Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268 e-ISSN: 2395-3454	Vol. 17	No. 2	pp. 383-390	2018

Original Research Paper | Open Access

Carbon Emission Measurement Using Different Utilization Methods of Waste Products: Taking Cotton Straw Resources of South Xinjiang in China as an Example

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 12-02-2018
Accepted: 15-04-2018

Key Words:
Agricultural waste
Carbon emission
Cotton straw
Recycling

ABSTRACT

Agricultural non-point source pollution is mainly caused by the improper utilization of agricultural waste, and thus agricultural waste recycling is considered the main method for reducing the extent of such pollution and ensuring the safety of agricultural resource utilization and agricultural ecological environment. To reduce agricultural non-point source pollution, the carbon emissions of agricultural cotton straw waste in China's South Xinjiang cotton region from 2006 to 2015 were estimated by measuring resource stocks and using different utilization methods. Results show that the carbon emissions of cotton straw with different usages are expressed as follows: fertilizer, straw wood burning, straw burning, straw, straw feed, and straw making biogas. The improvement on agricultural waste recycling mode effectively reduced the agricultural non-point source pollution and the intensity of carbon emission. The conclusions provide a reference for improving the utilization mode of agricultural wastes and improving the recycling of agricultural wastes.

INTRODUCTION

Currently, China's agricultural production, which is in transition from traditional agriculture to modern agriculture, has experienced double constraints of resources and market, economic growth and double pressure of ecological protection, and dual challenges of increasing farmers' income and food security. Improper utilization of agricultural waste is the main source of greenhouse gas emissions that cause considerable carbon emissions annually. The dynamic promotion of energy conservation and emission reduction and active development of low-carbon agriculture have gradually become the important means for China to practice the ecological civilization concept. China is an agricultural country with an average agricultural straw output of 900 million t per year and is also the largest straw country worldwide. Presently, unused straws in the country are approximately 200 million t. The agricultural waste, such as poultry faeces and straw crops, contain huge resource potential, and realizing their transformation and recycling resources has significant environmental effects. Agricultural waste can be recycled, that is, it can be converted to high-quality production matrix of other industries, such as biogas energy, biological hydrogen production of raw materials, and agricultural organic fertilizer, through proper processing.

South Xinjiang is an important cotton-producing area in China. As it is the largest agricultural straw resource in China, its cotton straw recycling and utilization efficiency is related to the fertility of its entire agricultural ecosystem, ecological security, efficient material conversion, efficient use of organic resources, and sustained development issues. Therefore, cotton straw resource recycling has important practical significance in improving the environment, developing sustainable agriculture, and enriching people's income. Cotton resources in South Xinjiang are estimated and analysed in this study by establishing the cotton resources related to each evaluation index system. The carbon emissions with different utilization methods of cotton straw resources in South Xinjiang region from 2007 to 2015 are also estimated. Carbon emission levels and carbon emission intensity with different utilization methods provide a valuable reference for low-carbon recycling and high-efficiency utilization of cotton straw resources in South Xinjiang and green agriculture development.

STATE OF THE ART

In recent years, numerous studies on agricultural waste recycling have been conducted. From a technical perspective, Menardo (2012), Trably et al. (2010), and Chen et al. (2010) believed that agricultural waste recycling is constantly developed towards safe mechanization, efficient, and integrated recycling. Song (2011) constructed a comprehensive evaluation index system on agricultural waste resource utilization and in which farmers and enterprises are the main subjects in agricultural waste recycling. Li (2013a) used a three-stage data envelopment analysis (DEA) model by eliminating the influence of external environment factors and statistical noises, measuring the performance of farmers' agricultural production waste recycling behaviour, and decomposing the technical efficiency of each decision-making unit. Xu et al. (2010) believed that factors, such as gender of agricultural production decision makers, household arable land area, farmers' awareness of circular agriculture, and government technical support, have a significant impact on agricultural waste treatment. Vries et al. (2012) discussed the resource constraints of farmers' agricultural waste recycling technology mode. Qiu (2012) thought that farmers' agricultural waste recycling behaviour is mainly affected by income level, education level, farming life, whether to participate in the circulation agriculture related training, degree of agricultural machinery modernization, and whether to establish the influence of factors such as facilities for central treatment of wastes. Li et al. (2013) used the three-stage DEA model to measure the recycling performance of agricultural waste products. Chambers (1992), He et al. (2013), and Scoones (1998) analysed the factors that affect the payment intention of agricultural waste resource ecological compensation. Ellis (2000) and Giuntoli et al. (2013) designed a logistics mode of agricultural waste recycling. Li et al. (2012a) conducted dynamic game analysis on farmer households and government behaviour in the context of agricultural waste treatment. Furthermore, the academic community conducted systematic research and discussion on agricultural cultural transformation (Wei et al. 2011, Li et al. 2012b, Li 2011) of agricultural waste recycling and rural welfare (Feng et al. 2013, Yuan et al. 2013, Wu 2013) and other aspects. Sustainable development of ecological environment was explored (Li et al. 2012a, Shi et al. 2011).

Overall, comprehensive studies and systematic discussion on the definition of agricultural waste, stock resources and resource values, resource recovery path and risk, carbon reduction potential, technology research development and evaluation, main body cognitive changes and behaviour choices, long-term incentive mechanism, logistics mode, and aspects on various main games are currently available. However, the carbon emissions of agricultural waste with different utilization methods remained unexplored. Therefore, on the basis of China's major crops in South Xinjiang in 2006-2015, we collected original data according to the formula to calculate cotton straw resources and carbon formula. The correlation coefficients of cotton straws under different utilizations of CO_2 emissions were calculated. Then, the cotton planting area was used for the calculation of carbon intensity in South Xinjiang on the basis of different utilizations of cotton straws. Finally, the conditions of different carbon utilizations were used, and low-carbon cotton straw recycling was summarized under the background of the new mode for the purpose of cotton straw resource circulation and utilization.

MATERIALS AND METHODS

Determination of related parameters: Grass valley ratio and collection coefficient: determination of grass-grain ratio is a key factor used in accurate cotton straw resource estimation. In this study, we consider the density of South Xinjiang cotton in recent years with the popularization and application of dwarf plant technology. We assume that the ratio of cotton straw and grass valley of South Xinjiang in China is 5.0. The collection coefficient is introduced according to the research results of Zuo et al. (2015) and the cotton straw collection coefficient is set to 0.9.

Coefficient of carbon emissions: cotton straw in burning, development of biogas fertilizer, straw feed, straw, and straw as life is estimated in terms of wood burning fuel use and carbon emissions. Therefore, the carbon emission coefficient of fertilizer used in the accounting process is 0.8956 (Zuo et al. 2015), which is expressed in kg CE/kg. The coefficient is obtained from American Oak Ridge National Laboratory. The carbon emission coefficient of ploughing is 312.6000 (Zuo et al. 2015), which is expressed in kg CE/km^2, and the coefficient is obtained from the Agronomy and Biotechnology College of China Agricultural University. The carbon emission coefficient of diesel combustion is 0.5927 kg/kg (Liu et al. 2012).

Carbon emission estimation of cotton straw in South Xinjiang: The greenhouse gases in the atmosphere mainly include CO, CO_2, and CH_4. For the convenience of estimation and analysis, they are converted into standard carbon emissions, and other forms of carbon emission are not included in the calculation.

(1) The direct burning of cotton straw is E_{t1}. Currently, the burning rate of crop straw in China is 60%, and 1.60 t of CO_2 are generated on average for every 1 t of straw. Approximately 12.9% of straw is directly burned, and the calculation formula is expressed as (Liu et al. 2012).

$$E_{t1} = P_c \times 12.9\% \times 60\% \times 1.6 \qquad ...(1)$$

(2) The fertilization of cotton straw is E_{t3}. In this study, the carbon emission calculation of cotton straw fertilizer is only considered as straw crushing and returning to the field, and the average amount of crop straw is crushed to the field, which is equivalent to more than 50 kg of standard ferti-

lizer. Considering that the collection of actual farmland area in South Xinjiang is difficult, the carbon emission of straw mulching is estimated based on the cotton planting area. The calculation formula is expressed as follows:

$$E_{t3} = S \times 312.6 + \frac{M}{500} \times 50 \times 0.8956 \quad ...(2)$$

Where, S is the cotton planting area (hm^2); 312.6000 kgC/hm^2 is the carbon emission coefficient of ploughing (Liu et al. 2012), M is the quantity (10^4 t) of cotton straw and 0.8956 kgC/kg (Liu et al. 2012).

(3) The cotton straw firewood burning is E_{t5}, and the calculation method is:

$$E_{t5} = N \times 45\% \times 87\% \times 44/12 \quad ...(3)$$

Where, N is the amount of cotton straw used for fuel burning (10^4 t), and 45% and 87% are the carbon emission coefficient and carbon oxidation rate of firewood burning, respectively (Liu et al. 2012).

(4) The biogas combustion of cotton straw is E_{t2}. Assuming that all cotton straw resources are used for methane fermentation, the formula is expressed as:

$$E_{t2} = L \times 0.0209 \times 15.3 \times 44/12 \quad ...(4)$$

Where, L is the biogas potential of cotton straw resource (10000 m^3), 0.209 TJ/10000 m^3 is the calorific value of methane combustion, and 15.3 t/TJ is the carbon content of methane combustion. Studies have indicated that the dung and straw methane fermentation pool 3:2 ratio was the main raw material. Dung production and straw contribution rate are 85% and 15%, respectively. The pool of 8 m^3 required 400 kg of straw (Liu et al. 2012), namely, the pool of 10000 m^3 required 5000 t straws. Thus, L = the required amount of straw biogas × 15% ÷ 5000.

(5) The feeding of cotton straw is E_{t4}. The data of straw feed processing carbon emissions are difficult to collect due to a large number of literature materials. Therefore, this study mainly expresses the carbon emissions by considering the carbon emissions from agricultural mechanization equipment in cotton straw processing. The computation formula of carbon emissions is expressed as follows:

$$i = \frac{F}{Z} \quad g = \frac{Q_m}{Q_n} \times Z \quad f = g \times i \quad E_{t4} = f \times 0.5927 \quad ...(5)$$

Where, i is the diesel consumption coefficient (kw/table), F is the agricultural diesel usage amount in South Xinjiang (t), Z is the total power of agricultural machinery in South Xinjiang (kw), g is the total power (kw) of feed processing machinery in South Xinjiang, Q_m is the number of machinery for feed processing enterprises in South Xinjiang, Q_n is the total number of agricultural machinery in South Xinjiang, f is the diesel consumption of feed processing machinery (t), and 0.5927 kg/kg is the carbon emission coefficient of diesel (Liu et al. 2012).

(6) The total carbon emission of cotton straw is E_w, and the carbon emission intensity is E_{qd} (Seungdo et al. 2004). The calculation formula is expressed as follows:

$$E_w = E_{t1} + E_{t2} + E_{t3} + E_{t4} + E_{t5} \quad ...(6)$$

$$E_{qd} = E_w / S \quad ...(7)$$

Data source: In this study, the first part mainly uses cross-section data, and the remaining parts adopt time-series data. The data of cotton sowing area, yield, land area, and agricultural population in the study area are obtained from the Statistical Yearbook of Xinjiang in China during 2006-2015. The relevant data of straw utilization are obtained from the results of the first survey on China's agricultural pollution sources (2010) and statistics. The cotton grass straw grass-to-grain ratio data and collectable coefficients are derived from the research results of other studies that are indicated in the specific source in this study. This study correlates the original coefficients on the basis of the relevant research results, the combination of cotton cultivation, and the popularization of agricultural mechanization level of South Xinjiang in China. In addition, the related coefficients of carbon emissions are derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and all the data in this study are obtained from the five States of South Xinjiang, China. On the basis of existing data, each index value of cotton straw resources is estimated, and the comprehensive assessment on cotton straw resources of South Xinjiang in China is conducted.

RESULTS AND DISCUSSION

Estimation of Collected Cotton Straws on South Xinjiang in China

The amount of cotton straw resources, their abundance, density and straw resource occupancy of per unit area are collected in Southern Xinjiang in 2015. The results are shown in Tables 1 and 2.

South Xinjiang is the main cotton producing area in Xinjiang. As given in Table 1, the amount of cotton straw resources that can be collected in the Aksu region in 2015 accounts for 39.08% of the total cotton straw resources in Southern Xinjiang (378.7889×10^4 t). Aksu, which is China's cotton capital and hometown of long-staple cotton, is an important high-quality cotton production base in our nation, which explains the rich cotton straw resources in the

Table 1: Basic situation of China's forest resource inventory data.

Area	Cotton sown area (10000 ha)	Cotton production (10000 t)	Cotton straw resources can be collected (10000 t)	Abundance of cotton straw resource (t/person)	Density of cotton straw resource (t/km^2)	Straw resource occupancy of per unit area (t/km^2)
Bazhou	220.59	43.8105	197.1473	1.4145	4.0587	893.7273
Akesu Prefecture	479.56	84.1753	378.7889	1.4969	29.7919	789.8676
Kizilsu Kirghiz Autonomous Prefecture	11.09	1.8485	8.3183	0.1395	1.1479	750.0721
Kashgar	481.01	79.9841	359.9285	0.8000	26.1617	748.2765
Hotan Prefecture	38.24	5.5828	25.1226	0.1081	1.0083	656.9717
South Xinjiang	1230.49	215.4012	969.3054	0.8545	9.1678	787.7394

Date resource: 2016 Xinjiang Statistical Yearbook.

Table 2: Statistics on cotton straw production in Xinjiang during 2006-2015 (unit: 10^4 t).

Year	Cotton sown area (1000 ha)	Cotton production (10000 t)	Theoretical cotton straw resources (10000 t)	Cotton straw resources that can be collected (10000 t)
2006	542.550	95.503	477.516	429.764
2007	591.540	107.158	535.792	482.212
2008	692.940	114.898	574.490	517.041
2009	634.950	109.746	548.728	493.855
2010	679.350	112.567	562.836	506.552
2011	728.170	128.807	644.034	579.630
2012	736.790	136.740	683.698	615.328
2013	729.630	135.430	677.151	609.436
2014	1423.080	235.460	1177.300	1059.570
2015	1230.490	215.401	1077.006	969.305

area. The second is the Kashgar area, and it accounts for 37.13% of the total cotton straw resources (359.9285×10^4 t), which is close to the amount of cotton straw in the Aksu area. Bazhou accounts for 20.34% of the total cotton straw resource, and Basque only has a proportion of 0.86%. Therefore, most of cotton straw resources in South Xinjiang come from Aksu and Kashi regions.

On the basis of 2016 Xinjiang Statistical Yearbook, this study calculates the cotton straw resources that can be collected, their abundance, density, straw resource occupancy of per unit area, and other related indicators in Southern Xinjiang during 2015. In addition, this study calculates the cotton straw resources from 2006 to 2015 to analyse the change trend in this region. A positive correlation is observed between the cotton straw resource and cotton production in Southern Xinjiang, China. However, the cotton straw resource in 2015 has a certain reduction. The cotton production is 2.154×10^6 t, the theoretical cotton straw resource is 1.077×10^7 t, and the cotton straw resource that can be collected is 9.693×10^6 t. The result indicates that the cotton planting area in Southern Xinjiang shows an upward trend from 2006 to 2015, but decrease in 2015. The cotton straw resource occupancy of per unit area is relatively high due to the high cotton production in Southern Xinjiang. The abundant straw resources of Southern Xinjiang have not been completely utilized and does not completely reflect its economic value.

Carbon Emission Estimation of Cotton Straw in South Xinjiang

On the basis of the nation's first survey results on agricultural pollution sources in 2010, the cotton straw utilization structure in Southern Xinjiang of China is expressed as follows: Approximately 3.22% of crop straws are burned in the field and are disposed on the roadside. Straws directly crushed and returned to the field account for 24.07%. Straws used as fertilizer and feed account for 1.29% and 53.04%, respectively. Straws used to take fire and as living fuels for social residents account for 14.30%. In other aspects, the amount is approximately 4.08%. Currently, the comprehensive utilization rate of cotton straw is 72.71%. The relevant department of the Chinese government issued a notice in December 2015 to require all localities to strengthen the comprehensive utilization of straws, prohibition of burning, and to achieve a comprehensive utilization rate of over 85% by 2020. A huge gap still existed with the target (Seungdo et al. 2004).

The existing research has shown that the utilization ratio of cotton straw in different methods can accurately estimate the consumption amount of cotton straws in different means, as shown in Table 3.

As shown in Table 3, the comprehensive utilization method of cotton straw in Southern Xinjiang mainly includes four forms as follows: used as fertilizer and feed, crushed to return to the field, burned in the field, and used as living fuels. On the basis of the existing literature, the estimation on the amount of cotton straws in different methods accurately calculates the carbon emissions of cotton straws, as shown in Table 4.

This study converts methane, carbon dioxide, and nitrous oxide into standard carbon equivalents based on the intensity of greenhouse effect. The nitrous oxide caused by land ploughing is based on the cotton planting area of Southern Xinjiang in the Statistical Yearbook of Xinjiang. Considering that the actual areas of cotton straw used for returning to the field are difficult to obtain, this study considers the annual cotton planting area to make an approximate estimation of carbon emission. The carbon emissions produced by cotton straws in fertilizers are the sum of carbon emissions from straw ploughing and straw compost, and are recorded as (the carbon emissions of straw compost and straw fuel are estimated based on Table 3. On the basis of formulas (1)-(6), the carbon emissions from different utilization methods of cotton straw and the total carbon emission are separately calculated.

On the basis of the analysis on main carbon sources from different utilization methods of cotton straws (Table 4), the carbon emissions caused by straw burning from 2006 to 2015 account for the largest proportion of total emissions with an average of 69.48%. The biogas produced by straw has the least amount of carbon emissions with an average of 0.03%. As shown in Table 5, the carbon emissions caused by straw feed, straw fertilizer, and straw living fuels account for relatively balanced carbon emissions that range between 10.96% and 13.92%. Compared with straw burning, other methods produce less carbon emissions and less pollution to the environment. Thus, these several methods should be developed to improve the efficiency of cotton straw resources and promote the development of low-carbon agriculture.

On the basis of the calculated data and the cotton planting area in South Xinjiang from 2006 to 2015, this study uses Formula (7) to estimate the carbon intensity and growth rate of cotton straws in different methods in Southern Xinjiang from 2006 to 2015. The results are shown in Table 5.

As shown in Table 6, the total carbon emissions of cotton straw resources in different utilization methods in Southern Xinjiang have gradually increased from 5.94 million t in 2006 to 13.39 million t in 2015 with the increase of cotton straw resources that can be collected. The total carbon emissions of cotton straws have rapidly increased in 2014 and 2015 and have shown a negative growth rate. The increase in carbon emissions from cotton straws under different methods caused serious pollution to the ecological environment. The carbon intensity of cotton straws decreased from 1094.386 t/hm^2 in 2006 to 1088.337 t/hm^2 in 2015 and tended to be stable.

Direct burning of cotton straw: The calculation results determined that the cotton straw burning in the field was approximately 312120 t in 2015, which accounted for 3.22% of the total carbon emissions. The average CO_2 emissions in the burning process and CO_2 emissions in 2015 accounted for 601.218×10^4 and 930.533×10^4 t. The carbon dioxide emissions were large, which accounted for 64.98% of the total cotton straw carbon emissions.

Straw burning has become an important source of agricultural non-point source pollution in China because it seriously pollutes the atmospheric environment, harms the farmland ecosystem, and causes the frequent traffic accidents and fires. Straw burning increases the concentrations of PM2.5, CO, SO_2, NO_2, and inhalable particles in the atmosphere and increases the incidents of smog weather that cause the air to be cloudy and reduce the visibility. Straw burning has reduced the organic matter, biomass, and density of the soil, which limited the development of the cultivated lands. The straws stacked on the edge of the field occupied a large amount of land and also provided habitat for mosquitoes, flies, and mice. The stench became a hidden danger to the ecological environment when the straws were rotten.

Marsh gas developed from cotton straw: Cotton straw gasification efficiency ranges from 70% to 75% (Ayhand 2014). Cotton straw gasification places straws in the biogas plant to make them fermented through the establishment of a centralized gas supply station. After the burning of cotton straws, they are converted into gas and are transferred to the homes of farmers through pipes to aid heating, lighting, and cooking. This process improves the efficiency of energy utilization and reduces the emissions of harmful gases, such as CO_2, at the same time. This process also reduces farmers' spending on energy expenditures, which benefits cotton farmers. Clean resources are beneficial to environmental protection. As shown in Table 4, the annual average CO_2 emission is 0.220×10^4 t and CO_2 emission in 2015 is 0.314×10^4 t, which accounts for 0.02% of the total cotton straw

Table 3: Comprehensive utilization status of cotton straws in Southern Xinjiang from 2006 to 2015 (unit: 10^4 t).

Year	Total	Burning	Returning	Fertilizer	Feed	Living fuels	Other
2006	429.764	13.838	103.444	5.544	227.947	61.456	17.534
2007	482.212	15.527	116.069	6.221	255.765	68.956	19.674
2008	517.041	16.649	124.452	6.670	274.238	73.937	21.095
2009	493.855	15.902	118.871	6.371	261.941	70.621	20.149
2010	506.552	16.311	121.927	6.535	268.675	72.437	20.667
2011	579.630	18.664	139.517	7.477	307.436	82.887	23.649
2012	615.328	19.814	148.109	7.938	326.370	87.992	25.105
2013	609.436	19.624	146.691	7.862	323.245	87.149	24.865
2014	1059.570	34.118	255.038	13.668	561.996	151.518	43.230
2015	969.305	31.212	233.312	12.504	514.120	138.611	39.548

Table 4: Carbon emissions from different methods in South Xinjiang from 2006 to 2015 (unit: 10^4 t).

Year	Straw burning	Straw biogas	Straw fertilizer	Straw living fuel	Total carbon emission
2006	412.573	0.151	92.814	88.220	593.759
2007	462.924	0.170	104.136	98.987	666.216
2008	496.359	0.182	111.676	106.136	714.353
2009	474.101	0.174	106.659	101.377	682.310
2010	486.290	0.178	109.410	103.983	699.861
2011	556.445	0.204	125.179	118.984	800.812
2012	590.715	0.216	132.877	126.312	850.120
2013	585.058	0.214	131.605	125.103	841.980
2014	1017.187	0.373	228.857	217.505	1463.921
2015	930.533	0.341	209.339	198.976	1339.188
Annual leverage	601.218	0.220	135.255	128.558	865.252
Average percentage	69.48%	0.03%	15.63%	14.86%	100%

carbon emissions. The carbon emissions of developed biogas from cotton straws is low, and the development of clean energy is beneficial to environmental protection.

Cotton straw fertilization: On the basis of the calculated result in Tables 3 and 4, the cotton straws directly returned to the field in southern Xinjiang is 2.33312 million t in 2015, which account for 24.07% of the total cotton straw carbon emissions. In the process of straw returned to the field, the annual average CO_2 emissions are 135.255 × 10^4 t and CO_2 emissions in 2015 are 209.339 × 2015 t, which account for 13.92% of the total cotton straw carbon emissions. The current straw returned to the field mainly use mechanical bury technology, high crop harvesting techniques, and interplanting technology. The application of ecological system theory and straw return to field should be strengthened in the future to realize the combination of fostering and land cultivation.

Utilization of cotton straw feeding: The results in Table 3 show that the amount of straw feeding in 2015 is approximately 514.12 million t, which account for 53.04% of the total cotton straw utilization in southern Xinjiang. However, the cotton farmers in Southern Xinjiang mainly use extensive direct feeding mode in cotton straws. The content of crude protein is low and crude fibre is high, which limit the digestion and absorption of cattle and sheep and lead to poor taste, low nutrition and wasting of straws because they are unsuitable for direct feeding.

On the basis of the calculated results in Table 5, the CO_2 emissions in straw feeding in 2015 are 164.872 × 10^4 t, which account for 10.96% of total carbon emissions of cotton straws. Compared with other uses of cotton, the carbon emissions in feeding are low and are less harmful to the environment. This condition is because the amount of animal husbandry and enterprise scale in Southern Xinjiang are small and cotton straw for feeding are mainly sold to northern Xinjiang where animal husbandry is developed comparing with the northern Xinjiang.

Cotton straw used as fuel for firewood: On the basis of the calculated results in Tables 3 and 4, the cotton straws used as fuels are approximately 1.38611 million t in 2015, which account for 14.30% of the total cotton production, and the utilization ratio is low. In the process of straws used as fuels, the average annual CO_2 emissions are 128.558 × 10^4 t and CO_2 emissions in 2015 are 198.976 × 10^4 t, which account for 13.23% of total carbon emissions of cotton straws. The carbon emissions in the process of cotton straws used as fuel

Table 5: Carbon emissions from different uses of cotton straw resources in South Xinjiang in 2015 (unit: 104 t).

Cotton straw resources can be collected	Straw burning	Straw biogas	Straw fertilizer	Straw feed	Straw living fuel	Total carbon emission
969.305	930.533	0.341	209.339	164.872	198.976	1504.061
Percentage (%)	61.87	0.02	13.92	10.96	13.23	100.00

Table 6: Carbon intensity and growth rate of cotton straws in different methods in South Xinjiang from 2006 to 2015.

Year	Total carbon emission of cotton straw (10000 t)	Cotton planting area (hm^2)	Carbon emission intensity (t/hm^2)	Growth rate (%)
2006	593.759	5425.5	1094.386	-
2007	666.216	5915.4	1126.240	2.91
2008	714.353	6929.4	1030.902	-8.47
2009	682.310	6349.5	1074.589	4.24
2010	699.861	6793.5	1030.192	-4.13
2011	800.812	7281.7	1099.760	6.75
2012	850.120	7367.9	1153.816	4.92
2013	841.980	7296.3	1153.982	0.01
2014	1463.921	14230.8	1028.699	-10.86
2015	1339.188	12304.9	1088.337	5.80

for residents are small. This condition is because the natural gas, solar, and other clean energies are promoted in southern Xinjiang, and the proportion of fuel wood used is reduced. The proportion of cotton straws as firewood is expected to decrease with the restriction on rural transportation machinery and increase on labour cost.

Considering the agricultural carbon emission reduction, the ownership ratio of transport machinery for farmers in southern Xinjiang, clean energy, such as natural gas and solar energy to replace wood burning, rising labour costs, and other factors, cotton straw recycling should be centered on biogas development to form “straw returning-biogas-organic fertilizer-green agriculture” cycle. The building and use of biogas is effective in efficient recycling of cotton straw utilization, and unites the farmers, rural living environment, agricultural production, and environmental protection at the same time. This process effectively relieves energy shortage and reduces the environmental pollution from cotton straws burned directly, which significantly improves the living conditions of peasants. The renewal and returning of biogas residues and fluid aid farmers to save cultivation cost, to supplement soil organic matter, to reduce the risk of damage by insects, and to produce green pollution-free agricultural products that meet the requirements in the society.

CONCLUSION

Agricultural waste recycling should be strengthened for the reduction of agricultural non-point source pollution and development of an environment friendly and resource-saving agricultural strategy. It increases the efficiency of agricultural resource utilization and ensures the safety of agricultural ecological environment. In this study, the resource stocks in southern Xinjiang, China from 2006 to 2015 were measured to estimate carbon emissions generated by the processes used for agricultural waste. The following conclusions are obtained:

1. In the past 10 years, the cotton planting area and output continued to grow in southern Xinjiang, China, planting area, and grain yield increased from 542 550 h and 955 031 t in 2006, which increased by 135.80% and 135.80%, respectively. The annual cotton straw resources that can be collected were 969.305 million t, the straw resources were rich, and the potential was huge.
2. The carbon emissions of cotton straw in 2015 were 1504.1061×10^4 t. The carbon emissions from cotton straw burning, developed biogas from straws, straw fertilizer, feeding, and for fuel were 930.533×10^4, 0.341×10^4, 209.339×10^4, 164.872×10^4, and 198.976×10^4 t, respectively. The order of carbon emissions from different uses of cotton straws were arranged as: straw burning > straw fertilizer > straw firewood > straw feeding > straw to make biogas.

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