Annex 10: Non – CO_2 Emissions from Fires in Uganda

Available data on fires in Uganda comes from MODIS burned area product. It shows that several areas of north and northeastern Uganda are burnt mostly in the months of December to March. However, due to the decline in forest cover, most these fires are occurring in non - forested areas (see Figure 1). In total, 41,098 ha of forest area were burnt in 2015 (see Table 3).

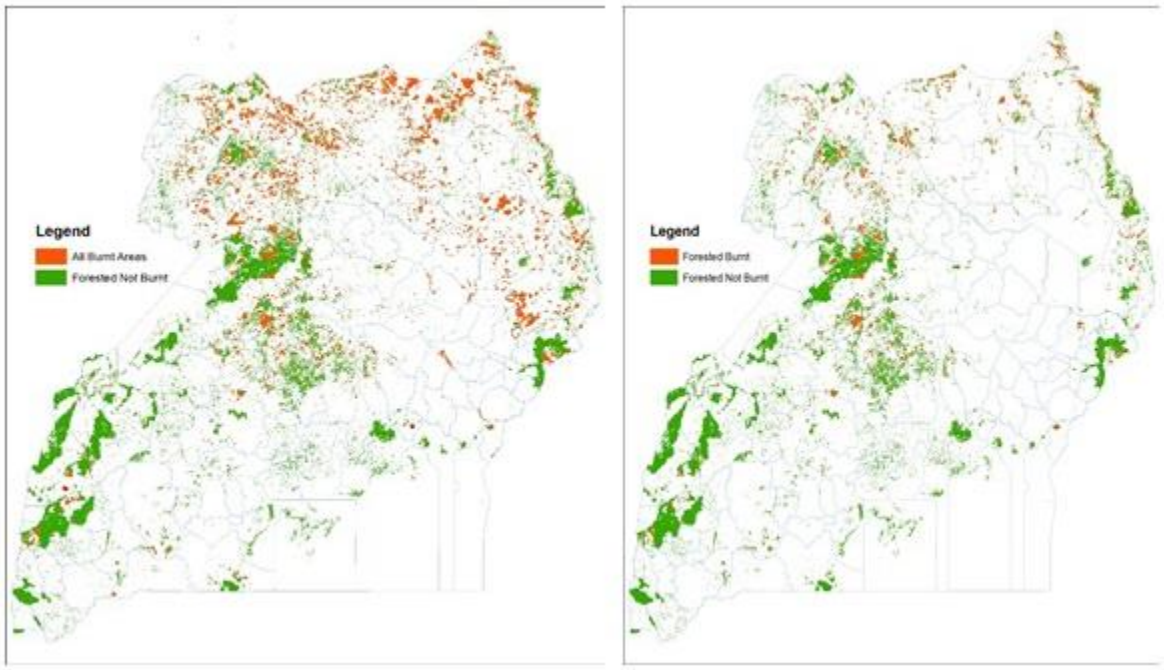

Figure 1: Burnt areas in Uganda in 2015. Left: All burnt areas and non-burnt forest areas. Right: Forest area burnt and non-burnt.

In fire climax vegetation, some of the CO2 emissions from burnt areas may be considered as carbon flux since some of the CO2 is removed as the vegetation regrows in subsequent seasons or years. Accounting for this is CO2 flux is complex and only non –CO_2 emissions are estimated here below.

The mass of fuel available for combustion is critical for estimating these non-CO_2 emissions. Uganda uses country specific biomass stocks by vegetable types and applies Table 3A. 1. 12 and 3A.1.16 IPCC default values for combustion fraction and emission factors respectively (see below). Activity data for the area burnt was downloaded from MODIS (NASA) website on

http://wist.echo.nasa.gov. This data was overlaid with the 2015 forest area data in Geographical Information System (GIS) environment.

The general equation (3.2.20) for estimating GHGs directly released in fires is presented below;

$$Lfi\ re = A \times B \times C \times D \times 10^{-6}$$

Where

Lfi re = quantity of GHG released due to fire, tonnes of GHG

- A= area burnt, (ha), estimated from MODIS data
- B= mass of "available" fuel, kg d.m./ ha, Default data or derived from overlaying MODIS data on spatial data on biomass distribution
- C= combustion efficiency (or fraction of the biomass combusted), dimensionless, IPCC Default value used from Table 3A.1.12)
- D= emission factor, g/(kg d.m.), IPCC default value used (see Table 3A.1.16 Emission Factors applicable to fuels combusted in various types of vegetation fires)

TABLE 3A.1.16
EMISSION FACTORS (G/KG DRY MATTER COMBUSTED)
APPLICABLE TO FUELS COMBUSTED IN VARIOUS TYPES OF VEGETATION FIRES
(To be used in connection with Equation 3.2.20)

	CO_2	CO	CH_4	NO_x	N_2O*	NMHC [2]	Source
Moist/infertile broad-leaved savanna	1 523	92	3	6	0.11	-	Scholes (1995)
Arid fertile fine-leaved savanna	1 524	73	2	5	0.11	-	Scholes (1995)
Moist- infertile grassland	1 498	59	2	4	0.10	-	Scholes (1995)
Arid-fertile grassland	1 540	97	3	7	0.11	-	Scholes (1995)
Wetland	1 554	58	2	4	0.11	-	Scholes (1995)
All vegetation types [1]	1 403 -1 503	67-120	4-7	0.5-0.8	0.10	-	IPCC (1994)
Forest fires	1 531	112	7.1	0.6-0.8	0.11	8-12	Kaufman *et al.* (1992)
Savanna fires	1 612	152	10.8	-	0.11	-	Ward *et al.* (1992)
Forest fires	1 580	130	9	0.7	0.11	10	Delmas *et al.* (1995)
Savanna fires	1 640	65	2.4	3.1	0.15	3.1	Delmas *et al.* (1995)

[1] Assuming 41-45% C content, 85-100% combustion completeness.
[2] NMHC non methane hydrocarbons.
* Calculated from data of Crutzen and Andreae (1990) assuming an N/C ratio of 0.01, except for savanna fires.

Table 1: Average Emission Factors for CH4, CO, N20 and NOX in woodlands and other forest types using IPCC default values

EF Sources	CH4 EF (g /kg d.m.)	**CO EF** (g /kg d.m.)	**N20 EF** (g /kg d.m.)	**NOx EF** (g /kg d.m.)
Savanna fires Ward et al. 1992	10.8	152	0.11	
Savanna fires Delmas et al. 1995	2.4	65	0.15	3.1
Average Savanna woodlands	6.6	108.5	0.13	3.1
Forest firesKaufman et al. 1992	7.1	112	0.11	0.7
Forest fires Delmas et al. 1995	9	130	0.11	
Average for forests	8.05	121	0.11	0.7

Table 2: EFs used in the calculations

Broad Forest type	CH4	CO	N2O	NOx
Woodland	6.6	108.5	0.13	3.1
All forests	8.05	121	0.11	0.7

Table 3: Non-CO2 emissions from forest areas burnt in Uganda in 2015.

Sub-categories for Reporting Year [1]	Area burnt (ha) A	Mass of available fuel (kg d.m. ha^{-1}) B	Combustion efficiency or fraction of biomass combusted (dimensionless) C	CH_4 Emission factor (g /kg d.m.) D	CH_4 Emissions from fires (tonnes CH_4) $E = A \cdot B \cdot C \cdot D \cdot 10^{-6}$ E	CO Emission factor (g /kg d.m.) F	CO Emissions from fires (tonnes CO) $G = A \cdot B \cdot C \cdot F \cdot 10^{-6}$ G	N_2O Emission factor (g /kg d.m.) H	N_2O Emissions from fires (tonnes N_2O) $I = A \cdot B \cdot C \cdot H \cdot 10^{-6}$ I	NO_x Emission factor (g /kg d.m.) J	NO_x Emissions from fires (tonnes NO_x) $K = A \cdot B \cdot C \cdot J \cdot 10^{-6}$ K
Forest Plantations	2,379	107,811	0.5	8.05	1032.32	121.00	15,517	0.11	14.11	0.70	89.77
THF	2,460	218,018	0.5	8.05	2158.42	121.00	32,443	0.11	29.49	0.70	187.69
Woodland	36,260	36,260	0.5	6.6	6535.82	108.50	107,445	0.13	128.74	3.10	3069.86
	41,098				**9,727**		**155,405**		**172**		**3,347**
GWP					**21**				**310**		
CO2 Eq					**204,258**				**3,424**		
Total CO2 Eq					**257,682**						

* Derived from MODIS

Note that Carbon monoxide (CO) and Nitrogen oxides (NOx) are not considered GHG but are precursor or act as indirect greenhouse gases. The results from this analysis show a total of 257,682 tons of CO2 equivalent are released annually from forest fires, using the area data generated by MODIS. This amounts to less than 3% of all emissions generated from deforestation and implies that at the moment, emissions from forest fires are not a significant source.