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WHY THE IMPLEMENTATION OF CDM AND REDD IS DIFFICULT IN THE BOLIVIAN AMAZON?
A CASE OF STUDY IN A MUNICIPALITY OF NORTHERN BOLIVIAN AMAZON

Carmelo Peralta Rivero[I*], Maria Guadalupe Galindo Mendoza[II]; Vincent Antoine Vos[III]; Carlos Contreras Servín[IV]

[I]Multidisciplinary Graduate Programme in Environmental Sciences, Autonomous University of San Luis Potosi, Mexico (peralta.carmelo@gmail.com)*
[II]Multidisciplinary Graduate Programme in Environmental Sciences and Coordination for Innovation and the Application of Science and Technology, Autonomous University of San Luis Potosi, Mexico (ggm@uaslp.mx)
[III]Autonomous University of Beni "José Ballivián", Bolivia (vicentvosbolivia@gmail.com)
[IV]Multidisciplinary Graduate Programme in Environmental Sciences and Coordination for Innovation and the Application of Science and Technology, Autonomous University of San Luis Potosi – Mexico (coser@uaslp.mx)
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ABSTRACT: Currently, many hopes are put on projects related to 'Clean Development Mechanism' (CDM) as well as 'Reduction of Emissions from Deforestation and Forest Degradation' (REDD), with regard to possible benefits they might offer for the mitigation of climate change. This study seeks to contribute to the debates pertaining to the potentials and deficits of different alternatives. Landsat Images for the years 1986, 2000 and 2011 were used to analyze land cover changes in the municipality of Riberalta in the Bolivian Amazon, in order to identify areas with a potential for CDM and REDD projects. Furthermore, 138 interviews were carried out with peasant, indigenous and urban population in the municipality to evaluate their perception and knowledge regarding forest valuation, CDM and REDD projects. The results illustrate that a total of 4.3% of the municipal area are available for reforestation activities, but only 0.58% of this area can be considered under CDM projects. Moreover, it was identified that 74.03% of the municipal surface could be used for REDD projects. However, there is still a considerable lack of knowledge within the local population with regard to these projects as well as the issue of climate change. Despite this, local population highly values forest resources and in particular non-timber forest products (NTFP). It was concluded that there is considerable potential for CDM and REDD project in the municipality, but their application requires capacity-building and coordination of efforts with local population in order to guarantee the success of a possible implementation.

KEY WORDS: Deforestation, Forest Degradation, Forest Perception, Bolivian Amazon, CDM, REDD

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1. INTRODUCTION: Environmental impact generated by human activities in Bolivian Amazon forest, has become one of the top priorities in global political agenda and has led to search for alternatives to reduce impacts of deforestation and the degradation of forests. Over time, reforestation and forestation projects under Clean Development Mechanism (CDM) and/or Reduction of Emissions from Deforestation and Forest Degradation (REDD) have received major attention due to their mitigation potential based on financial incentives. Currently, there are several CDM and REDD projects around the world who are seeking the best way to consolidate a mitigation tool. Nonetheless, their application in practice is still very limited (1).

The CDM projects offer to developed countries to quantify emission reductions of Greenhouse Gases in other countries in order to meet their reduction commitments, even without actually affecting their industries, while countries development have the opportunity to obtain financial and / or technological support to mitigate greenhouse gases (2). The REDD projects also aims to payment for environmental services or ecosystem carbon capture through actions that prevent deforestation and forest degradation. Both types of projects are linked to the carbon market.

Furthermore, the state of Bolivia is one of the countries which has adopted a critical stance towards the mercantilist position of these mechanisms and is currently developing alternative mechanisms to value the ecosystem functions of forests. This illustrates that the appropriate management of forest resources in the Amazon constitutes a strategic topic for the humanity. This requires the development and the implementation of appropriate tools to fight the threats and improve the life of the people, while maintaining the forest in this region in a sustainable manner (3).

Using Remote Sensing and Geographical Information System, which allowed analyzing changes in land use and land cover with a reasonable degree of effectiveness [(4), (5), (6)] made it possible to collect, to structure and to

analyze important spatial information about forest and the potential areas for restoration in the study area. Also, semi-structured interviews with the people of this municipality were consulted about CDM and REDD projects.

This study presents (a) fundamental contribution to the debates on the potential and outreach of the different alternatives evaluating the case of the municipality of Riberalta in the Bolivian Amazon with respect to deforestation, (b) the potential of CDM and REDD projects, and (c) the perception of the local population concerning the value of forests as well as the potential of these kind of projects in the region.

The main objective was to evaluate potential areas for CDM and REDD projects and analyze the local perception of the peasant, indigenous and urban population within the municipality of Riberalta, about forest valuation and knowledge of projects under the CDM and for REDD.

2. RESEARCH AREA: The municipality of Riberalta is located within the so called Northern Amazon of Bolivia (Fig. I). It is situated between 10°59'36" South Latitude and 66°04'25" West Longitude (7), with an approximate area of 9,725 km^2 and a projected population of about 106,545 inhabitants until the year 2010 (8), ranking it as one of the 24 largest cities in the continental Amazon (9).

In this area, the main kinds of vegetation are pluviseasonal semideciduous forests and pluviseasonal evergreen to semi-deciduous forests (10). Also, there is a slight difference in average temperature between the warmest and coldest month (25-27°C).

Moreover, it is an area with little relief, flat or gently undulating and an altitude range between 100 and 250 m. The climate is humid with annual rainfall between 1,800-2,200 mm and a dry season that lasts about three months a year (from July to September) giving a seasonal forest [(7), (11)].

Historically this region has been known for producing many forest resources. Nonetheless, forest cover has been modifying in various ways as a result of human-induced activities. Also, different biophysical factors come together with human-induced activities such as agriculture and livestock production, which may have an important impact on the transformation of ecosystems (3). The most important alteration can be observed with regard to forest. Also, the opening of roads and highways have accelerated and deepened these changes, the increase of livestock herding, the demand for wood and the need for wood-derived products (12).

Nonetheless, the large area of forest remnant and deforested areas, arouse the interest of implementing projects for forest conservation and restoration through CDM and REDD, as was for example the test program "REDD Amazonia Boliviana" developed since 2009 in the municipality by "Fundación Amigos de la Naturaleza" with the agreement of some municipalities of Bolivian Amazon.

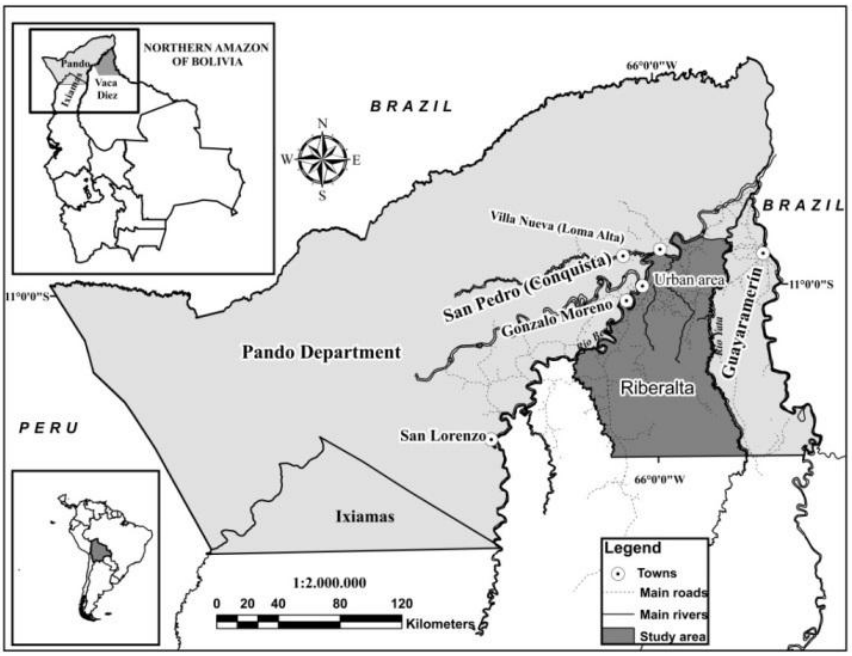

Fig I. Location of the study area in the Bolivian Amazon

3. METHODOLOGY:

3.1 LAND COVER AND POTENTIAL AREAS FOR CDM AND REDD PROJECTS: To this aim, LANDSAT TM5 images of the study area were obtained for the years 1986, 2000 and 2011 [(13), (14), (15)] (Fig. II).

For classification purposes, the collected satellite images were georeferenced and reprojected using the Envi 4.7 software. Groups of control points were used based on the already orthorectified images of 1986 (path 233, row 067 and path 001, row 068) and 1991 (path 001 row 68) (Fig. II).

For the classification of land cover we used the "Definiens Developer Ell Heart" software, which is a computer system that performs interpretation tasks of remote sensing images using multi-resolution segmentation, object-oriented analysis and decision hierarchy (16). This analysis allows the object to combine its structure (attributes) and its behavior (operations) into a single entity (16).

In the image processing, the algorithm multiresolution segmentation was used with a parameter of scale 30 and the criteria of shape 0.5 and compactness 0.5 for the bands 1 (blue), 2 (green), 3 (red), 4 (near infrared), 5 (mid infrared) and 7 (far infrared or thermal) of the electromagnetic spectrum. For the hierarchical classification, which results in different levels of interrelated classes according to a defined topology, the Nearest Neighbor Algorithm was used. The definition of thematic classes and selection of samples representing each of the kinds (Water bodies, Flooded areas, Urban areas, Terra Firme Forests, Floodplain Forests, Pastures, Savannas, Exposed soils, Secondary vegetation and, Alluvial deposits) was based on the prior knowledge of the study area and the used color composition.

The classification was drawing exclusively on the fuzzy modeling of spectral descriptors supported by the selection of training areas (more 30 samples per class). The fuzzy analysis provides a degree of involvement (relevance) of an object for all defined classes in the legend, the values of which can be inserted into new contexts of classification (17). This way, a supervised classification oriented to objects with field verifications in the area in the municipality of Riberalta was performed.

After the classification of covers, ArcGIS 9.3 software was used to perform to cross of the data and allow the quantification and detection of changes, potential areas for CDM and REDD projects.

In order to describe the dynamics of change in the forest cover, a "deforestation process" model was developed, based on which change rates were calculated according to the equation introduced by the Food and Agriculture Organization of the United Nations (18) as an equation:

$$\delta_n = \left(\frac{S_2}{S_1}\right)^{1/n} - 1$$

Where δ = change rate (in order to express percentage, it has to be multiplied by 100); S_1 = the surface on the first date 1; S_2 = the surface on the second date 2; and n = the number of years between the two points of time.

In this paper, all maps were generated working with a scale of analysis of 1:100,000 following earlier studies on the subject [(4), (17), (19)] and considering the minimum mappable area for different scales [(20), (21)].

The criteria to determine which areas are suitable and unsuitable for Clean Development Mechanism projects were based on the review of baseline methodologies for large and small-scale afforestation and reforestation projects approved by the United Nations Framework Convention on Climate Change [(22), (23), (24)], and also by observing the covers and land use that are developed in these (field work).

The criteria for the determination of the potential areas for Reduction of Emissions from Deforestation and Forest Degradation projects were based on the identification of two kinds of forests (terra firme forest und floodplain forest) with potential to capture and preserve the carbon stored in these ecosystems (1).

3.2 LOCAL PERCEPTION OF THE POPULATION: In order to know the perception of the population in Riberalta on forest value and forestry projects of carbon capture and storage, CDM and REDD, 138 semi-structured interviews were carried out. A semi-structured interview is based on a topic guide where the interviewer is free to introduce additional questions and can help to get better understanding of the research topic arises also helps to collect data and corroborating information.

The questions were developed taking into account the cultural aspects of the population, the relation between humans and the forest as well as necessities of small scale producers from rural areas, being a fundamental requirement for the functioning of forest projects (25). Three aspects were taken into consideration. 1) *What the person knows*: knowledge concerning the forest, climate change and its consequences, carbon credits, projects related to CDM and REDD. 2) *What the person does*: relation of the profession to the forest and other activities. 3) *What the person thinks:* Possible actions to be taken with regard to the usage of the forest; knowledge and criteria concerning CDM and REDD projects, climate change and others.

Stratified random sampling which properly conform which suites the characteristics of the study was applied. This kind of sampling is used when the population is not homogeneous with regard to the characteristics which are studied, such as social classes, regions, gender, age groups. In this case, the population is divided into strata or groups, and the sampling conducted in such a way that all groups are represented [(26), (27), (28)].

Two methods were used to determine the sample size for each stratum: 1) Proportional calculation to the stratum size: in this case, there is a proportional relationship between the size of the stratum and the number of elements provided by the sample. 2) Disproportional calculation to the stratum size: this type of calculation is applied to avoid oversized samples in the larger strata and too small samples in the smaller strata [(26), (27), (28)].

A calculation of sample size with precision and reliability (sample size for finite population) was conducted. The values were employed in the following mathematical expression:

$$n = \frac{\mathrm{N} * \mathrm{Z}_{\alpha}^{2} * \mathrm{p} * \mathrm{q}}{d^{2}\ \mathrm{N} - 1\ + \mathrm{Z}_{\alpha}^{2} * \mathrm{p} * q}$$

$$n = \frac{106{,}545 * 1.96^{2} * 0.9 * 0.1}{0.05^{2}\ 106{,}545 - 1\ + 1.96^{2} * 0.9 * 0.1} = 138$$

Where N is the Entire population (106,545 inhabitants); $Z\alpha^2$ is equal to 1.962 (with a security of 95%); p is the expected rate of success (in this case 90% = 0.90); q is the expected failure rate of 1 - p (in this case from 1 to 0.9 = 0.1 = 10%) and d is the precision (in this case 5%).

Interviews were conducted with people over 18 years among men and women. During the systematization of information, four interviews were removed due to errors made during the gathering of information, and the proportion of respondents ranged in strata. For this reason, the remaining interviews were: 53 interviews in urban areas, 47 interviews in rural communities, and 34 interviews in indigenous communities, the absolute results of which were then used to perform the statistical tests. The results of the interviews were furthermore tabulated and shown in percentages.

Finally, to differentiate the views of the interviewed groups, two types of statistical analyses were performed: 1) the Chi Square of independence (X^2) for which contingency tables were generated and which allowed us to determine whether the categorical variables analyzed were associated, in other words, whether the opinion of the interviewed stakeholders were statistically different. 2) The nonparametric Mann Whitney U test that permitted us to determine the differences between two populations based on the analysis of two independent samples (29). This allowed us to observe the association of two categorical variables, that is, to determine whether there were any statistical differences in the opinion of the urban population compared to rural and indigenous populations, and vice versa. The significance level used for both tests was 0.001 (99%) and 0.05 (95%). All analyses were conducted using STATISTICA 8.0 software and the categorization was done arbitrarily.

4. RESULTS AND DISCUSSION

4.1 LAND COVER AND LAND COVER CHANGE: The analysis of the georeferenced data enables a reconstruction of the dynamics of land cover in the municipality of Riberalta, Bolivian Amazon, for a time span of 25 years (1986 - 2011) (Table I).

Classes	Area in km^2			Area in %		
	1986	2000	2011	1986	2000	2011
Urban areas	5.13	14.31	21.19	0.05	0.15	0.22
Pasture	26.04	54.54	47.85	0.27	0.56	0.49
Savannas	960.23	935.14	930.28	9.87	9.62	9.57
Forests	8,038.73	7,814.81	7,200.81	82.65	80.35	74.04
Secondary vegetation	323.36	513.38	834.87	3.32	5.28	8.58
Water	151.81	127.61	137.82	1.56	1.31	1.42
Alluvial deposits	7.19	9.77	9.82	0.07	0.10	0.10
Flooded áreas (wetland)	149.90	104.80	175.67	1.54	1.08	1.81
Exposed soils	63.36	151.39	367.43	0.65	1.56	3.78

Table I. Absolute and relative areas of the different land cover classes in the municipality of Riberalta

Table I shows that when comparing land covers between 1986 and 2011 the most significant reduction of area has occurred within this same class. The total area occupied by forests was reduced from 8,038.73 km^2 in the year 1986 to 7,814.81 km^2 until year 2000, and by 2011 only 7,200.81 km^2 were left. That is, the overall loss or changed use of land cover in this class has been 837.92 km^2, over a time span of 25 years.

Reasonable evidence of land cover changes was found when crossing (1986-2011).The changes that occurred were the increase of the urban area (4.1%), pasture (2.4%), secondary vegetation (3.8%), alluvial deposits (1.2%) and exposed soil (7.2%) as well as a change in forests −0.43% (Table II).

The deforestation rate of forests found is higher than the general national deforestation rate for Bolivia −0.3% for the period 1975-1993 calculated by (30) with an increase of 80% between (1993-2000) (31). Nonetheless, it was lower than the period -between 2000-2005 (0.56%) and 2005-2010 (-0.78%) calculated by (32). Likewise, it can be observed

that the main changes occurred with regard to natural covers which transformed into non-original covers (secondary vegetation, pasture, urban area and exposed soil).

	2011											
1986	***Water***	***Urban area***	***Flooded areas***	***Forest***	***Alluvial deposits***	***Pasture***	***Savannas***	***Exposed soils***	***Secondary vegetation***	***Water***	**Loss**	**Loss rate (%)**
Water	**77.94**	0.14	9.17	31.27	4.40	0.63	0.01	1.30	26.94	**151.81**	73.87	-0.386
Urban area	0.01	**4.77**	0.03	0.01	0.00	2.74	0.14	0.15	0.16	**8.01**	3.24	4.1009
Flooded areas	12.19	0.05	**35.53**	54.16	0.86	0.00	0.00	3.40	40.82	**147.02**	111.48	0.6988
Forest	37.21	2.00	113.88	**6976.04**	2.22	34.44	35.92	221.45	615.57	**8,038.73**	1,062.69	-0.439
Alluvial deposits	2.02	0.00	0.33	0.51	**0.76**	0.31	0.00	0.18	3.08	**7.19**	6.44	1.254
Pasture	0.11	1.75	0.06	1.67	0.00	**0.74**	0.02	13.75	7.94	**26.04**	25.30	2.4638
Savannas	0.23	0.70	0.00	63.65	0.00	0.01	**892.60**	1.11	1.93	**960.23**	67.63	-0.127
Exposed soils	0.25	4.46	0.25	4.30	0.00	0.64	0.05	**41.99**	11.40	**63.36**	21.37	7.2838
Secondary vegetation	7.85	8.02	15.73	69.19	1.58	8.32	1.54	84.10	**127.03**	**323.36**	196.32	3.867
Total 2011	**137.82**	**21.89**	**174.98**	**7,200.81**	**9.82**	**47.85**	**930.28**	**367.43**	**834.87**			
Gain	59.88	17.12	139.44	224.77	9.07	47.10	37.68	325.44	707.84			

Table II. Cross-tabulation matrix or change matrix between 1986 and 2011 (data in km^2).

4.1.1 POTENTIAL AREAS FOR CDM AND REDD PROJECTS: Of the 16 large scale methodologies reviewed, we considered that 14 of them are likely to be implemented, while of the seven small scale methodologies, five could be implemented. All the methodologies can be applied in deforested or degraded areas, and in another kinds of land use or cover land. For this reason, we represent all de potential areas for CDM projects all the methodologies in (Table III and IV).

Code	Methodologies	Implementation
AR-AM0001	Reforestation of degraded lands	Possible with difficulties
AR-AM0002	Restoration of degraded lands through afforestation/reforestation	Possible with difficulties
AR-AM0003	Afforestation and reforestation of degraded lands	Possible with difficulties
AR-AM0004	Reforestation or afforestation of land currently under agricultural use	Possible with difficulties
AR-AM0005	Afforestation and reforestation project activities implemented for industrial and/or comercial uses	Possible with difficulties
AR-AM0006	Afforestation/Reforestation with Trees Supported by Shrubs on Degraded Land	Possible with difficulties
AR-AM0007	Land Currently Under Agricultural or Pastoral Use	Possible with difficulties
AR-AM0008	Afforestation and Reforestation of degraded lands for sustainable timber production	Possible with difficulties
AR-AM0009	Afforestation or reforestation on degraded land allowing for silvopastoral activities	Possible with difficulties
AR-AM0010	Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas	Not possible
AR-AM0011	Afforestation and reforestation of land subject to polyculture farming	Possible with difficulties
AR-AM0012	Afforestation or reforestation of degraded or abandoned agricultural lands	Possible with difficulties
AR-AM0013	Afforestation and reforestation of lands other than wetlands	Possible with difficulties
AR-AM0014	Afforestation and reforestation of degraded mangrove habitats	Not possible
AR-ACM0001	Afforestation and reforestation of degraded land	Possible with difficulties

AR-ACM0002	Afforestation or reforestation of degraded land without displacement of pre-project activities	Possible with difficulties

Table III. Large scale methodologies

Code	Methodology	Implementation
AR-AMS0001	Projects under the CDM implemented on grasslands or croplands	Possible with difficulties
AR-AMS0002	Simplified baseline and monitoring methodologies for Small scale A/R project activities under the CDM implemented on Settlements	Possible with difficulties
AR-AMS0003	Simplified baseline and monitoring methodology for Small scale CDM A/R project activities implemented on wetlands	Not posible
AR-AMS0004	Approved simplified baseline and monitoring methodology for Small-scale agro forestry A/R project activities under the CDM	Possible with difficulties
AR-AMS0005	Approved simplified baseline and monitoring methodology for Small-scale A/R project activities under the CDM implemented on lands having low inherent potential to support living biomass	Not possible
AR-AMS0006	Approved simplified baseline and monitoring methodology for Small-scale silvopastoril A/R project activities under the CDM	Possible with difficulties
AR-AMS0007	Afforestation or reforestation on grasslands and agriculture land	Possible with difficulties

Table IV. Small scale methodologies

Based on the land use classification of 1986, 89.40 km^2 of the municipal area of Riberalta were identified as potentially suitable for Clean Development Mechanism based on the criteria established by United Nations Framework Convention on Climate Change [(22), (23), (24)].These areas correspond mainly to areas classified as exposed soils and pasture in 1986. Since part of the identified areas in 1986 have suffered changes in land cover, the total potential area for the implementation of Clean Development Mechanism projects based on the Kyoto protocol (2), i.e. areas without changes in land cover from 1986, was calculated as 57.13 km^2 (Fig. IIa). However, we also identified all potential areas available until 2011 for reforestation projects, considering their possible importance in view of the end of the first commitment period of the agreement (2008-2012) and plausible future changes to the mentioned protocol (Fig. IIb).

The black areas in fig. IIa and fig. IIb represent suitable areas for CDM projects. Although savannas (marked in white) theoretically could be suited for the application of Clean Development Mechanism projects, we did not consider these, in view of the difficult implementation of afforestation activities within this type of vegetation, and probable negative environmental and ecological consequences such as changes in relation to soil properties and ecosystem functioning, according to another studies in this field [(33), (34)].

The black areas in fig. IIb belong to those that are potentially suitable for the implementation of reforestation projects (415.28 km^2), the same that were present until 2011. But, all these areas are not under the Kyoto protocol because they were suitable after 1990.

Furthermore, in this study we identified a total 7,200.81 km^2 of areas with a potential for the implementation of REDD projects within the Riberalta Municipality (based on data from 1986 to 2011).

The dark gray areas in fig. IIc represent forests until the year 2011 (6,950.41 km^2); (Table V). Considering that the forests of the Amazon capture on average 175 tons of carbon by hectare (35), the identified could represents 126,014,175 tC. However, takin into account the degradation by logging and other activities, amounts of carbon in practice could prove lower than these estimated values based on data for protected forests. Yet, values could also be higher, considering that the class "forests" represents different types of vegetation including for example, palm swamps dominated by Mauritia palms for which values of up to 600 tons of carbon by hectare have been indicated (36).

	Terra Firme Forests (km^2)	**Floodplain Forests (km^2)**	**Total (km^2)**
Forests until 2011	6,124.18	1,076.63	7,200.8

Table V. Status of the forests in the municipality of Riberalta until 2011

Furthermore, different studies indicate that forest degradation plays an important role for carbon loss and the magnitude of wood extraction, depending on the intensity or level of intervention, can cause the same negative impact like the deforestation, so more information is required on the subject [(37), (38)].

Despite the many benefits that forests can provide through their environmental services, it is still necessary to discuss the problems and co-benefits that can be obtained through CMD and REDD projects, especially in view of the poorest population communities depending on the forest. Reduction of Emissions from Deforestation and Forest Degradation projects could be of a high risk in terms of forest use restrictions for the poor who depend on these, however, they can also provide important opportunities for the reduction poverty and improvement of equity, allocating significant financial flows to rural areas (12).

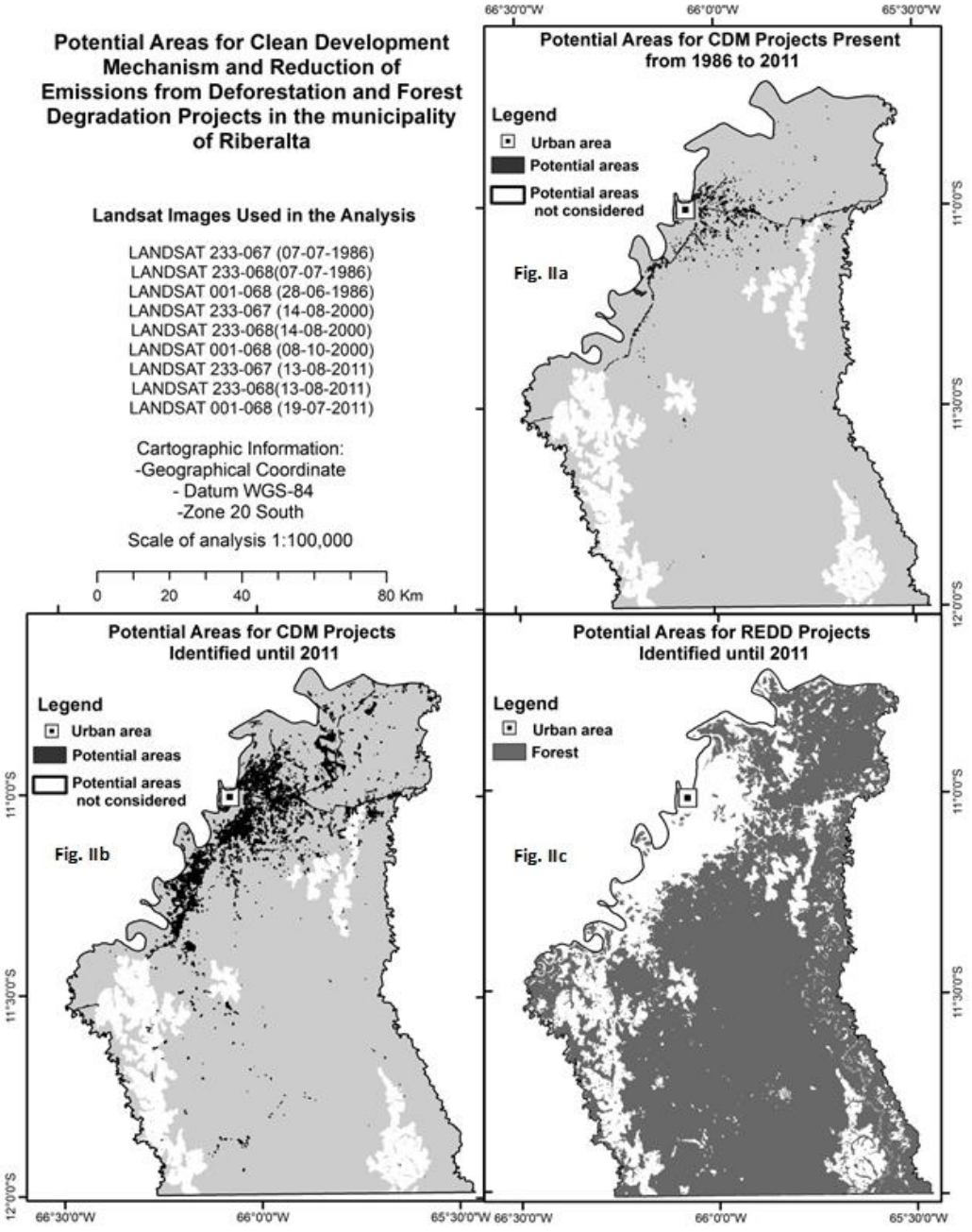

Fig II. Potential areas for CDM and REDD projects in the municipality of Riberalta

4.2 LOCAL PERCEPTION OF THE POPULATION REGARDING FOREST VALUE: Regarding the forest value it can be stated that peasants and the indigenous population generally deforest between one and two hectares of forest for their agricultural activities (39). This information is in agreement with the information provided [(40), (41)], which indicated that the primary activity of the population in Bolivian Amazon is based on the exploitation of non-timber forest products (NTFP) such as the gathering of chestnuts (70%) (*Bertholletia excelsa*) which activity involves the conservation of forests. The population living within the urban area does not have any access to free areas to realize activities that imply deforestation (Fig. III). It needs to be considered that among the people that were interviewed in urban area, there was no owner of private forest areas.

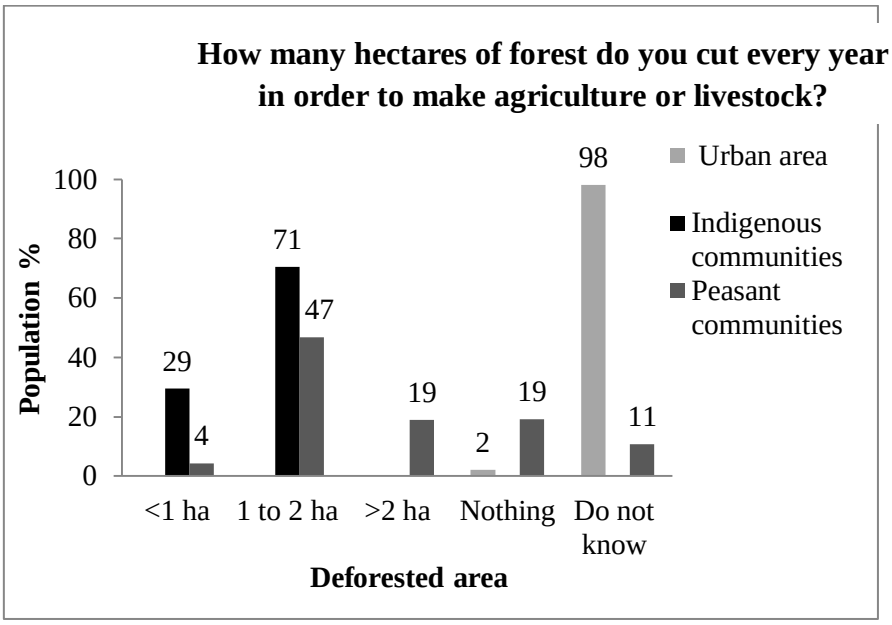

Fig III. Deforested area in Riberalta per year (p>0.001)

Figure III shows that despite the fact that the different actors in the Bolivian Amazon deforest on different scales [(42), (43), (44)] no significant difference can be observed between the indigenous, peasant and urban population in Riberalta when applying the U Mann Whitney test (p>0.001). Hence, they are not responsible for the large scale deforestation as indicated by (45), who classified the main users of the Northern Amazon as indigenous and peasant population, arguing that they are the main persons responsible for deforestation in this region. Furthermore, the mentioned communities have larger deforested areas due to the fact that in many cases they have settled on already deforested land i.e., areas that they were assigned to them as compensation for lack of territories demanded during the distribution of land in the northern Amazon region of Bolivia (3).

The major benefits provided by the forest which are perceived by the local population, are timber product (TP) and non-timber forest products (NTFP). The U Mann Whitney test indicates that there is no significant statistical difference (p>0.001) with regard to the benefits perceived by peasants the indigenous and urban population (Fig. IV).

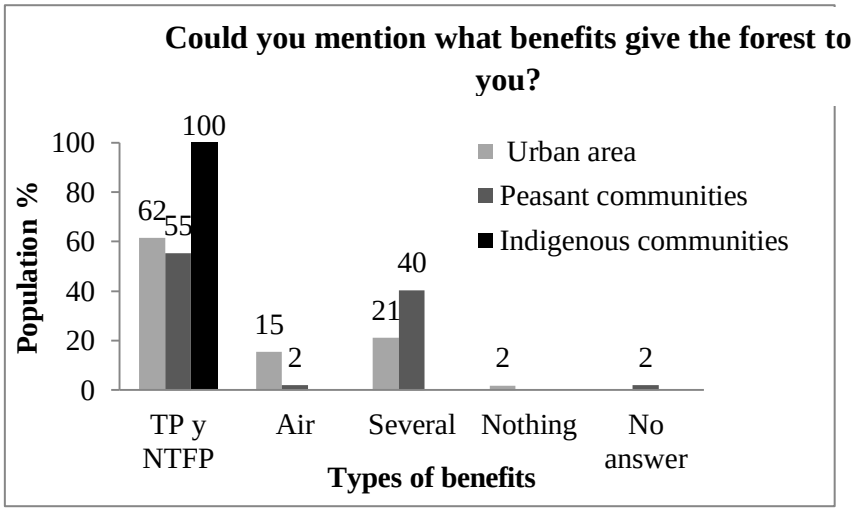

Fig IV. Benefits perceived by the population in the municipality of Riberalta (p>0.001)

Similar to the findings (46) the urban, peasant and indigenous population indicate that the forests play a fundamental role for their subsistence and municipal economy, and they do not perceive any better alternatives to the forest. The X^2 test (p=0.009) furthermore demonstrates that there is no statistical difference regarding the opinion of the mentioned social groups (p>0.001) (Fig. V).

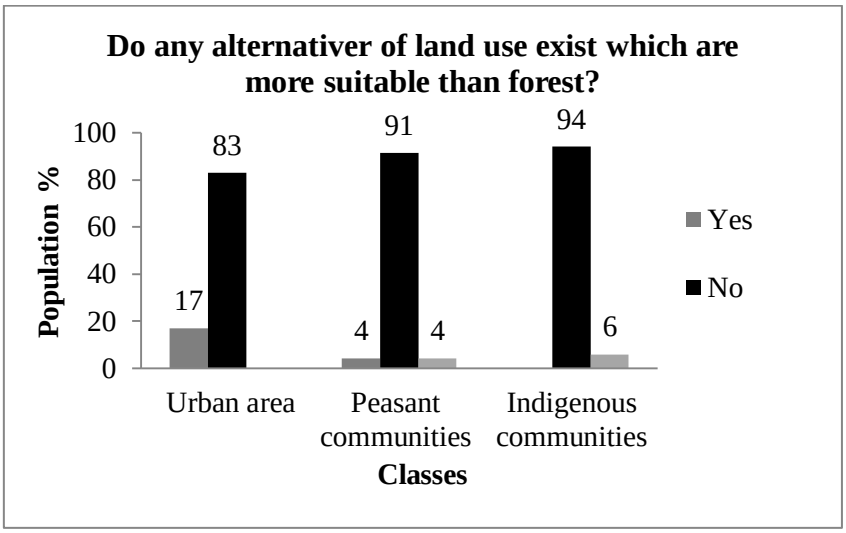

Fig V. Perception on alternative land use in Riberalta (p>0.001).

4.3 CLEAN DEVELOPMENT MECHANISM FOREST PROJECTS: This section provides the perceptions regarding the knowledge on CDM forest projects and alternative implementations (Table VI).

Questions	Urban (%)		Peasants (%)		Indigenous (%)		Chi^2 test
	Yes	No	Yes	No	Yes	No	X^2
¿Did you hear about projects under the Clean Development Mechanism of the Kyoto Protocol?	2	98	2	98	0	100	p>0.001
Have you heard about forestation, reforestation projects or carbon capture and storage?	42	58	34	66	6	94	p<0.001
¿Did you know that reforestation is a an important practice for the reduction climate change	91	9	77	23	9	91	p<0.001
¿Would you agree if your municipality / community received economic resources for reforestation?	98	2	100	0	94	6	p>0.001
Do you think that your municipality or community would accept to participate in reforestation projects?	92	8	68	32	100	0	p<0.001

Table VI. Knowledge of the population in Riberalta with regard to forest projects under the Clean Development Mechanism

Table VI shows that there is no significant statistical difference (p>0.001) between the interviewed actors concerning their knowledge of Clean Development Mechanism projects. In general, there is a total lack of knowledge among the population regarding the subject, similar to other countries in the region (47).

Yet, there is a statistically significant difference (p<0.001) with regard to the degree of knowledge on forestation and reforestation projects. It can be stated that the indigenous population has the least knowledge, followed by the peasant population. Furthermore, the indigenous population largely ignores that reforestation can be an important tool in the mitigation of climate, having less knowledge related to this subject than the urban and peasant population (p<0.001).

Regardless of the information gap regarding Clean Development Mechanism projects, there is no statistically significant difference (p>0.001) regarding the willingness of the population to receive economic resources for reforestation. Yet, a statistically significant difference exists (p<0.001) concerning the willingness to participate in reforestation projects, as 32% of the peasant population do not want to participate in this kind of projects. This may compromise the success of any forest projects seeking to involve the rural population (25)

There is also a statistically significant difference (p<0.001) with respect to the readiness of the different population groups to participate in reforestation activities (Fig. VI). Mainly the indigenous populations do not feel prepared to carry out this kind of activities in contrast to the peasant population which is experienced in working with agro-forest plantations that have been propagated by Non-Governmental Organizations in the region to reduce poverty (11).

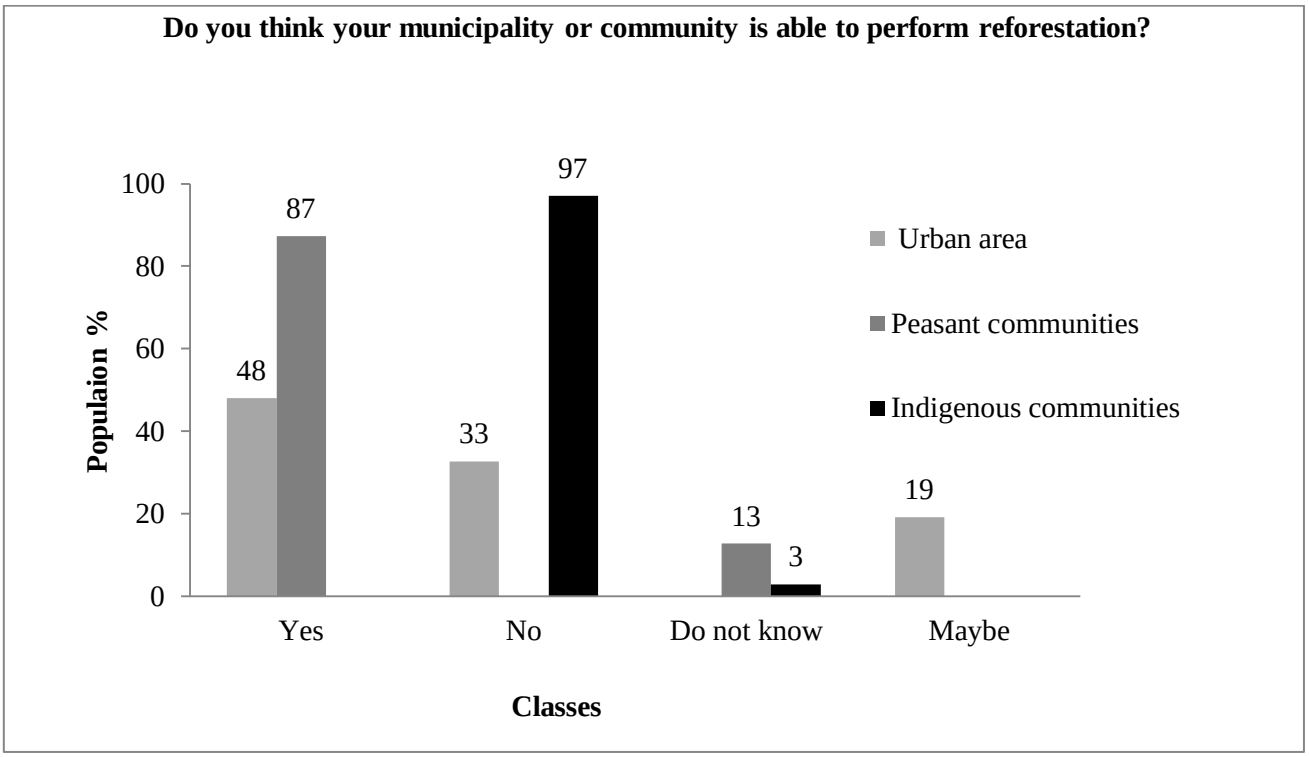

Fig VI. Perceptions concerning the development of reforestation projects in the municipality of Riberalta ($p<0.001$)

There is, however, no statistically significant difference ($p>0.001$) between the groups the with regard to the preferential reforestation areas. The entire population was in favor of reforesting the deforested and fallow areas (secondary vegetation) (Fig. VII).

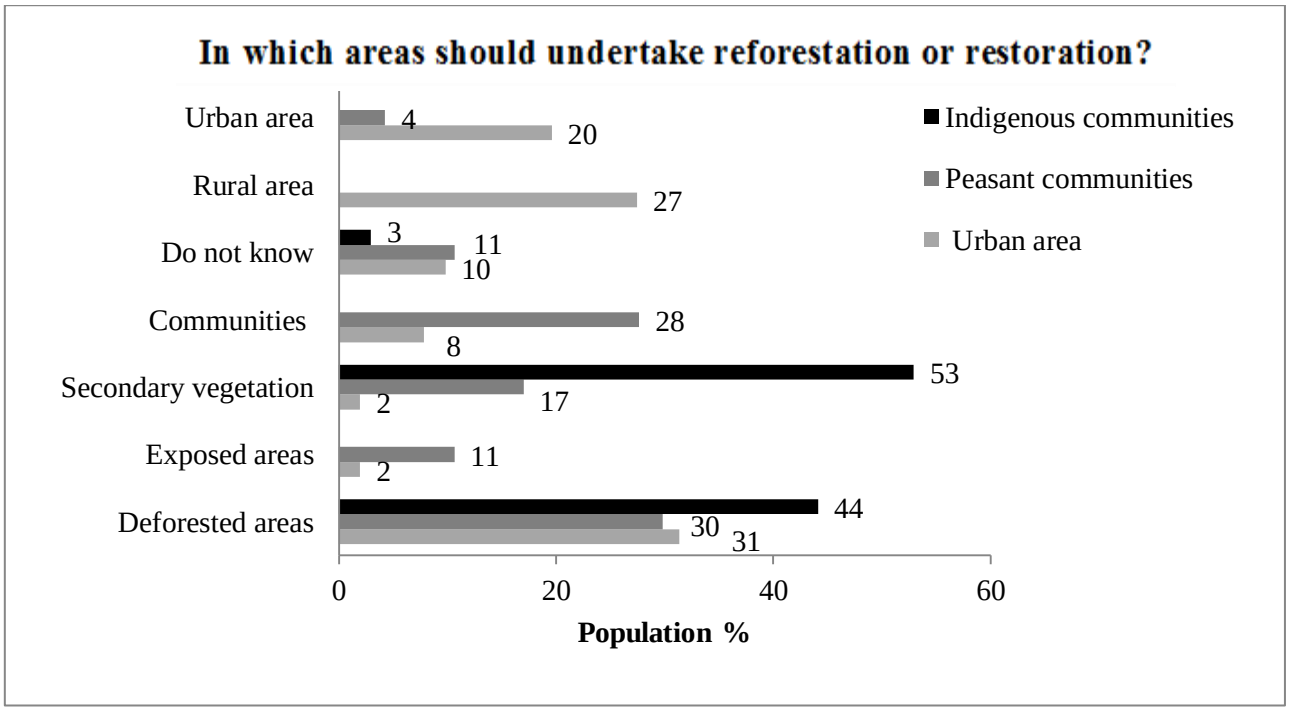

Fig VII. Order of priority of the potential areas for reforestation in the municipality of Riberalta ($p>0.001$)

Concerning the species to be used during the reforestation process, no statistically significant difference ($p>0.001$) was perceived among the different population groups. The majority was in favor of timber species, diverse species, non-timber and native species (Fig. VIII).

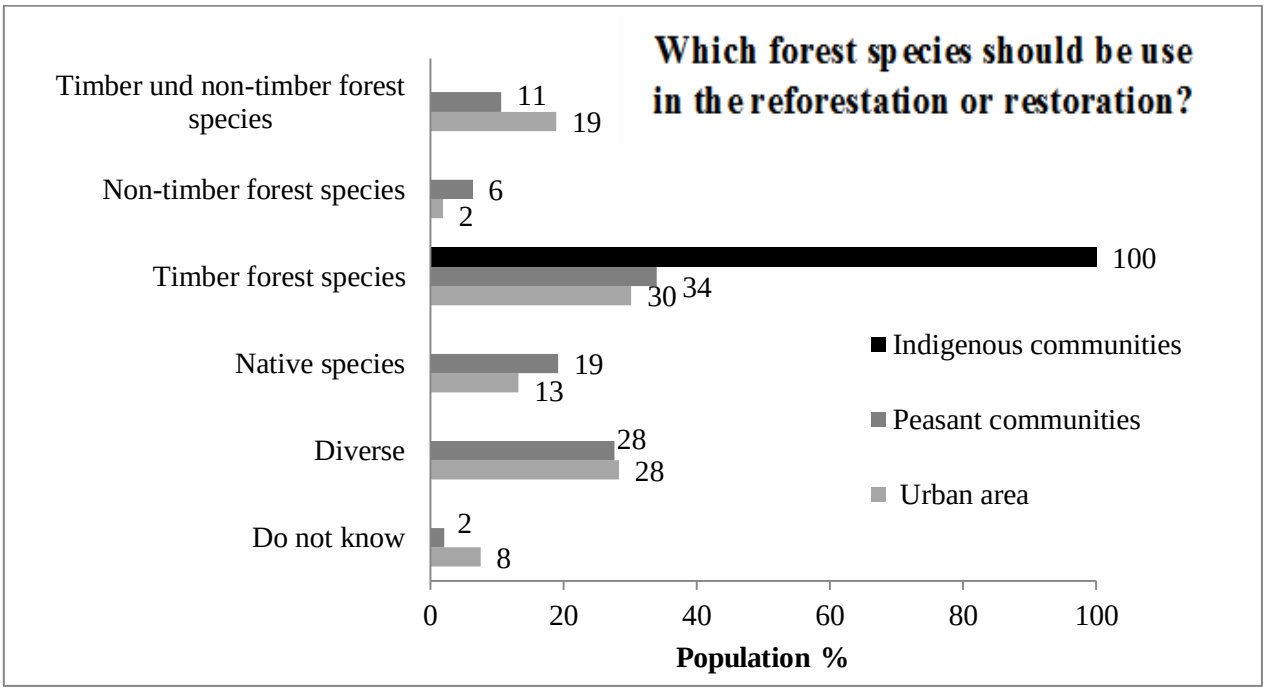

Fig VIII. Order of priority of the species to be used for reforestation in the municipality of Riberalta (p>0.001)

Given the case that reforestation projects will be implemented in practice, there is no statistically relevant difference between the population groups (p>0.001) regarding the time duration for which the planting should be preserved before it is exploited. The majority indicated that it should be preserved for a minimum period of 10 years, while others argued that it should be preserved indefinitely (Fig. IX).

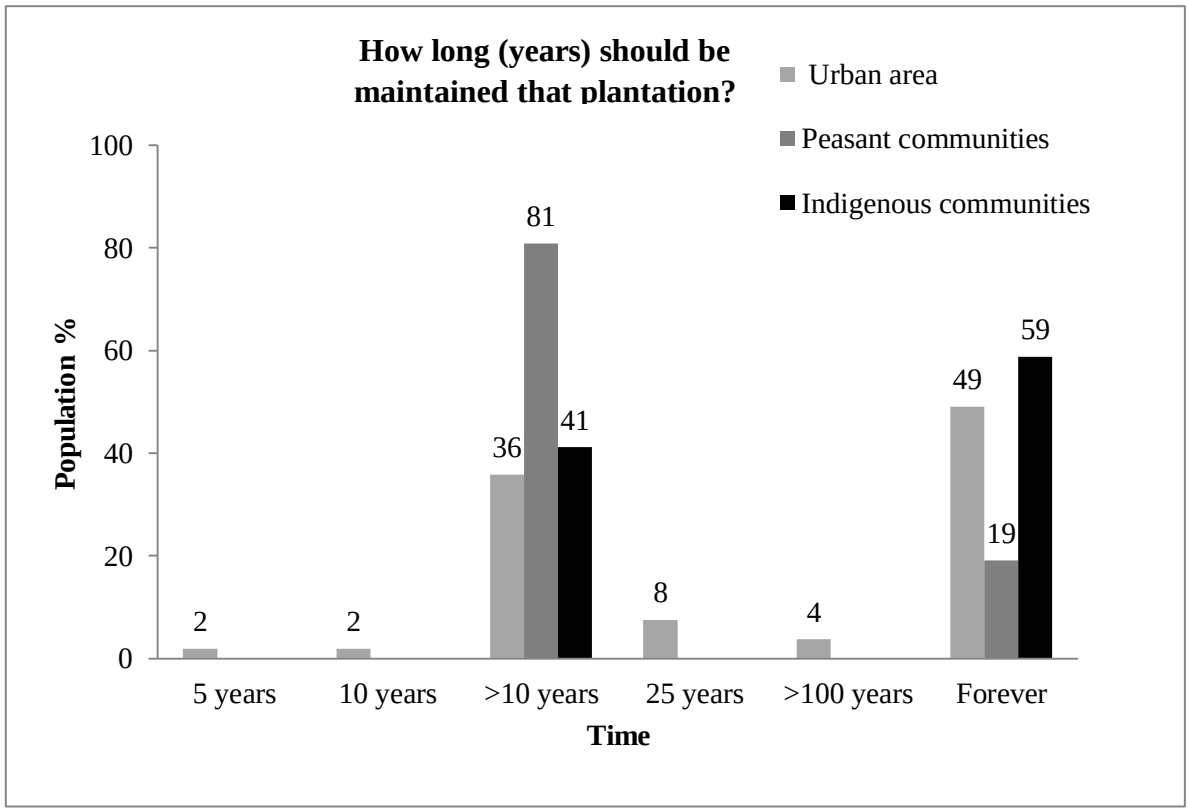

Fig IX. Conservation period of the planting according to the population of Riberalta (p>0.001)

Finally, no statistically significant difference was found among the urban and peasant population concerning the benefits that they hope to receive from the planting, and there is only a slight statistical significance between the urban and indigenous population (p>0.05). Yet, there is a statistically significant difference (p<0.05) between the expectations of the peasant and the indigenous population (Fig. X). Overall, the indigenous population was hoping for the inflow of economic resources.

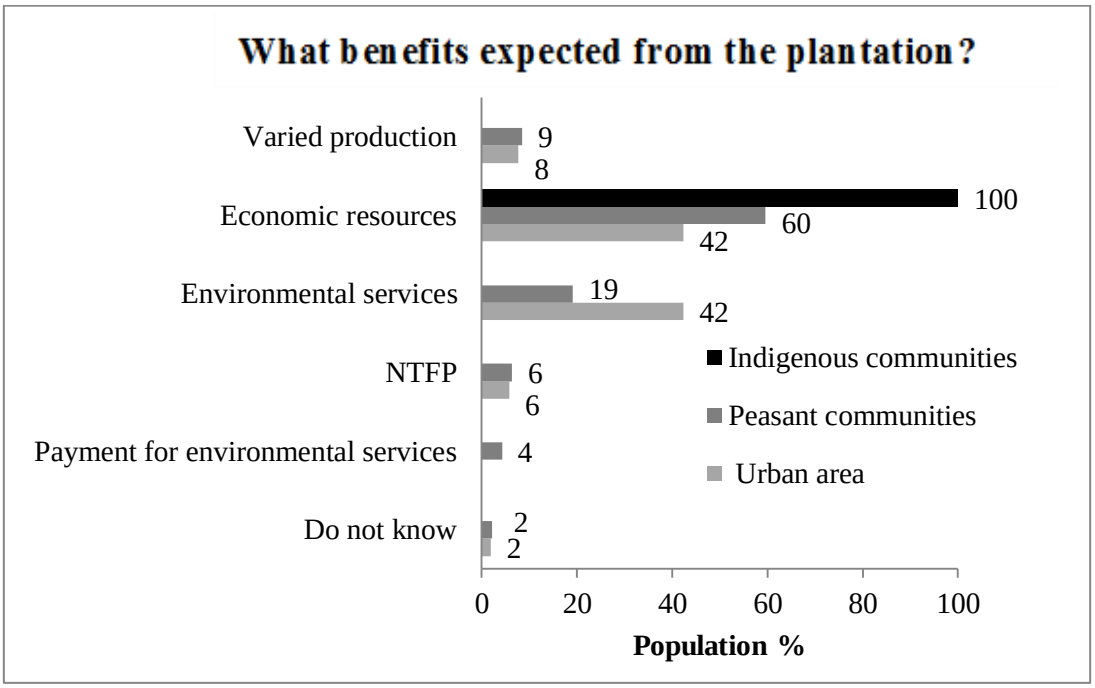

Fig X. Benefits expected from the planting in the municipality of Riberalta ($p<0.05$)

4.4 REDUCTION OF EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION FOREST PROJECTS: Different questions posed to the interviewees were related to climate change, greenhouse gases, Reduction of Emissions from Deforestation and Forest Degradation, carbon dioxide, and the importance of the role of trees as sinks and emitters of carbon dioxide.

No statistically significant difference was found between the different population groups ($p>0.001$) with regard to the question what or who causes climate change. The majority mentioned human activity as a major cause. This perception is supported by the research carried out by (48) (Fig. XI).

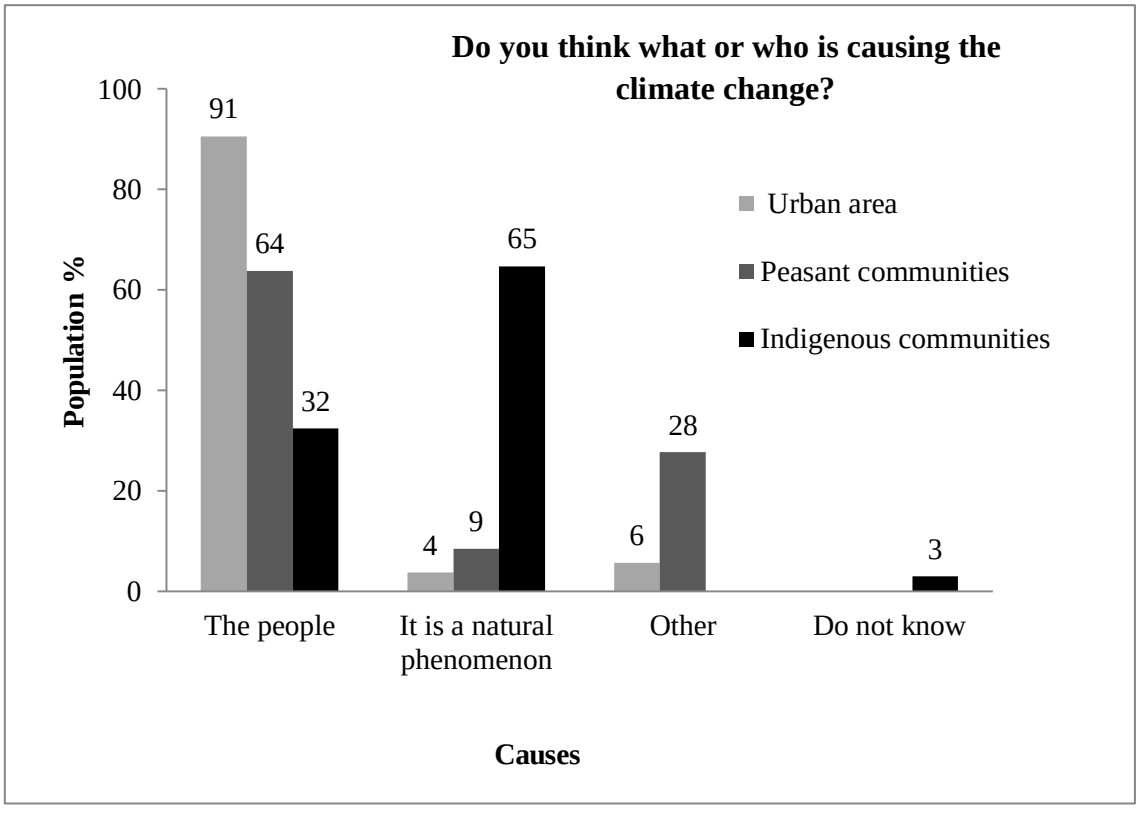

Fig XI. Causes of climate change according to the population of Riberalta ($p>0.001$)

The following table presents the perceptions in the municipality of Riberalta regarding climate change and Reduction of Emissions from Deforestation and Forest Degradation forest projects (Table VII).

Questions	Urban (%)		Peasants (%)		Indigenous (%)		Chi^2 test
	Yes	No	Yes	No	Yes	No	X^2
Have you heard about global climate change, global temperature increase? Do you think it is warmer now than in previous times?	92	8	87	13	6	94	p<0.001
Have you heard about greenhouse gases?	11	89	4	96	0	100	p>0.001
Have you heard about Reduction of Emissions from Deforestation and Forest Degradation programs?	0	100	0	100	18	82	p<0.001
Do you know anything about the impacts of carbon dioxide?	34	66	26	74	15	85	p>0.001
Have you heard that trees are the main carbon sinks or for other gases that pollute the atmosphere?	81	19	43	57	18	82	p<0.001
Do you know that the burning of forests causes the emission of greenhouse gases/CO_2 into the atmosphere which causes global warming?	26	74	26	74	18	82	p<0.001
Have you heard that forests are very important for the reduction of climate change?	98	2	81	19	21	79	p<0.001
Would you be willing to participate in a forest conservation project to fight climate change?	90	10	98	2	85	15	p>0.001

Table VII. Perception of the population in Riberalta concerning global warming, climate change and Reduction of Emissions from Deforestation and Forest Degradation

Table VII shows that there is a statistically significant difference between the analyzed groups ($p<0.001$) concerning their knowledge on global climate change. The indigenous population in particular has little knowledge on the issue. Yet, there is no statistically significant difference ($p>0.001$) with regard to the lack of knowledge concerning greenhouse gases. In general, the majority of the population in Riberalta lacks knowledge on the topic due to insufficient information, such as in other parts of Bolivia (49).

There is, however, a statistically significant difference ($p<0.001$) concerning the degree if knowledge regarding REDD projects. Except for 18% of the indigenous population, the rest of the population in Riberalta has no knowledge concerning this topic. Yet, in comparison to the urban and peasant population, mainly the indigenous population ignores that trees are the main carbon sinks ($p<0.001$).

Furthermore, there is a statistically significant difference ($p>0.001$) with regard to the degree of knowledge related to the fact that trees emit greenhouse gases and cause global warming. The indigenous population in particular lacks information about this issue.

There is however no statistically significant difference ($p>0.001$) between the analyzed groups concerning their willingness to collaborate in the mitigation of climate change. The majority of the population indicated their willingness to undertake actions in this respect.

Finally, fig. XII demonstrates that there is no statistically significant difference ($p>0.001$) between the different groups with regard to their necessities related to participation in forest conservation projects. Overall, the general needs that were identified relate to capacity building, tools and economic resources.

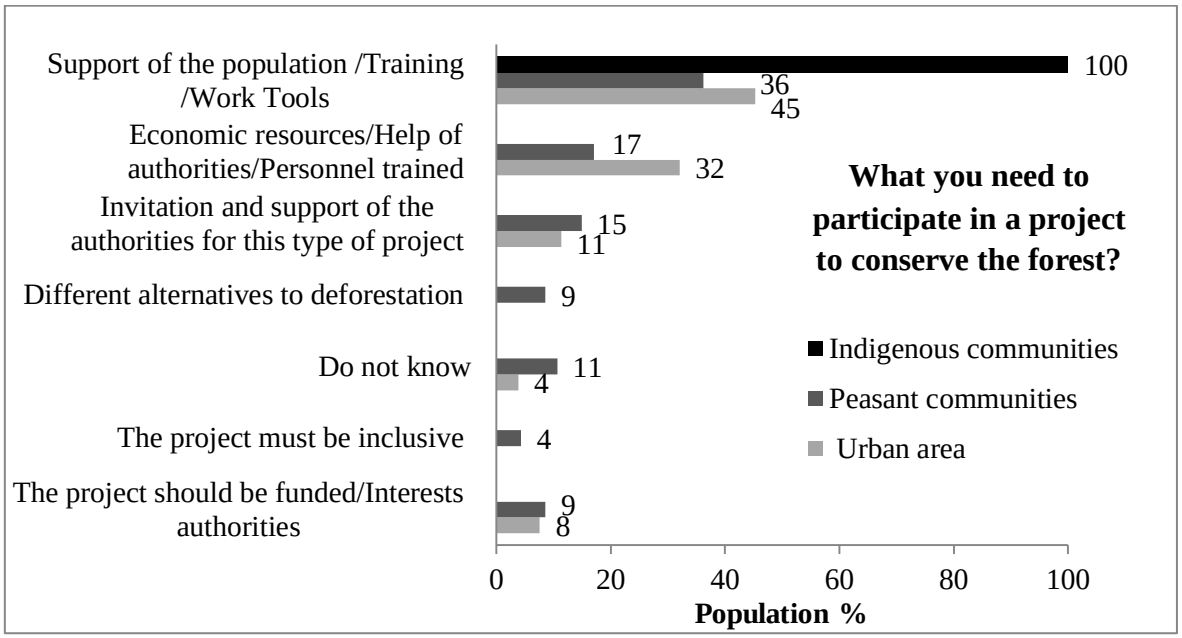

Fig XII. Necessities related to the participation in forest conservation projects according to the population in Riberalta (p>0.001)

5. CONCLUSION AND RECOMMENDATION: It can be concluded that the mapping of changes in land cover for the period of study (1986-2011) using techniques of Remote Sensing and Geographic Informatics System were adequate for the evaluation and the analysis of the changes that have occurred in Riberalta, and also to identify potential areas for CDM and REDD projects.

We estimate an area of 57.13 km^2 with potential for CDM "reforestation" projects according to the Kyoto Protocol. Furthermore, until 2011 a total of 415.28 km^2 was quantified as suitable for reforestation activities, regardless of the Kyoto Protocol.

In 2011 a total of 7,200.81 km^2 of forest areas was calculated to have potential for the implementation of Reduction of Emissions from Deforestation and Forest Degradation projects in the municipality of Riberalta.

We consider that there are potential areas for the implementation of CDM and REDD projects within the municipality of Riberalta, and therefore these area represent a valuable opportunity to establish a framework of payments for environmental services and the recovery of degraded covers and forests conservation through incentives. Nonetheless, there is almost a complete lack of information of the urban, peasant and indigenous population regarding forestation and reforestation projects, CDM and REDD in the municipality. It is mainly the indigenous population which has the largest lack of knowledge regarding reforestation projects and their importance for the mitigation of climate change.

The local population of the municipality perceives timber products and non-timber forest products as the main economic benefits related to the exploitation of the forest that is the main land use alternative. Also, the deforestation due to anthropogenic activities in the municipality of Riberalta generally amounts to between one or two hectares for the peasant and indigenous population.

Generally, the whole population agreed to receive economic resources for reforestation. However, 32% of the peasant population doubted about participating in reforestation activities. The urban and peasant population – in contrast to the indigenous population –indicate that they are sufficiently prepared or capacitated to realize reforestation activities, which should be carried out in deforested and fallow areas (secondary vegetation), and the species used should be preferably timber and nom-timber species. The plantings should be preserved for a minimum of ten years before they can be exploited.

The population of Riberalta considerably lacks knowledge with regard to Reduction of Emissions from Deforestation and Forest Degradation projects and the impacts of climate change. The indigenous population in particular has little knowledge about the issue, which may pose an obstacle to the implementation of forest projects unless communication is improved. Regardless of the lack of knowledge regarding to Reduction of Emissions from Deforestation and Forest Degradation, the population showed interested in participating actively in these projects. According to the population, yet, there is a need for a capacity development, tools and the generation of the economic resources like an alternative to try the successful implementation of forest projects. If these needs are not attended, it will be difficult to implement CDM and REDD projects.

We recommended making use of the information generated in this study to undertake the necessary steps for recover degraded areas, to conserve the forest. Also, the analysis of the perception of the local perception makes it possible to understand tendencies of the indigenous communities, as well as the peasant and the urban population of

Riberalta. It may also form the basis for the elaboration of strategies aimed at the implementation and development of communications as well as the development of CDM and REDD projects. Furthermore, it enables us to analyze the obstacles that might have to be overcome in the implementation and development of projects for the generation of environmental services. Also, this study must be helpful to improve other cases of studies about CDM or REDD projects around the world.

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