Table 3.6. Labor requirements and the equilibrium human population density

Land use systems	Labour requirement ps-days ha^{-1}	Relative rest period (year)	Local value chain multiplier	Equilibrium sustainable human Pop. Dens. (km^{-2})
Logging				
• low density logging (17 m3/ha)	48.00	10.00	0.50	3.91
• high density logging (40 m3/ha)	153.00	30.00	0.50	4.42
Upland paddy (Coastal)	122.00	5.00	0.05	12.75
Upland paddy (Dayak)	142.00	5.00	0.05	14.84
Cocoa based Mix Garden	39.00	0.00	0.10	25.61
Coconut Monoculture	69.00	0.00	0.10	45.31
Cocoa Monoculture	75.00	0.00	0.10	49.25
Pepper Monoculture	164.00	1.00	0.10	53.85
HTI Acacia mangium	84.00	0.00	0.10	55.16
Oil Palm	86.00	0.00	0.10	56.48
Rubber Monoculture	102.00	0.00	0.10	66.99

Results show that logging is aligned with the lowest human population densities, less than five person per square km, once the long resting periods are taken into account, followed by paddy rice/fallow rotations with about 10 persons km^{-2}. For the various tree crops the equilibrium population densities are calculated at 21 – 67 km^{-2}, with the lowest value for cocoa-based multistrata systems and the highest for rubber monoculture.

By comparing the 'sustainable human population density' with 'time-average of C stock' (t C/ha), we obtain a concave relationship that predicts that the C stock will decrease with the inverse of the square root of the human population density (or in fact with power -0.559) (See Figure 3.4. below)

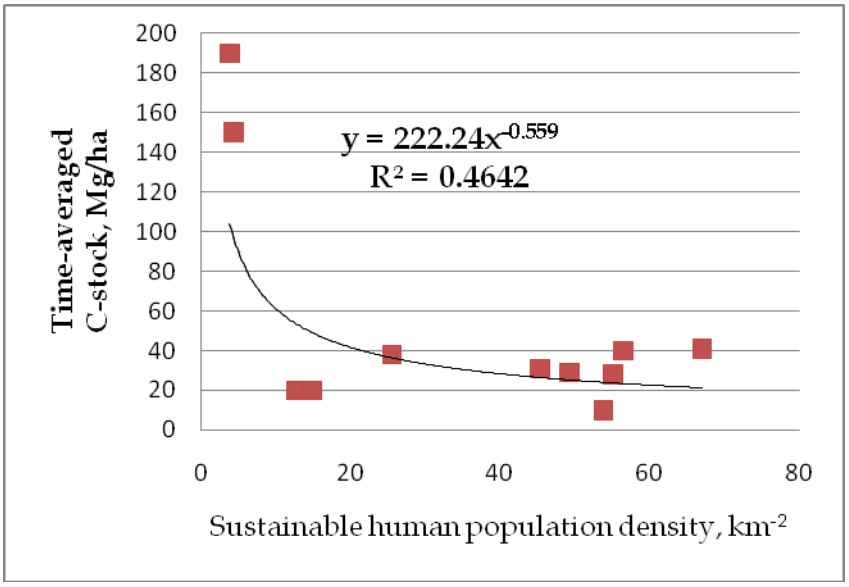

Figure 3.4. Relationship between sustainable human population - C Stock of ea land use system studied

If increase in human population density is seen as a given (which globally it may, but locally depends on stimulating or slowing down migration), we can see a number of land use types that are better than their comparators in maintaining C stocks.

According to the data presented earlier, land use with sustainable human population density below five person km^{-2}, such as the low-intensity logging with 10 year recovery is better than the higher intensity logging with longer recovery cycle. Between 10 and 30 persons km^{-2} the cocoa-based mixed garden are superior to the upland rice with fallow rotations. In the 'tree crop' domain cocoa between 40 and 60 persons km^{-2}, the cocoa and pepper monocultures represent the low end, HTI is on the expected line and coconut, oil palm and rubber are above the line.

The slope of the line, however, clearly indicates that a 'segregate' scenario that fully protects a part of the landscape from human use and, consequently, increases use elsewhere will lead to a higher landscape level C stock than an 'integrated' solution.

Concluding remarks

The profitability assessment selected eight land use systems representing the main land use system of Berau District. Some food crop systems were not included in the assessment, as they were scattered in small patches throughout the district (producing soybean, maize, cassava, sweet potato, and some vegetables). The study, within the time given, was not able to cover these food crop systems.

In identifying land use system based on land cover data identified in the carbon measurement study for this profitability analysis, we noted two problems. First, Land cover by definition is distinct from land use despite the two terms often being used interchangeably. Land use is a description of how people *utilize* the land. Whilst land cover is the physical material at the surface of the earth (grass, asphalt, tree cover, bare ground, water, etc.). Forest is a land cover. But it is also type of land use if there is a human activity involved: forest extraction (logging) or forest conservation. Therefore, from four forest categories under carbon measurement, this study considered only two type logging: logging on low density forest and logging on high density forest.

Second, problem to determine which land cover types considered as land use systems that can be accounted for profitability analysis, especially land cover data derived from satellite imagery. Some land use systems look similar in the satellite imagery data, such as cleared land, pepper cultivation and early stage of dry land paddy. By combining results from extensive and intensive groundtruthing and secondary data available, we gained more accurate and up-to-date information. Pepper cultivation was included in this profitability assessment, although it is not listed in the land cover data.

The upland paddy/bush fallow rotation (three year cycle) that practiced mostly by Dayak communities and other upland communities, stands out as being 'unprofitable', either in terms of potential profitability (returns to land at social prices) or smallholder production incentives (returns to labor at private prices). This does not necessarily mean that there are no positive cash flows. Instead, would be more profitable to do other things with the land, labor and capital than to devote them to this activity. However, although paddy productivity is relatively low and return to labor estimate is also less than agricultural wage rate the farmers keep practicing the systems to secure their staple food. For many Dayak communities and other upland communities, planting paddy is intended for their food security; which is relatively important than working for wages.

At the other extreme, oil palm plantation, the new emerging land use system in the last ten years, and is mostly operated by large scale investor, stands out as the most profitable systems in Berau District. Estimate return to land (NPV at social prices) reach IDR 138 million per hectare (25 years production scenario at 5% discount rate). Oil palm is widely viewed as the most profitable land use system. It is not surprising that large-scale oil palm monoculture is among the most profitable, either in terms of returns to land valued at social prices or in terms of returns to labor valued at private prices. The lowest unit cost probably relate to the official wage rate for plantation workers

are far below the estimate return to labor. Besides, the study also found some oil palm plots of 2-5 ha planted by independent smallholders began to appear scattered in the region, mostly located closed to the large scale plantation.

By comparing the 'sustainable human population density' with 'time-average of C stock' (t C/ha), we obtain a concave relationship that predicts that the C stock will decrease with the inverse of the square root of the human population density. The slope of the line, clearly indicates that a 'segregate' scenario that fully protects a part of the landscape from human use and, consequently, increases use elsewhere will lead to a higher landscape level C stock than an 'integrated' solution.

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Appendix

Appendix I. Spatial Data

Satellite Imageries

We rely on Landsat imageries as the source of remotely sensed data that cover the whole area of Berau district to produce wall-to-wall, four time series maps of land use/cover (1990, 2000, 2005, and 2008). Landsat images have 30 m spatial resolution and 7 spectral channels. The first three periods of Landsat imageries used in this research were from ICRAF archive, but nowadays Landsat images can be downloaded freely from United States Geological Survey (USGS) website (http://glovis.usgs.gov/). The most recent imageries were provided by SEKALA.

The most problematic issues of any land cover mapping activities in the humid tropics is the cloud and haze cover which is extensive and almost consistent throughout the year. Berau district is covered by five scenes of Landsat images and in order to maximize areas that are free of cloud and haze, we use different, but as much as possible closely spaced, acquisition dates. Table 1.7. shows acquisition dates of each scene per reference year.

Table 1.7. Satellite imageries and acquisition dates

Scene ID	1990's	2000's	2005's	2008
115-059	-	Sensor: Landsat 7 ETM+	Sensor: Landsat 7 ETM+ (SLC-off)	Sensor: Landsat 5 TM
		Acquisition date: 28 th, August 2000	Acquisition date: February 15th, 2005	Acquisition date: May 22nd, 2008
116-058	Sensor: Landsat 5 TM	Sensor: Landsat 7 ETM+	Sensor: Landsat 7 ETM+ (SLC-off)	Sensor: Landsat 5 TM
	Acquisition date: 16th, June 1991	Acquisition date: 6th, August 2001	Acquisition date: January 20th, 2005	Acquisition date: May 13th, 2008
116-059	Sensor: Landsat 5 TM	Sensor: Landsat 7 ETM+	Sensor: Landsat 7 ETM+ (SLC-off)	Sensor: Landsat 5 TM
	Acquisition date: 28th, January 1993	Acquisition date: 15th, Mei 2000	Acquisition date: May 16th, 2006	Acquisition date: March 26th, 2008, April 27th, 2008
117-058	Sensor: Landsat 5 TM	Sensor: Landsat 7 ETM+	Sensor: Landsat 7 ETM+ (SLC-off)	Sensor: Landsat 5 TM
	Acquisition date: 20th, April 1991	Acquisition date: 26th, June 2001	Acquisition date: October 8th, 2004	Acquisition date: June 5th, 2008
117-059	Sensor: Landsat 5 TM	Sensor: Landsat 7 ETM+	Sensor: Landsat 7 ETM+ (SLC-off)	Sensor: Landsat 5 TM
	Acquisition date: 22nd, April 1989	Acquisition date: 26th, August 2000	Acquisition date: September 25th, 2005	Acquisition date: June 5th, 2008

Digital Elevation Model (DEM)

We use the DEM produced from *Shuttle Radar Topography Mission* (SRTM) are arranged into tiles, each covering one degree of latitude and one degree of longitude. The resolution of the cells of

the source data is three arc second (one arc equals to 30 meter), so three arc second data approximate to 90 meter (for more detail information visit http://www2.jpl.nasa.gov/srtm/).

Thematic Maps

Table 1.8. provides the list of thematic maps used in this study.

Table. 1.8. List of thematic maps

Image and Thematic Map	Type of Data	Data producer	Data provider
Administration Boundaries	Shapefile	Bapeda Berau, East Kalimantan	SEKALA
Peat area	Shapefile	Wetland International	SEKALA
RTRW Kabupaten	Shapefile	Bapeda Berau, East Kalimantan	SEKALA
HPH	Shapefile	Ministry of Forestry	ICRAF archive
HTI	Shapefile	Ministry of Forestry	ICRAF archive
Plantation	Shapefile	Ministry of Forestry	ICRAF archive
Roads	Shapefile		SEKALA
Rivers	Shapefile		SEKALA

Geo-referenced points of various land use/cover

GPS points were collected through groundtruthing activities in various land use/cover in Berau district. We the upper watershed. The geo-referenced points were primary source of information in two activities: (i) interpreting spectral data from satellite imageries into land use/cover classes and (ii) assessing the accuracy of the land use/cover maps resulted from the interpretation of satellite compiled points collected recently by ICRAF and also by others who have generously shared the data with is. The points are still not as distributed across the whole landscape of Berau as ideally should be, mainly due to limitation of time and difficulties in accessing areas in imageries.

Table. 1.9. Name of person or institution conducting the groundtruthing

No.	Name of person or institution conducting the groundtruthing	Date of collection of GPS points
1	Rizky P. Permana (PhD Student of Utrecht Univ.)	October 28th – November 25th 2008
2	Bronson Griscom (TNC)	March 14th-19th 2009
3	Zuraidah Said (ICRAF)	July 30th -August 15th 2009
4	CSF team (UnMul)	August 2nd- 18th 2009

Appendix II. Plot level carbon data

Table 1.10. Description of plot level data

Number of plots	Land use/cover	Location	Year of data collection	Institution that collects the data
16 PSP	Natural forest (virgin, logged-over with RIL and conventional method	Berau	Biannually from 1994 – 2008	STREK
279 TSP	Natural forest (logged-over), shrubs	Berau	2009	PT Wanabhakti for Period Forest Inventory
20 PSP	Natural Forest inventory[9]	Berau	Between 1992-1999	Forest Planology, Ministry of Forestry of Indonesia
1941	Cacao, monoculture coffee, simple shade coffee, multistrata coffee, mixed garden, rubber agroforest, logged over forest, logged over swamp forest, virgin/undisturbed forest	Java, Sumatra and Kalimantan	Between 1994-2009	ICRAF
62 TSP	Coconut, cacao, coffee, rubber, oil palm, teak, Gmelina, Acacia, Sengon, shrub, old shrub, logged-over forest, virgin/undisturbed forest	Berau	2009	Center for Social Forestry, Universitas Mulawarman

Plot sizes for each datasets and the associated dbh class are presented in a series of figures below, which are self evident.

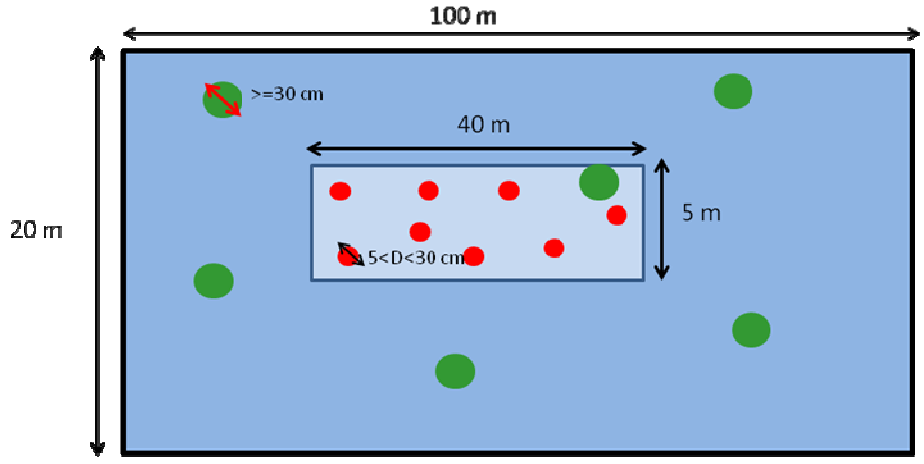

Figure 1.17. Rapid Carbon Stock Appraisal (RaCSA)

[9] The raw NFI data cannot be shared and will not be included in the database due to restrictions applied by the data custodians

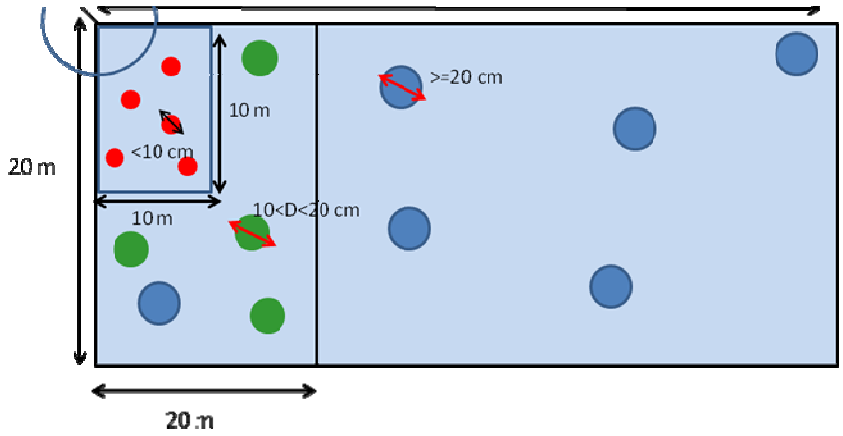

Figure 1.18. Periodical forest inventory (IHMB)

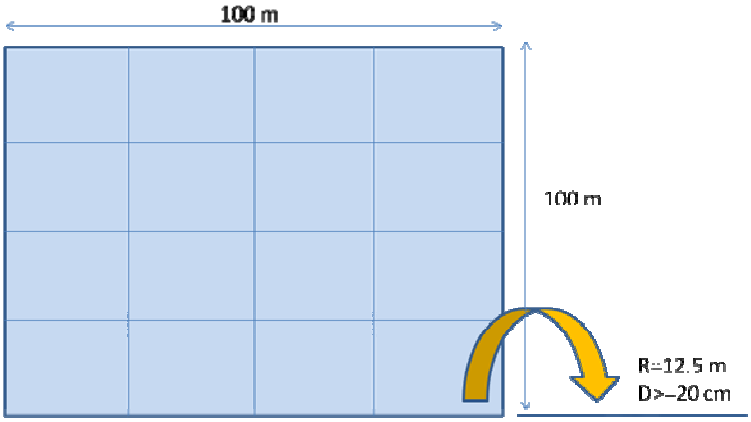

Figure 1.19. Permanent Sample Plots of National Forest Inventory

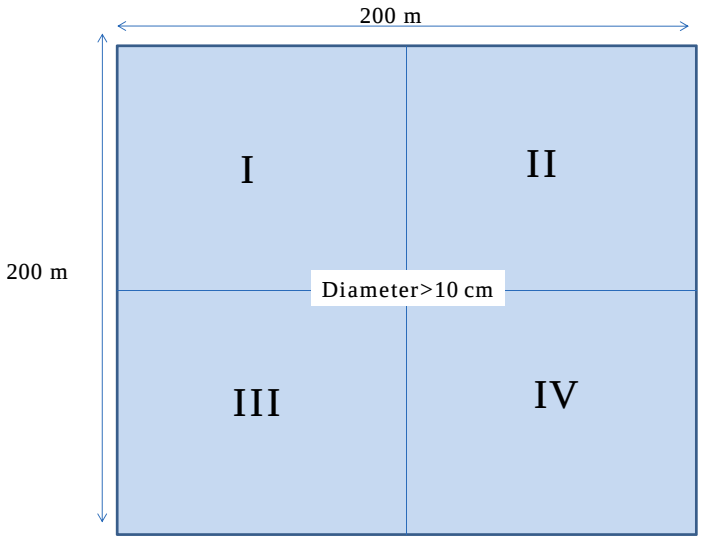

Figure 1.20. Permanent Sample Plot of STREK

Appendix III. Description of land use/cover types

Table 1.11. Description of land use/cover types

ID	Land use/cover types	Description
1	Undisturbed forest	Undisturbed forest is natural forest cover with dense canopy, highly diverse species and basal areas. It has no logging roads, indicating that it has never been logged, at least under large scale operation, and in Berau areas is usually located in areas with rough topography. Canopy cover of undisturbed forest is usually >80%. In satellite image, it is indicated by high value of vegetation index and infrared spectrum channels, and lower value in visible spectrum channels.
2	Logged-over forest (high density)	Logged-over forest (high density) is natural forest area with logging roads with dense tree cover and dense canopy. Canopy cover of logged-over forest is around 60-80%. Large trees with diameter >30cm can found. Spectral value of infra red channels is lower than undisturbed forest.
3	Logged-over forest (medium density)	Logged-over forest (medium density) is natural forest area with logging roads and medium level density of tree cover and canopy. Canopy cover of logged over forest (medium density) is around 40-60%. There are still small numbers of big trees with diameter >30cm. Spectral value of infra red channels is lower than logged-over forest (high density)
4	Logged-over forest (low density)	Logged-over forest (low density) is natural forest area with logging roads and low density of tree cover and canopy. Canopy cover of logged over forest low density) is around 20-40%. Usually there are no more big trees with diameter >30cm. Spectral value of infra red channels is lower than logged-over forest (medium density)
5	Undisturbed mangrove	Undisturbed mangrove is area along the coastline with high density of mangrove tree species, usually consists of diverse mangrove species composition, and has never been logged.
6	Logged-over mangrove	Logged-over mangrove is area along the coastline with various species of mangrove trees, has been logged in the past and partly degraded. Canopy over of logged-over mangrove is around 20-40%.
7	Undisturbed swamp	A swamp forest is a wetland featuring temporary or permanent inundation of large areas of land by shallow bodies of water with natural vegetation cover, has never been logged in the past and not degraded or affected by any human activities
8	Logged-over swamp	Logged-over swamp forest is swamp with natural forest cover that has been logged or degraded
9	Old shrub	Old shrub is an ex-forest clearing area that undergoes natural secondary regrowth process for several years. It has similar types of vegetation to shrub area but with higher and larger diameter trees than that found in shrub land. It is usually located in the forest edge area. This is usually resulted from traditional shifting cultivation activities that have been left for 2-3 years as part of the fallow/rotational systems. Tree cover of old shrub is fairly low

Appendix III. (continuation)

ID	Land use/cover types	Description
		around 5-10%. There are no tree with diameter >20cm.
10	Mixed garden	Mixed garden is an agroforest or tree based system with more than 30% of the area consists of various species of trees. Mixed garden usually located in 0.5-1km distance to settlement or road. Tree canopy cover is around 5-10%.
11	Old rubber	Rubber monoculture consists of old rubber trees mixed with other tree species.
12	Teak	Monoculture plantation of teak (*Tectona grandis*) tree, planted in both small and large scale. Canopy cover is around 5-10%, with tree diameter around 5-20 cm. Teak plantation is usually found in hilly area far from settlement or road. Closest distance to settlement is around 30km
13	Acacia	Monoculture plantation of Acacia, managed as large scale acacia plantation that is usually run by private company as timber plantation or HTI (hutan tanaman industry), and as small scale plantation managed by local people. By regulation, this type of land use/cover should only be found under convertible production forest area and area of other uses in the government land use plan. Tree canopy cover of acacia plantation is around 50-60%. Plantation size on satellite image is >10ha in average and distance to closest settlement is around 30km
14	Other forest plantation	Monoculture plantation of other tree crops (e.g., *Gmelina sp.*, Paraserianthes falcataria, coffee) where the area is less than 1 ha. Tree canopy cover is around 30-50%. Distance to closest settlement is around <1km.
15	Rubber	Monoculture plantation of rubber tree.
16	Oil palm	Monoculture plantation of oil palm planted by private companies and local people. Minimum size of plantation >10ha.
17	Coconut	Monoculture plantation of Coconut (*Cocos nucifera*) tree, usually planted in the coastal area by local people. Maximum distance to coastline is around 1km
18	Shrub	Shrub land is non-tree-based system consists of non tree vegetation usually less than 5-6 m (15-20 ft) tall, usually resulted from swidden agriculture activities that has been left for 2-3 years as part of the fallow/rotational systems
19	Cacao	Monoculture plantation of cacao (*Theobroma cacao*) tree, mostly managed by local people. Located close to settlement. Maximum distance to settlement is around 20km
20	Cropland	Cropland is an intensive cultivated land and is mostly planted with annual crops such as staple food, vegetables, fruit, etc.
21	Ricefield	Ricefield included irrigated and non irrigated (upland) rice field, it usually located nearby settlement or river. Ricefield appears in light blue in visible-NIR-MIR band combination.
22	Grass land	Area dominated by grass.
23	Cleared land	Area where almost no vegetation covers the land, it can be an ex logging area or slashed and burned area prepared for agriculture.
24	Burned forest	Burned forest refers to an ex forest area naturally burned recently or several times (months or years) ago.
25	Road and settlement	Road and settlement refer to settlement area (city or village), settlement along the road, main road, and logging road.
26	Water body	Water body refers to an area covered with water.
27	No data	No data refers to unclassified, clouds, and shadow area.

Appendix IV. Admistration and demographical conditions in the last 20 years

No	Description	1988	1998	2003	2008
1.	Location	116° BT - 119° BT	116° BT - 119° BT	116° BT - 119° BT	116° BT – 119° BT
		1° LU - 2° 33' LU	1° LU - 2° 33' LU	1° LU - 2° 33' LU	1° LU - 2° 33' LU
Administration					
1.	North	Kab. Bulungan	Kab. Bulungan	Kab. Bulungan	Kab. Bulungan
	East	Selat Makassar	Laut Sulawesi	Laut Sulawesi	Laut Sulawesi
	South	Kab. Kutai	Kab. Kutai	Kab. Kutai Timur	Kab. Kutai Timur
	West	Kab. Bulungan	Kab. Bulungan	Kab. Malianu, Kutai Barat & Kartanegara	Kab. Malianu, Kutai Barat & Kartanegara
2.	Land Teritory (km^2)	22.528,3	24.201,4	34.127	34.127
3.	No. of Sub-Districts	7	8	11	13
	No. of bridging Sub-District	2	1	-	-
4.	Village	75	99	95	97
	No. of Sub-Village	5	5	7	10
Demography					
1.	Population	55.859	107.188	136.628	164.501
	Male	29.372	59.384	74.901	90.419
	Female	26.487	47.804	61.728	74.082
2.	House Hold (KK)	11.852	23.187	29.677	37.417
3.	Population Density (people/km^2)	2,48	4,42	4,01	4,82
4.	Population Growth Rate (%)	0,86	6,73	6,81	2,56
Population Dynamics					
1.	Mortality	1.017	1.203	2.017	1.979
2.	Natality	210	261	430	379
3.	Imigration	1.438	5.079	13.277	3.271
4.	Move	1.768	3.440	8.781	769
5.	Job-Seekers	1.023	4.066	4.816	3.383

Source: Data Kabupaten Berau Dalam Angka 1988, 1998, 2003 & 2008 BPS Kab. Berau

Appendix V. Sub-District development in the last 20 years in Berau

No	1988		1998		2003		2008	
	Sub-District	Area (km^2)	Sub-District	Area (km^2)	Sub-District	Area (km^2)	Sub-District	Area (km^2)
1.	Kelay	6.650,00	Talisayan	2.593,54	Kelay	6.134,60	Kelay	6.134,60
2.	Talisayan	9.907,04	Biduk-Biduk	3.091,56	Talisayan	3.425,98	Talisayan	1.798,00
3.	Sambaliung	2.386,18	Kelay	6.134,60	Tubaan	2.977,72	Tabalar	2.373,45
4.	Segah	5.253,60	Segah	5.166,40	Biduk-Biduk	3.854,20	Biduk-Biduk	3.002,99
5.	Tanjung Redeb	75,80	Gunung Tabur	2.025,30	Pulau Derawan	3.858,95	Pulau Derawan	3.858,96
6.	Gunung Tabur	2.125,46	Sambaliung	2.460,30	Maratua	4.118,81	Maratua	4.118,80
7.	Pulau Derawan	6.301,92	Tanjung Redeb	67,20	Sambaliung	2.403,86	Sambaliung	2.403,86
8.	-	-	Pulau Derawan	2.662,10	Tanjung Redeb	23,76	Tanjung Redeb	23,76
9.	-	-	-	-	Gunung Tabur	1.987,02	Gunung Tabur	1.987,02
10.	-	-	-	-	Segah	5.166,40	Segah	5.166,40
11.	-	-	-	-	Teluk Bayur	175,70	Teluk Bayur	175,70
12.	-	-	-	-	-	-	Batu Putih	1.651,42
13.	-	-	-	-	-	-	Biatan	1.432,04

Source: Data Kabupaten Berau Dalam Angka 1988, 1998, 2003 & 2008 BPS Kab. Berau

Appendix VI. Transmigration dynamics in the last 20 years in Berau

No	Year	Location UPT (Settlement Unit)	Trans Umum		Bangdep		HTI Trans		Banpres	
			People	HH	People	HH	People	HH	People	HH
1	1982/83	Labanan I	1.139	273	-	-	-	-	-	-
2	1982/83	Labanan II	1.409	327	-	-	-	-	-	-
3	1984/85	Labanan III	1.307	351	-	-	-	-	-	-
4	1991/92	Talisayan IX/C/1	1.054	287	-	-	-	-	-	-
5	1991/92	Tasuk I	-	-	362	99	-	-	-	-
6	1991/92	Sambaliung	-	-	378	100	-	-	-	-
7	1991/92	Bebanir Bangun I	-	-	359	97	-	-	-	-
8	1992/93	Talisayan IX/C/2	1.451	360	-	-	-	-	-	-
9	1992/93	Bebanir Bangun II	-	-	377	100	-	-	-	-
10	1992/93	Sukan Tengah I	-	-	530	100	-	-	-	-
11	1993/94	Talisayan IX/C/3	1.243	320	-	-	-	-	-	-
12	1993/94	Merancang Ulu	1.797	474	-	-	-	-	-	-
13	1993/94	HTI Batu Putih	-	-	-	-	1.053	300	-	-
14	1994/95	Talisayan IX/A/1	940	250	-	-	-	-	-	-
15	1994/95	Talisayan IX/A/3	1.012	250	-	-	-	-	-	-
16	1994/95	Talisayan IX/A/4	747	200	-	-	-	-	-	-
17	1994/95	Talisayan IX/C/5	-	-	-	-	-	-	763	200
18	1994/95	HTI Muara Lesan	-	-	-	-	1.018	250	-	-
19	1994/95	Tumbit Melayu I	-	-	321	100	-	-	-	-
20	1994/95	Sukan Tengah II	-	-	378	100	-	-	-	-
21	1995/96	Tasuk II	-	-	326	100	-	-	-	-
22	1995/96	Talisayan IX/A/2	1.547	400	-	-	-	-	-	-
23	1995/96	Talisayan IX/B/1	898	235	-	-	-	-	-	-
24	1995/96	Talisayan IX/B/2	900	215	-	-	-	-	-	-
25	1995/96	Tanjung Perangat I	-	-	348	100	-	-	-	-
26	1995/96	Tumbit Melayu II	-	-	352	100	-	-	-	-
27	1996/97	Talisayan IX/B/3	-	-	-	-	-	-	1.594	350
28	1996/97	Tanjung Perangat II	-	-	370	100	-	-	-	-
29	1996/97	Gurimbang	-	-	383	110	-	-	-	-
30	1997/98	Malinau Segah VIII.c/C/2	1.371	375	-	-	-	-	-	-
31	1997/98	Malinau Segah VIII.c/C/3	1.115	300	-	-	-	-	-	-
32	1997/98	Malinau Segah VIII.c/C/6	1.023	300	-	-	-	-	-	-

Appendix VI. (continuation)

No	Year	Location UPT (Settlement Unit)	Trans Umum		Bangdep		HTI Trans		Banpres	
			People	HH	People	HH	People	HH	People	HH
33	1997/98 – 2003	Biatan Lempake IX.c/B/1	1.204	300	-	-	-	-	-	-
34	2004	Sukan Tengah III	761	200	-	-	-	-	-	-
35	2005	Sukan Tengah IV	701	150	-	-	-	-	-	-
		Jumlah	**21.528**	**8.159**	**4.493**	**1.206**	**2.071**	**550**	**2.357**	**550**

Source: Data Kabupaten Berau Dalam Angka 2008 BPS Kab. Berau

Appendix VII. Infrastructure dynamics in the last 20 years in Berau

No	Description	1988	1998	2003	2008
1.	**Road (km)**				
	Asphalted Road	-	147,84	172,02	586,59
	Paved/Graveled Road	-	268,87	822,66	632,43
	Bare-land Road	-	324,60	563,00	107,60
	Others	-	60,00	-	-
	Total	**-**	**801,31**	**1.557,68**	**1.326,62**
2.	**Education (unit)**				
	Pre-School (or equiv.)	19	25	34	64
	Elementary School (or equiv.)	117	144	161	152
	Middle-School (or equiv.)	15	20	38	36
	High-School (or equiv.)	5	5	8	13
	University	-	1	2	3
	Total	**156**	**195**	**243**	**268**
3.	**Health**				
	Hospital (unit)	1	1	1	1
	Health Center (unit)	11	10	14	17
	Sub-Health Center (unit)	47	65	71	84
	Medical Doctor (pers)	10	33	25	58
	Paramedic (pers)	66	135	160	368
	Nurse (pers)	10	78	53	80
4.	**Economic Facilities**				
	Market (unit)	6	-	-	-
	Permanent Shops/Rest-aurant (unit)	91	-	-	8.037
	Non-permanent Shop (unit)	691	-	-	-
	Others	38	-	-	-
	Dealer (pers)	-	-	-	1.320
	Street Vendor (pers)	-	-	-	1.409
	Stall (unit)	-	-	-	208

Source: Data Kabupaten Berau Dalam Angka 1988, 1998, 2003 & 2008 BPS Kab. Berau

Appendix VIII. Natural resource management dynamics in the last 20 years in Berau

No	Description	1988	1998	2003	2008
1.	**Forestry**				
	Protection (ha)	-	353.775.00	353.775.00	208,374.00
	Limited Production (ha)	-	786.975.00	786.975.00	[?]
	Permanent Production (ha)	-	758.049.00	752.925.00	589,567.00
	Conservation (ha)	-	328.950.00	334.025.00	[?]
	Shrubs (ha)	11,363.92	-	-	[?]
	Others (ha)	2,232,468.37	-	-	[?]
	Total	**2,243,832.29**	**2.227.749**	**2.227.700**	**[797.941 ?]**
2.	**Agriculture (ha)**				
	Wetland Paddy	2,416.00	1,700.00	3,032.00	4,135.00
	Upland Paddy	2,314.70	3,429.00	6,375.00	7,106.00
	Annual Crops	1,066.70	2,819.00	2,088.00	1,978.00
	Vegetables	191.13	845.00	248.00	946.00
3.	**Small-Scale Estate (ha)**				
	Coconut	1.627,33	11,155.00	11,695.00	2.908,3
	Rubber	3,00	753.50	743.00	694,2
	Coffea	241,00	1,971.00	2,233.00	903,1
	Clove	27,10	108.00	45.00	18,0
	Cacao	218,80	3,960.00	5,895.00	4.297,5
	Pepper	248,08	726,0	907	1.148,0
	Candle-nut	-	555,0	825	-
	Kapok	-	54,0	90	-
	Others	-	-	-	325,5
4.	**Small-Scale Husbandry (unit)**				
	Cow	2.284	5.238	6.235	7.847
	Buffalo	67	111	135	125
	Horse	13	67	74	42
	Goat	1.461	2.901	3.866	5.295

Appendix VIII. (continuation)

No	Description	1988	1998	2003	2008
	Pig	299	1.420	2.112	2.619
	Duck	7.004	4.625	7.909	10.973
	Local Chicken	76.459	100.077	120.655	251.992
	Breed Chicken	21.558	49.375	75.800	687.988
5.	**Natural Resource Production**				
	Log/Round Wood (m^3)	696.806,8300	902.678,7600	374.191,20	267.348,46
	Sawn Timber (m^3)	12.199,2204	14.230,6970	23.556,12	315.677,40
	Total	**709.006,0504**	**916.909,4570**	**397.747,32**	**583.025,86**
	Coal (ton)	-	1.977.276	7.720.002	13.502.262
	Pulp/Indistrial Timber Estate (ton)	-	175.067	101.477	57.670
	CPO	-	-	(2004) 60.504	132.243

Source: Data Kabupaten Berau Dalam Angka 1988, 1998, 2003 & 2008 BPS Kab. Berau

Appendix IX. List of timber concessionaires in the last 20 years in Berau

No	1988	1998	2003	2008/2009
A.	**HPH (Timber Concessionaires)**			
1.	PT Daisy Timber	PT. Daisy Timber	PT. Daisy Timber	PT. Daisy Timber
2.	PT Berau Timber Coy			-
3.	PT Dwi Warna Timber			-
4.	PT Sumalindo Lestari Jaya	PT. Sumalindo Lestari Jaya	PT. Sumalindo Lestari Jaya IV	PT. Sumalindo Lestari Jaya IV
5.	PT Tabalar Wood Industries (KL I)			-
6.	PT Pantai Harapan Coy (Harpindo)			-
7.	PT Hanurata Coy LTD			-
8.	PT Metro Jaya Buana (Troyana)			-
9.	PT Madya Kara Pasifik Raya (MPR)			-
10.	PT Rejosari Bumi			-
11.	PT Sentosa Kalimantan Jaya			-
12.	PT Sumber Buana Sejahtera			-
13.	PT Puji Sampurna	PT. Puji Sampurna	PT. Puji SAmpurna	PT. Puji Sempurna
14.	PT Meranti Samarinda Kalimantan			-
15.	PT Rangga Kesuma			-
16.	PT Inhutani I Berau	PT. Inhutani I	PT. Inhutani I	PT. Inhutani I
17.	-	-	-	PT. Aditya Kirana Mandiri
18.	-	-	-	PT. Mardhika Insan Mulia
19.	-	-	-	PT.Amindo Wana Persada
20.	-	-	-	PT. Widya Artha Perdana
21		-	-	PT.Wana Bhakti Persada Utama
22.	-	-	-	PT. UTama Damai Indah Timber
23.	-	-	-	PT. Karya Lestari
B.	**HPHTI (Timber Estates)**			
24.	-	PT. Tanjung Redeb Hutani	PT. Tanjung Redeb Hutani	PT. Tanjung Redeb Hutani

Appendix IX. (continuation)

No	1988	1998	2003	2008/2009
25.	-	-	-	PT. Belantara Pusaka
26.	-	-	-	PT. Sumalindo Lestari Jaya I

Source: Data Kabupaten Berau Dalam Angka 1988 BPS Kab. Berau

Appendix X. List of crop-estate enterprise in Berau

No	Year	Company	Core Bussiness	Are (ha)	Permit	Remarks
1.	1996	PT Sentosa Kalimantan Jaya	Oil Palm	6.800,00	34/HGU/BPN/1996	HGU
2.	1997	PT Jabontara Eka Karsa	Oil Palm	14.006,00	70/HGU/BPN/1997	HGU
3.	2004	PT Tanjung Buyu Perkasa Plantation	Oil Palm	4.890,00	99/HGU/BPN/2004	HGU
4.	2004	PT Intimung Kahuripan Indonesia	Oil Palm	2.900,00	SK Bupati No.47 tahun 2004 (proses perpanjangan)	Loc. Permit
5.	2005	Koperasi Long Kelatak	Oil Palm	2.400,00	SK Bupati No.278.a tahun 2005	Loc. Permit
6.	2007	PT Dwi Wira Lestari	Oil Palm	12.649,00	Kadastral 68-16.05-2007	HGU Process
7.	2007	PT Tanjung Buyu Perkasa Plantation	Oil Palm	2.260,00	SK Bupati No.518 tahun 2007	Loc. Permit
8.	2007	PT Yudha Wahana Abadi	Oil Palm	8.782,94	62-HGU-BPN RI-2007	HGU
9.	2007	PT Multigreen Semperna Plantation	Oil Palm	5.750,00	SK Bupati No.152 tahun 2007	Loc. Permit
10.	2007	PT Performa Kalimantan Sejati	Oil Palm	5.367,00	SK Bupati No.565 tahun 2007	Loc. Permit
11.	2007	PT Berau Sawit Sejahtera	Oil Palm	8.400,00	SK Bupati No.364 tahun 2007	Loc. Permit
12.	2007	PT Sanggam Mukti Kahuripan	Oil Palm	1.400,00	SK Bupati No.498 tahun 2007	Loc. Permit
13.	2008	PT Anugrah Surya Mandiri	Oil Palm	3.700,00	SK Bupati No.101 tahun 2008	Loc. Permit
14.	2008	PT Inti Energi Kaltim	Oil Palm	1.209,40	36-HGU-BPN RI-2008	HGU
15.	2008	PT Indo Alam Makmur	Oil Palm	7.000,00	SK Bupati No.244 tahun 2008	Loc. Permit
16.	2008	PT Satu Sembilan Delapan	Oil Palm	6.010,00	SK Bupati No.661 tahun 2008	Loc. Permit
17.	2008	PT Anugerah Agung Prima Abadi	Oil Palm	7.048,00	Kadastral 600/44/BPN-44/2008	HGU process
18.	2008	PT Indo Alam Makmur	Oil Palm	3.360,00	SK Bupati No.245 tahun 2008	Loc. Permit
19.	2008	PT Mahkota Jaya Abadi	Oil Palm	6.100,00	SK Bupati No.309 tahun 2008	Loc. Permit
20.	2008	PT Berau Karetindo Lestari	Oil Palm	7.023,70	44-HGU-BPN RI-2008	HGU
21.	2008	PT Hutan Hijau Mas	Oil Palm	7.287,88	19-HGU-BPN RI-2008	HGU

Appendix X. (continuation)

No	Year	Company	Core Bussiness	Are (ha)	Permit	Remarks
22.	2008	PT Natura Pasifik Nusantara	Oil Palm	4.435,26	45-HGU-BPN RI-2008	HGU
23.	2008	PT Malindomas Perkebunan	Oil Palm	7.971,00	18-HGU-BPN RI-2008	HGU
24.	2008	PT Pradana Tiara Agromas	Oil Palm	11.000,00	SK Bupati No.1 tahun 2008	Loc. Permit
25.	2008	PT Bina Karya Nuansa Sejahtera	Oil Palm	13.665,00	SK Bupati No.198 tahun 2008	Loc. Permit
26.	2008	PT Tanjung Buyu Perkasa Plantation	Oil Palm	471,62	35-HGU-BPN RI-2008	HGU Process
27.	2009	PT Gunta Samba Jaya	Oil Palm	6.673,00	41-HGU-BPN RI-2009	HGU
28.	2009	PT Tanjung Buyu Perkasa Plantation	Oil Palm	2.016,39	4-HGU-BPN RI-2009	HGU
		Total		**170.576,19**		
29.	2006	Koperasi Lakawan	Rubber	700,00	SK Bupati No.345 tahun 2006	Loc. Permit
30.	2006	PT Berau Agro Kusuma	Rubber	2.350,00	SK Bupati No.146 tahun 2006	Loc. Permit
		Total		**3.050,00**		
31.	2006	Koperasi Mangassan	Aloe-Wood	2.900,00	SK Bupati No.522.22/460/Kpts/DKB.III	Loc. Permit
32.	2007	PT Berau Prima Abadi	Aloe-Wood	1.580,45	SK Bupati No.119 tahun 2007	Loc. Permit
		Total		**4.480,45**		
33.	2006	PT Hijau Sanggam Persada	Rattan	2.500,00	SK Bupati No.522.22/370/Kpts/DKB.III	Loc. Permit
34.	2007	Koperasi Berdikari	Rattan	1.004,00	SK Bupati No.3 tahun 2007	Loc. Permit
		Total		**3.504,00**		

Source: Data Dinas Kehutanan & Dinas Perkebunan Kab. Berau, 2009 (Modifikasi).(HGU= Bussiness Permit; Loc.Permit= Location Permit)

Appendix XI. List of coal mining industry in Berau

No	Year	Company	Area (ha)	Location (Sub-District/Village)	Legal Permit (No of Decree)	Remarks
1.	1983	PT Berau Coal	118.400,00	Gunung Tabur	J2/JI.DU/12/83 Tgl 26 April 1983	Permit PKP2B (Central Government)
2.	2004 - 2024	PT Pelita Makmur Sejahtera	1.030,00	Teluk Bayur	540/103/PTB.II/III/2004 Tgl 31 Maret 2004	Production
3.	2004 – 2024	KP Berau Energi Mandiri	708,83	Teluk Bayur	540/106/PTB.II/III/2004 Tgl 31 Maret 2004	Production
4.	2004 – 2024	PT Anco Millenium Indonesia	9.339,00	Pulau Derawan	540/76/PTB.II/III/2007 Tgl 11 Maret 2004	
5.	2006 - 2016	PT Mega Alam Sejahtera	3.274,00	Teluk Bayur & Sambaliung	380 Tahun 2006 Tgl 17 Oktober 2006	
6.	2007 - 2017	PT Berau Bara Energi	5.000,00	Gunung Tabur	435 Tahun 2007 Tgl 18 September 2007	Production
7.	2007 – 2017	PT Nusantara Energi	4.793,00	Merancang Ulu & Gunung Tabur	523 Tahun 2007 Tgl 15 Nopember 2007	
8.	2009 – 2019	PT Sungai Berlian Bakti	1.000,00	Teluk Bayur	80 Tahun 2009 Tgl 16 Maret 2009	
		Total	**143.544,83**			

Source: Data Dinas Pertambangan Kab. Berau, 2009 (Modifikasi).

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The overall emission and proportion of emission that is associated with negative, low and high opportunity cost is presented in Figure 2. Conversions to oil palm is shown to be in the high end both in the opportunity cost curve of emissions, due to its NPV which by far is highest compared to any other land use systems. The proportion of emission from conversion to oil palm increases over time. Logging is the single activity that causes the highest proportion of emissions with lower benefit than oil palm conversion per unit C emitted, especially if the conversion is from logged over forest. From ICRAF study on carbon footprint from oil palm plantation development, when the land cover of C-stock lower than 40 t/ha, e.g., grassland, shrubs, is converted to oil palm, there is no C-debt in the long run (assuming 25 years rotation). It is interesting to note here is the large portion of emission that is associated with establishment of forest plantation, which seems to be increasing in the more recent period. The forest plantation to supply raw materials to pulp and paper industry has been established in logged-over forest and undisturbed forests.