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Small forests owners and environmental sustainability in Guatemala: The potential of the Carbon Banking approach

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Forest carbon is potentially an important income stream for small land owners in Guatemala that would help to cease deforestation and forest degradation pressures. However, the temporary nature of sequestered forest carbon, the risk of environmental disturbances releasing forest sequestered carbon, and the form of international carbon markets affect the ability of small forest owners to participate in carbon trading schemes. This paper reports the results of an investigation into the stability of carbon pools formed by small forest owners in Guatemala, accounting for forest fire risk and the effects on implementation of a carbon banking approach

Introduction

Forest ecosystems have a great significance for dealing with climate change as they help to sequester carbon dioxide from the atmosphere and regulate climate (Chenost et al., 2010; Seeberg-Elverfeldt, 2010). As a result, carbon sequestration through forestry or agro-forestry activities has been discussed as an alternative not only for reducing CO_2 from the atmosphere, but also as a stream of revenue for forest holders (Skole et al., 2009).

This could be significant for Guatemala with 35.5% of its territory under forest coverage (UVG et al., 2011) and around 43.4% of that in small forests (Estrategia de la Subsecretaría de Política Agraria, 2005). Small forest owners who sequester carbon from the atmosphere face some constraints to their participation in international carbon markets. These include; a) *market exclusion* as the international regulatory framework requires projects with large land forest cover (Milder et al., 2010), b) *high transaction costs* when demonstrating carbon sequestration levels (De Pinto et al., 2010; Beddoe, 2010; Cacho et al., 2005a; Pfaff, et al., 2007; Galik et al., 2009), c) *lack of access to carbon market information*, c) *lack of* technical assistance (Roncoli et al., 2007), and d) *the risk of environmental disturbances* such as forest fire, floods, and storms which can release forest sequestered carbon into the atmosphere (Feng et al., 2002; Chomitz & Lecocq, 2003; Skutsch & Trines, 2010).

One way to overcome these hurdles is carbon banking (Bigsby, 2009). This approach uses intermediary financial institutions to aggregate carbon credits from small owners and to package them for buyers who are unwilling to accept the additional risks and costs associated with sourcing carbon credits stemming from small owners individually (Bigsby, 2009; Milder et al., 2010). This paper addresses risk from forest fire, modelled by applying Monte Carlo simulation to show the potential leasable carbon storage after accounting for risk, as well as to demonstrate how this risk affects prices paid to small forest owners.

Theoretical Framework

Carbon Banking

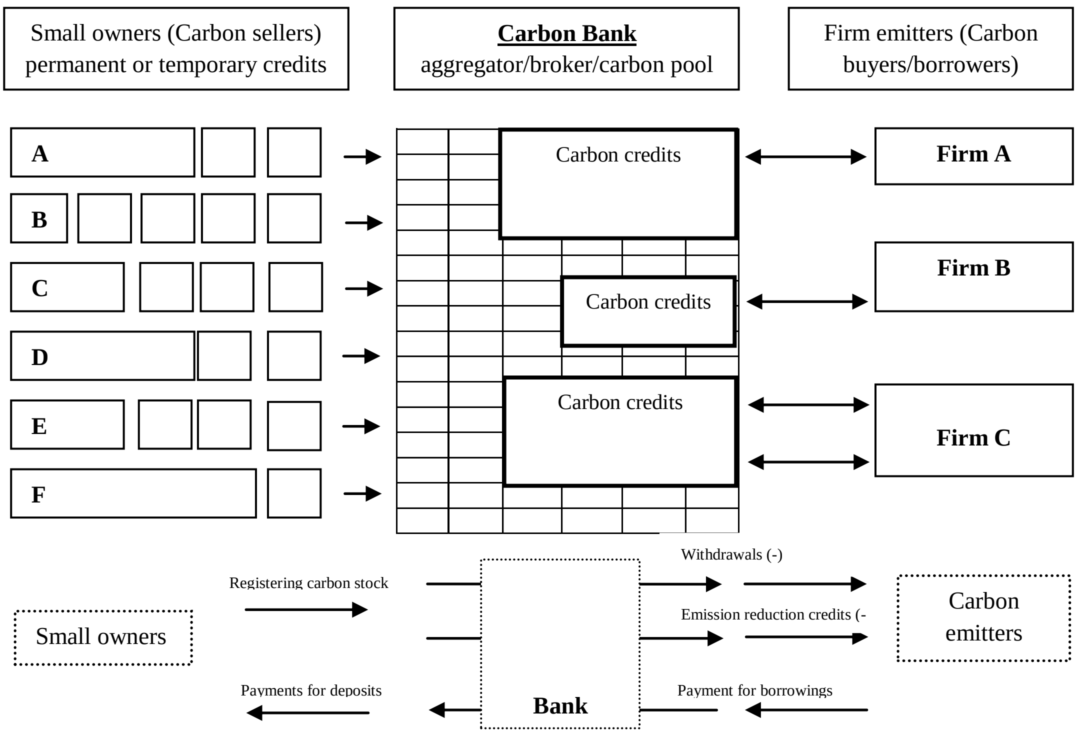
Carbon banking creates a carbon market and works like a financial institution (bank) in which sequestered carbon, not cash, is the medium of exchange. The system can work with emission reductions schemes that are both permanent and temporary. Financial institution services include deposits, renting or leasing and withdrawals. For instance, from the supply side, carbon sequestered in forestry or agro-forestry systems can be deposited in the bank. The capital is just rented, not purchased, and hence the use of interest rental payments for the use of capital carbon is implemented. The approach’s flexibility allows that any carbon sequester who would decide to make the deposit would also have the chance to withdraw their carbon credits at any time (Esuola & Weersink, 2006; Bigsby, 2009).

The carbon bank registers the carbon deposited for a certain period of time. The initial carbon deposit is certified by a baseline carbon study and subsequent procedures are required to monitor changes on carbon stock through applying carbon accounting systems (Bigsby, 2009a). Nevertheless, carbon deposits might be withdrawn for a variety of reasons. Firstly, depositors can find better and more profitable alternative uses of their assets (forest land). Secondly, they can use their carbon credits to meet their own emission reductions obligations. Further, current carbon markets may be affected by the uncertainties of international policies on GHG emissions surrounding the Post Kyoto-2012 agreement which might change carbon prices (Esuola & Weersink, 2006; Linacre et al., 2011, p. 47). Finally, withdrawals may also occur due to net harvest reductions (rotation length, stocking and harvesting intensity) as well as unexpected events, such as environmental disasters through forest fires, pests, storms, wind throws, landslides, hail, floods and droughts (Bigsby, 2009a; Bigsby, 2009b; MARN et al., 2009).

The carbon rental approach and temporary crediting of carbon storage have arisen to allow entities with emission reductions obligations to defer some obligations for a certain period of time (Marland et al., 2001; Sedjo & Marland, 2003). The main characteristic of a rental system is that it behaves like a direct credit-debit system for the renter of credits. For instance, credit is assigned when carbon is sequestered and debits are accrued when carbon is emitted. At the end of the rental period, the renter will have received some of the benefits and can decide either to renew the lease elsewhere or incur the emission debit and replace the credit with one from another activity (Sedjo & Marland, 2003; Marland et al., 2001).

Figure 1 depicts the main interactions amongst small owners, bank and carbon buyers/borrowers.

Figure 1. Carbon banking



Model

In order to complement the theoretical framework described above, this section will outline and itemise the mathematical model used to analyse carbon banking in Guatemala, accounting for forest fire risk.

Carbon banking empirical approach: measured variables

The variables used to set up an empirical carbon banking approach are:

C = *Volumen of carbon deposited from zone* $\boldsymbol{i}$
$\mathbf{P}_{\mathbf{F}\boldsymbol{i}}$ = *Risk-adjusted proportion of carbon available for lease from zone* $\boldsymbol{i}$[1]
ACR = *Annual carbon rental for all zones* $\boldsymbol{i}$[2]
I = *Bank annual revenue in zone* $\boldsymbol{i}$
S = *Percentage of participation of smallholders*
X = *Bank Costs*
F = *Fixed costs*[3] *for managing small forest owners' carbon accounts*
V = *Variable costs*[4]
Y= *Minimum profit rate for the bank*
P = *Maximum price the bank could paid to small forest owners*

Therefore, the three mathematical formulas are

$$\mathbf{I} = (\mathbf{ACR})(\mathbf{S}) \sum_{\boldsymbol{i}} \mathsf{C}_{\boldsymbol{i}}\, \mathbf{P}_{\mathbf{F}\boldsymbol{i}} \tag{1}$$

$$\mathbf{X} = (\mathbf{F})+(\mathbf{V})+(\mathbf{Y})(\mathbf{I}) \tag{2}$$

$$\mathbf{P} = (\mathbf{I} - \mathbf{X}) \Big/ \sum_{\boldsymbol{i}} \mathsf{C}_{\boldsymbol{i}} \tag{3}$$

[1] P_{Fi} is determined by the bank's attitude to risk through Monte Carlo simulation at 95^{th} percentile, given by 1 – 95^{th} percentile value
[2] See appendix X for calculation details
[3] The bank incurs administrative fixed costs such as; a) costs of designing and implementing a monitoring plan[3], b) costs of monitoring verification by a third party, c) contracts between bank-buyer, and bank-small landowners, and d) experts needed to implement carbon banking (Antinori and Sathaye, 2007)
[4] Cost per contract between smallholder and bank, number of smallholders and percentage of participation of smallholder.

Methods

Method for analysing risk

Monte Carlo simulation was used for risk analysis. Monte Carlo analysis provides significant insight into problems involving uncertainty by repeatedly randomly sampling probabilistic data to generate probability distributions for outcomes of interest (Rose et al., 1989; Vose, 2000). Monte-Carlo has already proven to be a very useful technique for examining the effects of uncertainties derived from the incidence of forest fires upon an ecosystem (Carmel et al., 2009; Conedera et al., 2011).

Historical forest fire data were obtained and distributions fitted to the data (Palisade Corporation, 2010). The best fitting probability distribution function was identified using a Chi-square test (Law & Kelton, 1982; Palisade Corporation, 2010; Vose, 2000). All these calculations were undertaken using @Risk software, a Microsoft Excel add-in. In addition, sensitivity analysis was also used as it is useful for testing sensitivity in inputs such as costs and receipts when analysing investment performances (Rose, et al., 1989). Sensitivity was carried out considering factors such as fixed costs, level of participation of small owners in the bank scheme, and bank profit rates. So, three scenarios were set to estimate how sensitive fixed costs are on the level of participation of small forest owners, profit margin rate as well as on the maximum payable to small forest owners. These calculations were also undertaken by using Microsoft Excel.

Data

To simplify data analysis information was categorised at the national level considering the Holdridge Life Zones System (De La Cruz, 1982). Three zones[5] were defined; 1) Wet and moist, 2) Montane, and 3) Dry.

Data collection

The most reliable secondary data sources were used wherever possible, such as published data and official statistics. The following criteria were applied to assure the quality of data: a) original purpose of the data collection, whether the document is produced for the government, a corporate or for marketing purposes, b) well-known authors, c) methods well-designed, d) date of publication, and e) document has to be well-referenced using official data (Atkinson and Brandolini, 2001). In cases where information did not fulfil these criteria, and data were unavailable, expert knowledge was used. This was obtained by direct personal contact via email or interview with relevant experts.

[5] Zone classifications used in this research are not official Guatemalan ecosystem classifications.

Results and Discussion

Table 1. Results of the Carbon banking model assuming 100% of participation of small forest owner into the carbon bank.

Zones	Area of forest land in zone ***i*** deposited in the bank (ha)	Volumen of carbon deposited from zone ***i*** (tCO_2e)	Risk-adjusted carbon available for lease from zone ***i*** (%)	Bank annual carbon rental revenue in zone ***i*** (USD)
		C	$\mathbf{P}_{Fi}$	**I**
Dry	1,454.94	37,807.42	97.13%	8,629.46
Montane	7,593.67	1,494,996.42	98.87%	354,742.55
Wet and moist	26,100.12	4,876,684.30	96.35%	1,127,703.39
TOTAL	35,148.73	6,409,488.14		1,491,259.00

To model forest fire, the proportion of forest area burned annually over the last ten years was used in each of the three zones. As a proxy for the proportion of forest carbon available for renting out to carbon market, a strong risk-averse position was assumed for the bank, requiring coverage of the 95th percentile of forest fire loss. Results are reported in Table 1 and risk distribution functions arising from forest fire occurrence for each zone are reported in the appendices 1, 2 and 3. The results demonstrate that from 4.87M tCO_2e deposited in the bank potentially available for contract between banks and small landowners in the Wet Zone, only 96.35% of it can be available for the bank to rent out to companies who have carbon liabilities when adjusted for fire risk. It means that there is an annual withdrawal of 3.65% of carbon due to forest fire. The carbon availability is also shown for the Montane Zone with 98.87% and for the Dry Zone 97.13%. This risk-adjusted forest carbon is the total size of the potential carbon pool available from small landowners to put into international carbon markets.

These results are surprising because environmental conditions make the dry zone highly susceptible to fire (Cochrane, 2003) but the Guatemalan case shows otherwise. According to the last State of the Environment Report (MARN et al., 2009) the main forest fire driver in the Wet and Moist Zone is encroachment, which is promoted for agricultural development. Also the lack of sound governance in this Zone may facilitate money laundering from drug smugglers, promoting a land black market in which slash and burn is used to establish large extensions of livestock farms.

In terms of bank annual income derived from leasing forest carbon are listed in the table 1. The highest annual revenue is shown in the Wet and Moist zone with USD 1.12 m as it possesses the highest risk-adjusted carbon available for renting out, followed by the Montane zone with USD 0.354 m and the Dry one with USD 0.0862 m. Bank income may change if annual carbon rental (ACR) value does. The variables related to ACR are interest rates and carbon price in international carbon markets. The driver of change for interest rates is market-driven and it relies on economic and financial national policies and for carbon price is classically influenced by the balance of demand and supply of carbon credits at international level (Chevallier, 2011). Thus, the increasing of ACR is associated to the rise of carbon prices and interest rates.

On the other hand, variables such as the level of participation of small owners into the carbon bank scheme, fixed costs, and bank profit rate influence the maximum payment the bank could pay to small owners for retaining their forest and sequester carbon dioxide from the atmosphere. The table 2, 3, and 4 show a sensitivity analysis to demonstrate different carbon payment options through three scenarios indicating changes in such variables.

Table 2. Scenario 1 with maximum payable (USD/ tCO_2e/yr) to small forest owners based on % of participation of small owners and bank profits margins with USD 1.163 m of fixed costs

		Minimum % of profit margin for the bank					
		0.00%	5.00%	10.00%	15.00%	20.00%	25.00%
% landowners in the scheme	100%	0.053	0.041	0.029	0.017	0.006	*-0.006*
	90%	0.032	0.021	0.009	*-0.003*	*-0.015*	*-0.026*
	80%	0.007	*-0.004*	*-0.016*	*-0.028*	*-0.040*	*-0.052*
	70%	*-0.025*	*-0.037*	*-0.049*	*-0.060*	*-0.072*	*-0.084*

Table 3. Scenario 2 with maximum payable (USD/ tCO_2e/yr) to small forest owners based on % of participation of small owners and bank profits margins with 25% less USD 0.872 m of fixed costs

		Minimum % of profit margin for the bank								
		0.00%	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%	40.00%	50.00%
% landowners in the scheme	100%	0.098	0.086	0.074	0.063	0.051	*0.039*	0.027	0.004	*-0.020*
	90%	0.083	0.071	0.059	*0.048*	*0.036*	*0.024*	0.012	*-0.011*	*-0.035*
	80%	0.064	*0.052*	*0.040*	*0.029*	*0.017*	*0.005*	*-0.007*	*-0.030*	*-0.054*
	70%	*0.040*	*0.028*	*0.016*	*0.004*	*-0.007*	*-0.019*	*-0.031*	*-0.054*	*-0.078*
	60%	0.007	*-0.004*	*-0.016*	*-0.028*	*-0.040*	*-0.052*	*-0.063*	*-0.087*	*-0.110*
	50%	*-0.038*	*-0.050*	*-0.062*	*-0.073*	*-0.085*	*-0.097*	*-0.109*	*-0.132*	*-0.156*

e 3. Scenario 3 with maximum payable (USD/ tCO_2e/yr) to small forest owners based on % of participation of small owners and bank profits margins with 50% less USD 0.581 m of fixed cost

		Minimum % of profit margin for the bank								
		0.00%	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%	40.00%	50.00%
% landowners in the scheme	100%	0.143	0.132	0.120	0.108	0.096	*0.085*	0.073	0.049	0.026
	90%	0.133	0.122	0.110	*0.098*	*0.086*	*0.074*	0.063	0.039	0.016
	80%	0.121	0.109	0.097	0.085	0.074	0.062	0.050	0.027	0.003
	70%	0.104	0.093	0.081	0.069	0.057	0.046	0.034	0.010	*-0.013*
	60%	0.083	0.071	0.059	0.048	0.036	0.024	0.012	*-0.011*	*-0.035*
	50%	0.053	0.041	0.029	0.017	0.006	-0.006	*-0.018*	*-0.041*	*-0.065*
	40%	0.007	*-0.004*	*-0.016*	*-0.028*	*-0.040*	*-0.052*	*-0.063*	*-0.087*	*-0.110*
	30%	*-0.068*	*-0.080*	*-0.092*	*-0.104*	*-0.115*	*-0.127*	*-0.139*	*-0.162*	*-0.186*

As can be seen from the table 2, 3 and 4 maximum payable prices vary according to the level of participation of small forest owners, the level of the bank's profit rates as well as to fixed costs.

The results show maximum amounts at which the bank could afford to pay when renting out forest carbon. From scenario 1, with 0% minimum profit margin of capital 80% of landowners in the carbon banking scheme need to deposit their carbon before the bank can pay landowners USD 0.05/tCO_2e/yr for their carbon deposits. Any percentage less than 80% of landowners in the scheme will show that the carbon banking system will not make profit from leasing forest carbon. With 5% of minimum profit margin the bank could afford to pay USD 0.041/ tCO_2e/yr, with 20% will be USD 0.006/ tCO_2e and after 20% profit margin, the bank will not pay anything to small owners as it does not generate income to pay off forest carbon. From scenario 1 to 2, if fixed costs are reduced at 25%, maximum payment to small owners rise USD 0.050/tCO_2e/yr rented and at least 60% of small owners have to be into the carbon banking system with their forest carbon. In scenario 2, bank profit rate reveals that the bank could set up a profit margin over 20% if there are at least 90% of small owners involved in the carbon bank.

The scenario 3 demonstrates that a minimum of 40% of small owners require to deposit their forest carbon in the bank before the bank can pay USD 0.005/tCO_2e/yr to small owners. However, there is not any profit margin when bank pays USD 0.005/tCO_2e/yr. In this scenario, the bank may increase their profit margin up to 30%, but it needs to have into the carbon bank 60% of small owners in order to pay a maximum of USD 0.12/tCO_2e/yr and if 100% of small owners are involved in the scheme, the maximum payment rise up to USD 0.073/tCO_2e/yr.

Considering the above empirical results and discussion, it is worthwhile to mention that this analysis needs to address some issues in order to enhance the carbon bank performance. Firstly, the forest carbon property rights have to be defined (Bigsby, 2009) when small landowners do not have land titles, when their land is under communal arrangement, and if they are leasing land from the State.

Property rights in forest carbon under such situations are still under legal and political discussions in Guatemala. Secondly, costs of designing and implementing monitoring plan should be assessed as it might be possible to create a new monitoring methodology. Also, costs of verification, setting up contracts and negotiation costs have to be analysed by drawing up a cash flow with its internal rates of return (IRR) and net present value (NPV). This may be useful when analysing possible profitable economic alternatives. In addition, the type of market that would ease rental of carbon is an essential step to start making forest carbon transaction either at national or international level. Finally, the level of participation of small landowners into the carbon bank would be a financial and political consideration when starting negotiation on launching a carbon bank project in Guatemala. This is a sensitive issue as many small landowners either are not well-organised or the ones with institutional organisation do not have a proper level of education to understand the context of carbon banking approach.

Conclusions

The aim of this study was to estimate the effective forest carbon pool availability for renting out to companies with carbon commitments accounting biophysical risk such as forest fire, and to identify how maximum payments to small forest owners are affected when considering fire risk, level of participation of small forest owners, bank profit margins and fixed costs. The stochastic analysis shows that for the three zones more than 96% of forest carbon from the maximum volume of carbon deposited in the bank can be available for leasing in carbon markets when adjusted for fire risk. The results arising from sensitivity analysis demonstrates that factors such level of participation of small forest owners, forest fire risk and bank profits rates are factors affecting the threshold of payment that bank could afford to small forest owner to keep forest stand and capture carbon dioxide. Thus, the higher profit margins are the high level of involvement from small forest owner into the carbon banking system is required. The scenario which fits the best is No. 3 where fixed costs were reduced at 50%, and the bank needs at least 50% of small owners' forest carbon; therefore, its profit margins may reach up to 50%. At this stage, the maximum payable to small owners will be only USD 0.26/tCO_2e/yr.

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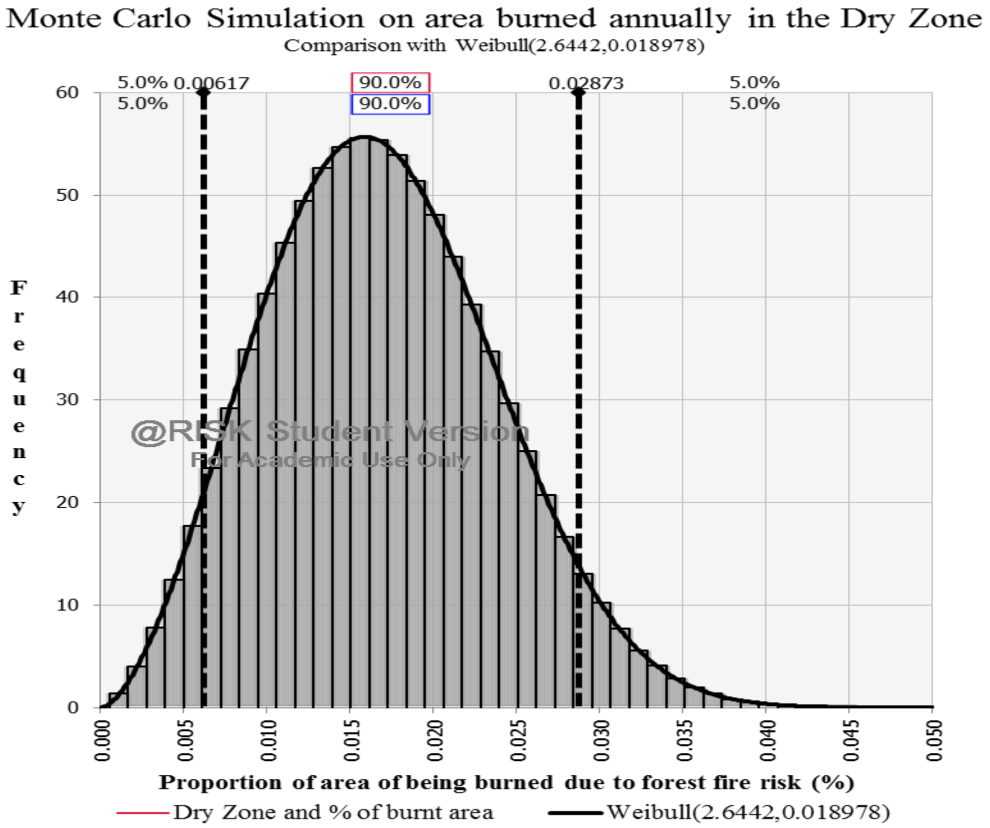
Appendix 1. Monte Carlo simulation on forest fires in the Dry Zone



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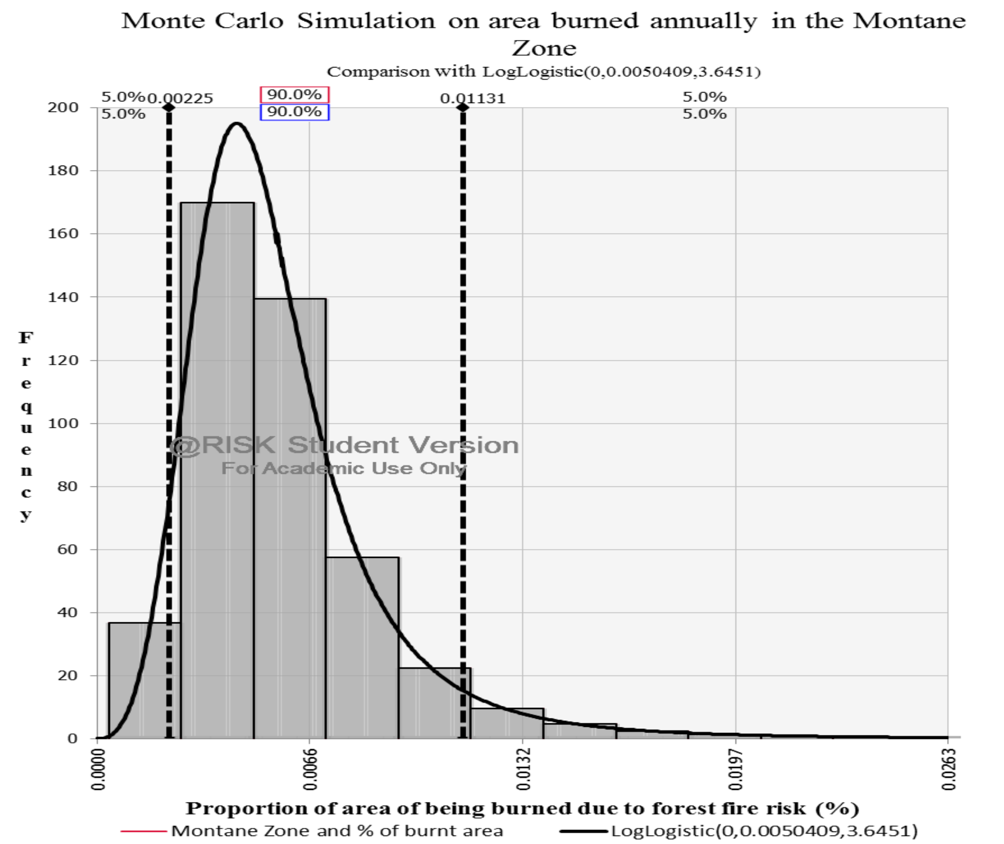
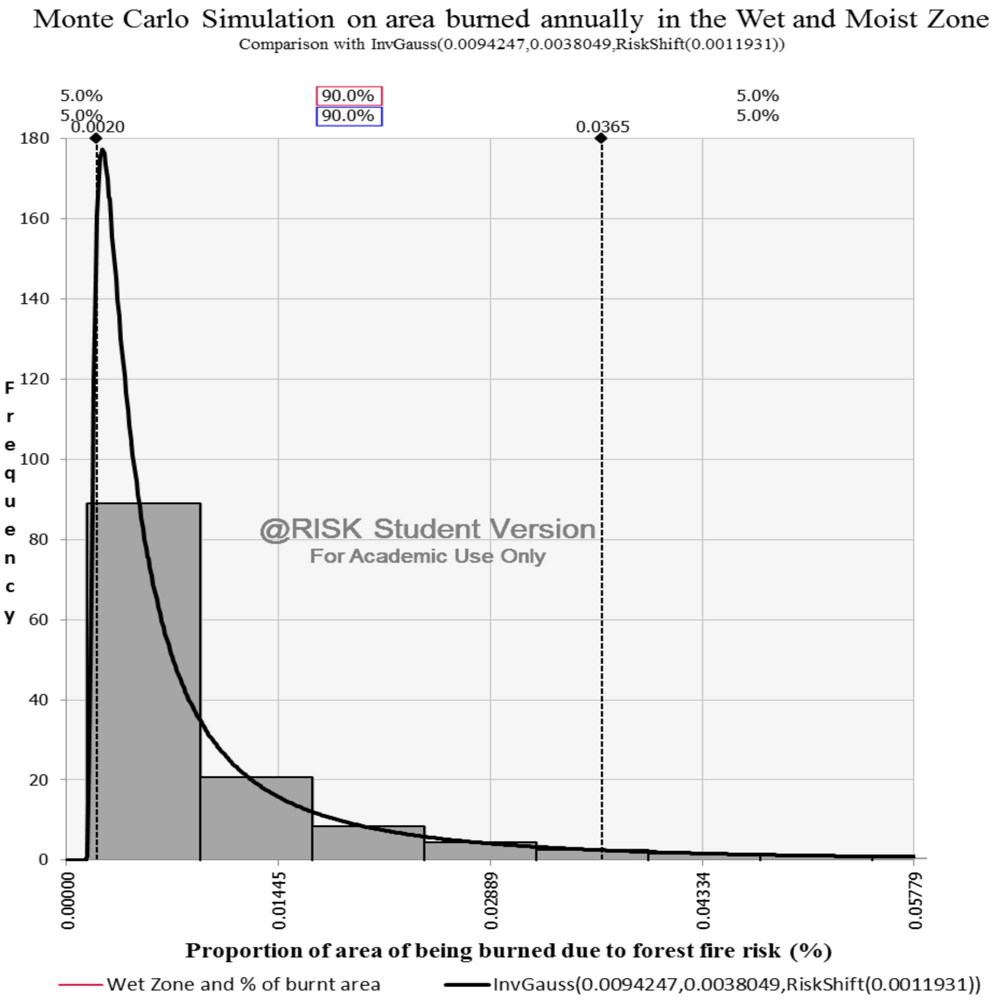
Appendix 2. Monte Carlo simulation on forest fires in the Montane Zone



Appendix 3. Monte Carlo simulation on forest fires in the Wet and Moist Zone



Appendix 4. Annual carbon rental variable and its value

Variables	Descripcion	Units at one fixed-year
Capital value for carbon	based on the international carbon price at ECX (USD)	4.80
Interest rate in Guatemala	market interest rate at fixed-term 365 days (%)	4.90%
Annual carbon rental value	based on the carbon rental formula	0.24
Number of small landholders	Total of small forest onwers willing to maintain their forest	6,734

Appendix 5. Costs for managing small landowners' accounts and costs for managing one ton of carbon

Fixed costs

Operational costs	Type of cost	Units	Cost per unit (USD)	Total cost (USD)
3 carbon management experts		3	40,000.00	120,000.00
Brokerage system		1	900,000.00	900,000.00
Monitoring Plan	Consultancy fee	1	20,000.00	20,000.00
Monitoring at field level	Adminstrative fee	1	75,000.00	75,000.00
Verification of monitoring developed by third party	Auditor fee	1	45,000.00	45,000.00
Administrative costs				
First ERPA (Emission Reduction Purchase Agreement) Bank-buyer	Consultancy fee	1	2,250.00	2,250.00
First contract Small forest owner-Bank	Administrative fee	1	750.00	750.00
	Subtotal			**1,163,000.00**

Variable costs

Variable cost per land owner				
Other associated costs when issuing one contract (energy, printers, paper, etc)	Administrative fee	6,734	1.00	6,734.00
	Subtotal			**6,734.00**
	Total costs			**1,169,734.00**