



HAL
open science

Reducing Emissions from Deforestation and Degradation in Cameroon—Assessing costs and benefits

Valentin Bellassen, V. Gitz

► **To cite this version:**

Valentin Bellassen, V. Gitz. Reducing Emissions from Deforestation and Degradation in Cameroon—Assessing costs and benefits. *Ecological Economics*, 2008, 68 (1-2), pp.336-344. 10.1016/j.ecolecon.2008.03.015 . hal-01149369

HAL Id: hal-01149369

<https://hal.science/hal-01149369>

Submitted on 29 Jun 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1 Title: Reducing Emissions from Deforestation and Degradation in Cameroon – Assessing
2 costs and benefits

3
4 Journal: Ecological Economics, 68 (2008) 336 – 344

5
6 Authors: Valentin Bellassen¹, Vincent Gitz²

7
8 Affiliation: ¹ Ecole Normale Supérieure (ENS)

9 ² Centre International de Recherche sur l'Environnement et le Développement
10 (CIRED)

11
12 Present addresses: ¹ 34, rue Boussingault, 75013 Paris (France)

13 ² CIRED, 45 bis, av. de la Belle Gabrielle 94736 Nogent sur Marne
14 CEDEX (France)

15
16 Corresponding address: Valentin Bellassen, vbella@lsce.ipsl.fr
17

18 **Abstract**

19
20 A new momentum is underway to account for emissions from “avoided deforestation
21 and degradation” at the United Nations Framework Convention on Climate Change
22 (UNFCCC). This paper assesses the feasibility of one of the Reducing Emissions from
23 Deforestation and Degradation (REDD) mechanisms currently discussed, namely that of
24 “Compensated Reduction”, in the case of Cameroon. Here we assess the differential revenues
25 that a farmer could get from one hectare of land out of two alternative land-uses: shifting
26 cultivation, the traditional land-use pattern in southern Cameroon, or carbon credits as
27 compensation for the conservation of primary forest. It is found that a break-even price of
28 \$2.85 per ton of carbon dioxide equivalent would level shifting cultivation with
29 “Compensated Reduction”. This result suggests that at current carbon prices, and
30 independently from variations in the discount rate, it could already be more profitable to
31 preserve the primary forest rather than to log it in order to grow crops.

32
33 Key words: deforestation, cost-benefit analysis, Cameroon, forest, slash-and-burn, agriculture;
34 carbon; opportunity costs

35 **Introduction**

36
37 Each year, an estimated 13 million hectares of tropical forest are destroyed, leading
38 14,000-40,000 species to extinction and emitting 2.1 Gt of carbon, that is 17% of total
39 anthropogenic emissions of greenhouse gas (Kremen, *et al.*, 2000, Rogner, *et al.*, 2007).
40 These figures show why the Land-Use, Land-Use Change and Forestry (LULUCF) sector
41 ought not to be dismissed as a credible part of the solution to climate change (UNFCCC,
42 2007). It is often argued that planting trees will not sequester nearly enough carbon to offset
43 all industrial emissions, and it is quite true. However, since deforestation is an important
44 source of emissions, reducing it is a key action to tackle climate change, not only to preserve
45 stocks in forest ecosystems, but also to maintain forest sinks and their capacity to store carbon
46 in the future (Gitz and Ciais, 2004). Indeed the potential amount of carbon that could be
47 conserved and sequestered through an aggressive program of such changes in LULUCF

48 practices over the first half of the 21st century was estimated at 12-15% of the “business-as-
49 usual” fossil-fuel emissions over the same time period (Brown, 1999).

50 This paper is focused on one particular idea for tackling the problem of deforestation,
51 that is “Compensated Reductions” (CR), and on one particular country, Cameroon. Cameroon
52 was especially interesting because it is one of the six countries forming the Congo Basin, an
53 area that contains the second largest area of contiguous rainforest after the Amazon, making
54 up to 15% of total remaining rainforests in the world and 90% those remaining in Africa
55 (Justice, *et al.*, 2001).

56 Cameroon is approximately the same size as Spain and is often referred to as “Africa
57 in miniature”. The continent’s main vegetation types are represented in the country: the north
58 is covered by Sudano-sahelian savanna, the centre by high altitude moist savanna, and the
59 south by tropical rainforests. It could as well be described as “African deforestation in
60 miniature” since the causes of deforestation in this country are diverse and complex, and
61 could be considered as a summary of the problem in Central Africa. Another advantage of
62 Cameroon is that it is relatively well documented compared to the other countries of the
63 Congo Basin.

64 In this paper we seek to find economic rationale for forest preservation versus shifting
65 cultivation in Cameroon. To do so, we compute the “break-even price” of carbon at which
66 these options yield comparable revenues. Several studies have already undertaken this
67 computation for other countries (Osafu, 2005, Silva-Chavez, 2005, Grieg-Gran, 2006,
68 Nepstad, *et al.*, 2007). However these analysis often rely on other studies for their assessment
69 of land-use returns, and therefore never detail the uncertainty associated with crop prices
70 variations or assumptions on other parameters. Here we explicitly model the revenues of the
71 different land-use, and test the robustness of our analysis against parameters uncertainty
72 through a Monte-Carlo procedure and a sensitivity analysis. This assessment of uncertainty is
73 especially important in the case of Cameroon where data is not always perfectly reliable.

74 We limited the scope of our analysis to the opportunity costs of CR, and did not assess
75 the transaction costs and the risks associated with the actual implementation of programs and
76 projects aimed at reducing deforestation.

77 **Methods**

78 **Compensated Reduction**

79 Compensated Reduction (CR) is one of the “Reducing Emissions for Deforestation
80 and Degradation” (REDD) mechanisms currently being discussed at the UNFCCC. Other
81 competing proposals are the “nested approach” and the “compensating fund” (Estrada, 2007,
82 Federative Republic of Brazil, 2007). As first described in Santilli *et al.*, 2005, the CR
83 mechanism consists in setting economic incentives to reduce emissions from tropical
84 deforestation by giving a monetary value to carbon stored in trees, thereby creating a financial
85 incentive for forest protection by turning tropical forests into valuable assets and increasing
86 the likelihood that they will be protected. As a result of the recent entry into force of the
87 Kyoto Protocol (KP), as well as the start of the EU Emissions Trading Scheme (EU ETS),
88 most developed economies now are carbon-constrained and for them carbon is no longer an
89 economic externality. CR seeks to use this monetary value of carbon by creating an incentive
90 to reduce deforestation emissions, which can then be turned into a tradable commodity
91 (Santilli, *et al.*, 2005).

92 Under CR, developing countries that elect to voluntarily reduce their national GHG
93 emissions from deforestation, using their historical (for example, 1980-1990) annual average
94 rate of deforestation as a baseline, would be authorized to sell carbon certificates to
95 government and private investors *post facto*. Measurable and quantifiable environmental

96 benefits will be required first before a country can receive carbon credits. National
97 deforestation will be measured and verified by robust satellite imagery techniques and, once
98 the emission credits are sold, participating developing countries would agree not to increase –
99 or further reduce – deforestation rates in future commitment periods (provided developed
100 countries fulfill their reduction obligations). As stated by European negotiators at the
101 UNFCCC, the national approach resolves the issue of “leakage” within national boundaries
102 (Bouyer and Merckx, 2007): if a conservation project leads to an increase of deforestation
103 elsewhere in the country, the national emissions from deforestation will not go down and
104 credits will not be issued.

105 CR would nevertheless have to deal with the issue of “permanence” that is used to
106 plague forestry carbon credits: as CR sets a “no regret” target, it has to guarantee the carbon
107 credits of the first commitment period against an increase in deforestation during the second
108 commitment period. It could do so by setting up an insurance fund (Federal Republic of
109 Germany, 2007). Based on similar existing schemes in the voluntary carbon market
110 (Bellassen and Leguet, 2007), this could amount to a risk premium of around 20%. Thus, CR
111 credits may not suffer such high discounts as those estimated by Chomitz and Lecocq (2003)
112 for temporary forestry CDM credits.

113 The *ex post* valuation of avoided deforestation would nevertheless generate a liquidity
114 gap for participating countries and stakeholders. To bridge this gap, they could seek advance
115 financing to fund deforestation reduction programs from private investors or negotiate
116 agreements with bilateral and multilateral financial institutions, provided that an appropriate
117 liability mechanism can be agreed upon. The World Bank has already initiated a Forest
118 Carbon Partnership Facility that will provide advance funding. They could also issue
119 discounted carbon bonds, which could be redeemable in the future, subject to verification and
120 certification of reductions. Provided appropriate liability, responsibility, enforcement, and
121 verification mechanisms exist, an instrument like this is likely to create substantial incentives
122 to reduce tropical deforestation through market access.

123 CR explicitly aims at valuing the carbon content of tropical forests. It is far from a
124 perfect valuation since tropical forests provide many more ecosystem services than holding
125 carbon: they play a role in the local climate, they are a tremendous source of biodiversity, and
126 three quarters of the world’s population depend directly on them for medicinal plants
127 (Serageldin, 1992). But, as imperfect as this valuation mode is, the financial incentive it offers
128 to protect tropical forests could be strong enough to foster forest conservation in the tropics.
129 And it is this possibility that we are trying to assess in this paper.

130 The specificity of CR compared to other potential REDD mechanisms is the direct link
131 with the carbon markets issued from the Kyoto Protocol. The financial incentive provided by
132 other mechanisms, such as the compensating fund proposed by Brazil in the UNFCCC
133 negotiations (Federative Republic of Brazil, 2007), would likely be limited by the size of the
134 fund. Whereas the value of carbon credits, exchangeable on all carbon markets, would
135 probably have a wider range of variation. Their theoretical production cost, that is the
136 opportunity costs of foregoing shifting cultivation to the financial compensation, is therefore
137 especially worth assessing.

138 **An essential requirement of Compensated Reduction: reliable monitoring**

139 An absolute requirement for implementing CR is to have a reliable estimate of
140 deforestation rates. Indeed, only after the precise measure of reductions in deforestation rates
141 can compensation be awarded.

142 *Deforestation* – Through remote sensing, Tucker and Townshend (2000) estimated
143 that 90% of the scenes must be sampled, in order to obtain an estimate with an accuracy

144 within $\pm 20\%$ of actual deforestation rates. However, the scenes are generally available and it
145 is most often the analysis that is lacking (Zhang, *et al.*, 2005).

146 *Forest degradation* – Zhang, *et al.* (2005) managed to discern primary forests from
147 degraded forests on satellite images in Central Africa. If this result proves to be repeatable
148 and reliable, a CR scheme could even be applied to the loss of carbon resulting from selective
149 logging. However, since it is still uncertain, we chose here to pursue only the study of CR as
150 applied to deforestation *stricto sensu*.

151 **State of southern Cameroon's Forested Lands**

152 Cameroon possesses an estimated 17 million hectares of tropical rainforest in the
153 southern part of the country, that is about one-tenth of the remaining rainforests of the Congo
154 Basin (Sunderlin, *et al.*, 2000). Estimates of the extent of closed canopy moist tropical forests
155 range from 155,000 km² (33 percent of national territory) to 206,000 km² (44 percent of
156 national territory) (Essama-Nssah and Gockowski, 2000). That is all the more worrisome
157 since Cameroon has the highest percentage of logged forest of any African nation with
158 substantial rainforest. The southern part of Cameroon, where tropical forest lies, has
159 traditionally been sparsely populated: in 1987, the average density of rural population in
160 southern Cameroon was only 8.3 inhabitants per km². This allowed shifting cultivation to be
161 practiced without excessive pressure on the rainforest. Depending on the sources, shifting
162 cultivation is estimated to provide for up to 20-50 people per km² in a sustainable way (Ndoye
163 and Kaimowitz, 2000). However, this is currently changing and the rainforest now faces two
164 dangerous threats: forest degradation and deforestation.

165
166 *Forest degradation* – The first threat is forest degradation. It is often due to
167 unsustainable logging and its consequences. Since roads or railroads are scarce in the region,
168 wood exploitation is costly and most of the time, it only makes economical sense to remove
169 the very few highly valuable trees such as Okoumé. On average, selective logging removes
170 only one tree per hectare and 10% of canopy cover, and overall it is only responsible for only
171 10% of the annual national loss of biomass (Justice, *et al.*, 2001). But even such “surgical”
172 removals are devastating for the forest ecosystem: in terms of direct consequences, it removes
173 20-35% of the total carbon amount and threatens the survival of the targeted tree species in
174 the long run. It also brings along a lot of other “collateral” damages: to export these trees,
175 roads are cut through the forest, leading to further damages and opening an easy access for
176 poachers, hunters, and eventually shifting cultivators (Mertens and Lambin, 2000).

177
178 *Deforestation stricto sensu and deforestation factors* – Although forest degradation is
179 often considered to be the most important threat to rainforests in the Congo Basin (Zhang, *et*
180 *al.*, 2005), the situation in Cameroon is different. Deforestation *stricto sensu*, that is clear-
181 cutting, has indeed become of comparable importance. As convincingly shown by Sunderlin
182 (2000), declining prices and subsidies for coffee and cocoa during the late 1980s crisis shifted
183 agricultural production from such cash crops to food crops (plantain, cassava, corn, yam, ...).
184 And as food crops require much more land than cash crops since a lot of them have to be left
185 fallow every year, this shift triggered a measurable increase in deforestation.

186 The general impoverishment of the country led many city-dwellers to migrate back to
187 the rainforested provinces: except for the South Province, all the provinces in the forest zone
188 of Cameroon had, at least until recently, a large positive migratory balance (Mertens and
189 Lambin, 2000). Consequently, the population pressure on the rainforest also dramatically
190 increased (+45% over the post-crisis decade).

191 As a result, deforestation due to shifting cultivation and fuelwood harvesting, both
192 being fuelled by population growth, has become a priority concern (Ndoye and Kaimowitz,

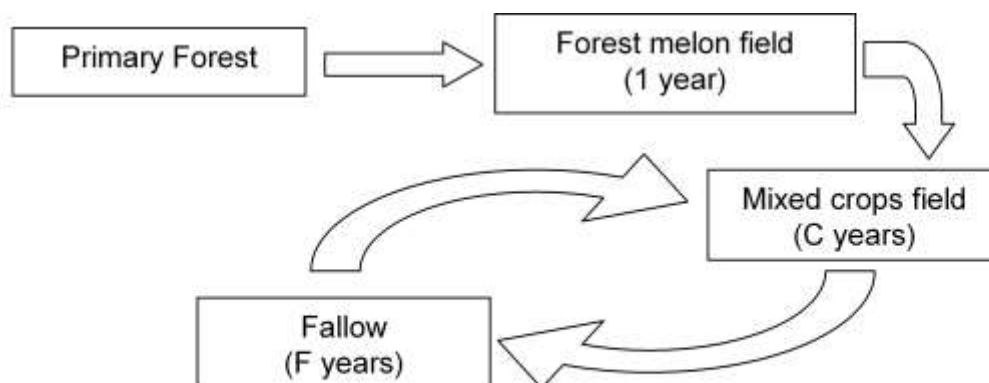
193 2000): agriculture has been rated by CARPE as a severe threat – one “expected to cause
194 irreversible damage within the next 10 years” – and it is widely reckoned to be the cause of
195 80-95% of total deforestation in Cameroon (CARPE, 2005). And while these estimates are to
196 be taken with caution, it is alarming that the models for the Congo Basin point out to a forest
197 loss on the order of 50% by 2050 if nothing is done (Zhang, *et al.*, 2002). Taking an average
198 figure of 309 tons of carbon emitted per hectare of deforested land (Palm, *et al.*, 2000), this
199 would amount to a total emission of around 2.6 GtC.

200 **A simple cost model for shifting cultivation**

201 The process of shifting cultivation in the Congo Basin has been described in numerous
202 studies. It is the traditional agricultural technique, and it is still in practice in most fields in
203 Cameroon (Grieg-Gran, 2006). Figure 1 is a way of representing it, based on Brown’s
204 description of the process (Brown, 2004).

205 During the long dry season, the forest is cleared and during the following rainy season,
206 melons are planted, sometimes with plaintain. After the harvest, the old melon field (“fulu”) is
207 cultivated with mixed crops (plaintain, cassava, groundnuts, corn, ...) for C (up to 3) years.
208 After that time, yield becomes so low that the field is put to fallow for a variable F (4 to 23)
209 number of years (Palm, *et al.*, 2000).

210 By furthering this description of shifting cultivation, we want build a simple economic
211 model able to compute the average revenue per hectare R of a parcel over N years following
212 the decision to put it under this use.
213



214 **Figure 1. The process of shifting cultivation (based on Brown's description)**

215 Figure 1. The process of shifting cultivation (based on Brown's description)

216

217 *Hypothesis* – To facilitate the calculations, the model simplifies the process described
218 in Figure 1 thanks to three seemingly reasonable assumptions:

219 1) The fallow time is assumed to be short enough so that the field doesn’t grow back
220 to a primary forest. Thus, we only consider the cycle from mixed crop field back to mixed
221 crop field, with one year of melon only when deforestation first occurs. According to most
222 studies, fallow time rarely exceeds 20-25 years.

223 2) As data is most reliable for plantain and cassava, we assumed that each hectare was
224 planted half in plantain and half in cassava. This assumption is unlikely to introduce a strong
225 bias in results as these two crops are by far the most commonly grown subsistence crops in
226 Cameroon (Kamegne and Degrande, 2004, FAO, 2005).

227 3) We set C, the cultivation time, and F, the fallow time, as constants. This is unlikely
228 to be strictly true since farmers adapt their choices to labour and land availability, crop prices

229 and other factors (Dvorak, 1992). However, since the main output we are interested in is an
 230 average over time and space, it is not a great concern.

231
 232 *Estimated revenue* – Based on this, the average revenue is obtained by the formula:

$$233 R = \sum_{I=1}^N (1-\alpha)^I * R_I \text{ where } R_I \text{ is the revenue during year } I \text{ and } \alpha \text{ is the discount rate.}$$

234 The average revenue of a cultivated patch of land is the difference between the price
 235 of total output and the cost of total input. For shifting cultivation as it is practiced in
 236 Cameroon, the only input is individual labour: there is very little use of fertilizers, machinery
 237 or even animal traction (Brown, 2004). The average revenue R_I of a cultivated parcel at year I
 238 is therefore given by:

$$239 R_I = Y_I * P_I - L_I \quad (1)$$

240 where Y_I is the yield of the crop cultivated at year I , P_I its producer price and L_I the annual
 241 opportunity cost of labour at year I .

242 The opportunity cost of individual labour (that is here, how much would the farmer get
 243 from another activity since he doesn't pay himself for farming) is difficult to value. We
 244 decided to approximate it from the median income in Cameroon, weighed by the average land
 245 area cultivated by each farmer:

$$246 L_I = \frac{MI \times NF}{AL} \quad (2)$$

247 where L_I is the annual opportunity cost of labour at year I , MI is the median income in
 248 Cameroon, AL is the total area of agricultural land and NF is the total number of farmers (see
 249 paragraph on *parameters estimation* for the actual figures).

250 **A simple cost model for Compensated Reduction**

251 As opposed to cultivating the land patch over N years, the stakeholder could make the
 252 choice to integrate it into a CR scheme. In order to compare these two alternative, we propose
 253 the following model for the revenues of CR. Since CR takes place at the national scale, the
 254 compensation has to be divided among all the patches that are under a conservation plan: the
 255 choice of conservation rather than cultivation has to be made for all the patches, whereas only
 256 those which fall under the historical threshold D_0 are compensated for.

257
 258 *Model hypothesis* – The commitment period after which the deforestation rate is
 259 monitored and after which compensation is received is 5-year long.

260
 261 *Estimated revenue* – Based on this model, the average revenue per hectare (R') of
 262 forest that would be conserved under the "Compensated Reduction" scenario is given by the
 263 formula:

$$264 R' = \frac{\text{Total revenue for "avoided emissions" compared to historical threshold}}{\text{Total land under "conservation"}}$$

$$265 R' = \frac{(D_0 - D_5') * 5 * \text{Carbon price} * \Delta_{\text{carbon}} * \theta * (1-\alpha)^5}{(D_5 - D_5') * 5}$$

$$R' = \frac{(D_0 - D_5')}{(D_5 - D_5')} * C_P * \Delta_C * \theta * (1-\alpha)^5 \quad (3)$$

266

267 where D_0 is the historical surface of yearly deforested land
 268 D_5 is the surface of yearly deforested land during the 5 years under the “business as
 269 usual” scenario
 270 D_5' is the surface of yearly deforested land during the 5 years under the “Compensated
 271 Reduction” scenario
 272 C_P is the price of a ton of carbon
 273 Δ_C is the difference of time-averaged carbon content between a primary forest and a
 274 field under shifting cultivation
 275 α is the discount rate
 276 θ is the conversion factor from C to CO₂e
 277 The discount rate is taken into account because under the chosen model of
 278 Compensated Reduction, the compensation is only gotten after the commitment period. The
 279 length of the commitment period is assumed to be 5 years, as the first commitment period of
 280 the Kyoto Protocol, and the second period of the European Trading Scheme.

281 $\frac{(D_0 - D_5')}{(D_5 - D_5')}$ in equation (3) represents a “dilution” of the compensated revenue: under a
 282 CR scheme, compensation is awarded at the national level for every hectare preserved under
 283 the historical baseline ($D_0 - D_5$). However, if deforestation pressure is expected to increase (D_5
 284 $> D_0$), a policy that attempts to bring it under control would have to spread this revenue over
 285 more land ($D_5 - D_5'$) than the hypothetical surface corresponding to the revenue ($D_0 - D_5'$).

286 **Parameters estimation**

287 In order to compare these two potential sources of revenue, it is necessary to estimate
 288 the different parameters of the two models.

289 - Estimated revenue of shifting cultivation: $R = \sum_{t=1}^N (1 - \alpha)^t \times (Y_t \times P_t - L_t)$ (4)

290 We set the discount rate α at 5%, as is sometimes the case in economic studies focused
 291 on Central Africa (Sankhayan and Hofstad, 2001). N was set at 50 years. This typical
 292 timeframe for 2 generations is long enough to compare cumulated revenues for an initial land-
 293 use decision. Other comparable studies have limited their timeframe to 30 years (Grieg-Gran,
 294 2006).

295 *Price, yield, and cost of labour estimates (P_t , Y_t , and L_t)* – Data on yields and prices
 296 are difficult to obtain for Cameroon. Moreover, their meaningfulness is questionable since, as
 297 it is true that most farmers sell part of their crops on local markets, the bulk of the production
 298 is for self-consumption: for example, only an estimated 33% of the cassava in each
 299 exploitation is sold on markets (Dury, *et al.*, 2004).

300 One method to estimate both price and yield is to take the FAO average data for
 301 Cameroon. It is often not deemed to be very reliable since it is based on scarce, poorly
 302 checked reports, and on modelling. However, in our case, it corresponded well with other
 303 studies on Southern Cameroon, taking into account the discrepancy between retail price and
 304 producer price as estimated by Dury *et al.* (2004). The actual figures are displayed in table 1.
 305 As for the three parameters used to compute the opportunity cost of labour (median income,
 306 total agricultural land and total number of farmers), we relied on national statistics as
 307 provided by the FAO (2005) and the UNDP (2007): $MI = 730 \text{ $.year}^{-1}$, $AL = 7.2 \text{ million ha}$,
 308 $NF = 3.7 \text{ million}$ (this figure pools together all agricultural workers, but as there is 4 times as
 309 much cropped land as pastures, this approximation should not be too much biased). L_t was
 310 thus set at $380 \text{ $.ha}^{-1}.\text{year}^{-1}$.

311

	Plaintain	Cassava			
Yield (t.ha ⁻¹)	6 ± 0.3	12.5 ± 1.5			
1996 – 2005 Mean (± annual standard deviation)					
Producer Price (\$.t ⁻¹)	90.9 ± 19.7	90.8 ± 19.3			
1996 – 2002 Mean (± annual standard deviation)					
Table 1. FAO data for crop prices and yields in Cameroon (Source: FAO (2005))					

312

313 - Estimated revenue of Compensated Reduction: $R' = \frac{(D_0 - D_5')}{(D_5 - D_5')} * C_P * \Delta_C * \theta * (1 - \alpha)^5$ (5)

314 We set the same $\alpha = 5\%$, and $C_P = 27.3 \text{ \$.tCO}_2\text{e}^{-1}$ which was the price of a second period
 315 credit on the European Carbon Exchange (ECX) on May 15th, 2007. θ is the conversion factor
 316 from C to CO₂e.

317 *Time-averaged carbon content estimate (Δ_C)* – At climax, tropical forests are net
 318 emitters of N₂O and net absorbers of CH₄, the two other major greenhouse gas. However,
 319 since the difference in these fluxes is slight between tropical forests and other land-uses in the
 320 tropics, we chose to ignore these gases and to concentrate here on CO₂ fluxes (Palm, *et al.*,
 321 2000).

322 Several studies estimate the carbon content aspects of land use changes. We chose to
 323 use the one conducted by Palm *et al.* (2000) both because it fits our needs well and because
 324 most of her data was gathered in southern Cameroon (see table 2). Moreover, it has gained
 325 important international recognition as the IPCC relies heavily on it.
 326

	Primary rainforest	Degraded rainforest	Short fallow (C = 2, F = 4)	Medium fallow (C = 2, F = 9)	Long fallow (C = 2, F = 23)
Time-averaged carbon content (tC.ha ⁻¹)	306 ± 99 (Indonesia)	228 ± 27	4.52 ± 1.84	31.51 ± 8.29	77 ± 21.3
N.B.: These figures include above-ground biomass and litter. In this study, the changes in root and soil carbon is not accounted for as the measures were not conclusive. However, it is estimated not to vary much overall for medium and long fallow times (90-100% of soil C remaining for the 0-20 cm layer) and to decrease by 35% for short fallow times.					
Table 2. Time-averaged carbon content of different land-uses (adapted from Palm <i>et al.</i> (2000))					

327

328 *Deforestation rates* – Whereas numerous studies have estimated past deforestation
 329 rates (D₀) in Cameroon, very few venture at projecting future deforestation rates (D₅) for
 330 Cameroon in the future based on population growth, road construction, etc ... The finding of
 331 both types of studies are summarized respectively in table 3 and 4.
 332

332

Source	Period	Net annual deforestation rate		
Kotto-Same, <i>et al.</i> (1997)	1973 – 1988	~0.8 % (133 000 ha)		
Mertens and Lambin (2000)	1973 – 1986	0.28 % (286 ha)		
	1986 – 1996	0.76 % (515 ha)		
FAO (2001)	1980 – 1990	0.6 % (122 000 ha)		
	1990 – 2000	0.9 % (221 763 ha)		
Laporte, <i>et al.</i> (1995)	Mid 1970s – 1989	0.8 % (130 000 ha)		
Myers (1991)	1980 – 1988	1.2 % (200 000 ha)		
as cited in Ndoye and Kaimowitz (2000)				
Schmidt (1990)	1981 – 1990	0.5 % (80 000 ha)		
as cited in Ndoye and Kaimowitz (2000)				
WRI (1994)	1976 – 1986	0.8 % (190 000 ha)		
as cited in Ndoye and Kaimowitz (2000)				

Table 3. Historical deforestation rates in Cameroon

333
334

Source	Period	Net annual deforestation rate
Zhang and Justice (2001)	1990 – 2050	0.62 % (100 713 ha)
Justice, <i>et al.</i> (2001)	1990 – 2050	0.62-0.7 % (100 713-122 000 ha)

Table 4. Projected deforestation rates in Cameroon

335
336

337 For the model, we chose the same $D_0 = D_5 = 150\,000$ ha/yr (middle value of the range
338 of estimates $80\,000$ - $220\,000$ ha.yr⁻¹) and $D_5' = 0.95 \cdot D_5$ (this assumes that a CR scheme
339 would have reduced the deforestation rate by 5% during the 5 years). The underlying
340 assumption, backed by the review of projections displayed on table 4, is that the business as
341 usual rate of deforestation is the historical rate. In this case, there is no “dilution” and the CR
342 revenue is strictly proportional to the amount of land that “needed” protection.

343 Results

344 **Model run**

345 A summary of the parameters chosen to run the models is provided in table 5. By
346 running the models for a medium fallow time ($C = 2$ and $F = 9$) which seems to be a
347 reasonable average, we obtain the results displayed in table 6.

348

Parameter	Estimate used in models	Source
-----------	-------------------------	--------

(± indicates the standard deviation, as used in the monte-carlo procedure)

C (cultivation time)	2 years	Palm <i>et al.</i> 2000
F (fallow time)	9 years	Palm <i>et al.</i> 2000
α (discount rate)	5%	Sankhayan and Hofstad, 2001
Y _{IC} (cassava yield)	12.5 ± 1.5 t.ha ⁻¹	FAO 2005, Dury <i>et al.</i> 2004
Y _{IP} (plaintain yield)	6 ± 0.3 t.ha ⁻¹	FAO 2005, Dury <i>et al.</i> 2004
P _{IC} (cassava producer price)	90.8 ± 19.3 \$.t ⁻¹	FAO 2005, Dury <i>et al.</i> 2004
P _{IP} (plaintain producer price)	90.9 ± 19.7 \$.t ⁻¹	FAO 2005, Dury <i>et al.</i> 2004
L _I (opportunity cost of labour)	380 \$.ha ⁻¹ .year ⁻¹	FAO 2005, UNDP 2007
D ₀ (historical deforestation rate)	122 000 ha.year ⁻¹	see Table 3
D ₅ (deforestation rate under business as usual)	122 000 ha.year ⁻¹	see Table 3
D _{5'} (deforestation rate under business as usual)	115 900 ha.year ⁻¹	see Table 3
C _P (carbon price)	27.3 \$.tCO ₂ e ⁻¹	EU ETS 2005
Time-averaged carbon content of a primary forest	306 ± 99 tC.ha ⁻¹	Palm <i>et al.</i> 2000
Time-averaged carbon content of a cultivated patch of land	31.5 ± 8.29 tC.ha ⁻¹	Palm <i>et al.</i> 2000
Δ _C (difference in time-averaged carbon content of a primary forest and a cultivated patch of land)	274.5 tC.ha ⁻¹	Palm <i>et al.</i> 2000
θ (conversion factor from C to CO ₂ e)	3.67	NA

Table 5. Summary of parameters used in the models

349

	R (net present value of cultivation)	R' (net present value of CR)	Break-even price of CO ₂ (BEP)
Net present value per ha	\$ 2 221 ± 329	\$ 21 260 ± 807	\$ 2.85 ± 0.44
Total yearly net present value over the area affected by CR (5% of 122 000 ha)	M\$ 13.5 ± 2	M\$ 129.7 ± 5	

Table 6. Model outputs

± indicates the standard deviation as computed by the Monte-Carlo analysis

350

351

352

The standard error is obtained by a Monte-Carlo procedure of which variables are crop yields, crop prices, and the time-averaged carbon content of primary forests.

353 The break-even price of CO₂ (BEP) is the price of CO₂ from which it begins to be
 354 financially more interesting to undertake Compensated Reduction rather than shifting
 355 cultivation on a parcel of land. It is computed from the following equation:

$$356 \quad R = R' \Leftrightarrow R = \frac{(D_0 - D_5')}{(D_5 - D_5')} * BEP * \Delta_C * \theta * (1 - \alpha)^5 \Leftrightarrow BEP = \frac{R * (D_5 - D_5')}{\Delta_C * \theta * (1 - \alpha)^5 * (D_0 - D_5')} \quad (6)$$

357 Sensitivity analysis

358 In this analysis, effect of uncertainty is taken into account directly by a Monte-
 359 Carlo procedure. However, for the three parameters (discount rate, the fallow time and the
 360 opportunity cost of labour), for which explicit distribution of uncertainty was not known, we
 361 further conducted a sensitivity analysis. We find that a change in discount rate has only a
 362 minor effect on break even prices. The results show that the model is very robust to a change
 363 in discount rate. It is also reasonably robust to changes in fallow time or opportunity cost of
 364 labour (see table 7). The robustness of the model to changes in discount rates shows that it
 365 plays a comparable role in both land-use options. This property is nevertheless very
 366 interesting as discount rates are often an important point of controversy in economic studies.
 367 In this case, it is indeed possible that a higher discount rate than 5% would be more
 368 appropriate for shifting cultivators. Indeed, for other African farmers such as the groundnut
 369 growers of Central Senegal, Tschakert (2004) uses a discount rate of 20%.

370 The model is less robust to changes in fallow time or opportunity cost of labour, but
 371 this is less concerning as these parameters are less arbitrary set.

372

Parameter	Initial value	Change of parameter value	Change in main model output (BEP)
Discount rate (%)	5%	+300%	2%
Fallow time (years)	9	-22%	13%
Opportunity cost of labour (\$.ha ⁻¹)	131	+50%	-41%

Table 7. Results of the sensitivity analysis

373

374 Discussion

375

376 For short fallow food systems in Cameroon, Gockowski *et al.* (2001) finds an annual
 377 revenue of around 600 \$.ha⁻¹.year⁻¹, and Kotto-Same (2000) finds 623 \$.ha⁻¹.year⁻¹. Our
 378 results are slightly lower since the revenue we compute shows an average of 440 \$.ha⁻¹.year⁻¹.
 379 The difference may come from the fact that we simplified the cycle to staple crops, and from
 380 different assumptions on crop prices and the opportunity cost of labour (eg. Gockowski *et al.*
 381 (2001) uses a lower opportunity cost of labour of 1.21 \$.day⁻¹ although without explaining the
 382 underlying assumptions). And although these food systems make up for most of the cultivated
 383 crops in Cameroon, they are also the least profitable. Furthermore, the general coherence with
 384 these previous studies on this point gives some confidence in the other results based on our
 385 simple cost model.

386

387 Silva-Chavez (2005) finds a slightly higher BEP for Bolivia of 4-9 \$/tCO₂e. And so
 388 does Osafo (2005) with a BEP of 8 \$/tCO₂e for Ghana. These differences could come from
 389 the fact that these two analysis used cash crops as a benchmark against deforestation. And
 while this choice makes sense for such countries, staple crops seemed more relevant in

390 Cameroon where they are prevalent. For the Brazilian Amazon, where the low returns of most
391 pastures are more similar to Cameroon's staple crops, Nepstad *et al.* (2007) finds an average
392 opportunity cost of 1.6\$/tCO₂e. At the global scale, Grieg-Gran (2006) finds a cost of
393 abatement from deforestation of 1-2 \$/tCO₂e on average.

394 The total estimated yearly revenue from CR for the scenario considered, (6 000 ha/yr
395 of deforestation reduction during 5 years) estimated at about 130 million dollars would
396 probably have a significant impact on the trade balance of Cameroon as its current exports
397 flow is about 4.7 billion dollars per year (World Bank, 2007). Indeed, in such a developing
398 and liquidity constraint economy, macro economic effects of an additional percent of direct
399 fundings might be substantial (Crassous, *et al.*, 2007).

400 *Model approximations* – The major problem with such a model is that it assumes a
401 functioning market system where the farmer can sell most of his products, whereas in the
402 rainforested zones of Cameroon, auto-consumption is preponderant and only the surpluses are
403 sold on local markets (Brown, 2004). This doesn't necessarily undermine the model itself, but
404 it raises an important doubt on the conclusion of the proposed comparison: in the case of
405 subsistence agriculture, utility is likely to differ from income. Indeed, even if the revenue
406 from a CR scheme is forecast to be higher than one from shifting cultivation, the farmer
407 cannot necessarily be expected to opt for CR. He will also have to weigh in the risk of food
408 shortage: shifting cultivation will provide him with food notwithstanding external conditions
409 whereas under CR, as he has to buy all his food, he becomes much more vulnerable to higher
410 prices for it (van Soest, 1998).

411 Even so, some studies show that macro-economic factors can have an impact over
412 farmers' local decisions in Cameroon. Indeed, when the price of cocoa and coffee dropped,
413 farmers showed a capacity to shift to staple crops (Sunderlin, *et al.*, 2000). This historical
414 example allows us to think that a new source of revenue (CR) could once again trigger a
415 change of local practices, back from the shifting cultivation of staple crops.

416 As it has already been discussed, numerous simplifications and approximations were
417 made both in the models and in the estimates. Therefore, it should be remembered that the
418 model outputs are only indications on what actual revenues might be. Among others are the
419 absence of accounting for timber and fallow revenues, and the approximation of all
420 cultivation years to a mixed cropping of half cassava and half plaintain.

421 Furthermore, opportunity costs are only a simplification of the costs of reducing
422 deforestation. Implementing programs or projects carry transaction costs of their own (eg.
423 monitoring costs, administrative costs, ...), which increase the actual cost. On the other hand,
424 opportunity costs need not always be fully compensated, which decrease the actual cost
425 (Nepstad, *et al.*, 2007). However, given the large discrepancy between the break-even price
426 and the current price of carbon, this simplification should not undermine the results: a CR
427 mechanism would be profitable, although not necessarily achievable (see below, *Practical*
428 *problems with the implementation of Compensated Reduction*).

429 The failure to account for timber revenues should not be an important bias, as the few
430 valuable trees are removed in advance by logging companies. And in any case, it is the
431 companies, and not the farmers, who benefit from timber sales. However, this points out to
432 another problem, namely the absence of incentives for logging companies to stop selective
433 logging which is what brings shifting cultivators in the first place. One solution, as discussed
434 below, could be a set of national policies enforcing land tenure rights for small holders,
435 financed locally by the benefits reaped from carbon credits.

436
437 *Practical problems with the implementation of Compensated Reduction* – Even if we
438 could know for sure that CR would be economically more profitable than shifting cultivation
439 or selective logging, whether it is practically possible for the government or any organization

440 to bring forth a change of practices once it has money to do so remains something to be
441 proven in Cameroon. Past experience in projects that aim to reduce deforestation by
442 compensating stakeholders shows contrasting levels of success (Chomitz, *et al.*, 2006). Indeed,
443 the corruption that plagues all Africa doesn't spare Cameroon which was rated 129th out of
444 145 countries by Transparency International (2004), with a Corruption Perception Index of
445 only 2.1/10. In the context of Compensated Reduction, this could be a particularly thorny
446 issue as channeling the money to the right stakeholders and ensuring their accountability
447 would be key to success.

448 However, in both cases of selective logging and slash-and-burn agriculture, causes are
449 known and some methods have been proven to be efficient in limiting these activities. In the
450 case of slash-and-burn agriculture in Central Africa, it has been shown that enforcing land
451 tenure is critical since the absence of land tenure rights pushes both logging companies and
452 small farmers to get as much of the land as they can before somebody else seizes it (van Soest,
453 1998). Moreover, Cameroon has been deemed to be one of only six ITTO (International
454 Tropical Timber Organization) producer countries to have already established all conditions
455 that enable them to manage their forest sustainably (FAO, 2001).

456 The BOLFOR project carried out in Bolivia shows that methods actually exist to get
457 deforestation under control (requirement for the logging companies to carry out inventories
458 and management plans, an independent "Forest Superintendency" that is able to monitor these
459 activities and enforce fines and penalties when necessary, ...) and can produce results when
460 they are funded and seriously implemented (The Nature Conservancy, 2004).

461 Another way would be to reduce the damages caused by selective logging (Reduced
462 Intensity Logging). This change in logging practices could save up to two thirds of total
463 logged biomass at the additional cost of 10\$/ton⁻¹. However, the technology to monitor these
464 reductions in a reliable way by remote sensing is not yet fully developed (Justice, *et al.*, 2001).

465
466 *Perverse incentives to grow tree or cocoa plantations* – An incentive system only
467 based on carbon content such as CR would probably generate some "perverse" incentives
468 such as growing cocoa or timber. Indeed, these land uses have higher carbon stocks than
469 shifting cultivation and yet yield revenues which a primary forest does not. The highest
470 profitability could therefore be found in these uses which could have a negative impact on
471 deforestation.

472 However, since CR is designed to be mainly monitored through remote sensing, these
473 perverse incentives could be avoided. Indeed, satellites can well distinguish tree or cocoa
474 plantations from primary forests and CR could therefore only compensate for the safeguard of
475 primary forests, and not the growing of trees or cocoa.

476 There used to be a prerequisite for obtaining formal land rights known as the "mise en
477 valeur" of forests, that is forests must be cleared for cultivation purposes before legal land
478 titles can be obtained. However, it is difficult to assess the importance of this factor in
479 practice: even in 1984, only an estimated 4% of the land was cultivated under formal land
480 rights, and now, the law has been turned down (van Soest, 1998).

481 **Conclusion**

482
483 The aim of this modeling exercise was to give a rough assessment of the economic
484 rationale of "Compensated Reduction" in Cameroon. Although it doesn't encompass the
485 entire complexity of the deforestation process, it is robust enough for this purpose. The break-
486 even price of 2.85\$/tCO₂e indicates that the idea would be worth a thought: indeed, with
487 carbon prices currently over 20\$/tCO₂e for second period allowances on the European
488 Trading Scheme, CR would be a profitable alternative to farming. Moreover, the margin

489 between these two land-uses could provide for the unaccounted transaction costs such as
490 monitoring or national policy implementation.

491 As the UNFCCC process on “avoided deforestation” moves forward, further studies
492 will be needed by negotiators and project managers that rely on more complex models
493 (especially to evaluate baselines and macro-economic effects of land-use changes), updated
494 data, and other conservation scenarios than CR.

495 **Acknowledgments**

496
497 The authors would like to thank Alexander Golub and Annie Petsonk (Environmental
498 Defense), Jonathan Wiener, and Virginie Delepine for their useful comments and suggestions.
499 We are also grateful to the reviewers selected by Ecological Economics for the seriousness
500 and constructiveness of their comments.

501
502 References cited in tables:
503 (Myers, 1991, Laporte, *et al.*, 1995, Sunderlin, *et al.*, 2000, Zhang and Justice, 2001)
504 Schmidt 1990, as cited in (Ndoye and Kaimowitz, 2000)
505 WRI 1994, as cited in (Ndoye and Kaimowitz, 2000)

506 **References**

507
508 Bellassen, V. and B. Leguet, 2007. The emergence of voluntary carbon offsetting. In: C. De
509 Perthuis, (Ed.) Mission Climat Research Report, Caisse des Dépôts, Paris, 40 p.
510 Bouyer, O. and V. Merckx, 2007. Communication to the Conference. International Regime,
511 Avoided Deforestation and the Evolution of Public and Private Forest Policies in the South,
512 Paris.
513 Brown, D. R., 2004. Personal Preferences and Intensification of Land Use: Their Impact on
514 Cameroonian Agroforestry Systems. Cornell University, 36 p.
515 Brown, S., 1999. Guidelines for Inventorying and Monitoring Carbon Offsets in Forest-Based
516 Projects. Winrock International, 14 p.
517 CARPE, 2005. The Forests of the Congo Basin - A preliminary assessment. Central African
518 Regional Program for the Environment (CARPE), 37 p.
519 Chomitz, K. M., P. Buys, G. De Luca, T. S. Thomas and S. Wertz-Kanounnifoff, 2006. At
520 Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical
521 Forests. In: World Bank, (Ed.) World Bank Policy Research Report, Washington D.C., 284 p.
522 Chomitz, K. M. and F. Lecocq, 2003. Temporary Sequestration
523 Credits: An Instrument for Carbon Bears. World Bank Policy Research Working Paper, 14 p.
524 Crassous, R., J. C. Hourcade, O. Sassi, V. Gitz and S. Mathy, 2007. IMACLIM-R: A
525 Modeling Framework for Sustainable Development Issues. Background paper for Dancing
526 with Giants: China, India, and the Global Economy, Institute for Policy Studies and the World
527 Bank, Washington, DC, 32 p.
528 Dury, S., J. Medou, D. F. Tita and C. Nolte, 2004. Limites du système local
529 d'approvisionnement alimentaire urbain en Afrique subsaharienne : le cas des féculents au
530 Sud-Cameroon. Cahiers d'études et de recherches francophones / Agricultures, 13: 116-124.
531 Dvorak, K. A., 1992. Resource management by West African farmers and the economics of
532 shifting cultivation. American Journal of Agricultural Economics, 74: 809-815.
533 Essama-Nssah, B. and J. Gockowski, 2000. Cameroon - Forest Sector Development in a
534 Difficult Political Economy. The World Bank, Washington, DC, 59 p.

535 Estrada, M., 2007. Views of Latin American Countries. International Roundtable on Reducing
536 Emissions from Deforestation and Forest Degradation in Developing Countries, Brussels.
537 FAO, 2001. Global Forestry Resources Assessment 2000. FAO, 511 p.
538 FAO, 2005. FAOSTAT.
539 Federal Republic of Germany, 2007. Submission by Germany on behalf of the European
540 Community and its member states. UNFCCC submission, 9 p.
541 Federative Republic of Brazil, 2007. Brazilian Perspective on Reducing Emissions from
542 Deforestation. UNFCCC submission, 9 p.
543 Gitz, V. and P. Ciaus, 2004. Future Expansion of Agriculture and Pasture Acts to Amplify
544 Atmospheric CO₂ Levels in Response to Fossil-Fuel and Land-Use Change Emissions.
545 Climatic Change, 67: 161-184.
546 Gockowski, J., G. B. Nkamleu and J. Wendt, 2001. Implications of Resource-use
547 Intensification for the Environment and Sustainable Technology Systems in the Central
548 African Rainforest. In: D. R. Lee and C. B. Barrett, (Eds.), Tradeoffs Or Synergies?
549 Agricultural Intensification, Economic Development and the Environment, CABI Publishing,
550 560 p.
551 Grieg-Gran, M., 2006. The Cost of Avoiding Deforestation - Report prepared for the Stern
552 Review of the Economics of Climate Change. IIED, London, 20 p.
553 Justice, C., D. Wilkie, Q. Zhang, J. Brunner and C. Donoghue, 2001. Central African forests,
554 carbon and climate change. Climate Research, 17: 229-246.
555 Kamegne, J. and A. Degrande, 2004. From alley cropping to rotational fallow: farmers'
556 involvement in the development of fallow management techniques in the humid forest zone of
557 Cameroon. In: J. Kamegne, (Ed.) Slash and Burn Agriculture in the Humid Forest Zone of
558 Southern Cameroon, Wageningen University, 230 p.
559 Kotto-Same, J., A. Moukam, R. Njomgang, T. Tiki-Manga, J. Tonye, C. Diaw, J. Gockowski,
560 S. Hauser, S. Weise, D. Nwaga, L. Zapfack, C. A. Palm, P. L. Woome, A. Gillison, D.
561 Bignell and J. Tondoh, 2000. Alternatives to Slash-and-Burn - Summary Report and
562 Synthesis of Phase II in Cameroon. ICRAF, Nairobi, 76 p.
563 Kremen, C., J. O. Niles, M. G. Dalton, G. C. Daily, P. R. Ehrlich, J. P. Fay, D. Grewal and R.
564 P. Guillery, 2000. Economic Incentives for Rain Forest Conservation Across Scales. Science,
565 288: 1828-1832.
566 Laporte, N., C. Justice and J. Kendall, 1995. Mapping the dense humid forest of Cameroon
567 and Zaire using AVHRR satellite data. International Journal of Remote Sensing, 16: 1127-45.
568 Mertens, B. and E. F. Lambin, 2000. Land-Cover-Change Trajectories in Southern Cameroon.
569 Annals of the Association of American Geographers, 90: 467-494.
570 Myers, N., 1991. Tropical forests: present status and future outlook. Climatic Change, 3-32.
571 Ndoye, O. and D. Kaimowitz, 2000. Macro-economics, markets and the humid forests of
572 Cameroon, 1967-1997. The Journal of Modern African Studies, 38: 225-253.
573 Nepstad, D., B. Soares-Filho, F. Merry, P. Moutinho, H. O. Rodrigues, M. Bowman, S.
574 Schwartzman, O. Almeida and S. Rivero, 2007. The Costs and Benefits of Reducing Carbon
575 Emissions from Deforestation and Forest Degradation in the Brazilian Amazon. WHRC,
576 IPAM & UFMG, 32 p.
577 Osafo, Y., 2005. Reducing greenhouse gas emissions from tropical deforestation: applying
578 compensated reduction to Ghana. In: P. Moutinho and S. Schwartzman, (Eds.), Tropical
579 Deforestation and Climate Change, 63-72 p.
580 Palm, C. A., P. L. Woome, J. Alegre, L. Arevalo, C. Castilla, D. G. Cordeiro, B. Feigl, K.
581 Hairiah, J. Kotto-Same, A. Mendes, A. Moukam, D. Murdiyarso, R. Njomgang, W. J. Parton,
582 A. Ricse, V. Rodrigues, S. M. Sitompul and M. van Noordwijk, 2000. Carbon Sequestration
583 and Trace Gas Emissions in Slash-and-Burn and Alternative Land-Uses in the Humid Tropics.
584 ICRAF, 34 p.

585 Rogner, H.-H., D. Zhou, R. Bradley, P. Crabbé, O. Edenhofer, B. Hare, L. Kuijpers and M.
586 Yamaguchi, 2007. Introduction. *Climate Change 2007: Mitigation. Contribution of Working*
587 *Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate*
588 *Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,
589 22 p.

590 Sankhayan, P. L. and O. Hofstad, 2001. A village-level economic model of land clearing,
591 grazing, and wood harvesting for sub-Saharan Africa: with a case study in southern Senegal.
592 *Ecological Economics*, 38: 423-440.

593 Santilli, M., P. Moutinho, S. Schwartzman, D. Nepstad, L. Curran and C. Nobre, 2005.
594 *Tropical deforestation and the Kyoto Protocol. Climatic Change*, 71: 267-276.

595 Serageldin, I., 1992. Saving Africa's Rainforests. In: W. Bank, (Ed.) *Environmentally*
596 *Sustainable Development*.

597 Silva-Chavez, G., 2005. Reducing greenhouse gas emissions from tropical deforestation by
598 applying compensated reduction to Bolivia. In: P. Moutinho and S. Schwartzman, (Eds.),
599 *Tropical Deforestation and Climate Change*, 73-86 p.

600 Sunderlin, W. D., O. Ndoye, H. Bikie, N. Laporte, B. Mertens and J. Pokam, 2000. Economic
601 crisis, small-scale agriculture, and forest cover change in southern Cameroon. *Environmental*
602 *Conservation*, 27: 284-290.

603 The Nature Conservancy, 2004. *Bolivia: Sustainable Forestry - \$15 Million Project Will*
604 *Protect Native Forests and Provide Income for Bolivian Communities*. 8 p.

605 Transparency International, 2004. *Transparency International Corruption Perceptions Index*
606 *2004*. p.

607 Tschakert, P., 2004. The costs of soil carbon sequestration: an economic analysis for small-
608 scale farming systems in Senegal. *Agricultural Systems*, 81: 227-253.

609 Tucker, C. J. and J. Townshend, 2000. Strategies for tropical forest deforestation assessment
610 using satellite data. *International Journal of Remote Sensing*, 1461-1472.

611 UNDP, 2007. *Human Development Report 2007/2008*. 399 p.

612 UNFCCC, 2007. *Decision 1/CMP.3 (Bali Action Plan)*.

613 van Soest, 1998. *Tropical Deforestation in Cameroon: A Case Study*. In: v. Soest, (Ed.)
614 *Tropical Deforestation: an economic perspective*, 64-96 p.

615 World Bank, 2007. *World Development Indicators Database*.

616 Zhang, Q., D. Devers, A. Desch, C. Justice and J. Townshend, 2005. *Mapping Tropical*
617 *Deforestation in Central Africa. Environmental Monitoring and Assessment*, 101: 69-83.

618 Zhang, Q. and C. Justice, 2001. Seeing the future now - Simulating forest changes in the
619 Congo Basin. *Congo Basin information series, CARPE* p.

620 Zhang, Q., C. Justice and P. V. Desanker, 2002. Impacts of simulated shifting cultivation on
621 deforestation and the carbon stocks of the forests in Central Africa. *Agriculture, Ecosystems,*
622 *and the Environment*, 90: 203-209.

623