Submission of the Republic of Peru
to the United Nations Framework Convention on Climate Change

Peru's submission of a Forest Reference Emission Level (FREL) for reducing emissions from deforestation in the Peruvian Amazon

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Acronyms

µm	Micro meters
AFOLU	Agriculture, Forestry and Other Land Uses
AGB	Above-ground biomass
AGB.t	Above-ground biomass of living trees
AWGLCA	The Ad Hoc Working Group on Long-term Cooperative Action under the Convention
BGB	Below-ground biomass
BGB.t	Below-ground biomass of living trees
BMUB	Ministerio Federal alemán para el Medio Ambiente, la Protección de la Naturaleza, la Construcción y la Seguridad de los Reactores (*Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorensicherheit*)
BUR	Biennial Update Report
C.I.	Confidence Interval
CDM	Clean Development Mechanism
CGIAR-CSI	Consortium for Spatial Information (CSI) of the Consultative Group for International Agricultural Research (CGIAR)
CP	Conference of the Parties to the UNFCCC
dbh	Diameter at breast height
DF	Deforestation
DF.an	Anthropogenic Deforestation
DF.na	Non-anthropogenic Deforestation
DF.to	Total Deforestation
DGCCDRH	General Directorate for Climate Change, Desertification and Hydrological Resources (*Dirección General de Cambio Climático, Desertificación y Recursos Hídricos*)
DGEVFPN	General Directorate of Evaluation, Valuation and Financing of the Natural Heritage (*Dirección General de Evaluación, Valoración y Financiamiento del Patrimonio Natural*)
DNA	Designated National Authority of the CDM
DW	Dead Wood
EF	Emission Factor
ENBCC	Strategy for Forests and Climate Change (*Estrategia Nacional de Bosques y Cambio Climático*)
EROS	Earth Resources Observation and Science Center
ETM+	Enhanced Thematic Mapper Plus

EZ	Eco-Zone
FAO	United Nations Food and Agriculture Organization
FCBM	Forest Cover Benchmark Map
FONAM	National Fund for the Environment (*Fondo Nacional del Ambiente*)
FRA	FAO's Forest Resources Assessment
FREL/FRL	Forest reference emission level and/or forest reference level
GHG	Greenhouse gas
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GPG	Good Practice Guidance
h	Tree height
ha	hectares
INDC	Intended Nationally Determined Contribution
INF	National Forest Inventory (*Inventario Nacional Forestal*)
IPCC	Intergovernmental Panel on Climate Change
LI	Litter
KfW	KfW Development Bank (*Kreditanstalt für Wiederaufbau, Entwicklungsbank*)
LULUCF	Land-use, Land-use Change and Forestry
m	meters
m.a.s.l.	meters above sea level
MDP	Map of the Departments of Peru
MEZ	Map of Eco-Zones
MFR	Map of Forest to River conversions
MGD	Map of Gross Deforestation
MINAGRI	Ministry of Agriculture and Irrigation (*Ministerio de Agricultura y Riego*)
MINAM	Ministry of the Environment (*Ministerio del Ambiente*)
MMR	Map of the Macro-Regions or Biomes of Peru
MODIS	Moderate Resolution Imaging Spectroradiometer
NAMA	Nationally Appropriate Mitigation Action
OLI	Operational Land Imager
OTCA	Organization of the Treaty for Amazonian Cooperation (*Organización del Tratado de Cooperación Amazónica*)
PNCBMCC/PNCB	National Forest Conservation Program for Climate Change Mitigation (*Programa Nacional de Conservación de Bosques para la Mitigación del Cambio Climático*)

ρ	Wood density
REDD+	Reducing emissions from deforestation and forest degradation, conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RIAV	Reserves of Indigenous People in Voluntary Isolation (*Reservas Indígenas en Aislamiento Voluntario*)
SAA	*Selva Alta Accesible*
SAD	*Selva Alta Difícil*
SB	*Selva Baja*
Sd OTCA	Observation Room of the Organization of the Treaty for Amazonian Cooperation (*Sala de Observación de la Organización del Tratado de Cooperación Amazónica*)
SERFOR	National Forest and Wildlife Service (*Servicio Nacional Forestal y de Fauna Silvestre*)
SERNANP	National Service of Natural Areas Protected by the State (*Servicio Nacional de Áreas Naturales Protegidas por el Estado*)
SINIA	National System of Environmental Information and Research (*Sistema Nacional de Información e Investigación Ambiental*)
SOC	Soil Organic Carbon
SRTM	Shuttle Radar Topography Mission
tCO_2-e	Ton of carbon dioxide equivalent
TOP	Top of atmosphere
TM	Thematic Mapper
UNALM	National Agrarian University of La Molina (*Universidad Nacional Agraria La Molina*)
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Service
VMDERN	Vice-Ministry for Strategic Development of the natural Resources (*Viceministerio de Desarrollo Estratégico de los Recursos Naturales*)
yr	Year
ZH	*Zona Hidromórfica*

1 Introduction

The Peruvian Amazon is of critical importance for Peru's economy and for the global climate. With 69,380,729 hectares (ha) of mature forest in 2014, the Peruvian Amazon contains some 32,281,231,580 equivalent tons of carbon dioxide (tCO_2-e) in its living trees alone (above- and below-ground biomass)[1]. Maintaining this carbon stored in the forest in the context of climate change, to avoid greenhouse gas (GHG) emissions, conserve biodiversity and protect the livelihoods of indigenous peoples and rural communities, while pursuing in parallel the goals of sustainable development, is a huge challenge. International incentives for reducing emissions from land use and land use-change are thus of strategic importance for Peru's ability to implement low carbon emission development strategies in the Peruvian Amazon.

In response to Decision 1/CP.16, paragraphs 70 and 71, Peru aims to provide a positive contribution to mitigation actions in the forest sector by reducing emissions from deforestation, in accordance with its national circumstances and respective capability. Peru therefore welcomes the opportunity to submit its proposed Forest Reference Emission Level (FREL) for deforestation in the Peruvian Amazon to the United Nations Framework Convention on Climate Change (UNFCCC) for a technical assessment, in accordance with Decision 13/CP.19 and its Annex.

The submission of this FREL, and of the subsequent Technical Annexes to the Biennial Update Report (BUR) in which the emission reductions of results-based actions may be reported, are voluntary and exclusively for the purpose of obtaining results-based payments for REDD+ actions, as per Decisions 1/CP.16, paragraph 71, 13/CP.19, paragraph 2, and 14/CP.19, paragraphs 7 and 8.

This submission therefore does not prejudge any Nationally Appropriate Mitigation Actions (NAMAs) currently being considered or undertaken by Peru pursuant to the Bali Action Plan (FCCC/AWGLCA/2011/INF.1), neither prejudges any Intended Nationally Determined Contribution (INDC) by Peru in the context of a new protocol, another legal instrument or an agreed outcome with legal force under the Convention currently being negotiated under the Ad Hoc Working Group on the Durban Platform for Enhanced Action.

Since 2012, Peru has been developing the four elements referred to in paragraph 71 of Decision 1/CP.16. The country now counts with a preliminary proposal for its National Strategy for Forests and Climate Change (*Estrategia Nacional de Bosques y Cambio Climático*, ENBCC). This year (2015), through the Supreme Resolution Nr. 193-2015-PCM, a Multi-Sectorial Commission attached to the Ministry of the Environment (MINAM) was created with the mandate of elaborating in a participatory way the National Strategy for Forests and Climate Change. The Commission has been tasked to prioritize the definition of the actions at the national scale that are necessary to reduce emissions from Land Use, Land Use-Change and Forestry (LULUCF) by addressing their direct and indirect causes. The collection of contributions and information has culminated and a dialogue with the relevant stakeholders is currently ongoing.

Regarding the development of a National Forest Monitoring System (NFMS), Peru has developed a protocol for measuring changes in forest cover and mapping forest lands (MINAM & MINAGRI, 2014.b) that has been successfully implemented in the Peruvian Amazon, generating the data that are reported further below in this submission. This protocol will be adapted, as needed, and implemented progressively in other Peruvian biomes and improved, when appropriate, in order to include other eligible REDD+ activities, although Peru will initially focus on deforestation, land-use change and early warning in the Peruvian Amazon.

[1] MINAM´s own estimate, based on the data compiled for the construction of the forest reference emission level presented in this submission.

The process of developing a robust and transparent NFMS is led by the Ministry of the Environment (MINAM) and the Ministry of Agriculture and Irrigation (MINAGRI) that, together with the Observation Room of the Organization of the Treaty for Amazonian Cooperation (Sd OTCA), culminated the historical time series 2001-2014 for deforestation in the Peruvian Amazon.

The elaboration of a 2011 land-use map for the Peruvian Amazon and of a deforestation map for the biomes "*Costa*" and "*Sierra*" is currently underway. In addition, an indirect approach, based on GOFC-GOLD´s methods, has been developed and is currently being tested for estimating activity data and emission factors for forest degradation.

Peru currently counts with national data on carbon stocks in the above-ground biomass of living trees for all its main forest types. These data are being improved with the collection of new data from field-measured plots as part of the activities implemented under Peru´s first National Forest Inventory, which will complete its first cycle in about 4 years. A systematic collection of carbon stock data for non-forest categories is underway, as well as a study on allometric equations.

With all these activities, Peru is implementing the necessary actions to improve the accuracy of its estimates of forest-related Greenhouse Gas (GHG) emissions, and generating the data and information that will allow incorporating, in due time, new sources of emissions an additional carbon pools in its FREL, while simultaneously improving the methods and technologies used under its NFMS.

Regarding the development of a system for providing information on how safeguards are being addressed and respected, Peru is planning to build its national system on existing structures, such as the national System of Environmental Information (*Sistema Nacional de Información Ambiental*, SINIA). An initial assessment of safeguards already exists and a Working Group on Safeguards has been convened with the mandate of elaborating the first national report on this topic.

2 Scope and boundaries of the Forest Reference Emission Level (FREL)

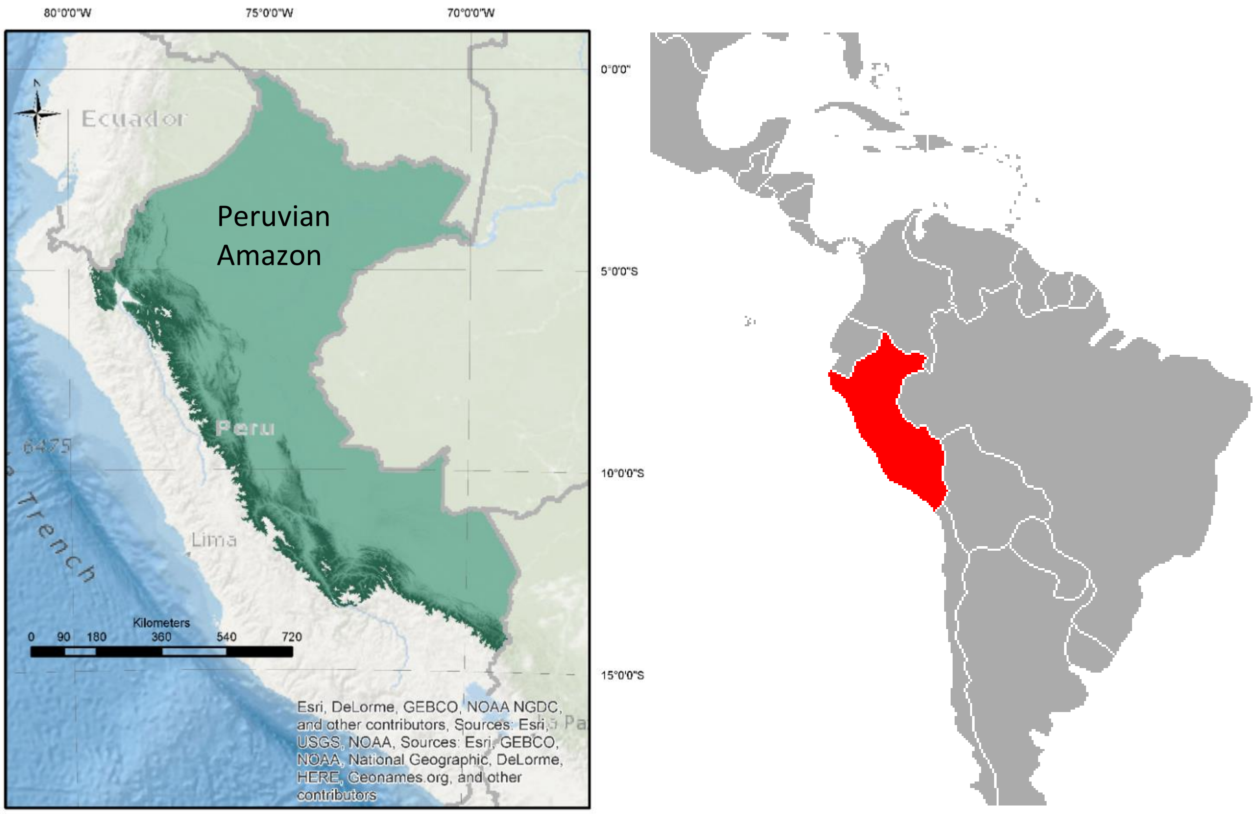
In defining the scope and the boundaries of its proposed Forest Reference Emission Level, Peru wants to recall paragraph 71(b) of Decision 1/CP.16 and paragraph 11 of Decision 12/CP.17 that state that Parties may elaborate a subnational Forest Reference Emission Level and/or Forest Reference Level (FREL/FREL), as an interim measure, while transitioning to a national FREL/FREL.

Peru also wants to recall paragraph 10 of Decision 12/CP.17 that indicates that the Conference of the Parties (CP) agreed that a step-wise approach to national FREL/FRL development may be useful, enabling Parties to improve their FREL/FRL by incorporating better data, improved methodologies and, where appropriate, additional pools, noting the importance of adequate and predictable support as referenced by Decision 1/CP.16, paragraph 71.

2.1 Geographical boundary of the proposed FREL

Peru is a highly diverse country, having three distinct macro-regions representing biomes with completely different ecological conditions: the Peruvian Amazon ("*Amazonia*"), the Andean Mountain Range ("*Sierra*"), and the Pacific Coast ("*Costa*"). While containing some hydromorphic and mountainous regions, the Amazon Region is dominated by the low-land Amazon forest and was, originally, almost 100% covered by forests. The Andean Mountain Range, being characterized by a variety of rainy to dry areas at high to very high elevations, has naturally a smaller percentage of forest coverage than the Amazon region. The Pacific Coast, with its extremely dry climate, has naturally almost no forest, with only some open and xerophytic forests in its more humid valleys.

Figure 1. Location of Peru and of the Peruvian Amazon.



Peru´s proposed subnational FREL includes the entire Amazonian biome of Peru. With an extension of approximately 78,308,801 ha, the Peruvian Amazon represents 60.9% of the national territory of Peru. Moreover, with some 69,380,729 hectares of mature forest in 2014, the Peruvian Amazon also contains approximately 92.7% of Peru´s forests.

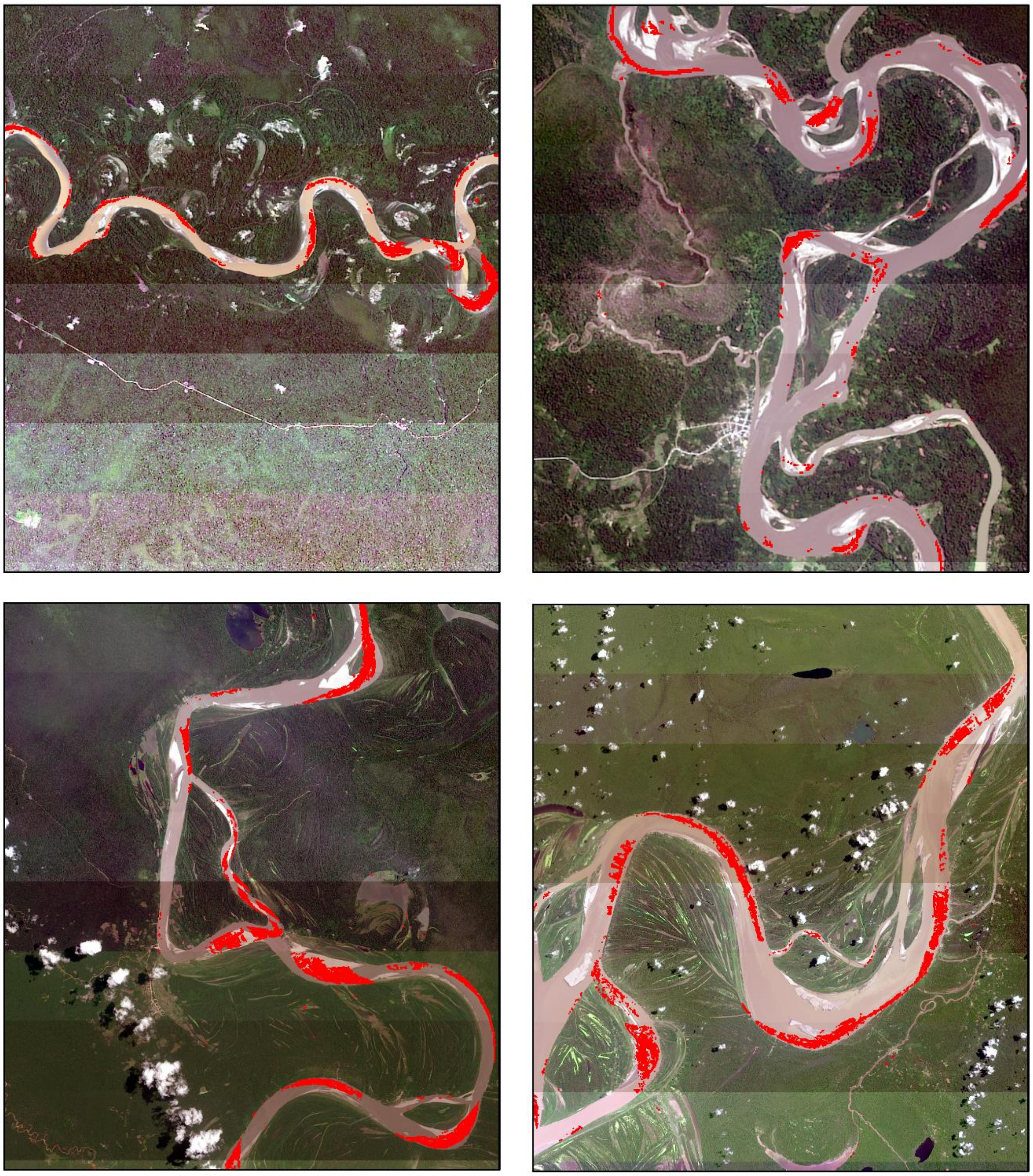
2.2 Exclusion of non-anthropogenic deforestation

The loss of forests in the Peruvian Amazon is associated to both, anthropogenic drivers and non-anthropogenic factors. Considering that only anthropogenic deforestation can be addressed through human actions, it is important to evaluate if non-anthropogenic losses of forest can be discriminated and excluded either from the accounting area (i.e. the area for which a reference level is established and over which forest-related emissions by sources and removals by sinks are being measured, reported and verified) or from the FREL (i.e. when the locations of non-anthropogenic losses in forest cover change over time). If non-anthropogenic GHG emissions and/or removals are excluded from the FREL, they also will have to be excluded in the subsequent reports on the results of REDD+ actions in order to maintain consistency with the FREL.

Although separating anthropogenic from non-anthropogenic changes in forest cover is not an easy task, there are conditions where the changes in forest cover can be associated unambiguously to natural factors. One of these conditions is the conversion of forest land to wetlands associated to the natural movement of the riverbeds in the Amazon forest.

To detect the conversions of forests to natural shallow water bodies (i.e. rivers and lagoons created by river meandering) a raster map was created showing the areas of forest land converted each year to natural shallow water bodies (i.e. the Map of Forest to River conversions, MFR). The MFR was created through multi—temporal spectral analysis of the same satellite images used to map deforestation. The conversions of forest land to natural shallow water bodies were then classified as "non-anthropogenic deforestation" (see Figure 2).

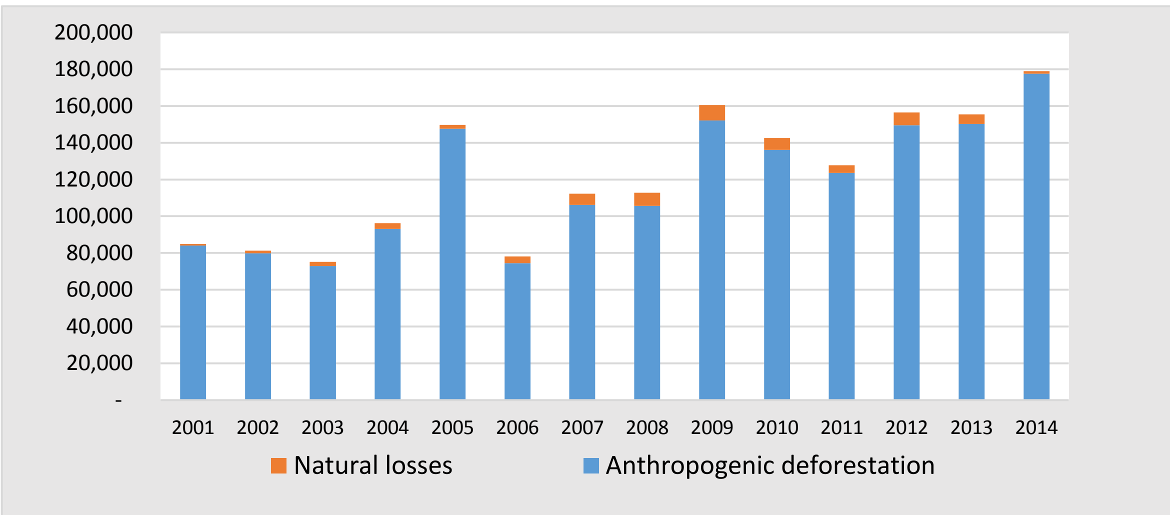
Figure 2. Examples of conversions of forests to natural shallow water bodies that are considered "non-anthropogenic deforestation" (source: Map of Forest to River conversions, MFR).



Note: Red areas represent the cumulative conversion of forests to wetlands in the period 2001-2014. For visibility reasons, the areas of annual conversions are not shown here.

As shown in Tables 1, 2 and 3, of the 1,712,284 hectares of forest that were lost between 2001 and 2014 in the Peruvian Amazon, 59,163 ha (3.46%) were associated to natural changes of the location of riverbeds. The remaining 1,653,121 ha (96.54%) could not be associated, with a high degree of confidence, to any non-anthropogenic factor and are therefore considered deforested through anthropogenic actions. For individual years, the loss of forest area associated to river meandering ranged from a minimum of 853 ha yr^{-1} (1.01% of the annual loss) in 2000-2001[2], to a maximum of 8,334 ha yr^{-1} (5.19%) in 2008-2009, or 6.24% (7,034 ha yr^{-1}) in 2007-2008. These data provide a good indication of the magnitude of the changes in forest cover associated to river meandering and of its inter-annual variability (see also Figure 3).

Figure 3. Anthropogenic gross deforestation and natural losses of forest cover in the Peruvian Amazon (in hectares).



The proposed FREL excludes only the losses of forest area associated to river meandering because losses caused by other natural factors, such as droughts, natural forest fires, landslides, windstorms, etc., could not be identified with a high level of confidence. Some of these factors, however, may be exacerbated by climate change and increase forest disturbances in the future, which makes it important for Peru to improve its capabilities to accurately measure all kinds of non-anthropogenic changes in forest cover in order to report them separately from anthropogenic deforestation.

In their peer-reviewed publication of Peru´s humid tropical forest change assessment, Potapov *et al.* (2014) attributed 92.2% of the loss in forest cover occurred between 2000-2011 to clearing for agriculture and tree plantations (i.e. to anthropogenic deforestation). The remaining 7.8% were attributed to natural disturbances such as river meandering (6.0%), fires (1.5%), windstorm (0.3%) and landslides (0.02%) (i.e. to non-anthropogenic factors). Non-anthropogenic losses of forest cover may thus be higher as considered in the construction of the proposed FREL, although the difference between the estimates of forest loss associated to river meandering in Potapov *et al*. (2014) and in this submission is attributable to the inclusion, in the study of Potapov *et al*., of areas with small trees and other natural vegetation that do not qualify as "forest"[3].

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2 For space reasons, in the figures and tables of this submission the years are indicated with only one year (e.g. 2001) to indicate a change that occurred from one year to the subsequent one (e.g. 2001 means 2000-2001).

3 According to the definition of "forest" used in the construction of the proposed FREL (see section 3.4).

Anthropogenic deforestation and non-anthropogenic forest losses in the Peruvian Amazon.

Table 1. Anthropogenic deforestation.

Eco-zone	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Name	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Selva Alta Accesible	37,083	32,873	29,623	40,302	62,083	29,852	51,104	29,274	57,118	48,948	39,009	43,898	39,478	50,374
Selva Alta Difícil	5,217	5,239	3,575	5,236	7,899	4,573	6,660	5,587	10,582	10,618	10,460	13,017	11,800	15,045
Selva Baja	39,527	38,973	37,551	43,571	74,388	37,739	45,637	67,493	79,120	72,914	70,767	85,103	93,312	104,635
Zona Hidromórfica	2,169	2,746	2,124	4,036	3,253	2,337	2,785	3,350	5,341	3,724	3,326	7,458	5,699	7,517
Annual total	**83,995**	**79,831**	**72,873**	**93,146**	**147,623**	**74,501**	**106,186**	**105,704**	**152,160**	**136,205**	**123,562**	**149,476**	**150,288**	**177,570**
Cumulative total	**83,995**	**163,826**	**236,699**	**329,845**	**477,468**	**551,969**	**658,155**	**763,859**	**916,019**	**1,052,224**	**1,175,786**	**1,325,263**	**1,475,551**	**1,653,121**

Table 2. Non-anthropogenic losses: conversions of forests to wetlands associated to the natural movement of rives.

Eco-zone	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Name	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Selva Alta Accesible	90	69	114	144	108	139	204	219	243	266	246	179	178	1
Selva Alta Difícil	66	65	55	62	63	47	104	88	139	122	100	55	67	0
Selva Baja	439	726	1,314	1,547	1,177	2,135	3,950	4,453	5,049	4,053	2,703	4,233	3,243	708
Zona Hidromórfica	259	607	825	1,265	806	1,270	1,781	2,274	2,902	2,011	1,116	2,617	1,730	739
Annual total	**853**	**1,466**	**2,308**	**3,019**	**2,154**	**3,590**	**6,038**	**7,034**	**8,334**	**6,451**	**4,165**	**7,084**	**5,218**	**1,447**
Cumulative total	**853**	**2,320**	**4,628**	**7,646**	**9,801**	**13,390**	**19,429**	**26,463**	**34,796**	**41,248**	**45,413**	**52,497**	**57,715**	**59,163**
% of total deforestation	**1.01%**	**1.80%**	**3.07%**	**3.14%**	**1.44%**	**4.60%**	**5.38%**	**6.24%**	**5.19%**	**4.52%**	**3.26%**	**4.52%**	**3.36%**	**0.81%**
	3.46%													

Table 3. Total losses of forest cover (= anthropogenic deforestation + non anthropogenic losses).

Eco-zone	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Name	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Selva Alta Accesible	37,172	32,942	29,737	40,446	62,191	29,991	51,307	29,493	57,361	49,214	39,255	44,077	39,656	50,374
Selva Alta Difícil	5,282	5,304	3,630	5,299	7,962	4,620	6,764	5,674	10,721	10,741	10,560	13,072	11,867	15,045
Selva Baja	39,966	39,699	38,865	45,119	75,565	39,874	49,587	71,946	84,169	76,967	73,470	89,336	96,555	105,343
Zona Hidromórfica	2,428	3,353	2,949	5,301	4,060	3,607	4,566	5,625	8,243	5,735	4,442	10,075	7,430	8,256
Annual total	**84,848**	**81,297**	**75,181**	**96,164**	**149,777**	**78,091**	**112,224**	**112,738**	**160,494**	**142,657**	**127,727**	**156,560**	**155,507**	**179,018**
Cumulative total	**84,848**	**166,146**	**241,327**	**337,491**	**487,269**	**565,360**	**677,584**	**790,322**	**950,815**	**1,093,472**	**1,221,199**	**1,377,759**	**1,533,266**	**1,712,284**

The separation between anthropogenic deforestation and non-anthropogenic losses of forest cover is shown and discussed here because non-anthropogenic factors could, in the context of climate change and its associated impacts on forests, result in greater losses of forest cover in the future and thus undermine Peru´s effort to reduce anthropogenic deforestation, if the impacts on forests of non-anthropogenic factors are not duly accounted in the assessment of the performance of REDD+ actions. The National GHG Inventory uses the same approach for factoring-out non-anthropogenic GHG emissions as it is based on the same activity data that were used in the construction of the proposed FREL.

Peru therefore proposes to continue monitoring changes in forest cover that are associated to non-anthropogenic factors and to report them separately from anthropogenic deforestation, as done for its proposed FREL (which excludes non-anthropogenic losses of forest cover), in order to facilitate future analysis and considerations on appropriate ways to account for non-anthropogenic forest-related GHG emissions by sources and removals by sinks in the context of result-based payments.

2.3 Accounting for emissions from gross deforestation

Following the guidance and suggestions provided in the literature (e.g. Angelsen *et al.*, 2009; GOFC-GOLD, 2014), Peru shares the view that IPCC´s approach 3 should be used to collect activity data and that at least a Tier 2-level monitoring should be aimed by countries reporting emissions under "deforestation" in the context of result-based payments. Such reported emissions should further include only net emissions from gross deforestation to avoid possible overlaps and double-counting with other REDD+ activities.

- Net emissions involves estimating emission factors that consider both the carbon stock of the forest being cleared and the carbon stock of the replacement land use.
- Gross deforestation implies accounting only the area deforested in a particular period inside the area classified as "forest" at the beginning of the monitoring and reporting period and not taking into account the area afforested/reforested or naturally regenerated and the loss of the area afforested/reforested or naturally regenerated in the same period[4].

Accounting for net emissions thus requires collecting Tier-2 or higher level carbon stock estimates for all forest and non-forest categories involved in the conversions of "forest" to "non-forest". In absence of Tier-2 level data on carbon stocks for the replacement land uses, a country may use default Tier-1 level data to estimate carbon stocks, such as those offered by IPCC, or decide to use a gross accounting approach for estimating emission factors (i.e. ignoring carbon stocks in the replacement land use), as an interim solution, until better data become available.

Peru currently does not have Tier-2 level estimates for carbon stocks in non-forest categories and also lacks of spatially explicit information on these categories for the years included in the historical reference period of the proposed FREL (2001-2014). Although acknowledging that Tier-2 or higher level net emission factors shall be aimed for estimating emission reductions in the context of result-based payments, Peru, recalling paragraph 10 of Decision 12/CP.17 that indicates that a step-wise approach to national FREL/FRL development may be useful, deemed more appropriate to estimate

[4] Noting however that if "enhancements of forest carbon stocks" through afforestation/reforestation and/or natural regeneration are included in the FREL/FRL, then conversions of any areas meeting the definition of "forest" to categories not meeting the definition of "forest" may be accounted under "deforestation, unless these areas are "temporarily unstocked" as a consequence of forest management, in which case the related emissions and removals should be counted under the REDD+ activity "forest management".

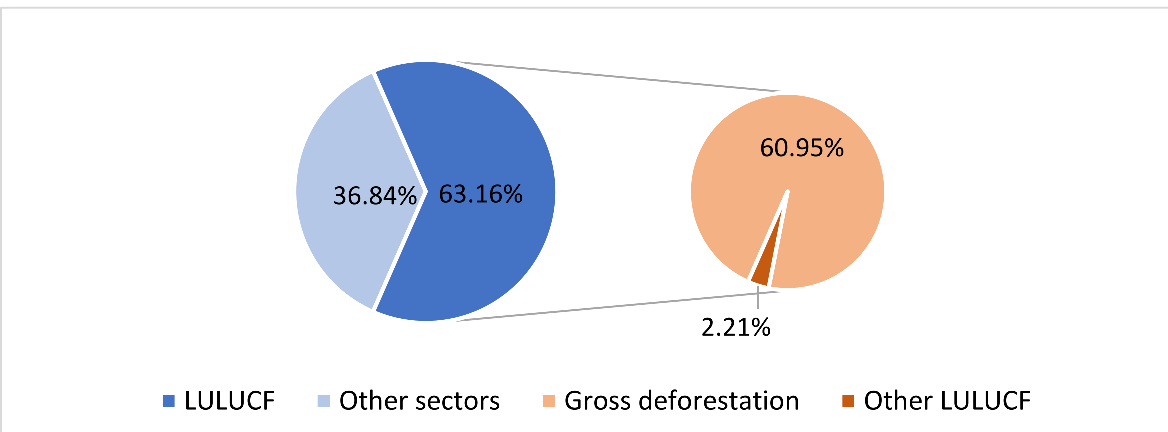
its emission factors for deforestation using a gross accounting approach, while maintaining Tier-2 level data for its forest carbon stocks, as further explained in section 3.3.2 of this submission.

Accounting for gross deforestation implies creating a "Forest Cover Benchmark Map" (FCBM) for the base year to represent the point from which each future forest area assessment will be made and actual negative changes will be monitored so as to report only gross deforestation going forward. Following this approach, Peru´s deforestation data represent only losses of areas classified as "forest" in the FCBM of year 2000 and does not include areas afforested, reforested or naturally regenerated since this base year, nor losses of areas that were afforested, reforested or naturally regenerated since this base year.

2.4 REDD+ activities included in the FREL

Considering the significant contribution of gross deforestation to total carbon dioxide emissions in Peru (60.95% of total CO_2 emissions and 96.51% of all land use, land-use change and forestry (LULUCF) based CO_2 emissions, according to the most recent national greenhouse gas inventory[5]) as well as the quality of data and information currently available to estimate forest-related GHG emissions by sources and removals by sinks, Peru deemed appropriate to initially focus its mitigation actions in the forest sector on "reducing emissions form deforestation" in the Peruvian Amazon, as an interim measure, while transitioning to a national strategy that will include all national forests and, if deemed appropriate, additional REDD+ activities.

Figure 4. Relative contributions of the Land-Use, Land-Use Change and Forestry sector (LULUCF) and of gross deforestation to total CO_2 emissions in Peru (year 2012).



Although the proposed FREL incudes only CO_2 emissions from gross deforestation in the Peruvian Amazon, Peru is already undertaking efforts to expand its FREL to the other macro-regions of the country.

2.5 Reference years

In accordance with paragraph 2(b) of the Annex to Decision 13/CP.19, the FREL proposed for the Peruvian Amazon has been established taking into account historical data on annual CO_2 emissions from gross deforestation from the period 2001-2014. This is the most recent period for which national

[5] BUR (2014) with 2010 as the reference for the GHG inventory (p. 43), (http://unfccc.int/resource/docs/natc/perbur1.pdf).

activity data have been generated using a consistent methodology. The years 2001-2014 also represents a period in which the broad policy changes that took place and influenced national circumstances in Peru since 2015 were not yet in place. The historical reference period chosen for the construction of the FREL therefore represents a good approximation to a scenario without enhanced mitigation actions for the post-2014 period.

Although early actions to reduce deforestation in protected natural areas, forestry concessions, Brazilian nut concessions and indigenous communities were started already a few years ago, the Peruvian Government started to implement new policies and programs to reinforce forest governance, reduce deforestation, and improve forest control and forest management in 2014 (see Box 1). All these policies and actions are expected to contribute to the reduction of forest-related GHG emissions and the year 2015 is therefore considered the start of Peru's national REDD+ program.

Peru proposes to use the FREL presented in this submission as its forest reference emission level in the context of results-based payments under the UNFCCC in the period up to 2020. It has not been decided yet, when the FREL will be revisited and improved pursuant a stepwise approach as per paragraph 10 of Decision 12/CP.17. However, Peru wants to emphasize that the FREL proposed in this submission may be revisited and improved at any time in the context of available data, methodologies and adequate and predictable support, as per Decisions 12/CP.17 and 13-14/CP.19.

Box 1. Recent developments on public frameworks on forests and climate change.

Peru is leading a process of development and implementation of public climate change policies that emphasizes the role of forests. In this regard, the country is working on the implementation of the Strategy to Fight against Desertification and Droughts and updating its National Strategy on Biological Diversity up to 2020 as well as its Action Plan for the period 2014-2018.

Recently (23.09.2015), the Supreme Decree Nr. 011-2015-MINAM approved the National Strategy on Climate Change that strengthens the commitment of the Peruvian Nation to address climate change in an integrated, transversal and multi-sectorial manner, thus complying with the international commitments acquired by Peru under the United Nations Framework Convention on Climate Change (UNFCCC) and taking into account current efforts to adapt the productive systems, the social services and the population to the effects of climate change.

In this context, the proposed Strategy for Forests and Climate Change (*Estrategia Nacional de Bosques y Cambio Climático*, ENBCC) represents an effort for integrating two key elements for the country´s commitment to contribute to the avoidance of an increase of the global average temperature above 2 ˚C before the end of the current century. By avoiding deforestation and forest degradation and sustainably managing the nation´s forest, Peru aims to develop as an economy with low carbon emissions.

The ENBCC is complemented by Peru´s Intended Nationally Determined Contribution (INDC) as well as by its Nationally Appropriate Mitigation Actions (NAMAs) and Green Growth Strategy, which is currently in preparation[6], together with other efforts to face the impacts of climate change in a planned and organized manner.

To achieve a successful implementation of Peru´s climate policies, the forestry sector has been strengthened through regulations that enhance legal security and sustainable management of forests. The new Law on Forests and Wildlife (Law Nr. 29763) and its recently approved Regulation (*Decreto Supremo* No. 21-2015 MINAGRI, September 30th, 2015) emphasize the allocation of rights on forests, provide clear guidelines for forest management and forest zoning, regulate the rights on

[6] Through this strategy, Peru will propose a sustainable growth strategy based on low carbon emissions.

ecosystem services, and strengthen the institutional framework of the forest sector in order to improve forest management and law enforcement.

In addition to the abovementioned developments of Peru´s policy and regulatory framework, the new Law on Mechanism for the Retribution for Ecosystem Services (Law Nr. 30295 of June 2014) regulates the forest ecosystem services with a clear intention to promote their provision and maintenance. This law recognizes that actions of conservation, restoration and sustainable management contribute to the permanence of the ecosystems and the economic, social and environmental benefits provided by their appropriate functioning (ecosystem services, including carbon storage). The draft Regulation of this Law is still under review after having received contributions through a public consultation process.

2.6 Greenhouse gasses and carbon pools

The proposed FREL includes CO_2 emissions from above-ground biomass (AGB) and below-ground biomass (BGB) of living trees. The exclusion of dead wood (DW), litter (LI) and soil organic carbon (SOC) is considered conservative in the context of results-bases payments as it leads to a lower estimation of GHG emission reductions from reduced deforestation compared to a scenario where all carbon pools are included.

Peru deemed appropriate to exclude all non-living biomass carbon pools and non-CO_2 gasses (i.e. from biomass burning) considering the limited availability of Tier-2 level data and information to estimate emission factors from these pools and gasses.

3 Information on the proposed FREL

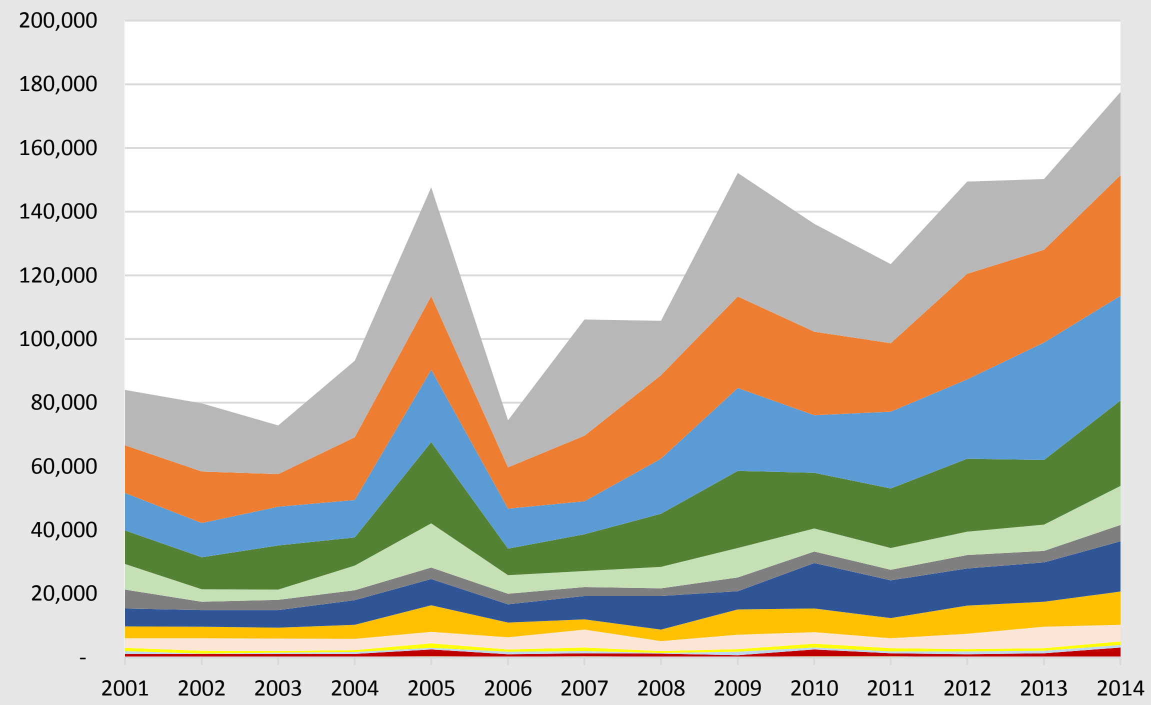
3.1 Description of the proposed FREL

The FREL proposed for the Peruvian Amazon has been constructed using the data and methodological approaches summarized in this section of the submission and further described in the following technical reports:

- Ministerio del Ambiente (MINAM), 2014. Estimación de los contenidos de carbono de la biomasa aérea en los bosques de Perú. Ministerio del Ambiente, Programa Nacional de Conservación de Bosques para la Mitigación del Cambio Climático, MINAM, Lima (Perú), 68 p.
- Ministerio del Ambiente (MINAM) and Ministerio de Agricultura y Riego (MINAGRI), 2014.a. Memoria Descriptiva del Mapa de Bosque/ No Bosque año 2000 y Mapa de pérdida de los Bosques Húmedos Amazónicos del Perú 2000-2011. MINAM, Lima (Perú), 111 p.
- Ministerio del Ambiente (MINAM) and Ministerio de Agricultura y Riego (MINAGRI), 2014.b. Protocolo de clasificación de pérdida de cobertura en los bosques húmedos amazónicos entre los años 2000 y 2011. MINAM, Lima (Peru), 43 p.
- Ministerio del Ambiente (MINAM), without date. Reporte de la Pérdidas de los Bosques Húmedos Amazónicos al 2011-2013. MINAM, Lima (Perú), 16 p.
- Asociación para la Investigación y el Desarrollo Integral (AIDER), 2015. Motores, agentes y causa de la deforestación en la Amazonía Peruana. Sistematización, patrones espaciales y cuantificación de impactos. Consultancy report to the Ministry of the Environment of Peru, Lima (Peru), 100 p. (unpublished).

Historical data on anthropogenic gross deforestation (in hectares) and related GHG emissions (in tons of CO_2-e per year) used to construct the proposed FREL are shown in Table 4 and Table 5, respectively. Figure 5 illustrates the historic trend of anthropogenic gross deforestation in the Peruvian Amazon and the contribution of each department.

Figure 5. Historical anthropogenic gross deforestation in the Peruvian Amazon (in hectares).



Department	ha	%	Cumulative %
SAN MARTIN	355,549	21.51%	100.00%
LORETO	320,586	19.39%	78.49%
UCAYALI	272,312	16.47%	59.10%
HUANUCO	235,718	14.26%	42.63%
MADRE DE DIOS	127,718	7.73%	28.37%
JUNIN	105,604	6.39%	20.64%
PASCO	84,070	5.09%	14.25%
AMAZONAS	58,470	3.54%	9.17%
CUSCO	51,167	3.10%	5.63%
PUNO	16,893	1.02%	2.54%
CAJAMARCA	12,310	0.74%	1.51%
AYACUCHO	9,032	0.55%	0.77%
PIURA	2,386	0.14%	0.22%
LA LIBERTAD	665	0.04%	0.08%
HUANCAVELICA	642	0.04%	0.04%
Total 2001-2014	**1,653,121**	**100.00%**	

Table 4. Historical anthropogenic gross deforestation in the Peruvian Amazon (in hectares).

Department	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Name	ha	ha	ha	ha	ha	Ha	ha	ha	ha	ha	ha	ha	ha	ha
AMAZONAS	3,034	3,924	3,890	3,554	3,622	3,858	5,581	3,049	4,544	3,594	3,179	4,751	6,687	5,202
AYACUCHO	952	92	468	586	497	798	719	193	1,088	603	564	897	803	773
CAJAMARCA	964	838	517	537	1,398	720	1,165	604	745	1,143	987	707	835	1,151
CUSCO	5,933	2,570	3,128	3,129	3,641	3,325	2,867	2,453	4,362	3,610	3,329	4,190	3,543	5,089
HUANCAVELICA	62	17	19	49	103	22	46	33	28	131	40	12	28	76
HUANUCO	10,610	9,978	13,856	8,774	25,556	8,324	11,494	16,697	24,190	17,456	18,730	22,842	20,376	26,834
JUNIN	8,018	3,964	3,302	7,763	13,849	5,878	5,000	6,673	9,221	7,184	6,857	7,390	8,227	12,278
LA LIBERTAD	24	27	16	50	82	32	46	21	58	110	46	35	48	49
LORETO	15,005	16,141	10,246	19,731	23,154	12,999	20,623	26,280	28,696	26,208	21,466	33,161	29,057	37,818
MADRE DE DIOS	5,603	5,223	5,626	7,766	8,288	5,756	7,338	10,503	5,691	14,286	11,768	11,702	12,401	15,767
PASCO	3,724	3,695	3,356	4,407	8,335	4,560	3,221	3,702	7,978	7,516	6,334	8,858	7,886	10,499
PIURA	254	273	94	133	223	197	276	148	118	167	317	81	42	63
PUNO	771	833	944	919	2,081	731	903	1,040	538	2,153	943	930	1,165	2,942
SAN MARTIN	17,311	21,480	15,290	23,996	34,109	14,811	36,552	17,008	38,812	33,873	24,873	29,007	22,281	26,146
UCAYALI	11,732	10,775	12,122	11,752	22,686	12,490	10,356	17,300	26,091	18,171	24,129	24,914	36,910	32,884
Annual total	**83,995**	**79,831**	**72,873**	**93,146**	**147,623**	**74,501**	**106,186**	**105,704**	**152,160**	**136,205**	**123,562**	**149,476**	**150,288**	**177,570**
Cumulative total	**83,995**	**163,826**	**236,699**	**329,845**	**477,468**	**551,969**	**658,155**	**763,859**	**916,019**	**1,052,224**	**1,175,786**	**1,325,263**	**1,475,551**	**1,653,121**

Table 5. Historical emissions from anthropogenic gross deforestation in the Peruvian Amazon (in tCO_2-e).

Department Name	2001 tCO_2-e yr^{-1}	2002 tCO_2-e yr^{-1}	2003 tCO_2-e yr^{-1}	2004 tCO_2-e yr^{-1}	2005 tCO_2-e yr^{-1}	2006 tCO_2-e yr^{-1}	2007 tCO_2-e yr^{-1}	2008 tCO_2-e yr^{-1}	2009 tCO_2-e yr^{-1}	2010 tCO_2-e yr^{-1}	2011 tCO_2-e yr^{-1}	2012 tCO_2-e yr^{-1}	2013 tCO_2-e yr^{-1}	2014 tCO_2-e yr^{-1}
AMAZONAS	1,151,569	1,489,321	1,471,828	1,345,955	1,374,526	1,459,906	2,121,008	1,158,323	1,726,857	1,368,771	1,209,922	1,813,039	2,553,913	1,981,597
AYACUCHO	363,176	35,317	176,695	221,800	188,470	302,549	273,597	73,862	414,619	230,788	216,416	337,843	304,952	293,722
CAJAMARCA	364,410	320,870	194,852	202,171	527,985	271,432	444,220	228,236	282,863	431,267	375,283	266,129	314,975	433,029
CUSCO	2,331,032	1,040,966	1,262,746	1,255,494	1,431,809	1,345,720	1,147,461	1,006,269	1,733,184	1,461,277	1,338,869	1,735,147	1,438,023	2,084,360
HUANCAVELICA	23,140	6,553	6,985	18,657	38,578	8,337	17,308	12,336	10,412	49,050	15,127	4,489	10,464	28,482
HUANUCO	4,959,358	4,760,660	6,426,624	4,083,068	12,219,604	3,961,322	5,317,165	8,077,994	11,645,579	8,306,370	8,978,929	10,880,209	9,837,855	12,815,582
JUNIN	3,109,408	1,533,146	1,312,337	3,008,245	5,276,300	2,280,040	1,942,183	2,584,162	3,582,710	2,765,229	2,674,241	2,867,515	3,230,948	4,761,988
LA LIBERTAD	9,233	10,520	5,962	19,116	31,667	12,037	17,253	7,843	22,362	42,367	17,274	13,403	18,011	18,371
LORETO	7,229,453	7,654,994	4,763,174	9,199,703	11,078,347	6,102,762	9,892,773	12,675,295	13,498,264	12,563,267	10,226,336	15,399,200	13,642,476	17,731,348
MADRE DE DIOS	2,818,746	2,637,441	2,870,943	3,944,309	4,224,287	2,946,231	3,750,193	5,379,152	2,913,607	7,308,851	5,994,088	5,993,081	6,351,386	8,052,319
PASCO	1,750,208	1,732,946	1,592,413	2,070,213	3,976,180	2,096,556	1,487,258	1,723,432	3,746,712	3,577,559	2,976,649	4,178,386	3,697,490	4,902,246
PIURA	95,686	105,937	35,470	50,673	85,290	74,658	108,646	56,122	44,789	64,180	121,868	30,930	16,040	23,849
PUNO	299,195	321,891	365,639	355,285	809,009	287,672	381,974	417,328	214,853	847,486	373,360	366,126	460,942	1,173,781
SAN MARTIN	6,753,236	8,415,155	5,981,325	9,401,761	13,312,866	5,864,272	14,259,054	6,989,356	15,293,927	13,387,760	9,929,199	11,756,531	9,093,366	10,676,910
UCAYALI	5,912,620	5,431,733	6,164,396	5,873,866	11,397,787	6,299,837	5,229,175	8,760,987	13,229,233	9,211,149	12,143,076	12,554,878	18,710,373	16,587,731
Annual total	**37,170,471**	**35,497,450**	**32,631,390**	**41,050,315**	**65,972,705**	**33,313,328**	**46,389,267**	**49,150,697**	**68,359,971**	**61,615,370**	**56,590,639**	**68,196,905**	**69,681,214**	**81,565,316**
Cumulative total	**37,170,471**	**72,667,921**	**105,299,311**	**146,349,626**	**212,322,332**	**245,635,660**	**292,024,928**	**341,175,625**	**409,535,595**	**471,150,965**	**527,741,604**	**595,938,509**	**665,619,724**	**747,185,040**

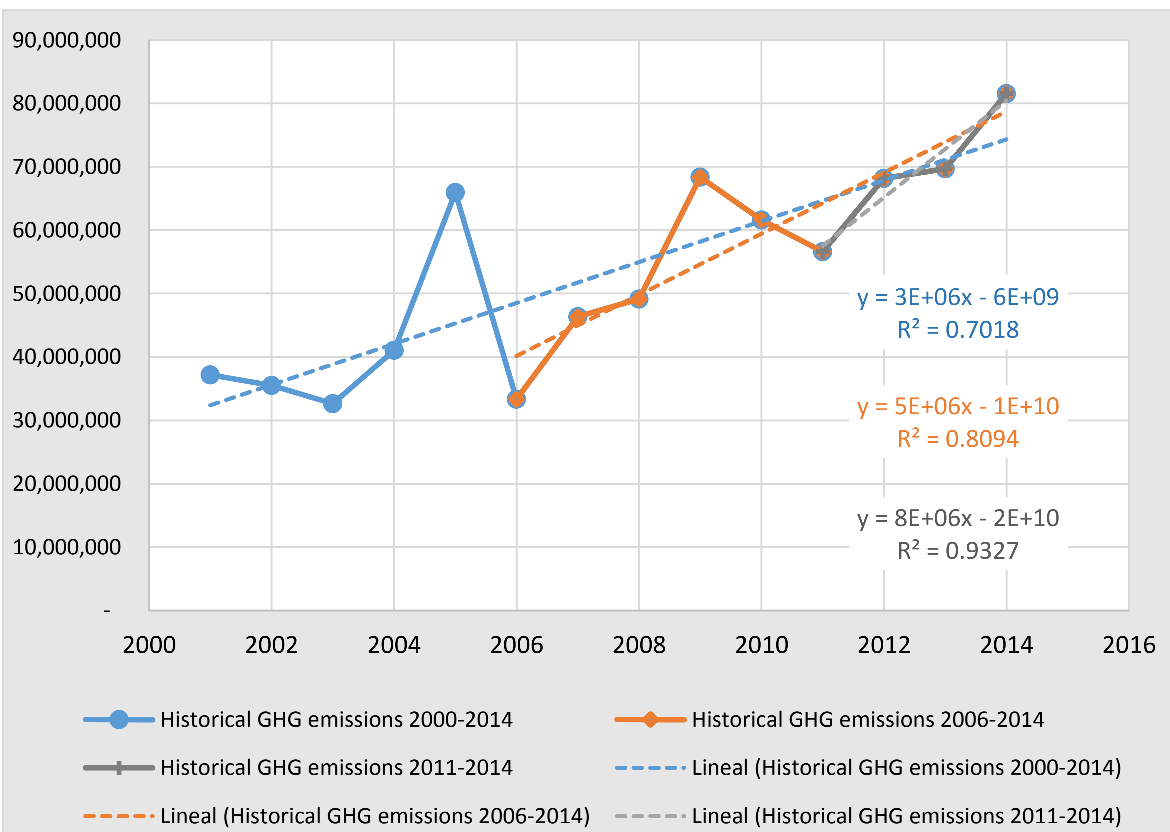
Between 2001 and 2014, anthropogenic gross deforestation accumulated a forest loss of 1,653,121 ha (118,080.10 ha yr^{-1}), which resulted in 747,185,040 tons of accumulated CO_2-e emissions, averaging 53,370,359.97 tCO_2-e yr^{-1} (see Annex 2 for the data used to perform this calculation).

As shown in Figure 5 and Table 4, all departments within the Peruvian Amazon had an increasing trend of deforestation between 2001 and 2014, except Piura. However, the department of Piura only represents 0.14 % (2,386 ha; 170.40 ha yr^{-1}) of the total anthropogenic gross deforestation. For all other departments, and overall for the Peruvian Amazon, historical deforestation and related GHG emissions have shown an increasing trend.

The increasing trend in gross deforestation and related GHG emissions is even more evident by ignoring the exceptionally high emissions of the year 2005. This was a particularly dry year during which persistent effects on the Amazonian forest canopy happened (Saatchi *et al.*, 2013) and forest fires were more frequent than usual (Brando *et al.*, 2014), which favored an exceptionally high deforestation.

The data also reveal an acceleration of the deforestation in the most recent years of the historical time series. The slope of the trend of increasing emissions is steeper, and the regression line of statistically higher significance (r^2 = 0.93), for the last four years (2011-2014) than for the second half of the historical period (2006-2014, r^2 = 0.81), which in turn shows a steeper slope and higher significance than the whole historical time series (2001-2014, r^2 0.70). This indicates that the trend of increasing deforestation is accelerating and becoming statistically more significant (see Figure 6).

Figure 6. Historical emissions from gross deforestation in the Peruvian Amazon (in tCO_2-e) and related trends considering three reference periods: 2001-2014, 2006-2014 and 2011-2014.



Under the current and historical national circumstances (as summarized in Box 2), as well as the national circumstances that could prevail in absence of enhanced mitigation actions, the historical trend of increasing deforestation is unlikely to change, unless sufficient and predictable international support becomes available for implementing the required mitigation actions.

Box 2. Agents, drivers and spatial pattern of deforestation in the Peruvian Amazon.

In 2015, MINAM commissioned an independent study (AIDER, 2015) on agents and drivers of deforestation in the Peruvian Amazon and their spatial patterns during the 2001-2013 period. The following are the key messages derived from this study:

1. <u>Spatial patterns of deforestation show an increasing fragmentation of the Peruvian Amazon.</u> Between 2001 and 2013, deforestation occurred primarily in 25 consolidated deforestation frontiers that cumulated between 3,000 and more than 300,000 hectares of deforestation in 13 years. These frontiers are associated to important roads and, in some cases, navigable rivers. Additionally, 15 hotspots of active deforestation of up to 5,000 ha yr^{-1} appeared between 2008 and 2013. These new frontiers are associated to different drivers, such as the cultivation of agro-industrial crops and coca leaves as well as mining and new roads.

2. <u>Direct causes of deforestation, i.e. the use of land after forest clearing.</u> The preliminary map of land use of the year 2011 shows the land uses that were established on deforested lands. The replacement land use for the areas cleared between 2008 and 2011 are shown in Figure 7.

Figure 7. Land uses after deforestation in the period 2008-2011.

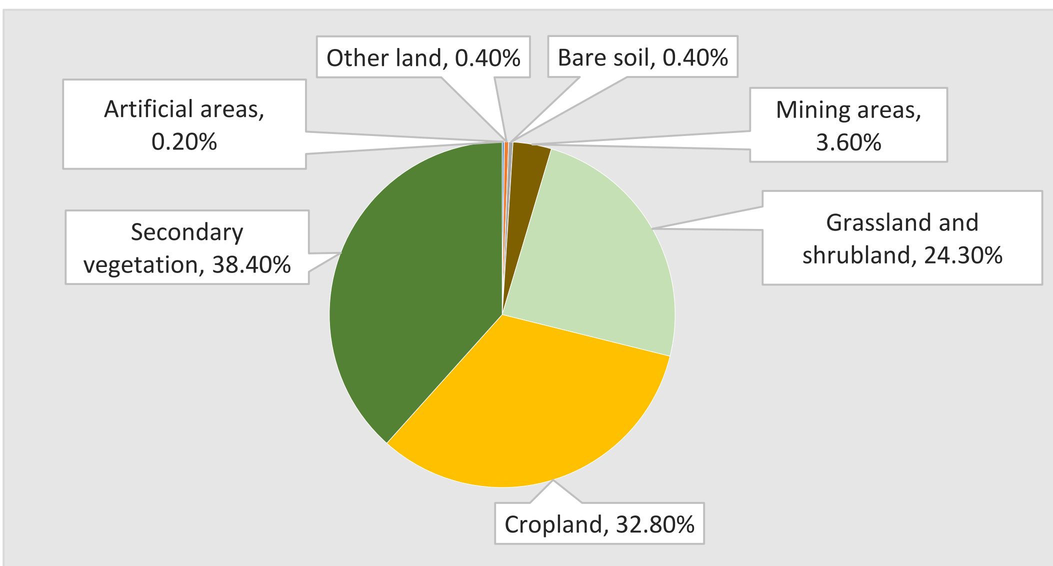


Figure 7 shows that more than 95% of the deforestation is driven by agriculture and livestock. At the same time, the high percentage of secondary vegetation indicates that land use is extensive and inefficient. In 68.9% of the cultivated area, agricultural production is intended for self-consumption and local markets, in 26.8% for cash cops and international markets, and in the remaining 4.3% for illegal crops (coca leaves).

3. <u>Agents of deforestation</u>. Deforestation in the Peruvian Amazon is, mainly, small-scale and fragmented, which indicates that it is caused by small agricultural and livestock producers

with an annual deforestation capacity of less than 0.5 ha yr^{-1} and up to 3.0 ha yr^{-1}. All together, these small producers are responsible for 88% of the deforestation.

4. Indirect causes of deforestation. Land grabbing is a common denominator of deforestation in the Peruvian Amazon. Activity data are statistically correlated with population growth and the Gross Domestic Product (GDP). During the historical period analyzed (2001-2013) a 1% increase in population resulted in a 0.54% increment in deforestation and a 1% increase in GDP in a 0.22% increment in deforestation. In regions with specific drivers, deforestation is correlated to the price of specific products, such as cash-crops (coffee, cocoa, oil palm) and gold in the case of alluvial gold mining.

In relation to the most likely trend of deforestation in the upcoming years:

5. The spatial patterns of deforestation reveal an increasing opening of the *Selva Baja*, a vast region that is no longer inaccessible. With few exceptions, deforestation was historically concentrated in the *Selva Alta*, in the vicinity of the regions that expulse colonizing populations. With the expansion of the road network, new possibilities to penetrate the *Selva Baja* were created, reducing the difficulties that are inherent to fluvial transport in this region. In that way, the contribution of the *Selva Baja* and *Zona Hidromórfica* to total deforestation gradually increased from 50.92% in the 2001-2002 period, through 52.82% in 2003-2006, 56.04% in 2007-2010 and reaching 62.88% in 2011-2014. With the improved road infrastructure in the *Selva Baja* and with the plans that further expand and improve the road and railroad networks in this vast region of Peru, the geographic and structural barriers that made it difficult to deforest the Peruvian lowland Amazon forest in the past are being removed.

6. The increasing patch size of defrosted areas suggests an enhanced capacity of the agents to deforest. The participation of smaller parches (<0.5 ha; 0.5–3.0 ha) to the total area deforested each year decreased from 83% in 2001 to 62% in year 2013. In the same period the contribution of medium-sized patches (3.0 – 19.9 ha) increased from 16% to 31%, and the large-scale deforestation (> 20 ha), that was incipient at the beginning of the historical period analyzed, reached a participation of 7% in 2013. This trend is attributed to an increasing investment capacity of small and medium producers as well as to the emergence of agro industrial deforestation agents. There is no indication that suggests that this trend will reverse in the future.

7. Increasing integration of the Peruvian Amazon in the national and global economy. As a consequence of an important increase in the price of meet in 2006, grasslands dedicated to livestock production increased from 8,435 ha in 2006 to 136,839 ha in 2013 in the largest deforestation frontier along the Federico Basadre road in the Department of Ucayali. Similarly, driven by an increasing demand and price in international markets, since 2008 there is evidence of an important increase of croplands dedicated to the production of cash corps, such as coffee, cocoa and oil palm (78%, 18% and 4% of the cultivated areas, respectively). Alluvial gold mining did also increase substantially as a consequence of increased gold prices in international markets. Nevertheless, in comparison to nearby countries, the rise of cash crops in the Peruvian Amazon is still at its initial stage. The combination of increasing international prices for cash crops and decreasing transportation costs, associated to improvements in the road and railroad infrastructure, are likely to drive higher deforestation numbers in the future.

8. Week governance capacities at the regional and local level make it difficult for the Peruvian Government to control deforestation in the short term. Peru is committed with a decentralization process that intends to transfer responsibilities and competencies to regional

and local governments. As part of this process, forestry competences are being transferred to the governments of the departments. In addition to the difficulties inherent to this process, such as creating the required governance capacities at the regional and local levels, the decentralization brings with it additional challenges for coordinating policies, strategies and coherent regional development programs for the Amazon between sectors and levels of government, making it difficult to reconcile the objectives of economic growth and environmental conservation in the short term. It is possible that the dynamic of governance will take years, and perhaps decades, before resulting in the required capacity to reduce deforestation in an effective and efficient way.

9. <u>Domestic migration toward the Amazon</u>. Without the important domestic migration of people that colonized the Amazon region since historical times, particularly form the Andean region (*Sierra*), the current level of cumulated deforestation in the Peruvian Amazon would not have been possible. In addition to the colonization policy that was promoted by the Peruvian Government sometimes in the past century, the migration toward the Peruvian Amazon is driven by the pronounced disparity of opportunities that exist in different regions of the country. This is a structural problem that does not have a short-term solution, which makes it likely that more people will migrate and colonize the Peruvian Amazon in the upcoming decade.

Considering the observed patterns and trends of historical deforestation and the prevailing national circumstances in Peru, the most likely trend of deforestation in the Peruvian Amazon, in absence of enhanced mitigation actions and result-based payments, is the continuation of the historical trend of increasing deforestation in the upcoming years. For this reason, the proposed FREL has been constructed by linearly projecting[7] the historical (2001-2014) GHG emissions from anthropogenic gross deforestation into the 2015-2020 period.

The projection was done for each department individually and then the projections of each department were added to obtain the proposed FREL for the entire Peruvian Amazon. It is worth mentioning that this method brings the same result as linearly projecting the aggregated historical emissions of the entire Peruvian Amazon. The data per department were generated with the sole objective of informing future analysis and decision making regarding the most appropriate mitigation measures for each department, but they do not necessarily represent departmental forest reference emission levels. The results of these calculations are shown in Table 6 (in hectares) and in Table 7 (in tons of CO_2-e yr^{-1}). The equations of the regression lines used to project the GHG emissions are given for each department in Annex 1.

Figure 8 shows the proposed FREL and the historic GHG emissions from anthropogenic gross deforestation. Peru deemed more appropriate to establish a FREL that reflects the continuation of the historical trend of increasing emissions from deforestation as our country has still vast extensions of forests and the historical rates of deforestation have been relatively low so far. The economic development of the country and the construction of new and improved road infrastructure in the Peruvian Amazon will be accompanied by an increasing level of investment in agricultural and mining activities, as well as immigration flows from other Peruvian Regions. For these reasons, in absence of enhanced mitigation actions and appropriate and predictable international support for implementing said mitigation actions, it will be extremely difficult for Peru to halt an increase of deforestation in the upcoming years.

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7 The historic trends of deforestation in each Amazonian Department as well as the linear regression lines used to project activity data of anthropogenic gross deforestation and related GHG emissions is given in Annex 1.

Figure 8. Historical emissions from anthropogenic gross deforestation and proposed forest reference emission level for the Peruvian Amazon (in tCO_2-e).

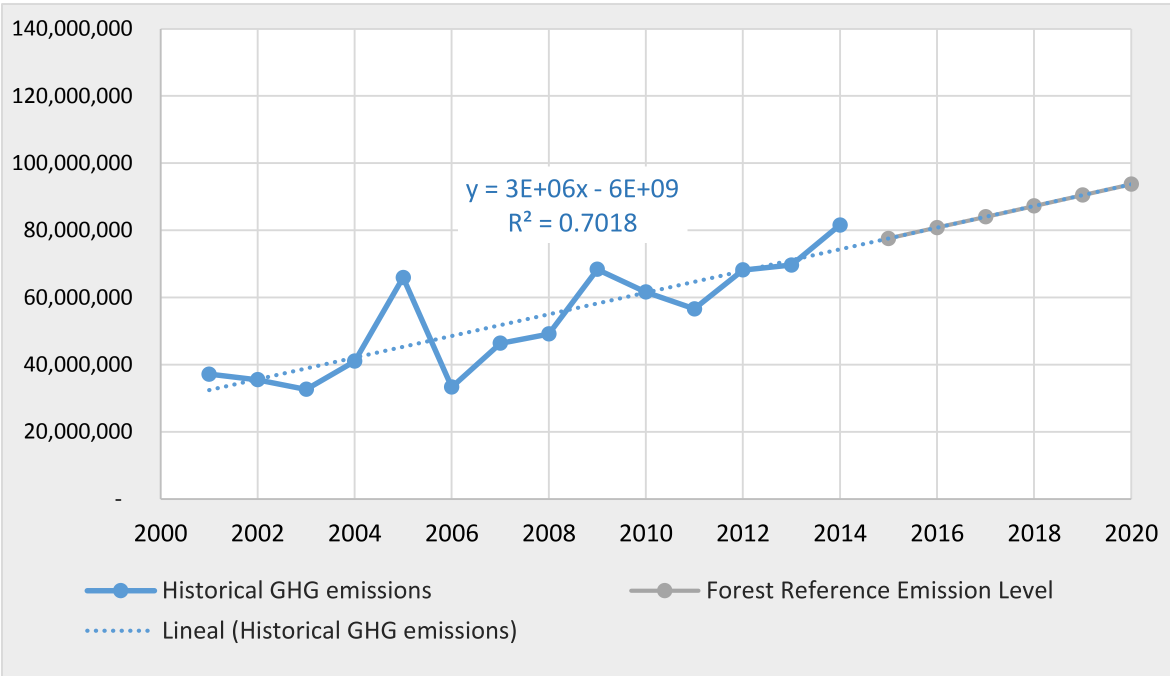

Table 6. Projected anthropogenic gross deforestation in the Peruvian Amazon (in hectares).

Department	2015	2016	2017	2018	2019	2020
	ha	ha	ha	ha	ha	Ha
AMAZONAS	5,216	5,355	5,494	5,632	5,771	5,909
AYACUCHO	811	833	855	877	900	922
CAJAMARCA	970	982	994	1,006	1,018	1,030
CUSCO	3,873	3,902	3,931	3,960	3,989	4,018
HUANCAVELICA	53	53	54	55	56	56
HUANUCO	24,884	25,956	27,029	28,102	29,175	30,248
JUNIN	9,375	9,619	9,863	10,107	10,351	10,595
LA LIBERTAD	60	62	64	66	68	70
LORETO	34,850	36,444	38,037	39,631	41,225	42,818
MADRE DE DIOS	14,509	15,227	15,945	16,663	17,381	18,099
PASCO	9,365	9,813	10,261	10,709	11,157	11,605
PIURA	96	87	77	67	57	47
PUNO	1,732	1,802	1,872	1,942	2,012	2,082
SAN MARTIN	30,416	31,085	31,754	32,424	33,093	33,762
UCAYALI	32,463	34,198	35,933	37,668	39,403	41,138
Annual total	**168,672**	**175,418**	**182,164**	**188,909**	**195,655**	**202,400**
Cumulative total	**1,676,280**	**1,796,319**	**1,916,359**	**2,036,398**	**2,156,437**	**2,276,477**

Note: The projections shown in this table were done by linearly extrapolating the historical data of anthropogenic gross deforestation of each department (see the historical data in Table 4).

Table 7. Proposed Forest Reference Emission Level for anthropogenic gross deforestation in the Peruvian Amazon (in tCO_2-e yr^{-1})

Department	2015	2016	2017	2018	2019	2020
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
AMAZONAS	1,990,284	2,043,974	2,097,664	2,151,354	2,205,044	2,258,734
AYACUCHO	308,301	316,705	325,109	333,513	341,917	350,321
CAJAMARCA	365,912	370,341	374,770	379,199	383,628	388,057
CUSCO	1,590,410	1,606,157	1,621,903	1,637,650	1,653,396	1,669,143
HUANCAVELICA	19,811	20,072	20,334	20,595	20,856	21,118
HUANUCO	11,951,959	12,476,312	13,000,665	13,525,019	14,049,372	14,573,726
JUNIN	3,645,646	3,741,938	3,838,229	3,934,520	4,030,812	4,127,103
LA LIBERTAD	22,975	23,701	24,427	25,153	25,879	26,605
LORETO	16,399,010	17,141,188	17,883,367	18,625,545	19,367,724	20,109,902
MADRE DE DIOS	7,430,080	7,799,952	8,169,823	8,539,694	8,909,566	9,279,437
PASCO	4,394,526	4,604,194	4,813,861	5,023,529	5,233,197	5,442,865
PIURA	37,061	33,296	29,531	25,767	22,002	18,237
PUNO	691,687	720,345	749,003	777,661	806,319	834,977
SAN MARTIN	12,313,646	12,611,516	12,909,386	13,207,255	13,505,125	13,802,995
UCAYALI	16,409,177	17,287,478	18,165,780	19,044,081	19,922,382	20,800,684
Annual total	**77,570,486**	**80,797,169**	**84,023,853**	**87,250,536**	**90,477,220**	**93,703,903**
Cumulative total	**159,135,802**	**239,932,971**	**323,956,824**	**411,207,360**	**501,684,580**	**595,388,483**

Note: The projections shown in this table were done by linearly extrapolating the historical data of emissions from gross deforestation of each department (see the historical data in Table 5).

3.2 Transparent, compete, consistent and accurate information

In accordance with paragraph 2(c) of the Annex to Decision 13/CP.19, the information provided in relation to the submission of a FREL/FRL should be transparent, complete, consistent and accurate, including methodological information, description of data sets, approaches, methods, models, if applicable, and assumptions used. Peru´s understanding of these concepts is as follows[8]:

- **Transparent information** means that the data, assumptions and methodologies used for establishing the FREL/FRL, as presented in this submission, are clearly explained to facilitate replication and assessment by the technical review team of the reported information.
- **Complete information** means, in the context of the technical assessment of submissions from Parties on proposed FREL/FREL[9], the provision of information that allows for the reconstruction of the FREL/FRL. All data and information used in the construction of the FREL proposed for the Peruvian Amazon is available for download through the following links:

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[8] See Todorova *et al*. (…).

[9] Note that in the context of national GHG inventories, *Completeness* means that an inventory covers all sources and sinks, as well as all gases and pools, included in the IPCC Guidelines as well as other existing relevant source/sink categories which are specific to individual Parties and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks of a Party, see Todorova *et al.* (…).

- http://www.bosques.gob.pe/propuesta-de-un-nivel-de-referencia-de-emisiones-forestales
- https://drive.google.com/folderview?id=0B651ZDvbhfYYZzlwMDBCVlNoQjA&usp=sharing

where the following information can be found:

(a) **MINAM (2014).** Technical report describing the data and methodology used to estimate average carbon stocks per eco-zone.

(b) **MINAM & MINAGRI (2014.a)**. Technical report describing the methodology used and result obtained in the classification of satellite images for the period 2000-2011.

(c) **MINAM & MINAGRI (2014.b).** Protocol describing the methodology used to classify Landsat ETM+ images.

(d) **MINAM (…).** Technical report describing the results obtained in adding to the 2000-2011 Map of Gross Deforestation (MDC) the results of the classification of Landsat 5 and Landsat ETM+ images of the period 2011-2013.

(e) **FREL & MRV TOOL PERUVIAN AMAZON**: Spreadsheets developed for calculating the proposed FREL for the Peruvian Amazon and for calculating and reporting the results of mitigation actions implemented in the Peruvian Amazon for reducing GHG emissions from anthropogenic gross deforestation on managed lands.

(f) **CARBON CALCULATION TOOL**: Carbon stock database and spreadsheets developed for calculating the average carbon stocks per hectare of each "eco-zone" (forest stratum) and their respective 95% confidence intervals, as shown in Table 8, section 3.3.2.

(g) **MMR**: Map of the Macro-Regions or Biomes of Peru, showing the location of the Peruvian Amazon, as shown in Figure 1 (section 2.1).

(h) **MGD**: Map of Gross Deforestation showing all areas deforested annually between 2001 and 2013, as shown in Figure 9 (section 3.3.1).

(i) **MEZ**: Map of Eco-Zones showing the forest strata existing in Peru and in the Peruvian Amazon, as shown in Figure 11 (section 3.3.1).

(j) **MDP**: Map of the Departments of Peru, showing the departments of Peru and their areas within the Peruvian Amazon, as shown in Figure 12 (section 3.3.1).

(k) **Reference cited:** Folder containing digital copies of all publications cited in this submission that are not IPCC literature or Decisions of the CP to the UNFCCC, as these are available for download in their respective websites.

- **Consistent information** means that the FREL/FRL should be internally consistent in all its elements and years. A FREL/FRL is consistent if the same methodologies are used for the base and all subsequent years (including the years when results of the mitigation actions will be reported) and if consistent data sets are used to estimate emissions and/or removals from sources and/or sinks, so that differences between years are real and not due to changes in methodologies or data sets.

The FREL proposed for the Peruvian Amazon has been constructed using one consistent methodology and source of data for estimating the annual historical activity data. The historical and projected emissions from deforestation were estimated using the same emission factors for every year.

- **Accurate information** means that a relative measure of the exactness of an emission and/or removal estimate should be provided. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties reduced as far as practicable and reported using appropriate methodologies, in accordance with the most recent IPCC guidance and guidelines, as adopted or encouraged by the CP, i.e. the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

  The accuracy of activity data, emission factors and of the proposed FREL has been estimated and is duly discussed and reported in section 3.3.1.3, 3.3.2.4 and 3.5.2, respectively, as well as in related technical reports (i.e. MINAM, 2014; MINAM & MINAGRI, 2014.a).

3.3 Information used for the construction of the FREL

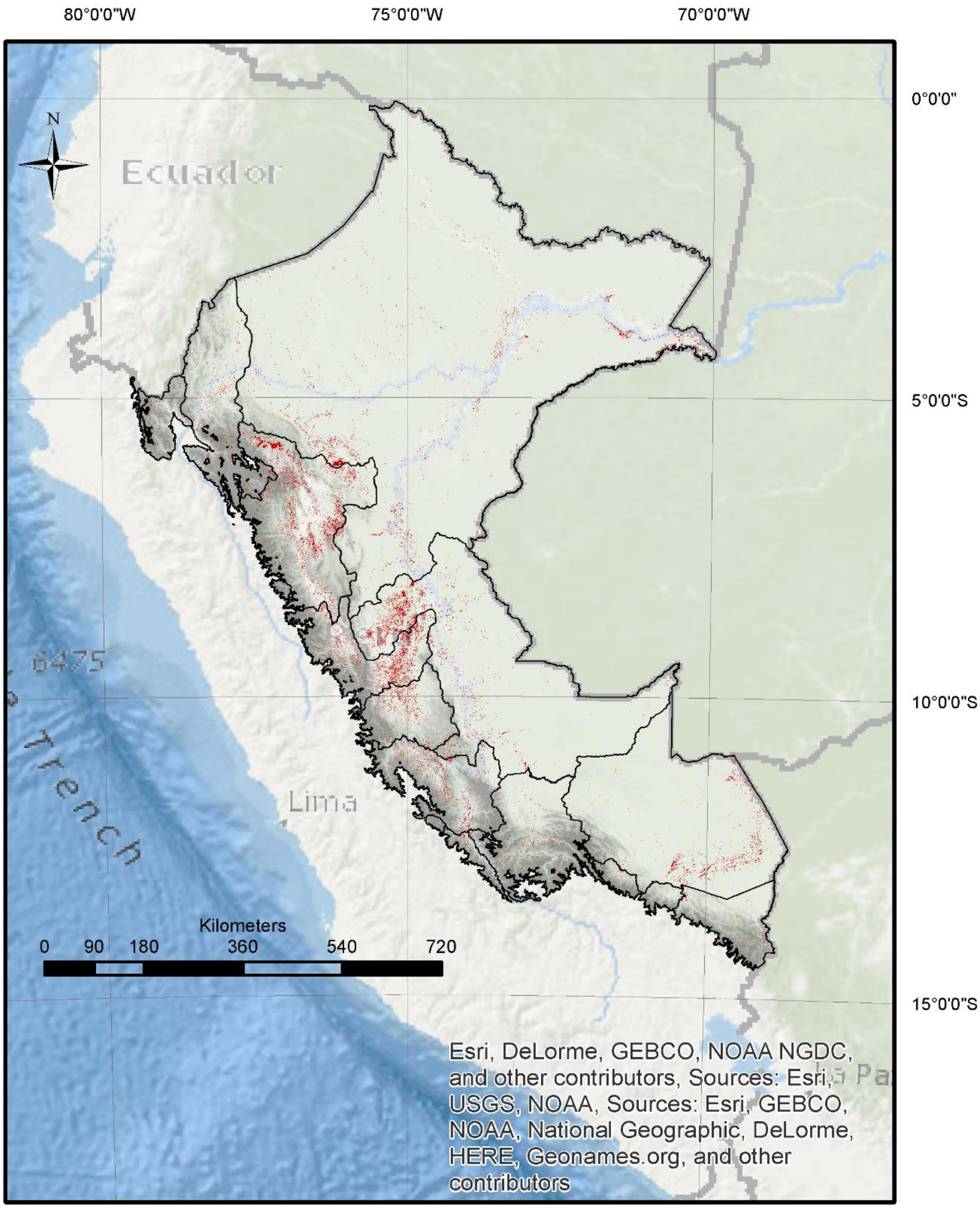
3.3.1 Activity data

Activity data used for the construction of the proposed FREL are the historic data of anthropogenic gross deforestation in the Peruvian Amazon shown in Table 4.

3.3.1.1 Source of data

The source of the historical activity data is a Map of Gross Deforestation (MGD) covering the entire Peruvian Amazon and containing information on annual areas deforested from 2001 to 2014 (see Figure 9). The MGD depicts only the non-overlapping annual areas that were deforested in lands classified as “forest land” in 2000.

Figure 9. Map of Gross Deforestation (MGD) showing the cumulative areas deforested between 2001 and 2014.

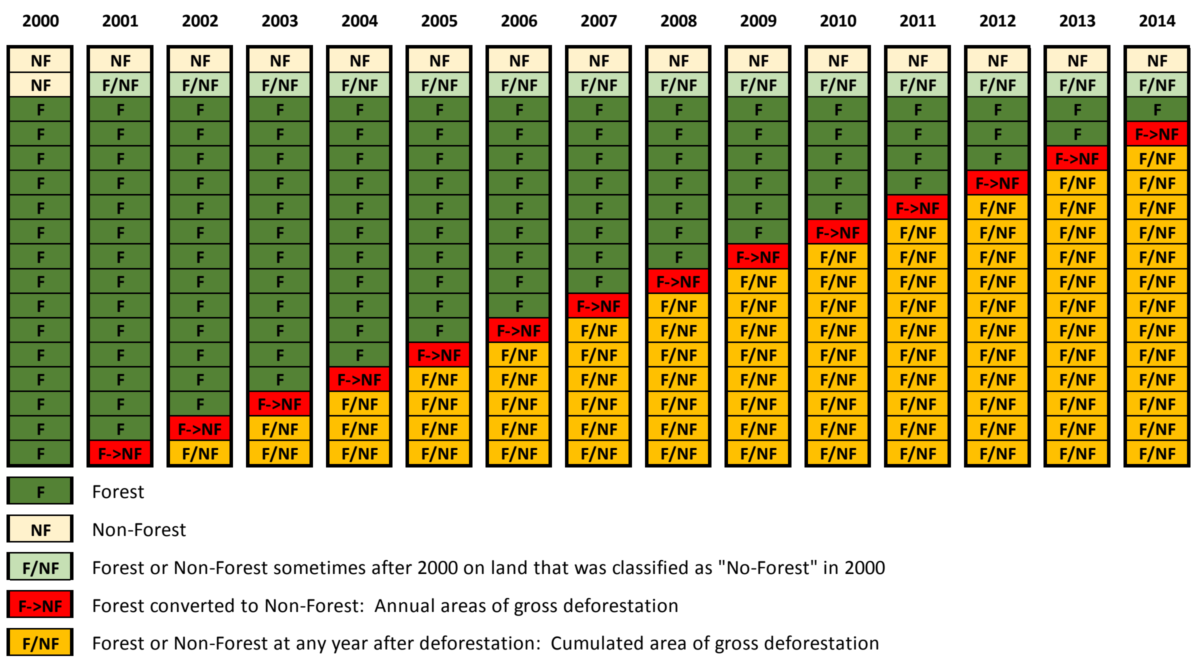


As shown in Figure 10, areas corresponding to clearings of secondary forests or forest plantations on lands that were classified as non-forest sometimes between 2001 and 2014 are excluded from the areas counted as "gross deforestation", whereas areas that were classified as forest since 2000 and then converted to non-forest (red areas in Figure 10) are counted as gross deforestation.

Once an area covered with forests since 2000 is cleared and counted as "deforested", it is not counted again under "gross deforestation", even if it appears covered with secondary forests or tree plantations sometimes after deforestation and then, a few years later, it appears again without trees.

The year 2000 will be maintained as the reference year for measuring gross deforestation at least until the reference level will be updated. This means that the FCBM created for the year 2000 will be used as the reference for measuring emissions from gross deforestation in the reports that will be annexed the future Biennial Update Reports.

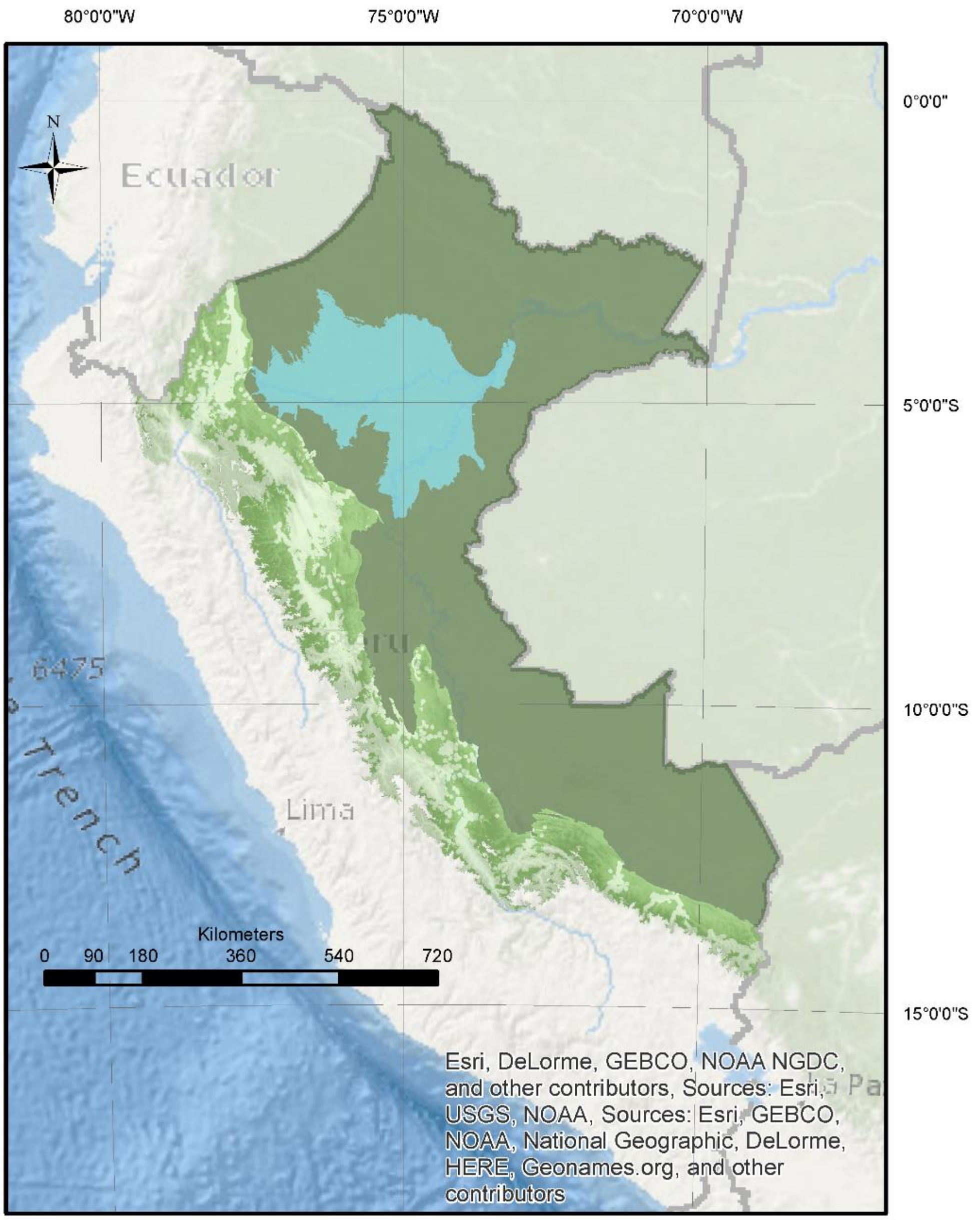
Figure 10. Schematic illustration of areas included and excluded from gross deforestation (only red areas are included)



Note: This figure only pretends illustrating the concept of gross deforestation. It shall not be interpreted that in 2014 only 1/14 of the forest existing in 2000 remained.

The pixels representing areas annually deforested were overlaid to a Map of Eco-Zones (MEZ) to extract information on annual deforestation (i.e. activity data) per eco-zone. The MEZ contains the eco-zones (i.e. the forest strata) existing in Peru and for which average carbon stocks have been estimated (see Figure 11). The results of this spatial intersection of maps (MGD x MEZ) were shown in Table 8.

Figure 11. Map of Eco-Zones (MEZ).



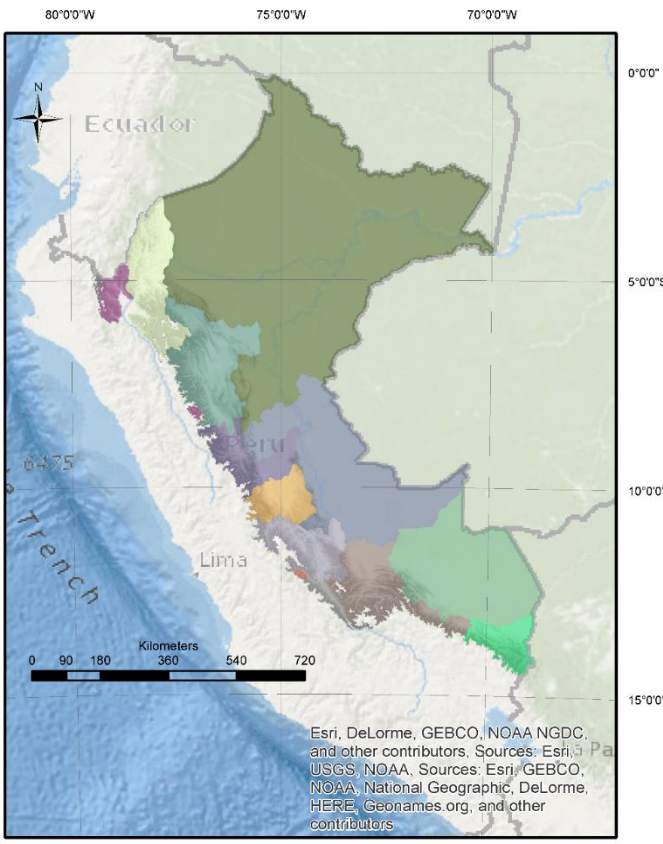
Eco-zone		Total area in the Peruvian Amazon	
Color	Name	ha	%
	Selva Alta Accesible	10,972,886.67	14.01%
	Selva Alta Difícil	11,132,433.90	14.22%
	Selva Baja	47,472,740.55	60.62%
	Zona Hidromórfica	8,730,739.62	11.15%
	Total	78,308,800.74	100.00%

Table 8. Activity data per eco-zone used in the construction of the FREL (in hectares).

Year	Anthropogenic gross deforestation				
	Selva Alta Accesible	Selva Alta Difícil	Selva Baja	Zona Hidromórfica	**Total**
	ha	ha	ha	ha	**ha**
2001	37,083	5,217	39,527	2,169	83,995
2002	32,873	5,239	38,973	2,746	79,831
2003	29,623	3,575	37,551	2,124	72,873
2004	40,302	5,236	43,571	4,036	93,146
2005	62,083	7,899	74,388	3,253	147,623
2006	29,852	4,573	37,739	2,337	74,501
2007	51,104	6,660	45,637	2,785	106,186
2008	29,274	5,587	67,493	3,350	105,704
2009	57,118	10,582	79,120	5,341	152,160
2010	48,948	10,618	72,914	3,724	136,205
2011	39,009	10,460	70,767	3,326	123,562
2012	43,898	13,017	85,103	7,458	149,476
2013	39,478	11,800	93,312	5,699	150,288
2014	50,374	15,045	104,635	7,517	177,570
Total	**591,018**	**115,508**	**890,729**	**55,866**	**1,653,121**
Average	**42,215.58**	**8,250.56**	**63,623.51**	**3,990.46**	**118,080**
Percentage	**35.75%**	**6.99%**	**53.88%**	**3.38%**	**100.00%**

The combined maps of gross deforestation and eco-zones (MGD x MEZ) was then overlaid to the Map of Departments of Peru (MDP, see Figure 12) to extract from the combination of the three maps (MGD x MEZ x MDP) information on activity data for each department and eco-zone. The results of this combination of maps were used to calculate the historic emissions of GHG from anthropogenic gross deforestation summarized in Table 5 and further detailed for each department and eco-zone in Annex 2.

Figure 12. Map of the Departments of Peru (MDP) with their area included in the Peruvian Amazon.



Department		Area included in the Peruvian Amazon
	Name	ha
	AMAZONAS	3,625,442
	AYACUCHO	345,155
	CAJAMARCA	781,792
	CUSCO	3,672,773
	HUANCAVELICA	69,129
	HUANUCO	2,357,277
	JUNIN	2,510,376
	LA LIBERTAD	82,948
	LORETO	37,511,604
	MADRE DE DIOS	8,498,853
	PASCO	1,763,882
	PIURA	82,388
	PUNO	1,609,895
	SAN MARTIN	4,863,123
	UCAYALI	10,534,163
	Total	**78,308,801**

3.3.1.2 Methodology used to create the Map of Gross Deforestation (MGD)

The Map of Gross Deforestation (MGD) was created, initially, for the period 2000-2011 and then completed for the period 2011-2014. Three technical reports and a scientific paper describe the methodology used and results obtained in creating these maps and the Forest Cover Benchmark Map (FCBM)[10] of year 2000:

- MINAM & MINAGRI (2014.a) describes the methodology used to create the 2000-2011 MGD map and the Forest Cover Benchmark Map of year 2000. It also includes a description of the main types of vegetation that can be found in the Peruvian Amazon, the definition of "forest" used in the creation of the FCBM and the MGD maps, and an assessment of the accuracy of the 2000-2011 MGD map.
- MINAM & MINAGRI (2014.b) describes with more details the methodological protocol followed in creating the 2000 FCBM and the 2001-2011 MGD maps. This same protocol was also applied for the 2012-2014 period, but using Landsat 5 and Landsat 8 images.
- MINAM (…), describes the addition of the years 2012-2014 to the MGD map of 2000-2011 and present the results of the entire 2000-2014 time series. It is worth noting that the numbers

[10] The Forest Cover Benchmark Map (FCBM) of year 2000 depicts the boundary of the forest in 2000 and is used as the base year for mapping gross deforestation from the year 2000 onwards.

of hectares deforested presented on page 11 of MINAM () are slightly different from those presented in this submission. This is due to small corrections of the boundaries of the map of the Peruvian Amazon that were done after the publication of the technical reports by MINAM.

- Potapov *et al.* (2014) describe in a peer-reviewed scientific paper methodology and results obtained in the creation of the 2000 FCBM and 2001-2011 MGD.

In short, the methodology described in the abovementioned documents can be summarized as follows.

Satellite data used:

- Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI) images. This type of data is ideal for mapping forest cover and detecting changes in forest cover because they can be obtained free of charge and provide almost continuous information since July 1999 with a temporal resolution of 16 days and a spatial resolution of 15 × 15 m in the panchromatic band, 30 ×30 m in the visible and infrared bands, and 60 × 60 m in the thermal band. The scenes cover an area of approximately 170 × 183 km.

Ancillary data used:

- MODIS (Moderate Resolution Imaging Spectroradimeter) images. Images of the satellites Terra-I and Aqua-1 with a spatial resolution of 250, 500 and 1000 m and a spectral resolution of 36 bands and a temporal resolution of 1 to 2 days were used for the pre-processing of Landsat images as well as for the normalization of the data, as further described below.
- SRTM (Shuttle Radar Topography Mission) images. The improved data of SRTM, available in CGIAR-CSI[11], at a 90 × 90 m spatial resolution were used to obtain elevation and relief data. The elevation data of SRTM were re-projected and resampled at 30 × 30 m resolution to match the spatial resolution of Landsat ETM images. The data of elevation and slope were included in the metrics of the classification.
- Hydrography. A supervised classification was realized for the years 2000, 2011 and 2014 to map the complex hydrographic network of the Peruvian Amazon. Some manual edition was necessary to complete the map, as some river could not be classified digitally.

Pre-processing

- Selection of satellite images. Landsat 5 and Landsat ETM+ images acquired between 1999 and 2011 (and, later, between 2011 and 2014) were downloaded from the Earth Resources Observation and Science Center (EROS) of the United States Geological Service (USGS). In total, more than 11,400 images covering all the Paths/Rows of Peru´s national territory were downloaded.
- Selection of spectral bands. The spectral bands corresponding to visible blue (0.452-0.518 µm) and green (0.528-0.609 µm) were excluded as they were affected by noise, which is typical for the atmospheric conditions of tropical regions.
- Re-projection. The downloaded images had a Standard Terrain Correction (Level 1T) processing level that includes a geometric rectification that is free of distortions related to the sensor (Potapov *et al.*, 2014). The Landsat 5 and Landsat ETM+ scenes had UTM projections

[11] http://srtm.csi.cgiar.org

that were re-projected to the Sinusoidal reference system (central meridian 60º W) as this system has a higher accuracy of the minimum mapping unit (1 pixel, i.e. 0.09 hectares).

- Data calibration. The digital numbers of the images were calibrated at reflectance values on the top of the atmosphere (TOA) and temperature (Thermal band 6-2). The correction was done following the approach described in Chander *et al.* (2009) with coefficient taken from the metadata. The equation used can be found in MINAM & MINAGRI (2014.b, p. 16 and 17).
- Quality evaluation. All the data passed through a quality evaluation for which a decision-tree model was used to detect clouds, shadows, haze and water to obtain a cloud-free database. The thresholds for the detection of these features were derived from training data compiled by the University of Maryland across the whole topical biome. For the collection of training data, a group of Landsat 5 and Landsat ETM+ scenes was selected on different parts of the Peruvian Amazon forest and the classes “land”, “water”, “cloud”, “haze” and “shadow” were classified. Of this group of images, 10% of the samples was randomly selected and used to create the decision trees. Each model was applied to each Landsat 5 and Landsat ETM+ scene to produce probabilistic values of the classes “cloud”, “shadow” and “water”. Based on these values, each pixel was assigned to a code of quality evaluation that reflects the probability that the pixel will be observed as land or cloud-free water. More details on this method can be found in Potapov *et al*. (2012).
- Data normalization. The spectral data were normalized using MODIS images following the methods described in Potapov *et al*. (2012). To this end, the products MOD44C of MODIS were used. More details on the procedure followed can be found in MINAM & MINAGRI (2014.b, p.18).
- Conversion to 8 bits. To reduce the size of the database and facilitate data analysis, the normalized reflectance data were reduced to 8 bits (see MINAM & MINAGRI, 2014.b, p. 19 for more details on this procedure).
- Creation of metrics. The analysis of the Landsat 5 and Landsat ETM+ time series used multi-temporal metrics (as described by DeFries *et al*., 1995; Hansen *et al*., 2008; and Potapov *et al.,* 2014) that allow an accurate change detection over the entire time period. To this end, the corrected bands were stacked to a cloud-free set of observations forming the base to calculate three types of metrics:

  (1) Reflectance values representing maximum, minimum and selected percentile values (10, 25, 50, 75 and 90% percentiles);

  (2) Mean reflectance values for observations between selected percentiles (max-10%, 10-25%, 25-50%, 50-75%, 75-90%, 90%-max, min-max, 10-90%, and 25-75%);

  (3) Metric capturing the correlation between reflectance values in each band and the image acquisition date, applying a linear regression model represented by its slope.

Within the supervised forest classification and deforestation detection, the first two metrics were applied to data representing the start and end years of the reporting periods (2000, 2011, 2014). The metrics capturing the correlation between reflectance values and acquisition date was used as input for a decision tree analysis that allocates forest cover changes detected for the periods 2000-2011-2014 to individual years of each period (see MINAM & MINAGRI, 2014.b, p. 19-23 for more details on the metrics used.

Classification:

- Classification algorithm. The pre-processed data were classified using a supervised classification algorithm developed at the University of Maryland. The algorithm is based on decision trees that are calibrated through a manual creation of training samples for forest / no-forest and loss / no-loss of forest and uses the metrics created at the end of the pre-processing step as data entries.
- 2000 FCBM. The first product of the classification was the creation of the Forest Cover Benchmark Map (FCBM) that depicts the areas classified as "forest land" (according to the definition of "forest", cf. section 3.4) and the areas classified as "no-forest land" in 2000. This map is key to assess gross deforestation, as only never overlapping areas of forest land converted to non-forest land within the area classified as "forest" in this FCBM are counted as "gross deforestation".
- 2000-2014 MGD. The second product of the classification was the Gross Deforestation Map of the period 2000-2011 to which the areas deforested between 2012 and 2014 were added later. The classification of this map used two groups of training samples: "loss" and "no-loss". All areas classified as forest in 2000 were then intersected with the areas classified as "loss" to obtain gross deforestation data.

Post-processing:

- Expert review. The result of the supervised classification were reviewed by a panel of national exerts from various institutions (MINAM, MINAGRI, Sd OTCA, SERNANP and UNALM) with good knowledge of the forests in Peru.
- Map edition. Based on the recommendation of the reviewers, the following editions were made:

  (a) Some wetlands ("*Aguajales*") have areas covered by bare soil and grasses and/or bushes and a natural dynamic that make their correct classification difficult. Classification problems were observed particularly in the department of Loreto, where most of the *Aguajales* are to be found. Post-processing to improve the classification of these wetlands included summing the bands 4 and 5 of the year 2000 and 2001, running a texture filter of 3×3 and applying the ratio band5/band4. The result was an image in which the highest values represented a higher probability of bare soil. Using high resolution images of Google Earth, threshold values of the gray tones were determined to identify areas of bare soil and bare soil with vegetation.

  (b) Some grasslands ("*Herbazales*") showed commission and omission errors, mainly with areas of forest of bright green color. To address this problem a similar approach to the one used to improve the classification of bare soil in wetland areas was implemented.

  (c) Some bamboo forests ("*Pacales*") presented omission problem that were manually/visually corrected.

Accuracy assessment:

The accuracy of the 2000-2011 MGD was independently assessed following the methods described in MINAM & MINAGRI (2014.a). The assessment of the accuracy of the last three years of the MGD map (2012-2014) is still underway.

The assessment of the accuracy of the maps involved placing 30 tiles of 12 × 12 km over the entire Peruvian Amazon to then evaluate the accuracy of the classification in each tile using high resolution images.

For the selection of the tiles to be evaluated, a stratification was performed to locate the tiles in areas with low probability of forest loss and high probability of forest loss. 9 tiles were located in the stratum with high probability of forest loss and 21 in the forest stratum with low probability of change. Then, in each tile, 100 pixels were randomly selected and, using high resolution RapidEye images of the year 2011 as well as Landsat 5 and 7 images of the years 2000 and 2001, their ground-truth condition visually determined. Using 2553 points representing losses and no-losses of forest area the error matrix shown in Figure 13 was created.

Figure 13. Confusion matrix of the Map of Gross Deforestation 2001-2011 with values in % (Source: MINAM & MINAGRI, 2014.a, p. 108).

	Forest	Loss of forest	Total	User's accuracy	Commission error
Forest	99.30	32.93	95.26	97.89	2.11
Loss of forest	0.70	67.07	4.74	86.15	13.85
Total	100.00	100	100		
Producer's accuracy	99.30	67.07		Overall accuracy: 97.33	
Omission error	0.70	32.93			

As can be appreciated in this matrix, the overall accuracy of the MGD is 97,33% for the 2001-2011 changes, which is a very good result. However, the information collected to evaluate the accuracy of the MGD is insufficient for assessing the accuracy of annual activity data per eco-zone. At this level it is unusual that map accuracies are reported. Nevertheless, it is acknowledged that Peru needs to improve its data and methods for assessing the accuracy of activity data.

3.3.2 Emission factors

The emission factors used for the construction of the proposed FREL are the forest carbon stocks per hectare (expressed in tCO_2-e ha^{-1}) estimated for the biomass of living trees, as reported by MINAM (2014) for the above-ground biomass and calculated with the equation of Mokany *et al.* (2006) for the below-ground biomass, using a default carbon fraction of 0.47 (IPCC, 2006)[12] and a stoichiometric ratio of 44/12 for the conversion of tons of carbon to tons of carbon dioxide equivalent. The calculated average carbon stocks per hectare and their corresponding 95% confidence interval (95% C.I.) are shown in Table 9.

[12] The average carbon stock values reported by MINAM (2014) for the above-ground biomass of living trees was calculated using a carbon fraction of 0.49, which is not the correct default value for the carbon fraction of tree biomass according to IPCC (2006). The values reported by MINAM (2014) were thus corrected by multiplying them by the ratio 0.47/0.49.

Table 9. Estimated average carbon stocks per eco-zone (in tCO_2-e ha^{-1})

Eco-zone	Above-ground biomass			Below-ground biomass			Total living tree biomass		
Name	Average	95% C.I.		Average	95% C.I.		Average	95% C.I.	
Costa	29.44	18.57	40.3	9.9	6.6	13.1	39.4	25.2	53.5
Selva Alta Accesible	297.33	277.28	317.4	77.7	73.0	82.4	375.0	350.3	399.7
Selva Alta Difícil	344.88	322.51	367.2	88.7	83.5	93.8	433.6	406.1	461.0
Selva Baja	410.58	399.71	421.4	103.6	101.1	106.0	514.1	500.8	527.4
Sierra	110.22	35.45	185.0	32.1	11.7	50.9	142.4	47.2	235.9
Zona Hidromórfica	247.10	203.81	290.4	65.9	55.5	76.1	313.0	259.3	366.5

3.3.2.1 Source of data

Peru´s national forest inventory (*Inventario Nacional Forestal*, INF) is currently being implemented for the first time. The project "National Forest Inventory and Sustainable Forest Management in Peru in the Context of Climate Change" ("*Inventario Nacional Forestal y Manejo Forestal Sostenible del Perú ante el Cambio Climático*") started in 2011 with the support of FAO-Finland and in co-execution between the Ministry of the Environment (MINAM) and the Ministry of Agriculture and Irrigation (MINAGRI). By the end of 2014, the project was institutionalized in the new Direction of Inventory and Valuation (*Dirección de Inventario y Valoración*, DIV) of the National Forest and Wildlife Service (*Servicio Nacional Forestal y de Fauna Silvestre*, SERFOR).

The INF counts with a paneled design with a systematic distribution of sub-samples. Each panel covers 20% of the total samples planned for each eco-zone and corresponds to the measurements that should be completed in one year, so that the first complete cycle of the INF will be available in 5 years. Although the fieldwork started already in 2013, completing the institutional arrangements caused some delays so that the measurement of the first panel is still ongoing.

As Peru´s national forest inventory has not yet been fully implemented, national carbon stock data from plots established and measured following a statistical design laid out for generating complete and accurate carbon stock estimates at the national level are not yet available. For this reason, the Ministry of the Environment (MINAM) through its National Forest Conservation Program (*Programa Nacional de Conservación de Bosques*, PNCB[13]) invited a number of private institutions, governmental and non-governmental organizations, public institutions and academic institutions to collect and provide forest inventory data that may be useful to estimate carbon stocks at the national level.

Data from the invited entities were obtained in two tranches, the first one between the 28th of December, 2012 and the 15th of February, 2013 and the second one through an extension of the delivery term to February 2014, since the first tranche contained serious information gaps for two important eco-zones: the "*Costa*" (Coast) and the "*Zona Hidromórfica*" (Hydromorphic Zone).

An Excel template was designed and provided to the invited entities to facilitate a consistent presentation and documentation of the data. Some 36 entities responded to the call and provided data from 1990 plots, most of them with information on individual trees, and a description of the protocols followed for laying out the plots and performing the field measurements.

[13] Now called "*Programa Nacional de Conservación de Bosques para la Mitigación del Cambio Climático*" (PNCBMCC).

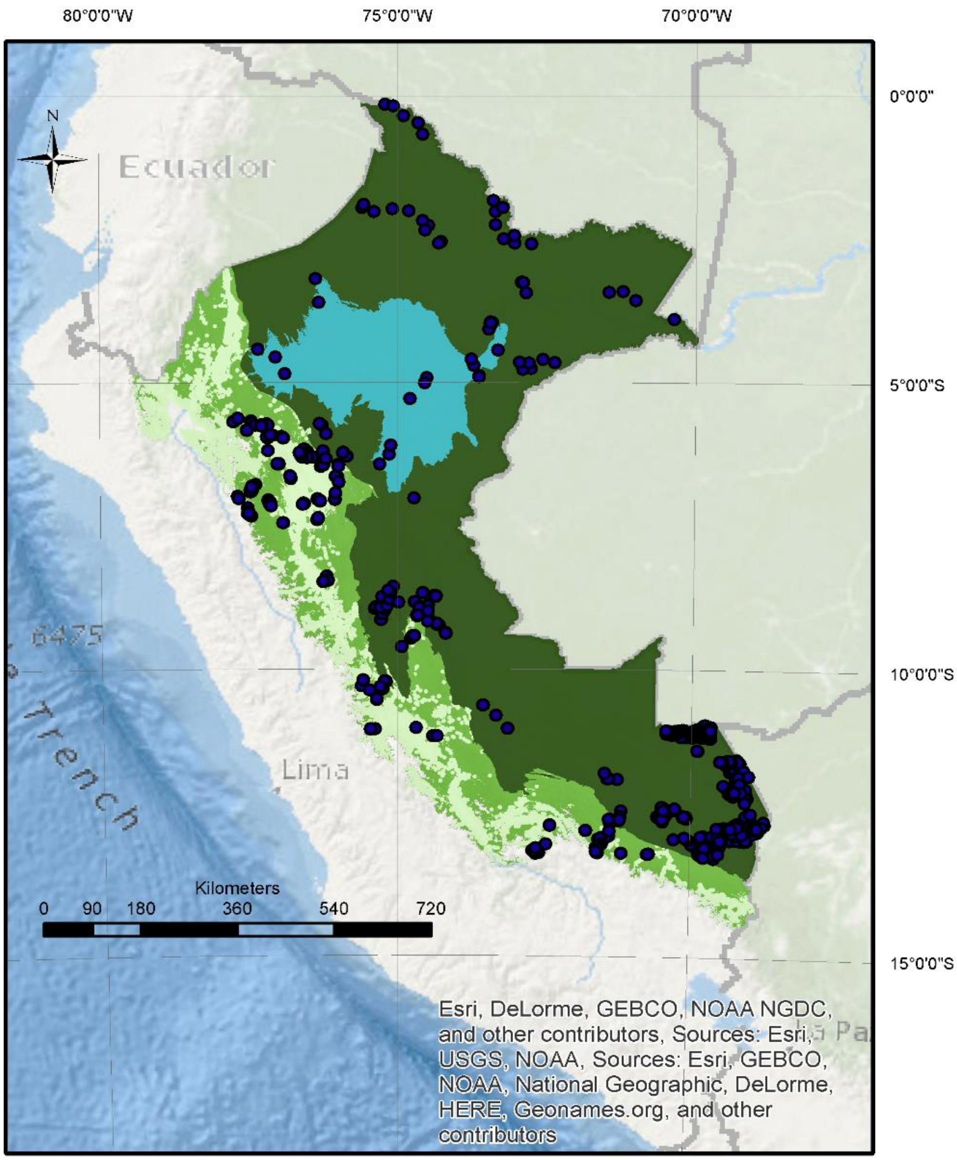
Since the data were generated following different protocols, a strict quality control was implemented to select only the data that met the minimum quality standards required for estimating carbon stocks. This process resulted in the elimination of 783 plots, so that only 1,207 plots were considered and analyzed for the calculation of average carbon stocks, 1,152 of which are located in the Peruvian Amazon (see Figure 14).

The reasons for excluding plots or plot data included:

- **Location problems.** Counting with accurate information on the location of the plots was critical, as the location was used to identify the forest stratum to which each plot belongs. Plots without location information, or with inaccurate or mistaken coordinates were discarded.
- **Methodological problems**. Plots measured with methodologies that were incompatible with the calculation tool developed for estimating average carbon stocks per hectare (e.g. linear plots) and all plots with a measured area that was not represented at least 10 times in the database for the eco-zones *Selva Alta Accesible*, Selva *Alta Dificil* and *Selva Baja* were discarded.
- **Plots falling outside forests**. All plots with accurate location information were overlaid to the most recent forest / no-forest map available at the time of the analysis and the plots falling outside areas classified as “forest” were discarded. Similarly, plots whose description corresponded to a non-forest category were also discarded.
- **Missing data**. Plots without information on the area measured or without data on carbon stocks or without data for calculating carbon stocks were discarded.
- **Wrong application of the protocol**. Plots where the measurement protocol was applied incorrectly in more than one tree (e.g. presence of trees below the minimum measurement diameter or with a dbh above the range of application of the allometric equation used [i.e. Chave *et al*., 2005: 5 cm ≤ dbh[14] ≤ 156 cm]) were discarded. If an error was detected only on one individual tree, the tree was discarded and the plot retained.
- **Data errors**. Plots with obvious erroneous values (e.g. trees with more than 100 m height) in more than one tree were discarded. If an error was detected only on one individual tree, the tree was discarded and the plot retained.

[14] dbh = diameter at breast height (130 cm).

Figure 14. Location the 1,152 plots used to estimate the carbon stocks of the Peruvian forest



Eco-zone		Number of plots	
Description		b.QC	a.QC
Color	Name	Nr.	Nr.
	Costa	112	24
	Sierra	51	31
	Selva Alta Accesible	293	192
	Selva Alta Difícil	456	131
	Selva Baja	1035	816
	Zona Hidromórfica	13	13
	Plots without location information	30	0
Total		1990	1207

Note: b.QC = before Quality Control; **a.QC** = after Quality Control.

3.3.2.2 Methods used for estimating carbon stocks

The data used to estimate the average carbon stocks per forest stratum present in the Peruvian Amazon (called "eco-zones" in this submission) can be found in the spreadsheet tool "**CARBON CALCULATION TOOL**" that also contains all data, calculations, equations, parameters and reference used in performing the estimations. A detailed description of the methods and equations used to perform the carbon stock estimates can be found in MINAM (2014).

Carbon stocks in the living above-ground biomass of trees were calculated using the allometric equations shown in Table 10. These equations were selected through a collaborative effort of the technical teams of MINAM's REDD+ project, the National Forest Conservation Program for Climate Change Mitigation (PNCBMCC), the General Directorate for Climate Change, Desertification and Hydrological Resources (DGCCDRH), the General Directorate of Evaluation, Valuation and Financing of the Natural Heritage (DGEVFPN) and of the National Forest Inventory (INF) and will also be used in the context of the National Forest Inventory.

Table 10. Allometric equations and default parameters used for estimating carbon stocks in the living biomass of trees

Equation or Factor	Application in Peru	IPCC climatic zone	Reference
Above-ground biomass in trees (AGB.t)			
$0.112 * (\rho*\mathbf{dbh}^2*\mathbf{h})^{0.916}$	*Costa* and *Sierra*	Dry forest	Chave *et al.*, 2005
$\rho*Exp(-1.239 +1.980*\ln(\mathbf{dbh}) +0.207*\ln(\mathbf{dbh})^2-0.0281*\ln(\mathbf{dbh})^3)$	*Selva Alta* and *Zona Hidromórfica*	Wet forest	Chave *et al.*, 2005
$\rho*Exp(-1.499+2.148*\ln(\mathbf{dbh})+0.207*\ln(\mathbf{dbh})^2-0.0281*\ln(\mathbf{dbh})^3)$	*Selva Baja*	Moist forest	Chave *et al.*, 2005
$6.666+12.826*h^{0.5}*\ln(\mathbf{h})$	Tall Palms (h>11m)		Pearson *et al.*, 2005
$23.487+41.851*\ln(\mathbf{h})^2$	Small Palms (h≤11m)		Pearson *et al.*, 2005
$10^{(0.12+0.91*\log(\mathbf{BA})}$	*Vines*		Putz, 1983
Below-ground biomass in trees (BGB.t)			
$\mathbf{BGB.t}=0.489*\mathbf{AGB.t}^{0.890}$	All		Mokany *et al.*,2006
Default parameters			
0.47	Default carbon fraction		IPCC, 2006
0.64	Default wood density		Average[15]
44/12	Stoichiometric ratio to convert tons of C to tons of CO_2-e		

Where: ρ = Wood density; **dbh** = Diameter at breast height; **h** = Tree height; **BA** = Basal area; **AGB.t** = Above-ground living tree biomass; **BGB.t** = Below-ground living tree biomass.

15 In cases where the institutions provided information at the level of individual trees, the wood density applied was the one indicated by the institutions. In cases where the institutions did not report a wood density value, a list with wood density values reported for 1418 tropical species by Baker *et al.*, 2004, Barbosa and Fearnside, 2004; CTFT, 1989; Fearnside, 1997 and Reyes *et al.* 1992 was consulted. In cases where no wood density value was provided by these authors, the average value of 0.64 t m^3 was applied, which is the average value of all wood densities reported for America in the aforementioned list.

3.3.2.3 Forest stratification

Knowing that forest carbon stocks vary across the landscape depending on many natural and anthropogenic factors, including time, the selection of the information used for stratifying the Peruvian forest in homogeneous units of carbon density (i.e. carbon stock strata) was carefully analyzed and discussed before extracting information from six different maps to create the Map of Eco-Zones (MEZ) shown in Figure 11 as the base for forest carbon stratification in Peru. The Map of Eco-Zones is also being used in the context of the National Forest Inventory currently underway. A discussion of all map sources considered and used for the creation of the MEZ can be found in MINAM (2014).

The Map of Eco-Zones was created through a participative process that involved experts from many institutions, including representatives from MINAM, MINAGRI (Ministry of Agriculture and Irrigation) and the regional governments of San Martín and Madre de Dios, as well as members of research centers and of the civil society, in particular those that provided information on forest carbon stocks.

The six eco-zones represented in the MEZ can be described as follows:

***Costa*:** With some 15,024,310 ha, the "*Costa"* (Coast) covers 11.69% of Peru. It is located along the Pacific coast of the country and its climate is dry (mainly desert-like), mean annual rainfall between 0 and 2,000 mm yr^{-1}. Some xerophytic open forests, with small and branchy trees can be found in its most humid valley on the North of the country, in the departments of Tumbes, Piura, Lambayeque and La Libertad.

***Sierra*:** With approximately 35,270,135 ha (27.44% of Peru), the "*Sierra*" (Mountain range) represents a mountainous region where forests can be found above 2,000 and below 3,800 m.a.s.l. from the North of the country, in the departments of Piura and Cajamarca, down to the South, in the departments of Puno and Tacana. Most of its vegetation are grasslands and paramos. Forest in this region have small trees, are fragmented and are often highly intervened.

***Selva Alta Accesible*:** This eco-zone covers some 11,083,358 ha (8,62% of the country) and covers parts of the departments of Amazonas and Cajamarca in the North and Puno in the South. Elevations in the "*Selva Alta Accessible*" (Accessible High Forest) range from 500 to 3,800 m.a.s.l. The name of this eco-zones highlights that access to it is facilitated by many roads that are generally in good shape and passable by truck. Forests in this eco-zone include tall trees up to 35 meters at the lower elevations and small trees up to 10 meters at the highest elevations.

***Selva Alta Difícil*:** With some 11,333,203 ha (8.82%) the "*Selva Alta Difícil*" (Difficult High Forest) is characterized by hilly terrain with steep slopes so that it remains mostly protected due to its difficult access conditions. Many areas of this zone are declared as Protected Natural Areas. Physiognomically and floristically, this eco-zone is similar to the "*Selva Alta Accessible*".

***Selva Baja*:** Covering 47,140,848 ha (36.68%) the "*Selva Baja*" (Lowland Forest) is the largest eco-zone in Peru. It is located in the eastern Part of the country, covering an area ranging from the department of Loreto in the North to Madre de Dios in the South. Elevations are between 100 and 500 m.a.s.l.

The natural vegetation in this eco-zone is mostly a highly diverse forest with tall trees up to 45 meters and more that 7,000 tree species.

***Zona Hidromórfica*:** With some 8,669,706 ha (6,75%) the "*Zona Hidromórfica*" (Hydromorphic Zone) is the smallest eco-zone of Peru. It is represented by the huge wetlands, some of which are protected, in the department of Loreto. Being often or permanently flooded, there it has a fewer number of tree species, mostly the palm *Mauritia flexuosa*, and some areas are covered by shrubs and grasses.

3.4 Definition of "forest" used in the construction of the FREL

Peru´s definition of forest has evolved over time and today some different definitions coexist and are used, depending on the institutional context and purpose for which they were formulated.

Currently, Peru is applying three forest definitions for international and multilateral reporting purposes:

(1) The Peruvian Designated National Authority (DNA) of the Clean Development Mechanism (CDM) reported to the UNFCCC the following definition of "forest", which is used in the context of afforestation and reforestation project activities under the CDM[16]:

- Minimum area: 0.50 hectares;
- Minimum tree height at maturity *in situ*: 5.00 m;
- Minimum crown cover: 30%.

(2) Currently being implemented, the National Forest Inventory applies specific forest definitions for the three biomes *Costa*, *Sierra*, and the Amazon. In case of the Amazon, the following parameters are used:

- Minimum area: 0.50 hectares;
- Minimum width: 20.00 m
- Minimum tree height at maturity in situ: 5.00 m;
- Minimum crown cover: 10%.

(3) Activity data used for constructing the proposed FREL is based on the following definition of "forest" of the National Forest Inventory (MINAM and MINAGRI, 2014.a) taking the minimum area to the technological requirements of a methodology:

- Minimum Mapping Unit: 1 Landsat pixel (0.09 hectares);
- Minimum tree height at maturity in situ: 5.00 m;

The Ministry of the Environment chose the third definition for REDD+ reporting purposes taking into consideration the scale of land-use change in the Amazon and the technical specifications of the activity data processing chain. This definition captures the spatiotemporal patterns of predominantly smaller deforestation events.

Moreover, the definition is compatible with the forest definition applied in the National Forest Inventory which requires a larger minimum forest area to accommodate the inventory clusters. Both forest definitions, the one used in the NFI and the definition used to provide activity data on deforestation, are used in the National GHG Inventories 2010 (submitted as part of the BUR in 2014) and 2012 submitted within the Third National Communication in 2015. The

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

Government of Peru will harmonize its forest definitions, once new remote sensing technologies provide the data and means to accurately capture land-use changes dynamics across different biomes.

3.5 Construction of the FREL

3.5.1 Method used to construct the FREL

The equation used to construct the proposed FREL and that will be used to measure, report and verify future GHG emissions from deforestation in the context of result-based payments is the following:

$$E_t = \sum_{i}^{I} \left(A_{i.t} * EF_{i,t} \right) \qquad \textbf{[Eq.01]}$$

Where:

E_t Emissions from deforestation in year *t*; tCO_2-e yr^{-1}

$A_{i,t}$ Area deforested in the eco-zone *i* to establish the new land-use category *LU* in year *t;* ha yr^{-1}

$EF_{i,t}$ Emission factor applicable to the eco-zone *i*, when changing to the land-use category *LU* in year *t* tCO_2-e ha^{-1}

i Eco-zone *i;* dimensionless

I Total number of eco-zones*;* dimensionless

t A year; dimensionless

LU One of the non-forest land use categories of IPCC, i.e. cropland, grassland, wetland, settlements or other land.

Notes:

- The annual emissions from deforestation (E_t) are calculated for each land-use transition and year in the sheet “GHG-EMIS” of the spreadsheet tool “FREL & MRV TOOL PERUVIAN AMAZON”.
- The area deforested annually in each eco-zone ($A_{i,t}$) are reported in the sheet “ACT-DATA” of the of the spreadsheet tool “FREL & MRV TOOL PERUVIAN AMAZON”.
- The estimated emissions factors (EF_i) are reported in the sheet “C-STOCKS” of the of the spreadsheet tool “FREL & MRV TOOL PERUVIAN AMAZON”.
- It is worth noting that equation Eq.1 is not written as shown above in the IPCC literature. The relation between Eq.1 with its corresponding IPCC equation is therefore discussed here below.

The term $A_{i,t}$ in the equations of IPCC

IPCC does not always use the same notations to refer to activity data. For example, equation 2.6 in IPCC, 2006 (Ch. 2, section 2.2.2, p. 2.10) and in equation 2.8 in IPCC, 2006 (Ch. 2, section 2.3.1.1, p. 2.12), IPCC uses the notation *A* to refer to the quantity of land area (e.g. hectares) that remained in the same category, while in equation 2.16 (IPCC, 2006, Ch. 2, section 2.3.1.2, p. 2.20), IPCC uses the notation $\Delta A_{TO\_OTHERS_i}$ to refer to the quantity of land area (e.g. hectares) that changed to another land use category. In all this cases the notion expressed by these notations is “quantity of land area”, i.e. "activity data", which in in this submission is represented by the notation $A_{i,t}$, as in equation Eq.01 above.

The term EF_i, in the equations of IPCC

In the context of transitions of forest land to other land use categories (i.e. "deforestation"), emission factors should be understood as the sum of two components:

- The emissions and removals of carbon dioxide associated to changes in carbon stocks that occur in one hectare that changes from forest land to another land use category (i.e. cropland, grassland, wetland, settlements or other land); and
- The emissions of non-CO_2 gasses that occurs in the same hectare that changed from forest land to another category in the year of the transition.

This is shown by the following equation:

$$EF_{i,t} = \Delta C_{i,t} + ENCO2_{i,t} \quad \textbf{[Eq.02]}$$

Where:

$EF_{i,t}$ Emission factor applicable to the eco-zone i, when changing to the land-use category LU in year t; tCO_2-e ha^{-1}

$\Delta C_{i,t}$ Change in carbon stock associated to the transition from eco zone i to the land use category LU in year t; tCO_2-e ha^{-1}

Note: $\Delta C_{i,t}$ is equivalent to ΔC_{LU} in equations 2.2 and 2.3 in IPCC, 2006 (Ch. 2, section 2.2.1, p. 2.7).

$ENCO2_{i,t}$ Emission of non-CO_2 gasses associated to the transition from eco zone i to the land use category LU in year t; tCO_2-e ha^{-1}

Notes:

- In the case of the proposed FREL, emission factors for a specific eco-zone do not change over time and space, as the average carbon stocks per hectare of mature forests are assumed to be constant. The notation $\Delta C_{i,t}$ is therefore equivalent to the notation ΔC_i, or the notation ΔC_{LUi} in IPCC, 2006. The assumption of no change in carbon stocks of mature forests will be maintained in future measurements, reports and verifications in the context of result-based payments in order to maintain consistency with the proposed NREF.
- Emissions of non-CO_2 gasses associated to the transition of forest land to non-forest land categories were assumed to be zero, although it is common practice to use slash-and-burn techniques to convert forest land to grassland or cropland. This assumption has been made due to the absence of spatially explicit and complete data on forest fire that could be associated to the forest areas that were cleared from 2000 to 2014. The same assumption will be made in future measurements, reports and verifications in the context of result-based payments in order to maintain consistency with the proposed FREL.

According to equation 2.3 in IPCC, 2006 (Ch. 2, section 2.2.1, p. 2.7) the annual changes in carbon stocks occurring in conversions from a category of land use to another (i.e. ΔC_{LUi}) is calculated as the sum of the carbon stock changes in each carbon pool:

$$\Delta C_{LU_i} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP} \quad \textbf{[Eq.03]}$$

Where:

ΔC_{LUi} Change in carbon stock associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{AB} Change in carbon stock in the living above-ground biomass associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{BB} Change in carbon stock in the living below-ground biomass associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{DW} Change in carbon stock in the dead wood biomass associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{LI} Change in carbon stock in the litter associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{SO} Change in carbon stock in the soil organic carbon associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

ΔC_{HWP} Change in carbon stock in the harvested wood products associated to the transition from eco zone *i* to the land use category *LU*; $tCO_2\text{-e}\ ha^{-1}$

Note: In the case of the proposed FREL, only ΔC_{AB} and ΔC_{AB} were estimated. Changes in all other carbon pools were ignored due to the lack of accurate data to estimate them, i.e $\Delta C_{DW} = \Delta C_{LI} = \Delta C_{SO} = \Delta C_{HWP} = 0$.

Annual changes in carbon stock in each carbon pool included in the FREL (i.e. ΔC_{AB} and ΔC_{AB}) were calculated using equation 2.5 in IPCC, 2006 (Ch. 2, section 2.2.1, p. 2.10):

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)} \qquad \textbf{[Eq.04]}$$

Where:

ΔC Annual change in carbon stock in the carbon pool *p*[17] of eco-zone *i*; tC año^{-1}

C_{t_1} Carbon stock in pool *p*, at time t_1, tC

C_{t_2} Carbon stock in pool *p*, at time t_2, tC

t_1 In the context of the National GHG Inventory and of the proposed FREL, t_1 is the beginning of a specific year; dimensionless

t_2 In the context of the National GHG Inventory and of the proposed FREL, t_2 is the end of a specific year; dimensionless

[17] Where *p* represents a specific carbon pool, i.e. *AB, BB, DW, LI, SO, HWP*. The index *p* does not appear in the equation of IPCC and was added here for more clarity.

Notes:

- The unit in equation 2.5 of IPCC, 2006 (Ch. 2, section 2.2.1, p. 2.10) is tons of carbon (tC), while the previous equations (Eq.01-Eq.03) were in tons of carbon dioxide equivalent (tCO_2-e). The conversion from tons of carbon to tons of carbon dioxide equivalent was done by multiplying the values in tons of carbon by the stoichiometric ratio 44/12.
- In absence of national data for carbon stocks in non-forest categories as well as spatially explicit information on the land-use category implemented on deforested lands for the entire historical time-series, the proposed FREL assumes that C_{t_2} is zero in all transitions from forest land to non-forest land. This assumption will consistently be made in future measurements and reports of the estimated emission reductions, so that it should not lead to non-conservative estimation's of GHG emission reductions from reducing deforestation. Moreover, since only the changes in the living biomass of trees is accounted, it is reasonable to assume that the reported GHG emissions from deforestation are not over-estimated nor under-estimated according to the data and information currently available to estimate them.

Carbon stocks in the above-ground biomass of living trees was calculated using the equations shown in Table 10.

3.5.2 Uncertainty of the FREL

The analysis of the uncertainty associated to the proposed FREL was commissioned to an international consultant firm with experience on carbon accounting (Winrock International) to ensure an independent and credible assessment. The consultant issued a report that describes the data, methodology and results obtained in its assessment of the accuracy of the proposed FREL (see Casarim and Pearson, 2015).

The uncertainty of the FREL was estimated as the combined uncertainty of activity data and emission factors of the historical period 2001-2013 using the add-in software SimVoi[18] of Microsoft Excel. 10,000 Monte Carlo simulations were run for the emission factors of each eco-zone existing in the Peruvian Amazon, as well as for activity data and for the total emissions estimated for the period 2000-2013.

For the uncertainty analysis of activity data, the numbers of observations used to estimate omission and commission errors, as reported in MINAM (2014.c), were used (see Figure 13). The data of numbers of observations to derive the estimates of omission and commission errors of the 2000-2011 Map of Gross Deforestation (MGD) were analyzed following the methodology described by Olofsson *et al*. (2014).

For the uncertainty analysis of emission factors, only the variance of the samples could be considered, as insufficient information was available to estimate the uncertainties associated to allometric equations used to estimate the above-ground biomass of the measured trees and the model used to estimate below-ground biomass (see section 3.3.2.2 for a description of the allometric equations and model for below-ground biomass used).

For the uncertainty of the historical emissions, only the distributions of emission factors per eco-zone (i.e. stratum) could be considered in the Monte Carlo simulations, as accuracy assessment information of activity data per eco-zone were not available.

[18] Available at: http://simvoi.com/

The stochastic numbers from emission factors (i.e. four in total – one per stratum) were weighted by the activity data per stratum to allow their combination with the single stochastic number from the activity data. The uncertainty of the total historic emissions was then estimated using the combined stochastic number as input data into the Monte Carlo simulations.

The Monte Carlo simulations resulted in an estimated uncertainty for activity data equivalent to 17.81% of the average at a confidence level of 95%. At this same confidence level (95%) the uncertainty associated to emission factors was estimated between 0.1% of the mean for “Selva Baja”, 0.3% for “Selva Alta Difícil” and ¨Selva Alta Accesible¨, and 3.1% for “Zona Hidromórfica”.

The low uncertainty of emission factors can be attributed to the high number of plots considered in the analysis as well as to the weighting of the average values using the methods described by Thomas and Rennie (1987) as cited by MINAM (2014.c) in addition to the exclusion of measurement units with less than 10 plots in total.

The uncertainty of historical emissions (total for the period 2000-2013), reflecting the combined uncertainty of activity data and emission factors, is estimated at 8.95% at a confidence level of 95%.

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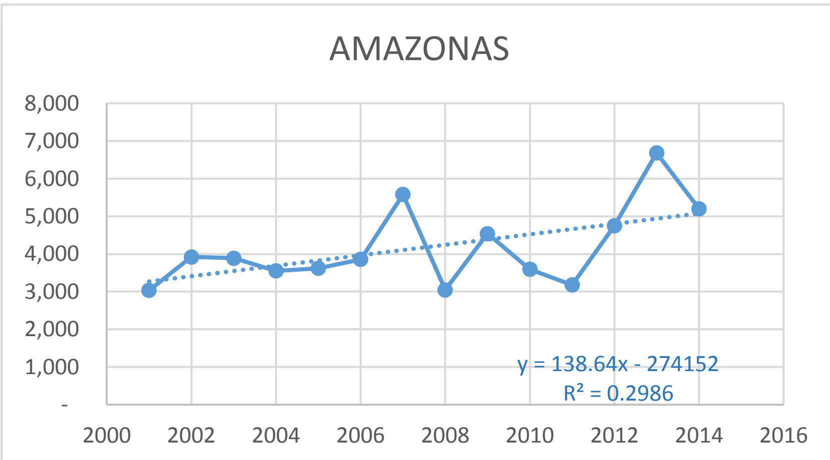
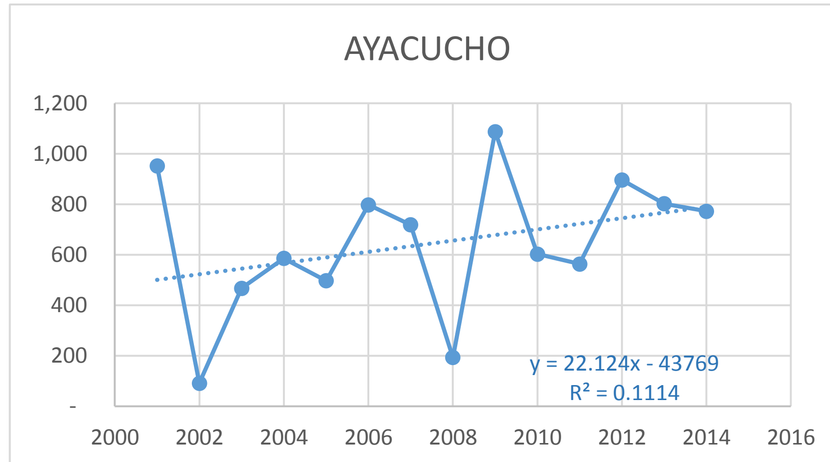
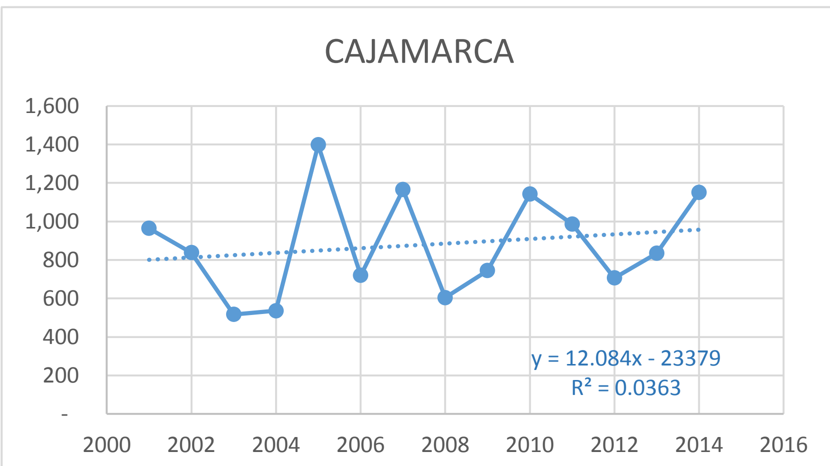
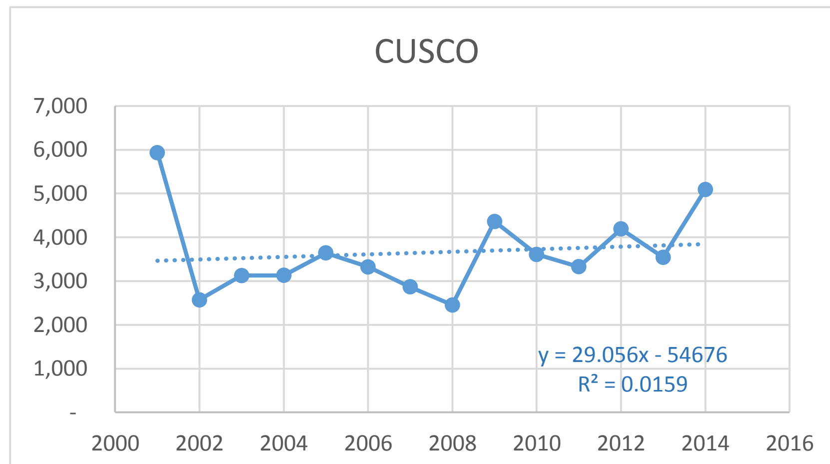
Annex 1: Historical trends of anthropogenic gross deforestation in Peruvian Amazon.

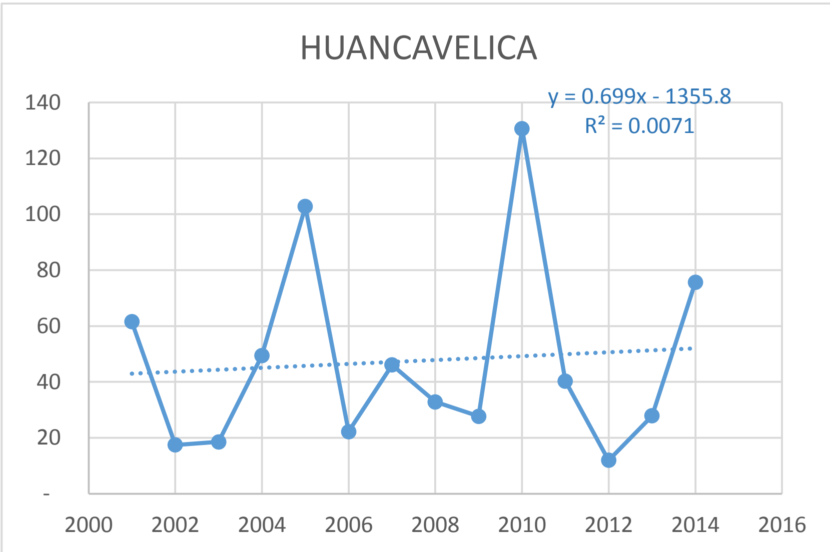
The figures below show the historical trend of anthropogenic gross deforestation in each Department of the Peruvian Amazon in hectares. The dotted lines are the regression lines used to calculate the projected activity data of each department. The projected activity data calculated for each department are reported in Table 6.

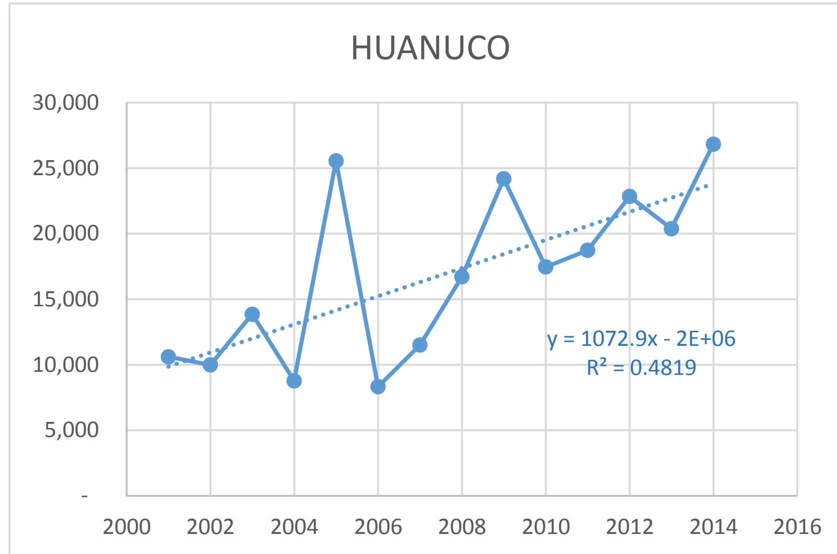


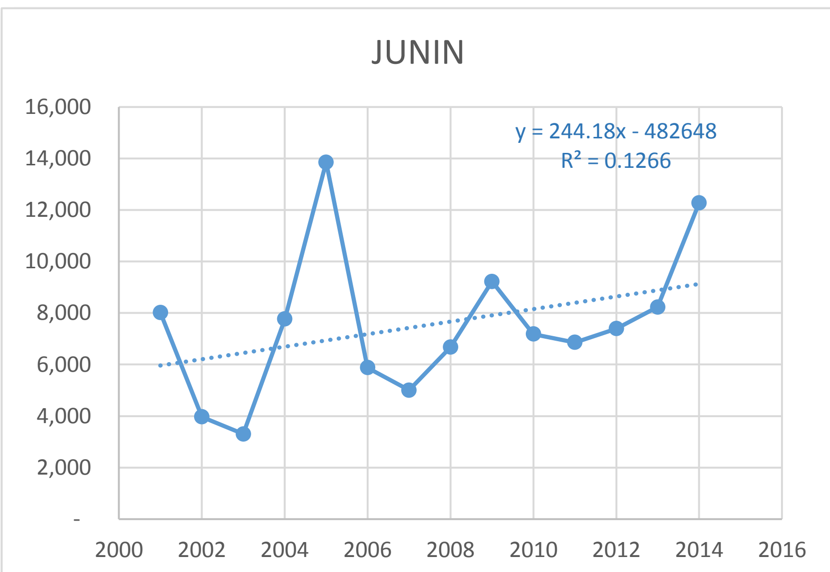


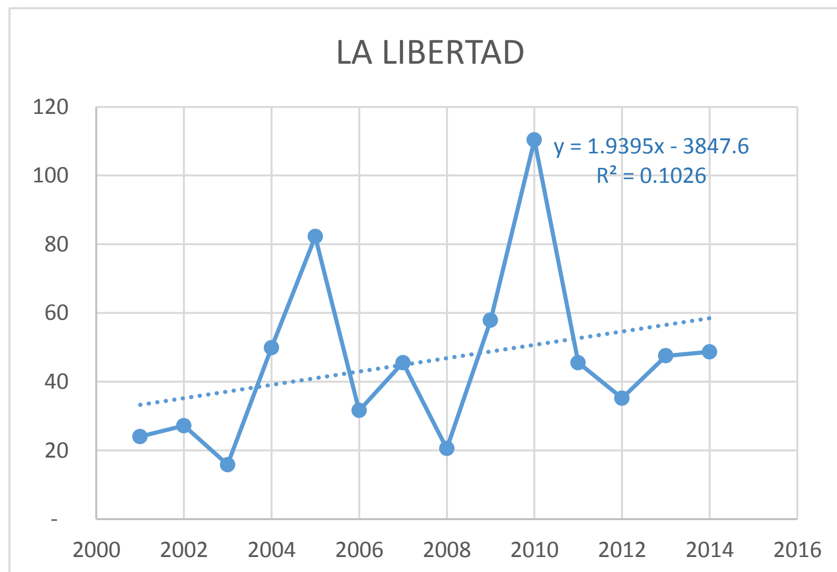


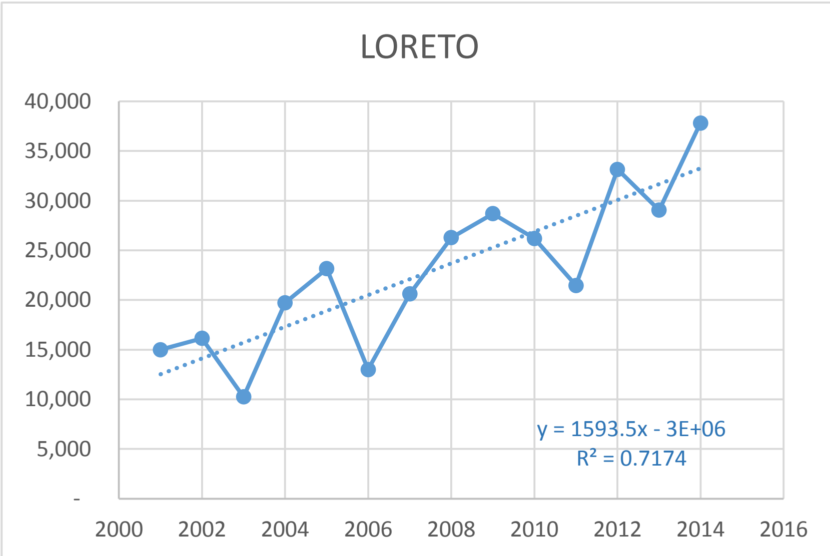


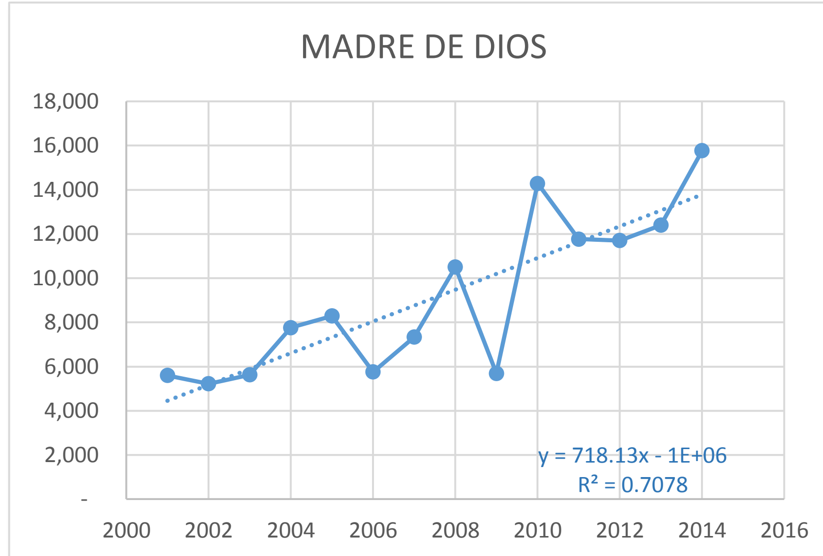

HUANCAVELICA
y = 0.699x - 1355.8
R² = 0.0071
140
120
100
80
60
40
20
-
2000
2002
2004
2006
2008
2010
2012
2014
2016

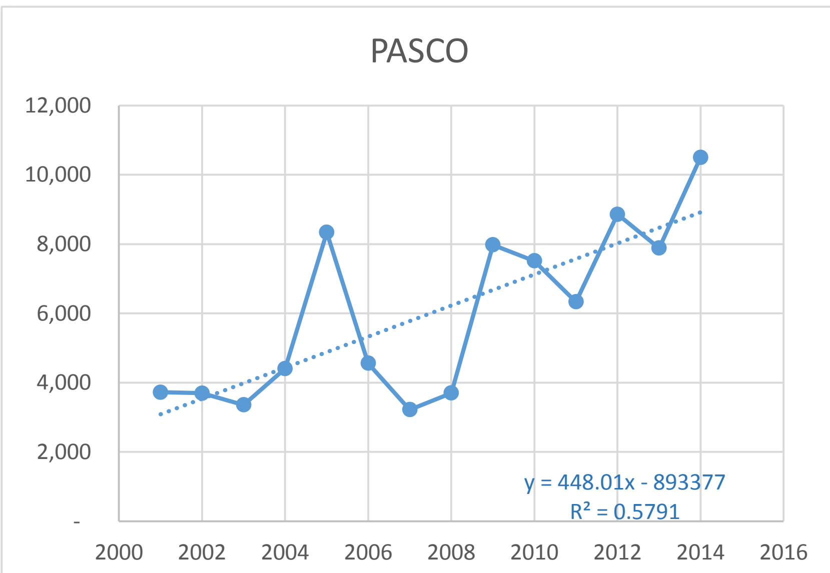

HUANUCO
y = 1072.9x - 2E+06
R² = 0.4819
30,000
25,000
20,000
15,000
10,000
5,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016

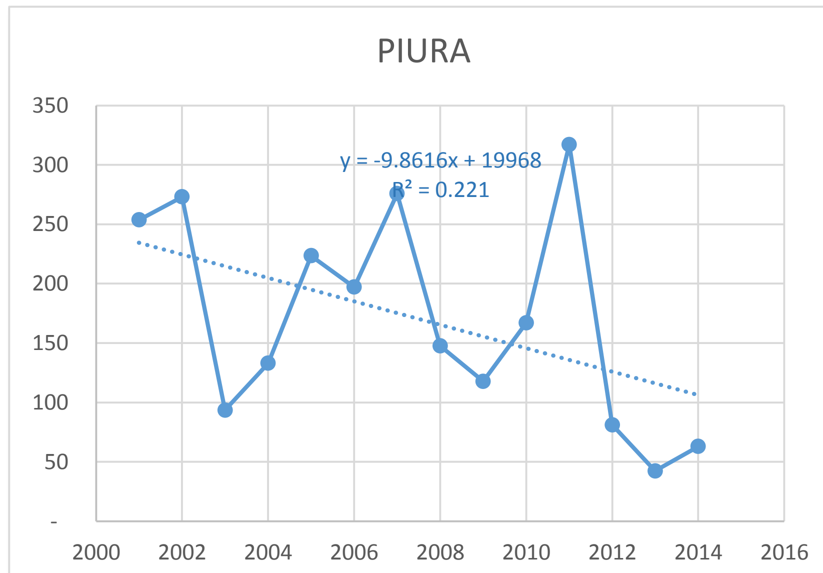

JUNIN
y = 244.18x - 482648
R² = 0.1266
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016

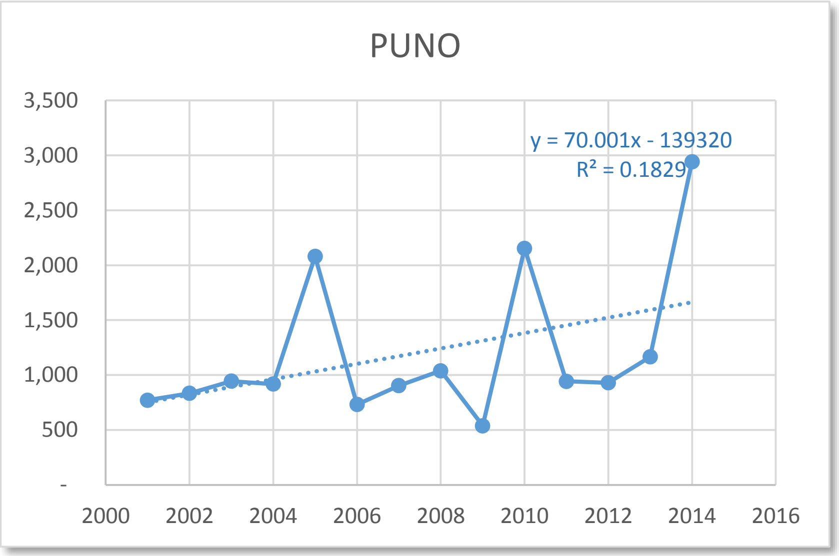

LA LIBERTAD
y = 1.9395x - 3847.6
R² = 0.1026
120
100
80
60
40
20
-
2000
2002
2004
2006
2008
2010
2012
2014
2016

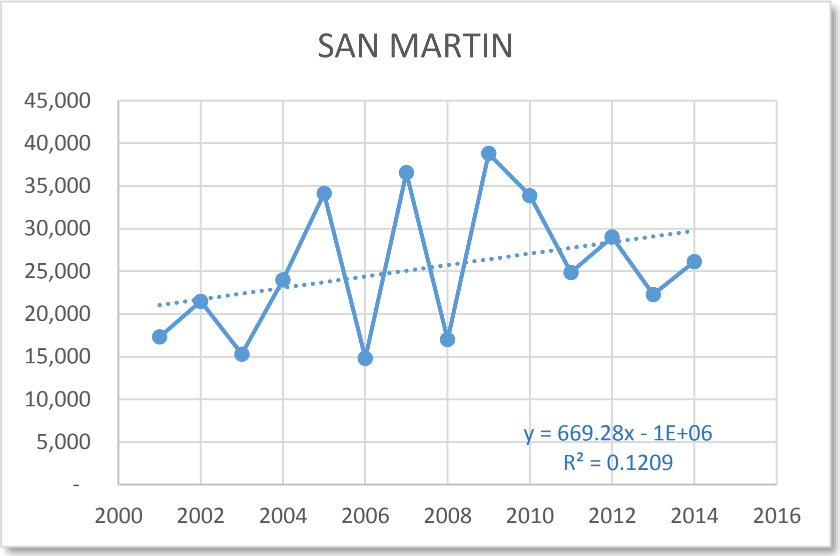

LORETO
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 1593.5x - 3E+06
R² = 0.7174


MADRE DE DIOS
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 718.13x - 1E+06
R² = 0.7078

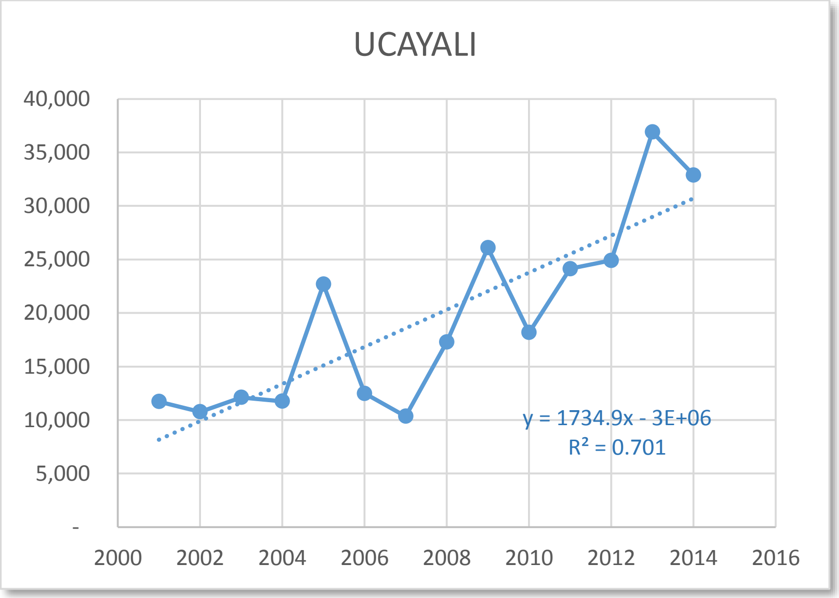

PASCO
12,000
10,000
8,000
6,000
4,000
2,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 448.01x - 893377
R² = 0.5791

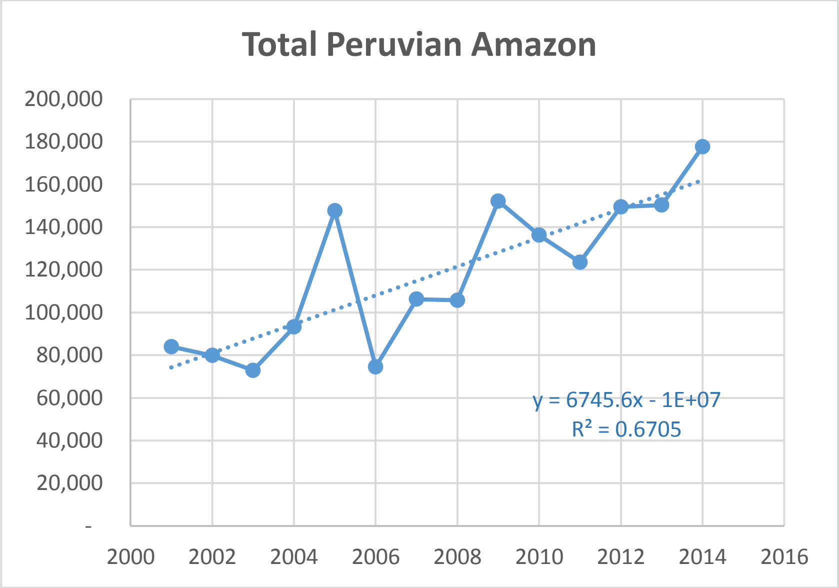

PIURA
350
300
250
200
150
100
50
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = -9.8616x + 19968
R² = 0.221


PUNO
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 70.001x - 139320
R² = 0.1829


SAN MARTIN
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 669.28x - 1E+06
R² = 0.1209

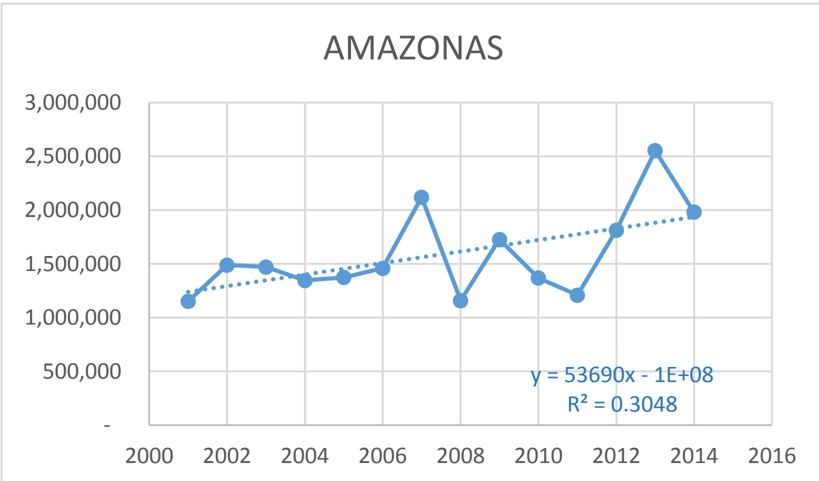
1290

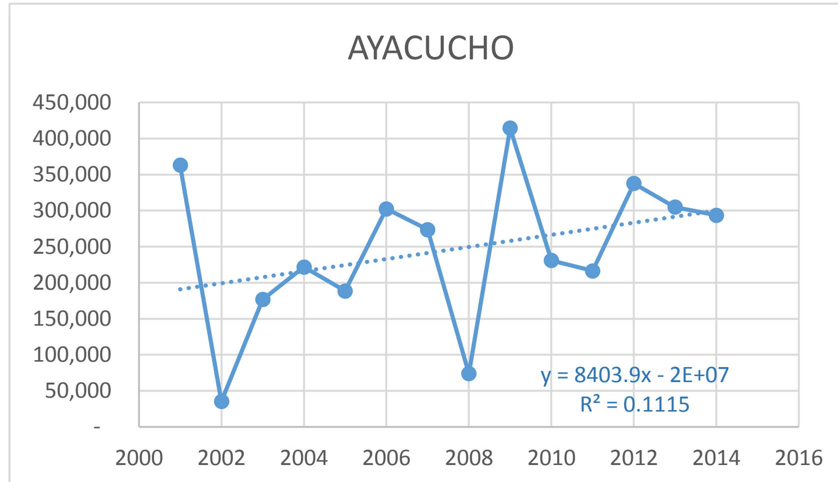

UCAYALI
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 1734.9x - 3E+06
R² = 0.701

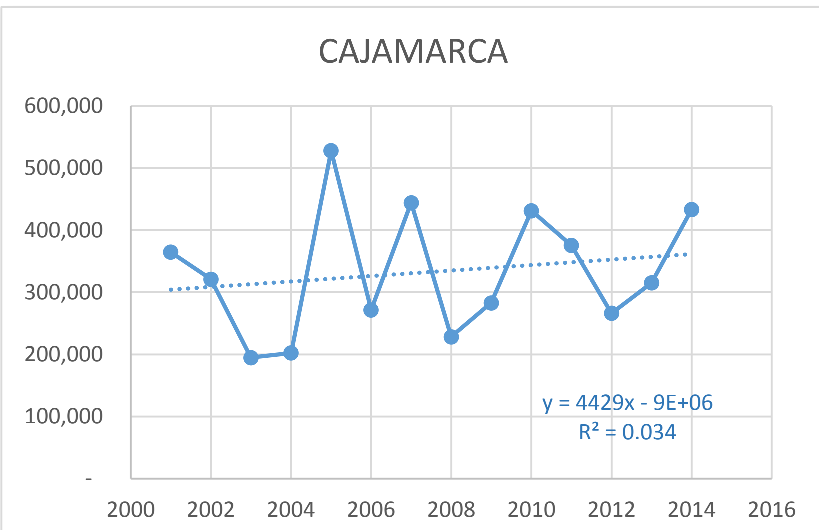

Total Peruvian Amazon
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 6745.6x - 1E+07
R² = 0.6705

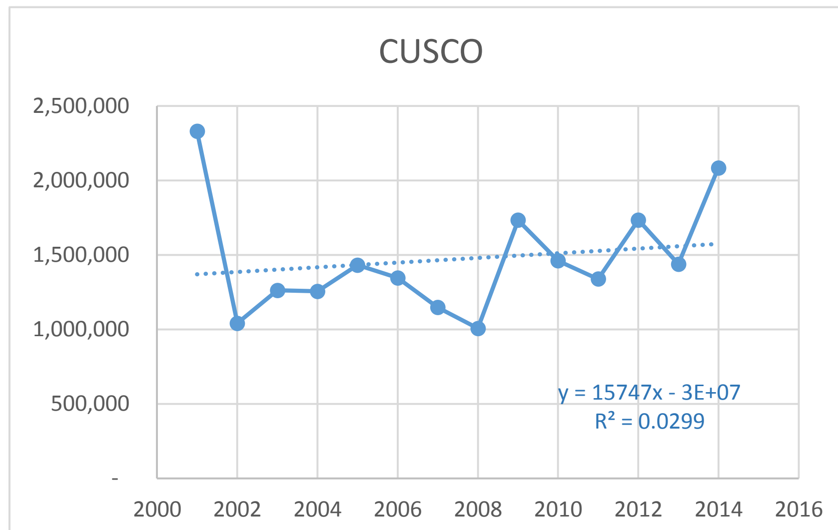
1291

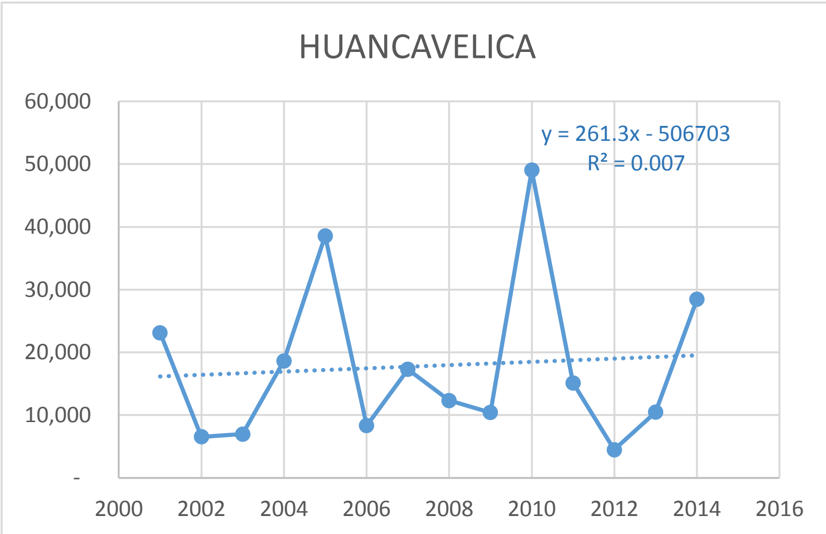
The figures below show the historical trend of emissions from anthropogenic gross deforestation in each Department of the Peruvian Amazon in tons of CO_2-e. The dotted lines and the equations displayed in the charts are the regression lines used to project the GHG emissions from deforestation and to construct the proposed FREL. The projected emissions calculated for each department were reported in Table 7.

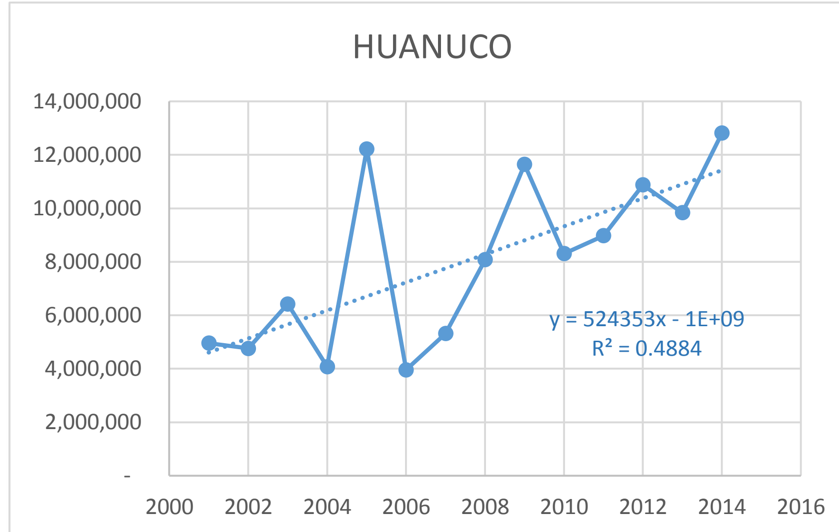


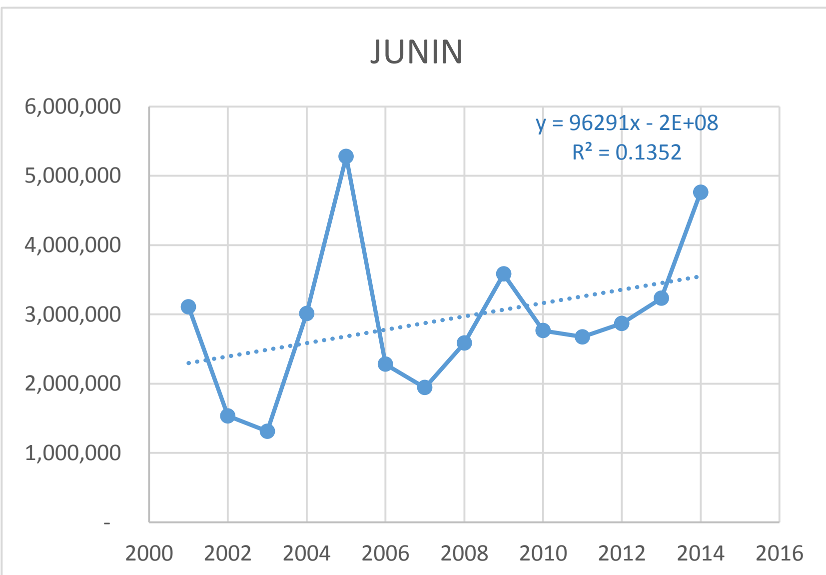


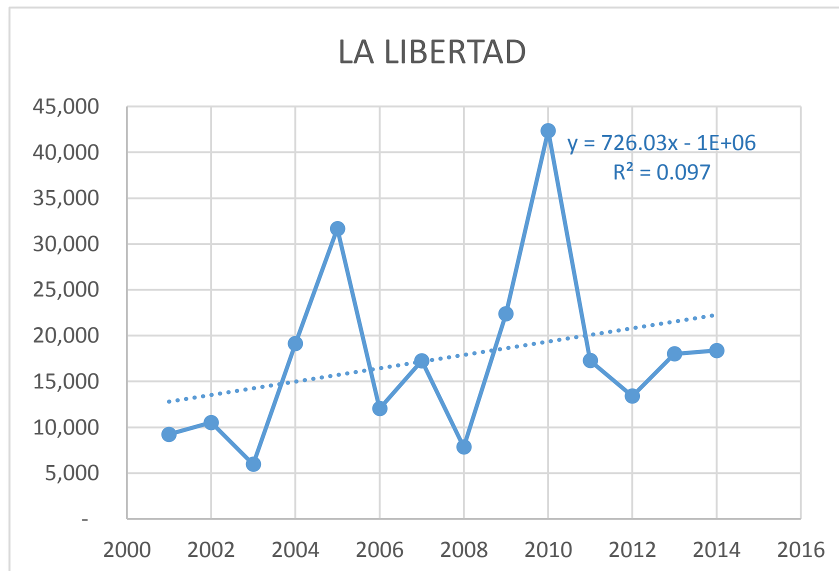


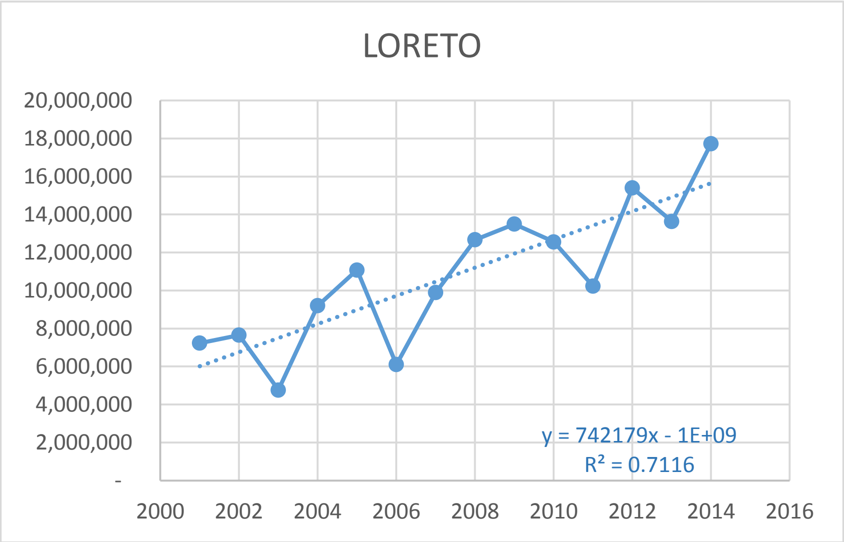


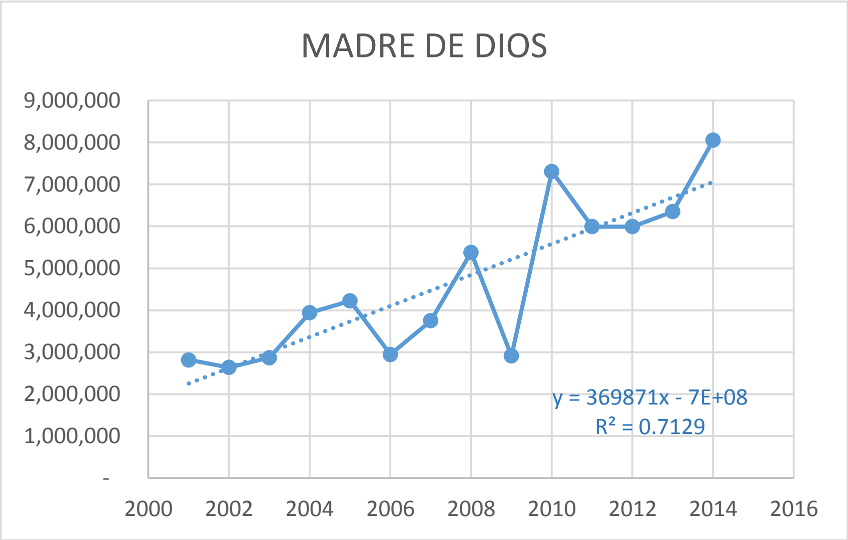

HUANCAVELICA
y = 261.3x - 506703
R² = 0.007


HUANUCO
y = 524353x - 1E+09
R² = 0.4884

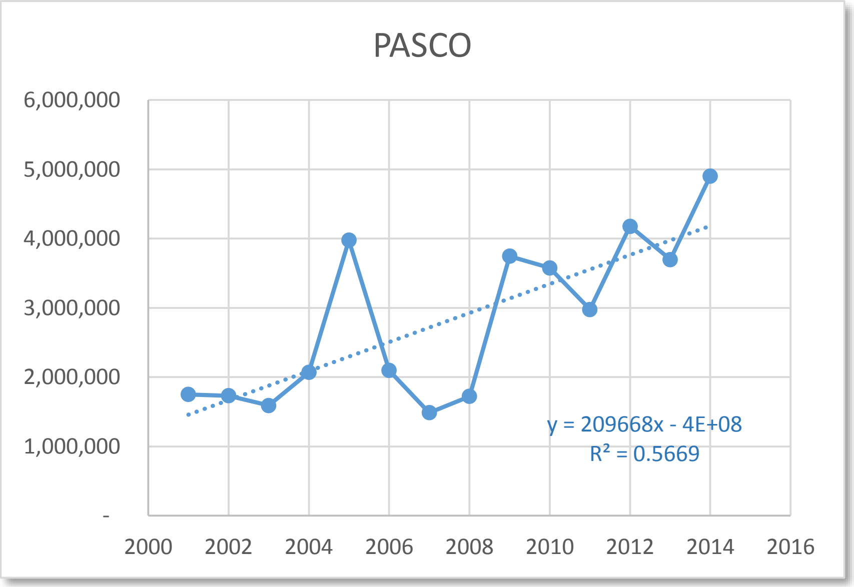

JUNIN
y = 96291x - 2E+08
R² = 0.1352

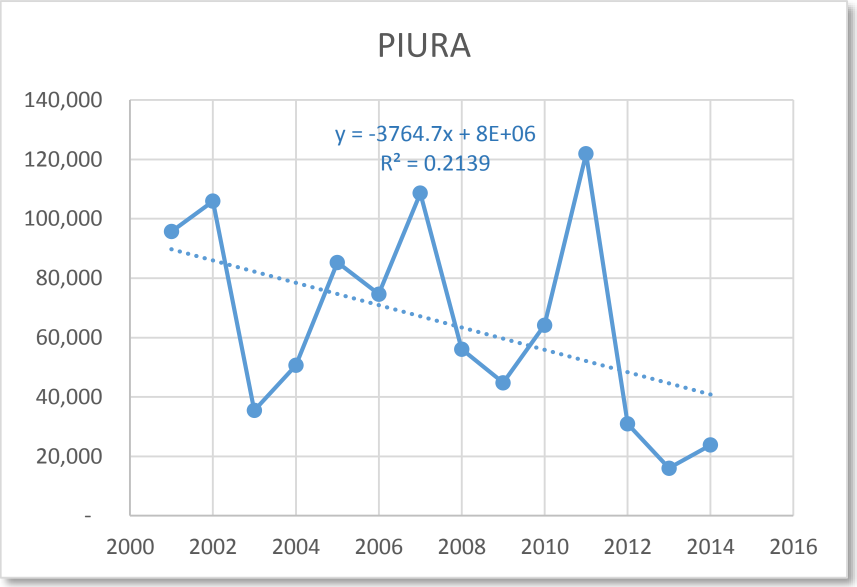

LA LIBERTAD
y = 726.03x - 1E+06
R² = 0.097


LORETO
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 742179x - 1E+09
R² = 0.7116

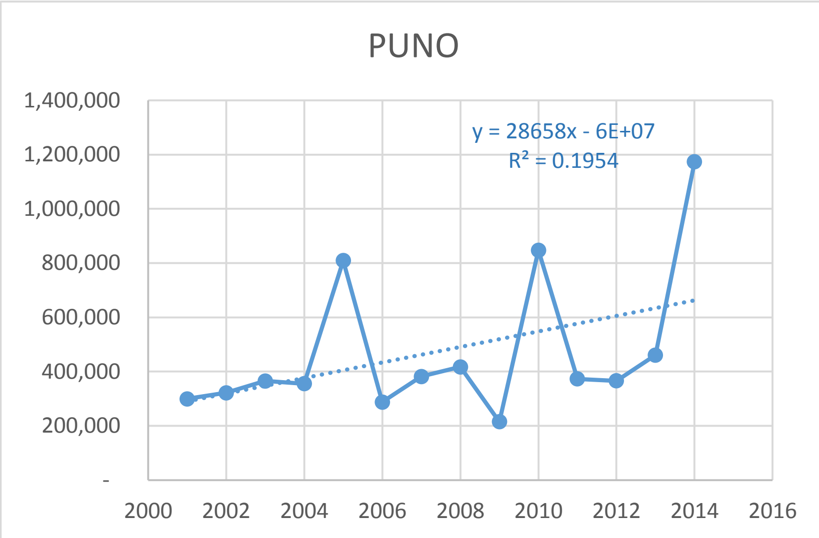

MADRE DE DIOS
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 369871x - 7E+08
R² = 0.7129

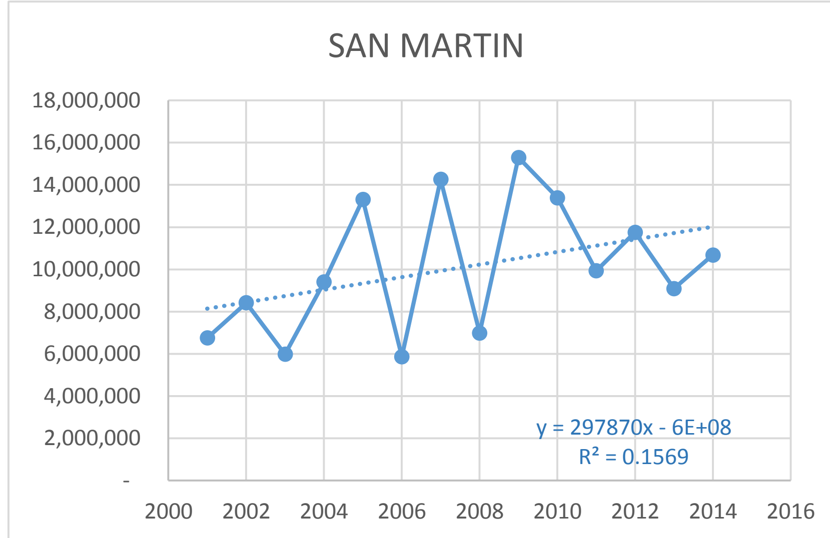
1300

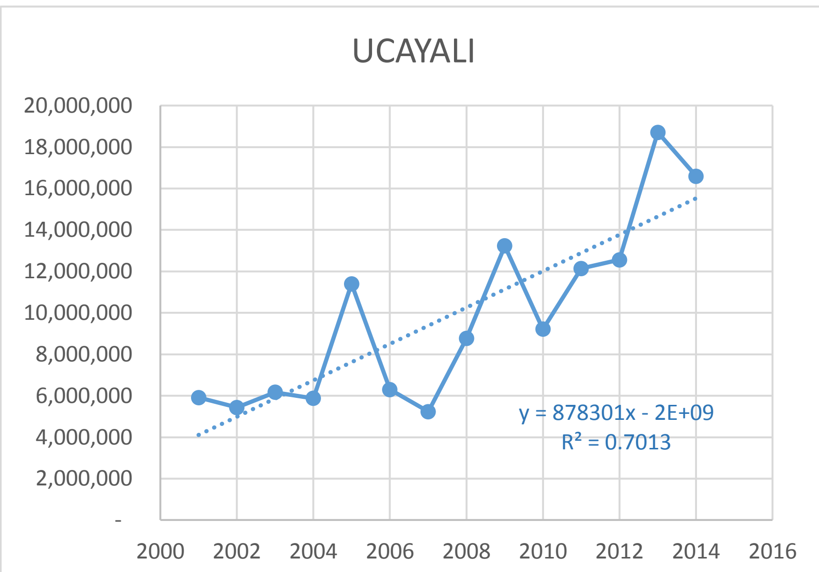

PASCO
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 209668x - 4E+08
R² = 0.5669

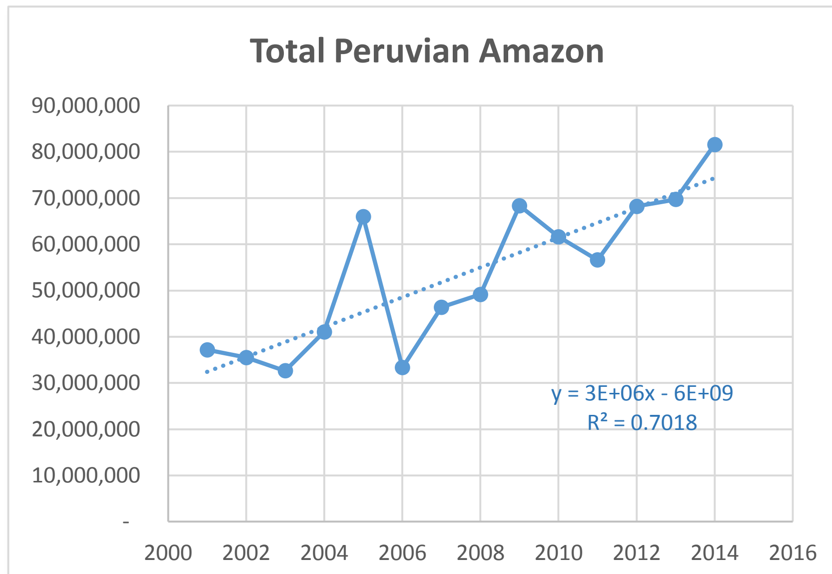

PIURA
140,000
120,000
100,000
80,000
60,000
40,000
20,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = -3764.7x + 8E+06
R² = 0.2139

1301


PUNO
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 28658x - 6E+07
R² = 0.1954


SAN MARTIN
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 297870x - 6E+08
R² = 0.1569


UCAYALI
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 878301x - 2E+09
R² = 0.7013


Total Peruvian Amazon
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
-
2000
2002
2004
2006
2008
2010
2012
2014
2016
y = 3E+06x - 6E+09
R² = 0.7018

Annex 2: Historical anthropogenic gross deforestation and related GHG emissions in the Peruvian Amazon.

The following table contains activity data of anthropogenic gross deforestation for each department and eco-zone. The eco-zones are identified as follows: **SAA** = *Selva Alta Accesible*; **SAD** = *Selva Alta Difícil*; **SB** = *Selva Baja*; and **ZH** = *Zona Hidromórfica*.

Depart-ment	Eco-zone	Anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
AMAZONAS	SAA	2,803	3,619	3,671	3,334	3,344	3,639	5,103	2,797	4,158	3,236	2,880	4,214	5,903	4,678	**53,376**
	SAD	232	305	219	221	278	220	478	252	386	358	300	536	785	524	**5,094**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**3,034**	**3,924**	**3,890**	**3,554**	**3,622**	**3,858**	**5,581**	**3,049**	**4,544**	**3,594**	**3,179**	**4,751**	**6,687**	**5,202**	**58,470**
AYACUCHO	SAA	847	76	445	551	462	744	652	170	977	525	477	871	735	705	**8,237**
	SAD	105	16	22	35	35	54	67	23	111	78	86	26	68	68	**795**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**952**	**92**	**468**	**586**	**497**	**798**	**719**	**193**	**1,088**	**603**	**564**	**897**	**803**	**773**	**9,032**
CAJA-MARCA	SAA	915	723	501	521	1,336	693	1,043	576	688	1,095	901	688	803	1,127	**11,610**
	SAD	49	115	16	16	62	26	123	28	57	47	86	19	32	24	**700**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**964**	**838**	**517**	**537**	**1,398**	**720**	**1,165**	**604**	**745**	**1,143**	**987**	**707**	**835**	**1,151**	**12,310**
CUSCO	SAA	4,606	1,566	2,185	2,175	2,791	2,288	2,052	1,523	3,225	2,411	2,198	2,690	2,468	3,091	**35,269**
	SAD	976	777	514	629	642	565	513	534	754	737	830	556	498	1,265	**9,787**
	SB	351	227	429	325	208	472	302	396	383	462	301	944	577	732	**6,110**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**5,933**	**2,570**	**3,128**	**3,129**	**3,641**	**3,325**	**2,867**	**2,453**	**4,362**	**3,610**	**3,329**	**4,190**	**3,543**	**5,089**	**51,167**
HUANCA-VELICA	SAA	61	17	18	47	102	22	46	33	27	129	40	12	28	74	**657**
	SAD	1	0	1	2	1	-	0	0	0	1	0	-	-	2	**8**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**62**	**17**	**19**	**49**	**103**	**22**	**46**	**33**	**28**	**131**	**40**	**12**	**28**	**76**	**665**

Depart-ment	Eco-zone	Anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
HUANUCO	SAA	3,280	2,391	4,670	2,767	6,076	2,068	3,944	3,279	4,990	4,208	4,041	5,329	3,975	6,006	**57,022**
	SAD	491	458	595	533	928	380	544	629	1,211	1,036	1,106	1,520	1,058	1,807	**12,295**
	SB	6,840	7,129	8,592	5,473	18,553	5,876	7,006	12,790	17,989	12,213	13,584	15,993	15,343	19,022	**166,401**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**10,610**	**9,978**	**13,856**	**8,774**	**25,556**	**8,324**	**11,494**	**16,697**	**24,190**	**17,456**	**18,730**	**22,842**	**20,376**	**26,834**	**235,718**
JUNIN	SAA	6,951	3,299	2,591	6,764	12,719	5,080	4,281	5,718	7,811	6,230	5,696	6,278	6,560	10,458	**90,435**
	SAD	570	573	309	524	928	443	410	639	887	765	731	731	1,073	1,189	**9,771**
	SB	497	93	403	475	202	356	309	316	522	189	430	382	594	630	**5,398**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**8,018**	**3,964**	**3,302**	**7,763**	**13,849**	**5,878**	**5,000**	**6,673**	**9,221**	**7,184**	**6,857**	**7,390**	**8,227**	**12,278**	**105,604**
LA LIBERTAD	SAA	20	22	15	43	68	28	43	18	47	94	42	32	44	47	**562**
	SAD	4	6	0	7	14	3	3	3	11	17	3	4	3	2	**80**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**24**	**27**	**16**	**50**	**82**	**32**	**46**	**21**	**58**	**110**	**46**	**35**	**48**	**49**	**642**
LORETO	SAA	252	475	431	716	991	587	837	894	980	819	670	699	590	677	**9,618**
	SAD	173	316	217	415	418	359	421	475	559	602	601	661	852	1,325	**7,393**
	SB	12,411	12,604	7,473	14,564	18,491	9,716	16,580	21,560	21,817	21,063	16,870	24,344	21,916	28,300	**247,708**
	ZH	2,169	2,746	2,124	4,036	3,253	2,337	2,785	3,350	5,341	3,724	3,326	7,458	5,699	7,517	**55,866**
	Total	**15,005**	**16,141**	**10,246**	**19,731**	**23,154**	**12,999**	**20,623**	**26,280**	**28,696**	**26,208**	**21,466**	**33,161**	**29,057**	**37,818**	**320,586**
MADRE DE DIOS	SAA	298	115	86	252	100	56	72	83	47	133	191	98	112	201	**1,843**
	SAD	252	397	123	169	283	70	152	114	75	221	369	123	112	324	**2,784**
	SB	5,053	4,711	5,418	7,345	7,904	5,631	7,113	10,306	5,570	13,932	11,208	11,481	12,177	15,242	**123,091**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**5,603**	**5,223**	**5,626**	**7,766**	**8,288**	**5,756**	**7,338**	**10,503**	**5,691**	**14,286**	**11,768**	**11,702**	**12,401**	**15,767**	**127,718**
PASCO	SAA	965	969	788	1,096	1,765	1,417	972	933	1,824	1,572	1,514	1,949	1,838	2,678	**20,279**
	SAD	373	396	293	533	788	630	414	620	1,260	846	861	1,301	1,260	1,533	**11,109**
	SB	2,386	2,329	2,275	2,778	5,782	2,513	1,834	2,149	4,894	5,099	3,960	5,608	4,788	6,289	**52,683**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**3,724**	**3,695**	**3,356**	**4,407**	**8,335**	**4,560**	**3,221**	**3,702**	**7,978**	**7,516**	**6,334**	**8,858**	**7,886**	**10,499**	**84,070**

Depart-ment	Eco-zone	Anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
PIURA	SAA	244	213	87	120	198	185	186	135	107	140	267	73	40	59	**2,053**
	SAD	10	60	7	13	25	13	89	13	10	27	50	8	2	4	**333**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**254**	**273**	**94**	**133**	**223**	**197**	**276**	**148**	**118**	**167**	**317**	**81**	**42**	**63**	**2,386**
PUNO	SAA	644	699	797	762	1,678	565	521	707	375	1,606	654	654	785	1,966	**12,411**
	SAD	93	114	108	139	342	120	123	233	121	450	254	261	360	814	**3,532**
	SB	34	20	39	19	61	46	259	99	42	97	35	16	20	163	**950**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**771**	**833**	**944**	**919**	**2,081**	**731**	**903**	**1,040**	**538**	**2,153**	**943**	**930**	**1,165**	**2,942**	**16,893**
SAN MARTIN	SAA	14,447	18,017	12,919	20,094	28,741	11,732	30,782	11,587	30,758	26,027	18,026	19,028	14,109	16,864	**273,131**
	SAD	1,706	1,521	1,029	1,744	2,808	1,472	3,125	1,782	4,744	5,054	4,362	6,332	4,958	5,212	**45,850**
	SB	1,158	1,942	1,342	2,158	2,560	1,607	2,644	3,640	3,309	2,792	2,485	3,647	3,214	4,070	**36,567**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**17,311**	**21,480**	**15,290**	**23,996**	**34,109**	**14,811**	**36,552**	**17,008**	**38,812**	**33,873**	**24,873**	**29,007**	**22,281**	**26,146**	**355,549**
UCAYALI	SAA	750	671	419	1,063	1,711	748	570	821	1,104	725	1,414	1,285	1,488	1,744	**14,514**
	SAD	184	185	122	255	347	220	197	242	394	378	821	940	738	952	**5,976**
	SB	10,798	9,919	11,582	10,434	20,627	11,522	9,589	16,237	24,593	17,068	21,894	22,689	34,683	30,187	**251,821**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**11,732**	**10,775**	**12,122**	**11,752**	**22,686**	**12,490**	**10,356**	**17,300**	**26,091**	**18,171**	**24,129**	**24,914**	**36,910**	**32,884**	**272,312**
PERUVIAN AMAZON	SAA	37,083	32,873	29,623	40,302	62,083	29,852	51,104	29,274	57,118	48,948	39,009	43,898	39,478	50,374	**591,018**
	SAD	5,217	5,239	3,575	5,236	7,899	4,573	6,660	5,587	10,582	10,618	10,460	13,017	11,800	15,045	**115,508**
	SB	39,527	38,973	37,551	43,571	74,388	37,739	45,637	67,493	79,120	72,914	70,767	85,103	93,312	104,635	**890,729**
	ZH	2,169	2,746	2,124	4,036	3,253	2,337	2,785	3,350	5,341	3,724	3,326	7,458	5,699	7,517	**55,866**
	Total	**83,995**	**79,831**	**72,873**	**93,146**	**147,623**	**74,501**	**106,186**	**105,704**	**152,160**	**136,205**	**123,562**	**149,476**	**150,288**	**177,570**	**1,653,121**
	Average	**83,995**	**81,913**	**78,900**	**82,461**	**95,494**	**91,995**	**94,022**	**95,482**	**101,780**	**105,222**	**106,890**	**110,439**	**113,504**	**118,080**	**118,080**

The following table contains the estimated historical GHG emissions from anthropogenic gross deforestation for each department and eco-zone. The values were calculated by multiplying the activity data shown in the previous table with the average carbon stocks in the above-ground and below-ground biomass of living trees as estimated for each eco-zone. These average carbon stock values are shown below:

Eco-zone		Average carbon stock in living trees
Symbol	Name	tCO_2-e ha^{-1}
SAA	Selva Alta Accesible	375.04
SAD	Selva Alta Difícil	433.56
SB	Selva Baja	514.14
ZH	Zona Hidromórfica	313.02

Depart-ment	Eco-zone	Emissions from anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	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	tCO_2-e	tCO_2-e	tCO_2-e
AMAZONAS	SAA	1,051,053	1,357,198	1,376,775	1,250,199	1,254,148	1,364,657	1,913,693	1,049,028	1,559,382	1,213,509	1,079,946	1,580,478	2,213,695	1,754,342	**20,018,103**
	SAD	100,516	132,123	95,053	95,756	120,378	95,249	207,315	109,296	167,475	155,262	129,977	232,561	340,218	227,254	**2,208,431**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**1,151,569**	**1,489,321**	**1,471,828**	**1,345,955**	**1,374,526**	**1,459,906**	**2,121,008**	**1,158,323**	**1,726,857**	**1,368,771**	**1,209,922**	**1,813,039**	**2,553,913**	**1,981,597**	**22,226,534**
AYACUCHO	SAA	317,756	28,488	166,979	206,504	173,291	279,176	244,410	63,794	366,429	196,918	178,995	326,566	275,530	264,223	**3,089,060**
	SAD	45,420	6,829	9,716	15,296	15,179	23,373	29,187	10,067	48,190	33,870	37,420	11,277	29,421	29,499	**344,744**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**363,176**	**35,317**	**176,695**	**221,800**	**188,470**	**302,549**	**273,597**	**73,862**	**414,619**	**230,788**	**216,416**	**337,843**	**304,952**	**293,722**	**3,433,805**
CAJA-MARCA	SAA	343,105	271,041	187,906	195,264	501,139	260,038	391,035	216,023	258,046	410,781	337,941	258,012	301,318	422,494	**4,354,145**
	SAD	21,305	49,829	6,946	6,907	26,846	11,394	53,185	12,213	24,817	20,486	37,342	8,116	13,657	10,535	**303,578**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**364,410**	**320,870**	**194,852**	**202,171**	**527,985**	**271,432**	**444,220**	**228,236**	**282,863**	**431,267**	**375,283**	**266,129**	**314,975**	**433,029**	**4,657,723**

Depart-ment	Eco-zone	Emissions from anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	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	tCO_2-e	tCO_2-e	tCO_2-e
CUSCO	SAA	1,727,610	587,414	819,503	815,622	1,046,665	858,151	769,717	571,178	1,209,391	904,360	824,195	1,008,793	925,489	1,159,368	**13,227,455**
	SAD	423,097	336,667	222,845	272,596	278,254	244,774	222,221	231,351	326,717	319,537	359,845	240,950	216,016	548,469	**4,243,339**
	SB	180,326	116,886	220,398	167,277	106,891	242,794	155,523	203,740	197,077	237,380	154,829	485,403	296,517	376,523	**3,141,564**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**2,331,032**	**1,040,966**	**1,262,746**	**1,255,494**	**1,431,809**	**1,345,720**	**1,147,461**	**1,006,269**	**1,733,184**	**1,461,277**	**1,338,869**	**1,735,147**	**1,438,023**	**2,084,360**	**20,612,359**
HUANCA-VELICA	SAA	22,750	6,514	6,751	17,721	38,344	8,337	17,113	12,219	10,295	48,504	15,088	4,489	10,464	27,779	**246,367**
	SAD	390	39	234	936	234	-	195	117	117	546	39	-	-	702	**3,551**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**23,140**	**6,553**	**6,985**	**18,657**	**38,578**	**8,337**	**17,308**	**12,336**	**10,412**	**49,050**	**15,127**	**4,489**	**10,464**	**28,482**	**249,918**
HUANUCO	SAA	1,229,981	896,833	1,751,507	1,037,821	2,278,603	775,657	1,479,217	1,229,576	1,871,332	1,577,980	1,515,468	1,998,550	1,490,727	2,252,444	**21,385,697**
	SAD	212,817	198,730	257,807	231,156	402,338	164,549	235,644	272,752	525,252	449,241	479,481	659,092	458,605	783,254	**5,330,717**
	SB	3,516,560	3,665,097	4,417,310	2,814,090	9,538,663	3,021,116	3,602,304	6,575,666	9,248,994	6,279,149	6,983,979	8,222,567	7,888,523	9,779,884	**85,553,903**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**4,959,358**	**4,760,660**	**6,426,624**	**4,083,068**	**12,219,604**	**3,961,322**	**5,317,165**	**8,077,994**	**11,645,579**	**8,306,370**	**8,978,929**	**10,880,209**	**9,837,855**	**12,815,582**	**112,270,317**
JUNIN	SAA	2,606,890	1,237,238	971,597	2,536,784	4,770,225	1,905,018	1,605,388	2,144,500	2,929,541	2,336,491	2,136,197	2,354,312	2,460,332	3,922,200	**33,916,714**
	SAD	246,998	248,247	133,762	227,371	402,377	192,058	177,893	276,966	384,740	331,750	316,767	316,728	465,122	515,692	**4,236,471**
	SB	255,519	47,661	206,979	244,090	103,698	182,963	158,901	162,696	268,429	96,988	221,277	196,475	305,494	324,096	**2,775,267**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**3,109,408**	**1,533,146**	**1,312,337**	**3,008,245**	**5,276,300**	**2,280,040**	**1,942,183**	**2,584,162**	**3,582,710**	**2,765,229**	**2,674,241**	**2,867,515**	**3,230,948**	**4,761,988**	**40,928,453**
LA LIBERTAD	SAA	7,595	8,101	5,806	16,033	25,619	10,632	15,965	6,751	17,484	35,070	15,830	11,881	16,607	17,552	**210,926**
	SAD	1,639	2,419	156	3,083	6,048	1,405	1,288	1,093	4,878	7,297	1,444	1,522	1,405	819	**34,494**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**9,233**	**10,520**	**5,962**	**19,116**	**31,667**	**12,037**	**17,253**	**7,843**	**22,362**	**42,367**	**17,274**	**13,403**	**18,011**	**18,371**	**245,420**
LORETO	SAA	94,578	178,286	161,815	268,375	371,762	220,310	313,942	335,274	367,374	307,056	251,194	262,130	221,288	253,861	**3,607,245**
	SAD	75,036	137,078	94,195	179,727	181,288	155,457	182,654	206,105	242,199	260,890	260,460	286,409	369,288	574,418	**3,205,204**
	SB	6,380,903	6,480,113	3,842,230	7,488,215	9,506,920	4,995,491	8,524,406	11,085,198	11,216,845	10,829,494	8,673,683	12,516,190	11,267,930	14,550,118	**127,357,735**
	ZH	678,937	859,517	664,935	1,263,385	1,018,377	731,505	871,771	1,048,717	1,671,846	1,165,827	1,040,998	2,334,471	1,783,969	2,352,952	**17,487,208**
	Total	**7,229,453**	**7,654,994**	**4,763,174**	**9,199,703**	**11,078,347**	**6,102,762**	**9,892,773**	**12,675,295**	**13,498,264**	**12,563,267**	**10,226,336**	**15,399,200**	**13,642,476**	**17,731,348**	**151,657,392**

Depart-ment	Eco-zone	Emissions from anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	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	tCO_2-e	tCO_2-e	tCO_2-e
MADRE DE DIOS	SAA	111,724	43,171	32,201	94,375	37,669	20,961	27,172	30,986	17,518	50,023	71,558	36,690	41,888	75,270	**691,206**
	SAD	109,257	172,158	53,341	73,319	122,602	30,202	66,022	49,634	32,348	95,912	159,788	53,302	48,580	140,629	**1,207,093**
	SB	2,597,764	2,422,112	2,785,401	3,776,614	4,064,016	2,895,068	3,656,999	5,298,532	2,863,741	7,162,916	5,762,743	5,903,089	6,260,918	7,836,419	**63,286,334**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**2,818,746**	**2,637,441**	**2,870,943**	**3,944,309**	**4,224,287**	**2,946,231**	**3,750,193**	**5,379,152**	**2,913,607**	**7,308,851**	**5,994,088**	**5,993,081**	**6,351,386**	**8,052,319**	**65,184,632**
PASCO	SAA	362,007	363,425	295,411	411,051	661,773	531,416	364,505	350,025	684,050	589,405	567,634	731,069	689,282	1,004,237	**7,605,290**
	SAD	161,505	171,884	127,128	231,039	341,740	273,337	179,571	268,733	546,245	366,791	373,190	564,233	546,440	664,594	**4,816,430**
	SB	1,226,696	1,197,637	1,169,873	1,428,123	2,972,668	1,291,802	943,182	1,104,675	2,516,416	2,621,364	2,035,825	2,883,083	2,461,768	3,233,416	**27,086,529**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**1,750,208**	**1,732,946**	**1,592,413**	**2,070,213**	**3,976,180**	**2,096,556**	**1,487,258**	**1,723,432**	**3,746,712**	**3,577,559**	**2,976,649**	**4,178,386**	**3,697,490**	**4,902,246**	**39,508,249**
PIURA	SAA	91,472	79,793	32,505	44,859	74,325	69,195	69,937	50,698	40,302	52,318	99,978	27,340	14,987	22,210	**769,919**
	SAD	4,214	26,144	2,966	5,814	10,965	5,463	38,708	5,424	4,487	11,862	21,890	3,590	1,054	1,639	**144,219**
	SB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**95,686**	**105,937**	**35,470**	**50,673**	**85,290**	**74,658**	**108,646**	**56,122**	**44,789**	**64,180**	**121,868**	**30,930**	**16,040**	**23,849**	**914,138**
PUNO	SAA	241,406	262,265	298,854	285,623	629,167	211,905	195,467	265,202	140,651	602,231	245,220	245,119	294,433	737,145	**4,654,687**
	SAD	40,113	49,400	46,980	60,130	148,238	51,936	53,380	101,180	52,638	195,140	110,232	113,003	156,237	352,743	**1,531,351**
	SB	17,676	10,226	19,805	9,532	31,604	23,831	133,127	50,947	21,563	50,114	17,908	8,005	10,273	83,893	**488,504**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**299,195**	**321,891**	**365,639**	**355,285**	**809,009**	**287,672**	**381,974**	**417,328**	**214,853**	**847,486**	**373,360**	**366,126**	**460,942**	**1,173,781**	**6,674,541**
SAN MARTIN	SAA	5,418,226	6,757,164	4,845,091	7,536,129	10,779,106	4,399,813	11,544,536	4,345,639	11,535,523	9,761,064	6,760,370	7,136,115	5,291,515	6,324,814	**102,435,104**
	SAD	739,708	659,560	446,119	756,330	1,217,433	638,255	1,355,018	772,485	2,056,993	2,191,262	1,891,001	2,745,389	2,149,628	2,259,587	**19,878,768**
	SB	595,302	998,432	690,115	1,109,302	1,316,327	826,204	1,359,500	1,871,233	1,701,411	1,435,434	1,277,828	1,875,027	1,652,223	2,092,510	**18,800,845**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**6,753,236**	**8,415,155**	**5,981,325**	**9,401,761**	**13,312,866**	**5,864,272**	**14,259,054**	**6,989,356**	**15,293,927**	**13,387,760**	**9,929,199**	**11,756,531**	**9,093,366**	**10,676,910**	**141,114,717**
UCAYALI	SAA	281,302	251,700	157,089	398,562	641,689	280,560	213,863	307,934	414,021	271,851	530,438	482,035	558,183	654,178	**5,443,407**
	SAD	79,718	80,382	52,716	110,740	150,657	95,366	85,298	104,808	170,753	163,768	356,138	407,567	320,161	412,952	**2,591,025**
	SB	5,551,599	5,099,651	5,954,590	5,364,564	10,605,440	5,923,912	4,930,014	8,348,245	12,644,458	8,775,529	11,256,501	11,665,276	17,832,028	15,520,601	**129,472,409**
	ZH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**5,912,620**	**5,431,733**	**6,164,396**	**5,873,866**	**11,397,787**	**6,299,837**	**5,229,175**	**8,760,987**	**13,229,233**	**9,211,149**	**12,143,076**	**12,554,878**	**18,710,373**	**16,587,731**	**137,506,841**

Depart-ment	Eco-zone	Emissions from anthropogenic gross deforestation														
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
NAME	Symbol	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	tCO_2-e	tCO_2-e	tCO_2-e
PERUVIAN AMAZON	SAA	13,907,455	12,328,631	11,109,789	15,114,922	23,283,525	11,195,827	19,165,960	10,978,825	21,421,340	18,357,561	14,630,052	16,463,580	14,805,739	18,892,117	**221,655,325**
	SAD	2,261,733	2,271,488	1,549,964	2,270,200	3,424,576	1,982,816	2,887,579	2,422,223	4,587,849	4,603,613	4,535,016	5,643,738	5,115,833	6,522,787	**50,079,415**
	SB	20,322,347	20,037,814	19,306,701	22,401,808	38,246,227	19,403,181	23,463,957	34,700,931	40,678,935	37,488,368	36,384,573	43,755,116	47,975,673	53,797,460	**457,963,091**
	ZH	678,937	859,517	664,935	1,263,385	1,018,377	731,505	871,771	1,048,717	1,671,846	1,165,827	1,040,998	2,334,471	1,783,969	2,352,952	**17,487,208**
	Total	**37,170,471**	**35,497,450**	**32,631,390**	**41,050,315**	**65,972,705**	**33,313,328**	**46,389,267**	**49,150,697**	**68,359,971**	**61,615,370**	**56,590,639**	**68,196,905**	**69,681,214**	**81,565,316**	**747,185,040**
	Average	**37,170,471**	**36,333,961**	**35,099,770**	**36,587,407**	**42,464,466**	**40,939,277**	**41,717,847**	**42,646,953**	**45,503,955**	**47,115,097**	**47,976,509**	**49,661,542**	**51,201,517**	**53,370,360**	**53,370,360**