Technical Report

REDD+ PROJECT FUTURE DEFORESTATION AND UNDERLYING CAUSE DEFORESTATION IN BERBAK PEAT SWAMP FOREST

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EXECUTIVE SUMMARY

The integration of a *Reduction Emission from Deforestation and Degradation* (REDD) as a potential element in a future global climate change agreement . A principal undertaking and among critical element of a REDD regime is the setting up of historical deforestation rates and patterns or reference emission level, as well the mayor causes and underlying forces of such deforestation. The study observed the feasibility of the REDD+ project in Berbak Peat Swamp Forest, Jambi Province, Indonesia to enter national or international carbon markets and analysis of REDD project future deforestation and its underlying cause as important parameter and baseline on REDD+ design and implementation.

The study concluded that historical deforestation in the reference region experienced a -3.13% deforestation rate and the BCI REDD Area of Interest (AoI) a rate of -1.96%. This result is 1.65 times faster than the national average. Between 2005 and 2008, this rate had increased to -4.86%, or 2.43 times faster than the 2000-2005 national average. Throughout 1989 until 1999, the highest forest loss has occurred in Grand Forest Park with the deforestation rates ranged from -2,4 – -3,% per-year , -2,1 – -2,3 0% per-year in Berbak National Park, -1,4 – -1,8% per-year in Production Forest and 0,5 – -0,6% per-year in Protection Forest respectivelly. In total, from 1989 to 1999, the BCI REDD AoI knowledgeable an average annual forest loss ranged from -1,6 % to -2 % of forest cover annually over that period. Regarding future deforestation rates, the model generated an annual deforestation rate ranging from -1.96 to -4.52 in reference region with average, the rate was approximately -3.13% annually. The average annual deforestation rate of -2.90% deforestation rates was calculated, corresponding with approximately 29,608 ha per year over 30 years being lost. It is likely that this is an overall under estimate based on empirical knowledge from this region. In total, approximately 888,240 ha within the reference region are expected to be lost within the next 30 years. The BCI REDD AoI exhibited a predicted average deforestation rate of approximately -0.90% annually over 30 years. This is slightly lower deforestation rate than the reference region but still remarkably high given that 74% of the BCI area is zoned as one kind of a protected area or another. On 2018 and 2037 predictions, much of the production forest area has been lost by 2037, whereas Berbak National Park, Grand Forest Park Area and most of the Protected Forest area remain intact. In total, it was predicted that 40,863 ha of forest area will be lost between 2008 and 2037 in BCI REDD AoI. This prediction will contribute to climatic impact.

Planned and unplanned deforestation is a direct cause of deforestation and forest degradation in Jambi Province. It involves many agents of deforestation, i.e. local resident, immigrant resident, private sectors, central and local government.

1. INTRODUCTION

A key task of a *Reduction Emission from Deforestation and Degradation* (REDD) design and implementation is the determination of historical deforestation rates and patterns, as well the proximate causes and underlying forces of such deforestation. This baseline mapping is critical for the identification of future REDD project scenarios and strategy options to reduce and conserve forest carbon.

Among the most critical elements of a new global REDD regime is how to set national baselines or reference lines/levels for both overall effectiveness and international distribution and equity benefits. Reference levels have profound implications for the environmental effectiveness, cost efficiency, and distribution of REDD funds among countries. Almost all submissions by the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) , as well as the Bali Action Plan (COP 13), suggest that baselines should include historical national deforestation but many countries do not have reliable data on that. The reference period is typically set to the average deforestation rate of the last 10 years, and updated every 3 years.

The implications of reference period for countries with different deforestation histories is the benefits and feasibility of REDD will differ by country depending on its historical deforestation and current forest cover. Practically is impossible to reach consensus about the best form of establishing the national reference levels of deforestation, or baselines, upon which the emissions reductions expected under REDD activities would be calculated. Currently, there are two basic approaches being considered: I). Through historical deforestation rates considering the average of previous deforestation and projecting it to a future baseline scenario, ii) and through projections and modelling of simulated deforestation based on the analysis of presumptions and socioeconomic parameters that interfere with the dynamics of deforestation in the future, such as population growth, infrastructure construction, governance policies and others. The great challenge is how to harmonize different deforestation and forest conservation scenarios in various countries without generating perverse incentives, for example, if the devised mechanism only benefits countries with large historic rates of deforestation, the result could be the opposite, creating an incentive for those who deforested the most. Besides this, the adoption of a historical baseline for countries like in the Congo basin or Guiana, with large forest cover and a history of low rates of deforestation, could fail to reflect a possible scenario of pressure over their forests in the future. The fact that historical deforestation rates were low does not necessarily imply that these forests will continue to be preserved. Thus, it is fundamental to structure a mechanism which allows rewarding countries that have decreased their deforestation rates and those who have conserved their forests.

The purpose of the technical report to examines the eligibility of the REDD+ project in Berbak Peat Swamp Forest to enter national or international carbon markets and analysis of future deforestation as important parameter and baseline on REDD+ design and implementation. In addition, for calculating reduction in emissions for REDD implementation the following data is needed i). accurate deforestation and degradation calculation, ii) geographical location of deforestation and degradation and iii) the process used to convert the forest.

2. METHODOLOGY

This report draws on 2 types of data. The main data source is documentation on relevant aspects in Jambi Forest, with a literature review that encompasses a range of publications, grey literature and official documents, particularly results of research conducted by the Zoological Society of London and the Forest Carbon in Year 2010 – 2011.

In order to better understand why deforestation is occurring within the Berbak area, it is useful to first understand the REDD Area of Interest (AoI) within a larger analytical domain. For this reason, a reference region has been established to examine regional rates of deforestation in similar habitat types. From this, it is possible to identify if the AoI is in some way experiencing above or below average deforestation rates for comparable habitat types and geographic locations. The reference region acts as a reference data set so that the Berbak Carbon Initiative (BCI) is not considered in a bubble, but in the context of regional deforestation.

Taking a step back and looking at land-use patterns in similar habitat and regional areas, three forest types are considered to be under high-threat, lowland production forests, forest areas near human settlements and agricultural conversion areas. Agricultural conversion of forest areas has had a tremendous effect on the land-cover of Sumatra. The reference region *is used to compare regional trends and rates at a macro-scale* against patterns seen in the smaller BCI REDD AoI of approximately 238,000 hectares.

The project reference region (Figure 1) comprises approximately 3.85 million ha of similar habitat type along the coast of eastern Sumatra. The specific region was chosen due to the similarity of forest and peat content to the BCI REDD AoI. Selection of the reference region was undertaken to sample size large enough that it could reflect the regional behavior of land use and land use change. Both the reference region and the BCI REDD AoI were represented and delineated with GIS data layers[1] for coastal peat land and forest cover were overlaid and clipped.

The northern end of the reference region straddles the equator. Stretching north to just over 2°30’00”N, and south to approximately 1°45’00”S. East-west it runs from 100°20’00”E to 104°25’00”. It crosses two Sumatran provinces. From north to south, these are: Riau Province, and Jambi Province.

The BCI REDD AoI is located in the southern region of Sumatra, Indonesia, in Jambi Province. The AoI spans approximately 238,000 hectares of peat swamp forest stretching to the Sumatran coast, just north of the Javanese Sea. The BCI REDD AoI rests between 1°15’00”S and 1°43’00”S, and across from 103°55’00”E to 104°25’00”E. The location entirely within Jambi Province. The western boarder of the BCI is easily accessible by road to the provincial capital of Jambi, approximately 50 km away. The city of Jambi, with a population of nearly 400,000, serves as the administrative, commercial and population hub of this region.

[1] Indonesian Department of Forestry, 2007

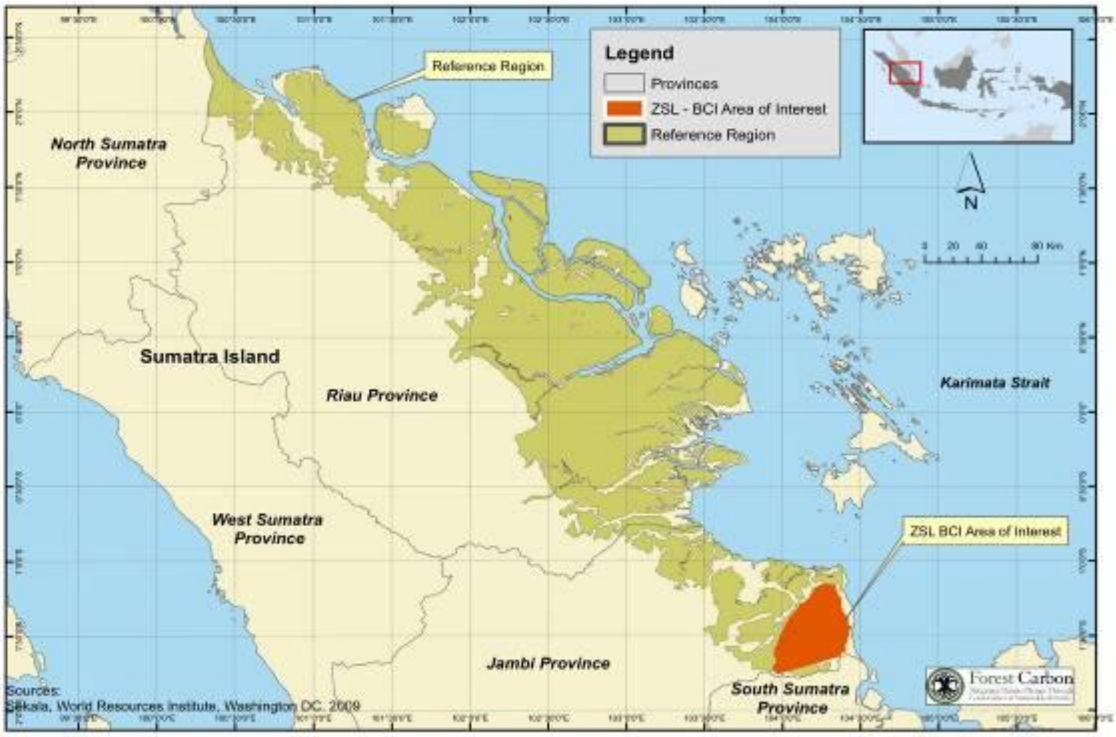


Figure 1: Geographic Location of Reference Region and BCI Area of Interest.

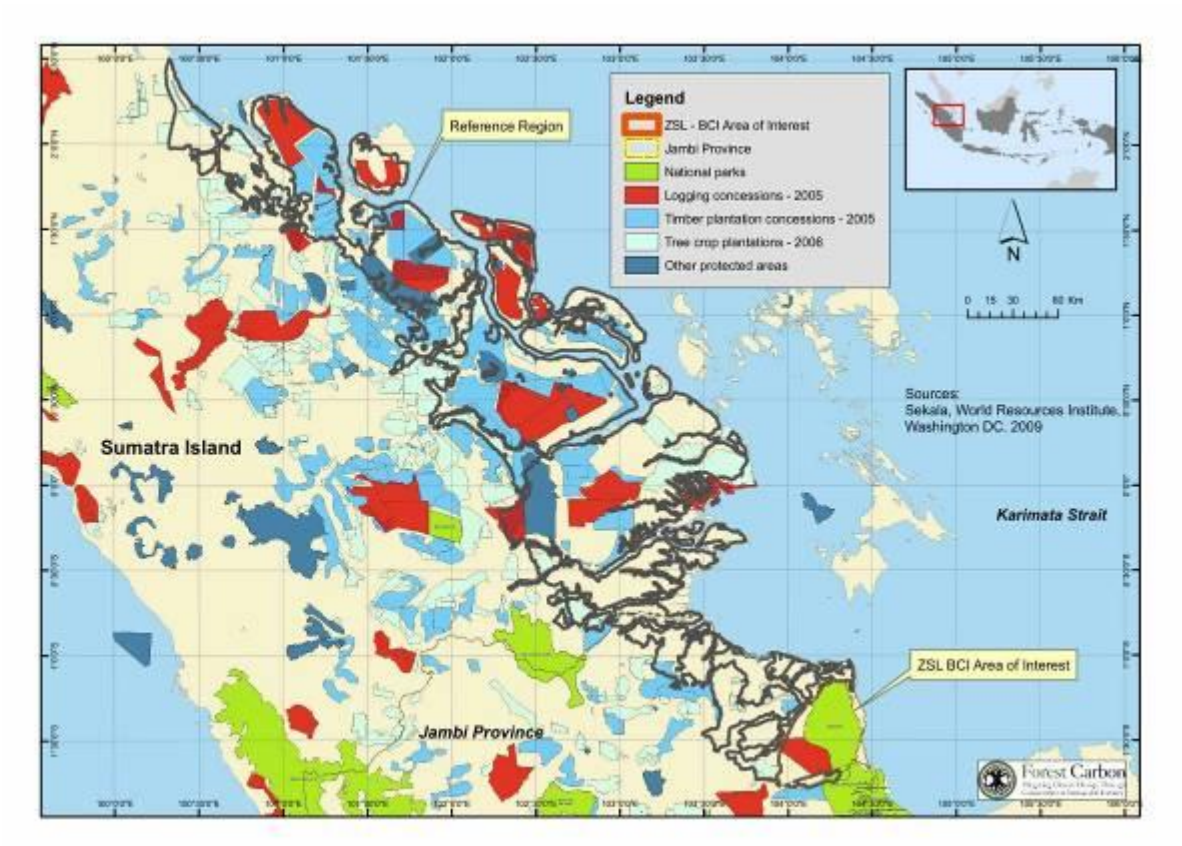


Figure 2: Land zoning components of reference region.

To calculate deforestation rates within the Berbak Peat Swamp Forest between 1989 and 1999, four main sections make up the methodology used within this research. Satellite imagery, image acquisition and pre---processing, change detection using Normalized Vegetation Index (NDMI), classification using a Gaussian Maximum Likelihood Classification algorithm (MLC), calculation of deforestation and land use change using post classification comparison and image differencing, accuracy assessment using field surveys, visual interpretation and high resolution imagery (SPOT) reference data and field Survey to obtain inside experience and insights into REDD AoI .

A geospatial computer simulation of future deforestation and degradation and its deforestation driver was designed using the latest versions of IDRISI[2]. Land Change Modeler (LSM) from Clark Laboratories at Clark University. This provides a basis for gauging the volume of carbon credits available from various carbon pools, but also gives insight into where project activities might best be focused. We have modeled deforestation on the project landscape and a reference region for a 30-year period ranging from 2008 to 2037.

Year 1990 and 2000 Landsat 5 imagery was obtained and classified by WCS/Conservation International. 2005 Landsat 7 data, 2008 ALOS and 2009 ALOS were classified by Forest Carbon. Classification was undertaken at a resolution of 28.5 meter. Although ALOS resolution is 50 m, the images were resized and treated at the higher resolution of 28.5m. Forest rasters grouped together all forest types into "forest" and "non-forest" were prepared in Arc GIS 9.3 with the Spatial Analyst extension. By setting the Spatial Analyst extension options to utilize the same extent and cell size as the mask layer, it was possible to ensure the same cell size and grid system for each layer (in the reference region this meant 100% accuracy across 32,000,000 cells). Rosters were then exported as ERDAS Imagine files, then imported into IDRISI Taiga, v.16.02. This approach was applied to both the project area or REDD AoI (238, 601 ha) and the reference region (3,840,000 ha).

3. RESULT AND DISCUSSION

3.1 Historical Deforestation Rates

Historical deforestation analysis concludes overall the reference region experienced a -3.13% deforestation rate and the BCI REDD AoI a rate of -1.96%. Deforestation rates are summarized in Table 1 below.

Table 1: Average historical deforestation in both the BCI REDD AoI and Reference Region

Historical Deforestation – Regional Summary					
Period	**Location**	**Forest Area Lost (ha)**	**% Deforestation over Period**	**Average Annual Loss (ha)**	**Average Annual Def. Rate**
1990 – 2008	**Reference Region**	1,288,469	45%	-71,582	-3.13%
1990 – 2009	**BCI REDD AoI**	64,867	28%	-6,427	-1.96

[2] IDRISI Taiga (v.16.1)

Approximately 1.3 million hectares, equivalent to 33% of the remaining forest were lost over this period. By comparing reference region deforestation (Figure 3) with land zoning in the reference region (Figure 2), reference region deforestation seems to have occurred in tree crop plantations, timber crop plantation concessions and to some extent in logging concessions. Deforestation was not limited only one region (e.g. coastal or in-land) but throughout the entire zone. The average historical annual deforestation rate across the period was -3.13%. However, this betrays a disturbing trend: from 2000 to 2005, the average annual deforestation rate was -3.37%. By comparison with the national average of 2.0% over this same period (FAO 2005), this is *1.65 times faster than the national average*. Between 2005 and 2008, this rate had increased to -4.86%, or *2.43 times* faster than the 2000-2005 national average. Indonesia Deforestation and Forest Degradation rate is quite high and estimated at 1.17 million hectares per-year in the period 2000- 2006.

Deforestation in both the reference region and BCI REDD AoI are summarized in Table 2 and 3 respectively below. The 4-year, 3-period mapping resulted in the following layers in Figure 1 and 2

Table 2 : Breakdown of Historical Deforestation Extent and Rates in Reference Region

Historical Deforestation – Reference Region							
Year	**Location**	**Forest Cover (ha)**	**Forest Area Lost (ha)**	**Deforestation over Period (-ha/forest)**	**Average Def. Rate (-ha/years)**	**Deforestation Rate over Period (-ha/ forest/years)**	**18-Year Average**
1990	**Reference Region**	2,839,403	-	-	-	-	**-3.13%**
2000	**Reference Region**	2,184,166	-655,236	-23.08%	-65,523	-2.31%	
2005	**Reference Region**	1,815,591	-368,575	-16.87%	-73,715	-3.37%	
2008	**Reference Region**	1,550,933	-264,657	-14.58%	-88,219	-4.86%	

Deforestation in Berbak National Park was particularly marked between 1990 and 2000. Even by skipping ahead and comparing deforestation over a similar period of time from 2000 to 2009, the period from 1990 to 2000 saw intense and widespread deforestation caused by forest fires throughout the Park. Some of the recent fire hotspots are visible from MODIS hotspot data, while the effects of other earlier fires can be seen from largely deforested areas in the middle of Berbak National Park and surrounding areas.

Interestingly, an area in the center of Berbak National Park where a large open area appears starting from 2000, human disturbance of that same area is visible in the 1990 map, even though no fire had yet taken place. It appears that temporary or semi-permanent human establishments inside the National Park have been around for quite some time and may have driven the small visible specks of localized deforestation.

Further deforestation around the margins of the areas opened by forest fires occurred from 2000 to 2005 and from 2005 to 2009. Whether this deforestation was driven by additional fires or illegal logging is not clear and requires further analysis and monitoring.

The period from 2000 to 2005 saw the beginning of an expansion of what appear to be either roads, canals or rail tracks into both the protected forest area and the PT Putra Duta Indah Wood (PIW) concession. The deforestation agent in the protected forest is unknown, although a likely cause is from logging canals, or light rail systems from the PT PIW concession for illegal logging and merits investigation.

In the following report of deforestation rates the Gaussian Maximum Likelihood Classification Algorithm technique (MLC) results are used due to their higher accuracy compare change detection using Normalized Vegetation Index (NDMI) technique. Figure 3 and 4 however; show the complete results for both classifiers of each region of the research area for easy comparison.

Forest Coverage	TN Berbak	THR	HL	HPT
	1989			
Area Size - No data	1348	162	187	620
Forest Cover Km2	1298.89	159.96	186.43	618.06
Forest %	96.33	98.74	99.84	99.6
	1999			
Area Size - No data	1343	159	173	602
Forest Cover Km2	1016	119	164	513
Forest %	75.65	74.84	94.8	85.22
Estimated Area Forest Loss km2	290.22	42.05	9.35	82.11
PA Forest loss % 18.1 PA Forest Estimated Area Loss 430Km2				
Forest Loss 89-99 % yr	2.11	2.4	0.5	1.4

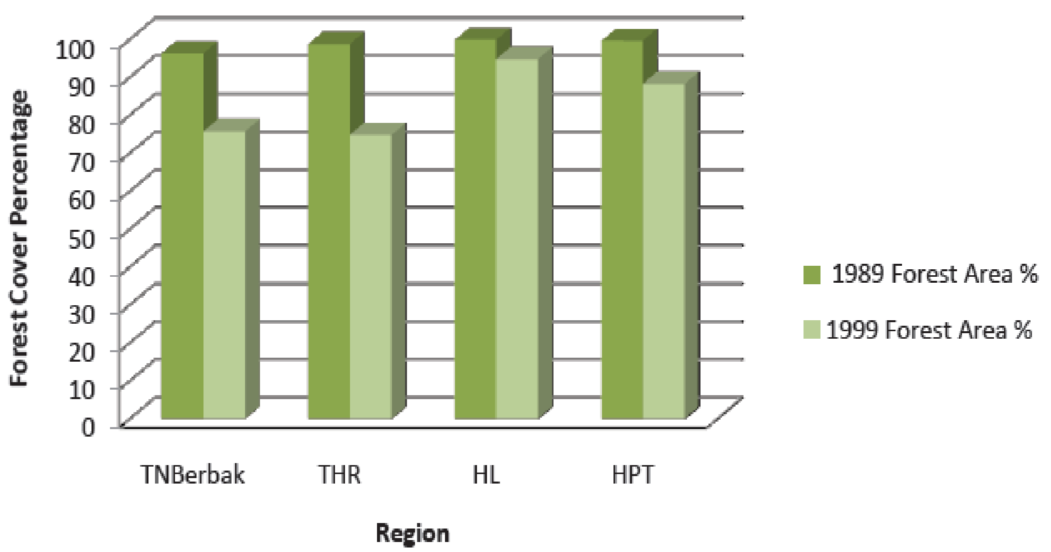


Figure 3. Gaussian Maximum Likelihood Classification Algorithm (MLC) technique deforestation result per- forest region. TN Berbak = National Park., THR = Grand Forest Park, HL = Protection Forest, HPT = Production Forest

Forest Coverage	TN Berbak	THR	HL	HPT
	1989			
Area Size - No data	1344.07	161.29	186.7	618.63
Forest Cover Km2	1293.16	151.57	186.61	616.95
Forest %	96.02	93.97	97.27	99.73
	1999			
Area Size - No data	1344	158.96	174.85	602.17
Forest Cover Km2	987.98	97.05	159.49	490.34
Forest %	73.51	61.05	91.22	81.43
Estimated Area Forest Loss km2	318.27	58.06	11.22	111.97

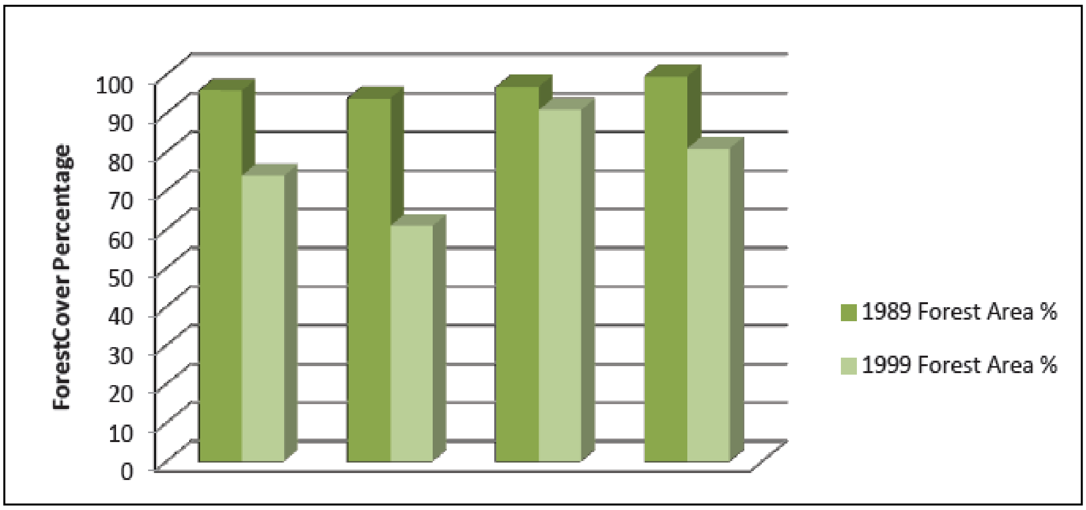
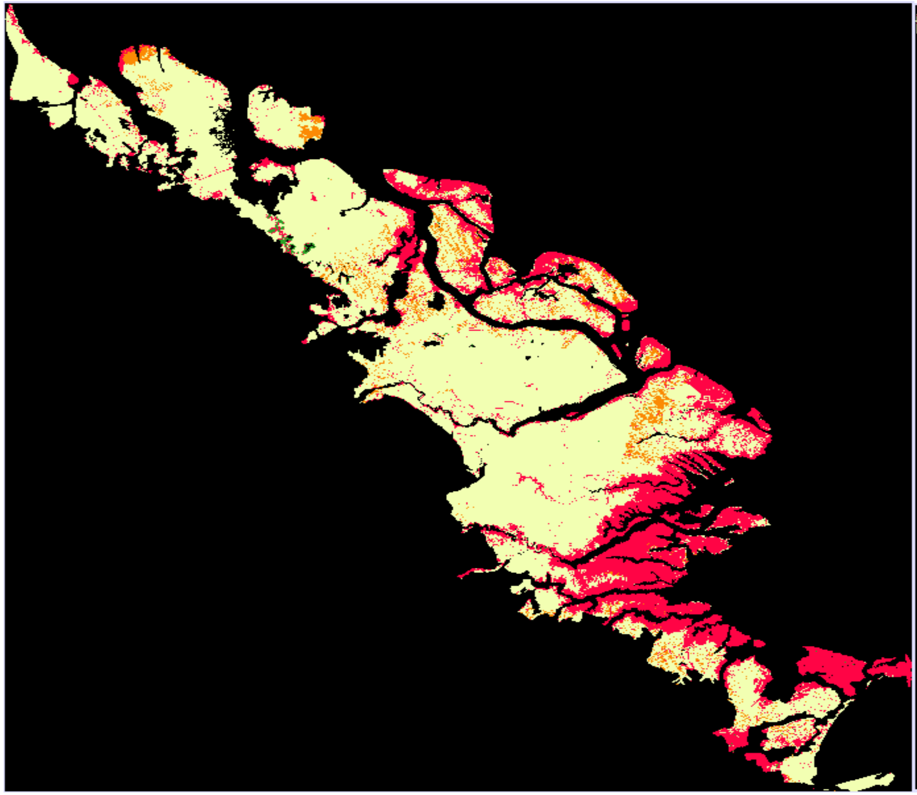


Figure 4. Normalized Vegetation Index (NDMI) technique deforestation result per-forest region. TN Berbak = National Park. THR = Grand Forest Park, HL = Protection Forest, HPT = Production Forest

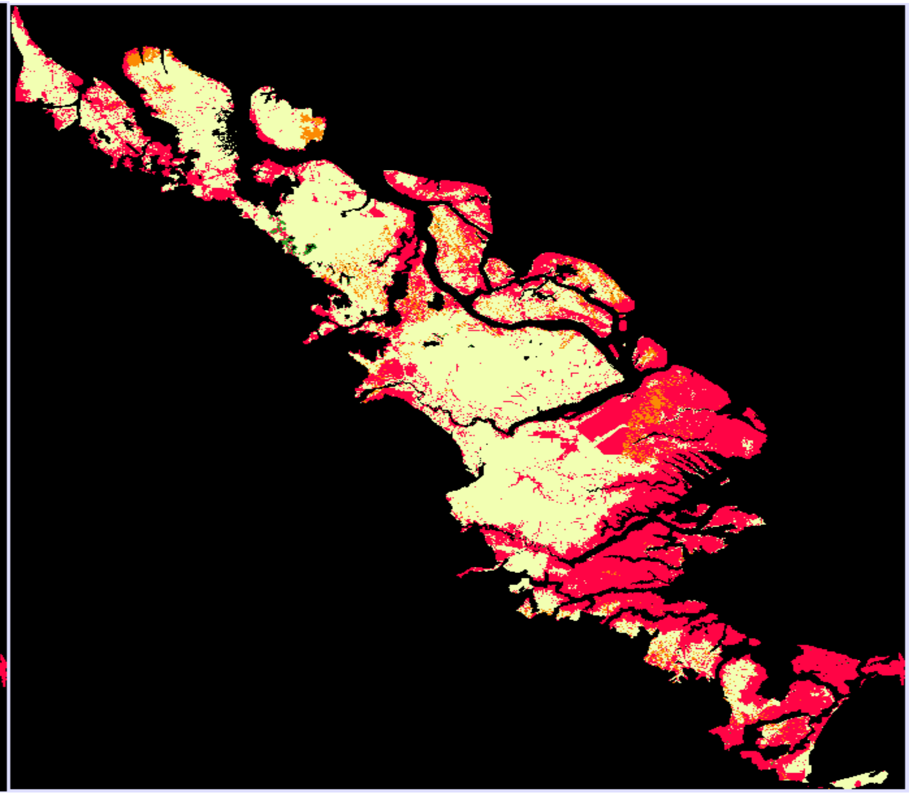
The extent of additional illegal deforestation in the protected forest from 2005 to 2009 is particularly concerning. It is expected that these access points will continue to be sources of further deforestation in the future and road/canal/rail access will expand further into the concessions, opening up the forest area for legal timber extraction and illegal deforestation.

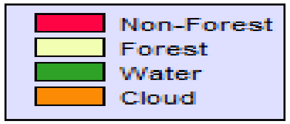
The deforestation in the PT PIW concession is concentrated in two principle areas. First, the region in the northwest margin of the concession; this area was lost due to a forest fire just prior to 2000. Second, deforestation associated with the construction of roads, canals and/or light rail systems for transporting timber. The extent of associated deforestation extending out from these roads is cause for concern. From SPOT imagery it does not appear that the associated forest areas have actually been totally converted, but rather logged with such intensity that they can effectively be classified as non-forest by an unsupervised (automated) land-cover classification.

Reference Region Land Cover 1990 (WCS/CI)

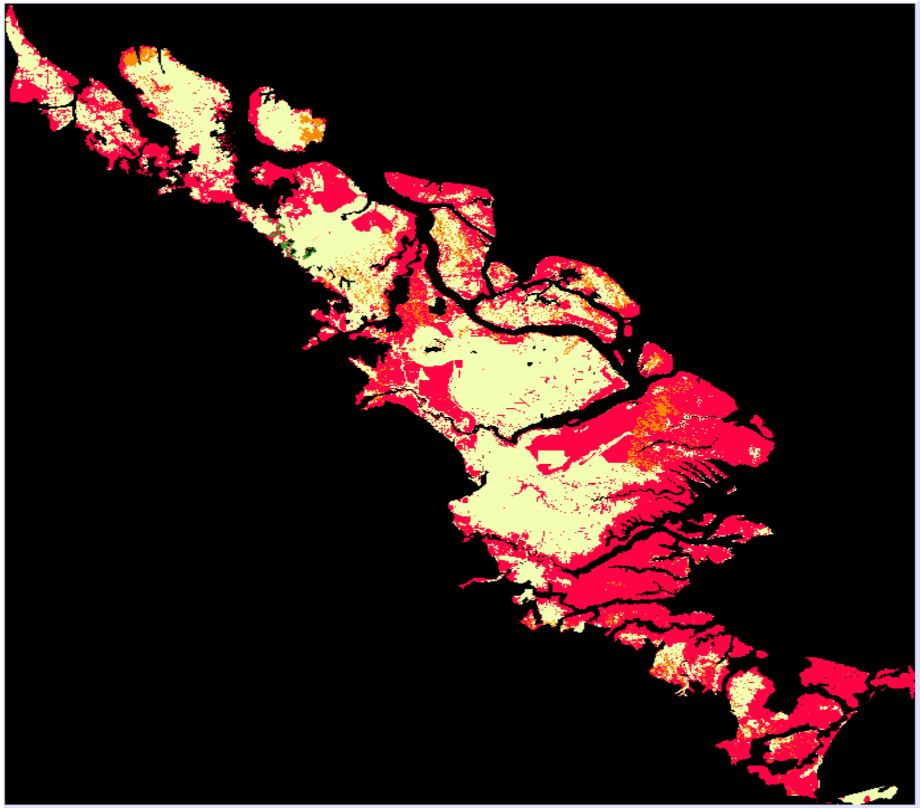


Reference Region Land Cover 2000 (WCS/CI)





Reference Region Land Cover 2005 (ZSL – Forest Carbon 2010)



Reference Region Land Cover 2008 (ZSL – Forest Carbon 2010)

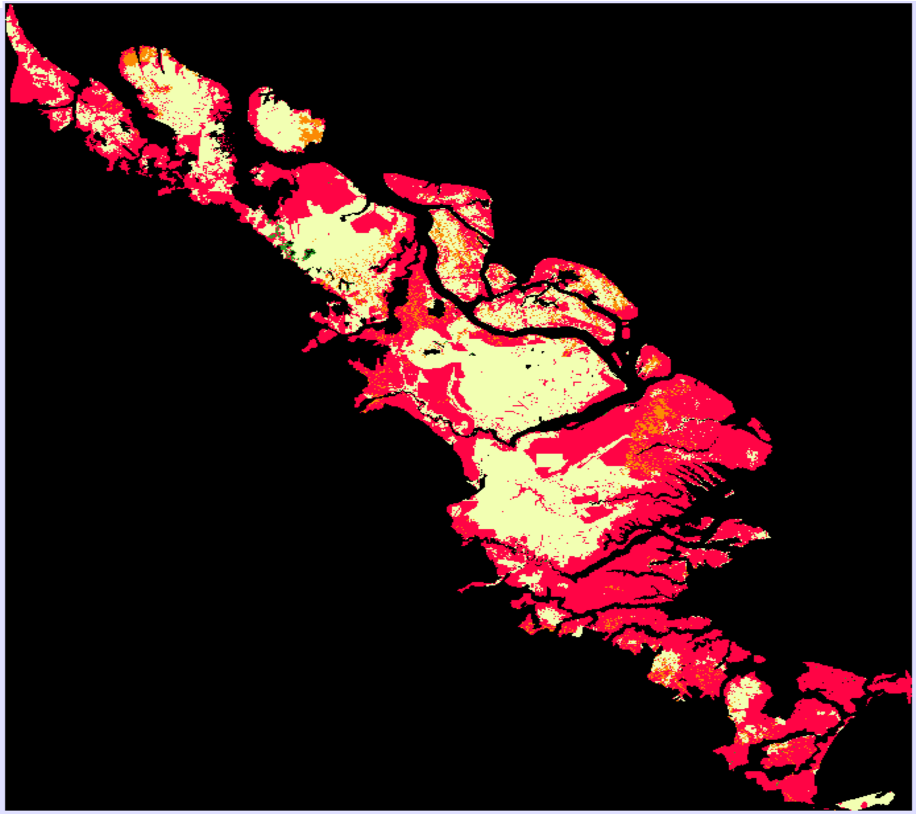


Figure 3: Land Cover maps showing known forest / non-forest areas within the reference region.

Throughout 1989 until 1999, forest loss or deforestation rates ranged from -2,1 – -2,3 0% per-year in Berbak National Park, -2,4 – -3,% per-year in Grand Forest Park,- 0,5 – -0,6% per-year in Protection Forest and -1,4 – -1,8% per-year in Production Forest. In total, from 1989 to 1999, the BCI REDD AoI knowledgeable an average annual forest loss ranged from -1,6 % to -2 % of forest cover annually over that period. See Table 2 and 3

Between 2005 and 2009 deforestation ranged from 0% in Berbak National Park up to -3.61% annually in the PT Persona Belantara Persada (PBP) logging concession and -4.31% in the Grand Forest Park. In total, from 1990 to 2009, the BCI experienced an average annual deforestation rate of -1.96%, ranging from -0.88% to -2.07% of forest cover annually over that period. From 1990 to 2000, forest fires in Berbak National Park and the surrounding areas caused immense damage. The Park, Grand Forest Park, and both PT PIW and PT PBP all lost over 20% of their forest cover (see Table 5). From 2000 to 2005, largely due to the drop in forest fires, deforestation dropped significantly and the BCI REDD AoI lost -0.88% forest cover as a whole. Compared with a -3.37% annual loss in the reference region, and -2.0% nationally, this rate, while not insignificant, it is far less than other similar habitats found in the region. From 2000 to 2009 however, the percentages climbed again as new legal and illegal conversion within the Protection Forest and Production Forests increased.

By the end of 2009, the BCI REDD AoI area's annual deforestation rate was around -1.29%. However due to relative area size of Berbak National park and the low deforestation rate there after the year 2000, the -1.29% deforestation rate masks much higher annual deforestation rates in the Grand Forest Park, Production forest and Protection Forest (in 2005-2009). On the whole however, the 19-year BCI REDD AoI average is approximately equal to the national average between 2000 and 2005.

3.2 Future Baseline Deforestation Scenario

The creation of a business as usual baseline carbon emissions from a project area must always consider both historical rates of deforestation *and* the likely future deforestation scenario based on known deforestation drivers at project start date (time n_0). In Section 3.1. historical deforestation was described. Here in this section, the process for ascertaining the *ex ante* future baseline deforestation scenario is described. *Ex ante* calculations of future emissions are a requirement of all carbon projects. Avoided Deforestation cannot reliably count on historical deforestation rates as a basis for future project emission quantification because 1) historical deforestation is not always an accurate indication of future deforestation and 2) the actual location of future deforestation must be known in order to tabulate the loss of specific carbon stocks from the site. The approach adopted herein addresses both of these issues. GEOMOD is another well-known tool for assessing *ex-ante* future deforestation. Land Change Modeler (LCM) to be a superior tool given that it is based on newer software and capable of more complex higher order regression analyses and control over zoning and dynamic variables. This approach is a fundamental step in the direction of acquiring the data required by voluntary carbon standards such as the Voluntary Carbon Standard (VSC).

Table 5. Historical Deforestation Extent and Rates in each BCI Forest Management Unit (FMU)[3]

Historical Deforestation in each BCI REDD AoI Each Forest Management Unit (FMU)							
Year	**Location**	**Forest Cover (ha)**	**Forest Area Lost (ha)**	**% Deforestation Over Period (-ha/forested area)**	**Average Annual Loss (ha)**	**Average Annual Def. Over Period (-ha/forested area/year)**	**FMU 18-Year Average**
1990	**National Park**	136,273.65	-	-	-	-	**-1.14%**
2000	**National Park**	106,750.91	-29,522.74	-21.66%	29,522.74	-2.17%	
2005	**National Park**	106,712.08	-38.82	-0.04%	38.82	-0.01%	
2009	**National Park**	106,712.08	0.00	0.00%	0.00	0.00%	
1990	**Protection Forest**	18,693.25	-	-	-	-	**-0.75%**
2000	**Protection Forest**	18,195.11	-498.14	-2.66%	498.14	-0.27%	
2005	**Protection Forest**	17,647.45	-547.65	-3.01%	547.65	-0.60%	
2009	**Protection Forest**	16,149.09	-1,498.35	-8.49%	1,498.35	-2.12%	
1990	**Grand Forest Park**	17,032.31	-	-	-	-	**-3.03%**
2000	**Grand Forest Park**	12,403.61	-4,628.70	-27.18%	4,628.70	-2.72%	
2005	**Grand Forest Park**	9,728.09	-2,675.51	-21.57%	2,675.51	-4.31%	
2009	**Grand Forest Park**	8,863.20	-864.88	-8.89%	864.88	-2.22%	
1990	**Total Prod. Forest**	61,937.38	-	-	-	-	**-2.43%**
2000	**Total Prod. Forest**	48,075.96	-13,861.41	-22.38%	-1,386.14	-2.24%	
2005	**Total Prod. Forest**	43,151.00	-4,924.96	-10.24%	-984.99	-2.05%	
2009	**Total Prod. Forest**	37,344.38	-5,806.62	-13.46%	-1,451.66	-3.36%	

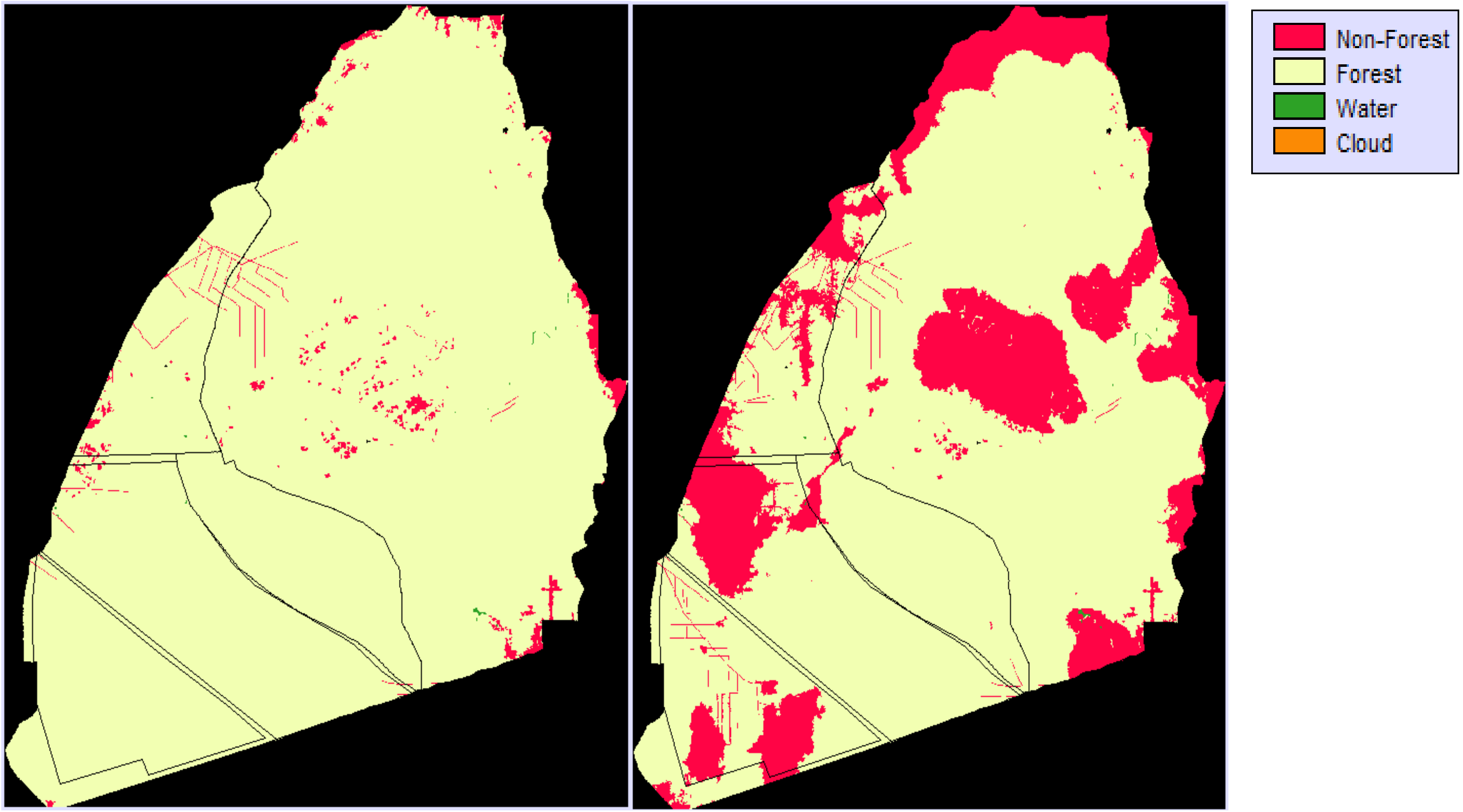
[3] Areas do not include water bodies

Historical Deforestation in each BCI REDD AoI Each Forest Management Unit (FMU)							
Year	**Location**	**Forest Cover (ha)**	**Forest Area Lost (ha)**	**% Deforestation Over Period (-ha/forested area)**	**Average Annual Loss (ha)**	**Average Annual Def. Over Period (-ha/forested area/year)**	**FMU 18-Year Average**
1990	**PT. PIW**	33,393.14	-	-	-	-	**-2.27%**
2000	**PT. PIW**	26,089.66	-7,303.48	-21.87%	7,303.48	-2.19%	
2005	**PT. PIW**	24,303.20	-1,786.45	-6.85%	1,786.45	-1.37%	
2009	**PT. PIW**	20,796.47	-3,506.73	-14.43%	3,506.73	-3.61%	
1990	**PT. PBP**	20,938.28	-	-	-	-	**-2.12%**
2000	**PT. PBP**	15,273.24	-5,665.03	-27.06%	5,665.03	-2.71%	
2005	**PT. PBP**	14,752.19	-521.05	-3.41%	521.05	-0.68%	
2009	**PT. PBP**	13,297.04	-1,455.14	-9.86%	1,455.14	-2.47%	

Table 6. Historical Deforestation Extent and Rates in the BCI REDD Area of Interest

Historical Deforestation BCI – Wide							
Year	**Location**	**Forest Cover (ha)**	**Area Lost (ha)**	**% Def. Over Period (-ha/forested area)**	**Average Annual Loss (ha)**	**Average Annual Def. Over Period (-ha/forested area/year)**	**BCI REDD AoI 18-Year Average**
1990	**BCI**	233,936.58					**-1.96%**
2000	**BCI**	185,425.58	-48,511.00	-21%	-4,851.10	-2.07%	
2005	**BCI**	177,238.63	-8,186.96	-4%	-1,637.39	-0.88%	
2009	**BCI**	169,068.76	-8,169.86	-5%	-2,042.47	-1.15%	

BCI REDD AoI Land Cover 1990 (WCS/CI) | **BCI REDD AoI Land Cover 2000 (WCS/CI)**



BCI AoI Land Cover 2009 (ZSL – Forest Carbon 2010)

BCI REDD AoI Land Cover 2009 (ZSL – Forest Carbon 2010)

Figure 3 and 4 Land Cover maps showing *actual* forest / non-forest areas within the BCI area of interest.

The following sub-sections explain the geospatial predictive modeling process for assessing future, *aboveground biomass change* over time. It makes use of IDRISI Taiga's Land Change Modeler (LSM) software developed by Clark Laboratories.

In order to understand where deforestation is likely to occur in the future, it is necessary to consider the location of existing deforestation and the associated variables leading to that deforestation. Once existing deforestation is understood, the next step is to take a look at the variables and their relative importance to driving deforestation.

In many circumstances, variables having to do with slope and elevation play a large role in the vulnerability or potential for deforestation, especially in respect to illegal logging or wide scale agricultural conversion. In the case of the BCI REDD AoI and the reference region, it is assumed that all slopes are under a grade of 8%. Elevation is nearly constant at just a few meters above sea level. Thus, these two variables were omitted given that they are constants across the project area and would not drive specific discriminating vulnerabilities.

Due to the large amount of data available for this study, eight variables were able to be included in the analysis for the BCI REDD AoI. Seven variables were available for the reference region. These seven to eight variables comprise the standard set of known deforestation drivers used for such analyses. Canals were excluded from the reference region analysis owing to a lack of reliable data covering the entire area.

Buffer ranges (Table) were assigned based on general empirical evidence from SPOT 2007 satellite data and rule of thumb standard buffer distances from observed affected distances seen elsewhere in Kalimantan and Sumatra. They are based on general assumptions about the potential threat of deforestation as a function of direct distance from the variable. Buffers shown below in (Table 7) are only indicated only for symbology purposes on the threat driver maps. The Buffer Ranges indicated do not play an analytical or modeling role in the LCM analysis and are listed only to indicate the buffers applied to each of the driver variables in Figure and Figure.

Logging plans do not currently factor directly into this analysis. This is for two reasons: first, detailed logging spatial plans for PT PBP do not yet exist. Logging plans for PT PIW were not obtainable at the time of writing. The annual work plan for 2009 was available but describes only 1 year of work, rather than all 30. Second, in theory logging operations relate to selective logging, not clear-cutting. Controlled selective logging results in degradation rather than deforestation. The LCM aspect of this desktop report focuses on modeling deforestation only and thus the plans are largely moot. Logging plans could come in to play to the extent that future scheduled road or other infrastructure development is mapped out. Such plans can be captured in dynamic variables. Emission (tCO_2e) from logging operations are captured in a separate spreadsheet analysis attached to this document.

The variables included in the analyses included:

Table 7: Variables included in simulation analysis of future land cover change.

Land Change Modeler – Deforestation Variables		
Variable	**Dynamic change**[4]	**Buffer Range (m)**
Distance to Disturbance occurring from 1990 – 2000	Yes	0 – 200
Distance to Roads	Yes	0 – 150
Distance to Rivers	No	0 – 100
Distance to Villages	No	0 – 150
Distance to Canals (*BCI REDD AoI only)	No	0 – 100
Distance from Fire Hotspots	No	0 – 400
Land Zoning	No	-
Land Change Evidence Likelihood[5]	No	-

Village data from all available sources was included in this analysis and included villages inside the project area and immediately outside of it. Villages greater than 150 meters outside the project area have no effective role in the threat mapping because the village buffer extents end at 150 meters. Village location data was collected from WRI data[6]. Points labeled "human settlements" or "*permukiman*" on logging concession maps from PT PBP and PT PIW were also included because although their permanence, existence or size could not be verified, the possibility of their existence could conservatively be ruled out. The extent of permanence of the WRI data and human settlements within the concessions should be verified on the ground at a future date.

Distance from Disturbance and Roads were given "dynamic" variable status. Dynamic variables are designated based on their ability to change over time. For example, disturbed areas may grow over time as fires and opportunistic illegal logging increase the size of the area. Likewise, roads are expected to expand further into concessions (and protection areas) over time. The Multi Layer Perception (MLP) neural network takes this into consideration when creating the transition sub-model. Other variables such as rivers are unlikely to change over time and are thus static.

By contrast with dynamic and static variables, land zoning maps are given specific land zoning weights given that they have inherent land use constraints or incentives that drive changes in forest cover depending on their zoning status. In other words, an assumption about the inherent risk affecting a forest is under based on zoning. For example: consider the

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[4] Indicates that the distribution of the variable is likely to change over time.
[5] The Evidence Likelihood variable is a quantification of the relative frequency with which different land cover categories (i.e. forest or non-forest) occur within the transition area from 1990 – 2000. In other words, it expresses the likelihood of transition at each pixel.
[6] Susan Minnemeyer, Lauriane Boisrobert, Fred Stolle, Y. I. Ketut Deddy Muliastra, Matthew Hansen, Belinda Arunarwati, Gitri Prawijiwuri, Judin Purwanto, and Rakhmat Awaliyan. 2009. Interactive Atlas of Indonesia's Forests (CD-ROM). World Resources Institute: Washington, DC.

differences in inherent risk between a National Park, and a Logging Concession; or a National Park that is surrounded by logging concessions, versus a National Park that is surrounded by Protection Areas. These constraints/incentive values act as multipliers for the other variables in the model. Values from 0 – 1 represent constraints. Values of 1 are unconstrained. This values greater than one represent incentives. See Table 8.

It should be noted that these constraint/incentive classifications are preliminary. They are relative values designed to elucidate the effects of certain land uses on the likelihood of deforestation. The category classes were assigned based on simple assumptions about the relative risk that the zones play in driving deforestation. For example, based on this classification Berbak National Park is 11 times less likely to be logged than a production forest and 13 times less likely than an agricultural conversion area. Although the classes are technically subjective, they are based on the model operator's professional knowledge from the field. It is meant to give the model operator control over the "reality" factor instead of treating all land classes equally, which is not a reasonable assumption. Without the classes, an agricultural conversion area has the same likelihood of being deforested as a National Park.

Table 8: Constraints and incentives scores for different land use zoning types.

Land Zoning Constraint & Incentive Class	
Zone – Reference Region	**Class**
National Park	0.1
Protection Forest	0.15
Production Forests (all types	1.1
Agricultural Conversion Areas	1.3
Zone – BCI REDD Area of Interest	**Class**
National Park	0.1
Protection Forest	0.2
Grand Forest Park	0.4
Limited Production Forest	1.3

Next Steps: Constrain and Incentive Classes

To err on the side of conservativeness, the current constraint classes are liberal (e.g. the hutan lindung /protection forest area) and the incentives are likely very conservative. The way that the classes are set now, it suggests that production forests create a slight incentive for deforestation. Other plausible scenarios for different classes could be proposed. Class values are depends entirely on the situation on the ground. Further field study, ground truthing and a careful analysis of production forest management plans in PT PBP and PT PIW are strongly recommended in order to refine these values in the future. Since current data is limited, we have chosen classes that give an overall conservative result. Initial raster data (with the exception of the Evidence Likelihood driver and Land Zoning) are buffered and given a range based on assumptions from empirical data and knowledge about the variable and region.

Known Threat Not Modeled

One well-known and historically relevant threat, forest fire, is not specifically captured by the LCM modeling process. This is especially true in Berbak National Park where fires do not follow a clear pattern. Several fires occurred through the 1990s, clearing large sections of the park, however in the last 10 years no forest has been lost to fire. Instead, the existing burned areas have been repeatedly burned. From interviews with local fisherman inside of Berbak National Park along the margins of the burned areas, fires in the area are believed to have most likely occurred as a result of deliberate land conversion for informal agricultural purposes. It is also possible that natural causes (lightning strikes) may have triggered some fires. While it is possible to model fires based off of historical deforestation in association with known driver variables, a lack of deforestation in the last 10 years would mean going outside of a strict reading of the ex-ante carbon emission prediction methodology under consideration. One option for approaching fire modeling would be to look at historic prevalence from MODIS hotspot data and draw correlations between frequency and extent of forest damage. Logistic regression has been applied in the past[7]. However, with respect to existing pre-VCS methodologies for carbon accounting, models are still emerging.

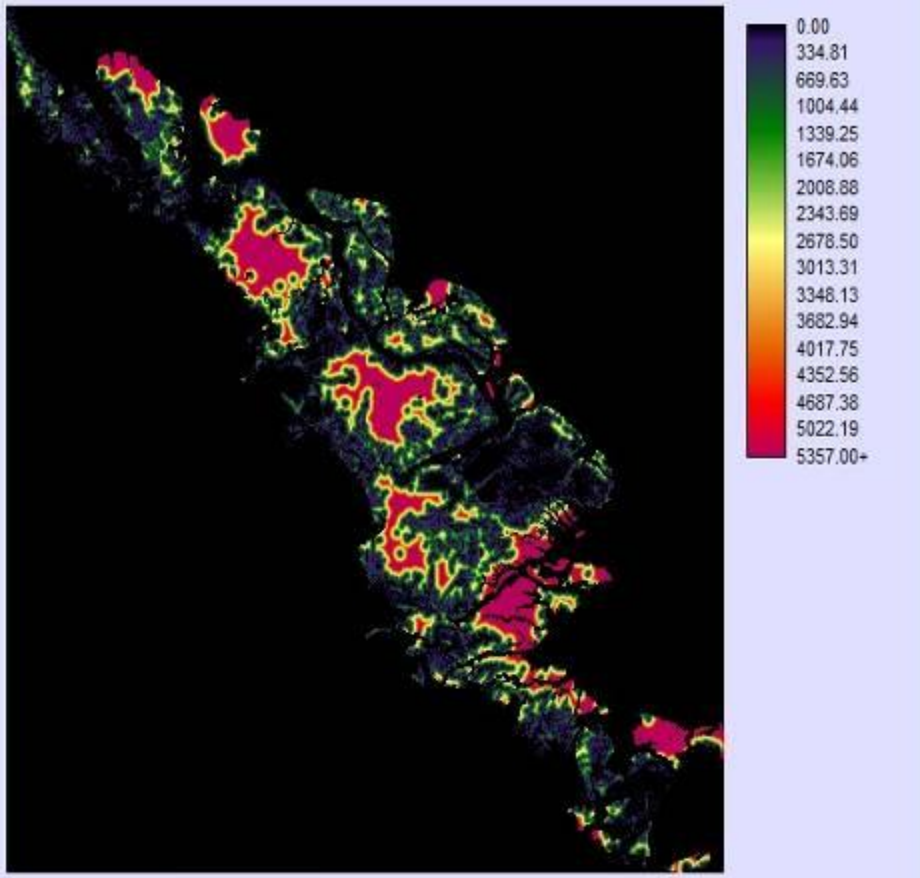
Transition Sub-Modeling - Multi-Layer Perception (MLP)

Once each driver layer is created, the complete suite of variable transition potential maps (Figure) can then be combined in LCM to produce a composite transition sub-model map (Figure). This composite map depicts the likely probability of each pixel (each 28.5 cubic meter unit of the project area and reference region) to transform from forest to non-forest. The transition sub-model can be derived by using either Logistic Regression or a Multi-Layer Perception (MLP) neural network. The model used for this project utilized MLP, due to the higher order regression and mathematical power of the predictive model.

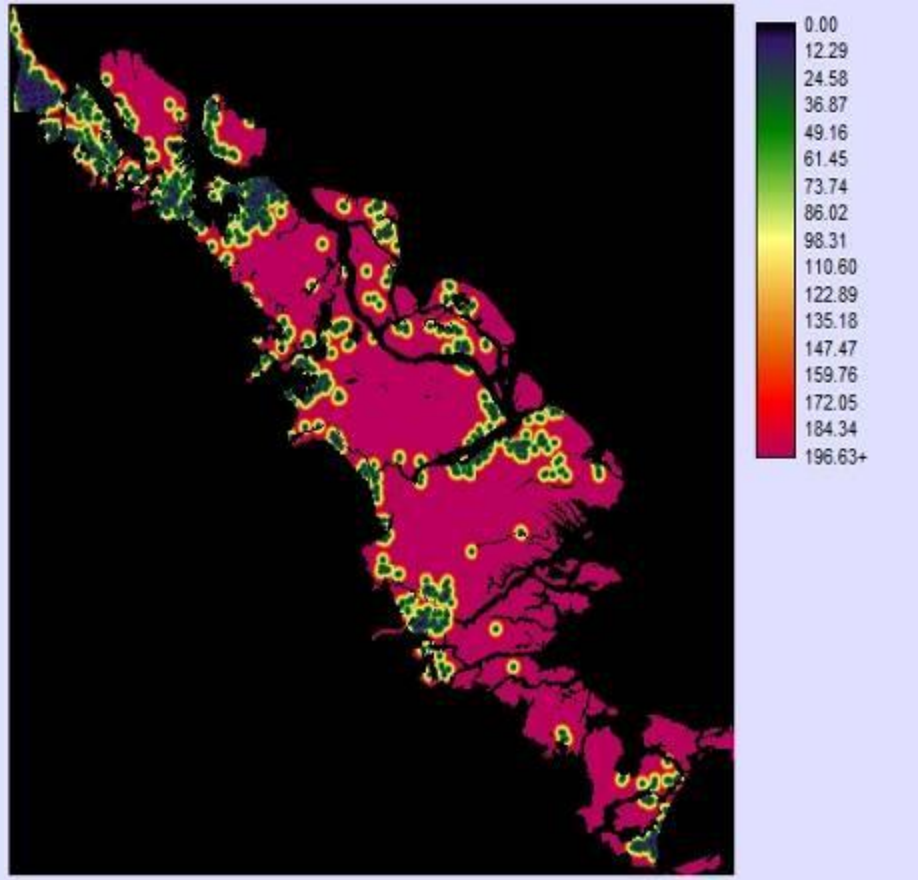
The transition sub-model was generated using the variables described in Table7 across the period from 2000 to 2005. The 2000 to 2005 period was chosen for several reasons. First, its positioning relative to existing deforestation data from WCS allowed for the inclusion that entire 1990-2000 deforestation data set to be included as a powerful driver. A date earlier than 2000 would have caused overlap with that dataset. Second, the amount of time given for the model to be established by the MLP analysis was similar to that described in the LCM manual. Third, using 2005 as the cut-off year allowed for a sufficient period of time afterwards for further deforestation to occur for which a future point could be used for the model validation process. Ideally, model validation is run for a date in the future over a period equal to that over which the model was developed. In other words, if the model was established using the 5-year period from 2000-2005 as the sample, the it is *ideal* to validate that model over the following 5-year period, i.e. from 2005-2010. This however is only an ideal, and is rarely feasible. In this case, sufficient 2010 data was not available and the available tests of model strength indicated impressively strong predictability score. Thus, the 2000-2005 modeling period was accepted for this study.

[7] Stolle, F., Chomitz, K.M., Lambin, E.F., and T.P. Tomich 2003. Land use and vegetation fires in Jambi Province, Sumatra, Indonesia. Forest Ecology and Management 179 (2003) 277-292

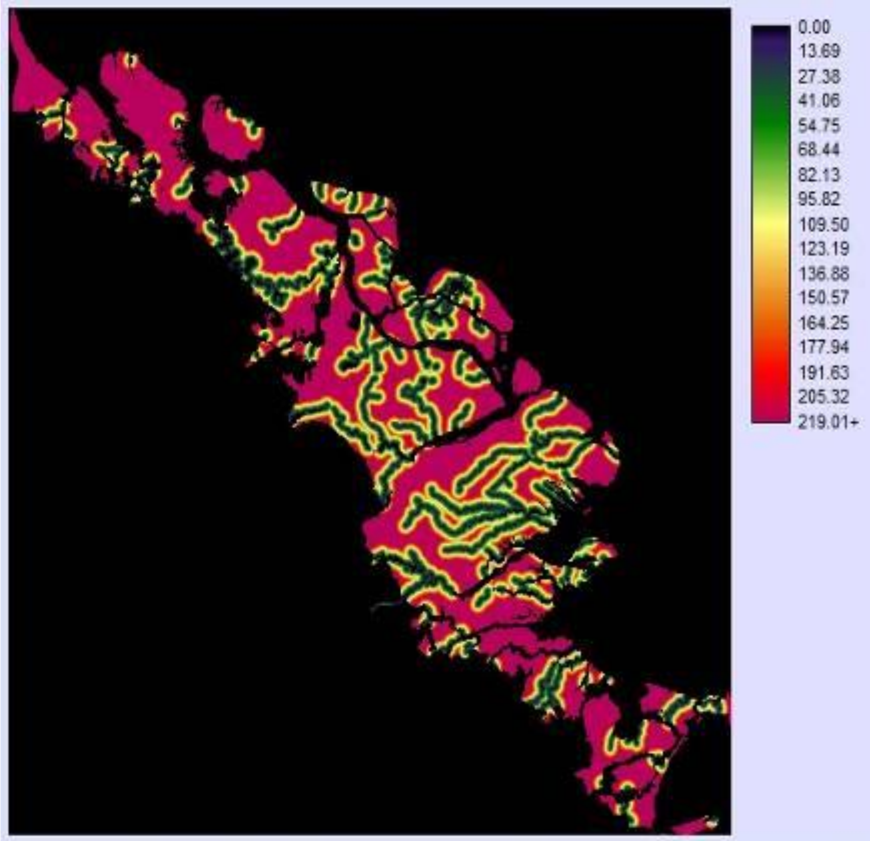
Distance from Disturbance



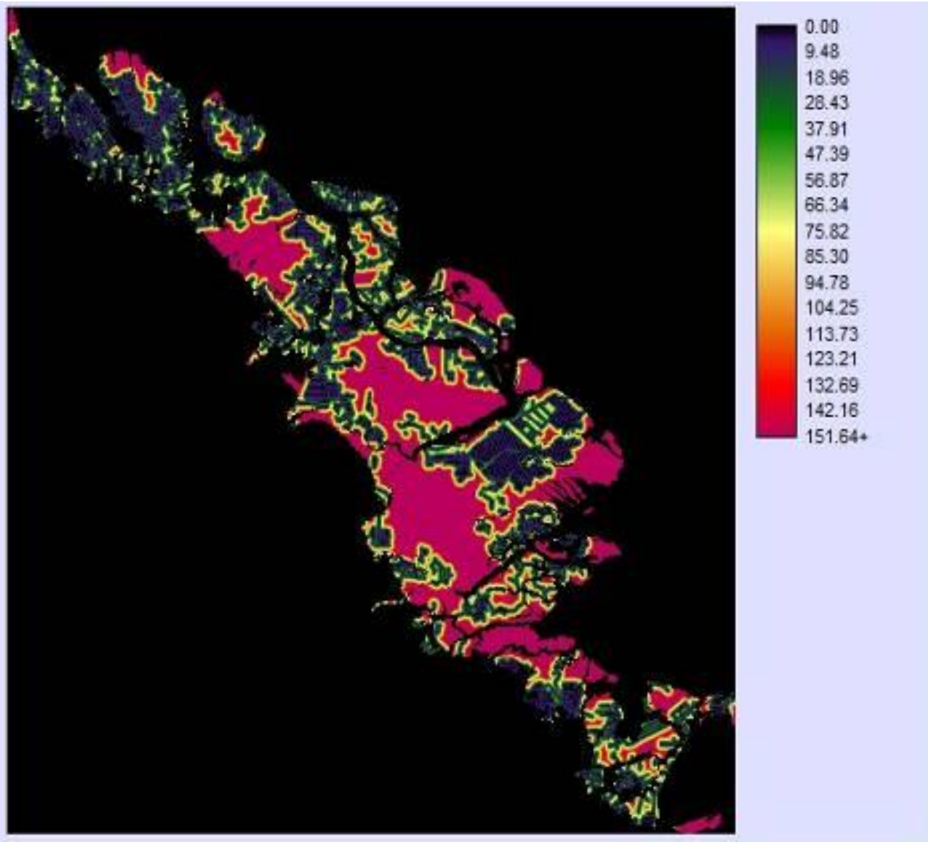
Distance from Fire Hotspots



Distance from Rivers



Distance from Roads



Distance from Villages **EVLIKELIHOOD**

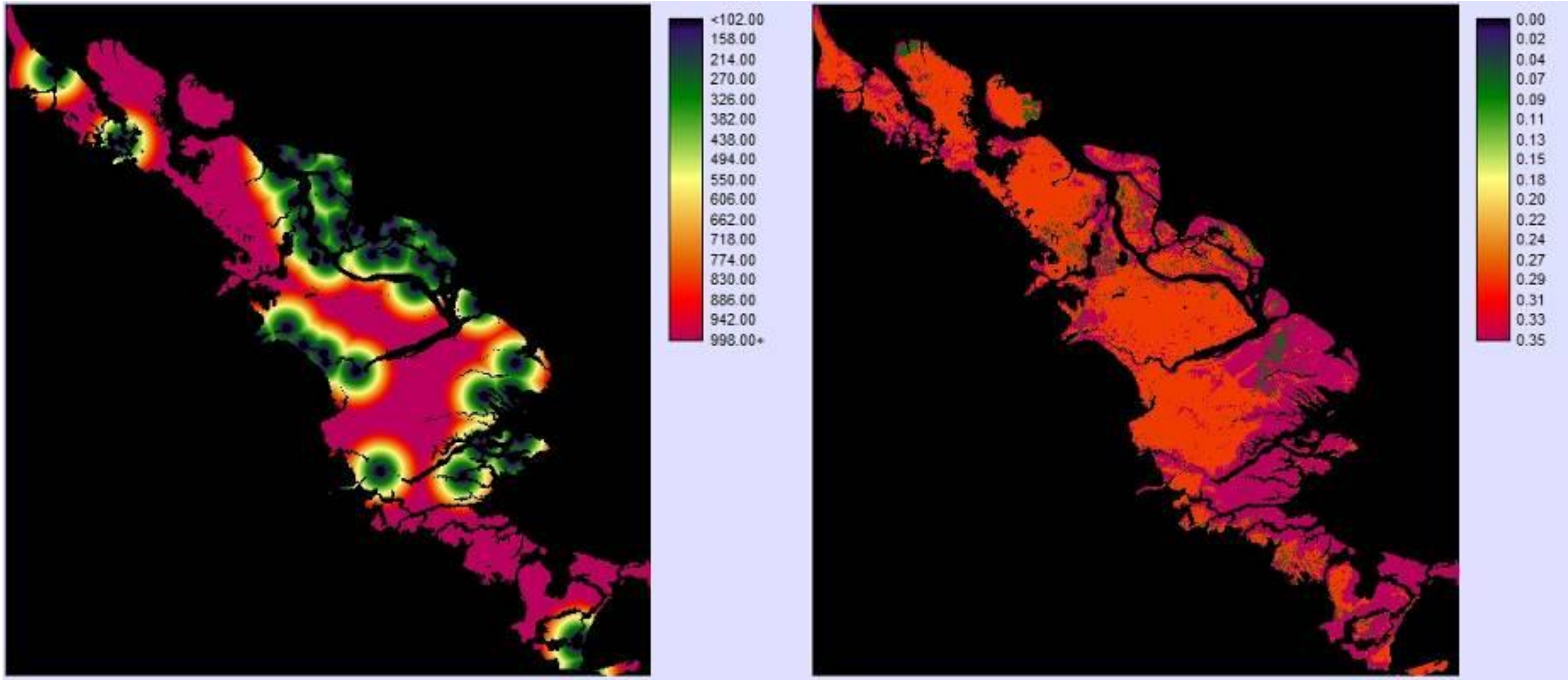


Figure 5 : Reference Region LCM MLP Driver Maps.
Vulnerability increases from high to low, moving from dark blue to pink. Legend indicates distance in meters.

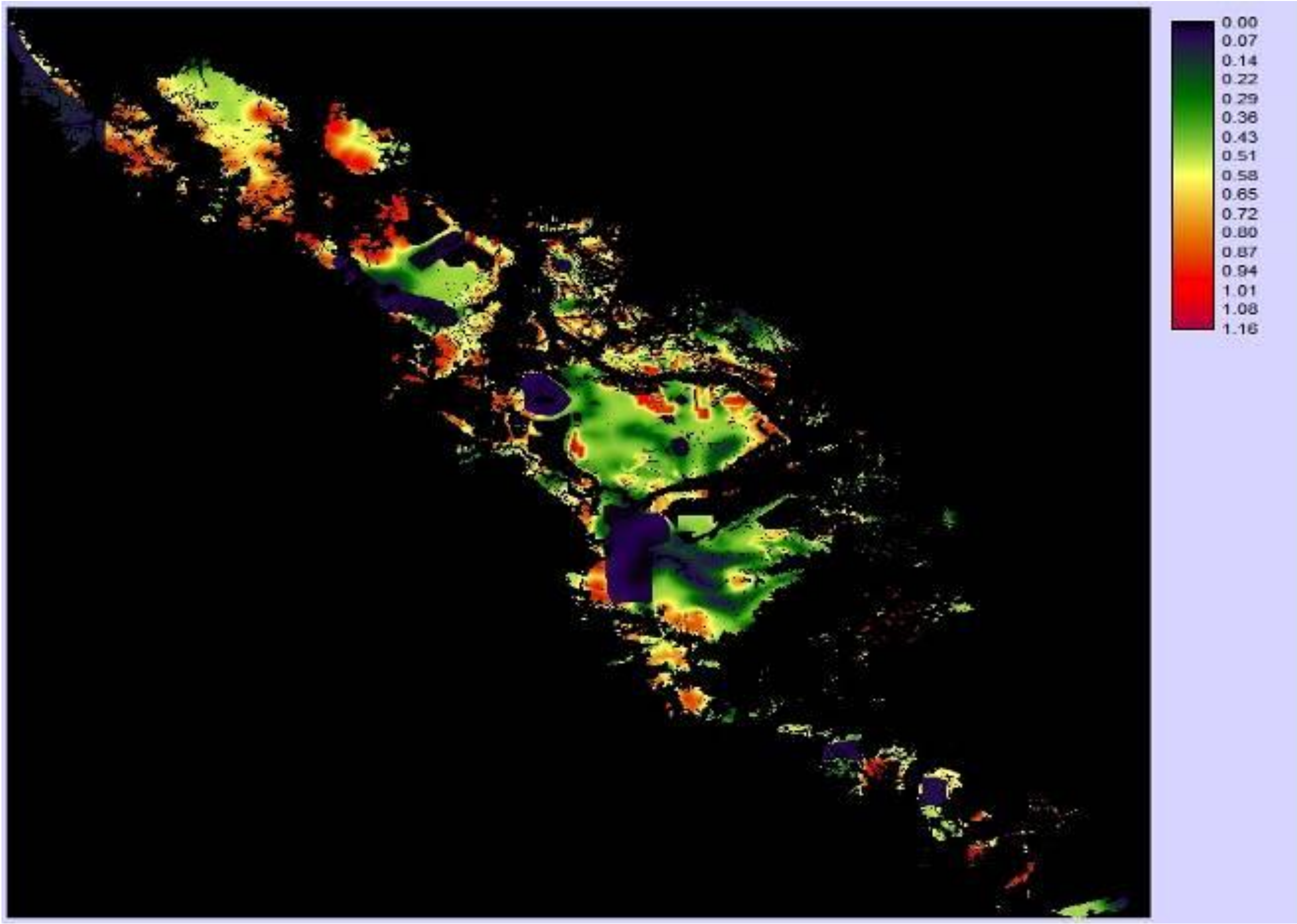
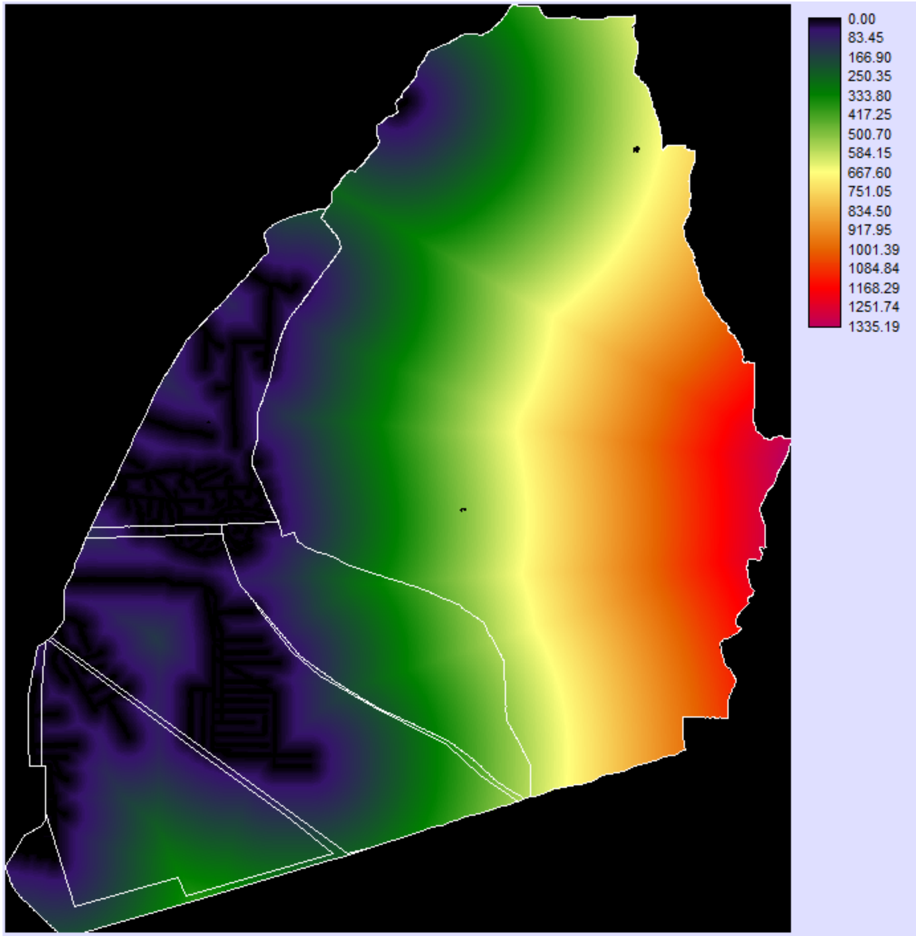


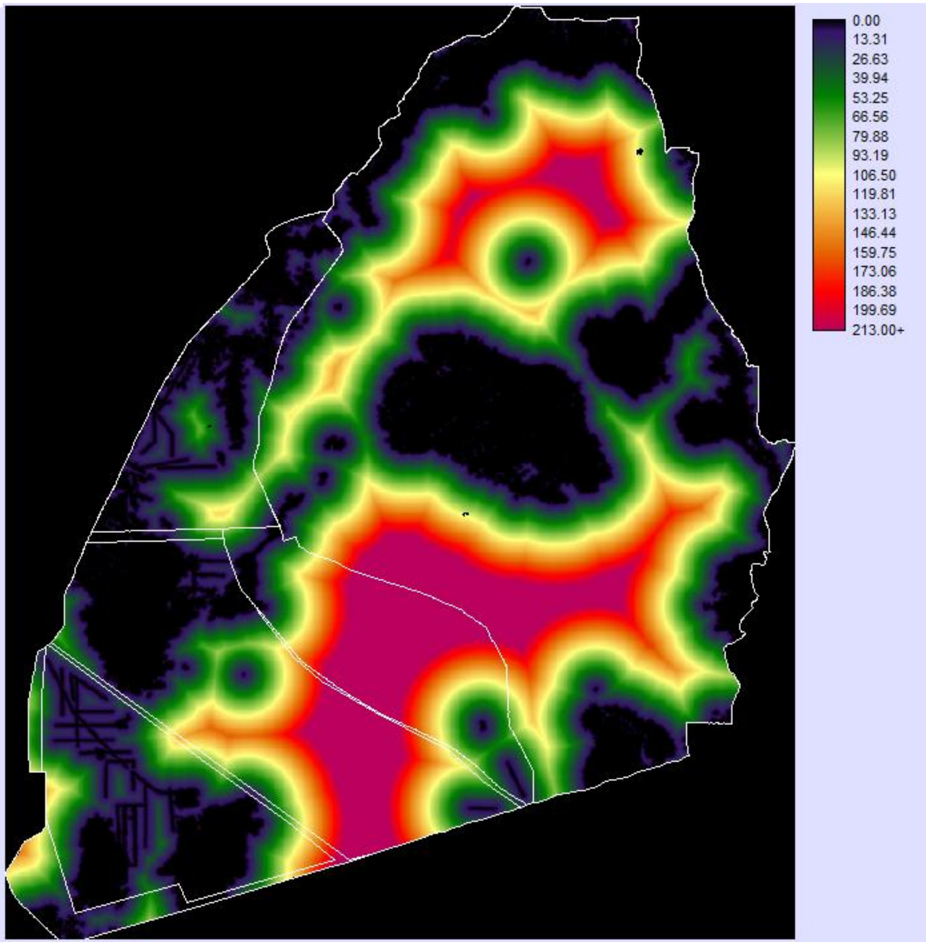
Figure 6 : Composite Transition Potential Driver Map.

Legend indicates probability of conversion.

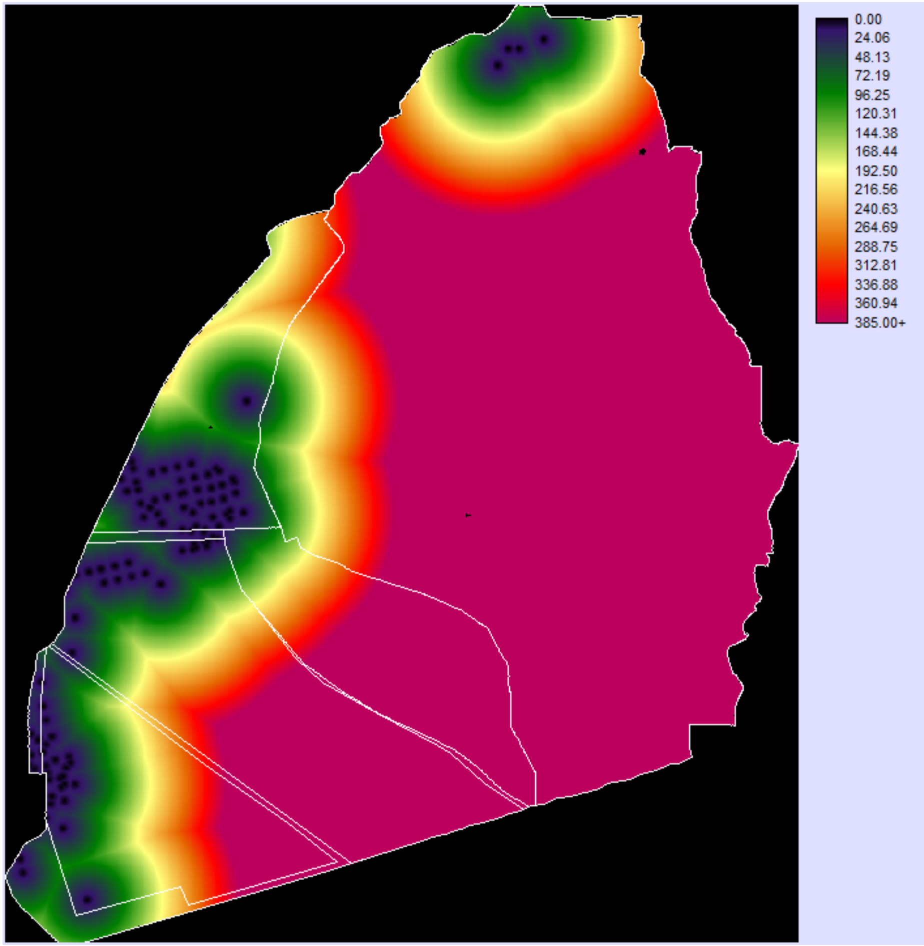
Distance from Canals



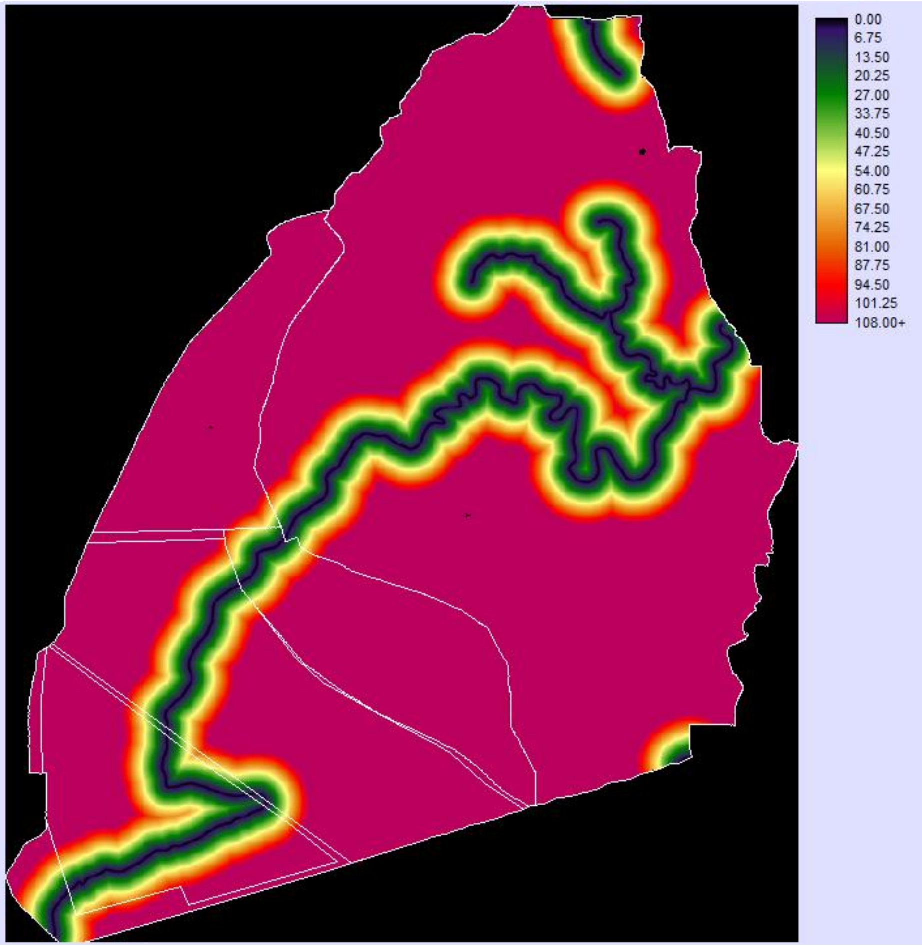
Distance from Disturbance



Distance from Fires



Distance from Rivers



Distance from Roads **Distance from Villages**

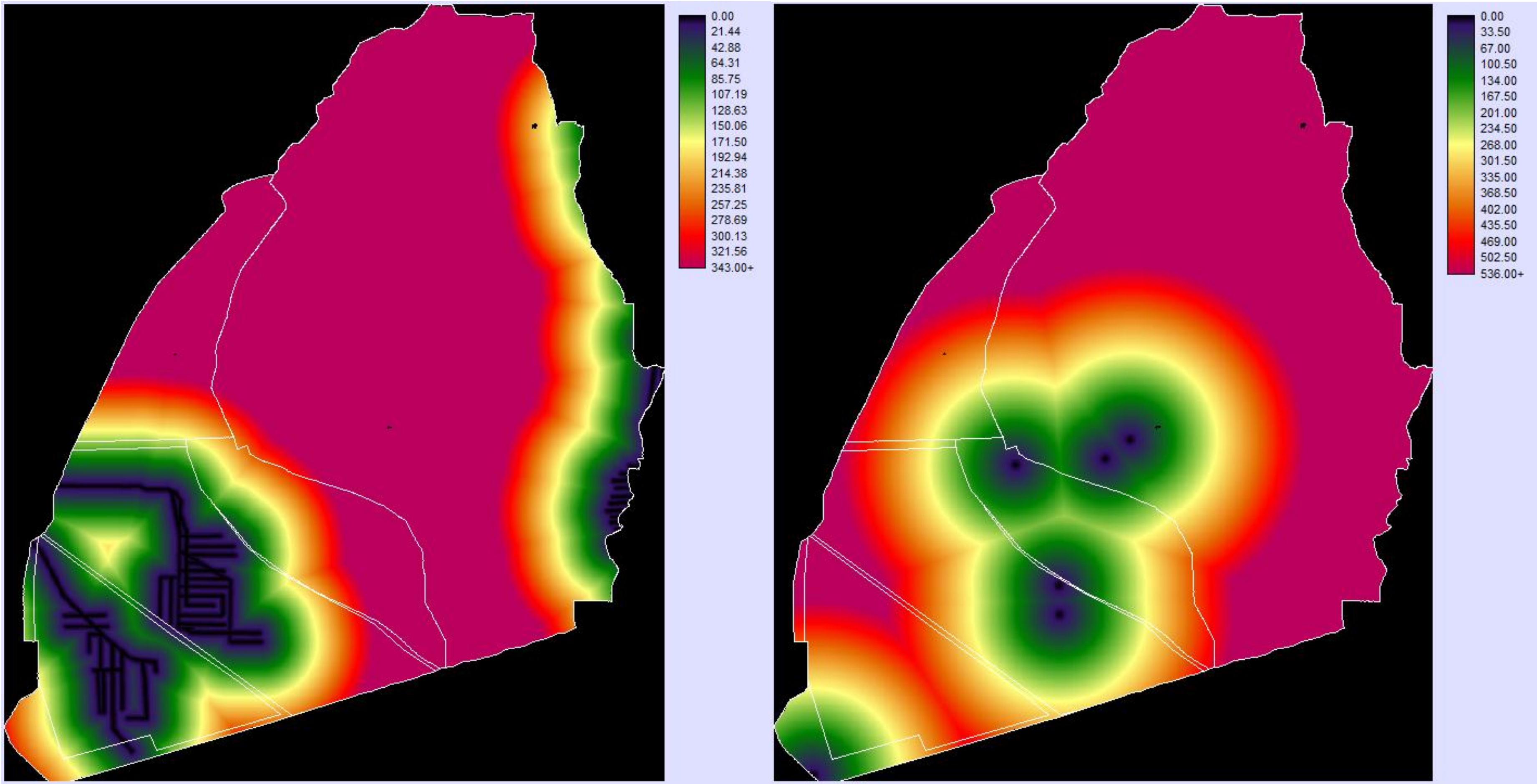


Figure 7 : BCI REDD Area of Interest LCM MLP Driver Maps.
Vulnerability increases from high to low, moving from dark blue to pink. Legend scale indicates units in meters.

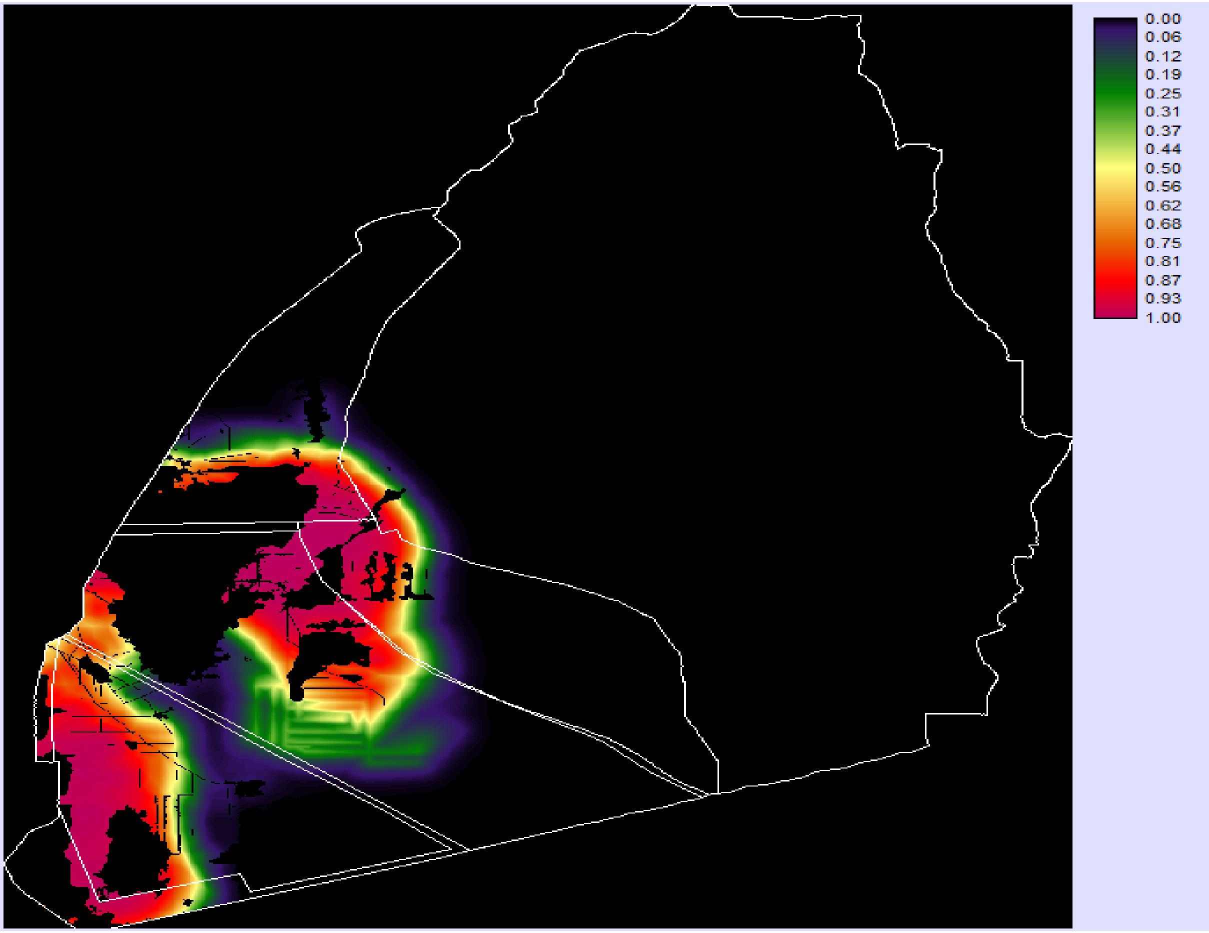


Figure 8 : BCI map of overall Driver Map (transition potential).
Higher potential infers a greater risk of a forest to non-forest transition. Areas in Black refer to either non-forest areas, or forest areas with no risk. Legend indicates units of probability.

Validation of Transition Sub-Model Results

The dataset selected for the reference region analysis was the 2000 – 2005 time period, and validated using a 2008 reference year. The project area used the same 2000 – 2005 period, and was validated using a 2009 reference year. Both the reference region and project area models returned extremely high overall kappa scores of approximately 0.90 to 0.89 respectively when their land cover *prediction* maps were cross tabulated for validation with the corresponding *actual* land cover maps from their respective validation years.

The vulnerability scores from this map (developed using deforestation data from 2000-2005) are validated by running the model for a future year for which known data is available (2009). The comparison is made by cross tabulating each *predicted* pixel with each pixel from the *actual* land cover map. The result is an overall kappa score. In the case of the BCI map, the kappa score was 0.90. This can be interpreted to mean that the model predicted deforestation in the validation period 90% better than by random chance alone. This is an excellent result and indicates that the model is strong enough for modeling future deforestation rates.

Predictions beyond a certain date will need to be re-verified in the future during each crediting phase that REDD Project wishes to redeem project credits. It should be noted that predictions beyond 10-years necessarily have a high specific error rate and should be taken as indicative, rather than highly reliable, given the complex and ever-changing nature of the forest situation on the ground. The transition-sub model should be revised and re-validated with the VCS every few years during monitoring periods.

Overall, the model performed extremely well. Some of the unpredicted deforestation that did occur was due to the expansion of logging rail, road and canal systems that, without future planning maps as a guide, would have been difficult or impossible to anticipate under any modeling system.

Baseline Deforestation in the Reference Region

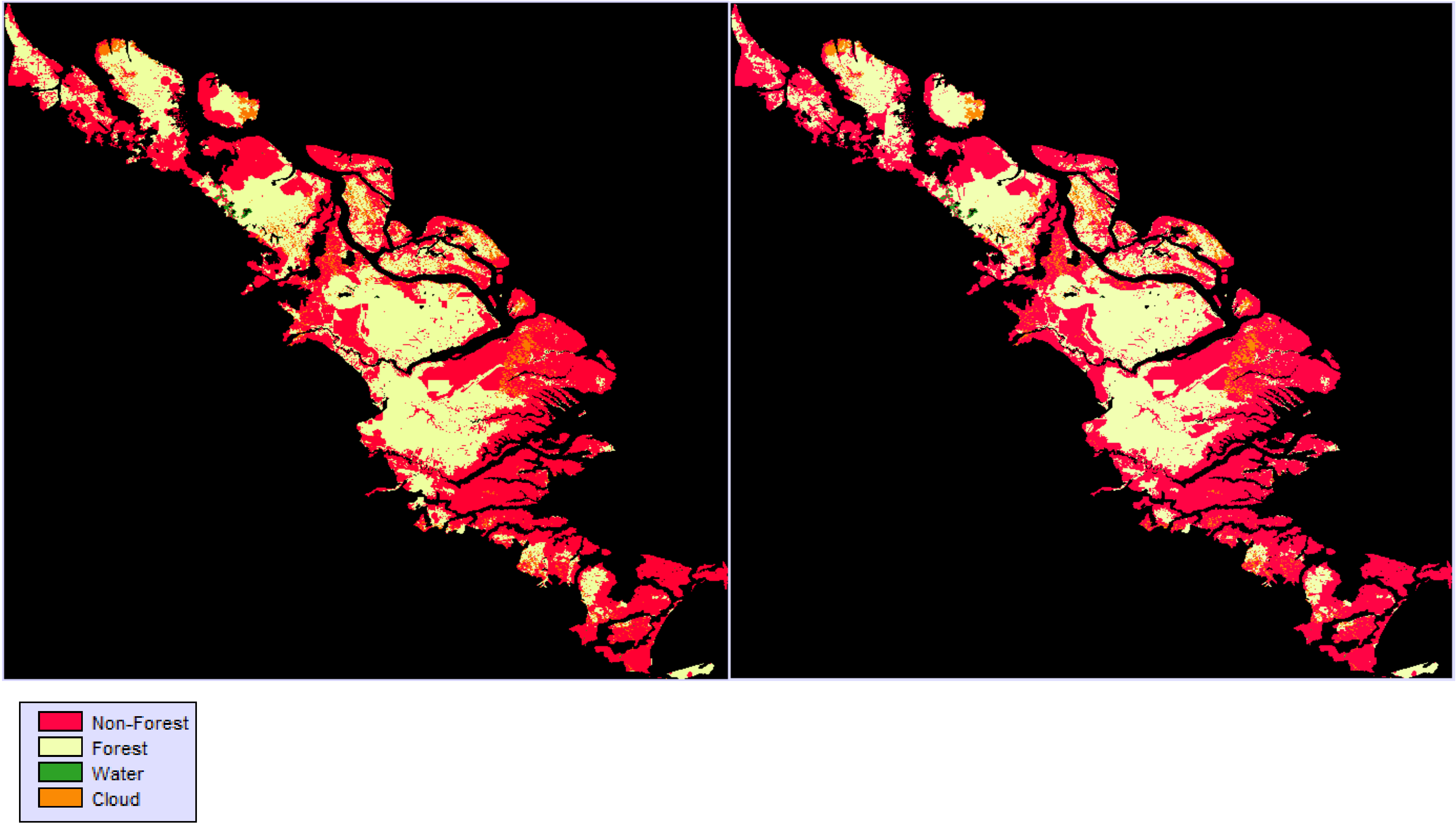
For the reference region, deforestation was simulated for years 2018 and 2037 individually. However, for the reference region, each prediction calculation took approximately 24 hours to complete. Computing power and time were not sufficient to model each year between 2009 and 2037. Thus, known deforestation data in 2009 was combined with 2018 and 2037 LCM predictions (Figure 10 : Land Change Moduler (LCM) simulation results of future forest loss in reference region in 2018 and 2037. A trend line was drawn with transitional points modeled based on the equation of the trend line (Figure). For the BCI REDD AoI, deforestation was simulated for every year between 2010 and 2037 (Table 9).

Regarding future deforestation rates, the model generated an annual deforestation rate ranging from -1.96 to -4.52. On average, the rate was approximately -3.13% annually. The range is accounted for by the deforestation rate having been generated from a trending line of best fit for three modeled control points. The trend line gave a linear deforestation rate over 30 years and thus, a constant area of deforestation year-on-year accounts for an increasingly higher relative percentage of remaining forest over time. By comparison, FAO 2005 data suggests an annual deforestation rate of 2.00%[8] from 2000-2005. This number is not representative of the deforestation of peat swamp forest throughout Indonesia. It is merely a representation of the deforestation anticipated to occur between 2010 and 2037 within the reference region itself, not all of Indonesia. One plausible explanation could be that the reference region overlaps with many hard to access and less desirable (due to the peat swamp conditions) conversion areas for palm oil plantations.

Modeling of future deforestation in the reference region was computationally labor intensive given the size and resolution of the data (28.5m resolution across 38.4 billion m^2). Each future prediction required a 24-hour long computation. Thus, computing 30 annual models would have taken over 1-month of non-stop calculation. To simply the process in estimating future deforestation rates for the reference region, a line of best fit (Figure) was calculated using forest cover tabulations at three sample points in time. The first was known forest cover in 2008. The second and third were derived from predicted forest cover tabulations in 2018 and 2037 land cover maps. The slope of the trend line fit to these three points represents the average deforestation rate across the entire 3.84 ha area over a 30-year period. The sample points show both overestimations and underestimations of the trending line of best fit for 2008, 2018 and 2037. 2018 appears to be a slight underestimate.

[8] FAO 2005. Global Forest Resources Assessment. p. 197

Reference Region Prediction – 2008 **Reference Region Actual – 2008**



Prediction Forest Cover – 2009

Actual Forest Cover – 2009

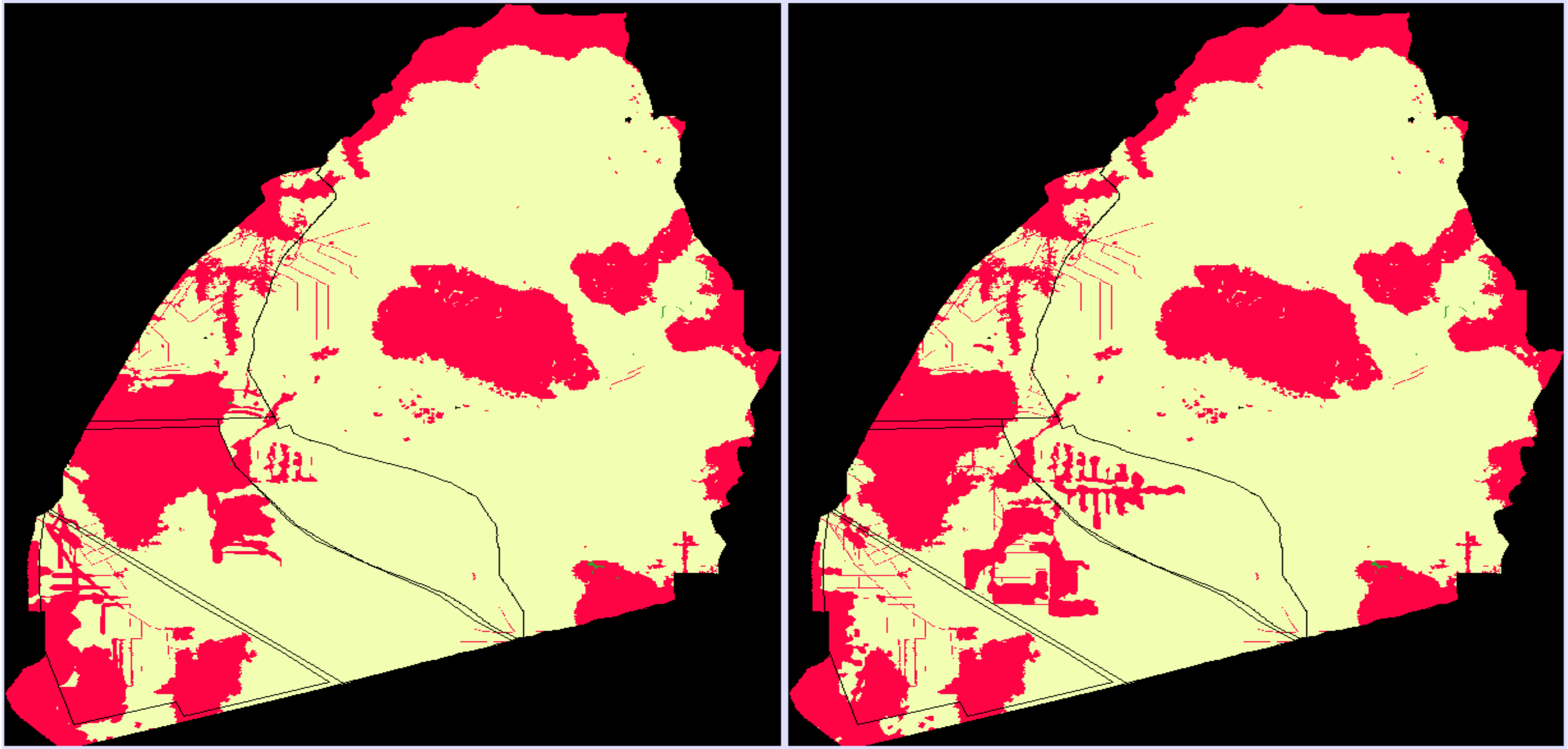


Figure 9: Comparison of *predicted* and actual deforestation.

from this trend, whereas 2008 and 2037 both appear to be overestimates (Figure). The line of best fit had an R^2 value of 0.969 with respect to the three control points. The average annual deforestation rate of -2.90% deforestation rates was calculated, corresponding with approximately 29,608 ha per year over 30 years being lost. It is likely that this is an overall under estimate based on empirical knowledge from this region. In total, approximately 888,240 ha within the reference region are expected to be lost within the next 30 years.

Baseline Deforestation in the BCI REDD AoI

Deforestation in the BCI REDD AoI was modeled for every year between 2010 and 2037. While deforestation in the reference region was projected based off of a line of best fit from three control points over the project lifetime, the BCI REDD AoI had simulations run for each of the 30 years of the project life. The BCI REDD AoI exhibited a predicted average deforestation rate of approximately -0.90% annually over 30 years. This is slightly lower deforestation rate than the reference region but still remarkably high given that 74% of the BCI area is zoned as one kind of a protected area or another. This indicates that the BCI area is similar to the reference region in terms of the relative strengths of its deforestation driver variables and unconstrained land areas.

As can be seen from the 2018 and 2037 predictions, the effect of the constraint variables has had a marked effect on the predicted forest loss. Much of the production forest area has been lost by 2037, whereas Berbak National Park, Grand Forest Park Area and most of the Protected Forest area remain intact. The validity of these assumptions should be considered in more detail in later analyses.

The large open areas in the western regions and central part of Berbak National Park are the result of approximately five different fire episodes over the last 12 years. Damage from such haphazard fire is significant, but cannot yet be easily simulated in a baseline scenario due to unpredictability.

Illegal incursion of some form, likely roads or canals, is visible on the western side of Berbak National Park. These areas were not shown to expand in the model. This was due to the constraint classification put on the Berbak National Park zone as a protected and monitored area. Given that these illegal incursion features were visible as early as 1990 and have not grown in any way since that date, the zoning constraint should likely be able to hold relative validity through the next several years.

The Protected Forest did show some degree of deforestation. Approximately 13% of the area is anticipated to be lost by 2037. This is likely an underestimate given that this model was based on a transition from 2000-2005, and as we saw in

Figure, the extent of illegal logging grew significantly from 2005 to 2009. Had this deforestation been captured in the model design, the predicted deforestation in the protected forest might almost certainly have been much larger.

In total, it was predicted that 40,863 ha of forest area will be lost between 2008 and 2037.

Reference Region Actual – 2008 **Reference Region Prediction – 2018** **Reference Region Prediction – 2037**

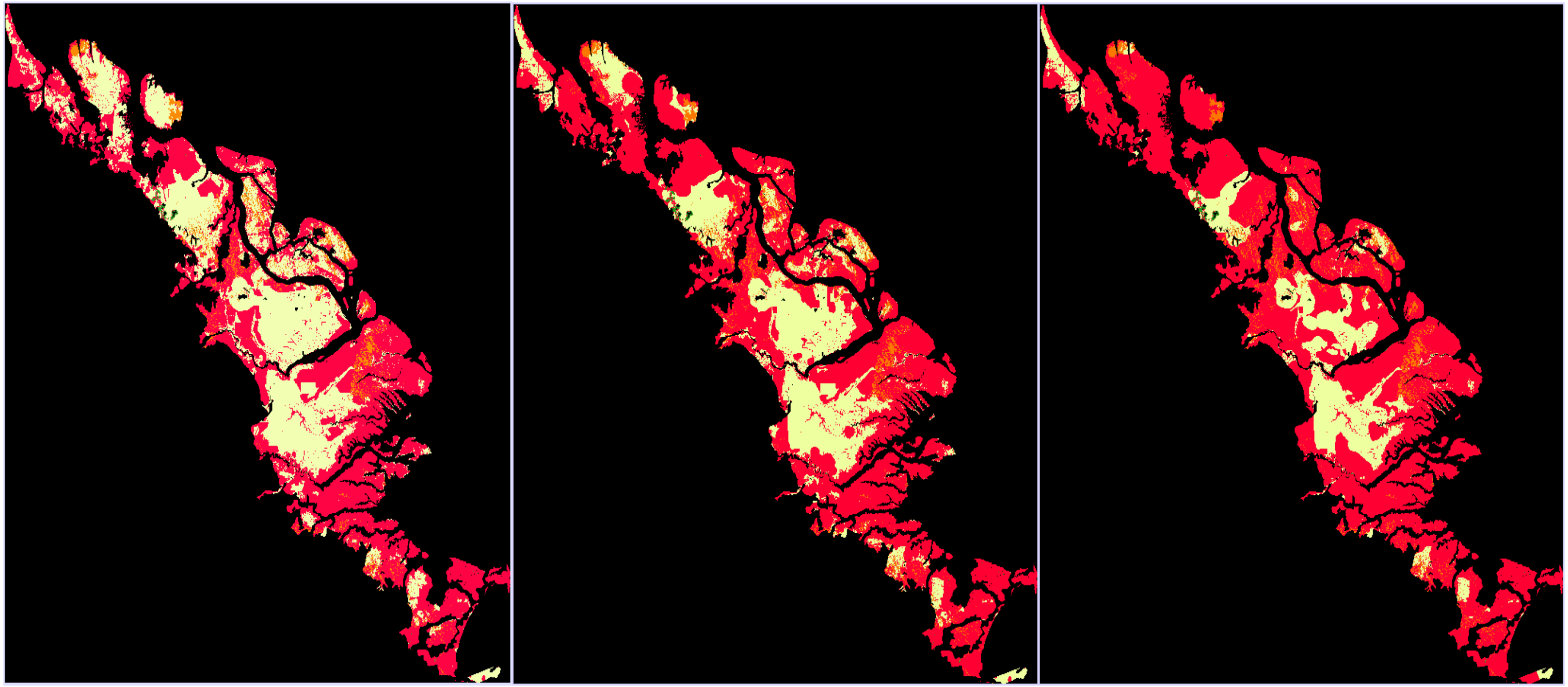


Figure 10 : Land Change Moduler (LCM) simulation results of future forest loss in reference region in 2018 and 2037.

Table 9 Annual Breakdown of Baseline Deforestation in Reference Region

Projected Deforestation, Reference Region 2008 – 2037					
Year	**Forest Cover (ha)**	**Control Points (ha)**	**Non Forest Area (ha)**	**Area Deforested (ha)**	**Deforestation Rate (% of area)**
2008	**1,514,392**	**1,630,406**	**2,317,482**	**29,608**	**-1.96%**
2009	1,484,784		2,347,090	29,608	-1.99%
2010	1,455,176		2,376,698	29,608	-2.03%
2011	1,425,568		2,406,306	29,608	-2.08%
2012	1,395,960		2,435,914	29,608	-2.12%
2013	1,366,352		2,465,522	29,608	-2.17%
2014	1,336,744		2,495,130	29,608	-2.21%
2015	1,307,136		2,524,738	29,608	-2.27%
2016	1,277,528		2,554,346	29,608	-2.32%
2017	1,247,920		2,583,954	29,608	-2.37%
2018	**1,218,312**	**1,182,369**	**2,613,562**	**29,608**	**-2.43%**
2019	1,188,704		2,643,170	29,608	-2.49%
2020	1,159,096		2,672,778	29,608	-2.55%
2021	1,129,488		2,702,386	29,608	-2.62%
2022	1,099,880		2,731,994	29,608	-2.69%
2023	1,070,272		2,761,602	29,608	-2.77%
2024	1,040,664		2,791,210	29,608	-2.85%
2025	1,011,056		2,820,818	29,608	-2.93%
2026	981,448		2,850,426	29,608	-3.02%
2027	951,840		2,880,034	29,608	-3.11%
2028	922,232		2,909,642	29,608	-3.21%
2029	892,624		2,939,250	29,608	-3.32%
2030	863,016		2,968,858	29,608	-3.43%
2031	833,408		2,998,466	29,608	-3.55%
2032	803,800		3,028,074	29,608	-3.68%
2033	774,192		3,057,682	29,608	-3.82%
2034	744,584		3,087,290	29,608	-3.98%
2035	714,976		3,116,898	29,608	-4.14%
2036	685,368		3,146,506	29,608	-4.32%
2037	**655,760**	**732,898**	**3,176,114**	**29,608**	**-4.52%**
Total				**888,240**	
Average				**29,608**	**-3.13%**

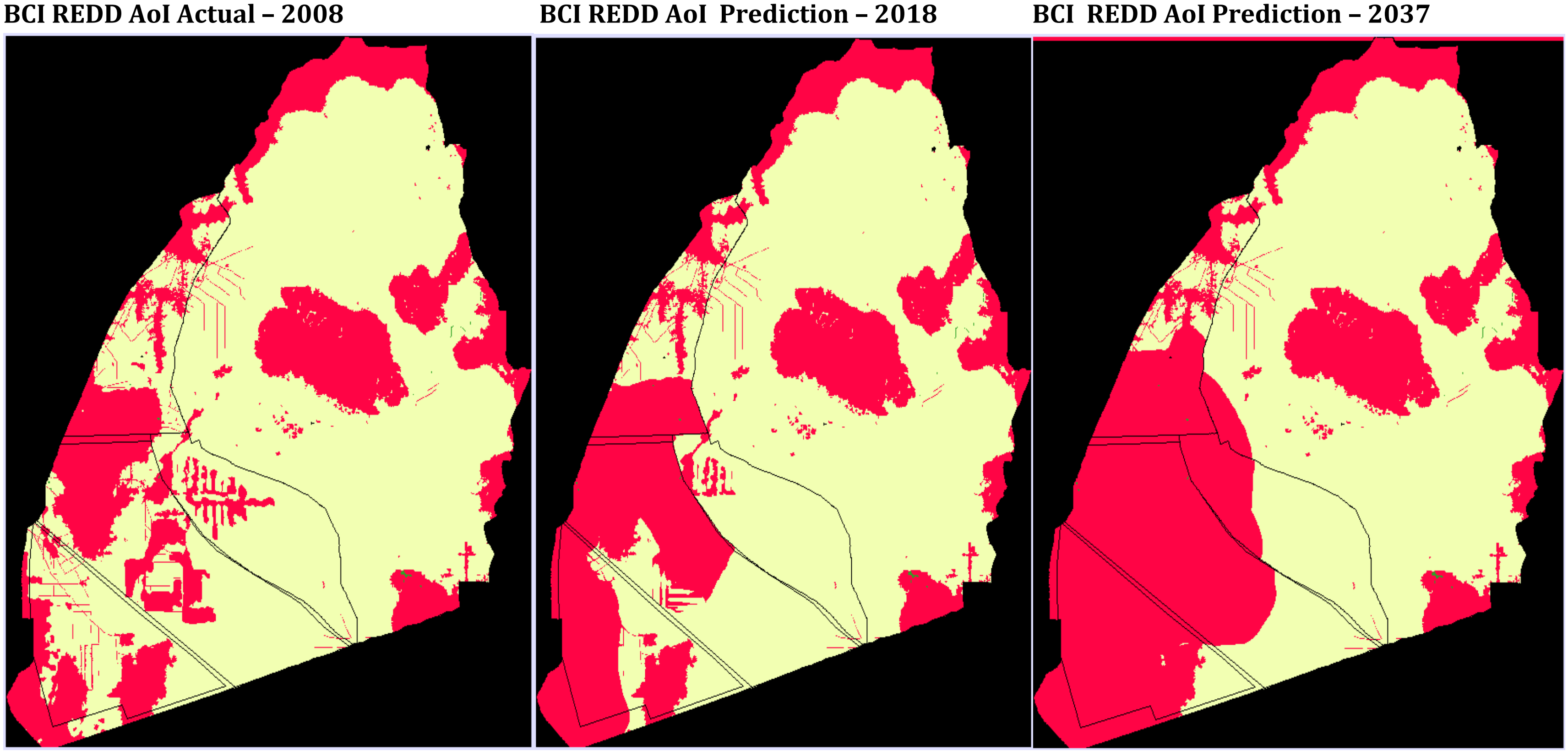


Figure 11 : LCM simulation results of future forest loss in the BCI REDD AoI in 2018 and 2037.

Table 1: Annual Breakdown of Baseline Deforestation in ZSL BCI Area of Interest

Projected Deforestation, BCI Area of Interest 2008 – 2037				
Year	Forest Cover (ha)	Non Forest Area (ha)	Area Deforested (ha/yr)	Deforestation Rate (% of area)
2008	172,498	66,104	1,549	-0.90%
2009	170,948	67,653	1,536	-0.90%
2010	169,412	69,189	1,533	-0.91%
2011	167,879	70,723	1,506	-0.90%
2012	166,372	72,229	1,493	-0.90%
2013	164,879	73,722	1,481	-0.90%
2014	163,398	75,203	1,468	-0.90%
2015	161,930	76,672	1,466	-0.91%
2016	160,464	78,137	1,440	-0.90%
2017	159,024	79,577	1,427	-0.90%
2018	157,597	81,005	1,416	-0.90%
2019	156,181	82,420	1,403	-0.90%
2020	154,778	83,824	1,401	-0.91%
2021	153,377	85,225	1,376	-0.90%
2022	152,001	86,601	1,365	-0.90%
2023	150,636	87,965	1,353	-0.90%
2024	149,283	89,318	1,341	-0.90%
2025	147,942	90,660	1,339	-0.91%
2026	146,602	91,999	1,315	-0.90%
2027	145,287	93,314	1,304	-0.90%
2028	143,983	94,618	1,293	-0.90%
2029	142,689	95,912	1,282	-0.90%
2030	141,407	97,194	1,280	-0.91%
2031	140,127	98,474	1,257	-0.90%
2032	138,870	99,731	1,247	-0.90%
2033	137,623	100,978	1,236	-0.90%
2034	136,387	102,214	1,226	-0.90%
2035	135,162	103,440	1,220	-0.90%
2036	133,941	104,660	1,162	-0.87%
2037	132,779	105,822	1,145	-0.86%
Total			**40,863**	
Average				**-0.90%**

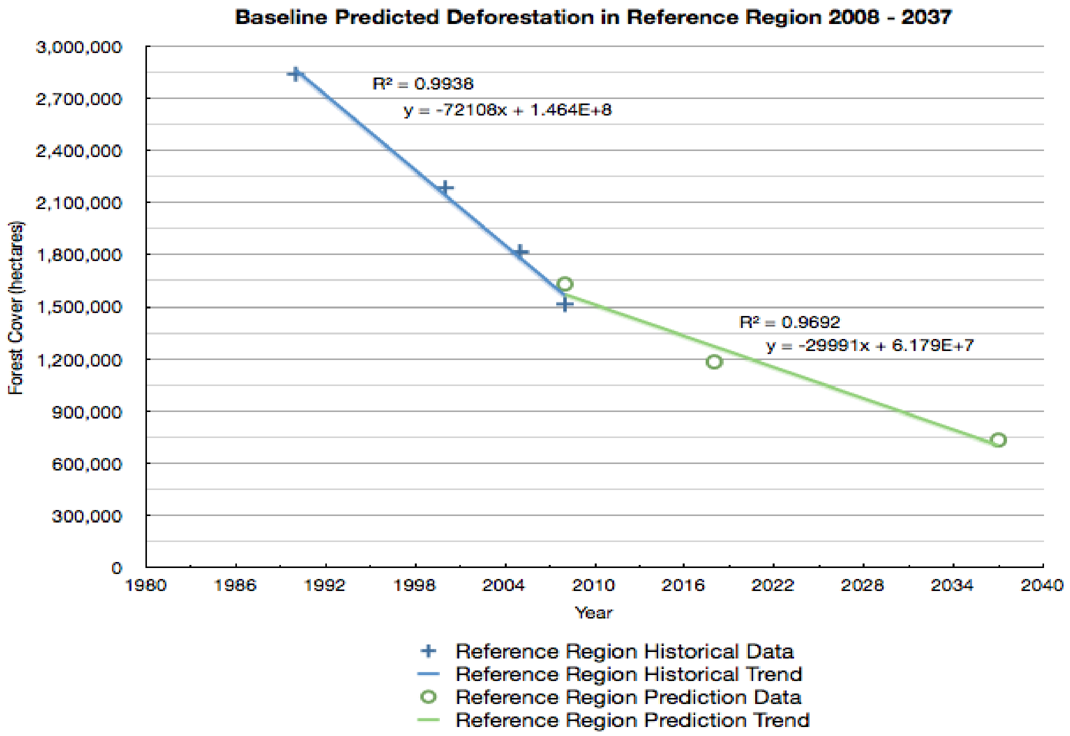


Figure 13 : Graph of Historical and Predicted Average Forest Cover Change Trends in the Reference Region

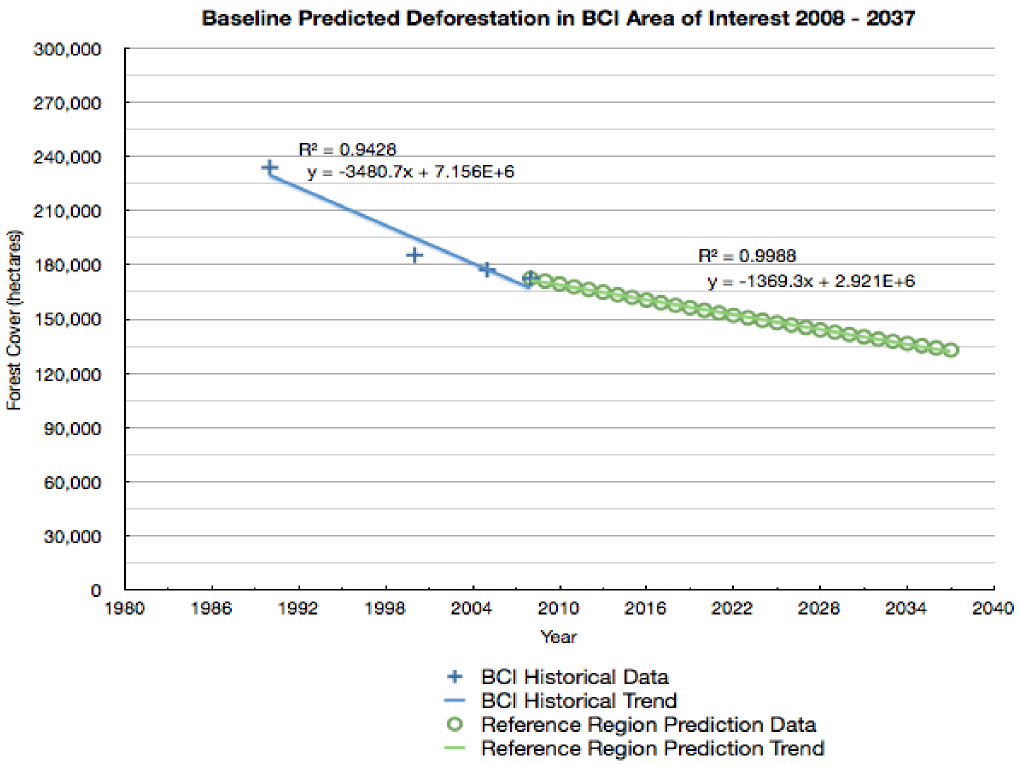


Figure 44 : Graph of Historical and Predicted Average Forest Cover Change Trends in the BCI REDD AoI

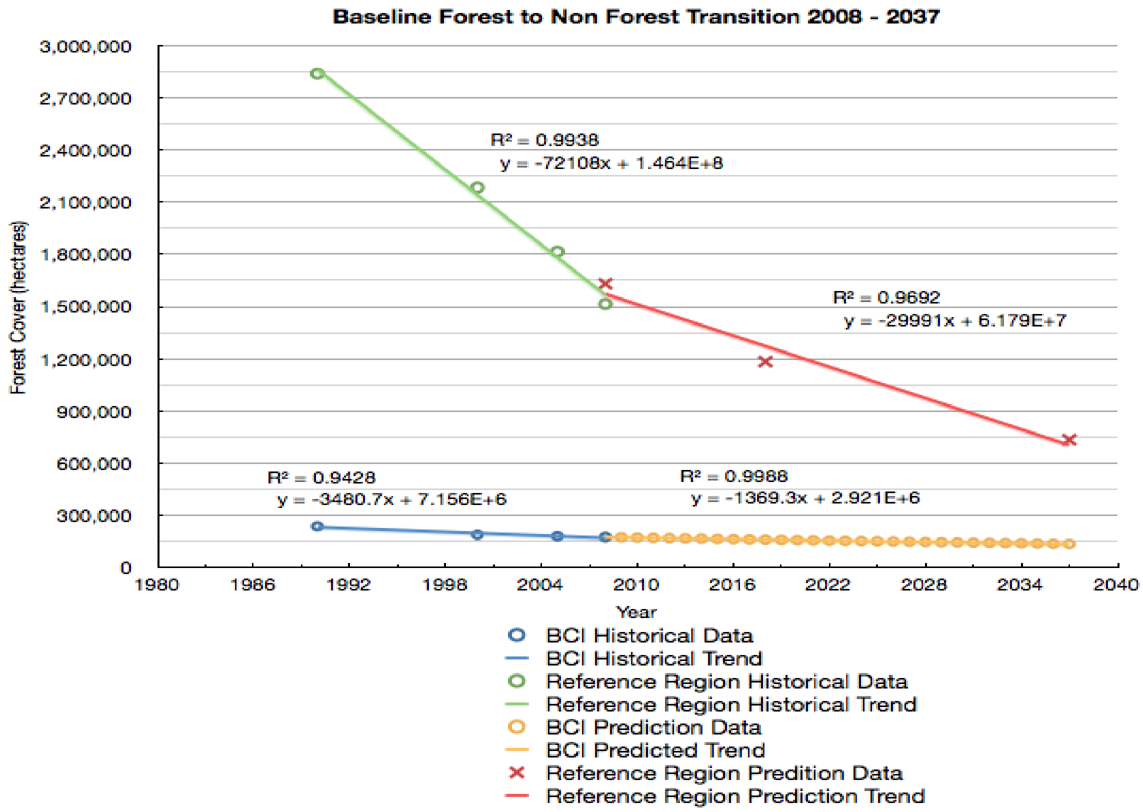


Figure 15 : Graph of Historical and Predicted Forest Cover Change in both the BCI REDD AoI and Reference Region

As can be seen from Figure 13, Figure 414 and Figure 15, the forest cover loss predictions take a lower slope going forward in time. Since this is a prediction, the indicated slope is acceptable given that it is a more conservative estimate over time than the historical trend. In reality, these curves could be affected by an incredibly diverse array of factors, such as the availability of easily log able remaining forest resources, zoning access, government policy, and local and international timber demand.

Table 2: Complete 30-year table of future modeled deforestation in the BCI REDD AoI

	Berbak National Park		Protection Forest		Grand Forest Park		Total Prod. Forest		PT. PIW		PT. PBP	
Year	Non-Forest (ha)	Forest (ha)	Non-Forest (ha)	Forest (ha)	Non-Forest (ha)	Forest (ha)	Non-Forest (ha)	Forest (ha)	Non-Forest (ha)	Forest (ha)	Non-Forest (ha)	Forest (ha)
2008	33,404.56	106,712.08	1,055.68	17,647.45	8,128.12	9,453.63	4,106.25	3,577.07	11,455.58	22,101.03	7,952.02	13,004.87
2009	33,404.59	106,711.86	1,055.68	17,647.43	8,155.88	9,425.92	4,258.30	3,425.01	11,522.09	22,034.47	9,254.94	11,701.92
2010	33,404.59	106,711.86	1,055.68	17,647.43	8,189.35	9,392.45	4,498.48	3,184.83	11,891.75	21,664.82	10,148.01	10,808.85
2011	33,404.59	106,711.86	1,055.76	17,647.35	8,259.20	9,322.60	4,708.94	2,974.38	12,370.73	21,185.84	10,922.08	10,034.78
2012	33,404.59	106,711.86	1,055.76	17,647.35	8,382.10	9,199.71	4,889.91	2,793.41	13,058.79	20,497.78	11,436.32	9,520.54
2013	33,404.59	106,711.86	1,055.93	17,647.19	8,838.99	8,742.82	5,008.50	2,674.82	13,546.22	20,010.35	11,866.73	9,090.13
2014	33,404.59	106,711.86	1,055.93	17,647.19	9,107.35	8,474.45	5,133.01	2,550.30	14,234.84	19,321.72	12,266.27	8,690.59
2015	33,404.59	106,711.86	1,055.93	17,647.19	9,444.84	8,136.96	5,262.16	2,421.15	14,824.86	18,731.70	12,677.76	8,279.10
2016	33,404.59	106,711.86	1,057.87	17,645.24	9,719.30	7,862.50	5,377.66	2,305.65	15,446.48	18,110.09	13,130.18	7,826.68
2017	33,404.59	106,711.86	1,121.39	17,581.72	9,924.31	7,657.49	5,454.18	2,229.14	16,184.65	17,371.92	13,486.60	7,470.26
2018	33,404.59	106,711.86	1,252.73	17,450.38	10,090.42	7,491.38	5,507.87	2,175.45	17,058.79	16,497.77	13,688.77	7,268.09
2019	33,404.59	106,711.86	1,368.64	17,334.47	10,261.40	7,320.40	5,560.09	2,123.22	17,941.87	15,614.69	13,882.33	7,074.54
2020	33,405.73	106,710.72	2,060.60	16,642.52	10,347.25	7,234.55	5,594.29	2,089.03	18,412.98	15,143.59	14,001.40	6,955.46
2021	33,408.41	106,708.04	2,747.19	15,955.92	10,422.79	7,159.01	5,643.51	2,039.80	18,854.43	14,702.13	14,147.04	6,809.82
2022	33,419.70	106,696.75	3,110.19	15,592.93	10,546.58	7,035.22	5,726.36	1,956.95	19,467.76	14,088.80	14,328.82	6,628.04
2023	33,440.25	106,676.20	3,418.52	15,284.60	10,713.90	6,867.90	5,795.00	1,888.32	20,039.67	13,516.90	14,556.66	6,400.21
2024	33,505.64	106,610.82	3,633.28	15,069.84	10,865.22	6,716.58	5,868.51	1,814.81	20,592.08	12,964.48	14,852.15	6,104.71
2025	33,832.97	106,283.48	3,806.77	14,896.34	11,045.06	6,536.74	5,926.83	1,756.49	20,964.25	12,592.31	15,082.35	5,874.52
2026	34,041.48	106,074.98	3,989.77	14,713.34	11,200.36	6,381.44	5,984.90	1,698.41	21,406.36	12,150.20	15,374.59	5,582.27
2027	34,147.48	105,968.98	4,167.49	14,535.62	11,309.36	6,272.44	6,054.35	1,628.97	21,938.79	11,617.77	15,695.35	5,261.51
2028	34,259.57	105,856.89	4,310.85	14,392.26	11,576.35	6,005.45	6,112.75	1,570.57	22,318.36	11,238.21	16,039.09	4,917.77
2029	34,385.87	105,730.58	4,462.10	14,241.02	11,769.02	5,812.79	6,173.42	1,509.89	22,713.76	10,842.81	16,406.23	4,550.63
2030	34,543.61	105,572.84	4,641.28	14,061.83	11,855.36	5,726.44	6,222.08	1,461.24	23,074.07	10,482.49	16,856.22	4,100.64
2031	34,776.81	105,339.65	4,752.96	13,950.15	12,229.15	5,352.65	6,266.59	1,416.73	23,195.99	10,360.57	17,250.89	3,705.97
2032	34,776.81	105,339.65	4,942.46	13,760.65	12,229.15	5,352.65	6,360.40	1,322.91	23,829.30	9,727.26	17,591.63	3,365.23

	Berbak National Park		Protection Forest		Grand Forest Park		Total Prod. Forest		PT. PIW		PT. PBP	
2033	34,938.04	105,178.41	4,942.46	13,760.65	12,888.86	4,692.94	6,411.98	1,271.33	23,897.29	9,659.28	17,897.77	3,059.10
2034	35,274.47	104,841.98	5,602.49	13,100.62	12,888.86	4,692.94	6,428.80	1,254.52	24,120.17	9,436.40	17,897.77	3,059.10
2035	35,274.47	104,841.98	5,602.49	13,100.62	12,888.86	4,692.94	6,527.89	1,155.43	24,928.85	8,627.72	18,215.68	2,741.18
2036	35,274.47	104,841.98	5,602.49	13,100.62	12,888.86	4,692.94	6,583.69	1,099.62	24,940.79	8,615.78	18,729.67	2,227.19
2037	35,274.47	104,841.98	5,602.49	13,100.62	12,888.86	4,692.94	6,583.69	1,099.62	24,940.79	8,615.78	18,729.67	2,227.19

3.3 Drivers and Underlying Causes and Agents of Deforestation.

Activities that deforestation agents would implement inside the project area in the absence of the REDD project activity could be displaced outside the project boundary as a consequence of the implementation of the REDD project activity. Where this displacement of activities increases the rate of deforestation, the related carbon stock changes and non-CO2 emissions must be estimated and counted as leakage.

Agents, drivers and underlying cause analysis of deforestation is needed to assess whether the future rates of deforestation described in Section 3.1 and 3.2 in the reference region and BCI REDD AoI area are likely to change compared to the rates measured in the previous step it is necessary to analyze the main groups of deforestation agents (farmers, ranchers, loggers, etc.). This analysis is also necessary to determine selection of REDD +strategies most appropriate, so as to reduce significantly the level of carbon emissions while reducing poverty, biodiversity conservation and environment services protection. The driver's deforestation, that motivates their land-use decisions, and their likely future evolution. Existing studies, expert-consultations, field-surveys and other verifiable sources of information was used to perform this analysis.

There are four different groups of deforestation agents may be displaced from BCI REED+ AoI areas :

a) Local deforestation agents obtaining their livelihood inside or near the BCI REDD AoI area since the start of the REDD project activity. This will be the main agent group in most cases of mosaic deforestation. This group will also be present in some cases of frontier deforestation. The risk of displacing activities of local agent groups must be addressed in the design of the REDD project activity using one or both of the following two approaches: i). Exclusion from the project area of the forest locations that are likely to be deforested by these groups during the implementation of the REDD project activity ii). Changes in the rate of deforestation in these areas, compared to the baseline case, must be counted as leakage, iii). Implementation of leakage prevention measures to maintain or increase the agents 'livelihoods, such as, but not limited to, the creation of alternative sources of fuel wood, improved crop, plantation or animal production systems, and land-based or non-land based employment.

b) Immigrant deforestation agents expected to encroach into the BCI REDD AoI area in future periods. This will be the main agent group in most cases of frontier deforestation. This group will also be present in some cases of mosaic deforestation. Influencing the land-use decisions of this deforestation agent groups will not be possible in most cases, particularly if the agents are coming from distant locations and are driven by economic reasons. Leakage prevention measures may not be sufficient to avoid some level of activity displacement from happening.

c) Private sector agents expected to encroach interested in BCI REDD AoI area in future period, such as PT. Putra Duta Indah Wood and PT. Persona Rimba Belantara. The risk of displacing activities of local agent groups must be addressed in the design of the REDD project activity using one or both of the following approaches: i). Exclusion from the BCI REDD AoI areas of the forest locations that are likely to be deforested by these groups during the implementation of the REDD project activity ii). Adjusts in the deforestation rate in these areas, compared to the baseline case, must be counted as leakage, iii). Implementation of leakage prevention measures to maintain or increase the agents, such as improved forest management in their timber concession, iv) Inclusion into the BCI REDD AoI through change of forest function from the management of production forest concession to forest conservation or ecosystem restoration concession.

Type of Deforestation		**Method of Deforestation**	**Key Deforestation Agents**
DEFORESTATION	**Planned**	Regional administrative and economic growth expansion (district, village)	Central and local government, people representative council
		The release forest area by official approval	Minister of Forestry, Governor, Head of District
		Forested to non forest area changes in another use areas	Minister of Forestry, Governor, Head of District, people representative council
		Release forested area for mining, plantation, plant crops, infrastructure and road.	Minister of Forestry, Governor, Head of District, development sectors agency, private sector
	Un planned	Forest encroachment	local and immigrant resident
		Large forest fire	local and immigrant resident, private sectors
		Forest land claiming	local and immigrant resident
		Canal construction in peat swamp forest	local and immigrant resident, private sector
FOREST DEGRADATION	**Planned**	Licensed timber logging concession	Minister of Forestry, private sector
		Licensed timber estate concession	Minister of Forestry, private sector
	Un planned	Timber harvesting outside the allowable cut	Private sector
		Illegal logging	Local and immigrant residents, private sector
		Small scale forest fire due to natural factors	
		Small scale forest fire due to land clearing	Local and immigrant residents, private sector

Table 15. Typology of Deforestation and Forest Degradation in Jambi Province

Based on Fish Bond Analysis though focus group discussion with various stake-holders inJanuary - February 2011, we concluded that cause of deforestation is multi-causal and identified are 2 main direct causes of deforestation and forest degradation in BCI REDD AoI. First, is unplanned deforestation and secondly is planned deforestation. Both are affected by several other underlying processes and parameters that determine the extent and the location of the impact on the forest cover change in BCI REDD AoI. Both planned and unplanned deforestation due to multiple cause factors : i). weaknesses of spatial and land use planning and implementation, ii) money politic in land use, forest conversion and spatial planning issues, iii) ineffective forest management unit, iv) land tenure conflict, v). lack of forest governance, and vi). poor of legal basis and law enforcement. See Figure 12 and Table 15 for more detailed about agents and underlying cause of deforestation in Jambi Province.

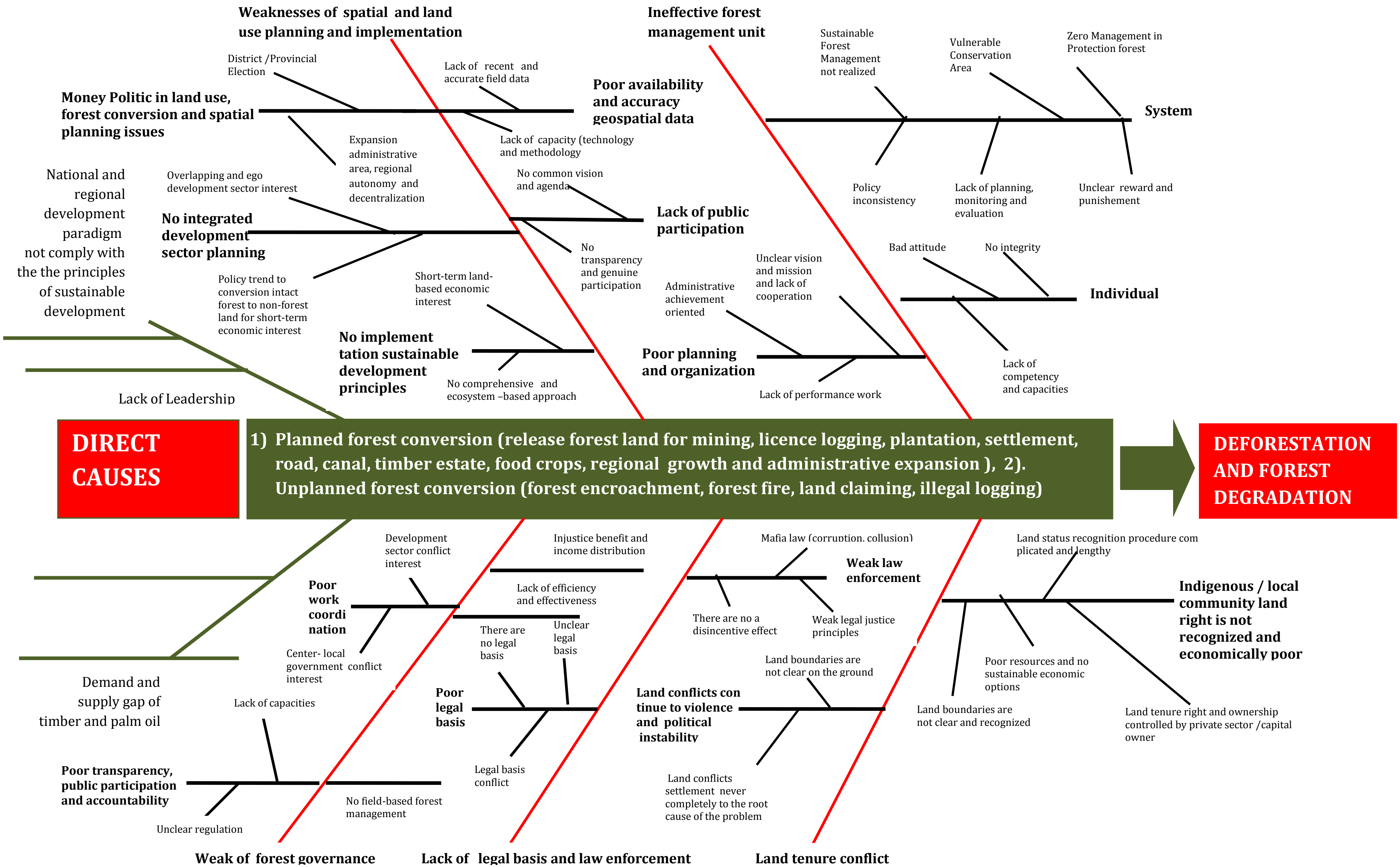


Figure 12. Fish Bond Analysis for the root cause deforestation in BCI REDD AoI in Jambi Province