Appendix I. Methodology to Avoid Unplanned deforestation, VM0015 versión 1.1

“Forest Management project to reduce deforestation and deterioration in the Shipibo Conibo and Cacataibo indigenous communities, in Ucayali Region“

Part 1 – Scope, implementation conditions and additionality

1. Scope of the methodology

The Project “Forest management to reduce deforestation and degradation in Shipibo Conibo and Cacataibo indigenous communities in the Ucayalio Region” is a strategy to reduce the forest deforestation progress of the 7 native’s communities. Thus the project is within the AFOLU´s category AUDD-VCS and meet with the border configuration according the established in the methodology. The improvements of the carbon stocks in the forest that have been deforested in the baseline are motted in a conservative way in the project of the 7 native’s communities. Credits of the reduction of the GHG emissions of avoided degradation are not take into account because they are excluded in the methodology.

Acivities that causes deforestation are migratory agriculture, mining, invasion by coca growers and illegal logging. With the project the activities include a community forest management, activity that are developing the communities in a sustainable way according to legal guidelines of the national policies. Therefore, the project falls within the category D (Table 1).

Table 1. Scope of the methodology (see table 1 – GHG-VM0015 calculations-emissions)

			Project activities	
			Protection without harvesting, wood collection or carbon production	Protection with controlled harvesting, wood collection or carbon production
Baseline	Deforestation	Mature forest without harvesting	**A**	**B**
		Mature forest with harvesting	**C**	**D**
		Deteriorated and still in deterioration process	**E**	**F**
		Secondary growth	**G**	**H**
	Non - Deforestation	Mature forest without harvesting	No changes	Deterioration
		Mature forest with harvesting	IFM	IFM-RIL
		Deteriorated and still in deterioration process	IFM	IFM
		Secondary growth	No changes	Deterioration

2. Conditions of applicability

The Project complies with the 5 aplicability conditions of the methodology on the following way:

a) The project promotes activities that avoid deforestation and degradation in the project area. Therefore, is within the unplanned deforestation and degradation of the category (AUDD) VCS AFOLU.

b) The project activity considers a community forest management of the forest (forest mature protection with controlled harvesting), thus the project falls within the category D.

c) Althougn there is no an official forest definition under the Peruvian law, the government os Peru has adopted the following parameters for its forest definition, according the UNFCC in 2001:

- A minimun canopy cover of 30 per cent,
- A minimum land area of 0,5 hectares, and
- A minimum tree height of 5 m.

The project does not consider secondary forest in the forest definition, only the primary forest.

d) The project area meets the conditions of forest according to the historical analysis of the past 10 years prior to the start date of the project.

e) The forest land located within the project area is characterized by low hill, average hill, riverbank complex, high terrace, low terrace and average terrace, therefore no forested wetland is found within the project area.

3. Additionality

See section 2.5 of PDD VCS.

Part 2 – Steps of the methodology for ex-ante estimations of GHG emissions reduction

Step 1 : Defining the boundaries

1.1 Spatial boundaries

1.1.1 Reference region

So far, there does not exists a national or sub-national baseline which meets the specifications of the VCS standard concerning the applicability of the existing baseline as specified in table 2. There are initiatives of the national state and likewise sub regional initiatives that are still under development. The project proponent agrees to follow the national and sub-national policies and the different regulations and/or control standards that might exist.

Table 2. Criteria determining the applicability of existing baselines (see table 1 – GHG-VM0015 calculation of emissions)

Applicability criteria	
1	The existing baseline must cover a broader geographical region than the project area. If a leakage belt must be defined, the broader region must include the leakage belt area.
2	The existing baseline must cover at least the duration of the first fixed baseline period and is not outdated.
3	The existing baseline must represent the location of future deforestation on a yearly base.
4	The spatial resolution of the existing baseline must be equal or finer than the minimum mapping unit of "forest land" that will be used for monitoring deforestation during the fixed baseline period.
5	Methods used to develop the existing baseline must be transparently documented and be consistent with a VCS approved and applicable baseline methodology.

For the determination of the reference region the project proponent defines this area according their similar geophysical characteristics to the project area, also were analized similar characteristics of the agents, drivers and different patterns of eforestation, whereby proposed that the reference region defined by this regional sub-limits (distrital limits) being the districts of Codo de Pozuzo, Puerto Inca, tournavista and Honoria, belonging to the Department of Huánuco, and likewise Calleria districts, Yarinacocha, Campo Verde, Masisea, Manantay, Irazola, and Iparia Department of Ucayali.

The surface of the reference region is 4'735,649.4 hectares, and the external perimeter of 1,540.01 km. Below shows the area covered by the reference region, according to figure 1.

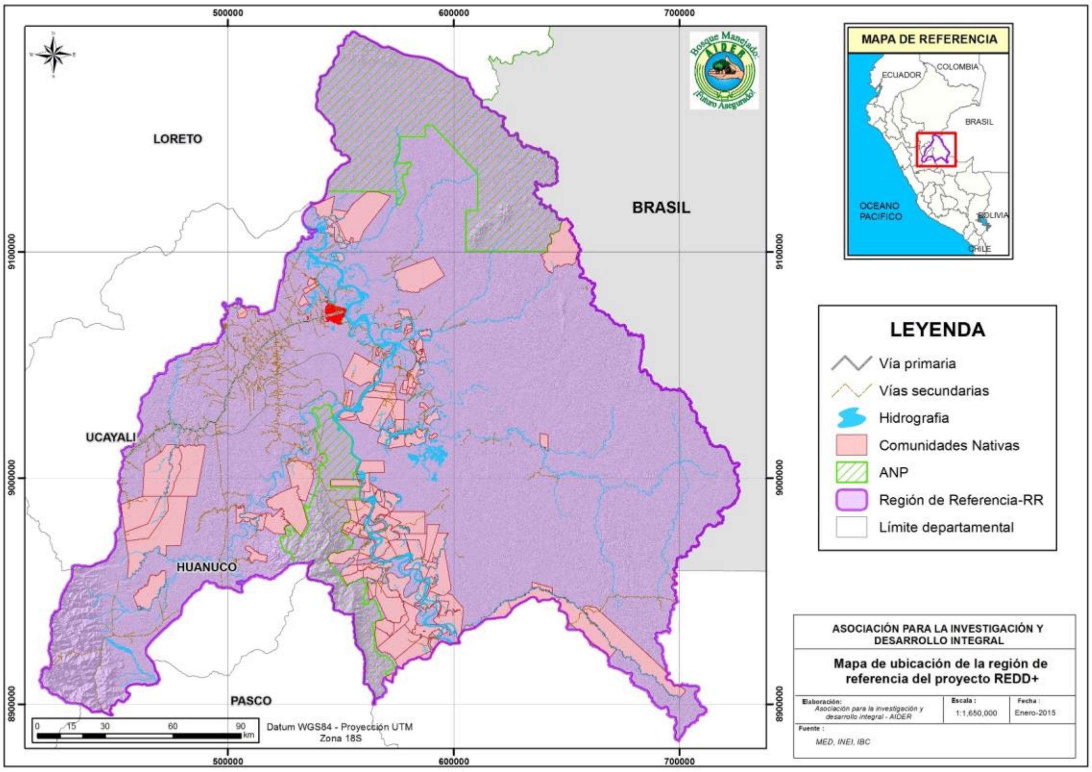

Figure 1. Location map of the reference region

The criteria used to define the reference region are based in altitude, slope, socio-economic and cultural conditions.

a. Agents and drivers of deforestation

The agents and drivers were analyzed according to the deforestation variations occurring in baseline periods, where the project proponent used participatory methods for its identification and location. A detailed description of the agents and causes of deforestation can be found in the Step 3 of this document.

Agent groups: the agents of deforestation, both for the reference region and the project area, are populations involved in timber, farming and agricultural activities.

- **Infrastructure drivers**: the great infraestructuire drivers both in the reference region and in the project area, are those directly linked to primary and secondary roads, and the navigable rivers.
- **Other spatial drivers expected to influence in the project area**: no other main drivers were identified in the reference region during the workshops and the consultation with specialists of the Ucayali region.

b. Landscape configuration and ecological conditions

- **Forest/Type of vegetation**

The 100% of forest types identified in the project area are distributed in about 91% of the reference region. The proportion area of each type of forest corresponding to the project area in relation to the reference region are indicated in the following table:

Table 3. Forest type at the beginning of the REDD+ propject (2010)

Type of forest	**Reference region (without the project area)**		**Project area**	
	he	**%**	**he**	**%**
High hill forest	20,951.88	0.58	-	-
Low hill forest	893,522.31	24.89	13,890.56	10.94
Average hill forest	93,836.42	2.61	4,487.87	3.53
Riverbank complex forest	157,546.32	4.39	3,896.34	3.07
Knoll forest	168,394.83	4.69	899.69	0.71
High terrace forest	845,720.50	23.56	30,194.73	23.77
Low terrace forest	342,700.95	9.55	16,936.69	13.34
Medium terrace forest	768,298.95	21.40	56,698.10	44.64
High mountain forest	56,515.71	1.57	-	-
Low mountain forest	242,221.01	6.75	-	-
Total	**3,589,709.88**	**100.00**	**127,003.97**	**100.00**

Source: Own elaboration

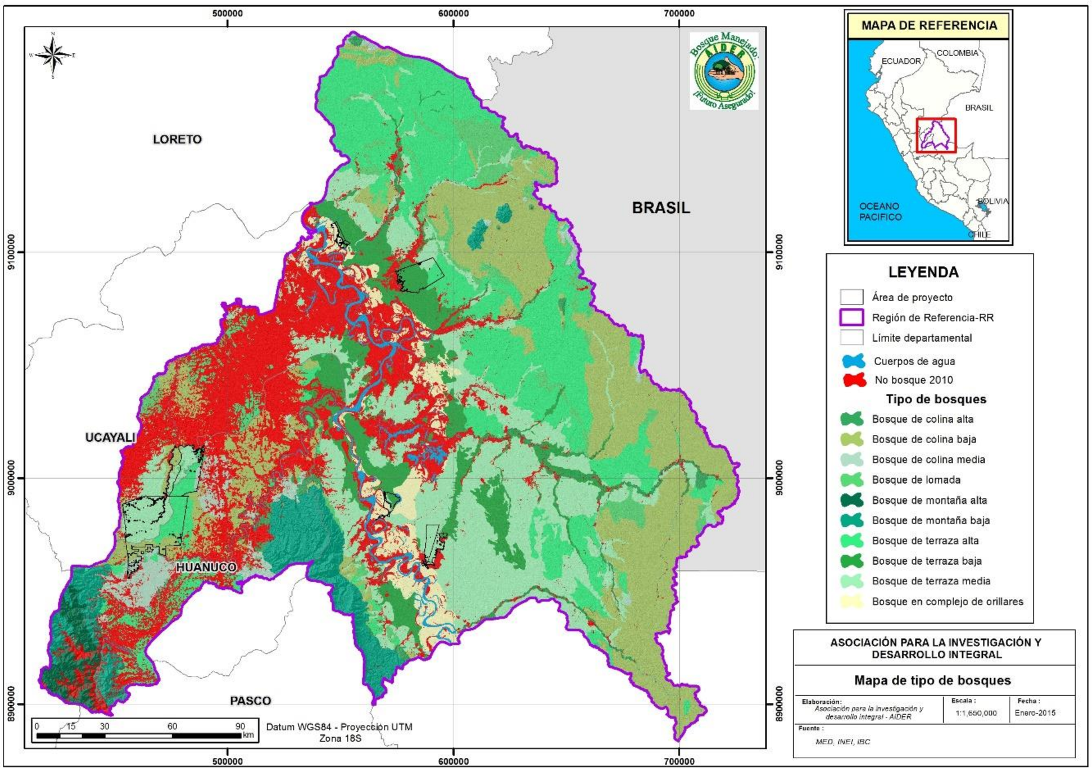

Figure 2. Type of forest map

1. Elevation:

To determinate elevation ranges was used cartographic information of “contour line” elaborated by the Ministry of education[1], furthermore, in order to complement the analysis was performed the download of a digital elevation model of the area of interest[2]. For the project area was determinated an elevation range of 120 -414 meters above sea level, in the case of the reference region the levation range is 120 - 4080 meters above sea level, from the analysis was defined that, 100% of the elevation range within the project area is located in approximately 90% of the reference region (see Table 4 and Figure 3)

Table 4. Elevation ranges in the reference region (Without project area)

Elevation range (masl)	Area	
	ha	%
120-414[3]	4,261,926.33	92.48
415-1,000	180,863.76	3.92
1,001-2,000	130,194.14	2.82
2,001-3,000	31,215.81	0.68
3,001-4,080	4,445.35	0.10
Total[4]	**4,608,645.39**	**100.00**

Source: own elaboration

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[1] Available information in: http://sigmed.minedu.gob.pe/descargas/

[2] Land elevation model SRTM (Shuttle Radar Topography Mission), tiles available in the web site of CIAT-CSI SRTM (http://srtm.csi.cgiar.org).

[3] Elevation range for the project area

[4] Area reference region without project area

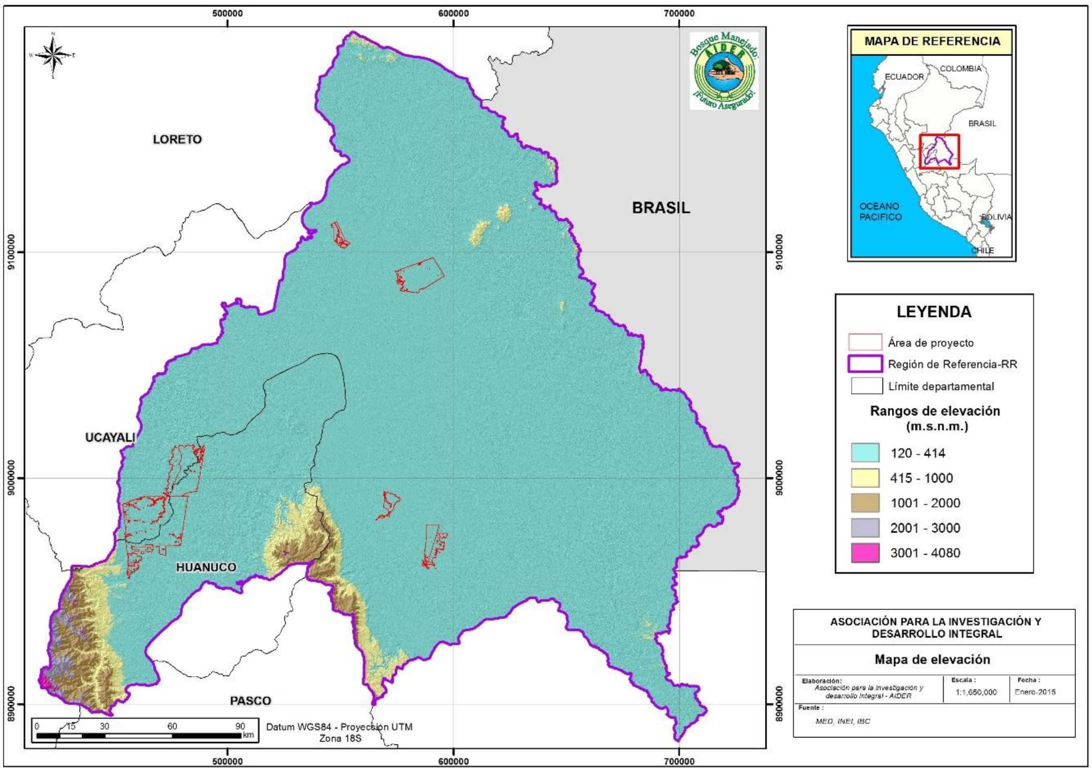

Figure 3. Elevation map

2. **Slope:**

As inputs to determine the slope of the area of interest was used the generated raster to determinate elevation ranges, and regarding the ranges of slopes used, was made use of the indicated in D.S. N° 017-2009/AG[5], with this data a slope map was generated (see figure 4). This inputs allowed obtain the table 5 data, the same where is appreciated the distribution of the different slope categories, also in the project area as in the rest reference region.

From the analysis made was detemined that, 100% of the project area presents a average slope of 12.7% (table 6), while that for aproximately 90.55% of the rest of the reference region the average slope is 12% (table 7).

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[5] The moderately steep category (15-25 %), was modified to effects of the present studie for the values of 15 – 30 %, similarly the steep category (25 – 50 %) was replaced by the values of 30 – 50 %.

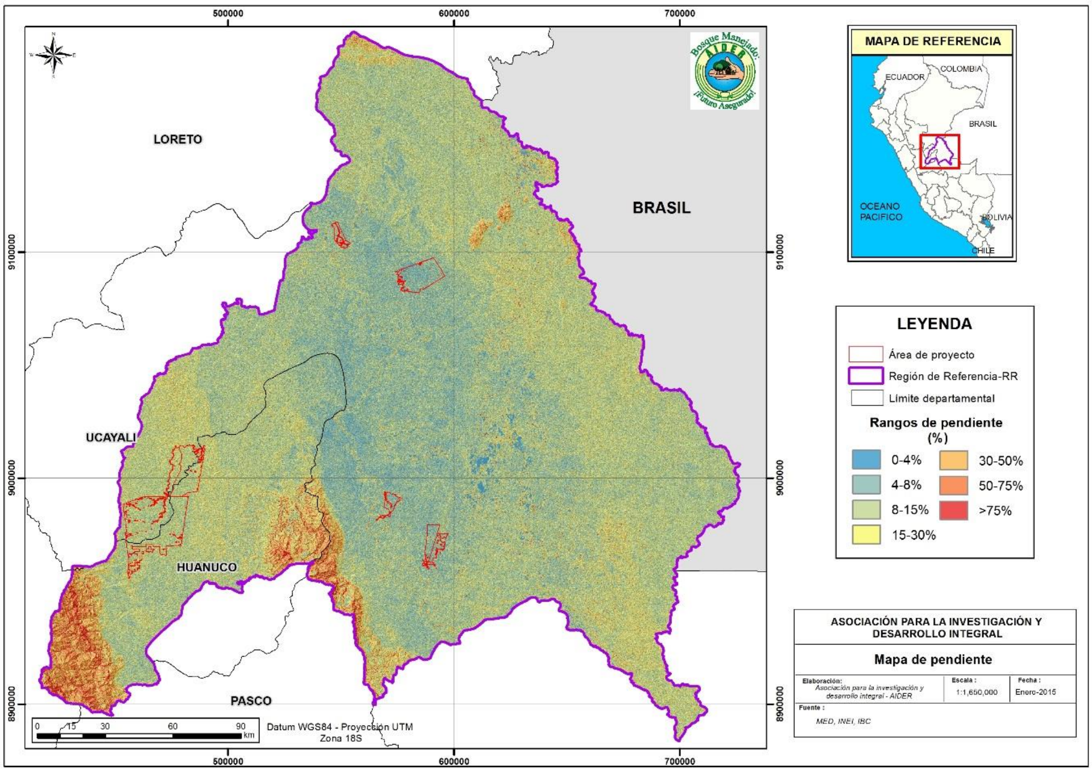

Figure 4. Slopes map of the reference region

Table 5. Slope category in the projecta rea and in the rest of the reference region

Slope range	**Category**	**Area of the reference region (without project area)**			**Project area**		
		Number of pixels	**ha[6]**	**%**	**Number of pixels**	**ha**	**%**
0-4%	Flat relief	4,886,206.00	439,758.54	9.54	143,904.00	12,951.36	10.20
4-8%	Moderately sloped	10,331,876.00	929,868.84	20.17	309,075.00	27,816.75	21.91
8-15%	Strongly sloped	16,961,820.00	1,526,563.80	33.12	498,728.00	44,885.52	35.35
15-30%	Moderately steep	14,192,120.00	1,277,290.80	27.71	409,874.00	36,888.66	29.05
30-50%	Steep	3,167,853.00	285,106.77	6.19	47,914.00	4,312.26	3.40
50-75%	Very steep	1,090,250.00	98,122.50	2.13	1,256.00	113.04	0.09
>75%	Extremely steep	581,663.00	52,349.67	1.14	14.00	1.26	0.00
Total		**51,211,788.00**	**4,609,060.92**	**100.00**	**1,410,765.00**	**126,968.85**	**100.00**

Source: own elaboration

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[6] The area in hectares is for reference as this analysis was conducted according to the number of pixels, which is why the totals do not reflect the original data, eg project area is 127,003.97 ha and in this table is 126968.85 ha.

Table 6. Average slope of the project area

Native community	Number of pixels	ha	Average slope (%)	Calculating average slope	
				Product	weighted average
Roya	46,275.00	4,164.75	8.37	34,874.28	**12.70**
Puerto Nuevo	683,346.00	61,501.14	14.14	869,583.38	
Pueblo Nuevo del Caco	49,220.00	4,429.80	9.23	40,879.49	
Flor de Ucayali	218,223.00	19,640.07	7.75	152,159.54	
Curiaca	65,479.00	5,893.11	8.70	51,242.28	
Callería	41,294.00	3,716.46	9.92	36,865.24	
Sinchi Roca	306,928.00	27,623.52	15.47	427,461.93	
Total	1,410,765.00	126,968.85		1,613,066.13	

Source: own elaboration

Table 7. Average slope of the rest of the referencese region

Slope range	Category	Number of pixels	ha	Average slope (%)	Calculating average slope	
					Product	weighted average
0-4%	Flat relief	4,886,206.00	439,758.54	2.58	1,133,921.79	**12.00**
4-8%	Moderately sloped	10,331,876.00	929,868.84	6.07	5,646,953.98	
8-15%	Strongly sloped	16,961,820.00	1,526,563.80	11.25	17,179,800.93	
15-30%*	Moderately steep	14,192,120.00	1,277,290.80	20.45	26,123,036.49	
Total		46,372,022.00	4,173,481.98		50,083,713.19	

Source: own elaboration

c. Socio-economical and cultural conditions

- Legal status of the land:

The region of reference mainly constituted by the boundaries of the native communities, protected natural areas, public and private properties, human settlements, and forestry and mining concessions. The project area is composed by the forests of 7 native communities (Roya, Pueblo Nuevo del Caco, Curiaca, Calleria, Flor de Ucayali, Puerto Nuevo and Sinchi Roca) that are constituted by the titles given by the Peruvian government.

- Land tenure:

The land-tenure system in the project area in the baseline scenario is in all the reference region. In synthesis the forest project area is the area that is managed by the settlers registered in each native community.

- Land-use:

The actual land-use and the projected use in the project area are related to the agricultural activity (which is growing, alongside other activities such as livestock production). A baseline of actual land-use is currently being defined through the Ecological Zoning studies of the Ucayali and Huánuco Region.

- Enforced policies and regulations:

  Policies, legislation and regulations are applicable to the native communities, which have a scope of national case-law. Nevertheless, this legislation is not currently strictly applied, and this occurs in the entire reference region.

1.1.2 Project area

The area of the project “Forest Management to reduce deforestation and deterioration in Shipibo Conibo and Cacataibo indigenous communities in Ucayali Region“ correspond to the forests of the native communities of Roya, Pueblo Nuevo del Caco, Curiaca, Calleria, Flor de Ucayali, Puerto Nuevo and Sinchi Roca. It correspond a total area of 127.004.0 he, located on the districts Codo de Pozuzo, Puerto Inca, Tournavista y Honoria (which belongs to the Department of Huánuco) and the districts of Calleria, Yarinacocha, Campo Verde, Masisea, Manantay, Irazola, and Iparia in the Department of Ucayali.

The project area includes the entire forest coverage of each native community at the beginning of the project, according to the last map on the deforestation analysis. See table 8.

Table 8. Project areas for each native community

Native community	Total surface (ha)
Callería	3,718.8
Curiaca	5,901.9
Flor de Ucayali	19,650.2
Pueblo Nuevo del Caco	4,422.4
Puerto Nuevo	61,517.5
Roya	4,165.8
Sinchi Roca	27,627.4
Total	127,004.0

Source : Own elaboration

The physical boundaries of the project area have been defined according to the VCS methodology VM0015, Version 1.1.

Project participants **:** Native Communities of Nativa Roya, Pueblo Nuevo del Caco, Curiaca, Calleria, Flor de Ucuyali, Puerto Nuevo, and Sinchi Roca, and Asociación para la Investigación y Desarrollo Integral (AIDER).

1.1.3. Leakage belt

At the beginning of the project, no jurisdictional programme had defined the boundaries of the region where the project takes place, and the project proposer was thus responsible for drawing up the leakage belt boundaries for this area. The boundaries of the project’s leakage belt do not overlap any area of other VCS AFOLU projects registered in the region, or in the leakage belt of any other VCS AFOLU project. For the present baseline, we analysed the two options that Methodology VM0015 establishes (Option I, Opportunity cost analysis and Option II, Mobility analysis) and Option II was selected.

The Opportunity Cost Analysis was not chosen because it does not allow an in-depth spatial analysis, as it does not consider the accessibility and mobility capacities of the deforestation agents. Therefore, in some cases, the information gathered to conduct the study came from regional and national sources, as well as from socio-economic diagnostics carried out in the native communities taking part in the project. Nevertheless, the results obtained from the analysis of some crops, such as hard yellow corn and oil palm, show that the evidence and information gathered is not sufficiently convincing. Therefore, a further mobility analysis is recommended, in order to determine the project's leakage belt areas.

Option II : Mobility Analysis

In the historical analysis of deforestation in the reference region, we could observe that deforestation does not occur in areas where it would be most profitable and where travel facilities are the easiest due to the presence of primary roads and markets. On the opposite, deforestation happens in areas of highest access points due to the proximity of urban centres and accessibility to navigable rivers. The location of the deforestation is potentially almost directly linked to the proximity of the secondary roads network and the location of urban centres. This point can be put forward according to the analysis of drivers and agents of deforestation that was conducted (Step 3). Nevertheless, in this case, a mobility analysis was considered more relevant for the identification of the leakage belt. The determination of the leakage belt was done according to the module of multi-analysis criteria of Idrisi software.

The variables assigned and as the weight by the behavior of each in were provided through the workshop "Memorial del Taller: Determination of the leakage belt of a REDD+ project through a movility analysis of deforestation agents and Displacement Factor definition Leak - FDF"[7]. Specialists from AIDER's headquarters in Ucayali and Lima and the main actors conducted the workshop. They were able to identify and prioritize the spatial variables linked to deforestation and deterioration in the areas of the REDD+ project. They are detailed in order of relative importance to the deforestation process and to the mobility of the different agents of deforestation in the project's reference region.
Subsequently, each variable was assigned a range of mobility in meters per class ; in turn, each class was assigned a weight depending on the deforestation probability (for further information see Appendix B).
Finally, we conducted a spatial analysis with the Idrisi Software in order to define the Leakage belt areas. The various elements and steps are shown below :

- **Distance to the main road**
  Type of membership function defined by the user and based on the deforestation pattern between 2000 and 2010.

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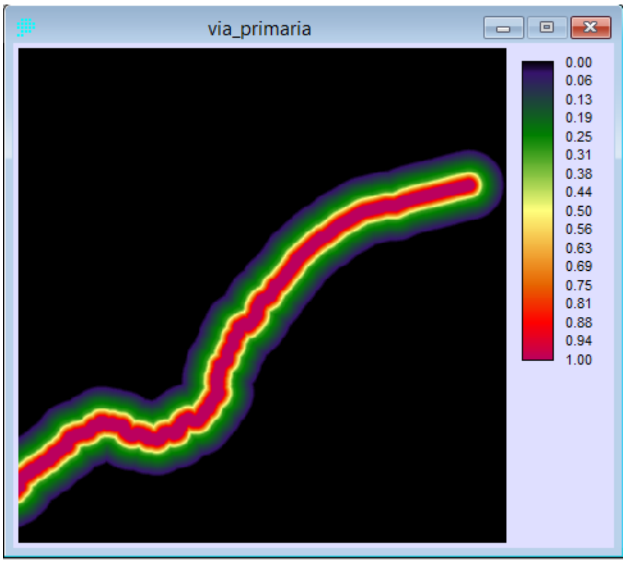
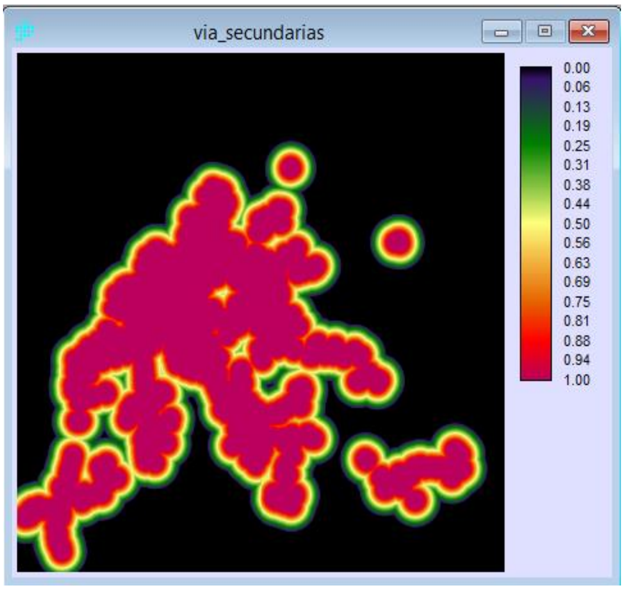
[7] Workshop's Memorial: Demarcation of REDD+ project's leakage belt through the Mobility Analysis of deforestation agents and determination of the FDF (Leakage Movement Factor)



Variable	Caminos principales
Valor (m)	**Peso asignado**
0-1000	1
1000-3000	0.3
3000-6000	0.1

Figure 5. Variables of primary roads

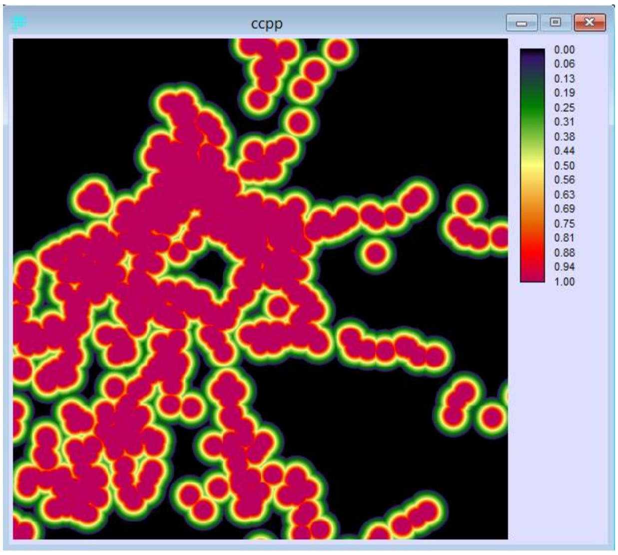
- **Distance to secondary roads**
  Membership function type defined by the user and based on the deforestation pattern between 2000 and 2010.



Variable	Caminos secundarios/terciarios
Valor (m)	**Peso asignado**
0-5000	1
5000-10000	0.5
10000-15000	0.1

Figure 6. Variables of secondary roads

- **Distance to populated centres**
  Membership function type defined by the user and based on the deforestation pattern between 2000 and 2010.



Variable	Centros Poblados
Valor (m)	**Peso asignado**
0-3000	1
3000-5000	0.5
5000-8000	0.05

Figure 7. Variables in urban centres

- **Distance to forest boundaries**
  We used the monotonically decreasing and lineary distributed function from 0 to 4km (4km is the maximum distance from the edge of the forest where it is possible to move a settler).

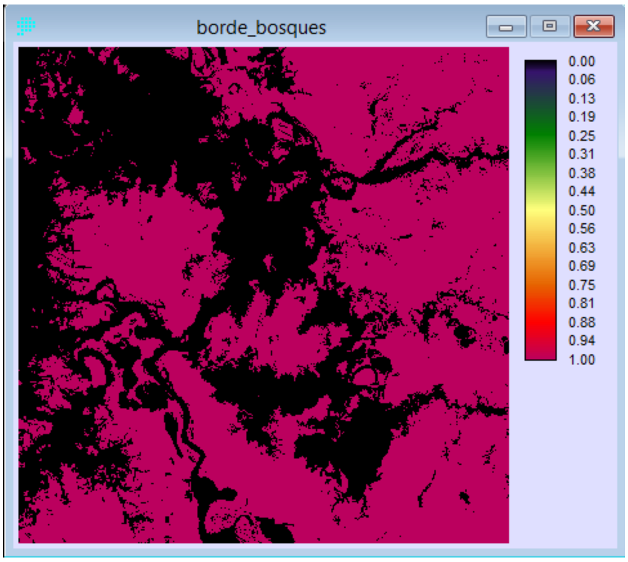


Figure 8. Distance to forest boundaries

- **Distance to project boundaries**
  We used a monotonically decreasing and lineary distributed function from 0 to 8km to the outside of the project area's boundaries.

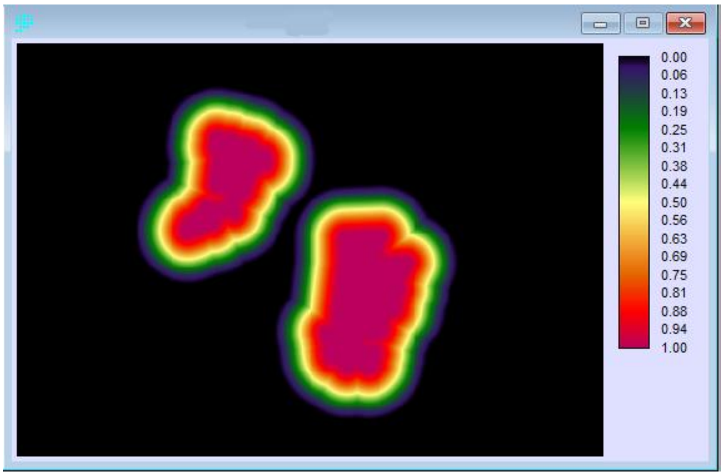
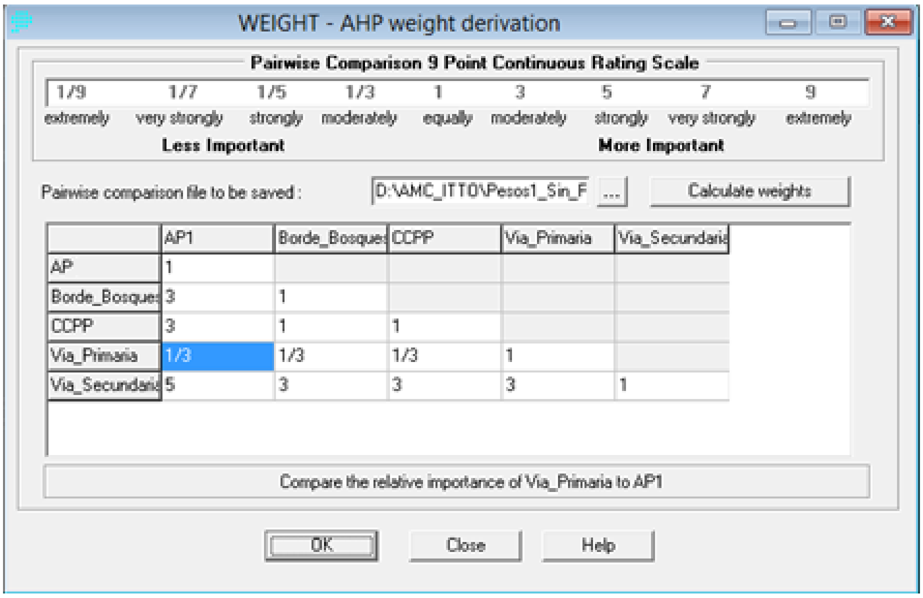


Figure 9. Distance to project boundaries

The subsequent step was to determine the relative importance of the maps' factors. The weights were defined in order to provide a series of comparisons of the relative importance of the factors to the suitability of pixels for the activity under evaluation.

According to this methodology is handled by scales, the scales vary from extremely less important (1/9) to extremely important (9/9), assigned to the factor that appears in the column on the row factor. The resulting weights were used as element for the analysis module of multi-criteria of the ArGis 9.3.1 software for the weighted linear combination.



WEIGHT - AHP weight derivation

Pairwise Comparison 9 Point Continuous Rating Scale

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely

Less Important — More Important

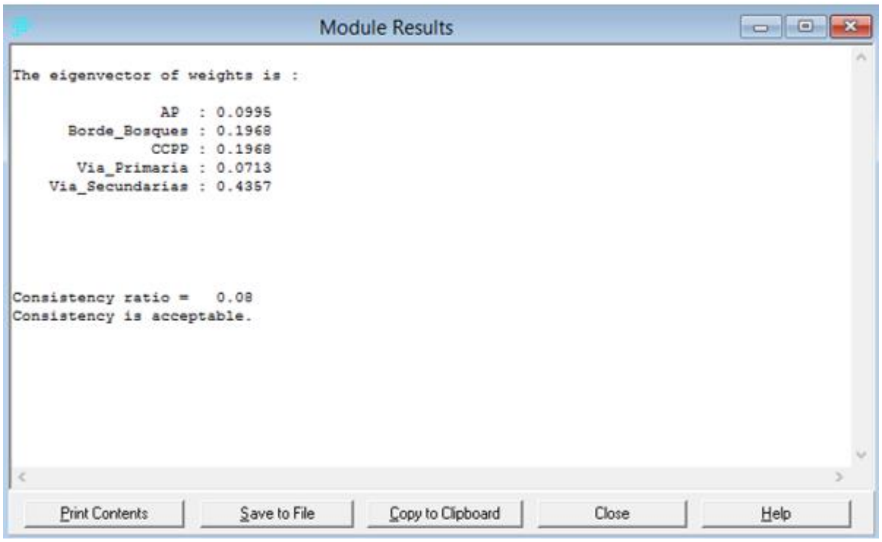
Pairwise comparison file to be saved : D:\AMC_ITTO\Pesos1_Sin_F

	AP1	Borde_Bosques	CCPP	Via_Primaria	Via_Secundaria
AP	1				
Borde_Bosques	3	1			
CCPP	3	1	1		
Via_Primaria	1/3	1/3	1/3	1	
Via_Secundaria	5	3	3	3	1

Compare the relative importance of Via_Primaria to AP1

Figure 10. WEIGHT – AHP weight derivation

Once the relative importance of each factor entered, we were able to get the weight with a consistency of ratio lower than 1.0 to be consistent and acceptable. The variable of navigable rivers was removed, because it was generating areas that were too far away from the project, and because it was a physical variable very irregular due to the constant movement of the river beds, due to the non-existent slope in the estudied area.



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The eigenvector of weights is :

               AP  : 0.0995
    Borde_Bosques : 0.1968
             CCPP : 0.1968
     Via_Primaria : 0.0713
  Via_Secundarias : 0.4357



Consistency ratio =   0.08
Consistency is acceptable.
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Figure 11. Results module

When the leakage belt was being developed, we registered an AFOLU project under the VCS module, which was masked in order to no conduct any kind of activity in this zone.

To define the size of the leakage belt was considered that this area must be adjacent or close to the area of the REDD+ project, thus, it was considered to make a buffer of 5 km to the project area and in this area of influence forest areas with the greatest potential for mobility agents of deforestation identified were selected, also, was taken into account that the extent of leakage belt should have a minimum area equal to the projected deforestation in the project area for the baseline (18 260.37 ha).

So that, the total area of leakage belt was defined in **54 837.9** he, this surface could absorb all the potential displacement of deforestation during the baseline period caused by the execution of the project.

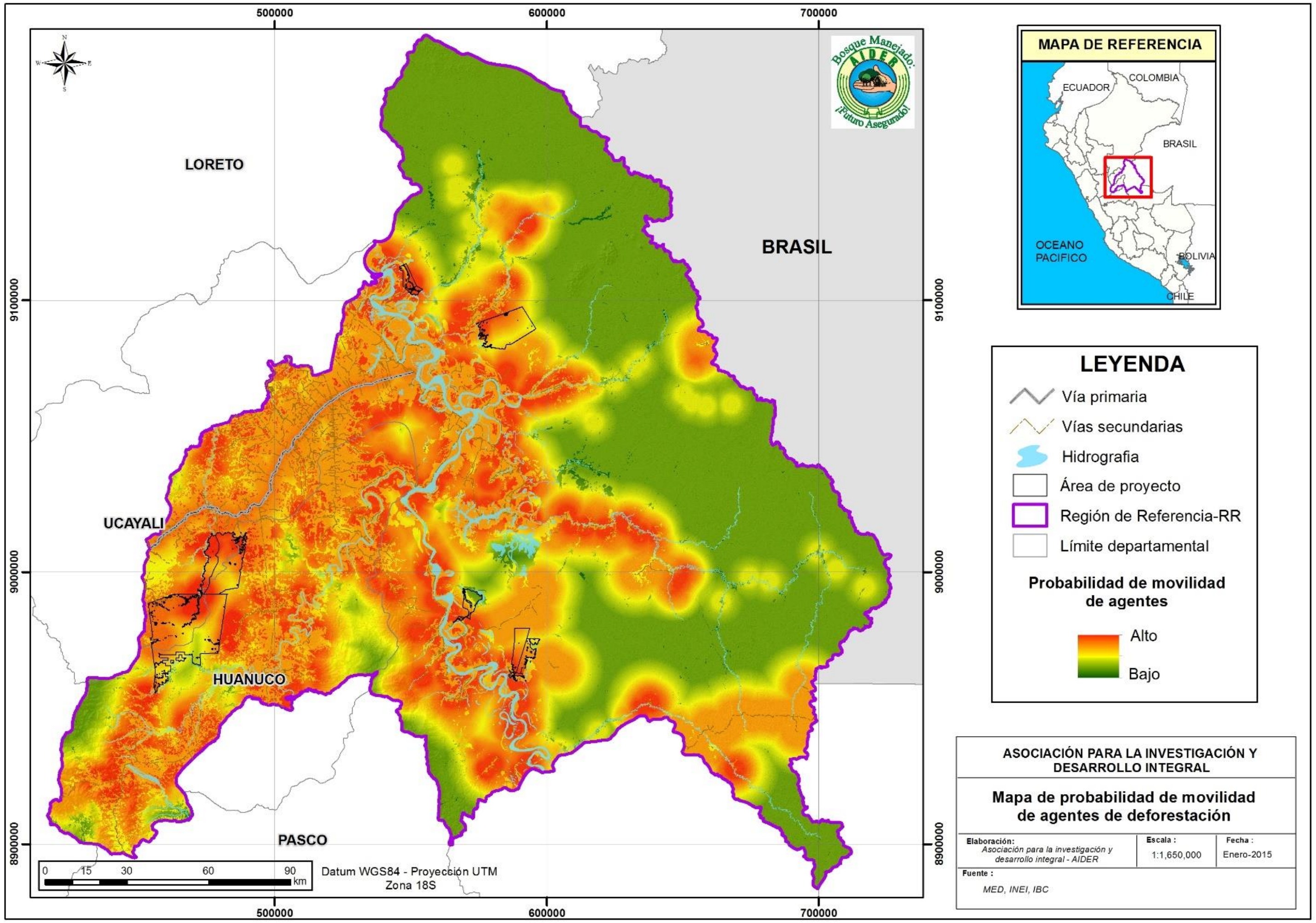

Figure 12. Leakage belt location map according to the mobility analysis

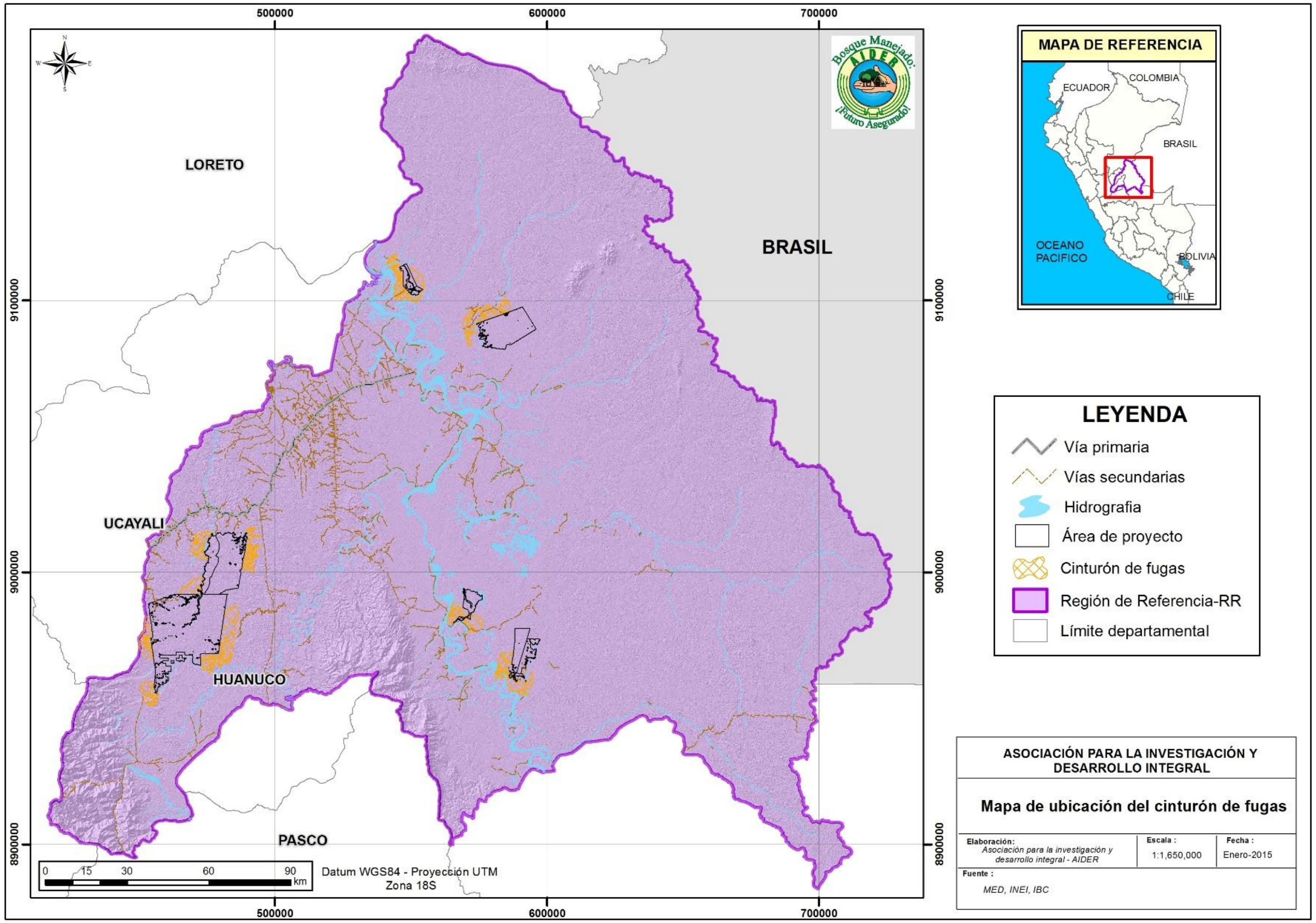

Figure 13. Leakage belt location map

1.1.4 Leakage management area

The leakage management areas include all the “non-forest“ lands inside and outside the boundaries of the project area, where all the activities will be made to minimize the risk of leakage. These areas were chosen according to the territorial management conducted by the native communities, following the REDD+ strategy and the mobility analysis’ criteria of agents and drivers to avoid leakages[8].

1.1.5 Forest

There exists no specific definition of forests in the Peruvian legislation. Although Article 3 of “Reglamento de la Ley Forestal y de Fauna“ includes some definitions of the natural, primary and secondary forests. However, those mainly describe subjective concepts, using broad terms and concepts, as « domain » and « ecosistem » and others, and do not specify the exact boundaries of the concepts for some sort of definition of Forest.In the MDL and CMNUCC frameworks, the definition of forests for Peru mentions taht is a minimum land area of 0.5 ha that must be covered in a minimum of 30% of tree tops and with trees of a minimum high of 5 meters at maturity. This definition of forest will be used here.

The deforestation reference scenario is based on a historical multi-temporal analysis. This analysis allowed us to obtain three maps of forest and “non-forest“ coverage. And always taking into consideration a minimum mapping unit (UMM) of 0.5 hectares. The images covered by clouds or shadows were excluded in order to filter all the coverages.

1.2 Temporal boundaries

1.2.1. Starting date and end date of the historical reference period

The historical reference period is from 2000 to 2010, for a total of 10 years.

1.2.2 Starting and end date of the project crediting period

The starting date and end date of the crediting period are : 01.07.2010 to 30.06.2030 – for a total of 20 years.

1.2.3 Starting date and end date of the first fixed baseline period

The fixed baseline period will be of ten years (starting on 01.07.2010 to 30.06.2020).

1.2.4 Monitoring period

The minimum monitoring period will be for one year, and it won’t exceed the fixed baseline period. The monitoring reports will be released on a yearly basis, depending on the project’s conditions.

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[8] DRP´document of native communities

1.3 Carbon pools

The pools located included in the boundaries of the project "Forest management to reduce deforestation and degradation in Shipibo Conino and Cacataibo indigenous communities in Ucayali region" are described in table 9.

Table 9. Carbon pools included or excluded within the boundary of the AUD project activities (see table 3 – GHG-VM0015 calculation of emissions)

Carbon pools	Included/TBD/Excluded	Justification/ Explanation of choice
Above-ground	Tree : included	This pool represents the major changes in carbon storage and is always significant.
Above-ground	Non-Tree : excluded	The carbon stock of this pool does not play a major role in the baseline because the forest conservation in the project area are for temporary crops, pasture grasses and young secondary forest, but no perennial crops.
Below-ground	Included	Recommended by the methodology, as it usually represents between 15% and 30% of the biomass above ground.
Dead wood	Excluded	We do not expect the carbon stock of this reservoir to be more important in the baseline in comparison with the project scenario. The exclusion is thus conservative and optional, according to the methodology.
Harvest wood products	Excluded	Timber harvesting will be limited, according to the project scenario. We conducted a historical analysis of the timber harvesting in the project area and applied the “A/R CDM tool“ in order to find out the significance of this reservoir (significance analysis). This analysis showed that this reservoir is not significant.
Litter	Excluded	Litter was not taken into account, as the last VCS AFOLU requirements (version 3.2) state that litter must only be measured if it is significant and it is optional to take it into consideration.
Soil Organic Carbon	Excluded	The baseline of the land-use in the project area forsees the conversion of forest to temporary crops. Therefore, in this case, the soil organic carbon will not be measured according to the VM0015 methodology Version 1.1

1.4 Sources of GHG emissions

The sources of GHG emissions included within the boundaries of the project "Forest management to reduce deforestation and degradation in Shipibo Conino and Cacataibo indigenous communities in Ucayali region" are specified in table 10.

Table 10. Sources and GHG included and exluded within the boundaries of the AUD project activities (see table 4 – GHG-VM0015 calculation of emissions)

Sources	Gas	Included/TBD/ Excluded	Justification/ Explanation of choice
Biomass burning	CO_2	Excluded	Change in the carbon stock already stored.
	CH_4	Excluded	The project activities aim at reducing the forest burning in order to lower the emissions of burned biomass. In the leakage belt areas, the agroforestry activities and the enrichment of the forest with further forest species will not create any further fires, as these trees will be planted in already cleared areas.
	N_2O	Excluded	Not a significant source.
Livestock emissions	CO_2	Excluded	Not a significant source.
	CH_4	Excluded	Not a significant source.
	N_2O	Excluded	Not a significant source.

Step 2 : Historical analysis of land-use and land-cover change

2.1 Collection of appropriate data source

We carried out a land-cover analysis of the reference region during the years 2000, 2005 and 2010, using satellite images with medium resolution and validating information generated with high-resolution images and field points. Table 11 shows the data source used in the analysis.

Table 11. Data used for historical LU/LC change analysis (see table 5 – GHG-VM0015 calculation of emissions)

Vector (Satellite or airplane)	**Sensor**	**Resolution**		**Coverage**	**Acquisition date**	**Scene or point identified**	
		Spatial	Spectral	(km^2)	(DD/MM/YY)	Path / Latitud	Row / Longitud
Landsat 5	TM	30m	0.45 - 12.5 µm	185 x 172 km	02-sep-00	5	66
Landsat 5	TM	30m	0.45 - 12.5 µm	186 x 172 km	14-jul-05	5	66
Landsat 5	TM	30m	0.45 - 12.5 µm	187 x 172 km	28-jul-10	5	66
Landsat 5	TM	30m	0.45 - 12.5 µm	188 x 172 km	02-sep-00	5	67
Landsat 5	TM	30m	0.45 - 12.5 µm	189 x 172 km	30-jul-05	5	67
Landsat 5	TM	30m	0.45 - 12.5 µm	190 x 172 km	28-jul-10	5	67
Landsat 5	TM	30m	0.45 - 12.5 µm	191 x 172 km	09-sep-00	6	65
Landsat 5	TM	30m	0.45 - 12.5 µm	192 x 172 km	3-Aug-04	6	65
Landsat 5	TM	30m	0.45 - 12.5 µm	193 x 172 km	16-may-10	6	65
Landsat 5	TM	30m	0.45 - 12.5 µm	194 x 172 km	01-sep-00	6	66
Landsat 5	TM	30m	0.45 - 12.5 µm	195 x 172 km	3-Aug-04	6	66
Landsat 5	TM	30m	0.45 - 12.5 µm	196 x 172 km	16-may-10	6	66
Landsat 5	TM	30m	0.45 - 12.5 µm	197 x 172 km	16-Aug-00	6	67
Landsat 5	TM	30m	0.45 - 12.5 µm	198 x 172 km	9-Aug-04	6	67
Landsat 5	TM	30m	0.45 - 12.5 µm	199 x 172 km	20-Aug-10	6	67
Landsat 5	TM	30m	0.45 - 12.5 µm	200 x 172 km	26-Aug-00	7	66
Landsat 5	TM	30m	0.45 - 12.5 µm	201 x 172 km	28-may-06	7	66
Landsat 5	TM	30m	0.45 - 12.5 µm	202 x 172 km	11-Aug-10	7	66
Landsat 5	TM	30m	0.45 - 12.5 µm	203 x 172 km	2-Aug-01	7	67
Landsat 5	TM	30m	0.45 - 12.5 µm	204 x 172 km	12-jul-05	7	67
Landsat 5	TM	30m	0.45 - 12.5 µm	205 x 172 km	11-Aug-10	7	67
Bing	Sincronized images	----	-----	Transepts	2009-2012	Selection Available	Selection Available

2.2 Definition of classes of land-use and land-cover

There exists no specific definition of forests in the Peruvian legislation. Although Article 3 of “Reglamento de la Ley Forestal y de Fauna“ includes some definitions of the natural, primary and secondary forests. However, those mainly describe subjective concepts, using broad terms and concepts, as « domain » and « ecosistem » and others, and do not specify the exact boundaries of the concepts for some sort of definition of Forest. In the CDM[9] and CMNUCC frameworks, the definition of forests for Peru mentions taht is a minimum land area of 0.5 ha that must be covered in a minimum of 30% of tree tops and with trees of a minimum high of 5 meters at maturity. This definition of forest will be used here.

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[9] Forest and carbon market, potential of forestry CMD in Andean communities.

The defined classes are applied with the conservative criteria of satellite images analysis in order to determine the loss of forest from period to period.
During the Seventh Conference of the Parties (COP 7) of the United Nations Framework Convention on Climate Change, the decision 11/CP7 "Land-use, land-use change and Forestry" (LULUCF)[10] was approved. This approves preliminarily the principles, definition, modalities and processes for the different activities linked to this topic. The document offers the following definition of forests :

"Forest" is a minimum area of land of 0.05-1.0 hectares (he) with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ. A forest may consist either of closed forest formations, where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily un-stocked as a result of human intervention (such as harvesting) or natural causes but which are expected to revert to forest.

The experts in remote perception state that the process of classification of medium resolution images is a reasonable method for the classification and quantification of forest coverage areas and for their continuous monitoring.

The validation process was conducted with images of high resolution provided by the package of the ArcGis[11] Software of Ersi, which allows to access a gallery of images (Basemap – Imagery) of high resolution between the years 2009 and 2011.

All the classes of land-use and of territorial coverage existing at the project's starting date within the reference region are presented in table 12, as well as the classes of forests defined in Step 1.1.1. As Forests/Classes of vegetation.

Table 12 List of all classes of land-use and land-cover existing at the project's starting date in the reference region (see table 6 – GHG-VM0015 calculation of emissions spreadsheet)

Identificador de clase		Trend in carbon stock	Presence in	Activities in the baseline case			Description
ID_{cl}	Name			LG	FW	CP	
1	Riverbank complex forest	Constant	PA, RR, LK	n	n	n	Riverbank complex forests mainly encompass riparian forests located in soils of young formation that are generated by sediments left by the changing course of the rivers (GOREU, 2013).
2	Low terrace forest	Constant	PA, RR, LK	y	n	n	Forest located in recent fluvial formation soils, with a 0-4% slope and with flooding periods (MINAM, 2009).

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[10] FONAM. 2006. Final Proposal for a Peruvian definition of forests to be used in projects using land-use change and forestry under the kyoto protocol during the first commitment period.

[11] http://www.esri.com/software/arcgis

3	Medium terrace forest	Constant	PA, RR, LK	y	n	n	Forest located in soils formed by subrecent accumulation, with a 0-4% slope. These might be floodable areas or not. This type of forest grows better than the one of the low terraces, with dominant trees of more than 1m diameter and 35m height. (MINAM, 2009).
4	High terrace Forest	Constant	PA, RR, LK	y	n	n	Forest located in soils of old fluvial accumulation, with a 4-15% slope. Similarly to the medium terrace forests, this type of forest grow easily (MINAM, 2009).
5	Knoll forest	Constant	PA, RR, LK	y	n	n	This kind of forest is located in soils of old fluvial accumulation and with a 15-25% slope. It encompasses an important diversity of forest species and possesses a good timber potential (MINAM, 2009).
6	Low hill forest	Constant	PA, RR, LK	y	n	n	This type of forest is located in lands with a topographic elevation of up to 80 meters from its basis, and with a 8-15% slope (MINAM, 2009).
7	Average hill forest	Constant	PA, RR, LK	y	n	n	Forests located between 80 and 150 meters of topographic elevation from its basis, and with a 15-25% slope (GOREU, 2013).
8	High hill forest	Constant	RR, LK	n	n	n	Forests located between 150 and 300 meters of topographic elevation, with a 15-50% slope (Martínez, 2010).
9	Low mountain forest	Constant	RR, LK	n	n	n	Forests located between 300-800 meters of topographic elevation (measured from its basis to its top), with a slope of up to 50%.
10	High mountain forest	Constant	RR, LK	n	n	n	This kind of forest is located in zones with a slope bigger than 50% and with a 800 meters of topographic elevation. In this type of forest one can find tree canopies with large and dense tops and that reach 25 meters, straight and circular shafts that can reach up to 80 cm of DAP in the lower parts, with deformed branches, with small to medium crowns, and with superficial roots in the high parts of the mountains (Martínez, 2010).
11	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n	This includes secondary forests, pastures, burned areas and areas of agricultural crops.
12	Bare soil	Constant	RR, LM	n	n	n	Encompasses alluvial mining, sandy areas and urban areas.

2.3 Definition of categories of land-use and land-cover change

The analysis conducted to identify the different types of land-use and land-cover in the project reference region allowed us to identify twelve types of land-cover and land-uses (ten of them correspond to different types of forest : riverbank system, low terrace, medium terrace, high terrace, knoll, low hill, medium hill, high hill, low mountain, high mountain (initial coverage), “non-forest“ vegetation, and bare soil (final coverage)).
In this sense, we gained twenty possible combinations for the land-use and land-cover changes. These combinations are detailed in tables 13.a and 13b.

Table 13.a. Potential land-use and land-cover change matrix (see table 7.a. – GHG-VM0015 calculation of emissions spreadsheet)

ID_{cl}		**Initial LU/LC class**									
		Riverbank complex forest	*Low terrace forest*	*Medium terrace forest*	*High terrace forest*	*Knoll forest*	*Low hill forest*	*Medium hill forest*	*High hill forest*	*Low mountain forest*	*High mountain forest*
Final LU/LC class	*“Non-forest“ vegetation*	I1/F1	I2/F1	I3/F1	I4/F1	I5/F1	I6/F1	I7/F1	I8/F1	I9/F1	I10/F1
	Bare soil	I1/F2	I2/F2	I3/F2	I4/F2	I5/F2	I6/F2	I7/F2	I8/F2	I9/F2	I10/F2

Table 13.b. List of land-use and land-cover change categories (see table 7.b. – GHG-VM0015 calculation of emissions spreadsheet)

ID_{ct}	Name	Trend in carbon stock	Presence in	Activities in the baseline case			Name	Trend in carbon stock	Presence in	Activities in the project case		
				LG	FW	CP				LG	FW	CP
I1/F1	Riverbank complex forest	constant	PA, RR, LK	n	n	n	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n
I1/F2	Riverbank complex forest	Constant	PA, RR, LK	n	n	n	Bare soil	Constant	RR, LM	n	n	n
I2/F1	Low terrace forest	Constant	PA, RR, LK	y	n	n	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n
I2/F2	Low terrace forest	Constant	PA, RR, LK	y	n	n	Bare soil	Constant	RR, LM	n	n	n
I3/F1	Medium terrace forest	Constant	PA, RR, LK	y	n	n	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n
I3/F2	Medium terrace forest	Constant	PA, RR, LK	y	n	n	Bare soil	Constant	RR, LM	n	n	n
I4/F1	High terrace forest	Constant	PA, RR, LK	y	n	n	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n
I4/F2	High terrace forest	Constant	PA, RR, LK	y	n	n	Bare soil	constant	RR, LM	n	n	n
I5/F1	Knoll forest	Constant	PA, RR, LK	y	n	n	“Non-forest“ vegetation	Decreasing	RR, LM	n	n	n
I5/F2	Knoll forest	Constant	PA, RR, LK	y	n	n	Bare soil	constant	RR, LM	n	n	n

I6/F1	Low hill forest	Constant	PA, RR, LK	y	n	n	"Non-forest" vegetation	Decreasing	RR, LM	n	n	n
I6/F2	Low hill forest	Constant	PA, RR, LK	y	n	n	Bare soil	Constant	RR, LM	n	n	n
I7/F1	Average hill forest	Constant	PA, RR, LK	y	n	n	"Non-forest" vegetation	Decreasing	RR, LM	n	n	n
I7/F2	Average hill forest	Constant	PA, RR, LK	y	n	n	Bare soil	Constant	RR, LM	n	n	n
I8/F1	High hill forest	Constant	RR, LK	n	n	n	"Non-forest" vegetation	Decreasing	RR, LM	n	n	n
I8/F2	High hill forest	Constant	RR, LK	n	n	n	Bare soil	Constant	RR, LM	n	n	n
I9/F1	Low mountain forest	Constant	RR, LK	n	n	n	"Non-forest" vegetation	Decreasing	RR, LM	n	n	n
I9/F2	Low mountain forest	Constant	RR, LK	n	n	n	Bare soil	Constant	RR, LM	n	n	n
I10/F1	High mountain forest	Constant	RR, LK	n	n	n	"Non-forest" vegetation	Decreasing	RR, LM	n	n	n
I10/F2	High mountain forest	Constant	RR, LK	n	n	n	Bare soil	Constant	RR, LM	n	n	n

2.4 Historical analysis of land-use and land-cover changes

The historical analysis of land-use and land-cover changes was conducted through the use and interpretation of Landsat 5TM satellite images, from this analysis qualitative and quantitative information was generated in the types of use and land cover. The historical analysis was conducted for the years 2000, 2005 and 2010.

Moreover, we measured the change in the forest cover in the period 2000-2005 and 2005-2010. From this analysis we have that, during the 2000-2005 period there was a loss of 0.7% in the forest cover, and of 1.05% in the period 2005-2010. This loss can be interpreted as the change from forest cover to a "non-forest" state ("non-forest" vegetation and bare soil). In order to offer a better understanding of the identified changes in the forest cover as shown in table 14, we will present the different types of forest cover and the analysed time periods, as well as the change in surface and percentages.

Table 14. Forest cover and forest loss in the reference region during the reference period 2000-2005-2010

DESCRIPTION	**Reference period**			**Changeover period**			**% Changeover period**		
	2000	**2005**	**2010**	**2000 - 2005 ha/year**	**2005 - 2010 ha/year**	**2000 - 2010 ha/year**	**2000 - 2005 %/year**	**2005 - 2010 %/year**	**2000 - 2010 %/year**
Riverbank complex forest	183,072.6	166,432.7	161,442.7	3,328.0	998.0	2,163.0	1.8	0.6	1.2
Low terrace forest	387,946.9	368,936.7	359,637.6	3,802.0	1,859.8	2,830.9	1.0	0.5	0.7
Medium terrace forest	857,784.8	843,965.9	824,997.0	2,763.8	3,793.8	3,278.8	0.3	0.4	0.4
High terrace forest	941,192.4	919,846.5	875,915.2	4,269.2	8,786.3	6,527.7	0.5	1.0	0.7

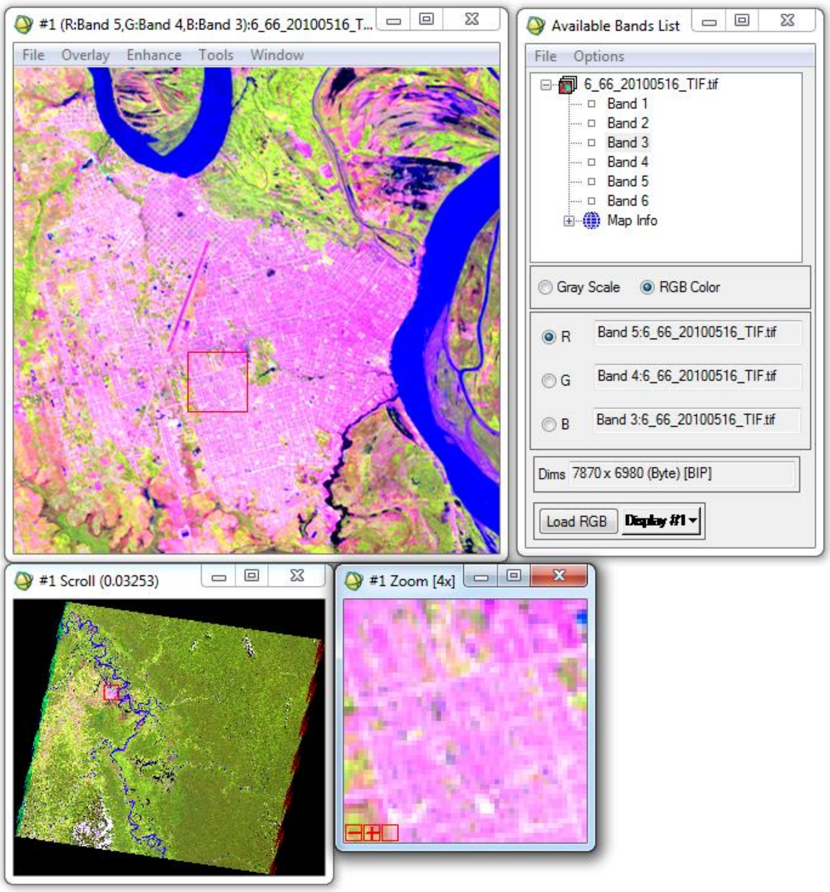
Knoll forest	177,654.8	176,421.6	169,294.5	246.6	1,425.4	836.0	0.1	0.8	0.5
Low hill forest	977,365.1	956,677.1	907,412.9	4,137.6	9,852.9	6,995.2	0.4	1.0	0.7
Average hill forest	124,151.5	116,804.3	98,324.3	1,469.4	3,696.0	2,582.7	1.2	3.2	2.1
High hill forest	23,403.0	22,042.3	20,951.9	272.1	218.1	245.1	1.2	1.0	1.0
Low mountain forest	251,065.8	248,441.8	242,221.0	524.8	1,244.2	884.5	0.2	0.5	0.4
High mountain forest	62,174.6	61,069.9	56,515.7	220.9	910.8	565.9	0.4	1.5	0.9
Total	**3,985,811.4**	**3,880,638.7**	**3,716,712.9**	**2,103.5**	**3,278.5**	**2,691.0**	**0.7**	**1.0**	**0.9**

2.4.1 Pre-processing

Part of preparing the images that would be used in the classification process, was conducted processes such as the bands' compositions and geometric correction. This was part of the pro-processing:

a) Bands' composition

Landsat 5TM satellite images encompass seven bands. When we downloaded the desired server, these bands appeared to be separated as independent files. We therefore needed to merge them in order to have the correct band composition of the image we would use (band 6 was excluded). The bands' composition was made through Envi Software (Figure 14).


#1 (R:Band 5,G:Band 4,B:Band 3):6_66_20100516_T...

Available Bands List

6_66_20100516_TIF.tif
- Band 1
- Band 2
- Band 3
- Band 4
- Band 5
- Band 6
- Map Info

○ Gray Scale ● RGB Color

● R Band 5:6_66_20100516_TIF.tif

○ G Band 4:6_66_20100516_TIF.tif

○ B Band 3:6_66_20100516_TIF.tif

Dims 7870 x 6980 (Byte) [BIP]

#1 Scroll (0.03253)

#1 Zoom [4x]

Figure 14. Bands' composition

b) Geometric correction

The geometric correction process transforms the images in order to clear undesirables geometric distortions coming from the sensor. This was done through the ortorectification process.

- DEM; this is a digital elevation model of the area of study with a 30 meters resolution, SRTM.
- Control points; 5 to 15 control points were chosen, as minimum for each Path Row with a maximum root mean squared error (RMSE) of one pixel per image.
- Transformation matrix; for this study we used the polynomial of grade one.
- Pixel sampling; in this case, we used the Nearest Neighboor method, as it transfers the original values without conducting an average and keeps the original radiometry.

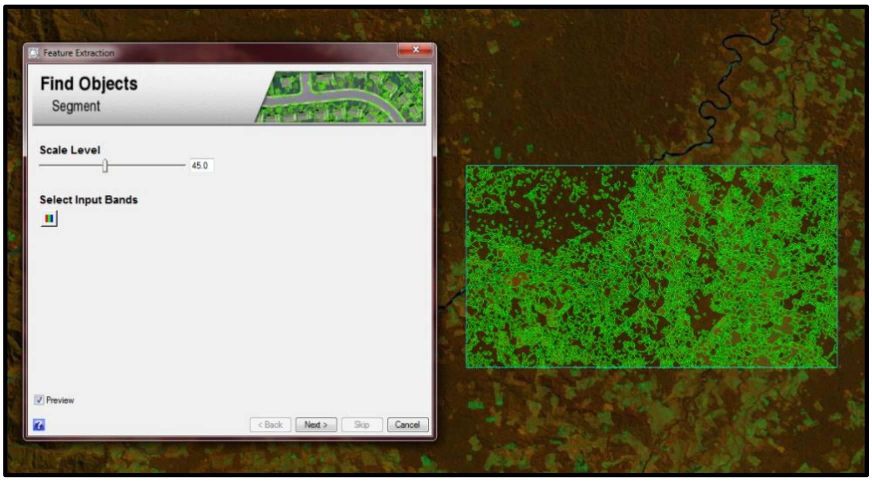
2.4.2 Interpretation and classification

At this stage, we checked similar studies, which allowed us to create a methodological framework for the development of the coverage and land-use classification and for the denomination of covery classes and land use designation used in document IPCC guidelines for inventory of greenhouse gases was revised. (IPCC, 2006). The legend allowed the naming of the classes of land-coverage and land-use that could be identified in the reference region area.

The Random Forest methodology on segments is based on a supervised classification of the segments incorporating additional information available for the image. In this sense, the information processing requires the creation of three different ranges of data : (1) segments ; (2) training areas ; (3) database with complementary information. The whole processing is based on the revision of the ortorrectified images (Arnillas, C.A; et al. 2012).

The development of the methodology used for the classification is outlined below :

- **Segmentation**: The process consisted in generating segments that could isolate some elements in order to create an image. This was implemented through the use of the Envi Ex Software (mode of proof). The parameters that define the segmentation grade of an image are: scale and merge. The values given to scale and merge will depend on the elements contained in the parcel to segment (this segmentation aiming at separating those elements).



Feature Extraction

Find Objects

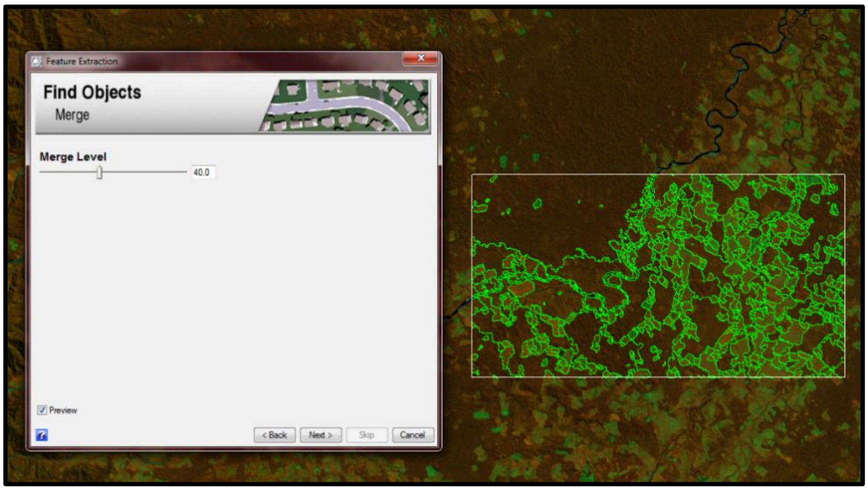
Segment

Scale Level 45.0

Select Input Bands

☑ Preview

Figure 15. Defining Scale's value



Feature Extraction

Find Objects

Merge

Merge Level 40.0

☑ Preview

Figure 16. Defining Merge's value

The elements used at this stage are : the image to segment and the DEM corresponding to the image to segment. As a result, we obtained a segmentation shapefile for every analysed scene.

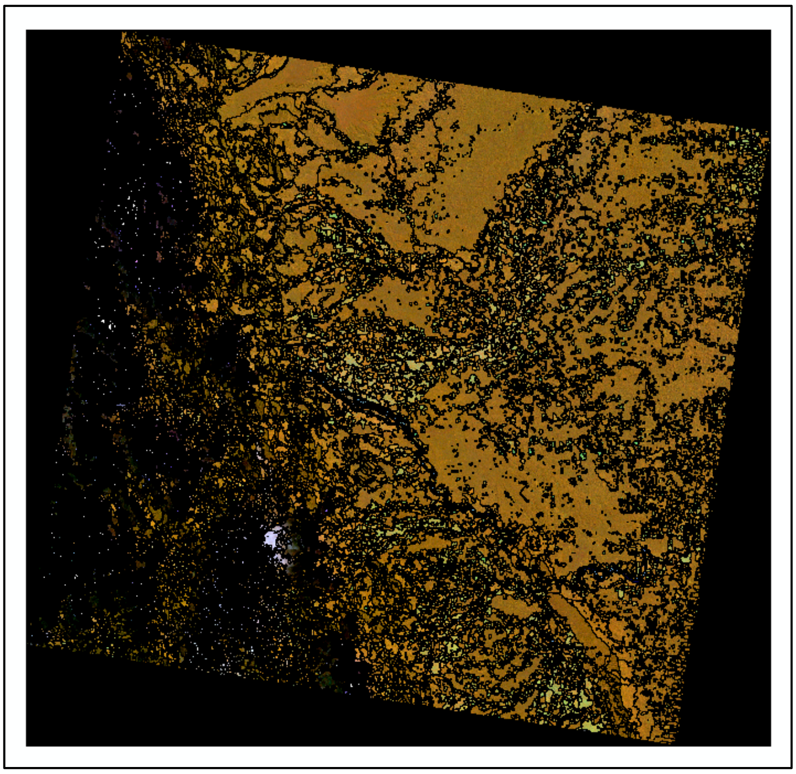


Figure 17. Path-row segmentation 7_67 (scale :45 and merge : 40)

- Training areas: The demarcation of the training areas in the area to classify is one of the most important processes, as these areas define the units that generate the classification of the vegetation coverage and land-use.

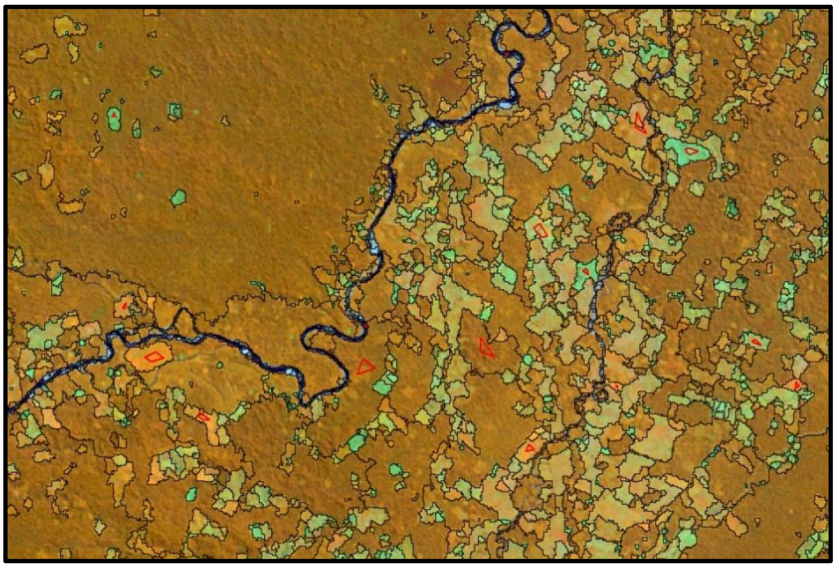


Figure 18. Demarcation of the training areas

- Complementary information: The collection of complementary information is part of the methodology used and allows the classification process. The following table shows the different elements, processes and complementary information generated.

Table 15. Complementary information generated

Elements	Process	Complementary information generated
5TM Landsat Image	Tasselep Cap	- bright - green - third o wet
DEM (original)	Resample	- dem (30 x 30 m)
dem	Slope del ArcToolbox	- slope
dem	Curvature del ArcToolbox	- plancurv - procurv
Final segmentation (shp)	Polygon to raster	- seg

Source : Own elaboration, 2014

- Classification: This process was conducted with the software R, whose information was prepared beforehand: training areas combined with the segmentation and the complementary information.
- Forest classification: The forest classification was carried out through a physiographic criterion. To that end, we used the shapefile of physiography corresponding to the reference region. As a result of the merging of forest and physiographic cover, we obtained the classification of the forest coverage.

2.4.3. Post-processing

The post-classification was performed using tools of Geographic Information Systems (GIS), in order to perform the edition of the layers obtained and the bonding thereof. At this stage we proceeded to discriminate areas below the defined minimum mapping unit (1 ha).

As a product of this step we have the following maps: forest and non-forest map, Land use and land cover map and Deforestation map.

- Forest and non-forest map:

Maps of forest and non-forest were made for 2000; 2005 and 2010.

Table 16. Forest and non-forest surface for the historical period in the reference region

Description	Surface (he)		
	2000	2005	2010
Body of water	96,821.92	96,821.92	96,821.92
Non-forest	653,016.07	758,188.78	922,114.58

Forest	3,985,811.38	3,880,638.66	3,716,712.86
Total	4,735,649.36	4,735,649.36	4,735,649.36

Source: Own elaboration, 2014

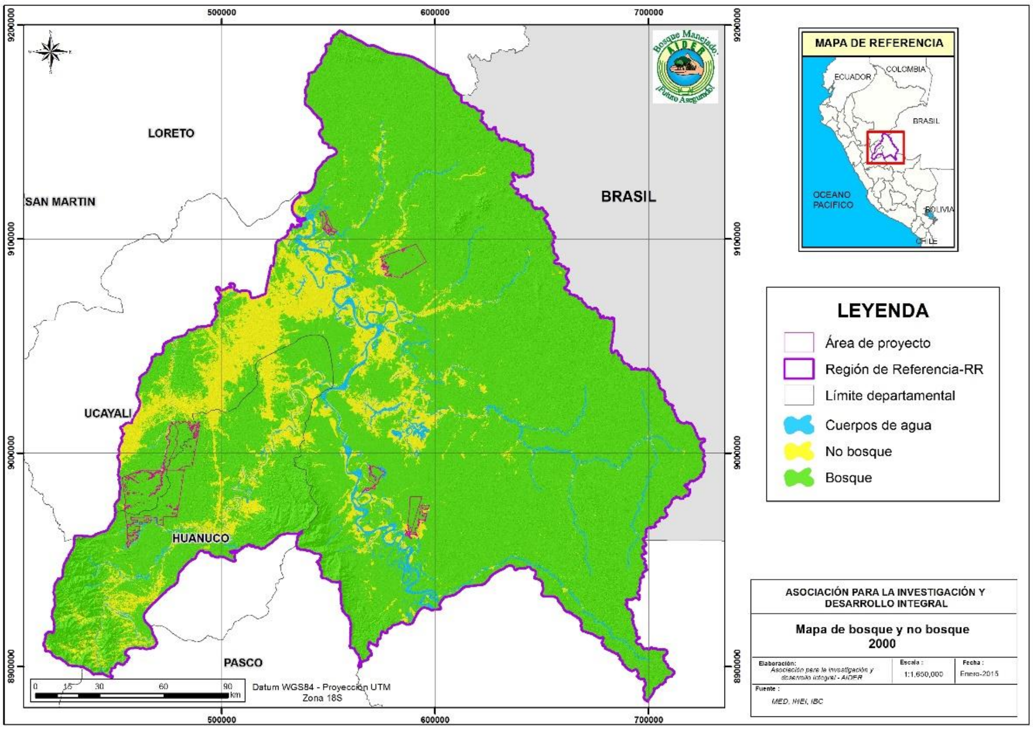


Figure 19. Forest and non-forest map, 2000

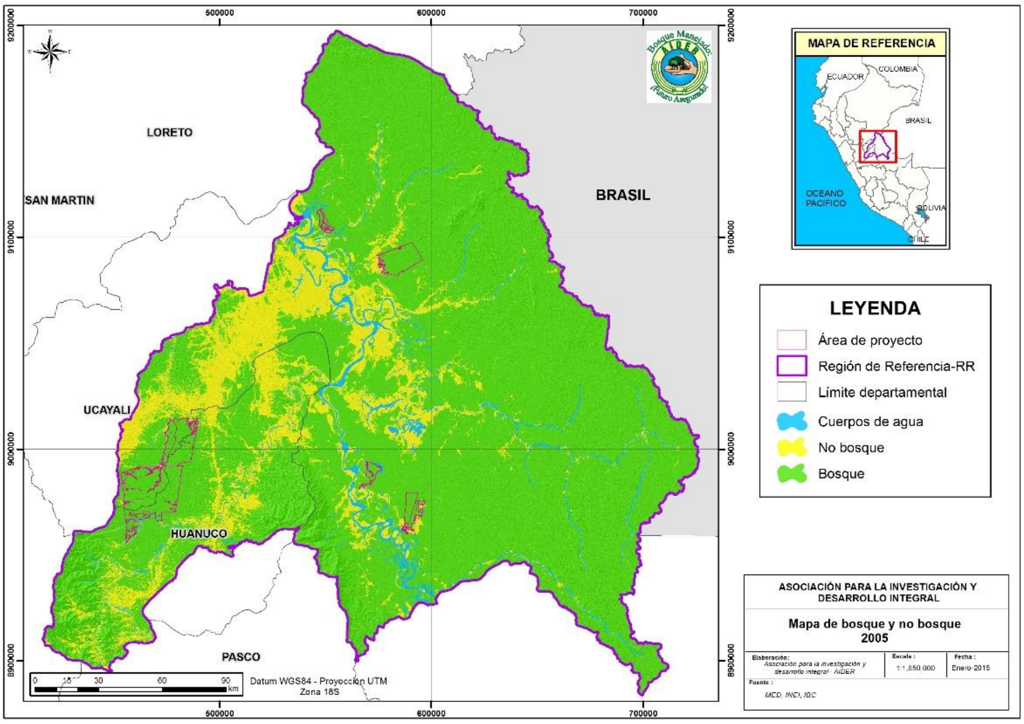


Figure 20. Forest and non-forest map, 2005

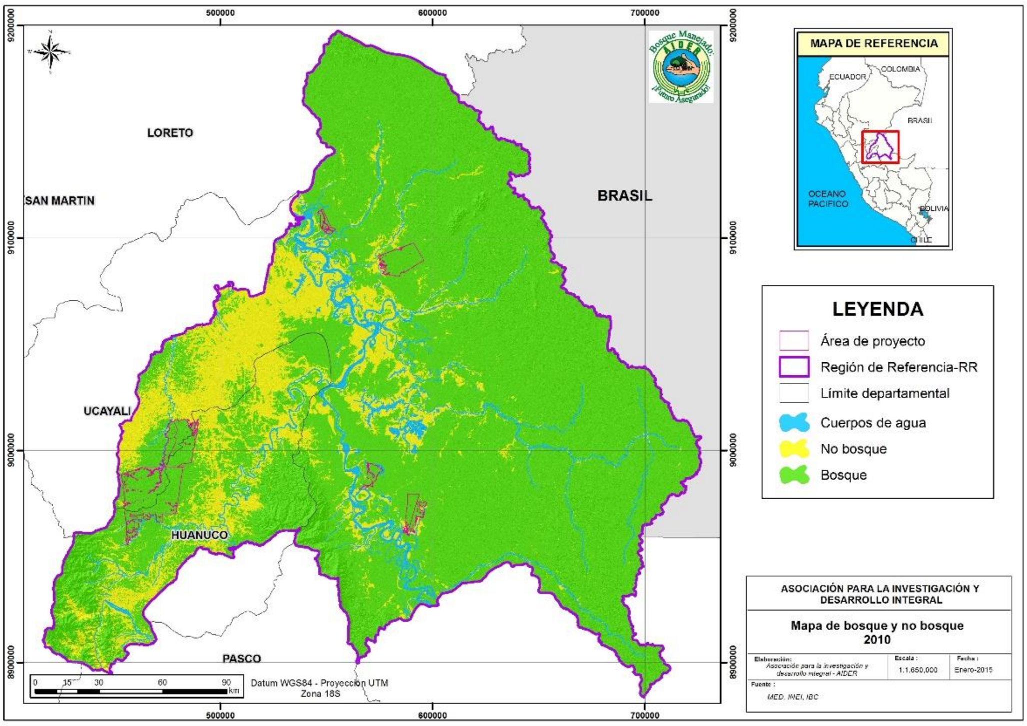


Figure 21. Forest and non-forest map, 2010

- Land use and land cover map:

With the development of the methodology was identified coverages and land use for the reference region. Taking as main cover and use: bare soil, non-forest vegetation and forest.

Bare soil, mostly comprise areas without vegetation, also covers areas with presence of urban infrastructure. For this classification this category includes: urbanized areas, areas with ravages caused by alluvial mining and soils that at the time of the interpretation of the images were classified as bare soils.

Non-forest vegetation, comprises all those lands with tree crown cover of more than 30% area, at a minimum area of 0.5 he and a minimum tree height of 5 m that reaches maturity in situ (UNFCCC[12]). While the height of the trees is an imperceptible feature by satellite images, features such as the shape of the treetops in order to infer their origin is used. The classification of forest types was performed by physiographic criteria, thus having the following types of forests in the region of reference of the project: Complex riverbank forest, low terrace forest, medium terrace forest, high terrace forest, knoll forest, low hill forest, medium hill forest, high hill forest, low mountain forest, high mountain forest.

Table 17. Coverage and land use in the reference region – 2000, 2005 and 2010

Type of coverage and lad use	Surface (he)		
	2000	2005	2010
High hill forest	23,402.95	22,042.26	20,951.88
Low hill forest	977,365.13	956,677.13	907,412.87

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[12] http://cdm.unfccc.int/DNA/index.html

Average hill forest	124,151.48	116,804.26	98,324.29
Knoll forest	177,654.81	176,421.60	169,294.52
High mountain forest	62,174.60	61,069.88	56,515.71
Low mountain forest	251,065.77	248,441.77	242,221.01
High terrace forest	941,192.42	919,846.50	875,915.22
Low terrace forest	387,946.85	368,936.72	359,637.65
Medium terrace forest	857,784.80	843,965.87	824,997.05
Riverbank complex forest	183,072.55	166,432.66	161,442.66
Body of water	96,821.92	96,821.92	96,821.92
Bare soil	16,825.63	17,657.54	21,752.88
Non-forest vegetation	636,190.43	740,531.24	900,361.71
Total	**4,735,649.36**	**4,735,649.36**	**4,735,649.36**

Source: Own elaboration, 2014

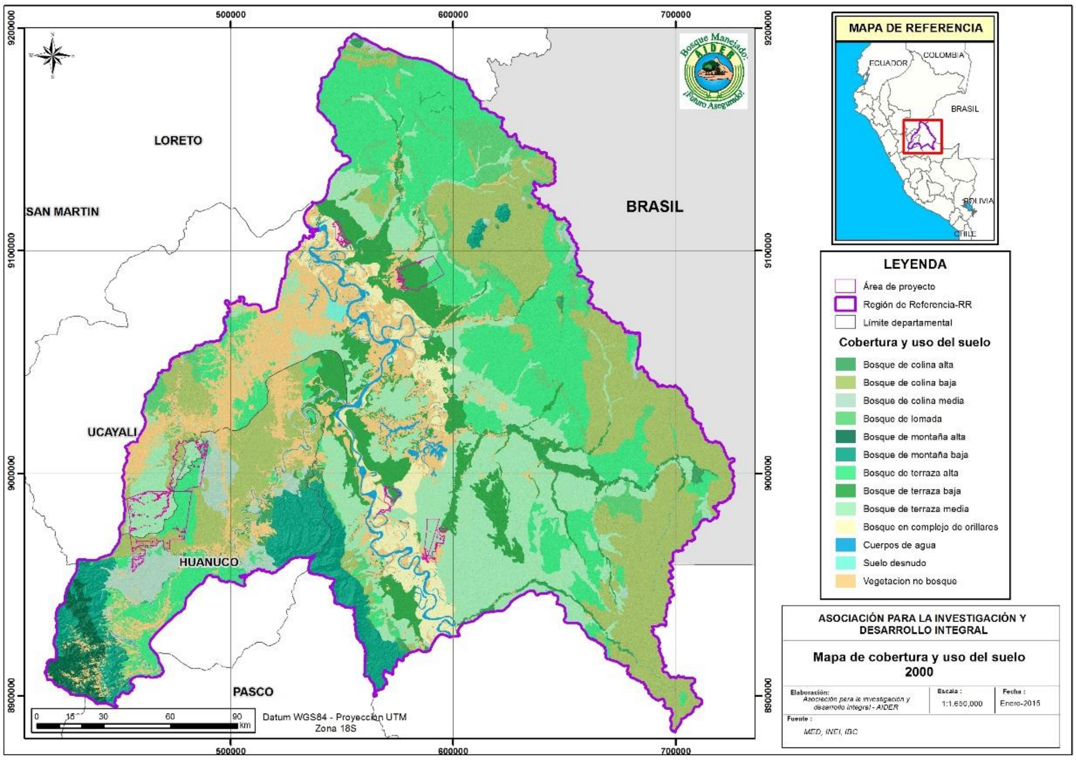

Figure 22. Coverage and land use map in the reference region - 2000

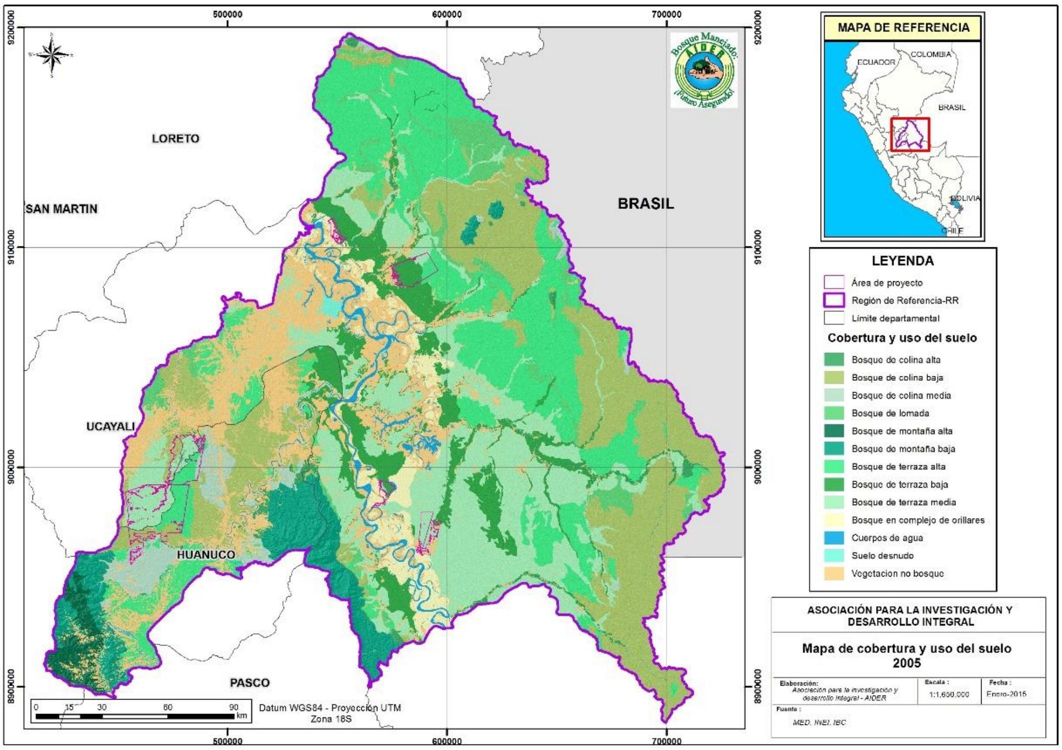

Figure 23. Coverage and land use map in the reference region - 2005

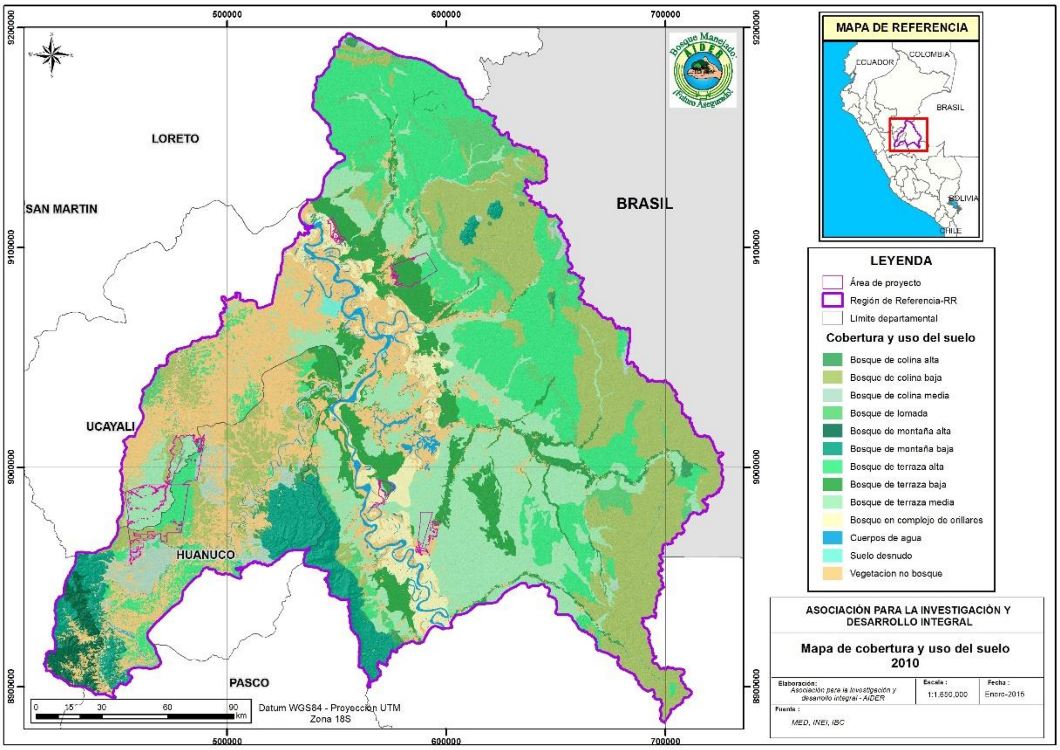

Figure 24. Coverage and land use map in the reference region - 2010

- Deforestation map:

Deforestation map were made considering the forest and non-forest maps of the years from the historical period 2000, 2005 and 2010.

Table 18. Deforestation in the reference region

Description	Period	
	2000-2005	2005-2010
Deforestation (he)	105,172.71	163,925.80

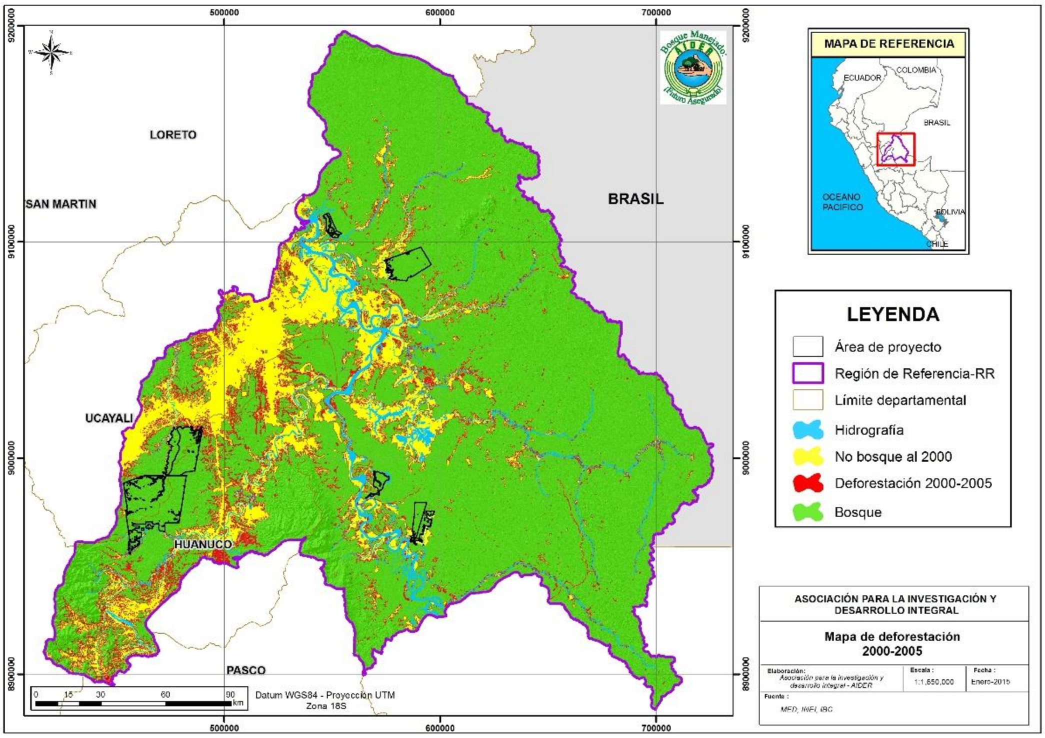

Figure 25. Deforestation map 2000 – 2005

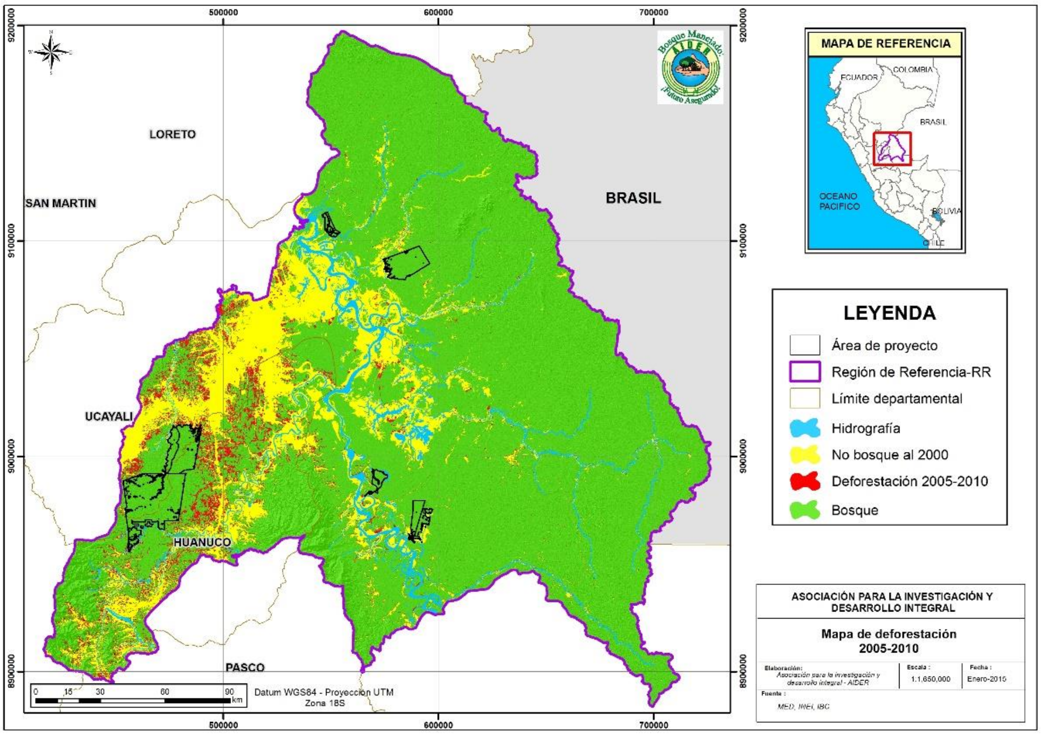

Figure 26. Deforestation map 2005 - 2010

2.5 Map accuracy assessment

a. Classification's accuracy:

Part of the methodology is to assess the quality of the classification, a process that we conducted through some unit of measure (Correctly classified percentage and Kappa index). The values that must exceed these indicators are : for PCC > 80% and for Kappa index[13] > 0.75. These values are given for each classified path-row.

For the classification of land-cover and land-use in the reference region, we obtained PCC values and Kappa index given by the Software R. Those are detailed in table 19.

Table 19. Indicator of classification quality

Path-row	% Correctly classified (PCC)	Kappa index
5_66	91.6	0.85
5_67	96.7	0.88
6_65	98.5	0.97
6_66	96.9	0.96
6_67	99.7	0.99
7_66	96.0	0.94

---

[13] Kappa index, this index relates the exhibit observers agree that, beyond due to chance, with the potential well beyond chance agreement. (http://dxsp.sergas.es/ApliEdatos/Epidat/Ayuda/5-Ayuda%20Concordancia%20y%20Consistencia.pdf)

7_67	97.1	0.94

Source : Own elaboration, 2014

b. Land-cover and land-use map precision LU/LC

The assessment of the land-cover and land-use map was conducted through the verification or comparison of the results obtained on the ground. In this case, we used the free access images of high resolution such as Basemap (tool of Arcmap), Bin aerial (part of ArcBru Tile) and Google earth. We only used the Landsat 5TM satellite images taken in 2010 in cases where we could not find high resolution images.

In order to determine the quantity of points to use in the map validation process, we used the following formula[14]:

Where :
Z : is the value of the abscissa of the normal standardized curve for a determined level of probability.
P: indicates the percentage of estimated successes
Q: is the error rate (q = 1 – p).
E: is the allowable error rate

We take into account that the land-cover and land-use map must have a minimum precision of success of 80% and an allowable error rate of 10% in order to be able to account for a reliance level of 95%. The formula was applied as follows :

$$n = \frac{1.96^2 \text{ x } 80 \text{ x } 20}{10^2} = 61.46$$

According to the formula, 61 points need to be validated as a minimum ; we chose 70 validation points. 50 points were distributed in a systematic way (10 x 10km) in the “non-forest“ area, and 20 points of the parcels assessed in the field were selectioned randomly beforehand for the forest coverage, during the carbon inventory.

Table 20. Validation points of the forest and non-forest and coverage and land use, 2010

DEPARTMENT	PROVINCE	DISTRICT	N°	EAST	NORTH	MAP RESULTS	RESULTS ON THE GROUND
Ucayali	Coronel Portillo	Callería	1	556514	9141510	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Yarinacocha	2	531422	9091447	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Yarinacocha	3	541514	9091495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Callería	4	571514	9091495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Campoverde	5	526514	9081495	Vegetación no bosque	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Callería	6	556514	9081495	“Non-forest“ vegetation	Forest

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[14] Chuvieco, 2008

Ucayali	Coronel Portillo	Campoverde	7	521525	9071516	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Manantay	8	551514	9071495	Bare soil	Bare soil
Ucayali	Coronel Portillo	Callería	9	571514	9071495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Callería	10	581514	9071495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Callería	11	576514	9061495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	12	491514	9051495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Manantay	13	561514	9051495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	14	486625	9041641	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Campoverde	15	506514	9041495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Honoria	16	516514	9041495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Honoria	17	536514	9041495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	18	491514	9031495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Campoverde	19	511514	9031495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Masisea	20	591514	9031495	“Non-forest“ vegetation	Forest
Ucayali	Padre Abad	Irazola	21	466543	9021553	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	22	486514	9021495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	23	536514	9021495	“Non-forest“ vegetation	Forest
Ucayali	Coronel Portillo	Iparía	24	546514	9021495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Masisea	25	566514	9021495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Masisea	26	576514	9021495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	27	491594	9011462	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	28	501654	9011504	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	29	521511	9011515	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	30	531514	9011495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Masisea	31	581514	9011495	“Non-forest“ vegetation	Forest

Ucayali	Coronel Portillo	Masisea	32	591514	9011495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Masisea	33	651514	9011495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	34	456501	9001516	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	35	496612	9001355	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	36	516564	9001509	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Tournavista	37	536514	9001495	“Non-forest“ vegetation	Forest
Ucayali	Coronel Portillo	Iparía	38	556514	9001495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Puerto Inca	39	511429	8991480	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Padre Abad	Irazola	40	456514	8981495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Puerto Inca	41	501518	8971346	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Puerto Inca	42	511514	8971495	“Non-forest“ vegetation	Forest
Ucayali	Coronel Portillo	Iparía	43	561514	8971495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Puerto Inca	44	496514	8961495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Codo del pozuzo	45	461514	8931495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Iparía	46	581514	8931495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Codo del pozuzo	47	436514	8921495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Codo del pozuzo	48	441514	8911495	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Codo del pozuzo	49	451686	8911320	“Non-forest“ vegetation	“Non-forest“ vegetation
Huánuco	Puerto Inca	Codo del pozuzo	50	461514	8911495	“Non-forest“ vegetation	“Non-forest“ vegetation
Ucayali	Coronel Portillo	Iparía	51	572443	8980520	Medium terrace forest	Forest
Ucayali	Padre Abad	Irazola	52	470767	8992351	Medium terrace forest	Forest
Huánuco	Puerto Inca	Tournavista	53	498769	8995778	Medium hill forest	Forest
Ucayali	Coronel Portillo	Iparía	54	537197	8996718	Low hill forest	Forest
Ucayali	Coronel Portillo	Iparía	55	536298	8997620	Low hill forest	Forest
Ucayali	Coronel Portillo	Iparía	56	538207	9000181	High hill forest	Forest

Ucayali	Padre Abad	Irazola	57	471408	9000552	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Masisea	58	557623	9017998	Low terrace forest	Forest
Ucayali	Coronel Portillo	Callería	59	575573	9090234	Low terrace forest	Forest
Ucayali	Coronel Portillo	Callería	60	558799	9094352	Low terrace forest	Forest
Ucayali	Coronel Portillo	Callería	61	593542	9100532	Knoll forest	Forest
Ucayali	Coronel Portillo	Callería	62	588374	9100721	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	63	587410	9101150	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	64	586577	9101518	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	65	587103	9101680	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	66	552797	9112296	Low terrace forest	Forest
Ucayali	Coronel Portillo	Callería	67	553495	9112466	Low terrace forest	Forest
Ucayali	Coronel Portillo	Callería	68	547788	9124597	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	69	547729	9125182	Medium terrace forest	Forest
Ucayali	Coronel Portillo	Callería	70	550598	9126012	Medium terrace forest	Forest

Source : Own elaboration, 2014

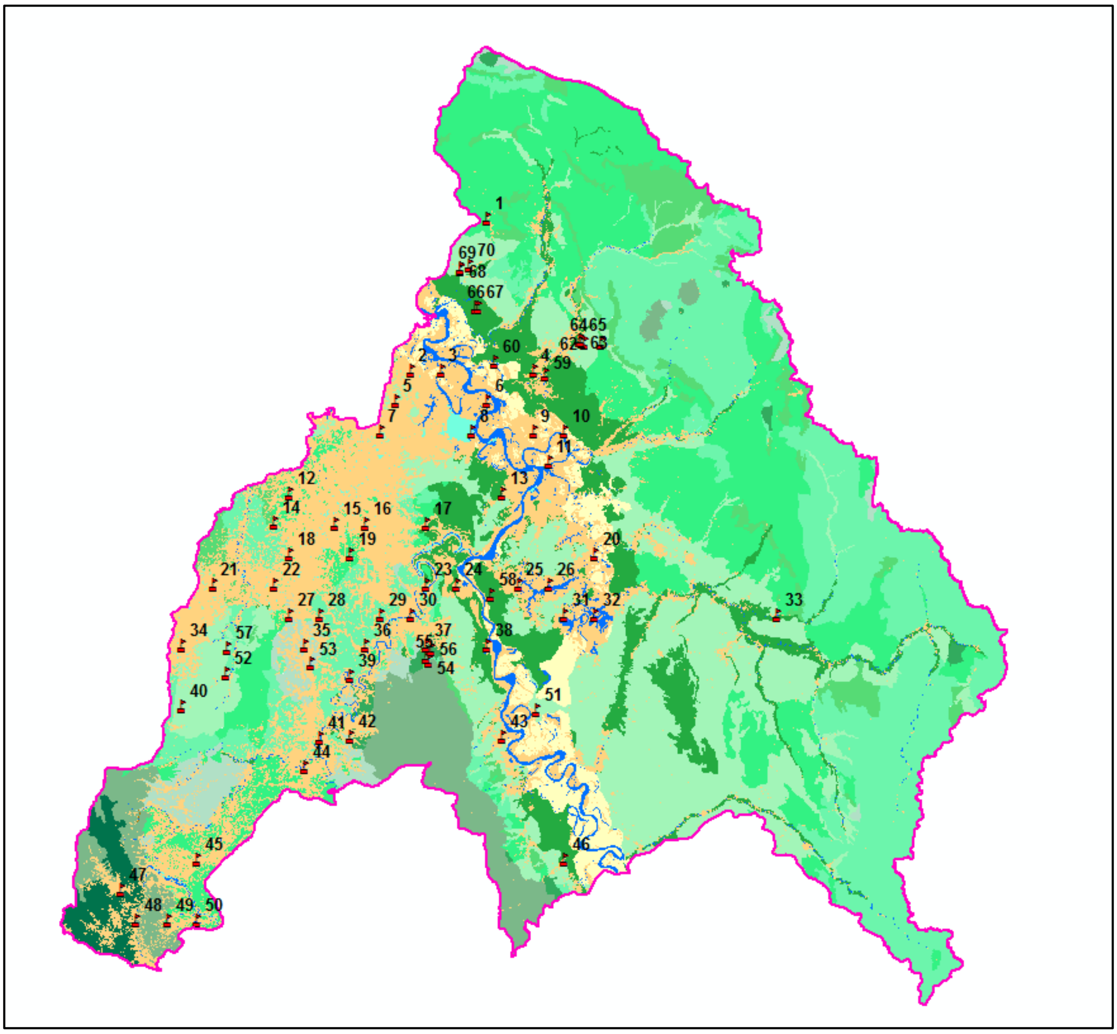


Figure 27. Distribution of validation points

Product of the analysis validation map has the following confusion matrix:

Table 21. Confusion matrix

Class in map	**Class in camp**				**Accuracy (%)**	**Commission error (%)**
	“Non-forest“ vegetation	**Bare soil**	**Forest**	**Total**		
“Non-forest“ vegetation	43	0	6	**49**	87.76	12.24
Bare soil	0	1	0	**1**	100.00	-
Forest	0	0	20	**20**	100.00	-
Total	**43**	**1**	**26**	**70**		
Accuracy (%)	100.00	100.00	76.92			

Omission error (%)	-	-	23.08

Source : Own elaboration, 2014

The data given in the confusion matrix defined the accuracy rate of the map through the following formula :

$$\boxed{F_m = \frac{\sum X_i}{\sum \sum X_{ij}} \times 100}$$

Where :
Fm : Map reliability
ΣX_i : Sum of the successes
$\Sigma\Sigma X_{ii}$: Total of the points shown

$$Fm = \frac{64}{70} \times 100 = 91.43\ \%$$

Therefore, the accuracy rate of the land-cover and land-use map for the reference region in 2010 is from 91.43%.

2.6 Preparation of the methodology annex to the PD

A detailed description of the methodology and processes used for the classification of satellite imagery based in detection methods of land use changes outlined in step 2 above. In sub-annex B you have tabs validation of forest and non-forest in the reference region.

Step 3 : Analysis of agents, drivers and main causes of deforestation and their likely future development

For the development of this step was developed a document where is explained the methodological process of the agents, drivers and main cause of deforestation analisys and its expected future development of the reference region of the project "Valoring the environmental good services in managed forest of 7 native communities". The document is the sub-annex C, which will be delivered for the validation process. Following, a summary of the document mentioned is presented.

3.1 Identification of agents of deforestation in the reference region

Were identified the main causes of deforestation un reference region, below is a description of the characteristics and relative importance of the deforestation agents in the reference region demonstrated through verifiable sources as the participatory rural diagnosis, participative workshops, interviews and studies carried out in the area

From the applied interviews in the reference region to identify the underlying agents of deforestation, the 67% of the interviewees notes the farmers as the main deforestation agents, a 60% to loggers, a 13% to livestock owners and a 7% indicates that nobody deforest in their area.

Also the deforestation agents interviewed has noted that the main reasons of the exctraction are : 53% indicated that agriculture is the unique reason to deforest, 7% extracts timber and then make agriculture, 7% extracts to make livestock and agriculture, while a 30% does not have definied yet the objective of extraction.

3.2 Identification of deforestation drivers in the reference region

Were identified the main drivers of deforestation in the reference region while the historical reference period and its realtion and relative importance with the main deforestation agents, as well as the factors that determine the decissions of land use by the diferent groups.

Two arrais of variables were distinguished: variables that explain the deforestation in terms of quantity (hectares) and variables that explain the location of deforestation, also called "predisposing factors".

The variables were listed according to their relative importance during the historical reference period and its impact is described in the decision-making of each group of deforestation agents identified in step 3.1. Additionally, is provided information on the most probable development of these variables.

3.2.1 Driver variables that explain the quantity of deforestation

a. Rural wages
b. Price of the farming products
c. Timber price
d. Access to credits and subsidies

3.2.2 Driver variables explaining the location of deforestation

a. Proximity to roads and navigable rivers
b. Soil fertility/ area’s physiography
c. Proximity to the existent populated center.
d. Property and security regime of land ownership

3.3 Underlying causes of forest deforestation and degradation

The agents’ characteristics and their decisions concerning to the land use are determined by boarder forces, called the underlying causes of deforestation. The underlying causes of deforestation were determined according to participatory rural diagnosis conducted in the reference region, participatory workshops, and interviews to relevant trials with a wide field experience within the project reference region.

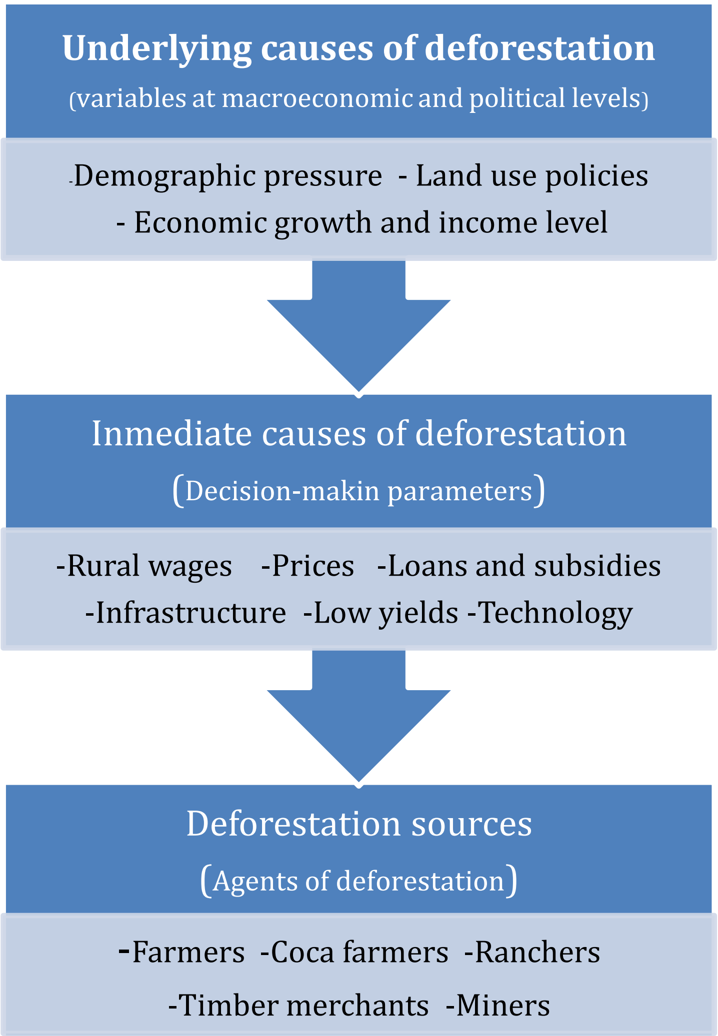
The conducted interviews in the reference region concerning to the underlying causes of deforestation noted taht: the necessity of developing agriculture to answer food needs (47%), poverty (40%), demographic pressure (20%) and activities of forest harvesting (13%); while a 27% do not specify any underlying cause of deforestation or consider that these do not exist.

a. Population growth
b. Land-use policies and their implementation
c. Economic growth and income level

3.4 Analysis of the chain of events leading to forest deforestation and degradation

Were analysed the relations between the main groups of deforestation agents, the key drivers and the underlying causes, explaining the sequence of events that has led and will lead to deforest. For this nalisys was used an historical evidence of these events in the reference region, as well as the interview of experts, analisys of literature and other information sources.

The relation between the main agents of deforestation, drivers or immediate causes and underlying causes are described in detailed in the previous steps. Figure 21 illustrates the relations between the main types of variables and provides a logical approach to analyse the deforestation in these three different levels.



Source : Own Elaboration

Figure 28. Chain of events that are leading deforestation and degradation in the reference region

The starting point to understand the chain was the identification and characteriszation of the main agents of deforestation in the project's reference region. The activities performed by the these agents are the deforestation sources. The analysis of the importance of these various sources of deforestation was carried out through a statistical analysis of the main activities conducted by these agents groups during the historical reference period.

The decisions regarding the quantity and the location of deforestation of these agents groups were evaluated according to their own features (records, preferences and resources) and the identified decision-making parameters. The same that are detailed in the previous steps.
Finally the agents' features and paremeters of decision-making were determined by boarder forces called underlying causes of deforestation that are linked to national policies and the macroeconomic level.

Below are detailed the different actors of the chain of events that lead to deforestation for each main deforestation agents :

a. Farmers
b. Livestock owners
c. Coca farmers
d. Loggers
e. Artisanal miners

3.5 Conclusion of the causal model of deforestation

The analysis conducted after the field studies, consulted sources of primary information as: the creation of 7 Participatory Rural Diagnosis, and the construction of surveys and interviews. As also used sources of secondary information formed by various cientific studies and reports generated in an regional, national and Amazon region level respecto to the deforestation process in the project area and reference region scope. Concludes on the assertion that the collected evidence about of the most likely development trend of deforestation in the reference region and the project area is "**conclusive".**

Moreover, provides that the weight of the evaluated variables indicates that the general trend of future deforestation baseline will be **"increasing"**. This assertion is conclusive demonstrated the relation between the different groups of deforestation agents, driver variables and underlying causes. These can be verified through the following statistical values: historical analyses and prediction of the various variables, official statistics, literature studies and reports cited, substantiated information given by the workshops' experts, communities, agents of deforestation and other groups with an extended knowledge of the project area and reference region.

Step 4. Projection of future deforestation

4.1 Quantity projection of future deforestation

According to the VM0015 v. 1.1 methodology, the reference region should be stratified according to the results of the analysis of agents and causes of deforestation (Step 3). In the case of the project « Forest management to reduce deforestation and degradation if Shipibo Conibo and Cacataibo native communities », the causes that has influence on deforestation have become more important and specialised, in which were observed that they are extended to the entire reference region and that they share a similar pattern to the temporal character of the baseline. Hence, there is no need of subdividing the reference region in different strata.

Table 22. Stratification of the reference region (see table 8 – GHG-VM0015 calculation of emissions)

Stratum ID		Description	Area
ID_i	Name		(he)
1	Reference region	The agents, drivers and underlying causes of deforestation are homogeneous in the reference region. There is therefore no need for a stratification of this region.	4,735,649.4

4.1.1 Selection of the baseline approach

As can be seen in Step 3, the main activities of the deforestation agents are agriculture and livestock production. These are the main causes of deforestation in the reference region and in the project areas. On the other hand other engines with less pressure the forest: illegal logging, building of secondary roads, mining, illegal land trafficking and immigration of populations from neighbouring provinces.
According to the methodology, if the rate of baseline deforestation is estimated by extrapolating the historical trend observed within the reference region as a function of time, then a formula of either linear regression, logistic regression or any other statistically sound regression technique shall be used.

The project considers the forest and "non-forest" coverage, as well as the relation with the population growth during the years 2000, 2005 and 2010. The analysis of historical deforestation showed a clear tendency of growth in the historical periods, and shows evidence that this trends will keep growing in the future. All of this is linked to the conclusive evidence of the analysis of agents and drivers of deforestation that explains the different rates of historical deforestation, as mentioned in Step 3. Thus, as there exists one variable that can be used to predict the deforestation rate (the demographic variable) the project proponent will use the approach "c". This is based on the fact that the rate of baseline deforestation estimates through extrapolating the historical tendency observed in the reference region in function of the population and using an exponential regression.

4.1.2 Quantative projection of future deforestation

4.1.2.1 Projection in the annual areas of baseline deforestation in the reference region

In light of the above, one can say that deforestation is linked to the amount of people in the study area. Firstly, we defined the variables that we would take into consideration. Then, we present the source and the historical data that were used for the extrapolation and its forecast until 2020.
This can first be demonstrated with the INEI statistics and with the fieldwork. Secondly, according to the approach "c", we developed three types of bivariate regressions : linear, exponential and potential.

- **Variables definition**
  The variables that will define the model will be the population density (exogenous) and the forest coverage (endogenous). Those variables are historical data provided by the Instituto Nacional de Estadística e Informática and AIDER[15].

- **Historical data obtained**
  Tables 23, 24, 25 and 26 describe the population in the study area and the total hectares distributed in forest, non-forest and water coverage.

Table 23. Population in the project area

Población Censada

Distrito	Provincia	Departamento	2007	2005	1993
Codo del Pozuzo	Puerto Inca	Huanuco	6,067	6,238	5,422
Honoria	Puerto Inca	Huanuco	5,628	5,054	4,757
Puerto Inca	Puerto Inca	Huanuco	8,633	8,845	10,856
Tournavista	Puerto Inca	Huanuco	5,052	6,024	6,322
Calleria	Coronel Portillo	Ucayali	136,478	208,292	173,297
Campoverde	Coronel Portillo	Ucayali	13,515	12,620	18,209
Iparia	Coronel Portillo	Ucayali	10,774	10,852	9,278
Irazola	Padre Abad	Ucayali	18,910	16,192	
Manantay	Coronel Portillo	Ucayali	70,745		
Masisea	Coronel Portillo	Ucayali	11,651	11,789	12,083
Yarinacocha	Coronel Portillo	Ucayali	85,605	67,681	35,582

Elaboración: Propia
Fuente: INEI, AIDER

Table 24. Total hectares of the districts distributed in forest, non-forest and water coverage for 2000

2000

Distrito	Departamento	Ha. Total Distrito	Ha. No Bosque	Ha. Bosque	Ha. Cuerpos de Agua
CODO DEL POZUZO	HUANUCO	323,443.33	53,666.26	266,013.61	3,763.45
HONORIA	HUANUCO	95,520.91	31,562.94	62,494.71	1,463.27
PUERTO INCA	HUANUCO	237,822.72	40,159.20	194,113.65	3,549.87
TOURNAVISTA	HUANUCO	174,036.57	33,317.98	138,491.49	2,227.11
CALLERIA	UCAYALI	1,164,370.15	87,489.97	1,059,128.28	17,751.90
CAMPOVERDE	UCAYALI	131,622.20	88,464.40	42,703.04	454.77
IPARIA	UCAYALI	736,356.57	52,445.76	655,990.12	27,920.69
IRAZOLA	UCAYALI	268,947.72	98,523.49	169,050.03	1,374.20
MANANTAY	UCAYALI	65,960.90	20,243.98	40,471.59	5,245.32
MASISEA	UCAYALI	1,470,932.59	103,542.99	1,342,210.71	25,178.89
YARINACOCHA	UCAYALI	66,635.69	43,599.11	15,144.14	7,892.44
TOTAL		**4,735,649.36**	**653,016.07**	**3,985,811.38**	**96,821.92**

Elaboración: Propia
Fuente: INEI, AIDER

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[15] Association for Research and Integral Development – AIDER (2014); Treatment and Classification of Landsat 5TM satellite images to determine deforestation 200, 2005 y 2010.

Table 25. Total hectares of the districts distributed in forest, non-forest and water coverage for 2005

2005

Distrito	Departamento	Ha. Total Distrito	Ha. No Bosque	Ha. Bosque	Ha. Cuerpos de Agua
CODO DEL POZUZO	HUANUCO	323,443.33	67,506.22	252,173.65	3,763.45
HONORIA	HUANUCO	95,520.91	41,489.77	52,567.88	1,463.27
PUERTO INCA	HUANUCO	237,822.72	53,679.43	180,593.42	3,549.87
TOURNAVISTA	HUANUCO	174,036.57	41,875.23	129,934.24	2,227.11
CALLERIA	UCAYALI	1,164,370.15	97,833.81	1,048,784.44	17,751.90
CAMPOVERDE	UCAYALI	131,622.20	93,002.44	38,164.99	454.77
IPARIA	UCAYALI	736,356.57	64,911.00	643,524.88	27,920.69
IRAZOLA	UCAYALI	268,947.72	107,657.07	159,916.44	1,374.20
MANANTAY	UCAYALI	65,960.90	22,128.56	38,587.02	5,245.32
MASISEA	UCAYALI	1,470,932.59	121,974.92	1,323,778.78	25,178.89
YARINACOCHA	UCAYALI	66,635.69	46,130.32	12,612.92	7,892.44
TOTAL		**4,735,649.36**	**758,188.78**	**3,880,638.66**	**96,821.92**

Elaboración: Propia

Fuente: INEI, AIDER

Table 26. Total hectares of the districts distributed in forest, non-forest and water coverage for 2010

2010

Distrito	Departamento	Ha. Total Distrito	Ha. No Bosque	Ha. Bosque	Ha. Cuerpos de Agua
CODO DEL POZUZO	HUANUCO	323,443.33	97,530.27	222,149.60	3,763.45
HONORIA	HUANUCO	95,520.91	49,732.39	44,325.26	1,463.27
PUERTO INCA	HUANUCO	237,822.72	76,692.45	157,580.40	3,549.87
TOURNAVISTA	HUANUCO	174,036.57	70,008.85	101,800.61	2,227.11
CALLERIA	UCAYALI	1,164,370.15	103,165.97	1,043,452.28	17,751.90
CAMPOVERDE	UCAYALI	131,622.20	107,166.22	24,001.22	454.77
IPARIA	UCAYALI	736,356.57	71,551.55	636,884.33	27,920.69
IRAZOLA	UCAYALI	268,947.72	145,313.12	122,260.40	1,374.20
MANANTAY	UCAYALI	65,960.90	23,207.99	37,507.59	5,245.32
MASISEA	UCAYALI	1,470,932.59	129,557.06	1,316,196.64	25,178.89
YARINACOCHA	UCAYALI	66,635.69	48,188.72	10,554.53	7,892.44
TOTAL		**4,735,649.36**	**922,114.58**	**3,716,712.86**	**96,821.92**

Elaboración: Propia

Fuente: INEI, AIDER

- **Treatment of variables**

The data showed previously allowed us to generate the variables of population density and forest coverage. For the first variable, we conducted an extrapolation of the data collected from the 2006 and 2011 elections. For the second variable, we took the data collected by AIDER, which was also extrapolated, for the years different to 2000, 2006 and 2010.

Table 27. Population density and forest coverage

Año	Densidad Poblacional	Cobertura de Bosque
2000	0.0673	3,985,811
2001	0.0687	3,964,777
2002	0.0702	3,943,742
2003	0.0716	3,922,708
2004	0.0731	3,901,673
2005	0.0747	3,880,639
2006	0.0767	3,847,853
2007	0.0788	3,815,068
2008	0.0818	3,782,283
2009	0.0849	3,749,498
2010	0.0881	3,716,713

Elaboración: Propia

Fuente: INEI, AIDER

- **Functions determination**

The population density and forest cover data were treated through three types of models. The aim was to compare them in order to show which one had the best goodness of fit. The exponential model appeared to be the most suitable one.

	Exponencial
R2	**99.53%**
Ecuación	$Y = 5 \times (10^{6}) e^{-3.437x}$

- **Projections for the year 2020**

With the obtained equation, can be determinated the following results for the future years and the variation rates between them. This data is shown in table 28.

Table 28. Projection of the forest coverage (ha)

Year	Equation of exponential projection
2011	3,651,482.57
2012	3,608,140.35
2013	3,563,695.59
2014	3,518,141.30
2015	3,471,472.16
2016	3,423,684.72
2017	3,374,777.45
2018	3,324,750.96

2019	3,273,608.13
2020	3,221,354.27

For the outcome defined, evidence the growing of deforestation because of increased population density. This can be the result of the the migration of people from the mountains (sierra), increase in the birth rate in the area of study, and all the economic activities that lead to a greater concentration of population, as mentioned in point 4.1.2.

Table 29. Deforestation annual growth rate

Year	Exponential
2011	0.0114
2012	0.0119
2013	0.0123
2014	0.0128
2015	0.0133
2016	0.0138
2017	0.0143
2018	0.0148
2019	0.0154
2020	0.0160

4.1.2.2 Projection of the annual areas of baseline deforestation in the reference region and in the leakage belt

The amount of annual areas of deforestation in the reference for the class of forest within the leakage belt and project area was determined through the use of geographical information. The map of the forest classes are then combined with the maps of annual deforestation projected in step 4.2.

4.1.2.3 Summary of step 4.1.2

The results of the baseline for this step are detailed in tables 30a, 30b and 30c.

Table 30a. Annual areas of deforestation in the reference region (see table 9a – GHG-VM0015 calculation of emissions spreadsheet)

Project year *t*	Stratum *i* in the reference region	Total	
		annual	cumulative
	$ABSLRR_{i,t}$	$ABSLRR_t$	*ABSLRR*
	he	he	he
2010-2011	62,154.3	62,154.3	62,154.3

2011-2012	41,532.0	41,532.0	103,686.3
2012-2013	43,298.5	43,298.5	146,984.8
2013-2014	45,138.3	45,138.3	192,123.1
2014-2015	46,803.3	46,803.3	238,926.5
2015-2016	48,652.4	48,652.4	287,578.9
2016-2017	49,984.8	49,984.8	337,563.7
2017-2018	51,539.1	51,539.1	389,102.8
2018-2019	52,602.9	52,602.9	441,705.6
2019-2020	53,865.0	53,865.0	495,570.6

Table 30b Annual areas of baseline deforestation in the reference region (see table 9b – GHG-VM0015 calculation of emissions spreadsheet)

Project year t	Stratum *i* in the reference region in the project area	Total	
		annual	cumulative
	$ABSLPA_{i,t}$	$ABSLPA_t$	$ABSLPA$
	ha	ha	ha
2010-2011	1,295.9	1,295.9	1,295.9
2011-2012	954.4	954.4	2,250.3
2012-2013	1,135.0	1,135.0	3,385.3
2013-2014	1,369.9	1,369.9	4,755.3
2014-2015	1,416.1	1,416.1	6,171.3
2015-2016	1,722.3	1,722.3	7,893.6
2016-2017	2,288.6	2,288.6	10,182.3
2017-2018	2,441.5	2,441.5	12,623.7
2018-2019	2,692.9	2,692.9	15,316.6
2019-2020	2,943.7	2,943.7	18,260.4

Table 30c. Annual areas of baseline deforestation in the leakage belt (see table 9c – GHG-VM0015 calculation of emissions spreadsheet)

Project year t	Stratum *i* of the reference region in the leakage belt	Total	
	1	*annual*	cumulative
	$ABSLLK_{i,t}$	$ABSLLK_t$	$ABSLLK$
	ha	ha	ha
2010-2011	2,459.0	2,459.0	2,459.0
2011-2012	1,821.3	1,821.3	4,280.3
2012-2013	2,095.9	2,095.9	6,376.2

2013-2014	2,206.8	2,206.8	8,583.1
2014-2015	2,554.3	2,554.3	11,137.4
2015-2016	2,742.8	2,742.8	13,880.2
2016-2017	2,770.0	2,770.0	16,650.2
2017-2018	3,082.4	3,082.4	19,732.6
2018-2019	3,076.4	3,076.4	22,809.0
2019-2020	2,978.6	2,978.6	25,787.6

4.2 Projection of the location of future deforestation

At present, exists several software packages that allow the modeling of land use change in the future, the project proponent made the change of land use to future dynamics software Dinamica Ego package, which allows this type of geographical space analysis.

The software Dinamica Ego[16], is a set of models that are expressed as a sequence of functors connected via inputs and compatible products. So the data flow is allowed through the functors to produce the outcome that represents the solution to a question about an environmental issue.

After having defined the baseline rate of deforestation for the future, we identified all the variables that could impact positively and negatively on the spatial variations of deforestation. This allows us to create risk maps and to find the most appropriate zones for the transition from forest to non-forest.

4.2.1. Preparation of factor maps

The different categories of deforestation drivers for the reference region are based on the results obtained in steps 1, 2 and 3 (Boundaries, forest and "non-forest" coverage in the reference period, and agents and drivers). This analysis was conducted through an empirical approach with the aim of creating factor maps. In the same way, we used maps of distance to primary and secondary roads, to population centres and hydrography generated by Euclidian distances as a group of continuous variables. For the factor maps of discrete and categorical data, were used the maps of the boundaries of the native communities, forest concessions, protected natural areas, mining cadastre, areas of regional conservation and cionservation areas.

4.2.2. Preparation of risk maps for deforestation

The combinations of variables of the different controllers linked to historical deforestation were used for the creation of the risk map for deforestation. These maps were generated in a raster format with a pixel size of 71 meters represented in the entire reference region.

Each Risk Map generated by the continuous variables was used for location in the years 2000-2005 and 2005-2010. We introduced a change rate in each of them, according to the sub-model of changeover matrix of Dinamica Ego. The maps show the spatial variation of the

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[16] http://www.csr.ufmg.br/dinamica/

driver in the reference region, while the graphs show the relation between the variable and the deforestation in the baseline period 2000-2010.
The spatial data available in digital format are detailed in the following table :

Table 31. List of variables, maps and factor maps (see table 10 – GHG-VM0015 calculation of emissions)

Factor map		Source	Variable reprensented		Meaning of the categories or pixel value		Other Maps and Variables used to create the Factor Map		Algorithm or Equation used	Comments
ID	File name		Unity	Description	Range	Meaning	ID	File name		
Hydrography distance	Hydrography	Ucayali Regional Government – Huánuco Regional Government	Meter	-	0-148205	Meters	-	-	Euclidian Distance	-
Distance to Crimary Roads	Primary Roads	Ucayali Regional Government – Huánuco Regional Government	Meter	-	0-87597	Meters	Primary roads	Primary roads	Euclidian Distance	-
Distance to Secondary Roads	Secondary Roads	Ucayali Regional Government – Huánuco Regional Government	Meter	-	0-18546	Meters	Secondary roads	Secondary roads	Euclidian Distance	-
Distance to Copulation Centres	Population Centres	Instituto Nacional de Estadística e Informática - INEI	Meter	-	0-16995	Meters	-	-	Euclidian Distance	-

Mining Cadastre	Mining Cadastre	Instituto Geológico Minero y Metalúrgico - INGEMMET	Hectare	-	0-2	Hectare	-	-	-	-
Native Communities	Native Communities	Instituto del Bien Común - IBC	Hectare	-	0-2	Hectare	-	-	-	-
Forest Concessions	Forest Concessions	Dirección General Forestal y de Fauna Silvestre	Hectare	-	0-2	Hectare	-	-	-	-
Protected Natural Areas	Protected Natural Areas	National Service of Protected Natural Areas	Hectare	-	0-2	Hectare	-	-	-	-
Regional Conservation Area	Regional Conservation Area	National Service of Protected Natural Areas	Hectare	-	0-2	Hectare	-	-	-	-
Ecotouristic Conservation Area	Ecotouristic Conservation Area	Ucayali Regional Government	Hectare	-	0-2	Hectare	-	-	-	-

Figure 29. Distance to Primary roads

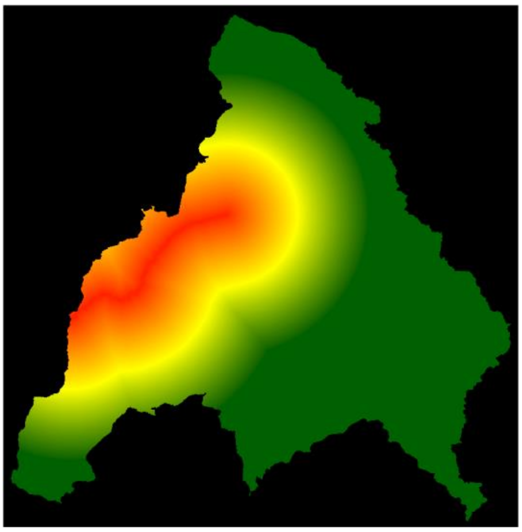


Figure 30. Distance to Secondary roads

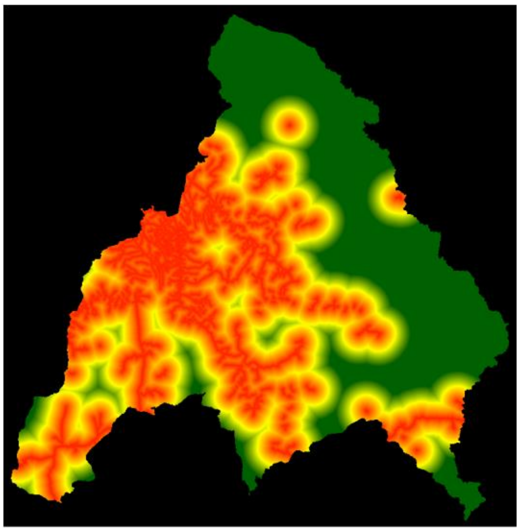


Figure31. Distance to the hydrographic

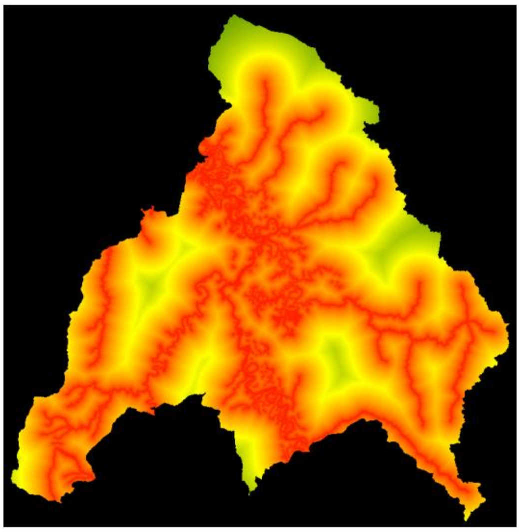


Figure 32. Distance to populated centers

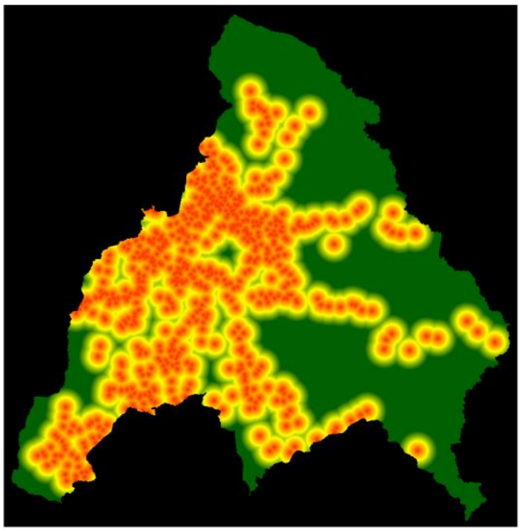


Figure 33. Native Communities

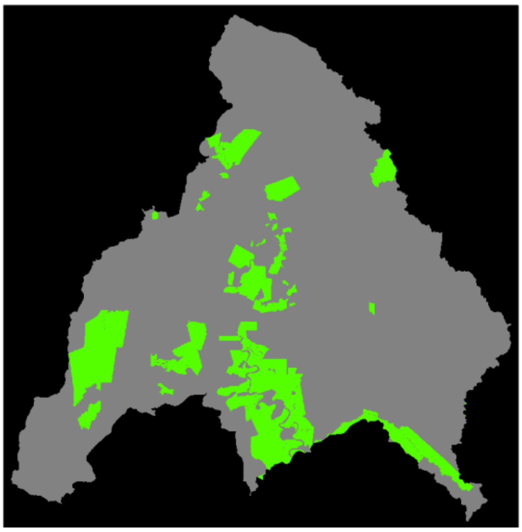


Figure34. Forest Concessions

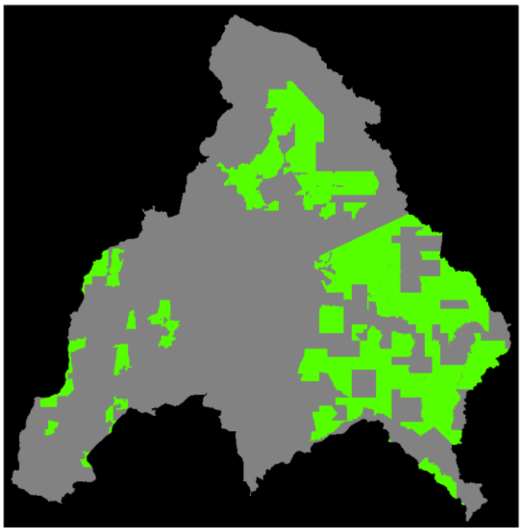


Figure 35. Protected Natural Areas

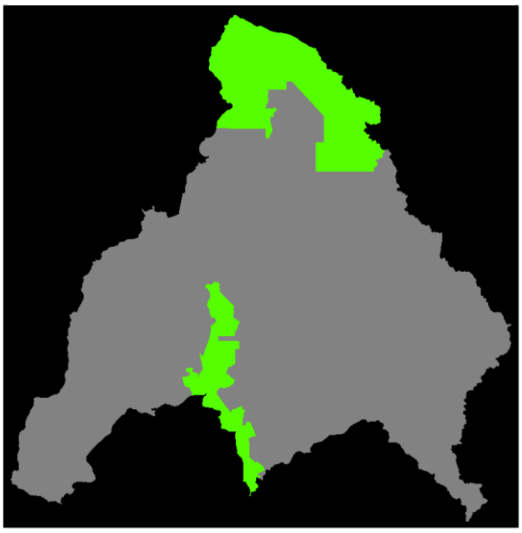


Figure 36. Regional Conservation Area

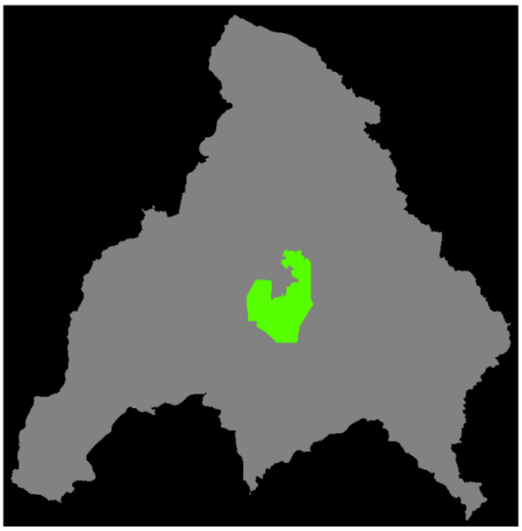


Figure 37. Mining Cadastre

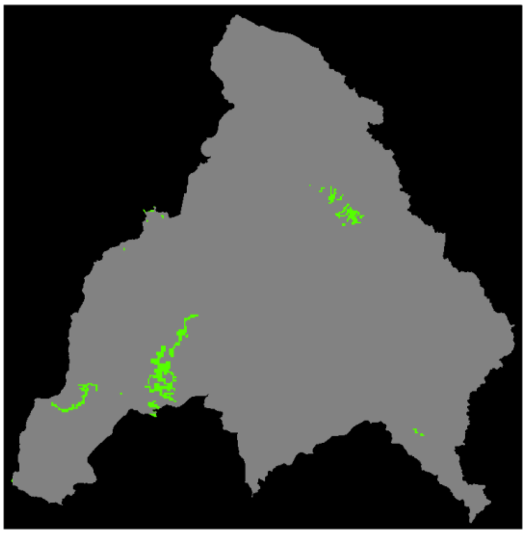
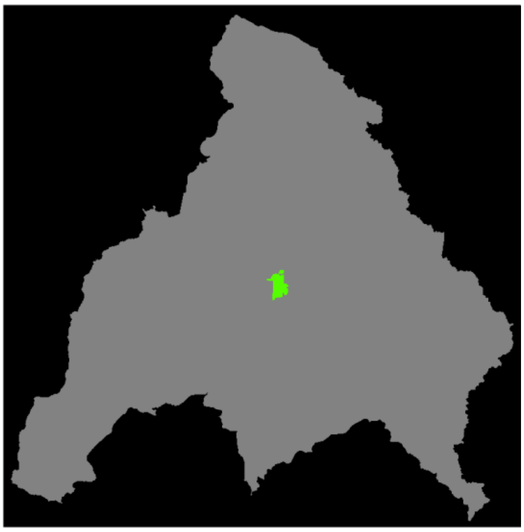


Figure 38. Ecotouristic Conservation Area



4.2.3 Selection of the most accurate deforestation risk map

After the elaboration of the risk maps of future deforestation, were used the Sub-models of the Dinamica Ego Software for the spatial distribution of future deforestation, which is linked to the projected deforestation rate. The Dinamica Ego Software allowed us to assign sequentially the deforestation to the pixels where we could locate the areas with the highest potential. This information also allowed us to use the function for the creation of new deforestation patches.

Following the VM0015 methodology, we opted for option A. According to this option, the simulated deforestation map is assessed through the comparison between a “real“ map and a validation of two sub-periods.

The real deforestation rate between the years 2000 and 2005 was attributed to the sub-model in order to predict the location of the deforestation simulated for 2005. The simulated map for the years 2000 to 2005 was validated with the changeover map generated in point 2.4. This was done through the superposition of raster layers and through a sub-model assessing windows of 1*1, 3*3, 5*5 and 7*7 pixels. This sub-model allowed us to obtain higher percentages than the minimum required by the Dinamico Ego software.

We used the tool "Figure of merit" (FOM) in order to assess the model accuracy. FOM varies from 0% (where there is no superposition between the change observed and the simulated one) to 100% (where there is a perfect superposition between both). The VM0015 proposes 50% as a minimum threshold for the configurations of borders. This threshold is measured through the figure of Merit approach.

If one could strictly follow the methodology, the comparative analysis of simulation versus real deforestation would result in a 0% FOM, as the project area was composed of forest lands at the beginning of the project.
According to the methodology, when the minimum standard of 50% is not reached, the project proponent should demonstrate that at least three models have been tried and that the one used is the one with highest FOM. In our case, the FOM was smaller than 50%, and we therefore tried two other models. The models that we tried (lineal regression, potential regression and exponential regression) will be provided to the validator.

Figure 39 shows the risk map selected based observed at the highest FOM. The colors of the map describe the risk of deforestation : dark red represents a high potential for deforestation and dark blue a low potential. The left panel shows the parameter used in the model including start and end rates and end performance statistics is tilted.

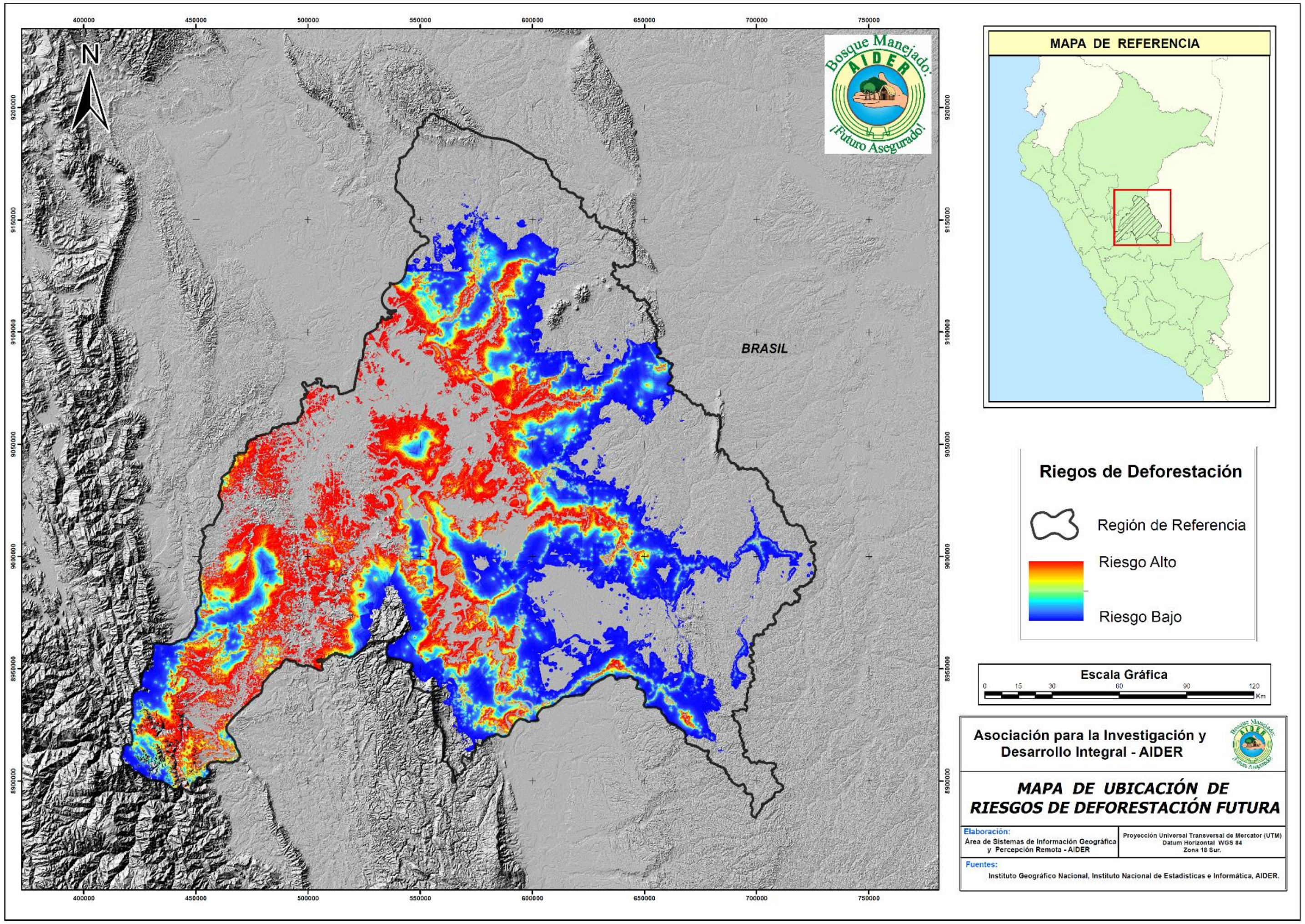


Figure 39. Map of future deforestation risks

4.2.4 Mapping of the locations of future deforestation

The prediction of deforestation during the crediting period of the project requires a map of forest reference for project start date 2010. The reference map encompasses the entire forest cover observed until 2010. The rates estimated in step 4.1.3 and described in table 23 were applied for the risks map in order to define the location of the future deforestation baseline (2010-2020), as shown in figure 40. The future deforestation, according to the model, will occur first in the location of the pixel with the highest risk of deforestation. Subsequently, the project area and the leakage belt boundaries were combined with the use of systems of geographic information in order to evaluate the amount of deforestation that will go over the reference scenario within these boundaries. The results are shown in tables 28.a, 28b. and 28c.

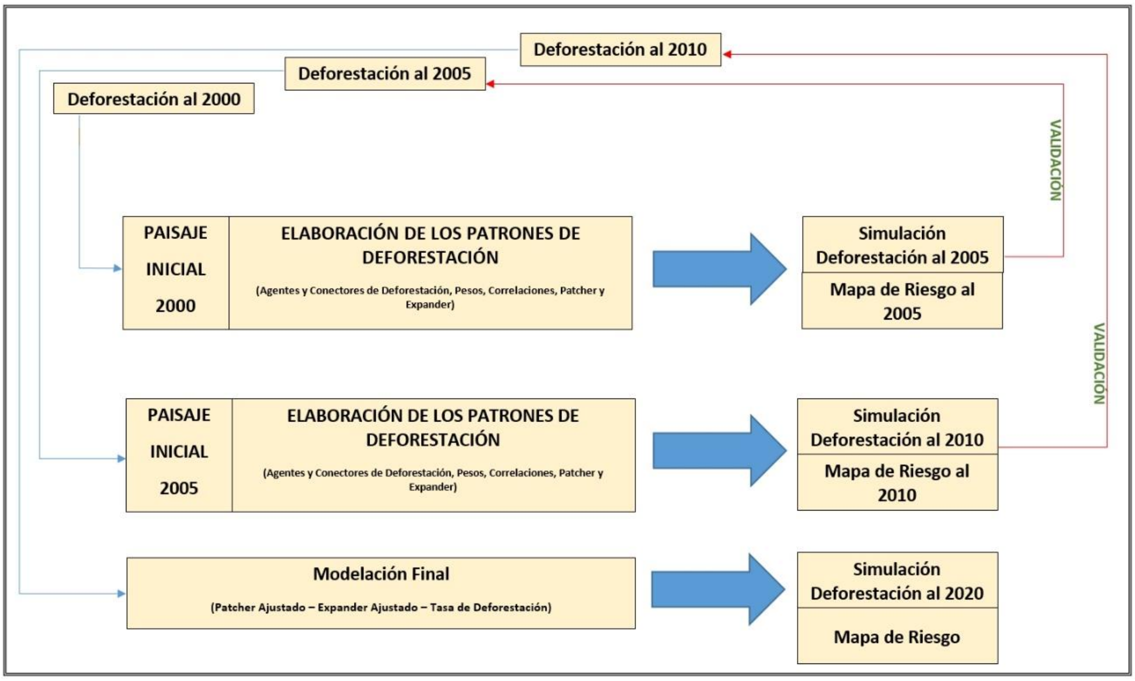


Figure 40. Flow chart of future deforestation mapping

The annual maps of deforestation of the baseline in the project area and in the leakage belt are shown below :

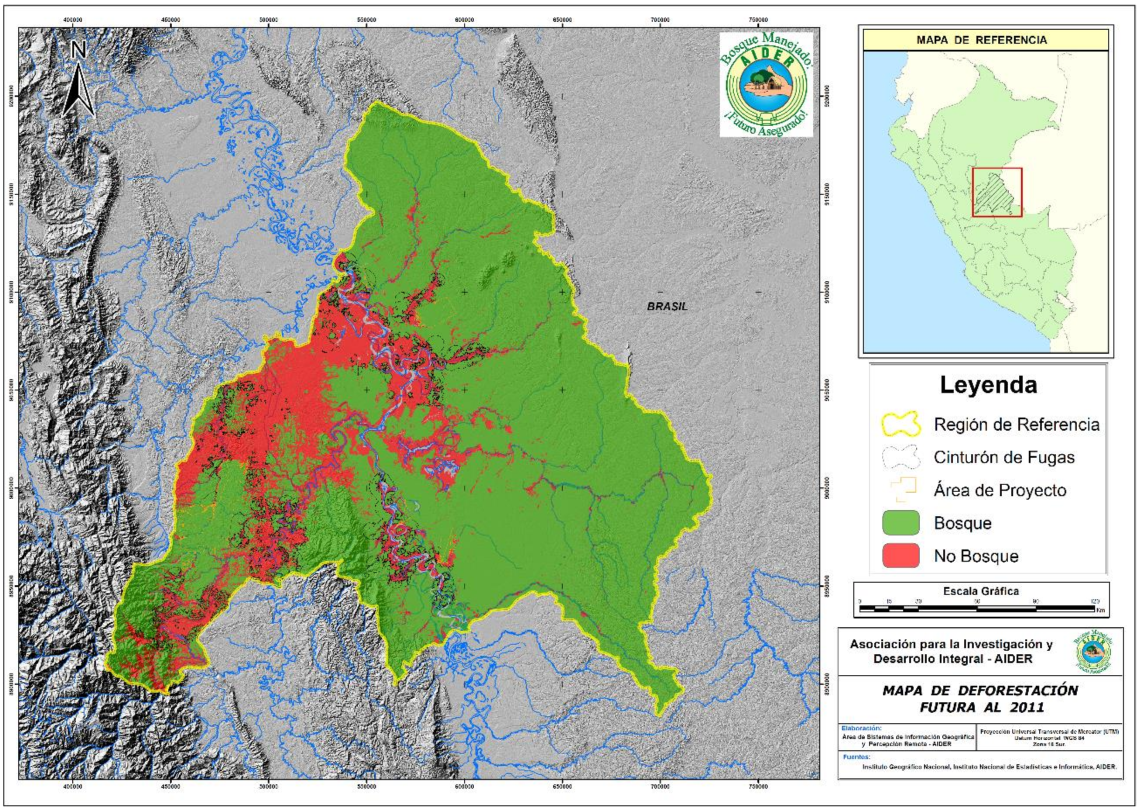


Figure 41. Map of future deforestation – 2011

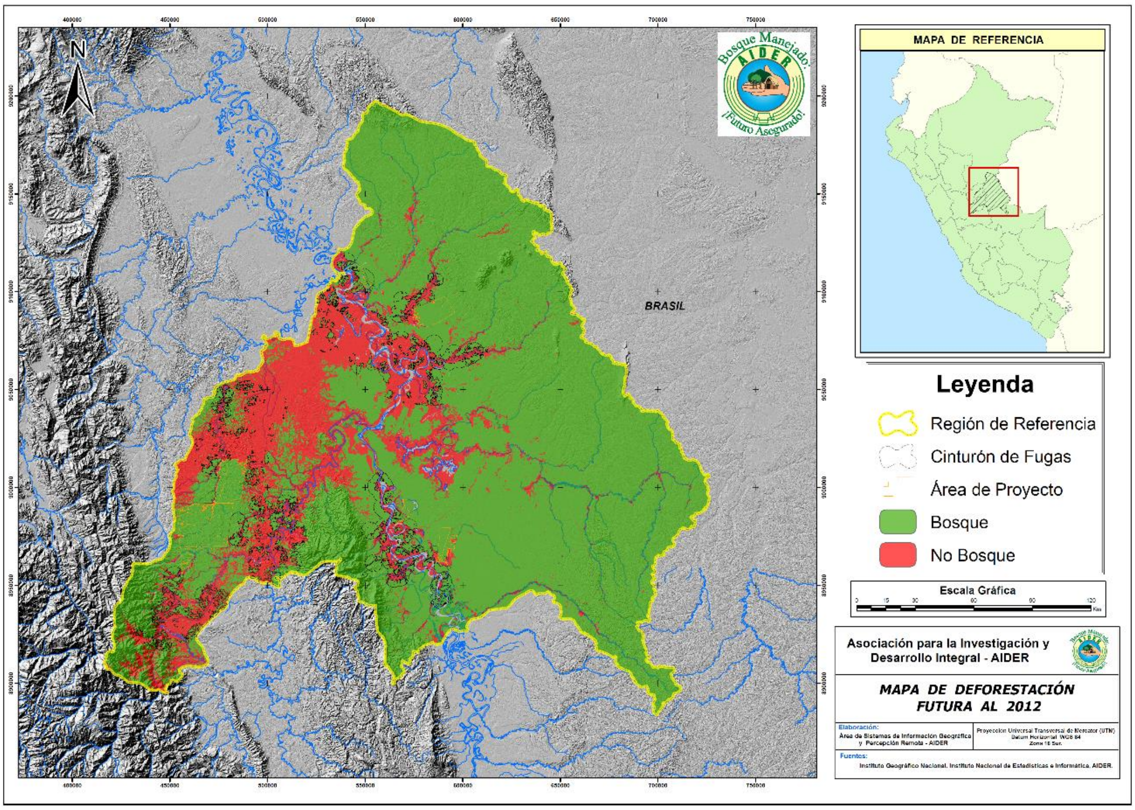


Figure 42. Map of future deforestation – 2012

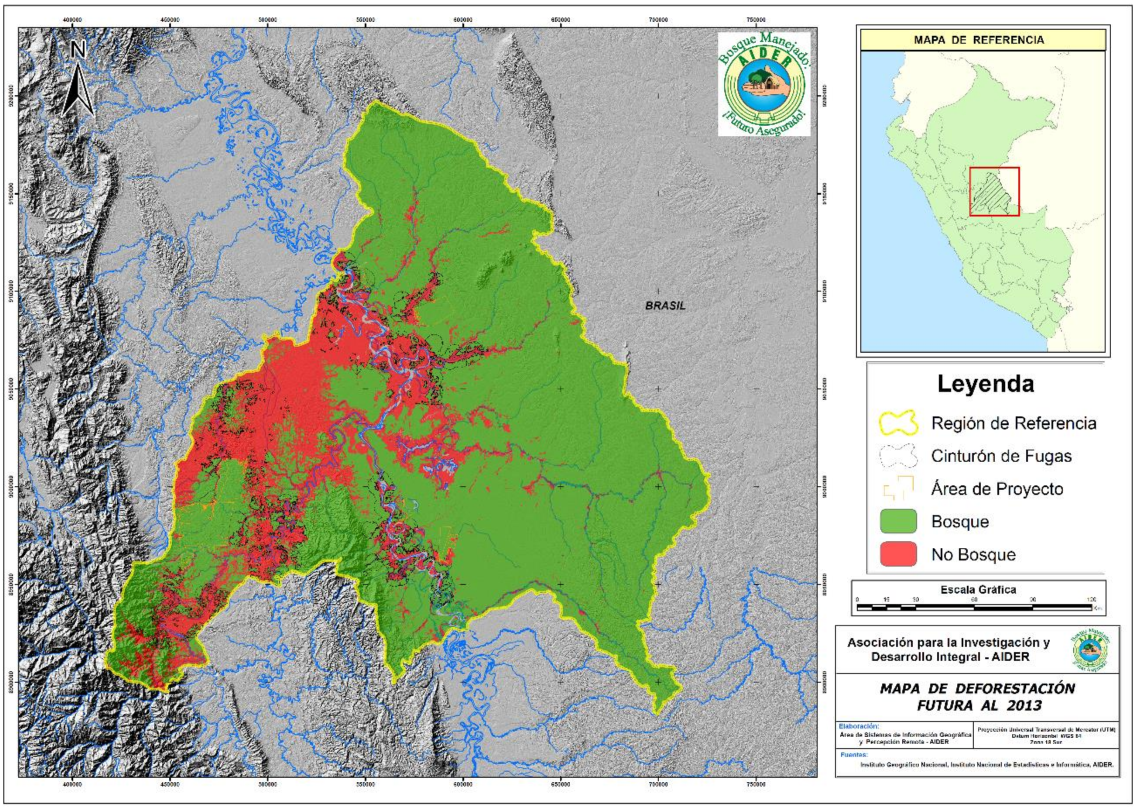


Figure 43. Map of future deforestation – 2013

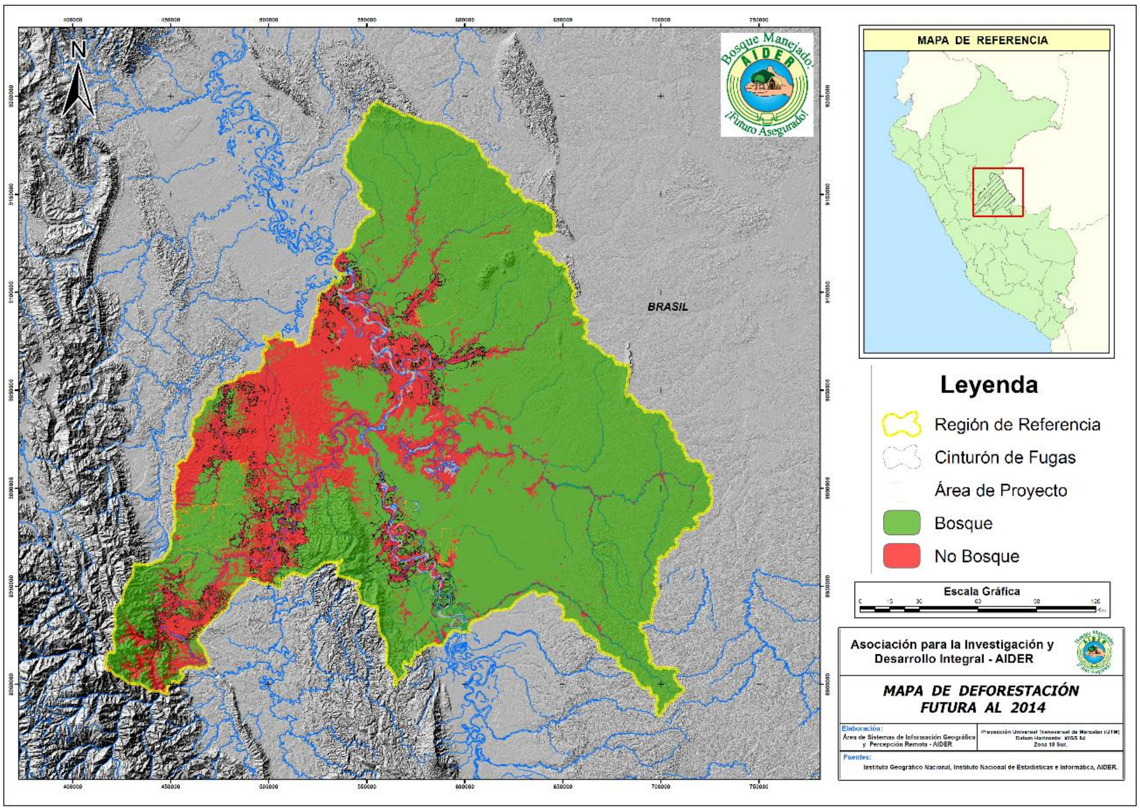


Figure 44. Map of future deforestation – 2014

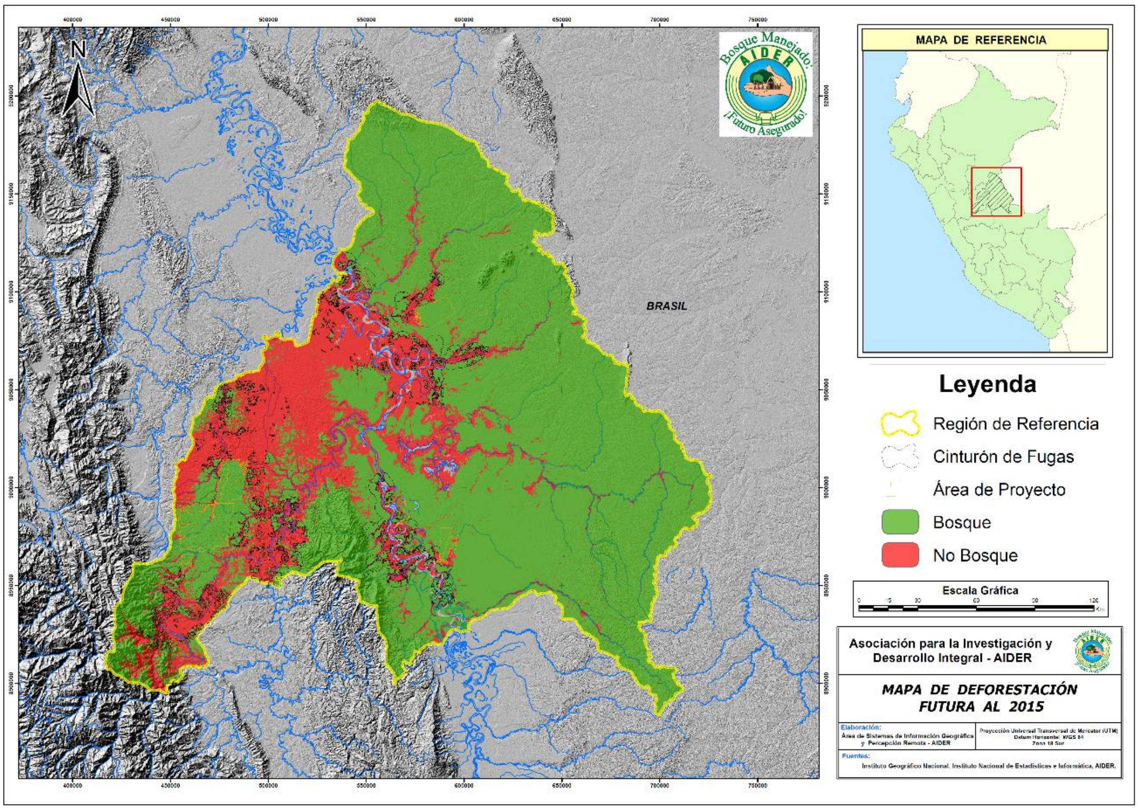


Figure 45. Map of future deforestation – 2015

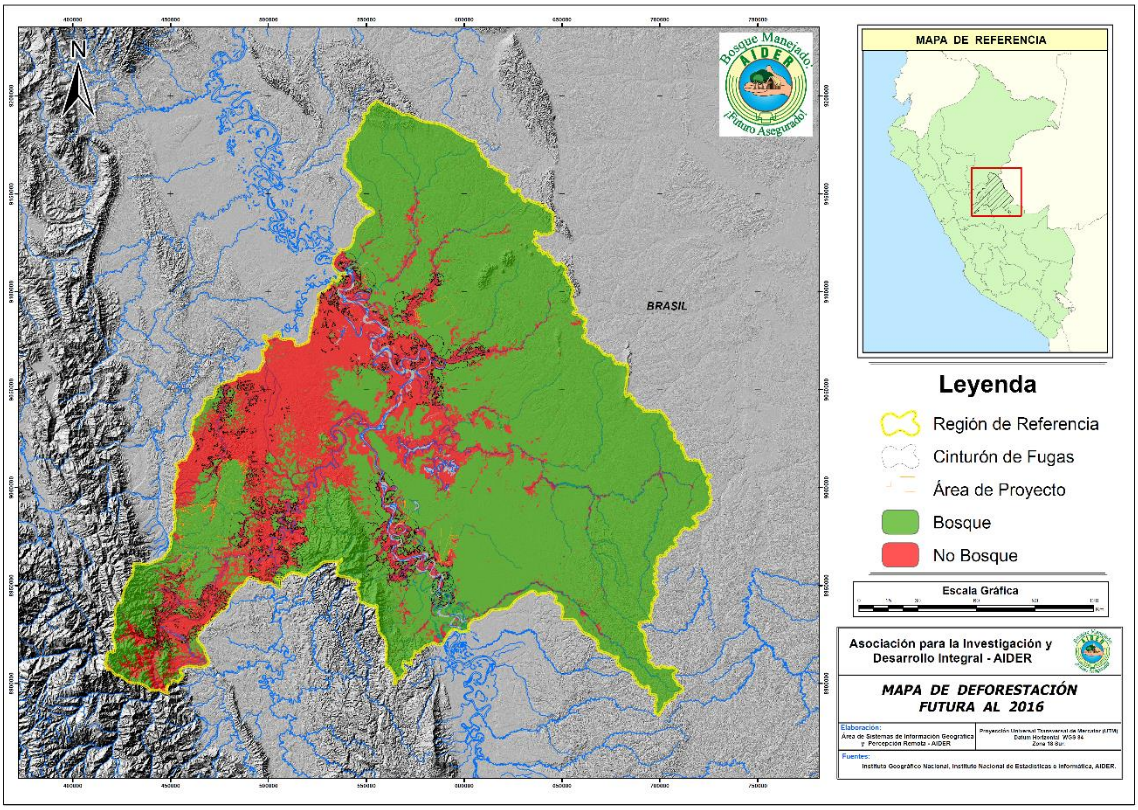


Figure 46. Map of future deforestation – 2016

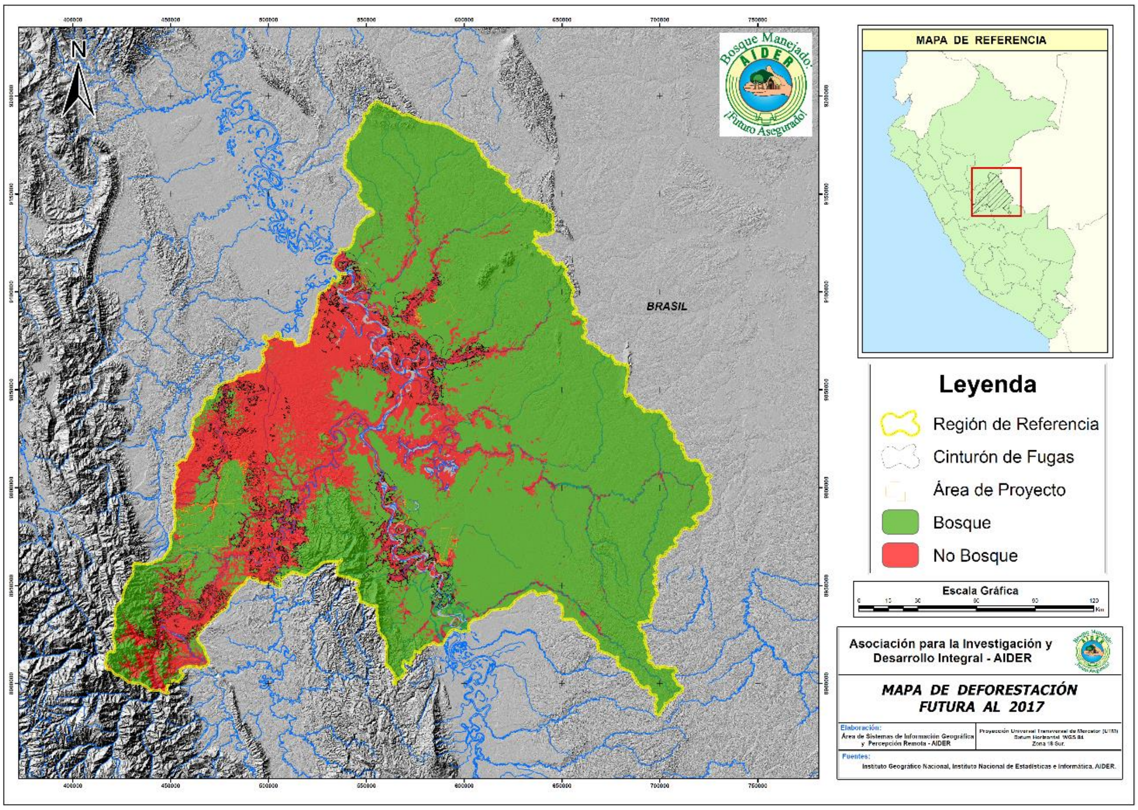


Figure 47. Map of future deforestation – 2017

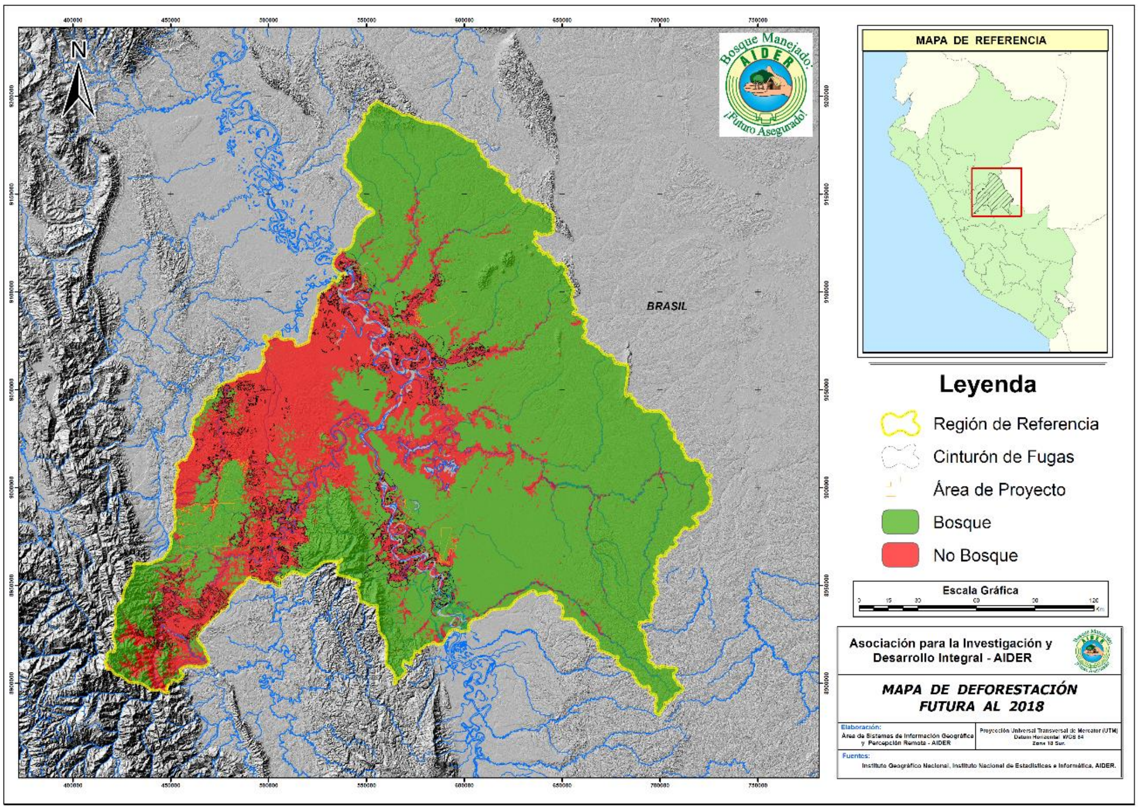


Figure 48. Map of future deforestation – 2018

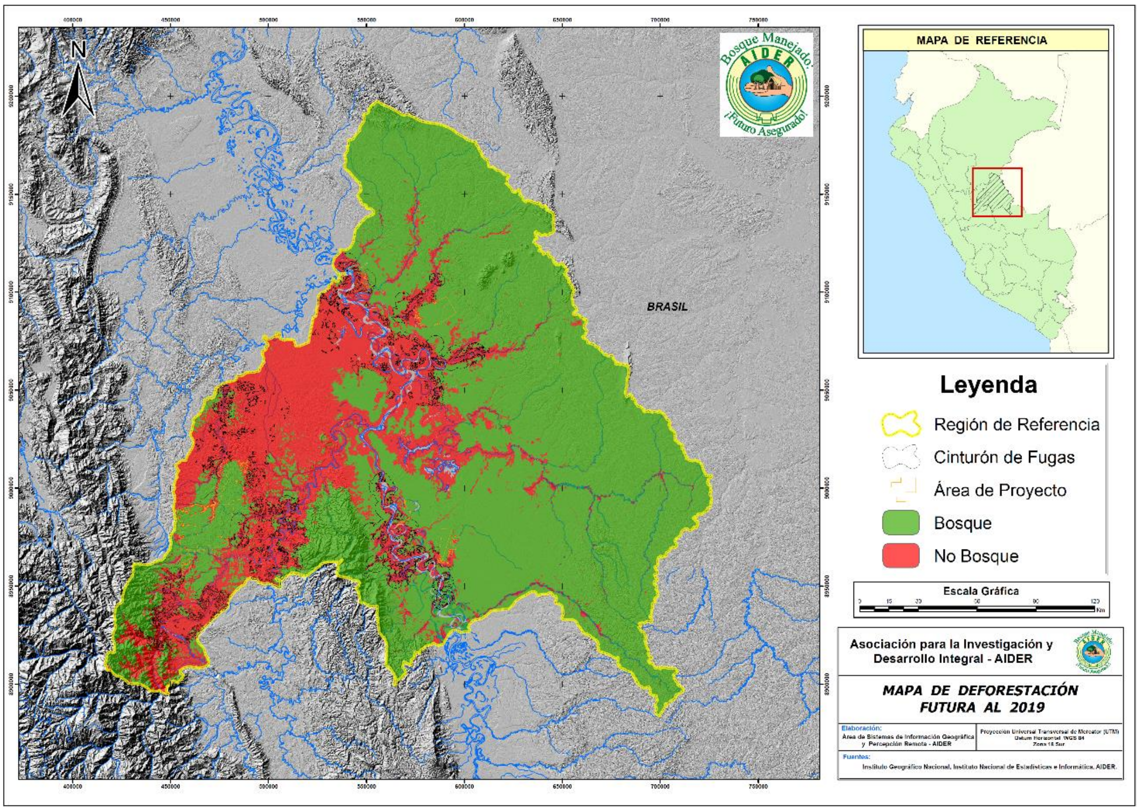


Figure 49. Map of future deforestation – 2019

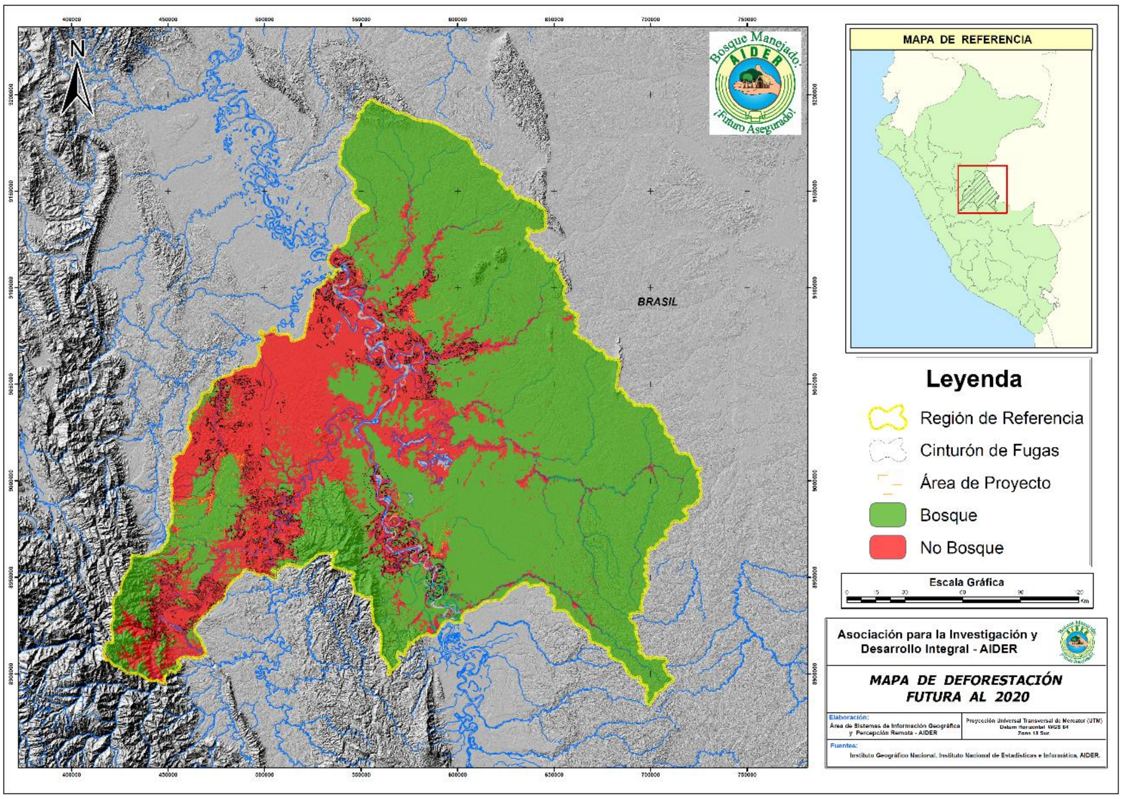


Figure 50. Map of future deforestation – 2020

Step 5. Definition of the land-use and land-cover change component of the baseline

5.1 Calculation of baseline activity per forest class

In order to evaluate the surface of each forest class inside the project area that will be deforested according to the reference scenario, we combined the maps of annual deforestation of the baseline for 2011-2020 with a map of the spatial distribution of the different types of forest in 2010. The results are shown in table 32.b and 32.c.

Table 32.b. Annual areas deforested per forest class, *icl* within the project area in the baseline case (see table 11b. – GHG-VM0015 calculation of emissions spreadsheet)

Area deforested per forest class *icl* within the project area							Total baseline deforestation in the project area	
IDicl>	1	2	3	4	5	6		
Name >	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	$ABSLPA_t$ annual	*ABSLPA* cumulative
Project year *t*	ha	ha	ha	ha	ha	ha	ha	ha
2010-2011	162.7	89.9	85.4	181.5	185.7	590.7	1,295.9	1,295.9
2011-2012	133.9	59.2	84.0	119.2	133.1	424.9	954.4	2,250.3
2012-2013	159.9	79.0	119.2	166.0	129.9	481.0	1,135.0	3,385.3
2013-2014	233.8	58.5	184.0	172.1	156.6	564.9	1,369.9	4,755.3
2014-2015	246.3	87.8	211.2	151.6	172.3	546.8	1,416.1	6,171.3
2015-2016	261.0	70.1	325.4	220.7	180.2	665.0	1,722.3	7,893.6
2016-2017	343.0	146.6	349.6	246.3	277.0	926.1	2,288.6	10,182.3
2017-2018	355.8	141.0	391.7	247.4	283.6	1,022.0	2,441.5	12,623.7
2018-2019	388.1	165.4	369.9	271.1	402.8	1,095.7	2,692.9	15,316.6
2019-2020	402.1	216.9	307.4	306.6	367.8	1,342.9	2,943.7	18,260.4

Table 32.c. Annual areas deforested per forest class, *icl* within the leakage belt in the baseline case (see table 11c. – GHG-VM0015 calculation of emissions)

	Areas deforested per forest class *icl* within the leakage belt area						Total baseline deforestation in the leakage belt area	
IDicl>	1	2	3	4	5	6	$ABSLPA_t$	$ABSLPA$
Name >	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	annual	cumulative
Project year *t*	ha	ha	ha	ha	ha	ha	ha	ha
2010-2011	492.0	461.1	152.0	366.6	309.8	677.5	2,459.0	2,459.0
2011-2012	308.3	374.8	95.4	275.5	246.8	520.5	1,821.3	4,280.3
2012-2013	388.1	352.3	130.8	349.3	218.1	657.5	2,095.9	6,376.2
2013-2014	436.2	395.3	95.9	365.9	320.3	593.2	2,206.8	8,583.1
2014-2015	489.5	451.5	143.2	422.9	316.1	731.1	2,554.3	11,137.4
2015-2016	493.2	473.7	148.2	423.8	363.9	840.0	2,742.8	13,880.2
2016-2017	530.5	492.8	159.0	359.9	368.9	858.9	2,770.0	16,650.2
2017-2018	657.5	482.2	232.8	330.3	426.9	952.8	3,082.4	19,732.6
2018-2019	654.8	458.9	309.3	289.4	431.3	932.6	3,076.4	22,809.0
2019-2020	696.0	404.4	290.5	299.2	452.7	835.7	2,978.6	25,787.6

5.2 Calculation of baseline activity data per post-deforestation class

Concerning the estimation of the information of the baseline activities, the two methods proposed in the methodology were analysed. We opted for method 1. The interpretation of Landsat images helped us to create the land-use and land-cover maps for the historical reference period. These images have a spatial resolution of approximately 30 meters, which allowed a precise distinction between the forest cover and “non-forest“ areas. Therefore, we were able to establish at least one zone for the different combinations of possible use of post-deforestation land-use (taking into consideration the historical location of the post-deforestation LU/LC classes – further details in point 2.4). The project considered two classes of non-forest land-use (“non-forest“ vegetation and bare soil), which would replace the forest vegetation. For this, we determined the proportion of these two classes that will constitute the areas that will be deforested.
Subsequently, we conducted an analysis based on the historical data (2000, 2005 and 2010) obtained by the coverage classification and land-use, and through the random forest methodology on segments (see point 2.4). For the three periods, we established a relation between the bare soil areas an the total of deforested areas. The same was done for the “non-forest“ vegetation areas and the total of deforested areas.

As a result, we obtained that the proportion of bare soil is equivalent to 2.42% of the deforested areas, while 97.58% represents the “non-forest“ vegetation.

The proportion found will serve as reference to deduce in which type of coverage and use could be transform the forest areas that for the initial date of the project are a total of 3,716,712.9 ha (considering the project area and the rest of the reference region that is forest).

Table 33 shows the surface of the zone and the area of each LU/LC post-deforestation class.

Table 33 Zones of the reference region encompassing different combinations of potential post-deforestation LU/LC classes (see table 12 – GHG-VM0015 calculation of emissions)

Zone		"Non-forest" vegetation		Bare soil		Total of all other LU/LC classes present in the Zone	
		IDf_{cl}	1	IDf_{cl}	2		
IDz	Name	Area (ha)	of Zone %	Area (ha)	of Zone %	Area (ha)	of Zone %
1	Zona 1	3,626,768.4	97.58%	89,944.5	2.42%	3,716,712.9	100.0%
Total area of each class *fcl*		3,629,741.8	97.58%	86,971.1	2.42%		

Thanks to the information generated in table 33, we were able to calculate the area that will be deforested in the project area and in the leakage belt. Tables 34b. and 34. show these calculations.

Table 34b. Annual areas deforested in each zone within the project area in the baseline case (see table 13b – GHG-VM0015 calculation of emissions spreadsheet)

Area established after deforestation per class fcl within the project area			Total baseline deforestation in the project area	
ID_{cl}	1	2		
Name >	Non-forest vegetationj	Bare soil	$ABSLRR_t$ annual	ABSLRR cumulative
Project year *t*	ha	ha	ha	ha
	97.58%	2.42%		
2010-2011	1,265	31	1,295.9	1,295.9
2011-2012	931	23	954.4	2,250.3
2012-2013	1,108	27	1,135.0	3,385.3
2013-2014	1,337	33	1,369.9	4,755.3
2014-2015	1,382	34	1,416.1	6,171.3
2015-2016	1,681	42	1,722.3	7,893.6
2016-2017	2,233	55	2,288.6	10,182.3
2017-2018	2,382	59	2,441.5	12,623.7
2018-2019	2,628	65	2,692.9	15,316.6
2019-2020	2,872	71	2,943.7	18,260.4

Table34. Annual areas deforested in each zone within the leakage belt in the baseline case (see table 13c – GHG-VM0015 calculation of emissions)

Area established after deforestation per class *fcl* within the leakage belt			Total baseline deforestation in the leakage belt	
ID$_{cl}$	1	2		
Name >	Non-forest vegetation	Bare soil	*ABSLRR$_t$* annual	*ABSLRR* cumulative
Project year *t*	ha	ha	ha	ha
	97.58%	2.42%		
2010-2011	2,400	60	2,459.0	2,459.0
2011-2012	1,777	44	1,821.3	4,280.3
2012-2013	2,045	51	2,095.9	6,376.2
2013-2014	2,153	53	2,206.8	8,583.1
2014-2015	2,492	62	2,554.3	11,137.4
2015-2016	2,676	66	2,742.8	13,880.2
2016-2017	2,703	67	2,770.0	16,650.2
2017-2018	3,008	75	3,082.4	19,732.6
2018-2019	3,002	74	3,076.4	22,809.0
2019-2020	2,907	72	2,978.6	25,787.6

5.3 Calculation of baseline activity data per LU/LC change category

Not applicable.

Step 6 : Estimation of baseline carbon stock changes and non CO_2 emissions

6.1 Estimation of baseline carbon stock change

6.1.1 Estimation of the average carbon stocks of each LU/LC classes

In 2011, we established the carbon inventories in the project area, being the first stage, which was then completed in 2012 and 2013. We measured a total of 104 field plots inside the forest areas. The field measurements were mainly focused on above-ground biomass, while below-ground biomass was estimated through the relation between above-ground/below-ground biomass. This relation was only used for the palmtrees such as huasai, ungurahui, aguajal, as well as for other types of palmtrees in general. For woody vegetation species, we used an allometric equation.

The allometric equations used to quantify the carbon stocks were obtained through the analysis of various sources of literature. This has allowed us to be sure that the information used was based on reliable sources. The equations that are shown in table 33 were used for the calculation of above-ground and below-ground biomass, as well as to indicate that those equations were used in carbon projects that were already validated according to standards such as the VCS. The methodology used in the carbon inventories and the estimations made for the quantification of above-ground and below-ground biomass are detailed in sub-annex D and in the spreadsheet of the carbon stock for each LU/LC class.

Table 35. Allometric equations used to measure the carbon stocks

Type of forest / grupo de especies	**Allometric equations**	**Source**
Aboveground biomass	$AGB = \rho x \exp(-1.499 + 2.148(\ln(D)) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3$	Chave et al. (2005)
Palms (Huasai)	$\mathrm{Biomass} = 6.666 + 12.826 * \mathrm{Ht}^{0.5} * \mathrm{Ln(Ht)}$	Pearson et al. (2005)
Palms	$\mathrm{Y} = 10.0 + 6.4 * \mathrm{TH}$	Fragi y Luyo. (1995)
Palms (Ungurahui)	$Y = 23.487 + 41.851 * (LN)Ht))^2$	Pearson *et al.* (2005)
Palms (Aguaje)	$\mathrm{Y} = 0.00006 * (Ht)^3 + 0.0046 * (Ht)^2 - 0.043 * (Ht) + 0.1259$	Freitas et al., 2006
Lianas	$Biomass = \exp(0.12 + 0.91 * Log(BA\ at\ dhb))$	Putz, F. (1983)
Species of Cecropia	$\mathrm{Biomass} = 12.764 + 0.2588 * (\mathrm{dbh})^{2.0515}$	Pearson et al. (2005)
Belowground biomass	$\mathrm{Biomass} = \exp(-1.0587 + 0.8836 * \mathrm{Ln\ (BSS)})$	Cairns et al. (1997)

We followed the criteria of the VM0015 v.1.1 methodology for the estimation of average carbon stocks for each LU/LC class. For a greater data reliability, the methodology recommends to conduct an uncertainty assessment as follows : *"If the uncertainty of the total average carbon stock (Ctotcl) of a class cl is less than 10% of the average value, the average carbon stock value can be used. If the uncertainty is higher than 10%, the lower boundary of the 90% confidence interval must be considered in the calculations if the class is an initial forest class in the project area or a final non-forest class in the leakage belt, and the higher boundary of the 90% confidence interval if the class is an initial forest class in the leakage belt or a final non-forest class in the project area."*
The results are shown in tables 36, 37 and 38. For more details, see the following documents : spreadsheet of the carbon stock for each LU/LC class and GHG-VM0015 calculation of emissions spreadsheet.

Table 36. Carbon stocks per hectare of initial forest classes *icl* existing in the project area and leakage belt

LU/LC Class		Average carbon stock per hectare ± 90% CI					
		Cab_{cl}		*Cbb_{cl}*		*$Ctot_{cl}$*	
		Average stock	± 90% CI	*Average stock*	± 90% CI	*Average stock*	± 90% CI
ID_{cl}	Name	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
1	Low hill forest	501.4	70.7	125.8	15.9	627.2	86.6
2	Average hill forest	355.3	104.1	93.0	31.5	448.3	135.6
3	Riverbank complex forest	492.6	204.5	129.6	54.1	622.2	258.6
4	Knoll forest	404.1	101.0	114.6	34.9	518.7	135.9
5	High terrace forest	382.2	109.8	122.8	29.5	505.0	139.3
6	Low terrace forest	297.7	55.3	75.3	13.4	373.0	68.8
7	Medium terrace forest	431.3	33.5	109.1	8.2	540.4	41.7

Table 37. Estimated values (see table 15a – GHG-VM0015 calculation of emissions spreadsheet)

Project year *t*	Initial forest class icl **Average carbon stock per hectare + 90% CI**																	
	IDicl= Low hill forest				***Ctot icl***		*IDicl= Average hill forest*				***Ctot icl***		*IDicl= Riverbank complex forest*				***Ctot icl***	
	Cabicl		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***			
	C stock t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}	*C stock* t CO$_2$e ha^{-1}	± 90% CI t CO$_2$e ha^{-1}
2010-2011	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2011-2012	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2012-2013	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2013-2014	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2014-2015	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2015-2016	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2016-2017	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2017-2018	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2018-2019	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6
2019-2020	501.4	70.7	125.8	15.9	627.2	86.6	355.3	104.1	93.0	31.5	448.3	135.6	492.6	204.5	129.6	54.1	622.2	258.6

IDicl= Knoll forest				***Ctot icl***		*IDicl= High terrace forest*				***Ctot icl***		*IDicl= Low terrace forest*				***Ctot icl***		*IDicl= Medium terrace forest*				***Ctot icl***	
Cabicl		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***			
C stock t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7
404.1	101.0	114.6	34.9	518.7	135.9	382.2	109.8	122.8	29.5	505.0	139.3	297.7	55.3	75.3	13.4	373.0	68.8	431.3	33.5	109.1	8.2	540.4	41.7

Table 38. Values to be used after discounts for uncertainties (see table 15b – GHG-VM0015 calculation of emissions spreadsheet)

Project year *t*	Initial forest class icl **Average carbon stock per hectare + 90% CI**													
	IDicl= Low hill forest				***Ctot icl***		*IDicl= Average hill forest*				***Ctot icl***		*IDicl= Riverbank complex forest*				***Ctot icl***	
	Cabicl		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***			
	C stock t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}
2010-2011	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2011-2012	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2012-2013	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2013-2014	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2014-2015	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2015-2016	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2016-2017	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2017-2018	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2018-2019	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6
2019-2020	501	430.7	126	109.9	627	540.6	355	251.2	93	61.5	448	312.7	493	288.1	130	75.5	622	363.6

IDicl= Knoll forest				***Ctot icl***		*IDicl= High terrace forest*				***Ctot icl***		*IDicl= Low terrace forest*				***Ctot icl***		*IDicl= Medium terrace*				***Ctot icl***	
Cabicl		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***				***Cabicl***		***Cbbicl***			
C stock t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	*C stock change* t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	C stock change t CO_2e ha^{-1}
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	
404	303.1	115	79.7	519	382.9	382	272.4	123	93.3	505	365.7	298	242.4	75	61.9	373	304.3	431		109		540	

The post-deforestation soil classes were established as : bare soil areas and non-forest vegetation (step 5, section 5.2). The carbon stock estimation of these classes, that will be projected to exist in the project area and in the leakage belt, were estimated according to the primary and secondary information from studies with similar features to this project. For the bare soil area, we determined that there was no carbon stock, according to analysis of historical land-use change that was conducted in the entire reference region area (step 2, section 2.4). To the case of non-forest vegetation areas, as well as the bare soil is also a product of the historical analysis of land-use change for the reference region (section 2.4, table 15). This analysis allowed the creation of a more detailed stratification of this class. Obtaining four classes as a result : secondary forest of 3 – 10 years, burned areas, pastures and cropland. The first stratum was considered like this, based on the reality of our amazonia where farmers leave the intervened areas to recover (secondary forest and/or young secondary forest) for a period of 3, 5 or 10 years, in order to cut down trees and partially burn the area, according to specific agricultural goals.

Table 39. Estratification of non-forest vegetation

Non –forest vegetation	Area (ha)	%
Secondary forest of 3-10 years	560,018.2	62.2
Burned areas	1,673.8	0.2
Pastures	204,814.5	22.7
Cropland	133,855.2	14.9
Total	**900,361.7**	**100.0**

To the stablished four stratus was made a research of carbon content bibliographic sources, in the case of the secondary forest stratum 3 – 10 years, was found information of carbon content from different ages for a better stratum representativity. With the information obtained was made a calculation of a weighted average for the secondary forest atratum 3 – 10 years, the calculation was made in fuction of the percentage surface of 62,2% with the establishes carbon content for the startum. In tables x, y and z are shown the results obtained.

Table 40. Carbon content of the secondary youth forest stratum of 3 – 10 years

Stratums	Aerial reservoir (tnC/ha)	Aerial reservoir (tCO$_2$/ha)	Underground reservoir (tnC/ha)	Underground reservoir (tCO$_2$/ha)	Source
Secondary youth forest (5 to 10 years)	29.89	109.60	9.14	33.51	Inventario de post-deforestación en bosque secundario de CCNN Infierno
Secondary forest of 5 years	42.1	154.37	1.66	6.09	Julio Alegre y Luis Arévalo ”Reservas de Carbono según el uso de la tierra en dos sitios de la Amazonia Peruana”
Secondary forest of 3 years	13.02	47.74	0.28	1.03	

Table 41. Weighted carbon content of the secondary youth forest of 3 – 10 years

Aerial reservoir (tnCO$_2$/ha)	Underground reservoir (tCO$_2$/ha)
103.90	13.54

Table 42. Carbon content of the stratums of pastures and croplands

Stratums	Aerial reservoir (tnC/ha)	Aerial reservoir (tCO$_2$/ha)	Underground reservoir (tnC/ha)	Underground reservoir (tCO$_2$/ha)	Source
Pastures	2.42	8.87	0.68	2.49	Julio Alegre y Luis Arévalo ”Reservas de Carbono según el uso de la tierra en dos sitios de la Amazonia Peruana”
Croplands	6.69	13.53	0.72	2.64	

With the calculations per each startum we porceeded to stimate the carbon stock of the post-deforestation class (non-forest vegetation). As well as for the secondary forest stratum was made a calculation of a weighted average in function of the percentages of each stratum areas with the carbon contents, having as a reult the average carbon stock of the post-deforestation class. According to the methodology an increase of 30% due the use of bibliographic sources was made, which was applied and the result was used in the calculation of the baseline.

Tabla 43. Weighted average and increase

Reservoirs	Weighted average		30% of the Weighted average	Increased value in 30%
Aerial (tCO$_2$-e)	Xi	**68.7**	20.60	89.3
Underground (tCO$_2$-e)	Yi	**9.4**	2.81	12.2

In tables 45 and 46 are shown the results. For more detail see files: spreadsheet of carbon stock per each LU/LC class and a spreadsheet of the calculation of GHG emissions – VM0015.

Table 45. Average carbon stocks per hectare long term (20-years) of LU/LC classes present in the reference region (see table 16 – GHG-VM0015 calculation of emissions spreadsheet)

Project year t	Post-deforestation class *fcl* **Average carbon stock per hectare + 90% CI**											
	IDicl = "Non-forest" vegetation				***Ctot icl***		*Idicl = Bare soil*				***Ctot icl***	
	Cabicl		***Cbbicl***				***Cabicl***		***Cbbicl***			
	C stock t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}	*C stock* t CO_2e ha^{-1}	± 90% CI t CO_2e ha^{-1}
Average to be used in calcultations (10 years "baseline")	89.3		12.20		101.5		0		0		0	

Table 46. Long-term (20-years) average carbon stocks per zone (see table 17 – GHG-VM0015 calculation of emissions spreadsheet)

Zone		Post-deforestation LU/LC-classes *fcl* **Average carbon stock per hectare + 90% CI**					
		Idicl = "Non-forest" vegetation		*Idicl = Bare soil*		Area weighted long-term (10 years) average carbon stocks per zone z	
Idz	Name	***Cabicl*** *C stock* t CO_2e ha^{-1}	***Cbbicl*** *C stock* t CO_2e ha^{-1}	***Cabicl*** *C stock* t CO_2e ha^{-1}	***Cbbicl*** *C stock* t CO_2e ha^{-1}	***Cabicl*** *C stock* t CO_2e ha^{-1}	***Cbbicl*** *C stock* t CO_2e ha^{-1}
1	Zone 1	89.3	12.20	0	0	89.3	12.20

6.1.2 Calculation of carbon stock change factors

The project did not consider the soil organic carbon. Therefore, tables 18a, 18b, 19a, 19b and 19c of the VM0015 methodology do not apply to the project.

6.1.3 Calculation of baseline carbon stock changes

The changes in the baseline carbon stock is calculated according to the following formula, based on the applicability of method 1 mentioned in step 5.

$$\Delta CBSLPA_t = \sum_{p=1}^{P}\left(\sum_{icl=1}^{Icl} ABSLPA_{icl,t} * \Delta Cp_{icl,t=t*} - \sum_{z=1}^{Z} ABSLPA_{z,t} * \Delta Cp_{z,t=t*}\right)$$

Where:

$\Delta \boldsymbol{CBSLPA_t}$: Total baseline carbon stock change within the project area at year *t*; tCO2-e

$\boldsymbol{ABSLPA_{icl,t}}$: Area of initial forest class *icl* deforested at time *t* within the project area in the baseline case; ha

$\Delta \boldsymbol{Cp_{icl,t=t*}}$: Average carbon stock change factor for carbon pool *p* in the initial forest class *icl applicable* at time *t* (as per Table 20.b); tCO2-e ha-1

$\boldsymbol{ABSLPA_{z,t}}$: Area of the zone *z* "deforested" at time *t* within the project area in the baseline case; ha

$\Delta \boldsymbol{Cp_{z,t=t*}}$: Average carbon stock change factor for carbon pool *p* in zone *z* applicable at time *t* = *t** (= 2^{nd} year after deforestation, as per Table 20.b); tCO2-e ha-1

$\boldsymbol{icl}$: 1, 2, 3 … *Icl* initial (pre-deforestation) forest classes; dimensionless

$\boldsymbol{Z}$: 1, 2, 3 … *Z* zones; dimensionless

$\boldsymbol{p}$: 1, 2, 3 … *P* carbon pools included in the baseline; dimensionless

$\boldsymbol{t}$: 1, 2, 3 … *T,* the year of the proposed project crediting period; dimensionless

$\boldsymbol{t^*}$: the year at which the area *ABSLPAicl,t* is deforested in the baseline case.

The results are shown in tables 39, 40, 41 and 42.

Table 47. Coefficients of variation of carbon stocks for icl initial forest classes (Method 1) (see table 20a – GHG-VM0015 calculation of emissions spreadsheet)

Year after deforestation		***Low hill forest***		***Medium hill forest***		***Riverbank complex forest***		***Knoll forest***		***High terrace forest***		***Low terrace forest***		***Medium terrace forest***	
		$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$	$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$
2010-2011	t*	430.7	11.0	251.2	6.2	288.1	7.5	303.1	8.0	272.4	9.3	242.4	6.2	431.3	10.9
2011-2012	t*+1		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2012-2013	t*+2		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2013-2014	t*+3		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2014-2015	t*+4		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2015-2016	t*+5		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2016-2017	t*+6		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2017-2018	t*+7		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2018-2019	t*+8		11.0		6.2		7.5		8.0		9.3		6.2		10.9
2019-2020	t*+9		11.0		6.2		7.5		8.0		9.3		6.2		10.9

Table 48. Coefficients of variation of carbon stocks for fcl or zone z final forest classes (Method 1) (see table 20b – GHG-VM0015 calculation of emissions spreadsheet)

Year after deforestation		$\Delta Cab_{cl,t}$	$\Delta Cbb_{cl,t}$
2010-2011	t*	8.9	1.2
2011-2012	t*+1	8.9	1.2
2012-2013	t*+2	8.9	1.2
2013-2014	t*+3	8.9	1.2
2014-2015	t*+4	8.9	1.2
2015-2016	t*+5	8.9	1.2
2016-2017	t*+6	8.9	1.2
2017-2018	t*+7	8.9	1.2
2018-2019	t*+8	8.9	1.2
2019-2020	t*+9	8.9	1.2

Table 49. Carbon stock change in the baseline of above-ground biomass in the project area (see table 21.b.1 – GHG-VM0015 calculation of emissions spreadsheet)

Carbon stock changes in the above-ground biomass per initial forest class *icl*							Total carbon stock change in the above-ground biomass of the initial forest classes in the project area	
Idicl> Name >	1	2	3	4	5	6		
	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	$\Delta CabBSLPA_{cl,t}$ Annual	$\Delta CabBSLPA_{cl}$ Cumulative
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	70,074.0	22,569.4	24,606.8	49,455.2	45,003.4	254,747.5	466,456.3	466,456.3
2011-2012	57,673.3	14,864.3	24,209.7	32,481.6	32,272.9	183,260.1	344,762.0	811,218.3
2012-2013	68,852.0	19,843.3	34,335.0	45,230.4	31,499.1	207,433.3	407,193.1	1,218,411.4
2013-2014	100,715.7	14,696.5	53,014.5	46,886.4	37,964.0	243,599.2	496,876.4	1,715,287.7
2014-2015	106,090.8	22,050.3	60,841.7	41,302.6	41,776.4	235,815.1	507,877.0	2,223,164.7
2015-2016	112,420.7	17,603.0	93,744.8	60,118.2	43,673.6	286,787.8	614,348.1	2,837,512.8
2016-2017	147,718.8	36,821.7	100,724.7	67,110.2	67,148.9	399,375.6	818,899.9	3,656,412.8
2017-2018	153,240.7	35,414.3	112,850.0	67,395.6	68,741.4	440,741.7	878,383.7	4,534,796.5
2018-2019	167,166.6	41,545.0	106,563.4	73,844.7	97,638.4	472,512.7	959,270.8	5,494,067.3
2019-2020	173,184.9	54,485.3	88,575.8	83,510.5	89,148.0	579,153.9	1,068,058.4	6,562,125.6

Idicl>	**Carbon stock change in above-ground biomass per post-deforestation zone Z**		Total carbon stock change in the above-ground biomass of post-deforestation zone in the project area		Total net carbon stock change in the above-ground biomass of the project area	
Name >	Non-forest vegetation	Bare soil	$\Delta CabBSLPAz_{,t}$ Annual	$\Delta CabBSLPAz$ Acumulativo	$\Delta CabBSLPAz_{,t}$ Annual	$\Delta CabBSLPAz$ Acumulativo
Project year *t*	t CO_2e		t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	11,286.1	-	11,286.1	11,286.1	455,170.2	455,170.2
2011-2012	19,598.5	-	19,598.5	30,884.5	325,163.6	780,333.8
2012-2013	29,483.6	-	29,483.6	60,368.1	377,709.5	1,158,043.3
2013-2014	41,414.8	-	41,414.8	101,782.9	455,461.6	1,613,504.9
2014-2015	53,747.5	-	53,747.5	155,530.4	454,129.4	2,067,634.3
2015-2016	68,747.8	-	68,747.8	224,278.2	545,600.4	2,613,234.7
2016-2017	88,679.9	-	88,679.9	312,958.0	730,220.1	3,343,454.7
2017-2018	109,943.1	-	109,943.1	422,901.1	768,440.6	4,111,895.3
2018-2019	133,396.5	-	133,396.5	556,297.7	825,874.3	4,937,769.6
2019-2020	159,034.2	-	159,034.2	715,331.9	909,024.2	5,846,793.8

Table 50. Carbon stock change in the baseline of above-ground biomass in the project area (see table 21.b.2 – GHG-VM0015 calculation of emissions spreadsheet)

Idicl>	**Carbon stock changes in the below-ground biomass per initial forest class *icl***						Total carbon stock change for below-ground biomass of the initial forest classes in the project area	
	1	2	3	4	5	6		
Name >	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	$\Delta CbbBSLPA_{cl,t}$ Annual	$\Delta CbbBSLPA_{cl}$ Acumulativo
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	1,788.3	553.0	644.6	1,693.5	1,148.7	6,445.1	12,273.2	12,273.2
2011-2012	3,260.1	917.2	1,278.8	2,805.8	1,972.5	11,081.6	21,316.0	33,589.3
2012-2013	5,017.2	1,403.4	2,178.2	4,354.7	2,776.5	16,329.7	32,059.7	65,648.9
2013-2014	7,587.4	1,763.5	3,567.0	5,960.2	3,745.5	22,492.8	45,116.5	110,765.4
2014-2015	10,294.9	2,303.8	5,160.8	7,374.6	4,811.9	28,458.9	58,404.8	169,170.2
2015-2016	13,163.8	2,735.1	7,616.5	9,433.2	5,926.6	35,714.7	74,590.0	243,760.2
2016-2017	16,933.6	3,637.3	10,255.0	11,731.3	7,640.6	45,818.9	96,016.8	339,777.0
2017-2018	20,844.3	4,505.0	13,211.2	14,039.2	9,395.2	56,969.7	118,964.7	458,741.8
2018-2019	25,110.4	5,523.0	16,002.8	16,567.9	11,887.5	68,924.4	144,015.8	602,757.6
2019-2020	29,530.0	6,858.0	18,323.1	19,427.6	14,163.0	83,577.0	171,878.6	774,636.2

Idicl>	**Carbon stock change for below-ground biomass per post-deforestation zone Z**		Total carbon stock change for below-ground biomass of the initial forest classes in the project area		Total net carbon stock change for below-ground biomass of the project area	
Name >			$\Delta CbbBSLPAz_{,t}$	$\Delta CbbBSLPAz$	$\Delta CbbBSLPAz_{,t}$	$\Delta CbbBSLPAz$
	Non-forest vegetation	Bare soil	Annual	Acumulativo	Annual	Acumulativo
Project year *t*	t CO_2e		t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	1,542.4	-	1,542.4	1,542.4	10,730.8	10,730.8
2011-2012	2,678.4	-	2,678.4	4,220.8	18,637.6	29,368.4
2012-2013	4,029.4	-	4,029.4	8,250.2	28,030.3	57,398.7
2013-2014	5,659.9	-	5,659.9	13,910.2	39,456.5	96,855.3
2014-2015	7,345.4	-	7,345.4	21,255.6	51,059.4	147,914.7
2015-2016	9,395.4	-	9,395.4	30,651.0	65,194.6	213,109.2
2016-2017	12,119.4	-	12,119.4	42,770.4	83,897.4	297,006.6
2017-2018	15,025.4	-	15,025.4	57,795.8	103,939.4	400,946.0
2018-2019	18,230.6	-	18,230.6	76,026.4	125,785.2	526,731.2
2019-2020	21,734.4	-	21,734.4	97,760.8	150,144.2	676,875.4

6.2 Baseline non-CO_2 emissions from forest fires

Non-CO2 emissions from forest fires baseline was omitted, because they do not have information available of wildfire in the reference historical period. Being that, the project is being conservative.

Step 7. *Ex ante* estimation of actual carbon stock changes and non-CO_2 emissions in the project area

7.1 *Ex ante* estimation of actual carbon stock changes

7.1.1 *Ex ante* estimation of actual carbon stock changes due to planned activities

- Significant decrease in carbon stock due to project activities

  The main part of the project activities are conducted in the leakage management areas. The main activity that will be conducted within the project area will be the community forest management (only timber extraction), which includes a forest management plan for each community.

  We used the tool A/R of MDL for the significance assessment of the GHG emissions coming from the community forest management. The results were not significant as there were lower than 5%. Thus, these emissions were not accounted for in the ex-ante estimations. The calculation was done with existing information based on timber extraction, over the historical period 2003 – 2012. We expect the same amount of harvesting in the project scenario. For more details, see spreadsheet of MDL A/R tool.

Additionally, there will be no coal production or firewood collection inside the project area. This statement is based, because neither of these activities is in the project area. In the case of firewood the 7 native communities use it to meet its energy needs. Firewood is collected from areas considered "purma" or secondary forest (forest vegetation in the case of the project), surfaces that are not within the project area.

- Significant increase in carbon stock due to project activities

  The forests in the project area are managed in a sustainable manner under management plans that existed already before the beginning of the project. One of the activities that allow the areas affected by the sustainable forest harvesting to recover is the development of native species in the area. Activities which involve forest management such as this one will help expand the forest coverage as the project is being developed. Therefore, it is conservative not to consider possible increases in carbon stocks in the project scenario.

7.1.2 *Ex ante* estimation of carbon stock changes due to unavoidable unplanned deforestation within the project area

The emission reductions generated by the project will be determined through ex-post measurements – which are the result of the monitoring plan. According to the methodology requirements, the *ex-ante* projections will be estimated according to an estimated value (Effectiveness Index – IE), (1-IE) that varies from 0 (no effectiveness) to 1 (maximum effectiveness) and that will be multiplied by the baseline projections.

The "IE" was estimated according to the project activities, mainly of the activity of community forest management and monitoring of community forests to avoid invasions and illegal logging. The activity of community forest management contemplated a IE value of 57%, this percentage was calculated in function to the project area and to the forest managed areathat the coummunities has established.to the percentage of 57% was added a 20% of the communal monitoring on the wood and the communal forest utilization to avoid invasions and illegal logging, all these reached 77% which was the IE by 2010. As other activities stated in the REDD+ strategy will be implemented, the IE will gradually increase by 5% for each year until it reaches 97%, which was maintained until the end of the first crediting period. This 97% will be obtained with the effectiveness of the implementation of activities.

Table 51. Determination of the effectiveness index

Native communities	Project area (forest)	Management area (ha)	Management area (%)	
Sinchi Roca	27,627.4	21,153.4	17	
Calleria	3,718.8	2,528.4	2	
Roya	4,165.8	3,000.3	2	
Curiaca	5,901.9	2,500.3	2	
Puerto Nuevo	61,517.5	28,150.5	22	
Pueblo Nuevo	4,422.4	2,839.9	2	
Flor de Ucayali	19,650.2	12,500.3	10	
Total	**127,004.0**	**72,673.0**	**57**	
			20	Communal monitoring of the wood and communal forest utilization to avoid

	invasions and illegal logging.
77%	**IE**

Table 52. increase of the effectiveness index

Projected years	**Effectiveness index (IE)**
2010-2011	**0.77**
2011-2012	0.82
2012-2013	0.87
2013-2014	0.92
2014-2015	0.97

For more details on the IE estimation, see methodological factors and effectiveness index spreadsheets.

7.1.3 *Ex ante* estimated net actual carbon stock changes in the project area

The results of the previous assessments are summarised in table 53.

Table 53. *Ex ante* estimated net carbon stock change in the project area under the project scenario (see table 27 – GHG-VM0015 calculation of emissions)

Project year *t*	Total carbon stock decrease due to planned activities		Total carbon stock increase due to planned activities		Total carbon stock decrease due to unavoided unplanned deforestation		Total carbon stock change in the project case	
	annual $\Delta CPAdPA_t$ tCO$_2$-e	cumulative $\Delta CPAdPA$ tCO$_2$-e	annual $\Delta CPAiPA_t$ tCO$_2$-e	cumulative $\Delta CPAiPA$ tCO$_2$-e	annual $\Delta CUDdPA_t$ tCO$_2$-e	cumulative $\Delta CUDdPA$ tCO$_2$-e	annual $\Delta CPSPA_t$ tCO$_2$-e	cumulative $\Delta CPSPA$ tCO$_2$-e
2010-2011	0	0	0	0	107,157.24	107,157.2	107,157.2	107,157.2
2011-2012	0	0	0	0	61,884.21	169,041.5	61,884.2	169,041.5
2012-2013	0	0	0	0	52,746.18	221,787.6	52,746.2	221,787.6
2013-2014	0	0	0	0	39,593.45	261,381.1	39,593.4	261,381.1
2014-2015	0	0	0	0	15,155.66	276,536.7	15,155.7	276,536.7
2015-2016	0	0	0	0	18,323.85	294,860.6	18,323.8	294,860.6
2016-2017	0	0	0	0	24,423.52	319,284.1	24,423.5	319,284.1
2017-2018	0	0	0	0	26,171.40	345,455.5	26,171.4	345,455.5
2018-2019	0	0	0	0	28,549.78	374,005.3	28,549.8	374,005.3
2019-2020	0	0	0	0	31,775.05	405,780.3	31,775.1	405,780.3

7.2 *Ex ante* estimation of actual non-CO2 emissions from forest fire

Not applicable

Step 8. *Ex ante* estimation of leakage

8.1 *Ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures

8.1.1 Carbon stock changes due to activities implemented in leakage management areas

The leakage management areas are deforested and degraded areas that are located in the boundaries of the project area. In these areas, activities such as productive agriculture (which is mainly used for survival) and, on a smaller scale, bovine cattle-raising are being developed. Therefore, the baseline for these areas is considered as “non-forestry“ and the carbon variation is non-existent.

The leakage prevention activities, according to the project scenario, are: agroforestry, silvipastoral activities, good livestock practice, and the improvement of traditional agriculture. These activities should allow an increase in the carbon stocks in the leakage management areas, in comparison to the baseline. Nevertheless, we are assuming – in a conservative way – that the leakage management areas will remain “non-forest“ lands, and that the carbon stocks will remain unchanged during the time span of the project.

8.1.2 Emissions of methane (CH4) and nitrous oxide (N2O) of grazing animals

There will not be an intensification of livestock rearing, by contrast, which looks to the project in the future is to decrease it, for it will be carried silvopastoral activities and good farming practices, with the existing breeding, in order to not intensify. Therefore it is not considering emissions as a result of grazing.

8.1.3. Total *ex ante* estimation of carbon stock changes and increases in GHG emissions due to leakage prevention measures

There is no significant increase in the GHG emissions due to the leakage prevention measures.

8.2 *Ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage.

The *ex-ante* estimation of the decrease of carbon stocks in the leakage belt baseline scenario is the same as the one mentioned in step 6.1.3. The calculations estimated in the *ex-ante* assessment of the leakage belt baseline are shown in tables 54 and 55.

Table 54. Carbon stock change in the above-ground biomass in the leakage belt (see table 21.c.1 – GHG-VM0015 calculation of emissions)

Carbon stock changes in the above-ground biomass per initial forest class *icl*							Total carbon stock change in the above-ground biomass of the initial forest classes in the project area	
IdIcl>	1	2	3	4	5	6		
Name >	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	$\Delta CabBSLPA_{cl,t}$ Annual	$\Delta CabBSLPA_{cl}$ Acumulativo
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	211,881.4	115,804.3	43,790.3	99,879.8	75,104.7	292,184.8	838,645.3	838,645.3
2011-2012	132,772.0	94,127.6	27,476.4	75,051.3	59,833.6	224,482.5	613,743.4	1,452,388.7
2012-2013	167,136.7	88,486.5	37,678.6	95,153.0	52,854.7	283,534.2	724,843.6	2,177,232.3
2013-2014	187,862.2	99,293.2	27,641.3	99,672.0	77,634.0	255,819.0	747,921.7	2,925,154.0
2014-2015	210,810.5	113,406.7	41,267.2	115,215.1	76,609.6	315,292.0	872,601.1	3,797,755.2
2015-2016	212,434.6	118,967.6	42,711.1	115,441.8	88,215.0	362,249.7	940,019.9	4,737,775.0
2016-2017	228,479.6	123,776.7	45,823.6	98,039.6	89,417.0	370,407.7	955,944.2	5,693,719.2
2017-2018	283,171.8	121,111.7	67,061.4	89,977.1	103,475.7	410,900.4	1,075,698.2	6,769,417.4
2018-2019	282,004.7	115,265.0	89,126.7	78,850.2	104,540.7	402,191.2	1,071,978.5	7,841,395.9
2019-2020	299,780.9	101,579.5	83,711.8	81,507.3	109,727.4	360,422.0	1,036,728.9	8,878,124.9

Idicl>	**Carbon stock change in above-ground biomass per post-deforestation zone Z**		Total carbon stock change in the above-ground biomass of the initial forest classes in the project area	
Name >			$\Delta CabBSLPAz_{,t}$	$\Delta CabBSLPAz$
	Non-forest vegetation	Bare soil	Annual	Acumulativo
Project year *t*	t CO_2e		t CO_2e	t CO_2e
2010-2011	21,416.2	-	21,416.2	21,416.2
2011-2012	37,278.2	-	37,278.2	58,694.4
2012-2013	55,532.3	-	55,532.3	114,226.7
2013-2014	74,751.9	-	74,751.9	188,978.7
2014-2015	96,998.1	-	96,998.1	285,976.7
2015-2016	120,886.0	-	120,886.0	406,862.8
2016-2017	145,010.9	-	145,010.9	551,873.7
2017-2018	171,856.4	-	171,856.4	723,730.1
2018-2019	198,649.2	-	198,649.2	922,379.3
2019-2020	224,591.0	-	224,591.0	1,146,970.3

Total net carbon stock change in the above-ground biomass of the project area	
$\Delta CabBSLPAz_{,t}$	$\Delta CabBSLPAz$
Annual	Acumulativo
t CO_2e	t CO_2e
817,229.1	817,229.1
576,465.2	1,393,694.3
669,311.3	2,063,005.6
673,169.8	2,736,175.4
775,603.1	3,511,778.5
819,133.8	4,330,912.3
810,933.3	5,141,845.5
903,841.8	6,045,687.3
873,329.3	6,919,016.6
812,137.9	7,731,154.6

Table 55. Baseline carbon stock change in the below-ground biomass in the leakage belt (see table 21.c.2 – GHG-VM0015 calculation of emissions)

Carbon stock changes for below-ground biomass per initial forest class *icl*							Total carbon stock change for below-ground biomass of the initial forest classes in the project area	
Idicl>	1	2	3	4	5	6		
Name >	Low hill forest	Average hill forest	Riverbank complex forest	High terrace forest	Low terrace forest	Medium terrace forest	$\Delta CbbBSLPA_{cl,t}$ Annual	$\Delta CbbBSLPA_{cl}$ Acumulativo
Project year *t*	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	5,407.2	2,837.5	1,147.1	3,420.2	1,917.0	7,392.3	22,121.4	22,121.4
2011-2012	8,795.5	5,143.8	1,866.9	5,990.3	3,444.3	13,071.7	38,312.5	60,433.83
2012-2013	13,060.8	7,311.9	2,853.9	9,248.6	4,793.4	20,245.2	57,513.9	117,947.69
2013-2014	17,855.1	9,744.8	3,578.0	12,661.8	6,775.0	26,717.4	77,332.0	195,279.72
2014-2015	23,234.9	12,523.5	4,659.0	16,607.1	8,730.5	34,694.3	100,449.4	295,729.10
2015-2016	28,656.2	15,438.4	5,777.9	20,560.3	10,982.2	43,859.3	125,274.3	421,003.39
2016-2017	34,487.0	18,471.2	6,978.3	23,917.5	13,264.5	53,230.6	150,349.2	571,352.57
2017-2018	41,713.5	21,438.7	8,735.0	26,998.6	15,905.8	63,626.5	178,418.1	749,770.66
2018-2019	48,910.3	24,263.0	11,069.7	29,698.7	18,574.2	73,801.9	206,317.8	956,088.45
2019-2020	56,560.6	26,751.9	13,262.6	32,489.8	21,375.0	82,920.6	233,360.6	1,189,449.03

Idicl>	**Carbon stock change for below-ground biomass per post-deforestation zone Z**		Total carbon stock change for below-ground biomass of the initial forest classes in the project area		Total net carbon stock change for below-ground biomass of the project area	
Name >			$\Delta CbbBSLPAz_{,t}$ Annual	$\Delta CbbBSLPAz$ Acumulativo	$\Delta CbbBSLPAz_{,t}$ Annual	$\Delta CbbBSLPAz$ Acumulativo
	Non-forest vegetation	Bare soil				
Project year *t*	t CO_2e		t CO_2e	t CO_2e	t CO_2e	t CO_2e
2010-2011	2,926.8	-	2,926.8	2,926.8	19,194.5	19,194.5
2011-2012	5,094.6	-	5,094.6	8,021.47	33,217.9	52,412.4
2012-2013	7,589.3	-	7,589.3	15,610.8	49,924.5	102,336.9
2013-2014	10,216.0	-	10,216.0	25,826.8	67,116.1	169,453.0
2014-2015	13,256.2	-	13,256.2	39,083.0	87,193.1	256,646.1
2015-2016	16,520.9	-	16,520.9	55,603.9	108,753.4	365,399.5
2016-2017	19,817.9	-	19,817.9	75,421.8	130,531.3	495,930.8
2017-2018	23,486.7	-	23,486.7	98,908.5	154,931.3	650,862.1
2018-2019	27,148.4	-	27,148.4	126,056.9	179,169.4	830,031.5
2019-2020	30,693.7	-	30,693.7	156,750.6	202,666.9	1,032,698.4

Nevertheless, the *ex-ante* leakage due to the displacement of activities can only be estimated based on the effectiveness combined with the proposed leakage prevention measures and project activities. Moreover, the methodology mentions the need for defining a “Displacement Leakage Factor“ (DLF). This factor is a percentage of expected deforestation to be moved outside the project boundary. This requires a multidisciplinary group of experts knowledgeable in the area of influence of the project and a percentage of the actors that participate in the prevention of leaks. This was done in order to analyze and to establish this factor, which is part of the methodological process. The analysis resulted in the participation to prevent leakage will be 92.8%, leaving 7.2% of the population would not take a part in the activities promoted by the project to prevent leakage.

Table 56. Leakage displacement factor

Deforestatiosn threats (deforestation agent)	**Relative importance of the deforestation agent (%)**	**Leakage factor displacements (%)**	**Weighted of the leakage factor displacement (%)**
Farmers	80	8	6.4
Rancherss	5	4	0.2
Illegal loggers (opening of roads)	10	5	0.5
Cocaleros	3	2	0.06
Artisanal miners (alluvial))	2	2	0.04
			7.2
			0.072

Table 57. *Ex ante* estimation of leakage due to activity displacement (see table 34 – GHG-VM0015 calculation of emissions spreadsheet)

Project year *t*	Total *ex ante estimated* decrease in carbon stocks due to displaced deforestation		Total *ex ante estimated* increase in GHG emissions due to displaced forest fires	
	annual $\Delta CADLK_t$ tCO$_2$-e	cumulative $\Delta CADLK$ tCO$_2$-e	annual $EADLK_t$ tCO$_2$-e	cumulative $EADLK$ tCO$_2$-e
2010-2011	33,544.9	33,545	0	0
2011-2012	24,753.7	58,299	0	0
2012-2013	29,213.3	87,512	0	0
2013-2014	35,634.1	123,146	0	0
2014-2015	36,373.6	159,520	0	0
2015-2016	43,977.2	203,497	0	0
2016-2017	58,616.5	262,113	0	0
2017-2018	62,811.4	324,925	0	0
2018-2019	68,519.5	393,444	0	0
2019-2020	76,260.1	469,704	0	0

8.3 *Ex ante* estimation of total leakage

The results of all the *ex ante* sources of leakage are summarised in table 58.

Table 58. *Ex ante* estimated total leakage (see table 35 – GHG-VM0015 calculation of emissions spreadsheet)

Project year *t*	Total *ex ante* decrease in carbon stocks due to displaced deforestation		Carbon stock decrease or non-CO2 emissions due to leakage prevention measures		Total net carbon stock change due to leakage		Total net increase in emissions due to leakage	
	annual $\Delta CADLK_t$ tCO$_2$-e	cumulative $\Delta CADLK$ tCO$_2$-e	annual $\Delta CLPMLKt$ tCO$_2$-e	cumulative $\Delta CLPMLK$ tCO$_2$-e	annual ΔCLK_t tCO$_2$-e	cumulative ΔCLK tCO$_2$-e	annual ELK_t tCO$_2$-e	cumulative ELK tCO$_2$-e
2010-2011	33,544.9	33,544.9	0	0	33,544.9	33,544.9	0	0
2011-2012	24,753.7	58,298.6	0	0	24,753.7	58,298.6	0	0
2012-2013	29,213.3	87,511.8	0	0	29,213.3	87,511.8	0	0
2013-2014	35,634.1	123,145.9	0	0	35,634.1	123,145.9	0	0
2014-2015	36,373.6	159,519.5	0	0	36,373.6	159,519.5	0	0
2015-2016	43,977.2	203,496.8	0	0	43,977.2	203,496.8	0	0
2016-2017	58,616.5	262,113.2	0	0	58,616.5	262,113.2	0	0
2017-2018	62,811.4	324,924.6	0	0	62,811.4	324,924.6	0	0
2018-2019	68,519.5	393,444.1	0	0	68,519.5	393,444.1	0	0
2019-2020	76,260.1	469,704.2	0	0	76,260.1	469,704.2	0	0

Step 9. *Ex* ante total net anthropogenic GHG emission reductions

9.1 Significance assessment

The aerial and underground reservoirs were considered, for the first case is mandatory and the underground reservoir is optional but recommended by the methodology because it represents between 15% and 30% of the carbon stored in aboveground biomass. The other reservoirs were excluded considering the methodological guidelines of V00015 Version 1.1.

9.2 Calculation of e*x-ante* estimation of total net GHG emissions reductions

The net anthropogenic GHG emission reduction of the proposed AUD project activity is calculated as follows:

$$\Delta REDD_t = (\Delta CBSLPA_t + EBBBSLPA_t) – (\Delta CPSPA_t + EBBPSPA_t) – (\Delta CLK_t + ELK_t)$$

Where:

$\Delta REDDt$: *Ex ante* estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year *t*; tCO2e

$\Delta CBSLPAt$: Sum of baseline carbon stock changes in the project area at year *t*; tCO2e

Note: The absolute values of *CBSLPAt* shall be used in equation 19.

$EBBBSLPAt$: Sum of baseline emissions from biomass burning in the project area at year *t*; tCO2e

$\Delta CPSPAt$: Sum of *ex ante* estimated actual carbon stock changes in the project area at year *t*; tCO2e

Note: If *CPSPAt* represents a net increase in carbon stocks, a negative sign before the absolute value of *CPSPAt* shall be used. If *CPSPAt* represents a net decrease, the positive sign shall be used.

$EBBPSPAt$: Sum of (*ex ante* estimated) actual emissions from biomass burning in the project area at year *t*; tCO2e

ΔCLK_t Sum of *ex ante* estimated leakage net carbon stock changes at year *t*; tCO2e

Note: If the cumulative sum of *CLKt* within a fixed baseline period is *> 0, CLKt* shall be set to zero.

ELK_t Sum of *ex ante* estimated leakage emissions at year *t*; tCO2e

t 1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless

9.3 Calculation of Verified Carbon Units (VCUs)

The ex-ante estimations of buffer credits are calculated on a risk factor (VBC_t), which was estimated through the VCS. The risk factor is of 14%.

The results of sections 9.2 and 9.3 are shown in table 48.

The number of Verified Carbon Units (VCUs) was calculated according to the following formula:

$$VCU_t = \Delta REDD_t – VBC_t$$

$$VBC = (\Delta CBSLPA_t - \Delta CPSPA_t) * RF_t$$

Where

VCU_t Number of Verified Carbon Units that can be traded at time *t*; t CO2-e

$$\sum_{t=0}^{t} \Delta REDD_t > 0$$

$\Delta REDD_t$ *REDDt Ex ante* estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year *t*; tCO2-e ha-1

VBC_t Number of Buffer Credits deposited in the VCS Buffer at time *t*; t CO2-e

$\Delta CBSLPA_t$ Sum of baseline carbon stock changes in the project area at year *t*; tCO2e

$\Delta CPSPA_t$ Sum of *ex ante* estimated actual carbon stock changes in the project area at year *t*; tCO2-e ha-1

RF_t Risk factor used to calculate VCS buffer credits; %

t 1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless

Table 59. *Ex ante* estimated net anthropogenic GHG emission reductions (*REDDt*) and Verified Carbon Units (*VCUt*) (see table 36 – GHG-VM0015 calculation of emissions)

Project year *t*	Baseline carbon stock changes		*Ex ante* project carbon stock changes		*Ex ante* leakage carbon stock changes		*Ex ante* net anthropogenic GHG emission reductions		*Ex ante* VCUs tradable		*Ex ante* buffer credits	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CBSLPA_t$	$\Delta CBSLPA$	$\Delta CPSPA_t$	$\Delta CPSPA$	ΔCLK_t	ΔCLK	$\Delta REDD_t$	$\Delta REDD$	VCU_t	VCU	VBC_t	VBC
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2010-2011	465,901.1	465,901.1	107,157.2	107,157.2	33,544.9	33,544.9	325,198.9	325,198.9	274,974.8	274,974.8	50,224.1	50,224.1
2011-2012	343,801.2	809,702.2	61,884.2	169,041.5	24,753.7	58,298.6	257,163.3	582,362.2	217,694.9	492,669.7	39,468.4	89,692.5
2012-2013	405,739.8	1,215,442.0	52,746.2	221,787.6	29,213.3	87,511.8	323,780.4	906,142.6	274,361.3	767,031.0	49,419.1	139,111.6
2013-2014	494,918.1	1,710,360.1	39,593.4	261,381.1	35,634.1	123,145.9	419,690.5	1,325,833.1	355,945.1	1,122,976.1	63,745.5	202,857.1
2014-2015	505,188.8	2,215,549.0	15,155.7	276,536.7	36,373.6	159,519.5	453,659.6	1,779,492.7	385,054.9	1,508,031.0	68,604.6	271,461.7
2015-2016	610,794.9	2,826,343.9	18,323.8	294,860.6	43,977.2	203,496.8	548,493.9	2,327,986.6	465,547.9	1,973,578.9	82,946.0	354,407.7
2016-2017	814,117.5	3,640,461.4	24,423.5	319,284.1	58,616.5	262,113.2	731,077.5	3,059,064.1	620,520.3	2,594,099.2	110,557.2	464,964.8
2017-2018	872,380.0	4,512,841.3	26,171.4	345,455.5	62,811.4	324,924.6	783,397.2	3,842,461.3	664,928.0	3,259,027.2	118,469.2	583,434.0
2018-2019	951,659.5	5,464,500.8	28,549.8	374,005.3	68,519.5	393,444.1	854,590.2	4,697,051.5	725,354.8	3,984,382.1	129,235.4	712,669.4
2019-2020	1,059,168.4	6,523,669.2	31,775.1	405,780.3	76,260.1	469,704.2	951,133.2	5,648,184.7	807,298.2	4,791,680.2	143,835.1	856,504.4

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