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Estimation of Greenhouse Gas Emissions and Absorption from the Agriculture, Forestry and Other Land Use Sector in the Monomodal and Bimodal Rainfall Forest Agroecological Zones of Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This greenhouse gas (GHG) accounting study of the Agriculture, Forestry and Other Land Use sector assesses carbon emissions and absorption for the period 2010 to 2018 in the Monomodal and Bimodal rainfall agroecological zones. The methodological approach used for GHG emissions calculations in the Livestock category is the one proposed by the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines, taking into account the national systems of other countries. In general, Tier 1 has been used for the calculation of emissions. Emissions/removals are calculated by integrating the activity data of the different sectors considered in the IPCC software. In the subcategory of land use change, the SEPAL platform and ArcGis 10.6 software were used to download and process the images. In addition, the Peng (2000) equation was used to assess the soil organic carbon stock.

Emissions from the two agroecological zones are 281,541.3 GgCO2Eq and absorptions are -2,924,841.22 GgCO2Eq. The potential carbon stock that can be recovered in the two agroecological zones is -2,643,299.92 GgCO2Eq.

It is clear that these two agroecological zones absorb more than they emit. These results show that the Bimodal and Monomodal rainfall agroecological zones have a high absorption potential that Cameroon could use in the framework of internationally transferable mitigation results.

Keywords: Greenhouse gas; emissions; absorption; agriculture; forestry and other land use sector.

1. INTRODUCTION

Cameroon, being part of the Framework Convention on Climate Change and a signatory to the Paris Agreement, has been committed for several years to the preservation of the environment and the sustainable management of its natural resources, particularly the forests. Indeed, they play a crucial role in the fight against climate change through the natural sequestration of carbon in soils and forest biomass [1]. On the other hand, the loss and/or reduction of vegetation cover causes major harm in that it contributes to an increase in the share of greenhouse gas emissions due to deforestation and forest degradation. They therefore constitute a dynamic reservoir of forest resources, carbon and biodiversity that grows as they expand and mature or, conversely, shrinks as a result of deforestation and forest degradation [2]. Characterised today as "Africa in miniature", Cameroon presents a great geoclimatic diversity divided into five Agroecological Zones of which the Congo Basin forests cover the largest part, that is 22 million hectares. However, they are a good and great opportunity to understand the manifestations, impacts, as well as responses of a developing country to climate change in terms of adaptation to adverse effects and reduction of greenhouse gas emissions [3]. This is why it is important to know the quantities of greenhouse gases emitted by sources and absorbed by sinks. To date, Cameroon does not have disaggregated data for its agroecological zones. This study presents the situation of greenhouse gas emissions and removals of the Agriculture, Forestry and Other Land Use sector in monomodal and bimodal rainfall agroecological zones.

2. MATERIALS AND METHODS

2.1 Geographical Location of the Study Areas

2.1.1 The monomodal zone

The agroecological forest zone with monomodal rainfall covers a total area of 45,658 km2 and includes the Littoral and South West regions. It is characterised with a rainfall of between 2,500 and 4,000 mm, with records of up to 11,000 mm at the foot of Mount Cameroon. The rainfall regime is monomodal with a fairly short dry season (3 to 4 months). The vegetation growth period is for about 300 days. The average temperature is 24°C [4].

This area holds one of the world's wettest localities, Debundscha, with records of 13,000mm of annual rainfall falling, Average temperatures are relatively stable, hovering around 26°C, while relative humidity remains above 80% for most of the year [5].

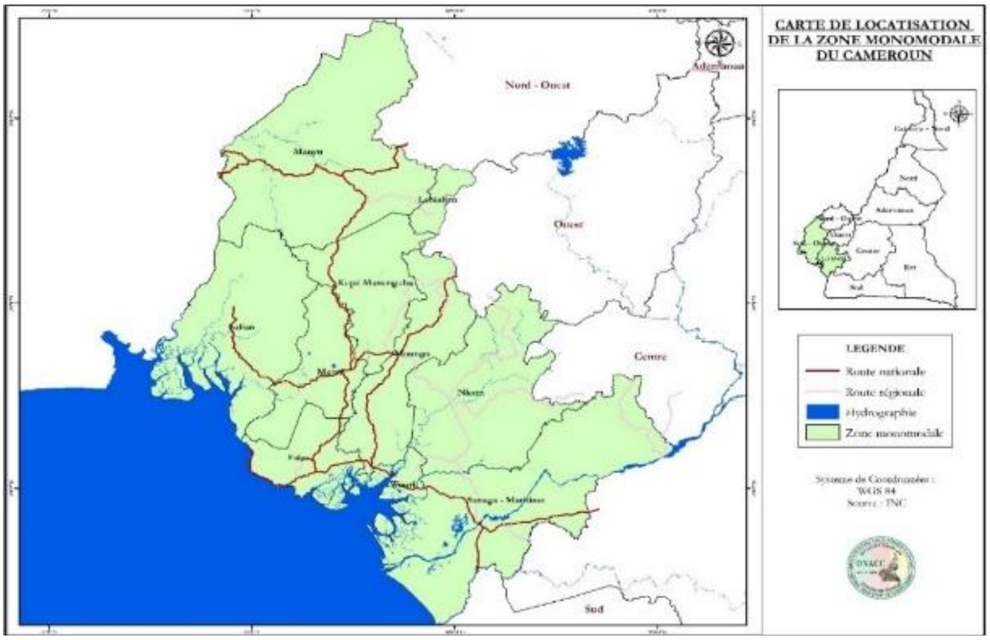

Fig. 1. Location map of the monomodal zone

The vegetation consists mainly of Mangrove forests, periodically flooded forests, lowland and midland forests of the coastal evergreen type.

2.1.2 The bimodal zone

The Bimodal Rainforest Zone covers an area of 165,770 km2 and extends between the 2nd and 4th degree of north latitude in the Central, Southern and Eastern regions [6]. The climate in this area is a tropical Guinean type, hot and humid. It is divided into two distinct wet seasons [7].

The vegetation here is mostly transitional of low and mid altitude ground transition forests and dense equatorial forests.

The forests covers about 17.3 million hectares or 86% of the area of the Agro-Ecological Zone (AGRO-ECOLOGICAL ZONE) [8]. The AGRO-ECOLOGICAL ZONE is almost 95% dominated by rainforest. A scrub tree savannah is present in the departments of Lom and Djerem, Mbam and Kim and Kadeï. The departments of Haut Nyong and Boumba and Ngoko are home to the largest forest areas.

2.1.3 Data collection

The quantification of Greenhouse Gas (GHG) emissions in monomodal and bimodal agroecological zones was done according to the requirements of the IPCC 2006 guidelines.

The study period is from 2010 to 2018 for the livestock category; 2010 to 2015 for land use and land use change. For soil organic matter carbon, the carbon is only for the year 2021.

2.1.4 Data collection in the agriculture subsector

In the livestock category, surveys were conducted in the regional and departmental delegations of the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) in the two agroecological zones with bimodal and monomodal rainfall. In particular, data on the number of heads of cattle, goats, sheep, pigs, poultry, horses and donkeys.

2.1.5 Data collection in the forestry and other land use (FOL) sub-sector

In the land use change category, data were collected by remote sensing using the SEPAL (System for Earth observations, data access, processing & analysis for land monitoring) platform. In this category, the aim was to collect data for the classes (cropland, grassland, wetland, settlement and other land) converted to forest land for a period of five (05) years, 2010-2015, in order to better assess the changes. In addition, for the other class changes these data were collected annually from 2010 to 2018.

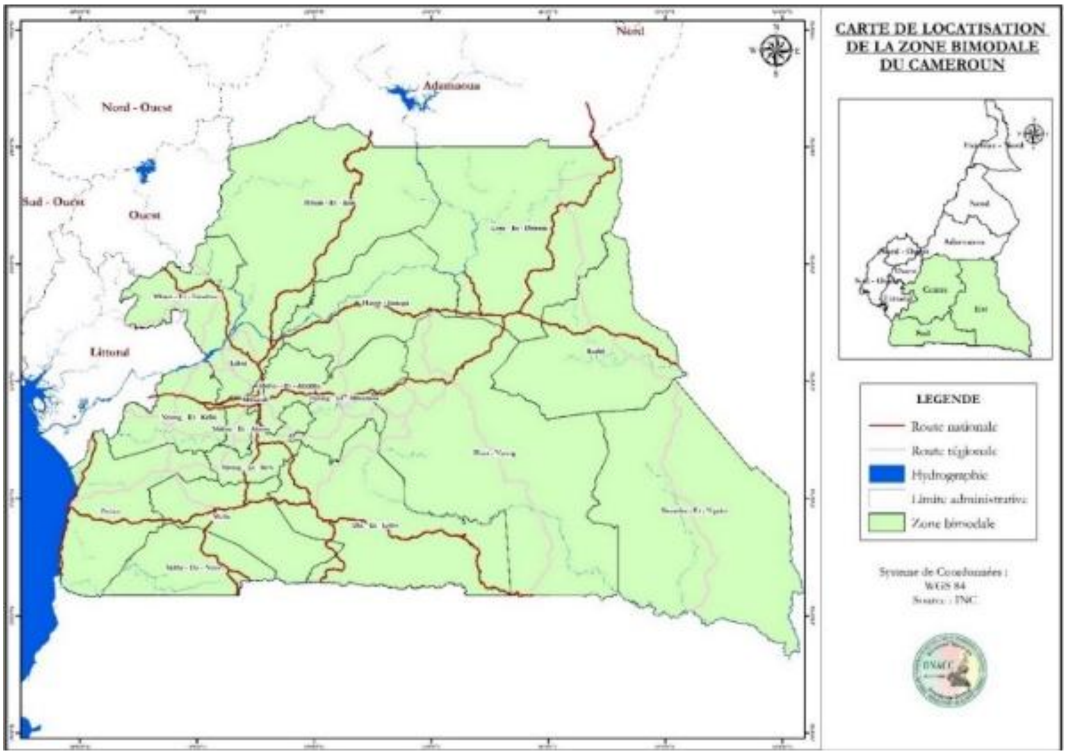

Fig. 2. Location map of the bimodal zone

2.1.6 Estimation of soil carbon stocks

- Identification of soil types encountered in the two agroecological zones: the FAO database [7] was used to identify the soil types encountered in the two (02) Monomodal and Bimodal agroecological zones.
- Subsequently, a grid of the zones was made in order to place soil collection samples.

Field sample collection: Soil samples were collected in the two agroecological zones of Bimodal and Monomodal rainfall. The points were selected according to soil types and each point was sampled in two soil profiles, i.e. 0-30 cm on the one hand and 30-60 cm on the other. The amount of soil taken was one kilogram of each profile. These samples were sent to the laboratory of the Ministry of Agriculture and Rural Development for analysis.

Soil sample analysis: This was carried out at the Ministry of Agriculture and Rural Development and aimed to determine the concentration of organic carbon in the various soil samples taken. This stage was carried out in three phases: pre-treatment (drying, grinding, sieving, labelling); sample processing and titration of the mixture according to the Walkey – Black [9] method.

The formula below allowed us to estimate the carbon stocks in the different soil types in the two agroecological zones:

$$q_{(i)} = 0{,}1 \times E_{(i)} \times da_{(i)} \times C_{(i)}$$

Equation 1

Where:

q(i)-Organic Carbon content in soil at point i (t.ha-1)
E(i)-Horizontal depth
da(i)-fine particle bulk density (g.cm-3)
C(i)-Concentration of organic Carbon in fine particle of the soil for point i (g.kg-1)

2.1.7 Processing data from different sectors of GHG emitting and absorbing activities

The data collected was processed by category using the following methods:

- The SEPAL platform and ArcGIS software were used to process the images obtained in the land use change category;
- Gaps in the data collected in the field for the livestock sub-sector were filled by literature reviews and documents

2.2 Estimates of Emissions and Absorptions

The estimation of greenhouse gases was done according to the IPCC guidelines, the calculation methods were chosen according to the availability of data through the decision tree [10,11].

In general, Equation 2 is used to estimate greenhouse gases, the IPCC software is used as a tool to apply this formula, depending on which sector you are in, there are additional parameters that can integrate each element.

$$E = AD \times EF$$

Source: GIEC, 2006 Equation 2

Where:

E: Emission
AD: activity data
EF: Emissions Factor

2.2.1 Estimation of emissions from enteric fermentation and manure management

The method used is the Tier 1 method, the activity data collected in the field was entered into the IPCC software, the default IPCC emission factors proposed by the software were used to obtain GHG emissions in giga grams of CO2, CH_4 and NO_2 for the two categories, enteric fermentation and manure management.

2.2.2 GHG estimates for the Forestry and Other Land Use sub-sector

The acquisition of satellite images (Landsat 30-metre resolution, December 2010 to January 2020) on the SEPAL platform made it possible to determine and classify land use and land use changes in the agroecological zones with Monomodal and Bimodal rainfall. The changes between the periods 2010-2015 and 2015-2020 were thus observed. The choice of five years of compliance allowed for a better observation of changes that are difficult to observe in one year. Later on, the images were processed and post-processed (or validated) to estimate the land cover areas for the six IPCC classes.

The images were processed in three stages, processing, pre-processing and post-processing or validation, at the end of which we obtained the land cover areas for the 06 IPCC classes.

2.3 Emissions Projections

The following equation 3 was used to project the emissions represented and to fill the gaps.

$$Y_{(t)}=Y_{(t-1)}+(Y_{(t-1)} - Y_{(t-2)}) \qquad \text{Equation 3}$$

Y(t) = emissions/absorptions in year t
Y(t-1) = emissions/absorptions in year t-1
Y(t-2) = emissions/absorptions in year t-2

3. RESULTS

3.1 Monomodal Agroecological Zone

3.1.1 Livestock sub-sector

Tables 1 and 2 present the estimated CH4 and N2O emissions from 2010 to 2021 for the enteric fermentation and manure management categories.

The analysis in Table 1 shows a relatively small increase in methane emissions between 2010 and 2018. The year 2010 had the lowest CH4 emissions at 6.898 GgCO2eq. From 2015 onwards, there is an increase in emissions up to a peak of 19.66 GgCO2eq in 2019.

Table 1. Summary of CH4 emissions from enteric fermentation (GgCO2eq)

Years	Littoral	South West	Total
2010	4,00	2,898	6,898
2011	4,24	3,876	8,115
2012	3,924	4,308	8,232
2013	4,166	3,779	7,945
2014	4,084	4,114	8,198
2015	4,084	5,009	9,093
2016	7,053	6,182	13,235
2017	5,733	11,938	17,671
2018	6,116	13,544	19,660
Total	**43,399**	**55,648**	**99,047**

3.2 Manure Management

Analysis of these Table 2 shows that CH4 and N2O emissions related to manure management for the period 2010 to 2018 vary from 2010 to 2013 and with a slight increase from 2014 to 2018.

3.3 Evolution of Emissions in the Livestock Category

Table 3 shows the CO2 eq emissions in the livestock category for the single-mode business park.

Table 3 shows that CO2 emissions from livestock production are roughly stable from 2010 to 2014 and increase from 2015 to 2018. However, 2010 was the year with the lowest emissions at 11.56 GgCO2 eq, while 2017 and 2018 were the years with the highest emissions at 31.95 GgCO2 eq and 35.14 GgCO2 eq respectively.

3.4 Land Use, Land Change and Forestry Sector (LULUCF 2010-2015)

The greenhouse gas inventory in this sector covers the following areas of activity:

- Change in forests and other woody biomass stocks.
- CO2 emission from forest and grassland conversion.
- On-site burning of forests.
- CO2 emissions and/or sequestration from soils due to land use change and management.

Table 2. Summary of manure management emissions in the Monomodal agroecological zone in Gg

	Littoral		South West		Total
Years	**CH_4**	**N_2O**	**CH_4**	**N_2O**	**CO_2eq**
2010	1,753	0,045	2,795	0,069	4,661
2011	1,678	0,049	3,233	0,079	5,039
2012	1,647	0,046	3,185	0,080	4,959
2013	1,664	0,049	3,39	0,081	5,184
2014	1,676	0,048	3,748	0,076	5,547
2015	2,16	0,069	3,609	0,151	5,988
2016	2,405	0,073	4,563	0,102	7,143
2017	3,129	0,097	8,896	0,197	12,319
2018	4,297	0,128	10,821	0,230	15,477
Total	**20,41**	**0,604**	**44,239**	**1,065**	**66,317**

Table 3. Summary of emissions from the livestock category from 2010 to 2018

Years	2010	2011	2012	2013	2014	2015	2015	2016	2017	2018	Total
Emissions in GgCO2 eq	11,55	13,15	13,19	13,12	13,74	15,08	20,37	31,94	31,94	35,13	167,32

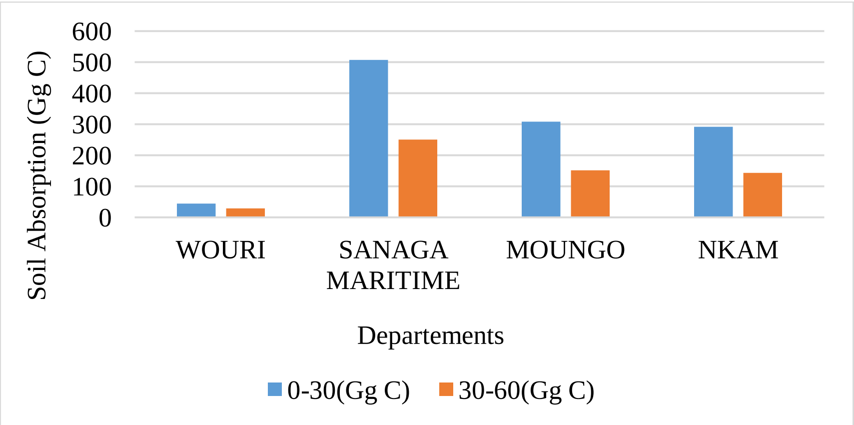

Fig. 3. Carbon uptake by department in the Littoral region from 2010 to 2018

Fig. 3 presents the level of carbon of soil organic matter absorbed in different departments of the Littoral.

The Fig. 3 shows that soil carbon uptake for the 0-30 cm profile is high in the Department of Sanaga Maritime Department, at 506.98 Gg CO2 Eq, followed by the Departments of Moungo and Nkam with 307.9 Gg CO2 Eq and 291.65 Gg CO2 Eq respectively.

For the 30-60 cm profile, soil carbon uptake is high in the Sanaga Maritime Department at 249.77 Gg CO2 Eq. It is followed by the departments of Moungo and Nkam with respectively 150.85 Gg CO2 Eq. and 143.08 Gg CO2 Eq. Finally comes the department of Wouri with 28.98 Gg CO2 Eq.

3.5 Absorption-emission Balance in the Agroecological Zone with Monomodal Rainfall

Table 4 presents the greenhouse gas emission-absorption balance of the Agriculture, Forestry and Other Land Use (AFOLU) sector in the single-mode Agro-ecological Zone.

This Table 4 presents emissions and removals from the sub-categories of enteric fermentation, manure management, land-use change and soil organic carbon. In the agroecological zone with monomodal rainfall, a total of 29,770.68 GgCO2Eq is emitted into the atmosphere. On the other hand, absorptions are estimated at -345,013.82 GgCO2Eq. The potential stock of recoverable carbon is -315,243.14 GgCO2Eq. It should be noted that the soil organic carbon removals only concerned the Littoral region, as the field visits were not carried out in the South-West region, due to the prevailing insecurity there.

3.6 Bimodal Rainfall Agroecological Zone

3.6.1 Livestock sub-sector

Table 5 presents the CH4 emissions of the enteric fermentation subcategory for the period from 2010 to 2018 in the Bimodal Rainfall Agroecological Zone.

Table 4. Emissions, removals and storage potential in the agroecological zone with monomodal rainfall in GgCO2eq from 2010 to 2015

Emissions	**Zone Monomodale ($GgCO_2$ eq)**
Enteric fermentation	48,48
Manure management	31,38
Conversion of forests(Clearing) to grassland	29 690,82
Total	29 770,68
Absorptions	Zone Monomodale (GgCO2 eq)
Change in forests and other woody biomass stocks	-344 152
CO2 uptake from soil	-861,82
Total	-345 013,82
Valuable carbon stock potential	-315 243,14

Table 5. Summary of enteric fermentation emissions in the bimodal rainfall agroecological zone

Years	Center Region	East Region	South Region	Total
2010	13,519	0,017	8,231	21,768
2011	13,143	0,017	8,914	22,074
2012	12,843	0,019	9,432	22,294
2013	14,805	0,019	10,025	24,849
2014	15,461	0,022	11,808	27,291
2015	16,163	0,019	6,448	22,631
2016	20,850	0,026	7,393	28,270
2017	16,801	0,023	8,684	25,509
2018	15,999	0,023	8,039	24,062
Total	**139,58**	**0,18**	**78,97**	**218,74**

CH4 emissions in Table 5 changes slightly between 2010 and 2013, with isolated peaks in 2014, 2016 and 2017 where a decrease in emissions is observed

3.7 Manure Management

Table 6 presents the emissions from the manure management sub-category of the Bimodal Rainfall Agroecological Zone for the period 2010 to 2018.

Table 6 shows a predominance of CH4 17.1069 (GgCO2Eq) emissions in the Central region compared to those observed in the Eastern and Southern region. N2O emissions are, however, higher in the Eastern region 8.7605 N2O (GgCO2Eq) compared to the other regions. However, 2016 was the year with the highest emissions of CH 4 (18.218 Gg CO 2 Eq) and N 2 O (0.75 Gg CO2 Eq).

3.8 Evolution of CO2 eq Emissions from the Livestock Category

Table 7 provides information on the development of emissions in the livestock category.

It is observed that greenhouse gas emissions in the bi-modal Agro-Ecological Zone are highest from 2016 to 2018.However, 2012 was the year with the lowest emissions in the livestock category.

3.9 Land Use, Land Use Change and Forestry Sector Forestry (LULUCF) of the Bimodal LFA (2010-2015)

The Greenhouse Gas inventory of activity cover the following areas:

- CO 2 emission from forest and grassland conversion.
- On-site burning of forests.
- Soil emissions and/or sequestration of CO 2 due to land use change and management.

Fig. 4 shows the carbon uptake by department in the Bimodal Rainfall Zone.

Fig. 4 shows that soil carbon uptake for the 0-30 cm profile is highest in Haut Nyong with 2313.99 GgCO2, followed by Lom et Djerem, Dja et Lobo, Boumba et Ngoko, Sanaga Maritime and finally Kadey.

The analysis of the 30-60 cm profile shows that soil carbon uptake is high in Lom and Djerem, Haut-Nyong, Dja and Lobo, Bouba and Ngoko and Kadey. Comparatively it is observed that the level of soil carbon uptake is higher in the 0-30 cm profile than in the 30-60 cm profile.

Table 6. Summary of emissions from manure management in the bimodal rainfall agro-ecological zone

	CENTRE		EAST		SOUTH		TOTAL
Years	**CH_4 ($GgCO_2Eq$)**	**N_2O ($GgCO_2Eq$)**	**CH_4 ($GgCO_2Eq$)**	**N_2O ($GgCO_2Eq$)**	**CH_4 ($GgCO_2Eq$)**	**N_2O ($GgCO_2Eq$)**	**($GgCO_2Eq$)**
2010	15,023	0,318	0,0012	3,978	1,547	0,003	16,892
2011	10,260	0,338	0,0012	3,550	1,027	0,038	11,665
2012	9,976	0,358	0,0014	4,248	1,095	0,040	11,470
2013	12,088	0,412	0,002	4,350	1,150	0,043	13,695
2014	11,416	0,417	0,001	4,667	1,165	0,045	13,044
2015	13,250	0,502	0,001	4,474	0,915	0,029	14,698
2016	17,107	0,717	0,002	5,257	1,109	0,036	18,971
2017	15,930	0,562	0,0015	8,761	1,176	0,037	17,707
2018	14,610	0,539	0,002	5,151	1,128	0,036	16,315
Total	**119,66**	**4,16**	**0,013**	**4,44E-04**	**10,31**	**0,31**	**134,46**

Table 7. Summary of emissions from the livestock category from 2010 to 2018

Years	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Emissions GgCO2 eq	37,11	32,67	32,63	37,35	39,12	36,38	46,09	42,01	39,21

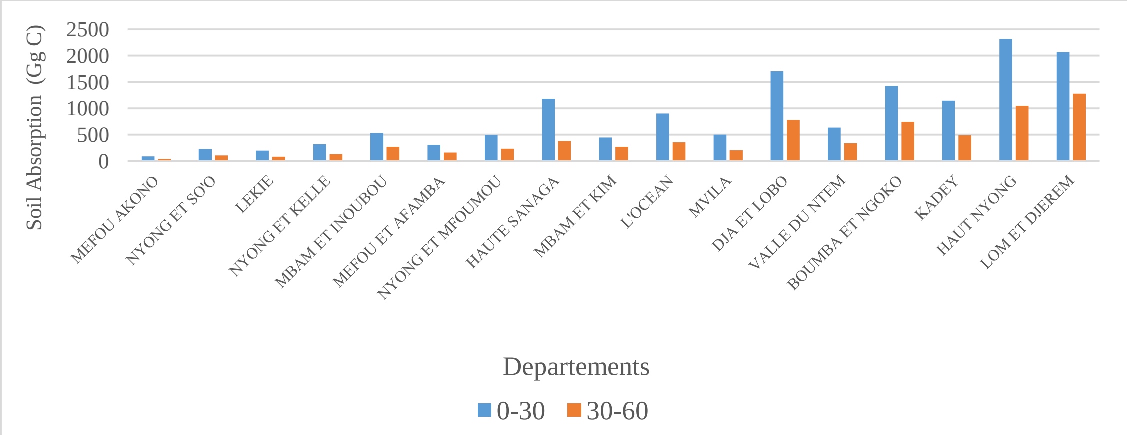

Fig. 4. Carbon uptake by department in the agroecological zone with bimodal rainfall

3.10 Absorption-emission Balance in the Agroecological Zone with Bimodal Rainfall

Table 8 presents the greenhouse gas emission-absorption balance of the Agriculture, Forestry and Other Land Use (AFOLU) sector in the bi-modal Agro-Ecological Zone.

Table 8 shows that in the agroecological zone with bimodal rainfall, emissions are in the order of 251,770.62 GgCO2 Eq and absorptions in the order of -2,579,827.4 Gg CO2Eq. The valorised carbon stock potential is -2,328,056.78 GgCO2Eq.

3.11 Summary of Absorption-emission in the Two Agroecological Zones

The data collected made it possible to estimate the emissions and absorptions of greenhouse gases in two agroecological zones, namely the Monomodal zone and the Bimodal zone. Thus, after an analysis of the values of emissions and removals, a summary has been presented in Table 9.

Emissions in these two agro-ecological zones are of the order of 281,541.3 GgCO 2 Eq. On the other hand, absorptions are of the order of -2,924,841.22 GgCO 2 Eq. The potential recoverable carbon stock in the two agroecological zones is -2,643,299.92 GgCO 2 Eq.

4. DISCUSSION

Greenhouse gas emissions in the livestock category are higher in the bimodal Agro-Ecological Zone (AEZ) 222.36 GgCO 2 Eq than the monomodal ZAE 79.86 GgCO 2 Eq. This can be justified by the fact that the single-mode Agro-Ecological Zone is not a favourable area for livestock farming and moreover its area is smaller 5.11 million hectares in contrast to the area of the dual-mode zone which is 17.3 million hectares [8].

Table 8. Emissions and absorptions of GHGs by sub-categories in the agro-ecological zone in the Bimodal rainfall in Gg

Emissions	Zone Bimodale (GgCO$_2$ eq)
Enteric fermentation	140,91
Manure management	81,46
Conversion of forests (Clearing) to grassland	251 548,25
Total	251 770,62
Absorptions	Zone Bimodale (GgCO2 eq)
Change in forests and other woody biomass stocks	-2 569 124,16
CO2 uptake from soil	-10 703,24
Total	-2 579 827,4
Valuable carbon stock potential	-2 328 056,78

Table 9. Summary of emissions and removals in the two agroecological zones with Bimodal and Monomodal rainfall from 2010 to 2015 in GgCO2 Eq

Emissions	Zone Monomodale	Zone Bimodale	Totaux
Enteric fermentation	48,48	140,90	189,39
Manure management	31,38	81,46	112,84
Conversion of forests (Clearing) to grassland	29 690,82	251 548,25	281 239,07
Total	29 770,68	251 770,62	281 541 ,3
Absorptions	Zone Monomodale	Zone Bimodale	Totaux
Change in forests and other woody biomass stocks	-344 152	-2 569 124,16	-2 913 276,16
CO2 uptake from soil	-861,82	-10 703,24	-11 565,06
Total	-345 013,82	-2 579 827,40	-2 924 841,22
Valuable carbon stock potential	-315 243,14	-2 328 056,78	-2 643 299,92

The increase in emissions in the livestock category Tables 3 and 7 in the two agroecological zones from 2010 to 2018 could also be explained by the improvement of data collection mechanisms in the services concerned (departmental and regional livestock delegations and MINEPIA); the increase in transhumance due to high demand.

For both soil profiles studied the bimodal zone absorbs more soil carbon, i.e. 14,487.25 GgCO2 eq (0-30 cm) and 6919.21 GgCO2 eq (30-60 cm) than the monomodal zone with 1150.96 GgCO2 eq and 572.68 GgCO2 eq respectively. These results would be justified by the fact that the forests in the bimodal zones are mainly represented by lowland dense forest and those in the bimodal zone are represented by dense moist forest. In the Land Use, Land Use Change and Forestry Sector Forestry (LULUCF) sub-sector for the period 2010 to 2015, the CO2 removals of the land-use change category in the bi-modal area -2,569,124.16 GgCO2 Eq are much higher than those in the monomodal area -344,152 GgCO2 Eq. to soil organic matter.

Two sub-sectors contribute to CO2 removals in Land Use, Land Use Change and Forestry Sector Forestry (LULUCF): land-use change or -2,569,124.16 GgCO2 eq and carbon removals by dead soil organic matter or -10,703.24 GgCO2 eq. In the LULUCF sector, the total CO2 absorbed for the period from 2010 to 2015 is estimated at -2,579,827.4 GgCO2 Eq. This result is explained by the fact that the bimodal area has more dense forests compared to the monomodal area which has a diversity of land use types and a high degree of anthropisation. It can be seen that these two agroecological zones absorb more than they emit. The agroecological zone with bimodal rainfall absorbs and emits more than the agroecological zone with monomodal rainfall.

5. CONCLUSIONS

In order to benefit from climate finance as an offset measure in accordance with Articles 6 and 9 of the Paris Agreement, Cameroon must produce regular GHG emissions inventory reports as well as its carbon sequestration potential. It is therefore in view of all these issues that the National Observatory on Climate Change has prepared a report on greenhouse gas emissions inventories in the Agriculture, Forestry and other Land Use sectors for the period 2010 to 2018 in the agroecological zones with monomodal and bimodal rainfall.

Emissions in these two agroecological zones is 281,541.3 GgCO2Eq. On the other hand, absorption is of the -2,924,841.22 GgCO2Eq. The potential carbon stock that can be recovered in the two agroecological zones is -2,643,299.92 GgCO2Eq. All in all, it appears that these two agroecological zones absorb more than they emit. These results show that Bimodal and Monomodal rainfall agroecological zones have a high absorption potential, which Cameroon could use as part of the mitigation results transferred to the international level.

6. LIMITATIONS OF THE STUDY

This work had some limitations due to the fact that some sources of emissions were not taken into account, in particular emissions from bushfires, which release gases such as methane, nitrous oxide, nitrous monoxide; emissions from rice cultivation; emissions from the use of pesticides; and emissions from the use of fertilisers, particularly nitrogenous fertilisers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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