 | -398,958.48 |
| **Jiujiang** | 0.6957 | 1.9774 | -2,475,392.18 |
| **Xinyu** | 0.6482 | 1.2653 | -524,056.35 |
| **Yingtan** | 0.5834 | 1.1486 | -476,365.87 |
| **Ganzhou** | 0.7961 | 1.9679 | -4,366,150.50 |
| **Ji'an** | 0.8808 | 1.6131 | -4,093,796.09 |
| **Yichun** | 0.9650 | 1.1374 | -2,403,979.70 |
| **Fuzhou** | 0.9707 | 1.0489 | -1,325,374.03 |
| **Shangrao** | 0.6955 | 0.3228 | -8,494.39 |

Obviously, low-carbon rice farming is the best way to develop low-carbon agriculture in Jiangxi Province. There was a sound linear relationship between the net agricultural carbon storage and the rice yield in all cities of Jiangxi Province, and the correlation coefficient reached 0.58 - 0.92. Therefore, the net agricultural carbon storage could be estimated based on the newly increased rice yield. A model for estimating net agricultural carbon storage based on rice yield in Jiangxi Province was established in this study as follow:

$$C_t = \sum_{i=1}^{n} C_{ti} = \sum_{i=1}^{n} A_{ti} \times B_i + c_i \quad (2)$$

Where $C_t$ was the total net carbon storage of agricultural production in the year $t$ (t C), $C_{ti}$ was the net carbon storage in the agricultural production of crop $i$ in the year $t$ (t C), $A_{ti}$ was the rice production of area $i$ in year $t$ (t), $B_i$ was the linear regression coefficient of net agricultural carbon storage based on rice yield in area $i$, $c_i$ was the calculation base of net agricultural carbon storage in area $i$ (t C). The linear model coefficients of net agricultural carbon storage (t C) and rice yield (t) for $A_{ti}$ and coefficient $B_i$ of various cities in Jiangxi Province were listed in Table 1.

Further, a model for estimating the net agricultural carbon storage based on the increased rice yield in Jiangxi Province was established as follow:

$$\Delta C_t = \Delta \sum_{i=1}^{n} C_{ti} = \sum_{i=1}^{n} \Delta A_{ti} \times B_i \quad (3)$$

where $\Delta C_t$ was the net increased carbon storage of agriculture in the year $t$ (t C), $\Delta C_{ti}$ was the net increased carbon storage of agriculture in the area $i$ in the year $t$ (t C), $\Delta A_{ti}$ was the increased rice yield in the area $i$ in the year $t$ (t), $B_i$ was the linear regression coefficient of net agricultural carbon storage in area $i$ based on rice yield (Table 1).

## Agricultural land consolidation in Jiangxi Province, China

### (1) Scale of agricultural land consolidation projects in Jiangxi Province

From 2010 to 2020, the total area of cultivated land in Jiangxi Province increased from 4.6177 million hectares to 4.8867 million hectares with an increase of 268,900 hectares. During the same period, a total of 1,336 agricultural land consolidation projects were implemented with a total consolidation area of 318,130.08 hectares (Figure 3). Spatially, agricultural land consolidation projects in Jiangxi Province were mainly distributed in four cities including Shangrao, Nanchang, Yichun, and Ganzhou with a total consolidation area of 204,342.41 hectares, accounting to 64.23% of the total area inside the

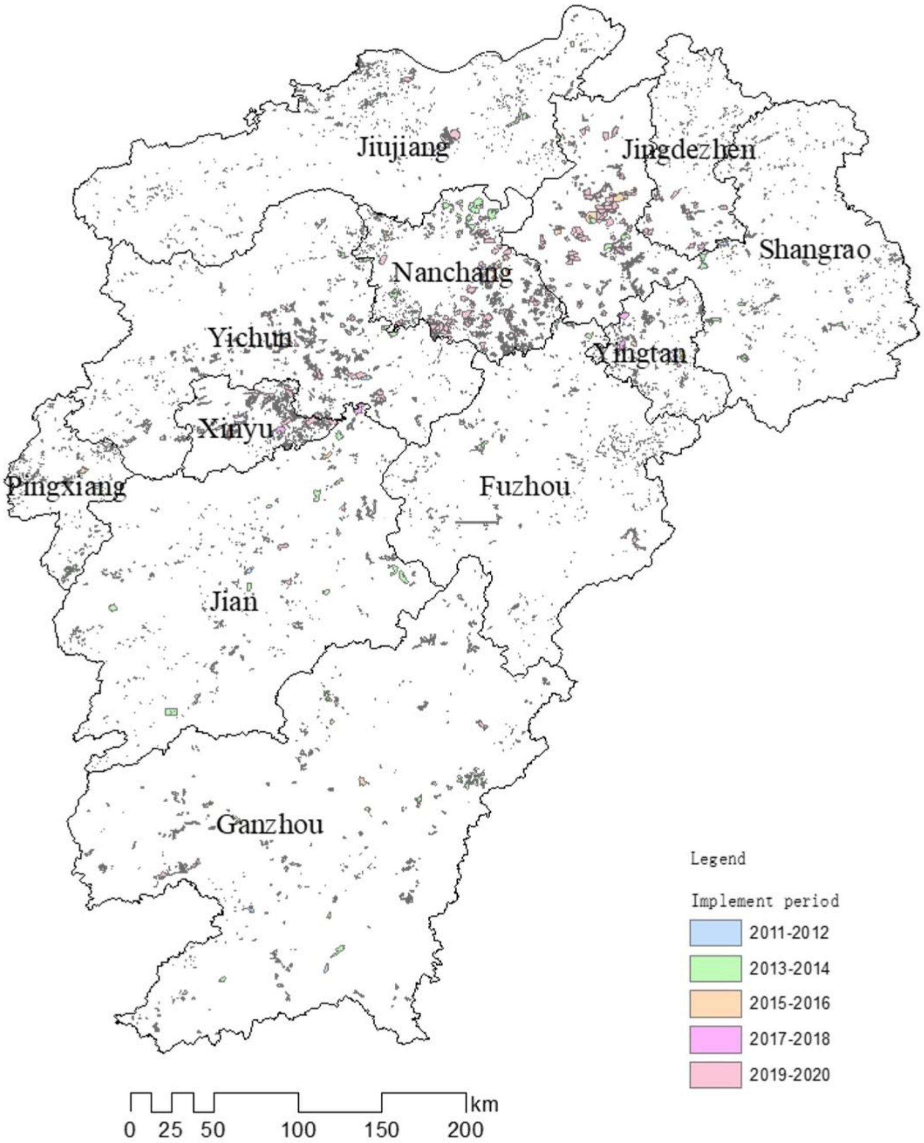

**Figure 3**. Consolidation area range of agricultural land consolidation projects implemented in the different period in Jiangxi Province, China.

province. Statistical analysis showed that the consolidation of agricultural land could effectively improve the quality of cultivated land and increase the net primary productivity (NPP) significantly. The analysis on rice production capacity of the plots involved in the agricultural land consolidation project in Jiangxi Province demonstrated that the rice production capacity had been significantly improved with a total annual increase of 610,400 tons of rice including 155,961.80 tons in Shangrao City, 77,436.27 tons in Ji'an City, 70,604.38 tons in Yichun City, 70,183.98 tons in Nanchang City, and 67,677.39 tons in Ganzhou City with 1,281 plots being consolidated. The annual output of newly increased rice in these five cities accounted for 72.39% of the total annual output in the whole province, while remarkable achievements had also been obtained in improving the quality of cultivated land.

### (2) Conversion of land use types in agricultural land consolidation in Jiangxi Province

**Table 2.** Land use transfer matrix of agricultural land consolidation projects in Jiangxi Province from 2010 to 2020.

| Land type before conversion | Area (ha) of land type after conversion | | | | | | |
|---|---|---|---|---|---|---|---|
| | Farmland | Construction | Forest | Rivers/ lakes | Grassland | Deserts | Total area converted |
| **Farmland** | - | 8,829.02 | 8,235.78 | 3,468.80 | 25.56 | 0.88 | 20,560.04 |
| **Construction land** | 3,956.94 | - | 124.43 | 210.63 | 2.44 | 1.34 | 4,295.78 |
| **Forestland** | 9,916.44 | 259.16 | - | 68.15 | 6.58 | 0.06 | 10,250.39 |
| **Rivers/lakes** | 3,040.08 | 294.50 | 51.77 | - | 4.64 | 0.50 | 3,391.49 |
| **Grassland** | 305.55 | 19.36 | 47.93 | 2.73 | - | 3.59 | 379.16 |
| **Deserts** | 28.42 | 4.38 | 0.02 | 1.09 | 7.50 | - | 41.41 |
| **Total** | 17,247.42 | 9,406.42 | 8,459.93 | 3,751.40 | 46.71 | 6.37 | 38,918.26 |

**Table 3.** Increase of rice capacity and net agricultural carbon storage in cities of Jiangxi Province from 2010 to 2020.

| Project locations | Rice capacity increased (ton) | Net agricultural carbon storage increased (t C) |
|---|---|---|
| **Total** | 610,357.92 | 709,556.40 |
| **Shangrao** | 155,961.80 | 50,338.74 |
| **Ji'an** | 77,436.27 | 124,911.24 |
| **Yichun** | 70,604.38 | 80,307.01 |
| **Nanchang** | 70,183.98 | 97,597.94 |
| **Ganzhou** | 67,677.39 | 133,182.80 |
| **Xinyu** | 41,792.02 | 52,880.57 |
| **Fuzhou** | 40,397.50 | 42,372.47 |
| **Jiujiang** | 31,874.04 | 63,027.48 |
| **Yingtan** | 27,989.81 | 32,149.18 |
| **Pingxiang** | 13,396.02 | 16,097.75 |
| **Jingdezhen** | 13,044.70 | 16,691.23 |

Among the 318,130.08 hectares of consolidated agricultural land in Jiangxi Province, many of them were converted from one type of land use to another (Table 2). A total area of 38,918.26 hectares were converted accounting to 12.23% of the total agricultural land consolidation area. Specifically, 17,427.42 hectares of farmland were converted from other types of land use, accounting for 44.32% of the total converted area including 9,916.44 hectares of forestland, 3,956.94 hectares of construction land, and 3,040.08 hectares of water areas. It had proved that the process of developing forest land, reclaiming construction land, and occupying water area had taken place respectively in the process of agricultural land consolidation. A total of 9,406.42 hectares of construction land were converted from other types of land use including 8,829.02 hectares of farmland due to the building of farm tractor roads and occupied by farm facilities in the process of agricultural land consolidation. A total of 8,459.93 hectares of forestland were converted from other types of land use including 8,235.78 hectares from farmland, which proved that farmland was returned to forests for protecting the fields in the process of agricultural land consolidation. In addition, a total of 3757.40 hectares of water areas were converted from other types of land use. Of which, 3,468.80 hectares came from farmland, which proved that the agricultural land had played a role of returning farmland to rivers and lakes in the process of consolidation.

## Carbon effect of agricultural land consolidation in Jiangxi Province

According to the model of net agricultural carbon storage based on rice yield in the cities across Jiangxi Province, the increased net agricultural carbon storage in the whole province was

**Table 4.** ESV change of cities in Jiangxi Province from 2010 to 2020.

| City | ESV Change (¥10,000, CNY) in the different year | | | | | |
|---|---|---|---|---|---|---|
| | 2012 | 2014 | 2016 | 2018 | 2020 | TOTAL |
| **Fuzhou** | -11.46 | -385.24 | 77.28 | 121.06 | -387.84 | -586.20 |
| **Ganzhou** | -84.05 | -95.65 | -653.80 | 113.79 | -6,600.64 | -7,320.35 |
| **Ji'an** | 62.53 | -1,140.54 | 31.07 | -116.11 | -3904.10 | -5,067.16 |
| **Jingdezhen** | -17.79 | -175.19 | -0.66 | -2.06 | -881.09 | -1,076.79 |
| **Jiujiang** | -28.13 | 25.89 | 158.90 | -92.58 | -2,349.45 | -2,285.37 |
| **Nanchang** | -8.81 | 49.13 | -40.84 | 302.34 | -507.65 | -205.82 |
| **Pingxiang** | -20.75 | -257.00 | -101.74 | -3.42 | -1,330.29 | -1,713.20 |
| **Shangrao** | -60.13 | -40.26 | 58.31 | 52.90 | 5261.91 | 5,272.73 |
| **Xinyu** | -43.12 | 23.31 | 474.67 | 139.67 | -970.11 | -375.58 |
| **Yichun** | 10.99 | -60.94 | 45.08 | 175.96 | -2,031.92 | -1,860.83 |
| **Yingtan** | -11.44 | -189.93 | 22.03 | -19.20 | -723.89 | -922.42 |
| **Total** | -212.15 | -2,246.43 | 70.29 | 672.36 | -14,425.06 | -16,141.00 |

estimated to be 709,556.40 t C through the agricultural land consolidation projects including net agricultural carbon storage in Ganzhou and Ji'an which exceeded 100,000 t C and reached 133,182.80 and 124,911.24 t C, respectively (Table 3).

### Changes of ESV in the agricultural land consolidation in Jiangxi Province

The total converted area from land use changes in Jiangxi Province reached 38,918.26 hectares. As the results, the ESV was decreased by ¥1,030.2551 million (CNY), while increased by ¥868.8452 million (CNY) with a net decrease of ¥161.41 million (CNY). The land type conversion with larger increment in ESV were farmland-forest, farmland-rivers/lakes, and construction land-farmland with ¥435.7404 million, ¥313.4537 million, and ¥79.2993 million (CNY), respectively. The land type conversion with big reduction in ESV were forest-farmland, rivers/lakes-farmland, and farmland-construction land with -¥525.0278 million, -¥267.2454 million, and -¥178.3197 million (CNY), respectively. The ESV from agricultural land consolidation in Jiangxi Province also presented a spatial-temporal change pattern. The increments of ESV in 2016 and 2018 were ¥702,900 and ¥6,723,600 (CNY), respectively, and the cumulative increment of ESV in Shangrao City was ¥52.7273 million (CNY). The land use changed from low ESV types such as construction land and unused land to farmland played an important role for the increments of ESV, but farmland consolidation in the province as a whole had a negative impact on ESV (Table 4).

## Discussion

From 2010 to 2020, the total amount of agricultural carbon emission in Jiangxi Province, China kept increasing, while the total amount of agricultural carbon sinks fluctuated within the range of 6.8099 - 8.3151 million t C. Rice production had the greatest impact. During this period, a total of 1,336 agricultural land consolidation projects were implemented with a total area of 318,130.08 hectares. From the spatial distribution, agricultural land consolidation projects in Jiangxi Province were mainly distributed in four cities including Shangrao, Nanchang, Yichun, and Ganzhou. By effectively improving the quality of cultivated land, the agricultural land consolidation in Jiangxi Province had greatly improved the rice production capacity with 1,281 plots being enhanced and a total rice annual increase of 610,400 tons, while the net agricultural carbon storage was expanded by 709,556.40 t C.

Farmland consolidation was still dominated by cultivated land with a converted area of 38,919.55 hectares, accounting for 12.23% of the total farmland consolidation area. As a result, ESV decreased by ¥1,030.2551 million (CNY) and increased by ¥868.8452 million (CNY) with a net decrease of ¥161.41 million (CNY). In 2016 and 2018, the ESV increased by ¥702,900 (CNY) and ¥6,723,600 (CNY), respectively. The cumulative increment of ESV in Shangrao City was ¥52.7273 million (CNY) through agricultural land consolidation. The land use types that were converted from low ESV types such as construction land and unused land to farmland played an important role, but, according to the overall trend, farmland consolidation had a negative impact on ESV. It was proved that only a limited area of construction land and unused land area could be used for consolidation. Therefore, they cannot become the main source of new cultivated land. Intensive use of cultivated land and quality improvement of cultivated land should still be regarded as the major method to improve the agricultural land consolidation. Therefore, it is necessary to improve the planning and design, allocate budget, and complete acceptance of land consolidation according to the specific zoning conditions, and improve the project implementation budget and construction quality. Also, ESV changes in the evaluation of agricultural land consolidation should be included as a constraint to realize the low-carbon and environmentally friendly development of the land consolidation project.

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