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Quantifying GHG Estimations for Agriculture, Waste, and Land Use, land Use Change and Forestry (LULUCF) for a Village Model in India

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ABSTRACT

This paper describes the sustainability impact assessment by quantifying the GHG estimates from the categories of agriculture, land use, land use change and forestry (LULUCF) and waste, for a semi-urban transiting village Bidholi, in the state of Uttarakhand, India. The study quantifies the GHG emission estimates in 2016 from the agricultural sector as 115.71 tons of CO_2-eq and waste emissions as 133 tons of CO_2-eq. The emissions identified from the various sources are in lieu with the life cycle activities such as crop cultivation, livestock manure management, enteric fermentation and waste generation. The large span of thick forest covering the village, acts as a prominent source of carbon sink sequestering 12205.22 tons net CO_2-eq. The carbon stock estimations for the above-ground biomass (ABG), below-ground biomass (BGB) and soil organic content (SOC) are accounted for the forest area in compliance with the country specific national inventory values.

INTRODUCTION

Quantifying the carbon footprint being emitted from the village Bidholi, located in the forest blanket, uptown from the city of Dehradun, Uttarakhand, India, endeavors a high impact assessment study on efficiently deploying sustainable models, to mitigate climate change issues.

The village encompasses a university within the premise, which has been deployed way back a decade ago. This has in-cultivated wind swept growth through the establishments of hostel buildings, commercial enterprises and overall populace. Whilst, the stride towards economic growth, the blissful geography had swerved off to construction, other land uses from previously forestlands and croplands. The number of residing populace has increased tremendously with compounded growth.

The paper identifies the various GHG emissions fumed from the sectors of agriculture, wastes and LULUCF using the sustainability tools and the scope of boundaries. As in the case of any globalization models, incorporating the emerging factors that contribute towards GHG emissions, the paper pools in the identified sources of emissions from each sector.

Attributing towards the global standard protocols on good practices and sustainability tools (IPCC 2006), the emission factor database for the village was recorded. The paper provides information about the country specific plus default values of tier estimation, to compute the grand total GHG emission from energy based life cycle activities.

MATERIALS AND METHODS

Estimating the carbon footprint levied into the atmosphere is the primary head approach towards quantifying the sustainability impacts generated. The estimates prepared were calculated in accordance with the IPCC and good practice guidance for National Greenhouse Gas Inventories. The paper has pooled in sources from peer reviewed journals, Indian Network on Climate Change Assessment (INCCA 2007), Indian GHG inventory estimates, and IPCC guidelines for estimations in waste and LULUCF.

A partial appraisal from the MNRE (Ministry of New and Renewable Energy) and Indian network for climate change assessment-research documents and peer reviewed databases were analyzed for identifying the similar ecological portfolios.

Activity data: The records and database formulated in this report were done in the line of:

i. Site survey.

ii. Site inspection inclusive checklist preparation.

iii. Sector wise satellite based remote area mapping.

With a total coverage of 207 acres, an aggregate of 21.62 ha of land is utilized for cropping lands and 14.59 is left uncultivated as grasslands.

Satellite based remote mapping for the village Bidholi: The individual satellite based scanned values for the areas were recorded. The total pan area was obtained by summing all the n-values to account for the total estimated area for indi-

Fig. 1: Satellite based remote mapping of farmlands.

Table 1: Total area in acres for landscapes mapped in Bidholi village (2016). Source: Own compilation based on satellite remote mapping tools.

Sl. No.	Type of land	Total area in acres
1	Bidholi area	207.00
2	Farming land	90.08
3	Cropping land used	21.62
4	Grasslands used	14.59
5	Forest coverage	70.00

vidual sectors. Resource mapping model as shown in Fig.1 is an imperative approach in analyzing the plethora of geographical emission possibilities and gauging the projection models from each sector as given in Table 1.

This paper includes an emission factor database that records the emission factors for the profile regime of the village activities. The emission factors derived are in conjunction with the IPCC revised guidelines, INCC assessment reports and GHG national inventory estimation reports. The EFDB for various sources recorded (agriculture, waste and forestry) is given in Table 2.

OBSERVATIONS

Agriculture Sector in Bidholi

***Enteric fermentation*:** The ruminant livestocks emit methane gas due to anaerobic fermentation occurring in their forestomaches. The methane produced varies up to 400 litres per day, attributing to its 12% of the energy (Zeimeer link et al. 1999). The methane emissions incurred are proportional to the size of the cow and the type of the feedstock. Higher anthropogenic CH_4 gases are fumed when the livestock feeds on low quality forage including grass, straws and crop residues (Johnson & Johnson 1995). To control the emissions recorded annually, it is important to improve the feedstock quality, enhance the concentrate feed, mainly with the rice brans and coconut cakes (Buvendran 1997).

In analyzing the emission factors, the country specific values for dairy and non-dairy cows were studied in lieu with the considerations for annual average temperature ranging between 15 and 25°C, geographic regimes, etc. The accounted methane emission for Indian sub-continent standards varies from 11-58 kg/head/year. The estimations analyzed and region-wise concerns accounted was for 52 kg/head/year (Lokupitiya 2016).

***Livestock manure management*:** In accordance with the IPCC guideline practices for cattle manure management being used for fuel with the remainder managed in dry systems, annual average temperature of 15-25°C, the emission factor chosen for estimations was 5 kg/head/year and 0.3 kg/head/year of N_2O gas (Hongmin et al. 2006).

The study has identified an annual estimation of 0.375 tons of CH_4 emissions and 0.0225 tons of N_2O emissions released into the atmosphere due to livestock manure management day to day activities.

***Perennial crop cultivation- rice and wheat*:** The major crops cultivated annually are rice, wheat and maize. Rice cultivation is done from the months of June-December, whereas wheat is cultivated between November and April, and the maize from June-September. The main source of manure is urea, dung cakes and fertilizers constituting NPK (sodium, phosphorus, potassium). The survey estimates recorded accounts that the harvest reaped from an acre of land produced an average of 50-70 kg. The production yield could have been higher if proper irrigation channels were available in the cropping lands.

***Methane gas production*:** Rice and wheat cultivation produces methane gase in higher levels, if anaerobic conditions pertain to exist in the soil layer. Flooded and dry soil stratum prevents sufficient oxygen to penetrate into the soil layers. The microbes or the methanogens respire CO_2 under the aerobic conditions, but under anaerobic conditions within the soil (dependent on the water regime and climate type) methane gas is produced by the bacteria living within the soil beneath.

Estimation as per country specific values for methane gas production from perennial crop cultivation (especially rice) with reference to inventory estimates from database records of Indian network of climate change assessment in 2007 were 66 kg/ha of CH_4 emissions for single aerated lands and 18 kg/ha of CH_4 emissions (INCCA 2007) from multiple aerated lands. In lieu with the EFDB recorded, the aggregate emission from cultivation of rice accounted was 0.962 tons of methane and 0.97 tons of methane from wheat cultivation.

Table 2: EFDB for various sources in the village (2016). Source: Own compilation based on country specific and default values IPCC (2006).

Sl no	Category	Unit	EFDB (CO_2-e/unit)	EFDB (CH_4-e/unit)	EFDB (N_2O-e/unit)	Carbon stock (C-e/unit)
Agriculture, forestry and waste						
1	Enteric Fermentation	kg/head/year	-	52	0.52	-
2	Livestock Manure management	kg/head/year	-	5	0.3	-
3	Rice cultivation	kg/ha	-	66	-	-
4	Wheat cultivation	kg/ha	-	66	-	-
5	Soils (rice farm)	kg/ha	-	-	0.76	-
6	Soils (Wheat farm)	kg/ha	-	-	0.66	-
LULUCF EFDB						
	Forestland					
7	Forestland remaining forestland	m^3/ha	-	-	-	59.79
8	Above ground biomass stock in plantation forests	tdm/ha	-	-		86.11
9	Forest fires ($NO+N_2O$)	g/kg dm combusted		-0.6-0.8		
	Cropland					
10	Cropland remaining cropland-Soil carbon stock forinorganic NPK fertilizer	tons/ha/year				1.89
11	Above ground biomass stock	tdm/ha	-	-	-	11.5
	Grasslands					
12	Grasslands remaining grasslands-Soil carbon stock 0-30cm layer	tons c/ha	-	-	-	85
Waste EFDB						
13	Domestic wastewater	fraction/	-	0.18	-	-
-		total kg				
14	Domestic wastewater-N_2O due to protein content	Percent of total CH_4	-	-	1.83	-
15	Waste- Unmanaged waste	Fraction (relative to total kg)	0.15	0.1	150 g/ton waste	-
16	Waste-Managed waste	Fraction (kg)	0.1	0.4	-	-
17	Combustion in open air/open burning of waste	Fraction (relative to total kg)	0.6	6500 g/ton waste	150 g/ton waste	

***Agricultural soils*:** The methodology is to identify the nitrogen content within the soil, through application of NPK fertilizers. The farmers plow in an aggregate 5-10 kg of fertilizers per acre of land cultivated.

In compliance with the INCC standards and inventory estimations for India, the emission factors obtained for the croplands in Bidholi were 0.76 kg/ha for rice cultivation and 0.66 kg/ha for wheat cultivation equivalent N_2O gas delivered (Pathak et al. 2002).

Incorporating the factors that generate N_2O from the agricultural soils through direct injection and indirect ways, inclusive volatilization of ammonia from the soils and combustion of biomass, the annual amount of N_2O emissions in 2016 recorded was:

1. Agricultural soils cultivating rice fumed an aggregate of 0.0111 tons of N_2O i.e., 3.44 tons equivalent of CO_2.
2. Agricultural soils cultivating wheat fumed an aggregate of 0.0096 tons of N_2O i.e., 2.99 tons equivalent of CO_2.

The total GHG emissions liberated from the agriculture sector is graphically represented as in Fig. 2.

Land Use, Land-Use Change and Forestry (LULUCF)

***Forestland remaining forestland*:** The outer covering forest zones contribute a major source towards curbing the pollution levels generated by the other sectors. The trees are the major sources in emulsifying the CO_2 released into the atmosphere. The soil organic matter content above and below the soil also adds up to the pool of carbon sink. A pictorial representation of the forest outlands captured is shown as in Fig. 3. Hence, estimations on above ground biomass, below ground biomass and soil organic carbon content are tapped in with reference to the geographical texture, identity of the forest zone, climate type (moist or dry), etc.

The average growing stock volume above ground for the Indian forest was accounted 59.79 m^3/ha (Jagdish Kishwan et al. 2006).

The above ground biomass stock attributes towards the carbon rupturing ecosystem regime such as the tree roots above the soil, organic matter from leaves or dead matter etc., the carbon content enriched in are all sources for carbon

Table 3: Total forest living biomass carbon stock (2016). Source: Compilation based on Jagdish Kishwan et al. (2006).

Item with symbolic description	Factor	2016
Growing Stock of Country in m^3-GS	59.79	4185.30
Mean Biomass Expansion Factor-EF	1.575	
Ratio (Below to Above Ground Biomass)-RBA	0.266	
Above Ground Biomass (Volume)		6591.85
Below Ground Biomass (Volume)		1753.43
Total Biomass (Volume) : TB = AGB + BGB		8345.28
Mean Density - MD	0.712	
Biomass in Mt = Growing Stock (m^3) × Mean Density (MD)		5938.50
Ratio (Other Forest Floor Biomass except tree to Tree Biomass)	0.015	
Total Forest Biomass in t (Trees + Shrubs + Herbs) - TFB		5849.42
Dry Weight in t (80% of TFB) - DW	0.80	4679.54
Carbon in t (40 % of DW)	0.40	1871.82
Net tons of CO_2-e (eq)		6863.32

Table 4: Total forest soil organic carbon stock (2016). Source: Compilation based on Jagdish Kishwan et al. (2006).

Forest Type (Group)	Sub-tropical broad leaved hill forest
Area (ha)	70
Mean soil carbon	86.11
Total SOC	6027.70
Net carbon content	1373.35
Net tons of CO_2-e (eq)	5035.62

dioxide sequestration (Jim Penman et al. 2003). The carbon content within the dry matter is 40-50% as per IPCC guidelines. As per Indian inventory estimates the value was taken as 40% (India's forest and tree cover; contribution as a carbon sink, Indian Council of Forestry Research and Education). The annual carbon stock for LULUCF is given as:

$$C(TLB) = C(AGB) + C(BGB) + C(SOC)$$

Where,

C(TLB) = The total land biomass for forestlands, croplands or grasslands.

C(AGB) = The living biomass above the ground.

C(BGB) = The living biomass below the ground.

C(SOC) = The soil organic content from 0-30 cm depth below the soil surface layer. The total GHG removals or carbon stocks estimated is summarized as in Fig. 4.

National conditions/parameters (Tables 3, 4):

a. The carbon sequestered from forestlands was estimated as country specific national inventory for GHG emissions (India's forest and tree cover; contribution as a carbon sink, Indian Council of Forestry Research and Education). The forest biomass mean expansion factor (BEF) is accounted 1.575 (Kaul et al. 2009).
b. The above ground biomass = annual growing stock × biomass expansion factor. The ratio between below to above ground biomass is taken as 0.266.
c. The mean bulk density of the total biomass for tropical Indian forest recorded is 0.7116.
d. Incorporating the other forest floor biomass except tree biomass as 0.015 fraction of the total biomass.
e. The national standards considered for the carbon content in biomass dry matter as 40% of the dry weight. Depriving 20% of moisture in the biomass, the recorded dry weight considered is 80% of the TFB (Total Forest Biomass)

***Croplands remaining croplands*:** The soil carbon stock is estimated from peer-reviewed similar ecological conditioned systems. The experimented results were obtained from calculations, including 2 inventories of estimation, one the SOC (ref) for an initial point of time and other at a later time, say after a default of 20 years.

Methods of approach include estimation of annual growth rates (tC/ha/yr) for above ground living biomass. IPCC inventories for climate type for tropical moist and dry zones are provided within the default coefficients for AGB and harvesting in cropping systems containing perennial species.

The annual average carbon stock is given as the difference in stock between the SOC (ref) and SOC (0-t) divided by the default period of years chosen. With reference to the country specific soil texture and profile, the SOC derived for annual carbon stock was 1.89 t/ha/yr (Jim Penman et al. 2003) as given in Table 5.

***Grasslands remaining grasslands*:** The estimations from databases providing the soil carbon stocks in the 0-30 cm

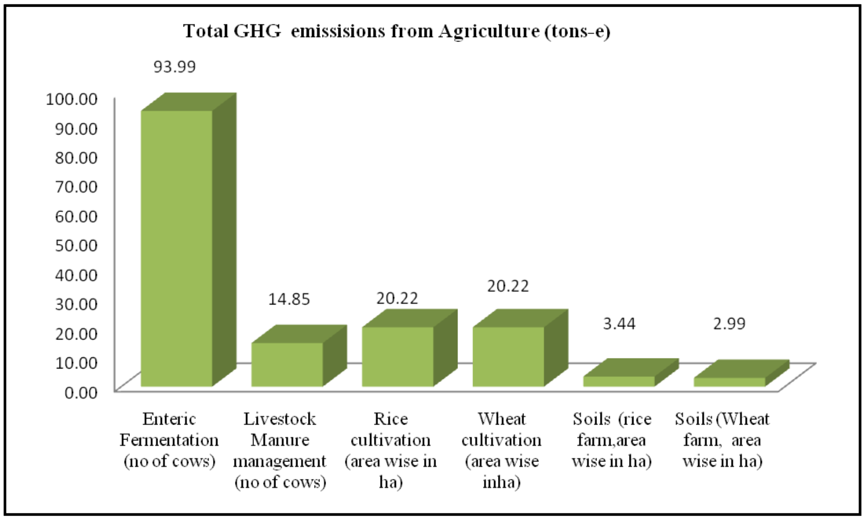

Fig. 2: Total GHG estimated from the agricultural sector in Bidholi (2016). Source: Compilation based on Table 10.

Fig. 3: Site view of the forestland area covering the village.

layer under pastures in a chronosequence, 42 years after being converted from native forest. The annual carbon stock estimated for grasslands was 85 tons C/ha.

The net total grassland biomass stock estimated was 1.7 tons C/ha for AGB and 85 tons C/ha for SOC, accounting total GHG sequestration of 60.57 tons of CO_2-e.

WASTE SECTOR

Emissions from solid waste disposal and open burning of waste are the major factors attributing to CH_4, N_2O emissions. Improper waste management schemes and open land filing adds upto the pool of GHG emissions. Land and waste assessments conducted for the village Bidholi, envisages the following undergoing practices:

a. Most of the villagers have a 5-10 feet compost pit for dumping the organic waste generated from kitchen and food waste.

b. Wastes such as the plastics, paper, wood straws, textiles etc. are open burned in their own premises. Around 20% of the population burns the waste in their own premises and another 10% of the population open dumps the waste to a nearby forest area, which cumulates annually and endeavors a bulk waste from open land filling.

c. The sewage and sludge are well managed. The village homes and hostels have individual septic/sewage tanks, for domestic waste and sludge water.

The method is based on the approach of first order decay kinetics, with respect to the overall decomposition of waste. The waste composition comprises of carbon degradable components that decomposes only over time. The rate of decomposition is identified from the first order decay equation (Riitta Pipatti et al. 2006) applied to the mass of waste on the disposal sites. DDOC (decomposed degradable organic carbon) is consumed by the bacteria, resulting in meth-

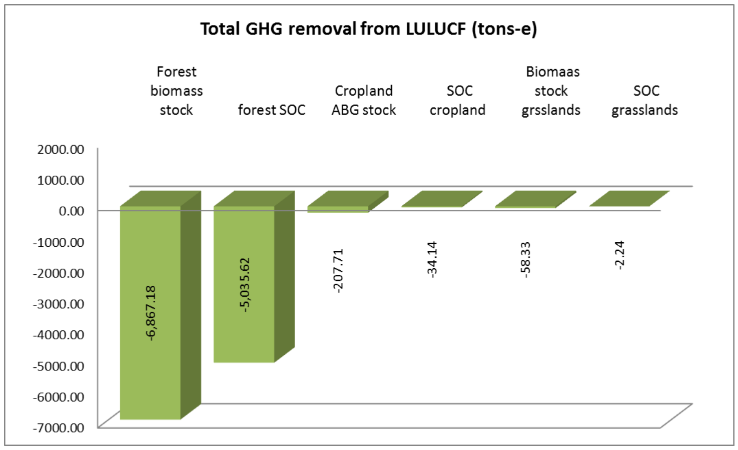

Fig. 4: Total GHG emissions estimated from the carbon stock in forestlands, croplands and grasslands in Bidholi (2016). Source: Penman & Gytarsky (2003).

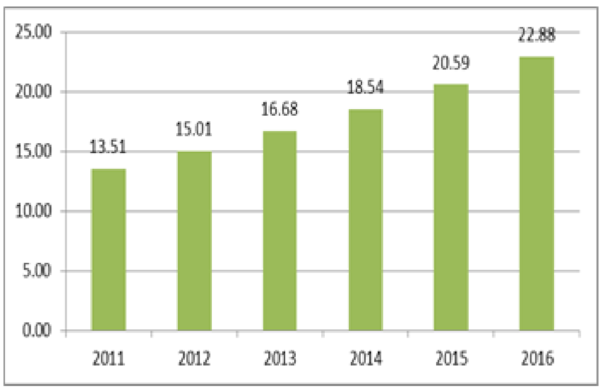

Fig. 5: Annual emissions from domestic wastewater based on the incrementing population in the village Bidholi (2011-2016). Source: GHG platform India.

ane emission from the process. The emissions are accounted maximum during the first year and decomposes thereafter with appraisal towards the tier 1 estimation listing the default FOD values, and using mainly the default parameters and activity data.

The net total organic waste generated from site and survey assessments yield an annual 384 tons of solid organic waste. Accounting other components of waste such as plastics, wood paper and textiles adding an additional elevation of 25% to the total organic waste. The total generated waste annually was 480 tons, of which 30% is left unmanaged.

The remaining 70% of the waste inspected accounted for kitchen, food and other organic waste, which was dumped into a compost pit, made available for every household.

Around 20 % of the villagers dump their waste which includes plastic, wood, paper, textiles, etc. behind their resident premises and practices open burning of the same on a periodical basis. The remaining 10% of the unmanaged waste is accumulated and dumped together into the nearby forest range. The wastes accumulated near to the forest area are incinerated in open once or twice every year.

The total amount of unmanaged waste openly burned in Bidholi was accounted 144 tons. The estimation is accounted from the GHG platform for waste emissions in India (Padmanabha 2016).

a. GHG emission calculation from managed solid waste (semi aerobic) disposed on solid waste disposal site (SWDS) in Bidholi as in Table 6.

b. GHG emission calculation from unmanaged shallow (<5 m) solid waste disposed on solid waste disposal site (SWDS) in Bidholi as in Table 7.

The domestic sewage and sludge are well managed by septic tanks and pits deployed for all houses, hostels and other utilities. The emissions identified from wastewater are mainly due to microbial activities on the degradable composition of sewage and sludge emitting methane. The fraction of decomposition rooting is dependent on the BOD (biochemical oxygen demand) present in the wastewater. The bacteria enhance anaerobic microbial digestion from the BOD available in the wastewater.

The string factors in determining the methane emissions from wastewater are the SBF (fraction of waste that settles), FTA (fraction of BOD in sludge that degrades anaerobically) are described in Table 8. The default national method to estimate the emissions from wastewater is given by the equation below (Jens & Riitta 2006). The Table 9 identifies the total CH_4 emissions generated annually and is graphically compounded as in Fig. 5.

$$WM = P \times D \times SBF \times EF \times FTA \times 365$$

Table 5: Cropland carbon stock in AGB and SOC (2016). Source: Compilation based on IPCC (2006).

Cropland	Area (ha)	Unit	Carbon stock per ha	Equivalent carbon sink	E-CO_2 removals	Net CO_2 equivalent
Cropland remaining cropland-Above ground biomass stock	21.62	tdm/ha	11.50	56.65	207.71	-207.71
Total soil organic content from urea/NPK fertilizers/minerals	21.62	tons/ha/year	1.89	9.31	34.14	-34.14

Table 6: GHG emissions from managed solid waste (2016). Source: Waste generation and management, Riitta Pipatti et al. (2006).

Computation of Baseline Emissions																	CO_2-tons eq
Period	φy	f	(1-f)	GWP_{CH4}	OX	(1-OX)	F	DOC_f	MCF	Municipal Solid Waste							
										$W_{j,x}$	DOC_j	k_j	e^{-kj}	$(1-e^{-kj})$	$k_j(y-x)$	$(e^{-kj(y-x)})$	
2016	0.9	0	1	21	0	1	0.5	0.5	0.5	336	0.20	0.4	0.670	0.330	0	1	70

Table. 7: GHG emissions from unmanaged solid waste (2016). Source: Waste generation and management, Riitta Pipatti et al (2006).

Computation of Baseline Emissions																			Baseline Emissions tons of CO_2
Period	Φy	f	(1-f)	GWP_{CH4}	OX	(1-OX)	F	DOC_f	MCF	y	x	Municipal Solid Waste							
												Wj,x	DOC_j	k_j	e^{-kj}	(1-e-kj)	kj (y-x)	(e-kj (y-x))	
2016	0.9	0	1	21	0	1	0.5	0.5	0.4	1	1	144	0.20	0.4	0.670	0.330	0	1.000	24

Table 8: Description and estimation factors (2016). Source: Jens E. Frøiland et al. (2006).

Description	Annual CH_4 emission per country, from domestic wastewater
Source	IPCC Good Practice Guidance and Uncertainty Management, GHG platform India
P	Population of the village Bidholi
BOD	Organic load in biochemical oxygen demand per person (BOD/person/day)
SBF	Fraction of BOD that readily settles, default = 0.5
EF	Emission factor (g CH_4/g BOD), default = 0.6
FTA	Fraction of BOD in sludge that degrades anaerobically, default = 0.8

Table 9: GHG emissions estimated from domestic wastewater pattern (2016). Source: Compilation based on GHG emissions from waste platform for India (2016).

Total Population	Bidholi	2011	2012	2013	2014	2015	2016
Nos		3809	4232	4702	5225	5805	6450
Biochemical Oxygen Demand (BOD)	Gm/person/day	2011	2012	2013	2014	2015	2016
Nos		40.50	40.50	40.50	40.50	40.50	40.50
Net Annual GHG emissions recorded	2011	2012	2013	2014	2015	2016	
Tons equivalent (CH_4)		13.51	15.01	16.68	18.54	20.59	22.88

RESULTS AND ANALYSIS

Greenhouse gas emissions by agricultural, waste sectors and quantified carbon stock by forest sinks from Bidholi village in 2016 (tons equivalent) is tabulated as in Table 10.

The results from estimating the other gases such as CH_4, N_2O from the categories of emission in tons of CO_2-eq

Table 10: Total annual GHG estimations from the various sectors of agriculture, LULUCF and waste in Bidholi (2016). Source: Compilation based on resources from IPCC, INCCA, GHG national inventory estimates-India.

Source	Annual figures	CO_2 emissions	CH_4	N_2O	CO_2 equivalent	CO_2 removals	Net CO_2 equivalent
Total GHG emissions from agriculture							
Enteric fermentation (no of cows)	75	-	3.9	0.039	93.99	-	93.99
Livestock manure management (no of cows)	75	-	0.375	0.0225	14.85	-	14.85
Rice cultivation (area wise in ha)	14.59	-	0.96294	-	20.22	-	20.22
Wheat cultivation (area wise in ha)	14.59	-	0.96294	-	20.22	-	20.22
Soils (rice farm ,area wise in ha)	14.59	-	-	0.0111	3.44	-	3.44
Soils (Wheat farm, area wise in ha)	14.59	-	-	0.0096	2.99	-	2.99
Total GHG removal from LULUCF							
Source	Area(ha)	Units	Carbon stock EFDB	Equivalent Carbon sink	E-CO_2 removals	Net CO_2 equivalent	
Forestland							
Forestland remaining forestland- Total Living biomass carbon (AGB+BGB)	70	m^3/ha	59.79	1872.87	6867.18	-6867.18	
Total Soil organic content in forestland	70	tdm/ha	86.11	1373.35	5035.62	-5035.62	
Cropland							
Cropland remaining cropland-Above ground biomass stock	21.62	tdm/ha	11.50	56.65	207.71	-207.71	
Total Soil organic content from urea/NPK fertilizers/minerals	21.62	tons C/ha/year	1.89	9.31	34.14	-34.14	
Grassland							
Grasslands remaining grasslands- Total Living biomass carbon (AGB+BGB)	10.808	tons C/ha	1.70	15.91	58.33	-58.33	
Total GHG emissions from domestic waste							
Source	Consumption	CO_2 emissions	CH_4	N_2O	CO_2 equivalent	CO_2 removals	Net CO_2 equivalent
Emissions from managed SWDS (semi-organic)	336	-	52.5	-	70	-	70
Emissions from unmanaged SWDS waste (Shallow<5m)	144	-	24	-	32	-	32
Emissions from domestic wastewater(sewage and sludge)	40.5 (BOD-g CH_4/kg MSW)	-	22.88	-	31	-	31

summed along with the CO_2, provides information on the net CO_2-eq GHG

1. The agriculture sector contributed to a total of 155.71 tons of net CO_2 equivalent in 2016, out of which 93.99 tons of CO_2 equivalent were attributed from the enteric fermentation from the cattles, mainly cows from the village. Enteric fermentation was recorded 60% of the total emissions, 10% fumed from livestock manure management practices. Perennial crops like rice and wheat cultivation accounted 40.44 tons of net CO_2 released. This aggregated a total of 26% of the total emissions. The remaining 4% of the emission were leveraged from the agricultural soils.
2. LULUCF: The carbon content in forest living biomass i.e. above ground and below ground biomass accounted to a sink of 6867.18 tons of CO_2-e. The total SOC estimated was 5035.62 tons of CO_2-e removals. The total forest biomass carbon stock estimated was11902.80 tons of CO_2-e removals or carbon sequestered relative to the carbon life cycle context.
3. The net CO_2-eq emissions fumed from the agricultural sector accounted was 155.71 tons. The net CO_2-eq emissions generated from the waste sector was 133 tons. The GHG emission sequestration potential identified by the forestry was 12205.22 tons net CO_2-eq.

CONCLUSIONS

The impact assessment study was carried on the sustainability portfolio for the semi-urban transiting village Bidholi due to the incurred life cycle activities such as the crop cultivation emissions and enteric fermentation. Livestock manure emissions and waste generation with re-

Table 11: Summary of grand total GHG estimations from the sectors of agriculture, LULUCF and waste. Source: Compilation based on Table 10.

Source	CO_2 emissions	CO_2-e (CH_4+N_2O)	CO_2 removals	Net CO_2 equivalent
Agriculture	-	155.71	-	155.71
Enteric fermentation	-	93.99	-	93.99
Livestock manure management	-	14.85	-	14.85
Rice cultivation	-	20.22	-	20.22
Wheat cultivation	-	20.22	-	20.22
Soils (wheat farm)	-	3.44	-	3.44
Soils (rice farm)	-	2.99	-	2.99
LULUCF			12205.22	-12205.22
Forestland	-	-	11902.80	-11902.80
Cropland	-	-	241.85	-241.85
Grassland	-	-	60.57	-60.57
Waste		133	-	133
Municipal solid waste	-	102	-	102
Domestic wastewater	-	31	-	31

spect to their specific scope of boundaries in 2016 was accounted as 115.71 tons of CO_2-eq from the agricultural sector and 133 tons of CO_2-eq from the waste sector and summarized as in Table(11). The large span of forest area envisaged a net carbon sink, estimations for above ground biomass stock, below ground biomass stock and soil organic content was accounted as 6591.85, 1753.43 and 6027.70 tons of carbon. The total carbon sequestration potential for the forest area estimated was accounted as 12205.22 tons net CO_2-eq.

The study can be used to compare the emissions incurred and carbon removals from the same, to identify the air quality, to monitor climate change issues and further identify clean energy sources to offset the emissions fumed for maintaining a sustainable livelihood.

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