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**Project title:** Namibia Integrated Landscape Approach for enhancing Livelihoods and Environmental Governance to eradicate poverty (NILALEG)

**GEF Implementing Agency :** United Nations Development Programme

**Country:** Republic of Namibia

**Implementing Partner:** Ministry of Environment and Tourism

**Management Arrangements:** National Implementation Modality (NIM)

**UNDP-GEF PIMS ID number:** 5640

**GEF ID number:** 9426

**Annex B(ii) Results of the calculations on the net avoided emissions**

# Results of the calculations on the net avoided emissions

R.S. Bhalla

## Introduction

An analysis of land use and trends in deforestation degradation was used to parametrise the FAO EX-Ante Carbon-balance Tool (EX-ACT) and to arrive at alternative measurements based on an analysis of satellite images and products, particularly, long term means and trends in the normalised difference vegetation index (NDVI) and net primary productivity (NPP). Data used here was derived from existing spatial datasets hosted by the Namibia Statistics Agency and sourced from a variety of government projects and programmes, chiefly the Atlas of Namibia. LANDSAT and MODIS images were analysed on the Google Earth Engine<sup>1</sup>.

The primary purpose of this analysis was to arrive at recent trends in forest/vegetation loss and estimates of primary productivity and land-cover change. This data also served to validate the results from the EX-ACT tool.

This document explains how the EX-ACT tool was parametrised, and the calculations used to derive the independent measures of NPP using satellite imagery. We used conservative estimates of productivity and expected impacts of project interventions.

## Evidence of land cover change

### Analysis of Normalised Difference Vegetation Index (NDVI)

Based on trends in NDVI<sup>2</sup> in the focal landscapes we estimate the annual rates of land cover change in classes relevant to this project, namely forests, scrub or bush, rangelands and degraded lands. We used FAO-based values of NDVI for land cover classes<sup>3</sup>. These are approximations of on-ground conditions and an accuracy matrix of the results could not be produced due to lack of ground control points. Moreover, there is a probable overlap between the adjacent land cover types, i.e. degraded forest and scrub, and degraded scrub and rangeland. The cut-off values used were:

1 > Forest > 0.4 > Scrub > 0.25 > Rangeland > 0.13 > Degraded land > 0 Moist soils and water > -1.

Area under different land cover types was then calculated.

1 Scripts used for the analysis can be accessed from <<https://gitlab.com/rsbhalla/nilaleg/tree/master>>.

2 Yengoh, Genesis T, David Dent, Lennart Olsson, Anna E Tengberg, and Compton J Tucker. 'The Use of the Normalized Difference Vegetation Index (NDVI) to Assess Land Degradation at Multiple Scales: A Review of the Current Status, Future Trends, and Practical Considerations'. Lund University Center for Sustainability Studies (LUCSUS): Lund University Center for Sustainability Studies (LUCSUS), and The Scientific and Technical Advisory Panel of the Global Environment Facility (STAP/GEF)., 2014.

3 Based on: Meneses-Tovar, C L. 'NDVI as Indicator of Degradation'. Unasylva 62, no. 238, (February 2011): 8.

Focal Landscape	Forest		Scrub		Rangeland		Other		Total
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	
Omaoipanga	23	0.01	56,051	27.86	144,858	72.01	243	0.12	201,175
Ruacana	748	0.68	76,156	69.38	32,788	29.87	76	0.07	109,768
Omauni Okongo	7,600	5.81	100,539	76.84	22,700	17.35	0	0.00	130,838
Nkulivere	4,302	2.17	163,208	82.35	30,683	15.48	0	0.00	198,193
Zambezi	34,578	15.77	152,418	69.50	29,769	13.57	2,540	1.16	219,306
Total	47,251	5.50	548,372	63.82	260,798	30.35	2,860	0.33	859,280

The trends averaged over the five focal landscapes were also estimated for the period between 2003 and 2018 (sixteen years)

Cover	% Trend
Forest	0.81%
Scrub	0.76%
Rangeland	-0.36%
Degraded	-1.35%
Moist soils and water	-2.32%

When broken down into the different focal landscape the following trends emerge.

Cover	Omaoipanga	Ruacana	Okongo	Nkulivere	Zambezi
Forest	-0.37%	0.06%	0.65%	0.87%	0.86%
Scrub	-0.85%	-0.23%	0.94%	1.29%	1.16%
Rangeland	-1.18%	-0.61%	0.66%	1.14%	1.27%
Degraded	-1.04%	-0.24%	-1.25%	0.80%	-2.09%
Moist soils and water	-0.32%	-0.05%	0.00%	0.00%	-2.42%

Omaoipanga stands out in showing decreasing trends in both forests and rangelands and almost a flat and slightly increasing (but still in the negative) trend in scrub or bush. This landscape clearly needs most attention as the graph suggests that thicker the forest greater its loss.

Ruacana shows very clear signs of degradation in all land cover classes, except forests which show a positive trend increasing towards higher NDVIs (denser forests). A good case for prioritising forest conservation.

All land cover types in Okongo show an increasing trend with increasing NDVI; however, over half the region under rangelands show a negative trend while rangelands in the upper NDVIs show a slight increase. This increase could well be due to bush encroachment. Scrub or bush is showing a gradual increase as well while forests are essentially 'flat', showing very marginal gains as NDVI increases.

Nkulivere shows a very slowly increasing trend for all cover types moving positively with higher NDVIs in each cover class. However, degraded areas seem to show removal of vegetation, wherever it exists which could be a sign of overgrazing.

Zambezi is an inherently more productive focal landscape; however, degraded areas are getting further denuded, particularly those with little vegetation to start with. Both rangelands and scrub are showing a very small increasing trend which doesn't change its slope with increasing NDVIs. Dense forests, however, seem to be increasing at a faster rate than sparse forests with lower NDVIs.

## Analysis of Net Primary Productivity (NPP)

Results of the NDVI were further supported by an analysis of trends in net primary productivity which is a proxy for carbon sequestered annually. We used mean NPP rates and trends for a period of fifteen years. Our results show a consistent rate of decrease in NPP in all the focal landscapes. We repeated this analysis for the most recent three years that the data was available i.e. 2011 to 2013 and 2012 to 2014. Interestingly, the trend for the years 2012 to 2014 was positive. This was probably because 2014 was an unusually rainy year; however, it also goes to show that given adequate moisture, these trends can be reversed<sup>4</sup>.

ID	Focal Landscape	Trend 2000 - 2014	Trend 2011 - 2013	Trend 2012 - 2014
1	Omaoipanga	-0.17	-0.83	0.08
2	Ruacana	-0.21	-1.42	0.21
3	Omauni Okongo	-0.20	-1.65	0.00
4	Nkulivere	-0.17	-1.54	0.07
5	Zambezi	-0.25	-0.63	0.43

The trend of loss in NPP has increase alarmingly in all focal landscapes. Even though no data was available for the past five years, given the recent field observations on the rates of deforestation, these trends have probably become even more negative in the focal landscapes.

Analysis of mean NPP was also quite revealing. The mean annual NPP in year 2000-2001 was substantially higher than the mean NPP and more than twice that of the latter years suggesting a continuous removal of vegetation which has increased in the latter years. While we do not have NPP data for the more recent period, this suggests an alarming loss of forests and productive vegetation in the focal landscapes.

4 A more sophisticated trend analysis would incorporate the effects of rainfall and temperature, however this was not possible in the time available.

Focal Landscape	2000 - 2014	2000 - 2001	2012 - 2013	2013 - 2014
Omaipanga	2.81	4.30	1.65	1.72
Ruacana	3.61	5.32	1.90	2.11
Okongo	4.62	6.63	2.88	2.88
Nkulivere	4.22	6.19	2.71	2.78
Zambezi	5.13	8.79	3.71	4.15

## Justification for values used to estimate NPP and parametrise the EX-ACT tool

Given these observations we make the following assumptions for the values used to parametrise the EX-ACT tool (see appendix for screen grabs).

Based on field experience we know that the greatest rate of forest loss in the recent past was in the Okongo focal landscape. This is borne out by the recent NPP trends. We also observed from the NDVI figures that the large proportion of area under bush or scrub is in Nkulivere and the largest under rangelands or grasslands is in Omaipanga. We therefore used their respective rates of NPP change as an index of degradation. Thus:

- Present grassland productivity was taken from the measured mean NPP (in mega grams of carbon per hectare per year, or  $\text{Mg C ha}^{-1} \text{y}^{-1}$ ) from Omaipanga focal landscape, which is a grassland dominated, during 2011/2013 ( $1.65 \text{ Mg C ha}^{-1} \text{y}^{-1}$ ). The potential productivity for grasslands was taken from the mean productivity of during 2001-2001 ( $4.30 \text{ Mg C ha}^{-1} \text{y}^{-1}$ ).
- Values of trends in NPP for forest areas were taken from Okongo for the period 2011/2013 ( $-1.65 \text{ Mg C ha}^{-1} \text{y}^{-1}$ ). Okongo has the second highest proportion of forests forest among the focal landscapes. Further, it is the focal landscape where forest degradation has been observed to be the highest. Furthermore, the NPP values of Zambezi, which has the highest proportion of forests, are probably higher due to the rapid re-growth of bush owing to favourable growing conditions.
- Values for trends in NPP for scrub were taken from Nkulivere ( $-1.54 \text{ Mg C ha}^{-1} \text{y}^{-1}$ ) which has the highest proportion of scrub among the focal landscapes.
- Under management, the total of 18,000 ha for forests to be protected was listed.
- 3,000 ha under land use and land cover change was listed under forests and another 3,000 for bush thinning.
- A total of 17,000 ha was listed under grasslands corresponding to restoration and sustainable rangeland management.

The proposed areas for different interventions for the project are as follows. These figures were used to populate the EX-ACT tool as indicated in the footnotes.

Activity	Forests restored (ha)	Grasslands restored (ha)	Forests protected (ha)	Grasslands protected (ha)
Regional Forest Reserve established in 10,000 ha leading to their sustainable management and restoration.			10,000 <sup>5</sup>	
Forest policy implemented in 3,00 ha of community forests leading to sustainable management and restoration.			3,000 <sup>6</sup>	
Restoration of savannah and forests in 10,000 ha.	3,000 <sup>7</sup>	7,000 <sup>8</sup>		
Agroforestry and sustainable crop/rangeland management in 15,000 ha.			5,000 <sup>9</sup>	10,000 <sup>10</sup>
Bush thinning in 3,000 ha.		3,000 <sup>11</sup>		
Totals	3,000	10,000	18,000	10,000

## NPP based estimates

In order to estimate the NPP of restored landscapes we assumed a modest 10% rate of increase in NPP per year. We calculated the increase in NPP over twenty years based on these values to estimate the scenarios as presented below:

Scenario without project	Scenario with project
<p>A. 10,000 hectares of woodland and savannah already in poor condition continues to be degraded, e.g.</p> <ul style="list-style-type: none"> <li>3000 ha of forests with a NPP lost @ -1.65 over 20 years. This amounts to about 32.48% of the total NPP in 20 years. <b>98,770.03 Mg C ha<sup>-1</sup>.</b></li> <li>7,000 ha grazing land currently with scrubby vegetation expected to be overgrazed and denuded of palatable species and eroded over 20 years. NPP lost @ -0.83 per year and 23.12% over 20 years: <b>116,666.69 Mg C ha<sup>-1</sup>.</b></li> </ul>	<p>A. 10,000 hectares of woodland and savannah is restored @ 10% per year.</p> <ul style="list-style-type: none"> <li>Forest degradation arrested and restoration done in 3,000 ha. NPP gained from preventing degradation (column on left) plus NPP gained from restoration (10% per year over 20 years): <math>98,770.03 + 30,411.56 = \mathbf{12,9181.59 \text{ Mg C ha}^{-1}}</math>.</li> <li>7,000 ha of rangeland denudation arrested plus gains from restoration of rangelands over 20 years at 10% per year: <math>116,666.69 + 50,457.11 = \mathbf{167,123.80 \text{ Mg C ha}^{-1}}</math>.</li> </ul>
<p>B. 3,000 hectares in Community Forests currently semi pristine but very poorly managed, forest slowly</p>	<p>B. 3,000 hectares better managed in Community Forests through effective protection and</p>

5 EXACT Sheet 5.Management: Row 13

6 EXACT Sheet 5.Management: Row 14

7 EXACT Sheet 2.LUC: Row 31

8 EXACT Sheet 4.Grassland: Row 22

9 EXACT Sheet 5.Management: Row 15

10 EXACT Sheet 4.Grassland: Row 23

11 EXACT Sheet 2.LUC: Row 49

<p>lost over 20 years till all is under crops except 20% which is thinned and degraded. NPP lost @ -1.65 over 20 years. This amounts to about 32.48% of the total NPP in 20 years. <b>98,770.03 Mg C ha<sup>-1</sup>.</b></p>	<p>implementation of management plans, and enriched with planting of useful species harvested sustainably over 20 years. Arresting degradation plus restoration @ 10% per year of NPP <b>98,770.03 + 30,411.56 = 129,181.59 Mg C ha<sup>-1</sup>.</b></p>
<p>C. 15,000 hectares currently under communal free for all and in moderate conditions but degrading / being lost to crops at the rate of -1.65 Mg C/ha for forests and -0.83 for grasslands.</p> <ul style="list-style-type: none"> <li>5,000 ha forest (after 20 years 32.48% NPP lost due to removal of large trees): <b>164,616.72 Mg C ha<sup>-1</sup>.</b></li> <li>10,000 ha grazing land currently with scrubby vegetation is totally overgrazed and denuded of palatable species, gets eroded over 20 years 23.12% NPP lost): <b>166,666.71 Mg C ha<sup>-1</sup>.</b></li> </ul>	<p>C. 15,000 hectares under new sustainable crop/rangeland management or agroforestry</p> <ul style="list-style-type: none"> <li>5,000 ha of forests prevented from degrading, sustainably managed and restored adding 10% NPP per year for 20 years: <b>164,616.72 + 50685.93 = 215,302.64 Mg C ha<sup>-1</sup>.</b></li> <li>10,000 ha of rangelands prevented from degradation and restored and sustainably managed over 20 years adding 10% NPP per year. <b>166,666.71 + 72081.58 = 238,748.29 Mg C ha<sup>-1</sup>.</b></li> </ul>
<p>D. 10,000 hectares currently relatively pristine but under communal tenure with no control - forest slowly lost over 20 years till all is under crops except 20% which is thinned and degraded. 32.48% NPP loss over 20 years @ -1.65 per year. <b>329,233.43 Mg C ha<sup>-1</sup>.</b></p>	<p>D. 10,000 hectares (and biodiversity therein) protected through establishment of Regional Forest Reserve. Area effectively protected consequently arresting degradation. Effective community-based management and sustainable harvesting over 20 years leading to 10% increase in NPP per year. <b>329,233.43 + 101,371.85 = 430,605.29 Mg C ha<sup>-1</sup>.</b></p>
<p>E. 3,000 hectares of rangelands encroached by bush making it unavailable for grazing and productive use and with negative affects on water and the economy as a whole. Furthermore, bush encroached rangelands are a serious fire risk and these fires typically result in the release of the bulk of above ground carbon into the atmosphere.</p>	<p>E. 3,000 hectares of encroacher bush thinned leading to an increase in herbaceous biomass, increased availability of rangelands for productive use, increased availability of water and reduced risk of fire.</p>
<p>As discussed in the proposal document, removal of bush encroachment may yield a net increase in carbon sequestration if grasses and other herbaceous biomass are allowed and encouraged to establish themselves. However, there is a lack of data, particularly from the northern parts of Namibia on the carbon consequence of removal of bush. Consequently, this intervention is being considered carbon neutral for the independent calculations for carbon sequestration, however is being included in the EX-ACT tool.</p>	
<p>Total loss of NPP without interventions: <b>974,723.61 Mg C ha<sup>-1</sup>.</b></p>	<p>Total gain of NPP with arrest of degradation and restoration/management interventions: <b>1,310,143.19 Mg C ha<sup>-1</sup>.</b></p>

Using these calculations, we estimated that the project would result in a total gain of 1,310,143.19 mega-grammes (tonnes) of carbon per hectare over a twenty-year period. This, for a total area of 41,000 hectares over 20 years amounts to a net increase of 1.6 mega-grams per hectare per year.

The estimates using the EX-ACT tool were a net gain of 1,368,445 mega-grams of carbon per hectare with 36.4% of uncertainty. The amounts to an increase of 1.67 mega-grammes per hectare per year.

## Implications for Monitoring Carbon Benefits

The procedure and results described above provide a basic framework for satellite imagery based monitoring of carbon sequestration, in terms of net primary productivity. Most of this analysis can be automated on cloud-based computing frameworks such as the Google Earth Engine or other subscription based alternatives. There are some caveats to the methods which ought to be addressed if this is to be developed into a formal monitoring framework.

1. More recent datasets for NPP need to be utilised. There are many remotely sensed indices which can be explored if the MODIS products are not brought on-line. Products based on LANDSAT or SENTINEL imagery would have the added advantage of better resolution and will allow easier ground validation.
2. Trends in NPP used for this analysis need to be improved upon by removing the influence of rainfall and temperature (de-trending). This will provide a more accurate estimate of NPP trends.
3. Non-linear regressions will improve the predictive ability of the model and should be utilised in place of the linear model used here. Furthermore, the adjusted  $R^2$  and  $p$ -values of the model should be used to determine how reliable the model is.
4. Actual rates of recovery and restoration need to be based on ground measurements of biomass accumulation. This is a non-trivial activity and would involve setting up of long-term monitoring plots in representative land cover across the focal landscapes. Ideally, this would be done in collaboration with other projects seeking to establish and report on Namibia's achievements of its LDN commitments.
5. Collaborations with other projects investigating the carbon storage consequence of bush encroachment and its removal with herbaceous species will provide an important source of data on the likely impact of NILALEG in regards to such interventions.



# Appendices

Screen grabs of relevant pages from the EX-ACT tool.

Start. Page 0.

The screenshot shows the Microsoft Excel interface with the EX-ACT tool embedded. The title bar indicates the file name: "NILALEG-EX-ACT-v7.1.8g-feb19 - Excel". The ribbon at the top includes File, Home, Insert, Page Layout, Formulas, Data, Review, View, and Help. The tool's main header is "The EX-Ante Carbon-balance Tool (EX-ACT)". Below this is a navigation bar with buttons for "Start", "Description", "Land Use Change", "Crop production", "Grassland Livestock", "Management Degradation", "Coastal Wetlands", "Inputs Investments", "Fisheries Aquaculture", and "Detailed Results". The central area displays the "EASYPol" logo and the text "Food and Agriculture Organization of the United Nations". Below the logo is the title "The EX-Ante Carbon-balance Tool (EX-ACT)" and "Version 7 - Multilingual Edition". A language selection box prompts the user to "Please select language interface" with a button for "English". A large green play button is centered on the page. The footer contains a disclaimer and copyright information: "© FAO (2013). FAO encourages the use, reproduction and dissemination of material in this product. Except where otherwise indicated, material may be copied, downloaded and printed for private study, research and teaching purposes, or for use in non-commercial products or services, provided that appropriate acknowledgement of FAO as the source and copyright holder is given and that FAO's endorsement of users' views, products or services is not implied in any way. All requests for translation and adaptation rights, and for resale and other commercial use rights should be made via www.fao.org/contact-us/licence-request or addressed to copyright@fao.org." The bottom of the Excel window shows a tabbed interface with tabs for "0.Start", "1.Description", "2.LUC", "3.Cropland", "4.Grassland", "5. Management", "6. Coastal", "7. Inputs", "8. Fish", "9. Results", "Help", "Yield", and "Calculations".

Description. Page 1.

Excel interface showing a project description for "The EX-ante carbon-balance tool (EX-ACT)".

Navigation buttons: Start, Description, Land Use Change, Crop production, Grassland Livestock, Management Degradation, Coastal Wetlands, Inputs Investment, Fisheries Aquaculture. A "Detailed Results" button is also present.

Project Name	NILALEG	
Continent	Africa	
Climate	Warm Temperate	Climate ?
	Moisture regime: Dry	
Dominant Regional Soil Type	Sandy Soils	Soil ?
Duration of the Project (Years)	Implementation phase	5
	Capitalisation phase	15
	Duration of accounting	20

Bottom navigation bar: 0.Start, 1.Description, 2.LUC, 3.Cropland, 4.Grassland, 5. Management, 6. Coastal, 7. Inputs, 8. Fish, 9. Results, Help, Yield, Calculations.

NILALEG-EX-ACT-v7.1.8g-feb19 - Excel

File Home Insert Page Layout Formulas Data Review View Help Tell me what you want to do

M31

The **EX-ACT** Carbon-balance tool (EX-ACT)

Start Description **Land Use Change** Crop production Grassland Livestock Management Degradation Coastal Wetlands Inputs Investment Fisheries Aquaculture Detailed Results

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### 2.1. Deforestation

AEZ map Zone 1 = Subtropical humid forest Zone 2 = Subtropical dry forest Zone 3 = Subtropical steppe Zone 4 = Subtropical mountains systems

Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha)				Deforested area (ha)				Total Emissions (tCO <sub>2</sub> -eq)		Balance	
				Start	Without	With	*	Without	With	Without	With				
Forest Zone 2	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0	0	0
#Harvested Wood Products															
* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)															
<b>Tier 2</b>											<b>Total Deforestation</b>		0	0	

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### 2.2. Afforestation and Reforestation

AEZ map Zone 1 = Subtropical humid forest Zone 2 = Subtropical dry forest Zone 3 = Subtropical steppe Zone 4 = Subtropical mountains systems

Type of vegetation that will be planted	Fire Use? (y/n)	Previous land use	Area that will be afforested/reforested				Total Emissions (tCO <sub>2</sub> -eq)		Balance			
			Without	*	With	*	Without	With				
Forest Zone 2	NO	Perennial/Tree Crop (>10 yrs)	1500	D	1500	D	-1,29,769	-1,29,769	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0			
* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)												
<b>Tier 2</b>								<b>Total Af-/Reforestation</b>		-1,29,769	-1,29,769	0

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### 2.3. Other Land Use Changes

Fill with your description	Initial land use	Final land use	Message	Fire Use? (y/n)	Area transformed (ha)				Total Emissions (tCO <sub>2</sub> -eq)		Balance	
					Without	*	With	*	Without	With		
Bush thinning	Perennial/Tree Crop (>10 yrs)	Grassland		NO	0	D	3000	D	0	3,14,963	3,14,963	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
Select Initial Land Use		Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0	
* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)												
<b>Tier 2</b>								<b>Total Other LUC</b>		0	3,14,963	3,14,963

0.Start 1.Description **2.LUC** 3.Cropland 4.Grassland 5.Management 6.Coastal 7.Inputs 8.Fish 9.Results Help Yield Calculations

NILALEG-EX-ACT-v7.1.8g-feb19 - Excel

File Home Insert Page Layout Formulas Data Review View Help Tell me what you want to do

B46 =HLOOKUP(select,translations!\$A\$76:\$H\$144,26,)

**The EX-Ante Carbon-balance Tool (EX-ACT)**

Start Description Land Use Change **Crop production** Grassland Livestock Management Degradation Coastal Wetlands Inputs Investments Fisheries Aquaculture Detailed Results

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**3.1. Annual systems (to be used also for pluri-annual systems such as cotton or sugarcane)**

**3.1.1. Annual systems from other LU or converted to other LU (please fill step 2.LUC previously)**

Description	Main season crop	Management options			Residue management	Yield? (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)		Balance
		Improved agronomic practices	Nutrient management	No till & residue retention			Water management	Manure application	Start	Without	With	
Annual after Deforestation	Default	?	?	?	?	Please select	0	0	0	0	0	0
Converted to AR	Default	?	?	?	?	Please select	0	0	0	0	0	0
Annual after non-forest LU	Default	?	?	?	?	Please select	0	0	0	0	0	0
Converted to OLU	Default	?	?	?	?	Please select	0	0	0	0	0	0

**3.1.2. Annual systems remaining annual systems (total area must remain constant)**

Fill with your description	Main season crop	Management options			Residue management	Yield? (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)		Balance		
		Improved agronomic practices	Nutrient management	No till & residue retention			Water management	Manure application	Start	Without	With		Without	With
description 1	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 2	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 3	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 4	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 5	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 6	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 7	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 8	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 9	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
description 10	Default	?	?	?	?	Please select	0	0	D	0	D	0	0	0
Total (ha)							0	0	D	0	D	0	0	0

**Tier 2** Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total Annual Systems** 0 0 0

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**3.2. Perennial systems (agroforestry, orchards, tree crops...)**

**3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)**

Description	Residual biomass burning	Yield (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)		Balance
			Start	Without	With	Without	With	
Perennial after Deforestation	NO		0	0	0	0	0	0
Converted to AR	NO		1,500	0	0	-1,238	-1,238	0
Perennial after non-forest LU	NO		0	0	0	0	0	0
Converted to OLU	NO		3,000	3,000	0	-19,800	-2,475	17,325

**3.2.2. Perennial systems remaining perennial systems (total area must remain constant)**

Fill with your description	Residual biomass burning	Yield (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)		Balance
			Start	Without	With	Without	With	
Enter description of your system 1	NO	0	0	0	D	0	0	0
Enter description of your system 2	NO	0	0	0	D	0	0	0
Enter description of your system 3	NO	0	0	0	D	0	0	0
Enter description of your system 4	NO	0	0	0	D	0	0	0
Enter description of your system 5	NO	0	0	0	D	0	0	0
Enter description of your system 6	NO	0	0	0	D	0	0	0
Enter description of your system 7	NO	0	0	0	D	0	0	0
Enter description of your system 8	NO	0	0	0	D	0	0	0
Enter description of your system 9	NO	0	0	0	D	0	0	0
Enter description of your system 10	NO	0	0	0	D	0	0	0
Total (ha)			0	0	0	0	0	0

**Tier 2** Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total Perennial Systems** -21,038 -3,713 17,325

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**3.3. Flooded rice systems**

**3.3.1. Flooded rice systems from other LU or converted to other LU (please fill step 2.LUC previously)**

Description	Cultivation period (days)	Water regime	Organic amendment type (straw or other)	Yield (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)	
					During the cultivation period	Before the cultivation period	Area (ha)	Without	With
Rice after Deforestation	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	0	0	0
Converted to AR	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	0	0	0
Rice after non-forest LU	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	0	0	0
Converted to OLU	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	0	0	0

**3.3.2. Flooded rice systems remaining flooded rice systems (total area must remain constant)**

Fill with your description	Cultivation period (days)	Water regime	Organic amendment type (straw or other)	Yield (t/ha/yr)	Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)	
					During the cultivation period	Before the cultivation period	Area (ha)	Without	With
Rice 1	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	D	0	D
Rice 2	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	D	0	D
Rice 3	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	D	0	D
Rice 4	150	Please select water regime	Please select pre-season water regime	Please select type of Organic Amendment	0	0	D	0	D
Total (ha)					0	0	0	0	0

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The **EX-ANTE** Carbon-balance Tool (EX-ACT)

Start Description Land Use Change Crop production **Grassland Livestock** Management Degradation Coastal Wetlands Inputs Investments Fisheries Aquaculture Detailed Results

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### 4.1. Grassland systems

#### 4.1.1. Grassland systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Initial State	Final state of the grassland		Fire use to manage?				Yield			Area (ha)			Total Emissions (CO2-eq)		Balance
		Without project	With project	Periodicity (Without)		Periodicity (With)		Start	Without	With	Start	Without	With	Without	With	
				(y/n)	(year)	(y/n)	(year)									
Grassland after Deforestation	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Converted to A/R	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Grassland after non-forest LU	Select state	Select state	Select state	NO	5	NO	5				0	0	3,000	0	0	0
Converted to O/LUC	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0

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#### 4.1.2. Grassland systems remaining grassland systems (total area must remain constant)

Fill with your description	Initial State	Final state of the grassland		Fire use to manage?				Yield			Area (ha)			Total Emissions (CO2-eq)		Balance		
		Without project	With project	Periodicity (Without)		Periodicity (With)		Start	Without	With	Start	Without	With	Without	With			
				(y/n)	(year)	(y/n)	(year)										(tha/yr)	
Restoration of savannah	Moderately Degraded	Severely Degraded	Non degraded	NO	5	NO	5	4	2	4	7,000	7,000	D	7,000	D	1,06,677	-21,335	-1,28,013
Sustainable rangeland ma	Moderately Degraded	Moderately Degraded	Non degraded	NO	5	NO	5	4	2	4	10,000	10,000	D	10,000	D	0	-30,479	-30,479
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Select state	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Tier 2** Total Grassland Systems 1,06,677 -21,335 -1,28,492

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### 4.2. Livestock (and manure management)

Livestock categories	Head number (mean per year)				Technical mitigation option (%)									Production (meat, milk, etc) in tonnes of product per year			Total Emissions (CO2-eq)		Balance
	Start	Without project	With project	D	Feeding practices*			Specific Agents*			Breeding*			Start	Without	With	Without	With	
					Start	Without	With	Start	Without	With	Start	Without	With						
Dairy cattle	0	0	D	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0
Other cattle	0	0	D	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0
Buffalo	0	0	D	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0
Sheep	0	0	D	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0	0
Swine (Market)	0	0	D	0	Feeding practices: e.g. more concentrates, adding certain oils or oilseeds to the diet, improving pasture quality...			Specific agents: specific agents and dietary additives to reduce CH4 emissions (ionophores, vaccines, BST...)			Breeding: increasing productivity through breeding and better management practices (reduction in the number of replacement heifers)			0	0	0	0	0	0
Swine (Breeding)	0	0	D	0	Feeding practices: e.g. more concentrates, adding certain oils or oilseeds to the diet, improving pasture quality...			Specific agents: specific agents and dietary additives to reduce CH4 emissions (ionophores, vaccines, BST...)			Breeding: increasing productivity through breeding and better management practices (reduction in the number of replacement heifers)			0	0	0	0	0	0
Please select	0	0	D	0	Feeding practices: e.g. more concentrates, adding certain oils or oilseeds to the diet, improving pasture quality...			Specific agents: specific agents and dietary additives to reduce CH4 emissions (ionophores, vaccines, BST...)			Breeding: increasing productivity through breeding and better management practices (reduction in the number of replacement heifers)			0	0	0	0	0	0
Horses	0	0	D	0	Feeding practices: e.g. more concentrates, adding certain oils or oilseeds to the diet, improving pasture quality...			Specific agents: specific agents and dietary additives to reduce CH4 emissions (ionophores, vaccines, BST...)			Breeding: increasing productivity through breeding and better management practices (reduction in the number of replacement heifers)			0	0	0	0	0	0
Goats	0	0	D	0	Feeding practices: e.g. more concentrates, adding certain oils or oilseeds to the diet, improving pasture quality...			Specific agents: specific agents and dietary additives to reduce CH4 emissions (ionophores, vaccines, BST...)			Breeding: increasing productivity through breeding and better management practices (reduction in the number of replacement heifers)			0	0	0	0	0	0

**Tier 2** Total Livestock 0 0 0

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### 4.1. Grassland systems

Back

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**The EX-ACT Carbon-balance Tool (EX-ACT)**

Start Description Land Use Change Crop production Grassland Livestock **Management** Coastal Wetlands Inputs Investment Fisheries Aquaculture Detailed Results

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**5.1. Forest degradation and management**

AEZ map Zone 1 = Subtropical humid forest Zone 2 = Subtropical dry forest Zone 3 = Subtropical steppe Zone 4 = Subtropical mountains systems

Type of vegetation that will be degraded	Degradation level of the vegetation			Fire occurrence and severity						Area (ha)			Total Emissions (tCO <sub>2</sub> -eq)		Balance	
	Initial State	At the end		Without	Periodicity	Impact	With	Periodicity	Impact	Start	Without	With	Without	With		
Forest Zone 2	Moderate	Moderate	Low	NO	1	100%	NO	1	100%	10,000	10,000	D	10,000	D	0	-8,56,801
Forest Zone 2	Moderate	Moderate	Low	NO	1	100%	NO	1	100%	3,000	3,000	D	3,000	D	0	-2,57,040
Forest Zone 2	Moderate	Moderate	Low	NO	1	100%	NO	1	100%	5,000	5,000	D	5,000	D	0	-4,28,401
Select the vegetation	Select level	Select level	Select level	NO	1	100%	NO	1	100%	0	0	D	0	D	0	0
Select the vegetation	Select level	Select level	Select level	NO	1	100%	NO	1	100%	0	0	D	0	D	0	0
Select the vegetation	Select level	Select level	Select level	NO	1	100%	NO	1	100%	0	0	D	0	D	0	0
Select the vegetation	Select level	Select level	Select level	NO	1	100%	NO	1	100%	0	0	D	0	D	0	0
Select the vegetation	Select level	Select level	Select level	NO	1	100%	NO	1	100%	0	0	D	0	D	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Tier 2** Total Forest Degradation and Management 0 -15,42,242 -15,42,242

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**5.2. Degradation and management of organic soils (peatlands)**

**5.2.1. Drainage of organic soils**

Type of vegetation concerned by drainage	Surfaces of drained organic soils (ha)				Percentage (area) of ditches			This should concern only area not accounted for elsewhere	Total Emissions (tCO <sub>2</sub> -eq)		Balance
	Start	Without	With	*	Start	Without	With		Without	With	
Forest	0	0	D	0	D	5%	5%	5%	0	0	0
Plantation	0	0	D	0	D	5%	5%	5%	0	0	0
Annual	0	0	D	0	D	5%	5%	5%	0	0	0
Perennial	0	0	D	0	D	5%	5%	5%	0	0	0
Grassland	0	0	D	0	D	5%	5%	5%	0	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total for Drainage** 0 0 0

**5.2.2. Active peat extraction**

Type of peat	Surfaces where peat is extracted				Height of extraction (cm)			Quantity of peat produced (t/yr)			Total Emissions (tCO <sub>2</sub> -eq)		Balance
	Start	Without	With	*	Start	Without	With	Start	Without	With	Without	With	
Nutrient-poor peat	0	0	D	0	D	50	50	50	-	-	-	0	0
Nutrient Rich	0	0	D	0	D	50	50	50	-	-	-	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total for Extraction** 0 0 0

**5.2.3. Rewetting of organic soils (peatlands)**

Type of peat	Surfaces of rewetted organic soils (ha)				This should concern only area not accounted for elsewhere	Total Emissions (tCO <sub>2</sub> -eq)		Balance
	Start	Without	With	*		Without	With	
Nutrient-poor peat	0	0	D	0	D	0	0	0
Nutrient Rich	0	0	D	0	D	0	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total for Rewetting** 0 0 0

**5.2.4. Emissions from fire of organic soils (peatlands)**

Fire Type	Area burnt (ha)				Fire occurrence and severity						Total Emissions (tCO <sub>2</sub> -eq)		Balance
	Start	Without	With	*	Without	Periodicity	Impact	With	Periodicity	Impact	Without	With	
Wildfire (drained peat)	0	0	D	0	D	1	100%	1	100%	1	100%	0	0
Wildfire (undrained peat)	0	0	D	0	D	1	100%	1	100%	1	100%	0	0
Prescribed fire	0	0	D	0	D	1	100%	1	100%	1	100%	0	0

\* Note concerning dynamics of change: "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

**Total for Fire** 0 0 0

**Tier 2**

0.Start 1.Description 2.LUC 3.Cropland 4.Grassland **5. Management** 6. Coastal 7. Inputs 8. Fish 9. Results Help Yield Calculations

