ADVANCES IN CLIMATE CHANGE RESEARCH 2(4): 178–186, 2011
www.climatechange.cn
DOI: 10.3724/SP.J.1248.2011.00178

POLICY FORUM

# Analysis of LULUCF Accounting Rules after 2012

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**Abstract**

Land use, land-use change and forestry (LULUCF) activities can allow Annex I parties in the *Kyoto Protocol* to decrease their carbon emission reduction pressure, and comparably expanding more emission space for their domestic industries and energy production. The loopholes resulted from LULUCF activity types and specific accounting methods are always argued among the different parties, particularly including harvested wood products, influences of force majeure, threshold values of the reference level, and gross-net or net-net accounting methods. For estimating uncertainties in accounting loopholes, and to avoid that developed countries take advantage of the accounting loopholes of LULUCF to decrease their emission reduction pressure, the LULUCF data submitted from the main developed countries in Annex I, including EU 27, Canada, Japan, and Russia, were collected. According to the analysis of these data, the loopholes influence the accounting results of LULUCF. The results show that the uncertainty of harvested wood products is excessive. The carbon sink produced by LULUCF activities will increase averagely by at least 30% without force majeure. The threshold values of the reference level of carbon sink should be set to a higher level. The net-net accounting method might be more suitable for LULUCF after 2012.

**Keywords:** LULUCF; accounting methods; after 2012

**Citation:** Liu, S., Y. Li, Q. Gao, et al., 2011: Analysis of LULUCF accounting rules after 2012. *Adv. Clim. Change Res.*, **2**(4), doi: 10.3724/SP.J.1248.2011.00178.

## 1 Introduction

The Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) confirmed that the increase in greenhouse gas (GHG) concentration in the atmosphere and the global climate change might be mainly resulted from human activities in the latter half of the 20th century [*UNFCCC*, 2001]. In order to protect the global climate and to reduce the effects caused by human activities, the *Kyoto Protocol* was signed in 1997, providing quantified emission reduction targets determined by the developed countries (Annex I parties) for the first commitment period (2008–2012). The procedures for the reduction of GHG emissions include: the emission reduction in domestic industries, energy, and other sectors; the promotion of new techniques in land use, land-use change and forestry (LULUCF) activities enhancing the potentials of a carbon sink; the emission trading scheme and joint implementation among Annex I parties; and the clean development mechanisms between Annex I and non-Annex I countries [*UNFCCC*, 1997], with which Annex I parties could use the carbon sink produced by afforestation, reforestation, forest management, cropland management, grazing land management and re-vegetation activities being carried out in the non-Annex I countries after 1990, as was stipulated in the accounting rules of carbon source/sink produced by LULUCF

Received: 19 August 2011
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activities in the first commitment period to complete the emission reduction targets. This means that Annex I parties could use the carbon sink produced by LULUCF activities to decrease their emission reduction pressure during the first commitment period [*Chen and Yang*, 2009].

There was a certain progress on LULUCF issues in the United Nations Framework Convention on Climate Change (UNFCCC) at the 16th Conference of the Parties (COP 16) held in Mexico at the end of 2010, which mainly concluded: how to establish the forest management reference level and its review process after 2012; whether to incorporate natural disturbances resulting from force majeure, harvested wood products and the increase of wetland management into the LULUCF accounting system. It was imminent how to prevent Annex I parties from taking use of the accounting loopholes to increase the carbon sink resulting from LULUCF activities to reduce their emission reduction obligations after 2012.

In this paper the LULUCF data submitted by the main developed countries and the potential loopholes in accounting rules of LULUCF were analyzed to provide technical support for developing countries and to give recommendations on the modification of the accounting rules of LULUCF after 2012. This analysis, with its several findings and strategic recommendations, will promote the formation of substantial and beneficial activities on LULUCF issues in developing countries.

## 2 Key and focus problems on LULUCF accounting rules during the first commitment period

### 2.1 *Key problems on LULUCF accounting rules during the first commitment period*

The LULUCF accounting rules during the first commitment period should be based on the qualified activities and accounting methods as stipulated in paragraph 3, 7 and 12 of Article 3 in the *Kyoto Protocol* [*UNFCCC*, 1997]. The qualified activities of LULUCF include: afforestation, reforestation, deforestation, which are listed under Article 3.3; and forest management, cropland management, grazing land management and re-vegetation, which are listed under Article 3.4. All of these activities must have occurred since 1990 [*Li et al.*, 2008].

### 2.2 *Focus problems on LULUCF accounting rules for the second commitment period*

#### 2.2.1 *Main problems on LULUCF accounting rules*

Almost all Annex I parties put forward their consideration about modifying all types of qualified activities and accounting rules of LULUCF after 2012.

(1) Several modifications of qualified activities, which are required for LULUCF accounting under Article 3.4 of the *Kyoto Protocol*, are proposed, e.g., incorporation of harvested wood products and wetland management into the LULUCF accounting system after 2012 as new activity types of carbon removal/emission reduction.

(2) Accounting rules of forest management under Article 3.4 of the *Kyoto Protocol* are questioned, e.g., how to set the reference level threshold value; whether to eliminate carbon emission caused by natural disturbances produced by force majeure; and how to select the gross-net accounting and net-net accounting methods.

#### 2.2.2 *Viewpoints on modification of LULUCF activity types*

Some Annex I parties actively required adding two types of carbon removal/emission accounting methods for harvested wood products and wetland management as new eligible types of qualified activities. However, the specific measurement methods for the wetland management after 2012 were not clearly introduced yet. Measurement methods of carbon removal/emission produced by harvested wood products activities were emphasized in the *IPCC Good Practice Guidance 2000* [*IPCC*, 2000]. Some of Annex I parties calculated the amount of carbon removal/emission for their domestic harvested wood products activities by using different methods. Compared with the different accounting methods, in this guidance paper the additional harvested wood products activities are ana-

lyzed on how they would impact the amount of carbon removal/emission reduction arising from LULUCF accounting activities.

(1) Main assessment methods of harvested wood products. The carbon stock change of harvested wood products is estimated by the default parameter model as stipulated in the *IPCC Inventory Guidance 2006*. Annex I parties developed different assessment methods, which mainly include the stock change approach (SCA), the production approach (PA) as well as the stock change approach of domestic origin (SCAD) for havested wood products [*Pingoud and Wagner*, 2006; *Bai et al.*, 2009; *Wang and Cai*, 1979]. The main difference is whether the amount of carbon emission produced by the harvested wood products should be attributed to the importing countries or the exporting countries, which would cause differences between carbon emission levels and trends in various countries, and result in differences in the estimation results of the carbon output.

(2) Analysis results on harvested wood products according to the materials submitted by some Annex I parties. In accordance with the analysis of carbon removal/emission arising from harvested wood products activities estimated by the IPCC model, SCA, PA, and SCAD, separately used by EU 27 [*IPCC*, 2006], Canada [*Canada*, 2009; *Lemprière et al.*, 2008], and Norway [*Norway*, 2009], large differences among the accounting methods are found (Table 1). The amount of carbon removal in 2006 estimated by means of PA as used by EU 27 was up to 83.7 Mt $CO_2$-eq. Compared with 1990, it increased by 62.5%, and is expressed as carbon sink. The amount of carbon removal of 2006 estimated by means of SCAD was up to 19.7 Mt $CO_2$-eq. Compared with 1990, it decreased by 18.6%, and is expressed as carbon emission source. Thus, with respect to the carbon source/sink of 1990, there was an opposite trend of carbon source/sink caused by harvested wood products estimated by the two methods used by EU 27. All the harvested wood products activities accounted by means of PA and SCAD used by Norway showed a decrease in carbon removal (carbon emission source), while the accounting results received by means of SCA showed an increase in carbon removal (carbon sink). The changes in carbon removal/emission amounts of Canada's domestic

**Table 1** Harvested wood products carbon source/sink (unit: Mt $CO_2$-eq) comparison of some Annex I parties in 1990–2006

| Year | IPCC model | SCAD | | PA | | SCA | |
|---|---|---|---|---|---|---|---|
| | Canada | EU 27 | Norway | EU 27 | Norway | Canada | Norway |
| 1990 | 147.2 | –24.2 | –482 | –51.5 | –1,374 | 135.7 | –783 |
| 1991 | 145.8 | –12.5 | –241 | –51.1 | –1,089 | 135.5 | –533 |
| 1992 | 154.4 | –9.0 | –159 | –42.2 | –846 | 141.1 | –493 |
| 1993 | 159.2 | –9.4 | –12 | –39.9 | –1,009 | 144.2 | –405 |
| 1994 | 167.0 | –10.6 | 42 | –49.7 | –447 | 148.5 | –872 |
| 1995 | 172.1 | –11.5 | 337 | –51.7 | –97 | 151.5 | –706 |
| 1996 | 167.2 | –12.2 | 109 | –47.9 | –328 | 145.7 | –829 |
| 1997 | 171.0 | –12.0 | 180 | –65.8 | –343 | 147.3 | –880 |
| 1998 | 162.2 | –10.3 | 133 | –72.1 | –159 | 139.1 | –923 |
| 1999 | 181.8 | –13.3 | 279 | –63.0 | –273 | 153.3 | –526 |
| 2000 | 184.2 | –17.7 | 220 | –71.3 | –114 | 154.8 | –705 |
| 2001 | 170.0 | –13.8 | 214 | –60.8 | –143 | 141.3 | –519 |
| 2002 | 179.1 | –11.7 | 153 | –66.6 | –54 | 148.8 | –572 |
| 2003 | 165.5 | –14.1 | 125 | –72.9 | 81 | 136.0 | –605 |
| 2004 | 190.0 | –17.2 | 10 | –84.3 | –4 | 158.8 | –794 |
| 2005 | 186.0 | –15.9 | –96 | –77.4 | –167 | 155.4 | –1,086 |
| 2006 | 171.1 | –19.7 | –131 | –83.7 | –554 | 144.0 | –1,096 |
| Rate of increase /decrease (%) | –16.2 | 18.6 | 72.8 | –62.5 | 59.7 | –6.1 | –40.0 |

Note: The positive value indicates the carbon emission (source) and the negative value indicates the carbon removal (sink). The rate of increase/decrease indicates the percentage of increase or decrease of carbon source/sink amount of 2006, compared with that of 1990

harvested wood products were evaluated by the IPCC default value and SCA. The estimation showed an increase in carbon emissions (carbon emission source), with a difference of 10% between the two methods.

In general, the harvested wood products accounting had a great impact on carbon emissions [*Zhang and Hou*, 2009]. There is a large difference among the results by the different accounting methods used by the countries. Due to the inconsistent principles and standards of accounting methods and the significant difference among the selected accounting parameters, the accounting accuracy of carbon emission amounts produced by harvested wood products activities is very uncertain.

## 2.3 *Viewpoints about the modification of LULUCF accounting methods*

### 2.3.1 *Settings of the reference level and threshold*

The Annex I parties estimate the amount of forest carbon sink at the beginning of the next commitment period by models with various related parameter combinations to accounting reference values for the next commitment period. The threshold of the reference level should be set according to the tree growth characteristics and the resource utilization conditions [*Zhang and Hou*, 2009].

Neither uniformity in reference level calculation methods nor data resources transparency exists under the Annex I parties, except within the member states of the European Union. However, the reference level could reflect the difference of accounting rules during the different commitment periods. It might become an important indicator connecting the LULUCF accounting systems during the first and following commitment periods. In order to improve the transparency of data and models on accounting for the forest management carbon source/sink by the threshold of the reference level (forest age structure, harvesting rates, forest management practices, and other key accounting factors), Annex I parties should be required to submit the related data to the Subsidiary Body for Scientific and Technological Advice (SBSTA) of UNFCCC. SBSTA would organize related eligible experts to review all the materials submitted by Annex I parties.

The difference between the reference level and the average value of forest management carbon source/sink during the first commitment period should be the LULUCF accounting gap. The accounting gap between the proposed reference level and the average value actually measured by the Annex I parties during 1990–2008 is shown in Figure 1. A descending/rising curve represents the increase/decrease of carbon sink amounts. The difference between the actual average and the proposed reference level should be the accounting gap. Descending in short dashed line may represent that the reference level carbon sink amount after 2012 will increase, and then the developed countries must increase the absolute emission reduction based on the quantified emission reduction targets, which will help to prevent the developed countries from taking use of the carbon sink produced by LULUCF activities to ease the emission reduction pressure during the next commitment period. It is thus clear that the carbon sink value produced by forest management activities represented by the reference level threshold should be set at a higher level.

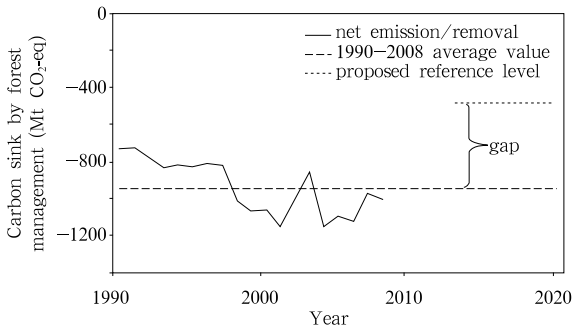


**Figure 1** Net emission/removal (solid line) during 1990–2008, actual average value (long dashed line), and proposed reference level (short dashed line) [*Canada*, 2009]

### 2.3.2 *Analysis of emission resulted from natural disturbance produced by force majeure*

There exists no clear definition of natural disturbances produced by force majeure yet. But, a general thought about its definition is that the severity and damage degree due to extreme climate events are beyond control range, while the carbon emissions caused

by natural disasters would be re-absorbed in a long time [*Flannigan et al.*, 2005]. However, definitions did not consider the classification of disaster grades and the difference among the disaster resistant technical capacities of each country. Therefore, it is difficult to find one definition for different regions and countries at different development levels.

Most of the countries requested to remove the carbon emissions caused by natural disturbances produced by force majeure, especially the carbon emissions caused by the natural disturbance on forest management [*Balshi et al.*, 2009; *Kurz et al.*, 2008]. However, to directly remove the effect caused by force majeure would likely decrease the carbon emission amount produced by LULUCF forest management activities, and would relatively increase the carbon sink amount produced by LULUCF activities. Annex I parties could take use of more carbon sinks produced by LULUCF activities to reduce the emission reduction pressure of their domestic industry, energy and other sectors.

The comparative results of carbon emission caused by two conditions (including or excluding natural disturbances) on forest management submitted by Canada for 1990–2007 [*Kurz et al.*, 2008] show that the amount of GHG emission after removing the natural disturbances was at around –125 Mt to –160 Mt $CO_2$-eq (Fig. 2). The amount of GHG emission as being influenced by the natural disturbance fluctuated from –100 Mt to 170 Mt $CO_2$-eq. It can be seen that the natural disturbances had great impact on carbon emission. A great difference between the final natural accounting results (carbon source/sink) might be resulted from the large interannual variation. If not considering the impact of force majeure on forest management, the amount of forest carbon sink might be increased by 30%, which would greatly improve the possibility of relieving emission reduction pressure of LULUCF.

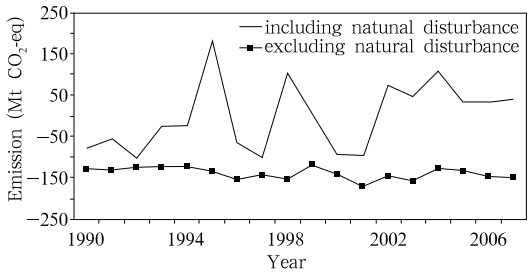


**Figure 2** Comparison of carbon emission on forest management in Canada during 1990–2007 [*Canada*, 2009]

Russia pointed out that the death rate of standing trees of domestic forests and the amount of carbon loss have increased due to force majeure. By means of the Tier 2 approach as stipulated in the *IPCC Good Practice Guidance* 2003, the domestic GHG emission conditions were evaluated [*Russian Federation*, 2010b]. Here, the amount of forest carbon loss caused by domestic fires and other factors in 1990–2008 was analyzed, and the amount of carbon loss caused by fires accounted for 40%–50% of the total losses (Fig. 3). From the perspective of the change since the late 1990s, the amount of carbon loss and the total amount of annual losses caused by major fires and other factors in Russian forest management activities have decreased, but the ratio of the former accounting for the latter has increased significantly. Thus, fires and other factors were deemed as a huge obstruction to improve the forest management carbon sink accounting in Russia. Therefore, Russia actively supported to remove the natural disturbances so as to increase the amount of carbon sink produced by the domestic LULUCF forest management activities.

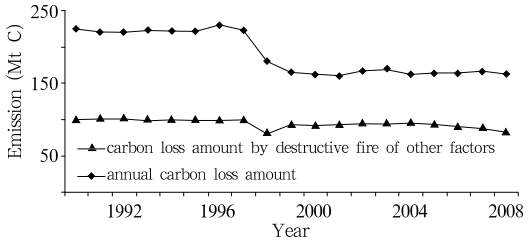


**Figure 3** Annual total carbon loss in forest management and those resulted from other reasons such as destructive fires and death of trees in Russia during 1990–2008 [*Russian Federation*, 2010b]

### 2.3.3 *Gross-net accounting and net-net accounting*

The gross-net accounting only considers the carbon stock changes caused by the difference between GHG carbon removal and emission during the commitment period, but does not compare it with the base year. The net-net accounting compares the carbon re-

moval and emission related to a certain activity during the commitment period with those in the base year [*Li et al*, 2008]. If a net carbon sink appears when comparing the two periods, there will produce a quantum of GHG emissions reduction to help parties to get close to their reduction target. The difference is that the gross-net accounting only considers the amount of carbon removal and emission produced by LULUCF forest management activities at the end of the whole commitment period, while the net-net accounting further compares the results with the reference level set at the beginning of the commitment period. As determined for the forest carbon removal sink countries in 1990, if these countries continuously maintain or increase the amount of carbon sink in forest management during the next commitment period, they would not decrease the total domestic amount of carbon sink accounted thereof, and even could make great contributions to their emission reduction obligations. However, as determined for the forest carbon emission source countries in 1990, even if they actively promote the carbon removal in forest management during the next commitment period, compared with the amount of carbon removal of 1990, they might only decrease their carbon emission, but not becoming a forest carbon removal sink country in the short term. Therefore, the forest carbon sink countries were inclined to the gross-net accounting approach, while the forest carbon source countries were inclined to the net-net accounting approach. So, there is a key dispute on which accounting approach should be used for LULUCF in all countries after 2012.

Among the natural factors, tree species and forest age structure are important factors which have impact on the cumulative amount of forest carbon sink. After the forest reaches a certain age, the increasing in forest tree growth will reduce, inducing a gradual decrease in the potential increasing of carbon sink [*Zhang et al.*, 2005]. Japan put forward the standpoint that the reference level after 2012 should be set to zero. It emphasizes that the constrictive gross-net accounting approach will better stimulate a sustainable forest management in each country, to achieve the maximum effectiveness in global emission reduction. This idea is related to the changes of forest age structures and forest carbon removal sink capacities in Japan.

The reports provided by *Japan* [2009a] show that the *Cedrus deodara* and *Chamaecyparis obtuse* are the two main tree species planted in its domestic artificial intensively-managed forests, where both species cover 70% of the total forest management area. The study shows that the potential carbon sink amount of tree species with a forest age of 20–40 years in the artificial management forests is close to the peak, due to the fact that $CO_2$ absorption capacities of tree species with a forest age of more than 40 years are limited by forest tree growth, when the carbon stock amount gradually stabilizes, and the carbon sink potential decreases [*Wu et al.*, 2008]. According to the distribution of existing intensively-managed forests with different age classes (Fig. 4), only a small proportion of young and older forests exist. Most of the forests are in the mid-forest age (6–11 years). These findings indicate that the $CO_2$ absorption capacities of intensively-managed forests will gradually decrease, so that the LULUCF accounting carbon sink amounts will reduce in Japan in the following years. If the net-net accounting approach was used, the Japanese forest carbon removal amount used as offsetting their domestic industry emission would be significantly reduced, and the emission conditions appeared. If the gross-net accounting approach was used as Japan required, the decrease of carbon removal amount caused by aging of trees would be avoided. The reason was that,

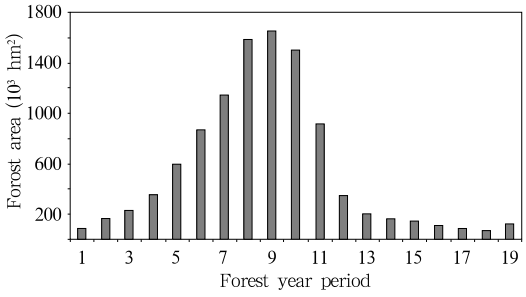


**Figure 4** Areal extent and age class structure of intensively-managed forests in Japan. The abscissa shows the Japan forest year classes from 1 to 19+, those classes represents different forest year period: 1, 1–5; 2, 6–10; 3, 11–15; 4, 16–20; 5, 21–25; 6, 26–30; 7, 31–35; 8, 36–40; 9, 41–45; 10, 46–50; 11, 51–55; 12, 56–60; 13, 61–65; 14, 66–70; 15, 71–75; 16, 76–80; 17, 81–85; 18, 86–90; 19+, ⩾91 [*Japan*, 2009a]

compared with 1990, as Japan was a forest carbon removal sink country, the LULUCF forest management activities still made contribution to its domestic carbon sink during the next commitment period, only except for the decrease in contribution rate. Therefore, Japan insisted on requesting that, during the post-Kyoto period, it should continue to follow the rules used during the first commitment period. On the surface, it adhered to the fairness and sustainability of LULUCF accounting rules. In fact, it aimed to continue using the carbon sink service arising from LULUCF forest activities for itself during the next commitment period.

## 3 Impacts of LULUCF on the emission reduction commitment of Annex I parties after 2012

### 3.1 *The emission reduction commitment of Annex I parties for the period until 2020*

As the first commitment period is coming to an end in 2012, some Annex I parties proposed emission reduction targets for the period until 2020. The EU 27 made a unilateral commitment that the emission will be reduced by at least 20% based on the emissions of 1990 [*EU*, 2011]. Norway announced that their emissions will be reduced by 30% based on the emissions of 1990 on condition that the existing LULUCF rules do not change [*Norway*, 2011]. *New Zealand* [2010] announced that their emissions will be reduced by 10%–20% based on the emissions of 1990. Japan announced that their emissions will be reduced by 15% based on 2005, which is more than 8% of emission reduction based on 1990, while all the emission reduction targets depend on the domestic emission reduction actions [*Japan*, 2009b]. Russia announced that, compared to the emissions of 1990, their emission will be reduced by 10%–15% [*Russia Federation*, 2010a]. Although not signing the *Kyoto Protocol*, but as a member of UNFCCC, the United States put forward the emission reduction target of 17% compared to the emission of 2005 (roughly equivalent to 4% of emissions in 1990) by 2020 [*United States*, 2011], but whether this target will be implemented is subject to the approval of its domestic legislation.

As a whole, there is a larger gap between only 15%–20% of emission reduction of various countries and regions in 2020 (compared to the emissions of 1990) and at least 40% of emission reduction as required in developing countries.

### 3.2 *Impacts of LULUCF on the emission reduction commitment of some Annex I parties*

Looking at the potential carbon sink in 2015 and 2020 produced by LULUCF activities submitted by EU 27, New Zealand, and Norway, it is indicated that a significant change in forest carbon sink amounts due to afforestation, reforestation, deforestation, and forest management activity, is needed (Table 2). All forest management activities are expressed as carbon emission source, except in Norway. Compared to the emission in 1990, the emission forecasted by EU 27 for 2015 and 2020 decreases by 20.5% and 21.9%, respectively. The emission forecasted by New Zealand for 2015 and 2020 decreases by 27.1% and 54.2%, respectively.

**Table 2** Variations of carbon source/sink of forest management activities of some Annex I parties in 2015 and 2020

| Year | Party | Afforestation and reforestation (Mt $CO_2$-eq) | Deforestation (Mt $CO_2$-eq) | Forest management (Mt $CO_2$-eq) | Total (Mt $CO_2$-eq) | Comparison to forest management in 1990 (Mt $CO_2$-eq) | Variance rate (%) |
|---|---|---|---|---|---|---|---|
| 2015 | EU 27 | –49.5 | 27.5 | –311.2 | –333.2 | –419.2 | 20.5 |
| | New Zealand | –19.2 | | –19.3 | –14.0 | –19.2 | 27.1 |
| | Norway | –0.5 | 0.6 | –21.1 | –20.9 | –14.2 | –47.2 |
| 2020 | EU 27 | –59.7 | 34.0 | –301.5 | –327.2 | –419.2 | 21.9 |
| | New Zealand | –13.6 | | –8.8 | –8.8 | –19.2 | 54.2 |
| | Norway | –0.6 | 0.6 | –19.2 | –19.1 | –14.2 | –34.5 |

Note: The variance rate refers to the proportion of increase or decrease of carbon sink amounts produced by three kinds of forest management activities in 2015 and 2010, respectively, compared with the carbon sink amount of 1990

Changes in LULUCF activities might be expressed as carbon source/sink in the future [*Cowie et al.*, 2006; *Pingoud et al.*, 2006]. It is indicated that the existing LULUCF accounting system on forest management decreasingly contributes to the future emission reduction targets of Annex I parties in the next commitment period. Therefore, it is more actively required to revise the LULUCF accounting system for each country after 2012, so as to adapt to the new carbon emission conditions caused by changes of forest resources.

## 4 Conclusions

In order to strictly control the use of carbon sink amounts produced by LULUCF activities, it is required to improve the exploring of new sustainable forest management methods to complete the emission reduction targets in the developed countries during the commitment period. More loopholes in accounting methods produced by harvested wood products activities and greater differences between accounting results have been found. After removal of the carbon emissions produced by force majeure, the carbon sink produced by LULUCF activities might increase by 30%. The threshold of the reference level should be set to a higher level of carbon sink. The net-net accounting approach is more suitable for LULUCF accounting rules after 2012. The modification of LULUCF accounting rules would have an important impact on the completion of emission reduction obligations of Annex I parties after 2012.

### Acknowledgements

This work was supported by China "973" projects of Special Negotiating Problems for LULUCF Response to Climate Change (No. 2010CB955702), and of Space-time Pattern of Carbon and Nitrogen and Water Flux of Chinese Terrestrial Ecosystem and its Regional Response (No. 2010CB833504). We are sincerely grateful to Associate Director Chunfeng Wang from the Network Center of Forest Restoration and Sustainable Management on the Asian-Pacific Region of the State Forestry Bureau of China for his technical help.

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