Improvement and application of IPCC Tier 2 method for quantification of carbon absorption in grassland biomass

Sle-gee Lee[a*], Jeong Gwan Lee[b], Du Hee Lee [b], Hyun-Jun Kim[b]

[a]Forest Resource Research Center, Chonnam National University, [b]Department of Forest Resources, Chonnam National University

1. Introduction

- In each field of LULUCF (land use-land use change and forestry), greenhouse gas statistics are calculated and reported to the international community.
- Grassland biomass is an important carbon sink on the surface that fixes atmospheric carbon.
- However, Tier 1 method is applied in most countries.
  - Only 20 % of the National Inventory Reports (NIRs) reported to the United Nations Framework Convention on Climate Change (UNFCCC) apply Tier 2 or higher methods.
  - The Tier 1 method results in an underestimation of carbon absorption in the grassland sector because atmospheric carbon dioxide absorbed by biomass is not counted.
- Therefore, the purpose of this study is to improve a formula for calculating the carbon absorption of grassland biomass using Tier 2 method.

2. Methods

- Tier 2 calculating formula was developed by IPCC guidelines and reviewing the NIRs of UNFCCC.
- The coefficients are identified by field surveys at 16 sites to understand the amount of growth and current status according to climate zones and soil types.
  - The soil type and management regime were not considered because there was no applicable activity data.
- The developed formula and coefficients were applied to the Republic of Korea (ROK) to quantify carbon absorption in grassland biomass.
  - It divided into cold and warm temperate climate zones according to standards of the IPCC guidelines.

3. Results

- According to the analysis of IPCC guidelines and NIRs, the major issues in the Tier 2 calculation formula are whether to consider the usage type of grassland and the amount of carbon absorption by human activity.
- Therefore, Tier 2 formula is developed composing average above-ground biomass (B_{AB}), cultivation and grazing activity (n), annual loss (B_L), carbon fraction (CF), and area (A) to reflect human activity (Equation 1).
  - The main factors affecting the developed equation are the average above-ground biomass, number of annual regeneration, and area.

$$\Delta C_{grass} = (B_{AB_{c,s,i}} \times n - B_L) \times CF_{c,s,i} \times A \quad \textbf{(Equation 1)}$$

ΔC_{grass}: annual carbon change in grassland biomass (Mg C yr^{-1})
B_{AB}: average above-ground biomass (ton ha^{-1} yr^{-1})
n : number of annual regeneration; no management as 1
B_L: annual loss in grassland biomass (ton ha^{-1} yr^{-1})
CF : carbon fraction
A : area (ha)
c : climate zone
s : soil type
i : management regime

<Table 1. Coefficients to apply the Tier 2 method>

Climate Zone	Average above-ground biomass (Mg $ha^{-1}yr^{-1}$)	Number of yearly cultivation	Carbon Fraction
Cold Temperate	3.72	2	0.4170
Warm Temperate	8.48	4	0.4149

- The carbon absorption was calculated by applying coefficients derived from field surveys (Table 1).
  - Average above-ground biomass in cold temperate is 3.72 (±0.56) Mg ha^{-1}, and 8.48 (±0.86) Mg ha^{-1} in warm temperate was applied.
  - The number of yearly cultivation assumed 2 for cold temperate and 4 for warm temperate to identify the maximum carbon absorption.
- As a result, the total annual carbon absorption was 366,041 Mg C through the country; 50,958 Mg C in cold temperate climate and 315,082 Mg C in warm temperate climate zone.
  - The reason that carbon absorption in warm temperate is about six times higher is because the average above-ground biomass and the number of annual regeneration is high.

4. Conclusions

- The carbon absorption of grassland biomass was analyzed to be 0.87 % of the ROK's total carbon absorption of LULUCF in 2017 when the developed Tier 2 formula was applied.
  - It was relatively low in the ROK because of the narrow grassland area and the low frequency of cultivation in mountainous region.
  - On the other hand, in countries where grassland is widely distributed and management intensity is high, it can make a great contribution to reducing greenhouse gas emissions.

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