Calculation and Analysis of Regional Land Use Carbon Emissions

Dan Song[1,a], Qi-gang Jiang[2,b*], Shu-jie Li[1,c]

[1] College of Earth science, Jilin University, Changchun, 130000, China

[2] College of Geo-Exploration Science and Technology, Jilin University, Changchun, 130000, China

[a]26225152@qq.com, [b]garlar@126.com, [c]450127875@qq.com

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Abstract. Land as the carrying capacity of human activities, the influence of carbon emissions different way of land use contributed to is different. Thus, the paper taking Changchun City in China as an example, estimates the net land use carbon emissions from 2001 to 2013 and explores the measuring method.

Introduction

It is well known that global warming has become an indisputable fact. Except the natural factor the important things that causes the increase of CO_2 emissions are the frequent activities of human beings. And land as the carrier of human activities, the use of the way will no doubt affect the size of carbon emissions. The correlation coefficient method is used on the use of carbon emissions accounting. However, at present, the research on the combination of low carbon economy and land use is still in the stage. Therefore, the paper takes Changchun city in China as an example, calculating the net carbon emissions from 2001 to 2013. In order to provide the guidance and basis for the government to change the land use pattern or adjust the land use structure in the new period.

Method

Based on previous research results, combined with the regional reality, the correlation coefficient method is used to calculate the carbon emissions and carbon sink of the various land types. The carbon source land is mainly cultivated land, construction land and other land use, while the carbon sequestration land is cultivated land, garden, woodland, grassland, water and other unused land.

Carbon Emissions. The carbon emissions of cultivated land is mainly due to the chemical fertilizers, pesticides, agricultural plastic film, agricultural machinery, paddy cultivation and agricultural tillage and irrigation. Carbon emission coefficient is shown in Table 1. The carbon emission formula of cultivated land is:

$$E_f = \sum E_{fi} = \sum T_i \times d_j \tag{1}$$

Eq.1, E_f is the total amount of carbon emissions of the cultivated land; E_{fi} is the carbon emissions of the cultivated land; T_i is the amount of carbon emissions; d_j is the carbon emission coefficients of various carbon emissions.

The study area is northeast single cropping of rice planting area, and the safety of rice growing period is about 100-120 days. With Fei Lu (2010) on methane emission from rice fields in China's national various provinces data [2], the paper determines the discharge coefficient of paddy field 2.86 gC/（m²·d） and the median value of rice growth cycle is 110 days.

Table 1 Carbon emission coefficient and reference source of the cultivated land use

Carbon source	Carbon emission coefficient	Reference source
Chemical fertilizer	0.8956kg/kg	Oak Ridge National Laboratory
Pesticides	4.9341kg/kg	Oak Ridge National Laboratory
Plastic sheeting	5.18kg/kg	Institute of agricultural resources and ecological environment, Nanjing Agricultural University（IREEA）
Diesel engine	0.5927kg/kg	IPCC
Plowing	312.6kg/km^2	College of biology and technology, China Agricultural University
Irrigation	266.48kg/hm^2	Duan Huaping et al.[1]

Industrial Land Carbon Emissions. In our country, there are few experimental researches on industrial carbon emissions, so the paper mainly uses IPCC carbon emission coefficient to measure. The carbon emission formula of industrial land is:

$$E_c = \sum_j Q_j C_{fj} \qquad (2)$$

Eq.2, E_c is the industrial carbon emissions; Q_j is the energy consumption of J energy consumption; C_{fj} is J energy carbon emission coefficient.

Table 2   All kinds of energy carbon emission coefficient   Unit: t/tC

Energy	Carbon emission coefficient	Energy	Carbon emission coefficient	Energy	Carbon emission coefficient
Raw coal	0.7559	Gasoline	0.5538	Coke oven gas	0.3548
Coke	0.8550	Kerosene	0.5714	Blast furnace	0.3548
Coal	0.7559	Diesel engine	0.5921	Other coking	0.6449
Other coal	0.2155	Fuel oil	0.6185	Other gas	0.3548
Briquette	0.4691	Liquefied	0.5042	Other fuels	0.7559
Refinery	0.4602	Other	0.5857	Power	2.5255
Crude oil	0.5857	Natural gas	0.4483	Heat	0.2600

Source: IPCC national greenhouse gas emissions inventory guide

Residential Land Carbon Emissions. The paper selects the five indicators closely related to living, including household electricity consumption, artificial gas consumption, natural gas consumption, household liquefied petroleum gas consumption, household water consumption, etc. The carbon emission formula of the residents' life is as follows:

$$E_{l1} = E_a k_a + E_b k_b + E_c k_c + E_d k_d + E_f k_f \qquad (3)$$

Eq.3, E_{l1} is family life direct energy consumption of carbon emissions, E_a, E_b, E_c, E_d and E_f is annual household electricity consumption, artificial gas consumption, natural gas consumption, household liquefied petroleum gas consumption, household water consumption, k_a, k_b, k_c, k_d and k_f is the corresponding carbon emissions coefficient. The model of carbon emissions caused by residents' daily living garbage is :

$$E_{l2} = P \times m \times k_m \qquad (4)$$

Eq.4, E_{l2} is carbon emissions due to the daily living garbage, P is the annual population, m is the annual per capita waste emissions, k_m is the carbon emissions of garbage. Carbon footprint calculation method for carbon emission coefficient of daily living garbage.

Transportation Land Carbon Emissions. The carbon emissions of the transportation land mainly comes from the private car, the vehicle's travel and so on. The model of carbon emissions caused by transportation is :

$$E_{t1} = N \times L \times k_e \tag{5}$$

Eq.5, E_{t1} is the carbon emission by residents' travel; N is the number of private cars; L is annual average opening range; k_e is Carbon emission coefficient per hundred kilometers of private cars. Calculation model of carbon emissions for working vehicle is:

$$E_t = GDP_t \times \frac{U}{GDP} \times k_t \tag{6}$$

Eq.6，GDP_t is the annual turnover of transportation; $\frac{E}{GDP}$ is Unit GDP energy consumption;

k_t is standard coal discharge coefficient.

Other Land Carbon Emissions. Livestock farming is another major source of CH_4 emissions, including the two aspects of intestinal fermentation and manure management. Carbon source CH_4 carbon emission coefficient and source are shown in Table 3.

Table 3　Carbon emissions coefficient of main livestock species　　Unit：kgCH$_4$/(head·a)

Carbon source	Intestinal fermentation carbon emission factor	Control of feces carbon emission factor	Reference source
Cow	61	18	IPCC
Buffalo	55	2	IPCC
Other cattle	47	1	IPCC
Horse	18	1.64	IPCC
The donkey	10	0.9	IPCC
Mule	10	0.9	IPCC
Pig	1	4	IPCC
Goat	5	0.17	IPCC
Sheep	5	0.15	IPCC

Cultivated Land Carbon Absorption. The carbon absorption of cultivated land mainly comes from the carbon which is synthesized during the process of the growth and development of crops. The formula for calculating the carbon absorption is:

$$C_t = \sum_i C_{di} = \sum_i C_{fi} D_{wi} = \sum_i C_{fi} Y_{wi} / H_i \tag{7}$$

Eq.7, C_t is carbon absorption of cultivated land; C_{di} is the amount of carbon in the whole growth period of crop I; C_{fi} is the carbon absorption rate; Y_{wi} is the yield of crops; D_{wi} is the economic output of crops; H_i is the economic coefficient, which is shown in Table 4.

Table 4　Main crop economic coefficient and carbon absorption rate in China

	Rice	Wheat	Corn	Sorghum	Milet	Potato	Soybean	Sunflower	Peanut	Tobacco	Other
Economic coefficient	0.414	0.484	0.471	0.450	0.450	0.423	0.450	0.450	0.450	0.450	0.450
Carbon Absorption rate	0.450	0.400	0.400	0.350	0.400	0.700	0.340	0.300	0.430	0.550	0.400

Source: Ke-rang Li, 2002

Forest land, garden land and grassland carbon absorption. Because the study area is a temperate coniferous and broad-leaved forest and mixed forest region, according to the research results of Li Lai et al.(2010), the carbon absorption capacity of the type of vegetation is $0.585tC/hm^2/a$[3]. Garden is mainly park, and vegetation types are mainly dominated by trees, shrubs, lawns. So the garden solid carbon capacity is determined by woodland and grassland. Combined with Chong-bao Zhang (2005) research, forest land and grassland of the area is roughly proportional to 1:1[4]. So the carbon absorption coefficient is $0.303tC/hm^2/a$. The grassland types are temperate meadow steppe, and Li Lai et al. (2010) studies show that the carbon absorption capacity of this type vegetation is $0.021tC/hm^2/a$.

Waters and Unused Land Carbon Absorption. According to Xiao-nan Duan et al. (2008)'s research on the carbon fixation rate and carbon sequestration potential of the five major lakes over the country, the carbon sequestration rate of the northeast plain and lake wetlands in mountainous is $0.004tC/m^2/a$ that is the lowest in the five lakes. And the average carbon sequestration rate of the five lakes is $0.025tC/m2/a$[5]. Combined with Li Lai's study(2010), the carbon absorption coefficient of the study area is $0.074tC/hm2/a$. Because the carbon emission and the absorption capacity of the unused land is weak, and the carbon absorption rate varies little with the geographical position, the carbon absorption coefficient is $0.005tC/hm^2/a$.

Analysis

According to the method of carbon emission measurement, the carbon emission and carbon absorpiton of different land types is obtained, which can be used to get the net carbon emissions of land use.
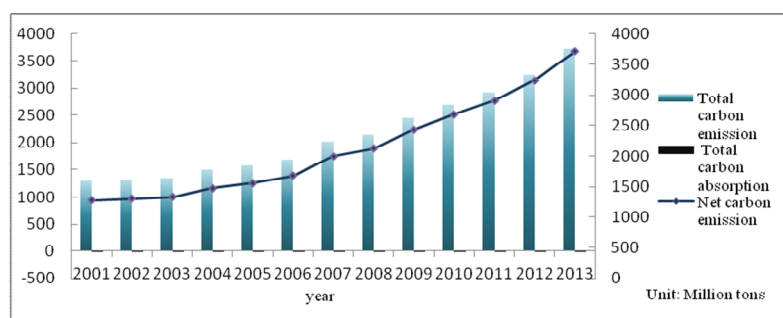

Fig. 1 Net carbon emissions change trend in Changchun City From 2001 to 2013

Fig.1 shows that the land use net carbon emissions in Changchun city from 2001 to 2013 is increasing year by year. As we see from Table 5 and Fig.1, according to the growth rate it can be divided into three stages: the first stage is from 2001 to 2004, and it rises by 15.7%；the second stage is from 2007 to 2004, and it rises by 34.9%；the third stage is from 2013 to 2007, and it rises by 85.4%.

Table 5　land use Net carbon emissions in Changchun city from 2001 to 2013　Unit: Million tons

| | Carbon source | | | Carbon sink | | | | | | Net |
	Cultivated land	Construction land	Other land	Cultivated land	garden	Woodland	grassland	waters	unused land	carbon emissions
2001	150.08	1132.69	10.70	-0.11	-0.16	-11.69	-0.77	-0.85	-0.02	1279.87
2002	144.27	1164.38	11.56	-0.12	-0.16	-11.69	-0.76	-0.85	-0.02	1306.61
2003	140.55	1196.07	13.30	-0.12	-0.16	-11.69	-0.76	-0.85	-0.02	1336.32
2004	166.13	1314.34	14.92	-0.12	-0.16	-11.69	-0.76	-0.85	-0.02	1481.78
2005	129.33	1431.60	15.27	-0.13	-0.16	-11.69	-0.75	-0.85	-0.02	1562.59
2006	160.36	1512.08	15.65	-0.13	-0.16	-11.72	-0.75	-0.85	-0.02	1674.46
2007	175.53	1821.75	15.27	-0.12	-0.16	-11.73	-0.75	-0.85	-0.02	1998.92
2008	184.84	1942.08	16.41	-0.13	-0.16	-11.75	-0.74	-0.84	-0.02	2129.69
2009	191.04	2236.74	17.01	-0.11	-0.04	-9.98	-0.34	-0.62	-0.02	2433.68
2010	194.35	2487.77	9.35	-0.12	-0.04	-9.98	-0.34	-0.62	-0.02	2680.36
2011	202.39	2708.70	11.96	-0.13	-0.04	-9.95	-0.33	-0.61	-0.02	2911.97
2012	207.87	3029.24	12.24	-0.13	-0.04	-9.93	-0.32	-0.61	-0.02	3238.29
2013	206.49	3497.52	12.36	-0.12	-0.04	-9.93	-0.32	-0.61	-0.02	3705.33

Conclusions

Through the research, the main conclusions are as follows:(1) the net carbon emissions will keep increasing for the foreseeable future. (2) on the current carbon emissions measurement, the correlation coefficient that the majority research uses is based on the results of previous studies, not to consider the regional differences. In the future, we should explore the establishment of carbon emissions and carbon sequestration measurement system, measuring the carbon emissions coefficient to better serve the realization of low-carbon development goals.

Acknowledgements

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