Annex 9: Estimating forest degradation in Uganda

Uganda has a rich source of data from a variety of forest inventories that have been conducted over the last twenty years and therefore is fortunate enough to be able to analyse the occurrence of forest degradation in some of the inventory sites that have been revisited over the years. Analysis of the National Biomass Study repeated measurements 1995-1999 was published in the Second National Communication (SNC 2014) which estimated emissions from forest degradation (loss of carbon stock in forests remaining forests) at about 6million tons per year or 61% of the total LULUCF sector emission (Table 1).

Table 1.LULUCF emission and removals 2,000 reporting year. Source; SNC 2014

GREENHOUSE GAS SOURCE AND SINK CATEGORIES (Gg CO_2)		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO
Total Land Use, Land-Use Change and Forestry		**10,387.4**	**-1,651.4**	**68.8**	**1.4**	**32.4**	**1,132.2**
A. Forest Land		**6,373.4**	**-36.5**	**61.7**	**1.2**	**29.0**	**1,013.9**
	1. Forest Land Remaining Forest Land	6,373.4		61.7	1.2	29.0	1,013.9
	2. Land Converted to Forest Land		-36.5	0.0	0.0	0.0	0.0
B. Cropland		**3,280.5**	**-1,374.3**	**0.0**	**0.0**	**0.0**	**0.0**
	1. Cropland Remaining Cropland		-428.6	0.0	0.0	0.0	0.0
	2. Land Converted to Cropland	3,280.5	-945.7	0.0	0.0	0.0	0.0
C. Grassland		**204.5**	**0.0**	**7.1**	**0.1**	**3.3**	**117.1**
	1. Grassland Remaining Grassland		0.0	7.1	0.1	3.3	117.1
	2. Land Converted to Grassland	204.5		0.0	0.0	0.0	0.0
D. Wetlands		**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**1.2**
	1. Wetlands Remaining Wetlands			0.0	0.0	0.1	1.2
	2. Land Converted to Wetlands			0.0	0.0	0.0	0.0
E. Settlements		**6.8**	**-48.7**	**0.0**	**0.0**	**0.0**	**0.0**
	1. Settlements Remaining Settlements		-1.5	0.0	0.0	0.0	0.0
	2. Land Converted to Settlements	6.8	-47.2	0.0	0.0	0.0	0.0
F. Other Land		**9.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	1. Other Land Remaining Other Land			0.0	0.0	0.0	0.0
	2. Land Converted to Other Land	9.3		0.0	0.0	0.0	0.0
G. Other (Please specify)		**512.8**	**-191.9**	**0.0**	**0.0**	**0.0**	**0.0**
	Harvested Wood Products						
	Abandonments		-191.9				
	Soils	512.8					

The calculations were based on the National Biomass Study repeated measurements from the year 1995 to around 1999 (table 2) and the NBS Wall to Wall Land use / cover mapping 1990 to 2002. The IPCC default root to shoot ratio of 1:0.24 was used to convert above ground biomass annual stock changes to total biomass stock change.

Table 2. Stock changes in Uganda forests in the late 1990s, highlighted in red (Adopted from NBS 2002)

Land Cover/Use	Predicted Weight 1st Visit(Tons/Ha Airdry)	Predicted Weight 2nd Visit(Tons/Ha Airdry)	Difference between the 1st and 2nd Visit	Duration in Decimal Years	Rate of annual change (Tons/Ha Airdry)	Rate of annual change (%)
CLASS	VistA (TON-HA)	VistB (TON-HA)	Difference	YEARS	change	Change in %
Plantations (Hardwoods)	46	38	-7.8	2	-3.4	-7%
Tropical High Forest THF	189	110	-79.0	3	-24.3	-13%
THFDegraded	119	87	-31.2	4	-8.3	-7%
Woodland	39	33	-6.3	3	-1.9	-5%
Bushland	15	12	-2.3	4	-0.6	-4%
Grassland	8	7	-0.2	3	0.0	-1%
Wetlands	0	0	0.0	2	0.0	
Subsistence Farmland	8	8	0.2	3	0.1	1%
Commercial Farms	0	0	0.0	4	0.0	-25%
Built up Area	4	5	0.4	3	0.1	3%

It is important to note that the biomass stock changes and related emissions were based on period 1995 to 2000 when the forested area was about 20% of the total land area. With an annual population growth rate of over 3% (UBOS 2014) and over-dependency on biomass based energy, the pressure on the wood resources is expected to be increasing over time.

The 1995 ESD study estimated that charcoal demand for Kampala alone was 200,000 tonnes per annum and the main sources were mainly within 150 kilometres (figure 1) from the districts of Luwero , Masindi and Kamuli. In 2004 the study on supply in Kampala estimated demand for Kampala to have increased by 50% to 300,000 and sources to have extended up to 250 kilometres away (Figure 1) with the district of Kiboga becoming an important source (Knöpfle 2004). The same study found out that Producers have to go much deeper in the forest to get enough wood material for their kilns and transporters have to go increased distances to reach their producers.

The National Charcoal Survey report 2016 indicated that charcoal sources to Kampala and other urban centres have extended up to 500 kilometres from the districts of Koboko in the North west and Kabongo in the northeast. Unlike in the past, Uganda has also started importing charcoal from neighbouring countries). In the past factors that determined charcoal distance were mainly economic. Earl (1974) found out that within East Africa fuelwood was more attractive up to a road distance of 82 km, and charcoal beyond that distance. Scarcity of the preferred woody biomass for charcoal production is however increasing becoming a critical factor (BEST 2014).

The 2016 charcoal survey report estimated that charcoal production land categories are 43% privately owned forests followed by Central forest reserves (22%) and on-farm trees (20%). The biomass Energy Strategy (BEST 2014) estimated sustainable biomass supply as 26.3 tonnes per ha per year while total woody biomass was 44.2 million tonnes implying that the wood resource base was being depleted / degraded.

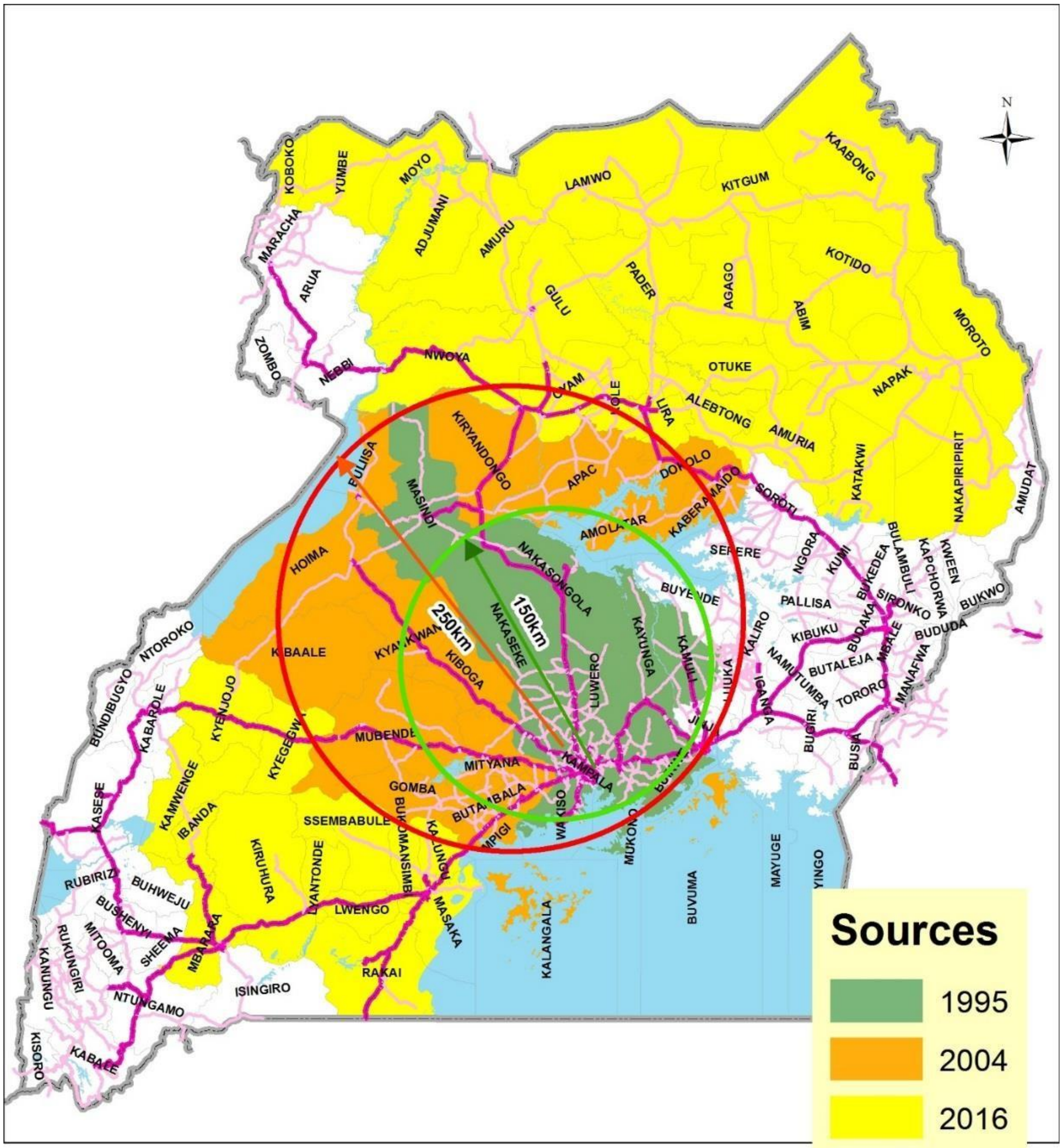

Figure 1: Charcoal demand for Kampala (1995-2016).

Proof of Degradation in Uganda

Like in many countries, forest degradation in Uganda is likely to be a significant contributor of greenhouse gas emissions from forestry. However, quantifying emissions from forest degradation in an accurate and precise manner is proving very difficult. In particular, measuring degradation consistently over time to assess change in emissions from degradation (monitoring) is challenging. Estimates of degradation will likely be imprecise (i.e. with wide-ranging confidence intervals) as the nature of the disturbance is more difficult to measure than deforestation. Imprecise estimates, even with the best possible measurement and monitoring system, may yield estimates of degradation rates with no statistical significance and little importance for decision-making. Further complicating quantification of emissions from degradation is the fact that some of these degraded lands eventually transition into non-forest and therefore emissions are accounted for under deforestation.

Using Proxy measure

Uganda has reasonable information on biomass energy consumption. There is, however, still a need to apportion how much of the biomass energy is a byproduct due to agricultural activities i.e. land preparation processes and which is purely for energy purposes. Records on timber production are considered incomplete. Uganda has thus not been able to use this approach to estimate degradation attributable to extraction of biomass.

Using Remote sensing

Mapping forest degradation is far more challenging than for deforestation because forest degradation typically manifests as subtle changes in forest structure and carbon losses are smaller and more difficult to detect and quantify than deforestation using remote sensing where often significant reductions in canopy cover are observed (Mitchell 2017). From a remote sensing perspective, the parameters often used to define forest degradation are loss of canopy cover within the forest minimum mapping unit. Partial reduction in forest canopy cover is generally more accurately identified in dense tropical forests than in sparse dry forests, because the signal from the sensors tends to more distinct in dense tropical forests.

In recent years, dense time series have been increasingly used, largely due to open data policies (e.g. opening of the Landsat data archive in 2008) and access to cloud computing systems (e.g. SEPAL). The Breaks for Additive Season and Trend (BFAST) can be used for near-real-time disturbance detection and continuous change monitoring trend analysis. BFAST methods can be applied to any series of satellite images (i.e. MODIS, Landsat, Rapid Eye, RADAR data and Sentinel data). The tool is based on the concept that deviations from average seasonal vegetation dynamics trend (derived from vegetation indices, e.g., NDVI) over multiple years, can indicate disturbances (abrupt and gradual). BFAST iteratively estimates the time and number of abrupt changes within time series, and characterizes changes by its magnitude and direction (Figure 2). Different parameters for the algorithm can be tested and modified in this application to explore and identify custom settings for running the BFAST algorithm at a spatial scale (running the dense time series analysis for an area of interest rather than for one coordinate). Running BFAST spatial requires high quality time series data and a benchmark forest/non-forest mask that is used to limit the algorithm to the pixels which are known to have been forested at the beginning of the first monitoring period.

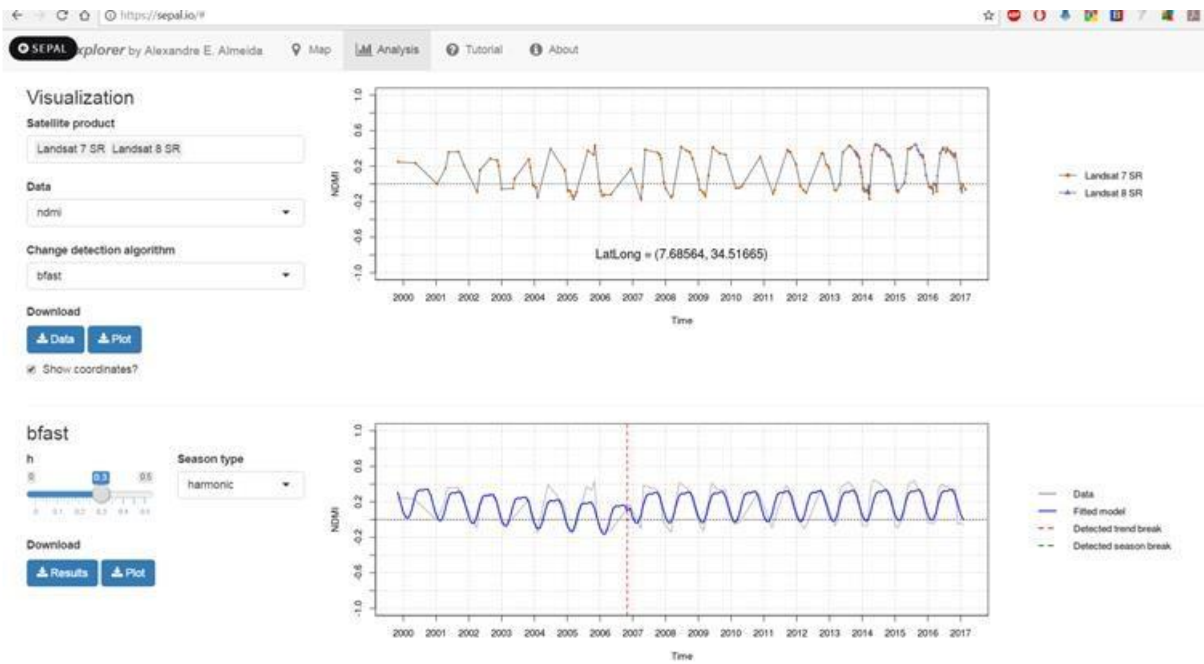

Figure 2: BFAST explorer in SEPAL can be used to view the trends and identify breaks in a trend of a point location.

Uganda is already experimenting using this technique to estimate degradation. Remotely sensed data being used range from Landsat, high spatial resolution data (RapidEye). Use of active sensors such as RADAR and LIDAR is also being discussed. This is however at a very early stage and no results are available to be incorporated in this FRL. Moreover, there are cost implications for using these active sensors.

Direct field Measurement

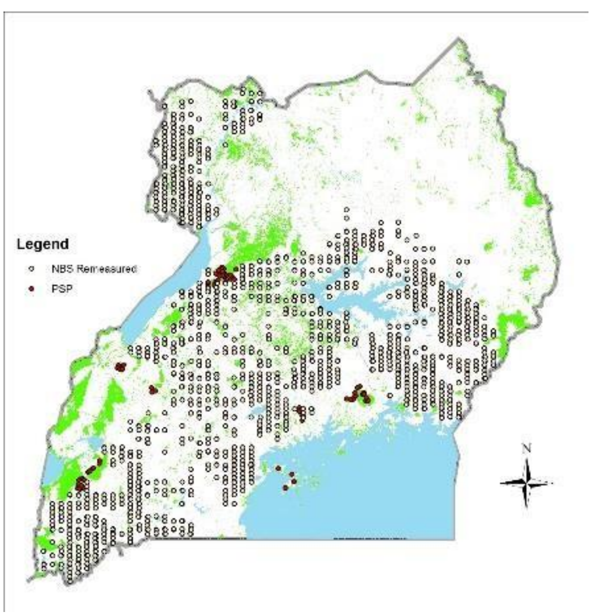

Figure 3: Spatial Distribution of repeated forest measurement in Uganda

Uganda has Permanent Sample Plots (PSPs) in Tropical High Forests (THF) that were established since the 1930s. However, continuous monitoring has not been systematic and the design was never intended for biomass monitoring. The prospects of utilising PSPs that were re-established in 1990s are nevertheless high. In 1993, a nation-wide biomass monitoring system was established under the then Forest Department. Biomass monitoring in some of the plots continued up to 2006. Though the data indicates that there could be degradation in both THF and woodlands, the degree of uncertainty is too high to be used in the FLR.

Figure 4: Change in AGB in tropical high Forests on private land from 1995-2005

Recent analysis of the NBS and PSP data (1995-2005) shows a significant trend in degradation in Tropical High Forest (THF) outside of NFA and UWA lands (Figure 4). The THF that was surveyed on private land as a part of the NBS study indicated an average annual loss of 11.7 tons/ha in aboveground biomass at 95% confidence level (CI 55%). In contrast, the woodlands on private lands did show a negative trend (0.2 tons/ha), however the degree of uncertainty was too high to be used in the FRL. Although the analysis tends to not show degradation in woodlands, there appears to be a common perception that degradation is indeed taking place in woodlands. This could be due to the fact that emissions from forest degradation continues to decline as the area of forests and stock of wood (biomass) in these forests reduce. It could also be due to misclassification in the field (whereby degraded forests are characterized as non-forest). Uganda has plans to conduct repeated measurements using the existing sampling frame to possibly develop more conclusive results. In addition, there is a plan to improve the exiting sampling frame by filling existing geographical gaps (Figure 3).

Conclusions

- Analysis of 1995-2005 PSP and NBS forest inventory data indicates that degradation is occurring in Tropical High Forests on private lands, with an annual aboveground biomass loss of 11 tons/ha
- Given that these remaining THF forests on private land constitute an area of approximately 83K hectares and given that there is a strong trend of deforestation outside of NFA and UWA lands, these remaining forests are considered to eventually be lost as deforestation.
- Analysis of this same data for biomass loss in woodlands was inconclusive and may greatly benefit from ongoing additional data collection efforts throughout the country which are revisiting older plots wherever possible and gathering new data in areas that were never before surveyed.
- Better utilization of remote sensing processing techniques (times series analysis) could improve understanding of where degradation is taking place in order to improve monitoring of these lands.

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