Applied Mechanics and Materials *Online: 2013-02-13*
ISSN: 1662-7482, Vols. 291-294, pp 1385-1388
doi:10.4028/www.scientific.net/AMM.291-294.1385

Research on Spatial-temporal Characteristics and Affecting Factors Decomposition of Agricultural Carbon Emission in Suzhou City, Anhui Province,China

Yong Zhang[1,2,a], Gang Fang[1,2,b]

[1]Engineering Research Center of Coal Mining Exploration,Anhui Province,Anhui,Suzhou,China,234000

[2] School of Earth Science and Engineering,Suzhou University,Anhui,Suzhou,China,234000

[a]cuplife@126.com, [b]gangf0809@126.com

Keywords: Agricultural emissions,Spatial and temporal characteristics,Factor decomposition,Kaya identity

Abstract. This paper takes the Suzhou City, Anhui Province as a example, the 2004-2009 agricultural carbon emissions were estimated based on six major aspects of the carbon source of agriculture production.The result shows that Suzhou's carbon emission is on the rising trend since 2004. Suzhou's agricultural carbon emissions and intensity's average annual growth rate were 3.68% and 3.49% respectively.Factors decomposition research has been approached based on Kaya equation, and the result indicates that efficiency factor, structural factor and labor scale factor restrict the growth of carbon emission, and it already realized carbon emission reduction during 2004 to 2009. Agricultural economy development has added more carbon emissions.

Introduction

Consuming of chemical fertilizer, pesticide, energy resources during agricultural productions, emissions of greenhouse gases,caused directly or indirectly by the process of ploughing both are called agricultural carbon emissions.Suzhou Ctiy has 8897 kilometers of the vast champaign which constitute 91% of the whole region. The area of the agricultural land is 997.79 ten thousand mu which constitute 67.97% of the total surface area.There are wheat, corns, beans, sweet potatos, cottons, peanuts, vegetables and fruits, such as apples, pears, peaches, grapes, mulberries and so on. The total output of grain, cottons, oil-bearing crops, fruits were 3060,000 metric tons, 80,000 metric tons, 405,000 metric tons and 865,000 metric tons. The largest fruit producing areas of the country is in Suzhou, which is 120 ten thousand mu.Its size and output are both constitutes 70% of Ahhui province. Peanut planting is 80 ten thousand mu and along the provincial road and the national road there is a green houses for vegetables,which is 40 ten thousand mu.Wastefulness could be seen everywhere in the process of agricultural production, such as Crop Straw burning, chemical fertilizer's over spreading, it adds more unnecessary carbon emission and environmental pollution.

Therefore, for such a large scale of agriculture in Suzhou city, the analysis of spatial-temporal characteristics and influence factors of agricultural emissions is so important thant it can establish scientific measures to cut carbon emissions of Suzhou city.

Calculation Methods and Data Sources

There are six main sources of agricultural carbon emissions.First, it's caused by directly or indirectly in the process of using and producing chemical fertilizer ; second, it's caused by using and producing pesticides ; third, it's caused by directly or indirectly in the process of using and producing agricultural films ; fourth, it's caused by directly or indirectly using agricultural machinery fuel consumptions ; fifth, the organic carbon pool has been damaged by agricultural tilling,so it release large amounts of carbon into the atmosphers ; the final part of carbon emissions is caused by fossil fuels consumptions used for generate electricity to supply irrigation.

Formula for carbon emissions estimation(Eq.1):

$$E = \sum E_i = \sum T_i \cdot \delta_i \quad (1)$$

In the formula E is agricultural carbon emissions, Ei is carbon emissions caused by single carbon source, Ti is quantities of carbon emissions released by single carbon sourse,δi is carbon emission's factors of single carbon sourse. According to the empirical data, carbon emission's factors has been listed in table 1.

Tab.1 Agricultural carbon emission source，coefficient and reference sources

Source	Coefficient	Reference
Chemical Fertilizer	$0.8956kg \cdot kg^{-1}$	T.o.West[1], Oak Ridge National Laboratory[2]
Pesticide	$4.9341kg \cdot kg^{-1}$	Oak Ridge National Laboratory
Agricultural film	$5.18kg \cdot kg^{-1}$	Farm resources and ecological environment research institute of Nanjing Agricultural University
Diesel oil	$0.5927kg \cdot kg^{-1}$	IPCC
Plough	$312.6kg \cdot km^{-2}$	Biology and technology School of China Agricultural University[3]
Agricultural irrigation	$20.476kg \cdot hm^{-2}$	Dulbey

Kaya carbon identities first proposed by Japanese Professor Yoichi Kaya[4]. He used mathematical technique to establish connections between carbon emissions ,produced by social activities, and factors such as economy, policy, population and so on. According to the Kaya carbon identity, carbon emissions are mainly determined by the population, living standards,energy consuming intensity and carbon intensity. There are the equations as follow(Eq.2,Eq3):

$$C = \frac{C}{E} \times \frac{E}{GDP} \times \frac{GDP}{P} \times P \quad (2)$$

$$CI = \frac{C}{E}, EI = \frac{E}{GDP}, G = \frac{GDP}{P} \quad (3)$$

Where, C, E, GDP and P mean carbon emission, energy consumption, gross domestic product, population respectively. CI, EI, G mean energy structure factor, energy efficiency factor and economic scale factor respectively.

Since the main purpose of this paper is analyse the agricultural emission factors,combined with the actual conditions of agricultural production,the Kaya identity has a deformation formula as follow(Eq.4,Eq.5):

$$C = \frac{C}{AGRI} \times \frac{AGRI}{AGR} \times \frac{AGR}{P} \times P \quad (4)$$

$$EI = \frac{C}{AGRI}, AI = \frac{P}{AGRI}, EL = \frac{AGR}{P} \quad (5)$$

Where, C, AGRI, AGR and P are agricultural carbon emission, total output value of farming, gross output value of farming, forestry, animal husbandry and fishing and scale of agricultural labor force respectively. EI, AI, EL are agricultural production efficiency factor, agricultural structure factor, and agriculture economic development level factor respectively.

Datas of chemical fertilizer, pesticide, agricultural film and diesel oil were all quoted from Statistical Year Book of Anhui(2004-2009), data of plough came from the crop's real sown area of Suzhou in the same year, data of agricultural irrigation came from the crop's real irrigate area in the same year, the crop's sown area and crop's irrigate area were quoted from Statistical Year Book of Anhui(2004-2009).

Results and Discussions

According to the the agricultural carbon emission estimation formula(Eq.1), agricultural carbon emissions of Suzhou City (2004-2009) has been calculated(Table 2).Results show that agricultural carbon emissions in 2004 and 2009 were 46.32 million tons, 55.36 million tons respectively, the average annual growth rate was 3.68%. The upward trend of growth rate of average annual link relative ratio of agricultural carbon emissions could be seen from the condition of average annual link relative ratio. Carbon emissions caused by Chemical Fertilizer, Pesticide, Agricultural film, Diesel oil, Irrigation, Plough were all increased more or less, the growth rate of average annual link relative ratio were 2.53%, 2.54%, 11.34%, 2.36%, 0.61%, 0.23%. The upward trend of growth has not only found in carbon emissions but also in carbon intensities.It's 31.83 kilogram per mu in 2004, but the number turn out to be 37.64 kilogram per mu in 2009,the the growth rate of average annual link relative ratio was 3.49%. The upward trend of growth rate of average annual link relative ratio of agricultural carbon intensities could be seen from the condition of average annual link relative ratio.But there is an unusual trend appeared in 2007,because the 17th people's congress have emphasized the importance of resource conservation and ecological environment protection, as a result, in the year carbon intensities have reduced a little.For another, central document No.1 in 2008 have announced that achieving production increasing should be through reducing production costs, and taking efforts to develop resource-saving agriculture, for example, in order to raise agricultural product benefits, the government encourages farmers to collect stalk and castoff of living, and make full use of it.

The growth of carbon emissions has slow down between 2004 and 2007, average annual link relative ratio was ranging from 0.2% to 2.0%.Due to excessive burden on farmers, the three agricultural issues get further highlights,and the pressure of survival makes an increasing number of farmers rush into big cities to finding jobs instead of farming in rural areas. Under the influence of the tide of wage earners, demanding of agricultural means of production have reduced, carbon emissions have reduced as a rusult.But at the same time, the overall grain output appears on a downward trend in Suzhou City. Even it has a substantial increase in 2006, it doesn't have changed the general trend. So, Suzhou's agricultural production, especially grain production, was now facing enormous challenges.

Tab.2 Agricultural carbon emissions in Suzhou City from 2004 to 2009

Year	Chemical Fertilizer (million tons)	Agricultural film (million tons)	Pesticide (million tons)	Diesel oil (million tons)	Irrigation (million tons)	Plough (million tons)	Total (million tons)	Link relative ratio	Agriculture carbon intensity (kilogram/mu)	Link relative ratio
2004	26.2112	6.6636	6.3966	6.0146	0.7285	0.3032	46.3176	—	31.8318	—
2005	25.8897	7.5364	6.4336	6.2887	0.73318	0.3052	47.1866	1.88%	31.8950	0.20%
2006	25.8666	7.3913	6.9526	6.0506	0.7371	0.3026	47.3010	0.24%	32.5747	2.13%
2007	26.3936	7.2313	7.3380	5.9746	0.7419	0.3112	47.9905	1.46%	32.1415	-1.33%
2008	25.9553	7.0521	10.0310	6.5721	0.7468	0.3042	50.6614	5.57%	34.7098	7.99%
2009	29.4776	7.4856	10.6147	6.7219	0.7508	0.3065	55.3571	9.27%	37.6419	8.45%
Average annual link relative ratio	2.53%	2.54%	11.34%	2.36%	0.61%	0.23%	3.68%	—	3.49%	—

According to the agricultural structure and scale of the various regions, due to the proportional relationship of the value of agricultural production and carbon emissions, the contribution of the total agricultural carbon emissions in order is Yongqiao> Lingbi> Sixian> Xiaoxian> Dangshan.

In order to analyze the different effects of various factors on agricultural carbon emissions change in Suzhou City, according to Eq.2,Eq.3,Eq.4 and Eq5, the carbon emissions of agricultural were decomposed in 2004-2009. The calculation results are shown in Table 3.

Tab.3 Factors decomposition of agricultural carbon emission based on Kaya equation units:10^4t

Year	Efficiency factor	Structural agent	Level of economic development	Workforce scale
2004	-26.9995	-11.1524	-2.1045	-0.6619
2005	1.2060	0.3312	7.8626	-0.5969
2006	-3.6739	-3.8202	0.3504	-0.5024
2007	1.2858	-0.2788	4.7555	-1.4057
2008	2.9658	0.6475	3.1150	-0.8285
2009	0.3394	-2.8276	1.6349	-0.1731
total	-24.8764	-17.1003	15.6138	-4.1680

From table 3, although efficiency factors of agricultural production, agricultural structures and workforce scale factors inhibit agricultural carbon emissions to some extent and promote agricultural carbon reduction year by year,but it's in a limited role. Compared to the base period in 2004-2009, efficiency factors of agricultural production, agricultural structures and workforce scale factors only cumulative contributions is 24.8764×10^4t, 17.1003×10^4t, 4.1680×10^4t of carbon reduction respectively.Overall, the effect size of the order for agricultural carbon reduction is: labour scale factor > agricultural structural factors > efficiency factors of agricultural production. Increments of various factors stabilized since 2006, with the improvement of the efficiency of agricultural production and the optimization of the structure of agriculture ,it can get agricultural carbon reduction. With the transfer of non-farm agricultural labor, it's conducive to agriculture to realize the scale of operation, thus conducive to agricultural carbon reduction.

Agricultural economic development has become the most important factor of the increase in agricultural carbon emissions. From table 3,the results show that from 2004 to 2009 compared to the base period, the level of economic development factors accrues 15.6138×10^4t agricultural carbon emissions incremental.This is consistent with EKC verify the results of many scholars on the environment and economic development of agricultural resources[5,6], economic development and environmental quality in Suzhou City is still in the turning point of the left, along with economic development will bring the deterioration of the quality of the environment. Therefore with the agricultural economic development in Suzhou city, agricultural carbon emissions will increase,but the prospect of reducing carbon emissions in Suzhou city is optimistic.

Conclusions

Agriculture carbon emissions and carbon intensity presents obvious increasing trend in Suzhou city from 2004 to 2009.Six major agricultural carbon source including fertilizer, plastic sheeting, pesticides, agricultural diesel, irrigation, tillage which produce the carbon emissions have got different degree of rise, but the total output of farming in Suzhou City only have fluctuant change,it don't get stimulation, the efficiency of agricultural production is not ideal thereby in Suzhou City.

According to the decomposition results of carbon emissions impact factor, efficiency factors of agricultural production, agricultural structures, the size of the labor force factors have contributed to the carbon emission reduction, but it get limited role. The development of the agricultural economy is a major factor in the increase of agricultural carbon emissions. Overall, factors on the incremental carbon emissions tends to decline and stabilized.

Acknowledgements

This work was financially supported by Scientific Platform Foundation of Anhui Engineering Research Center of Coal Mining Exploration(2011YKF23,2012YKF12) and University Excellent Youth Fund Project in Anhui Province(2012SQRL208).

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