



Research Article

Environmental Impact of Logging and Strategies for Reducing Damage: A Case Study of BK Business Sarl in Eastern Cameroon

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Abstract

This study examined the environmental impacts of logging and strategies aimed at minimising damage: the case of BK Business Sarl in the Eastern Region of Cameroon. The methodological approach focused on two plots, each 250 m long by 20 m wide, covering a total area of 0.5 ha. Surveys were carried out using four transects to cover each plot. A survey was carried out on tree trunks with a diameter of ≥ 10 cm, measured using a dendrometric tape at chest height (1.30 m). 125 people were interviewed (70 Baka, 35 Zime, 17 loggers from BK Business and 3 loggers from the Lomie communal forest). These individuals were selected on the basis of their connection to the Lomie communal forest and the various activities they carry out. Descriptive statistics were used to analyse logging damage, whilst a participatory, goal-oriented approach was adopted to gather proposals for priority measures aimed at reducing damage caused by logging operations. The results show that skidding is the forestry operation that causes the most damage (10.53 per cent) due to the type of formation and equipment used in the process; felling comes second with a disturbance rate of 10.15 per cent; road construction causes less damage, with a rate of 9.24 per cent; and clearing timber yards is the forestry operation that causes the least damage to the ground, at just 6.2 per cent. In order to limit the environmental impact of forestry operations, various strategies have been considered: controlled felling; the implementation of staff training programmes; mapping the locations of trees to be felled; limiting the width of skid trails to 4-5 metres and the area of timber yards to a maximum of 0.5 hectares; and holding site managers accountable through the introduction of a remuneration system based on the nature of the damage caused and on their performance bonuses.

Keywords

Environmental Impact, Logging, Strategies, Damage, BK Business Sarl

1. Introduction

Forests are plant communities that are essential to life on Earth and cover approximately 30.6 per cent of the world's land area [6]. They play a vital role in global climate regulation. Forests also have clear socio-economic, cultural and religious significance for the local communities that live there

and depend heavily on them for their survival. Indeed, forests are rich in important resources that are exploited. This exploitation includes timber products (timber, fuelwood and utility wood) and non-timber products (fruit, tubers, fodder, rope, bark, roots, etc.) [9].

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Whether at global, national or local level, forests fulfil numerous and significant environmental and socio-economic functions [5]. However, deforestation and forest degradation are two phenomena that have posed a genuine global challenge in recent decades. The consequences of these phenomena are manifold and deeply worrying for the future of the planet (loss of biodiversity, contribution to climate change, impacts on local communities dependent on these environments, etc.), affecting both developed and developing countries [7].

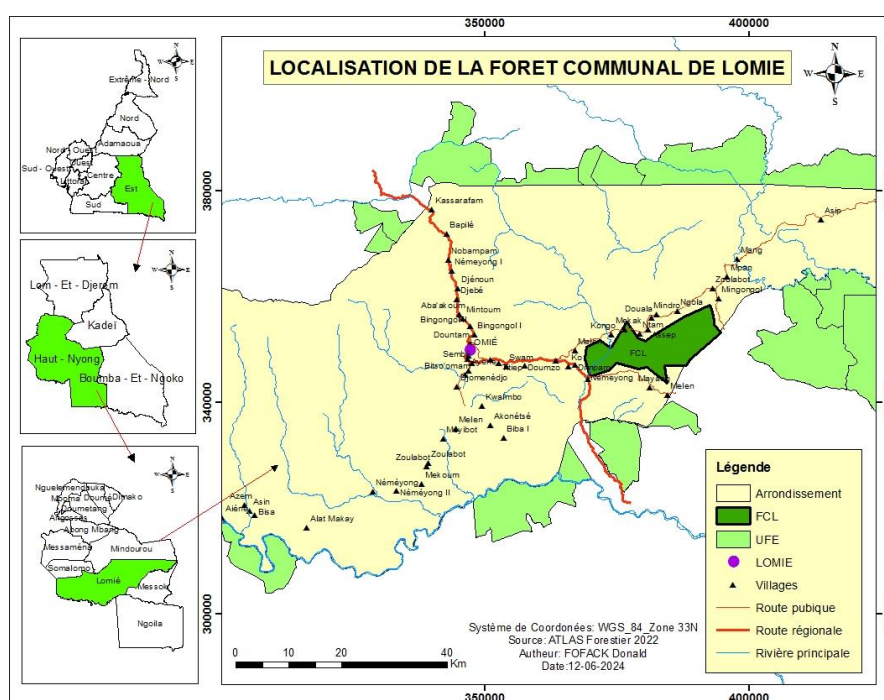
In Cameroon, and specifically in the East, logging results in significant damage to the forest stand. Its impact on the vegetation cover is evident in the creation of clearings, which cause injuries some of them fatal to young stems during felling and skidding operations [14]. However, this damage is directly linked to the methods and intensity of logging operations. It can lead to significant disturbances and changes in the forest's plant composition, resulting in a decline in species of high commercial value. The reduction in the forests' timber potential means that particular attention must be paid to forest plantations [15]. Their abandonment therefore calls into question Cameroon's commitment to implementing a sustainable forest management policy in terms of afforestation and regeneration

that is to say, how to move from exploitation that causes degradation to exploitation that promotes regeneration? Thus, at a time when timber production from natural forests can no longer meet the needs of the domestic and international markets, it is urgent, indeed essential, that the plantations established should not only be rehabilitated but also integrated into a participatory, rational and sustainable management process [11]. Hence the research question: what strategies could help to reduce or even limit the damage caused by logging operations at BK Business Sarl in East Cameroon?

2. Methodology

2.1. Description of the Study Area

The Lomie Communal Forest (FCL) underwent a classification procedure in 2008 and 2009. This process resulted in the classification, pursuant to Decree No. 2010/3837/PM of 8 June 2010, of a forest area of 15,194 ha on behalf of the municipality of Lomie. Figure 1 shows the geographical location of the Lomie Communal Forest (FCL).



Source: author.

Figure 1. Map showing the geographical location of the Lomie Communal Forest (FCL).

2.2. Data Collection

2.2.1. Quantification of Timber Losses Associated with Logging Operations

The study protocol was mixed, combining quantitative data

to measure impacts and qualitative data to understand damage-reduction strategies. Sampling focused on two plots comprising annual felling area 5 (aac5) of forest management unit 2 (ufe2) and annual felling area 1 of forest management unit 3. The two selected plots were each 250 m long by 20 m wide, covering a total area of 0.5 ha. The team, positioned across the

full width of the plot, moved along its entire length. They thus covered 20 m across the width, and the inventory was carried out in this manner, with four passes required to cover each plot. An inventory was carried out on stems with a diameter of ≥ 10 cm, measured using a dendrometric tape at chest height (1.30 m). These stems were examined to determine the types of damage. The types of damage sustained by stems affected by forestry operations were classified as follows: debarking, delimbing, crushing, uprooting and breakage [14].

After mapping the roads, we returned to the site to survey the damage. On this occasion, damage was recorded over a width of 28 metres, corresponding to the average right-of-way of the main roads, and 26 metres for secondary roads. All damage was recorded according to the different types of damage caused to tree species. Thus, all destroyed or damaged trunks with a diameter of 10 cm or more were recorded. The team responsible for the post-harvest assessment was the same as that for the pre-harvest inventories, and we worked in groups.

1) For the timber yards:

Once the roads had been marked out, and with the help of the team leader, we identified the various locations intended to house the timber yards. At each of these locations, a square plot measuring 30 m $\times$ 20 m was established, within which a full inventory was carried out on all tree species with a diameter at breast height (DBH) of 10 cm or more. All the timber yards within the selected plots were inventoried. After the timber yards had been established, we returned to record any lost or damaged stems. In this way, the damage caused by the establishment of the timber yards to the remaining stand was estimated.

2) At the felling sites

Using the tree selection map and skid trails, all trees to be felled in the various plots were identified. We returned after felling to record the stems destroyed by the impact of felling. All damaged and destroyed stems around the felled tree were recorded according to the different types of damage in the felling record sheet.

3) On the skid trails

After the skid trails had been cleared, we returned to follow their road. All stems with a diameter at breast height (DBH) of 10 cm or more were counted along all the skid trails and

recorded in the skidding record sheet. Similarly, the lengths of the tracks were measured in order to determine the area disturbed by this operation. The damage caused by skidding was thus assessed and recorded.

2.2.2. Proposals for Priority Strategies to Reduce Damage Associated with Logging Operations

A participatory, goal-oriented approach (PGOA) was adopted to gather proposals for priority measures aimed at reducing damage caused by logging operations, through semi-structured interviews conducted in the two villages closest to the forest: Messok and Payo. A total of 125 people were interviewed (70 Baka, 35 Zime, 17 loggers from BK Business and 3 loggers from the Lomie communal forest). These individuals were selected on the basis of their interaction with the Lomie communal forest and the various activities they carry out.

2.3. Data Processing and Analysis

2.3.1. Quantification of Timber Losses Associated with Logging Operations

To estimate timber losses associated with logging operations, the data were entered into Microsoft Excel and the following formula was used based on the method described by [7]:

$$T (\%) = Si/Sp \times 100, \text{ Where:}$$

T = Impact rate (%); Si = area affected and Sp = area of the sampled plot.

$$Si = \text{number of trees felled} \times \text{average area affected per tree}$$

2.3.2. Proposal for Priority Strategies to Reduce Damage Associated with Logging Operations

The data from the interviews were listed and organised in Microsoft Excel 2016, and a content analysis was carried out. This analysis highlighted the priority areas for reducing damage caused by logging operations, broken down by sector of activity.

2.4. Results

2.4.1. Assessment of Timber Losses Associated with Forestry Operations

Table 1. Breakdown of damage recorded across all logging operations on future-generation trees by type of damage.

Types of damage	Main road	Secondary road	Timber yard	Felling	Skid track	Total
Damaged	364	321	121	1,445	520	2,771
Stripped of bark	83	63	3	301	377	827
De-branched	160	142	0	497	0	799

Types of damage	Main road	Secondary road	Timber yard	Felling	Skid track	Total
Broken	121	116	118	647	143	1145
Lost	576	527	1079	522	1,521	4,225
Uprooted	468	409	1062	0	1314	3,253
Toppled	7	21	17	422	112	579
Crushed	101	97	0	100	95	393
Total	940	848	1,200	1967	2,041	6,996
(%)/ residual stem (19,371)	4.85	4.37	6.19	10.15%	10.53	36.09

Table 1 shows that skidding is the forestry operation that causes the most damage to the residual stand. Skidding alone destroys 10.53 per cent of the stems in the residual stand. After this operation, felling is the second operation to cause significant damage to the residual stand, accounting for 10.15% of the stems in the residual stand. Operations such as the construction of roads and timber yards cause less damage to the site's residual stand.

The total damage rate caused by forestry operations is 36.09

per cent of the remaining stand. This rate is significantly higher than the damage rate permitted under forestry legislation, which is 7 per cent.

In **Table 1**, skidding and felling account for more than 20.68 per cent of the destroyed stems. In terms of logging damage to the residual stand, skidding is the most destructive operation, followed by felling, and then the construction of timber yards and roads. **Table 2** shows the breakdown of damage caused by each logging operation.

Table 2. Breakdown of the proportion of stems lost by logging operation.

Forestry operation	Number of stems lost	% of total lost stems	% of the remaining stand
Main road	940	13.44	4.85
Secondary road	848	12.13	4.37
Timber yard	1,200	17.15	6.19
Felling	1967	28.11	10.15
Logging track	2041	29.17	10.53
Total damage	6,996	100.00	36.09
Total remaining stand	19,371		

During logging operations, small-diameter stems (10, 20, 30 cm) suffer more damage than large-diameter stems. This is because machine operators take greater care with large-diameter trees, which they regard as stems to be harvested in future years. Skidding results in the highest proportion of lost stems (29.17%), followed by felling (28.11%).

2.4.2. Proposed Priority Strategies to Reduce Damage Associated with Forestry Operations

Based on this assessment, a number of priority strategies have been identified for implementation across several areas of activity (planning of forestry operations, felling, delimbing and cross-cutting, skidding, Skid trail marking, Infrastructure

through the creation of log yards and tracks, Monitoring, Auditing and Training, and the Post-logging phase) to minimize damage associated with the various forestry operations. These priority strategic areas, together with those responsible for their implementation, are set out in **Table 3**.

Table 3 shows that planning is the most important step in preventing damage. Before any operations, it is essential to draw up a survey plan and/or a micro-zoning plan for the logging site. This plan enables the mapping of the location of trees to be felled, future tree species, seed trees, watercourses and steep slopes. Based on this plan, all main and secondary tracks, as well as skid trails, must be marked out and sign-posted on the ground before the machinery arrives. This mark-

ing system thus limits detours and prevents uncontrolled traffic. Finally, sensitive areas such as low-lying areas, riverbanks within 30 meters of the water's edge and slopes steeper than

35 per cent must be excluded from logging operations. This measure directly reduces the area of disturbed soil and protects water resources.

Table 3. *Priority strategies for reducing damage associated with forestry operations by sector of activity.*

Sectors of activity	Priority actions	Responsible parties
Planning of logging operations	Priority 1: Draw up a sampling and clearing plan prior to the actual logging operations	Operator: BK Business Sarl
	Priority 2: Mark trees for felling, future tree species and skid roads	Operator: BK Business Sarl
	Priority 3: Avoid steep slopes and low-lying areas	Operator: BK Business Sarl
	Priority 4: Train staff in best practices for low-impact forestry operations (directional felling)	MINFOF / Operator: BK Business Sarl
Felling, Delimbing and Logging Sector	Priority 5: Protect future stems of primary and secondary tree species during logging operations (use wedges and winches to control the direction in which large-diameter trees fall)	Logging operator: BK Business Sarl
	Priority 6: Comply with the standards (diameter) for harvestable tree species whilst prohibiting the felling of seed trees and future-generation tree species	MINFOF / Logging operator: BK Business Sarl
	Priority 7: Adhere to the skid trails that have been marked out for the inventory	MINFOF / Operator: BK Business Sarl
Sector: Skidding, Marking of skid trails	Priority 8: During the logging process, the team in charge must ensure that low-impact machinery is used	Operator: BK Business Sarl
	Priority 9: Carry out skidding in dry weather to minimise the formation of ruts, ridges and holes in the ground caused by the repeated passage of skidding machinery	Operator: BK Business Sarl
	Priority 10: Limit the width of tracks to 4-5 m and log yards to 0.5 ha	MINFOF / Operator: BK Business Sarl
Infrastructure (creation of log yards and skid trails)	Priority 11: Reduce skidding distances by increasing the density of the network	Operator: BK Business Sarl
	Priority 12: Install structures to combat soil erosion	Operator: BK Business Sarl
	Priority 13: Annual training and refresher courses for staff on health, safety and the environment (HSE)	MINFOF / Operator: BK Business Sarl
Monitoring, Auditing and Training	Priority 14: Implement a quarterly audit to ensure compliance with standards during the logging phase	MINFOF
	Priority 15: Implement a payment system for compensation linked to damage rates for each logging operation	MINFOF
	Priority 16: Plant cover species on degraded and/or bare areas	Operator: BK Business Sarl
Post-logging	Priority 17: Close tracks and skid trails not used during the logging period	Operator: BK Business Sarl
	Priority 18: Assess damage over a six-month period following logging operations	MINFOF / Operator: BK Business Sarl

Damage caused by felling and skidding accounts for around 36.09 per cent of the total. The first measure is directional felling. All fellers must be trained in the use of wedges and winches, and in making directional cuts to ensure the tree falls into a natural clearing and to avoid damaging remaining trees (future stems). The second measure involves identifying and protecting seed trees and future stems. These trees must be marked prior to felling, and their felling must be strictly prohibited. The third measure is the optimization of bucking. By reducing the number of logs and working as close to the ground as possible, handling operations and collateral damage to the ground and regeneration are minimized. It is necessary to put in place controls and penalties for any operator who deviates from the planned road.

The creation of skid tracks and log yards is a major source of forest degradation. The width of skid tracks must therefore be limited to 4-5 metres and the area of log yards to a maximum of 0.5 hectares. At the same time, it is recommended that the network of skid tracks be made denser in order to reduce the average skidding distance to less than 300 meters. To combat erosion, drainage structures must be installed: ditches, culverts and outlets every 50 meters. When crossing watercourses, the use of temporary wooden bridges and culverts is preferable to embankments, which disrupt the flow.

Monitoring the logging site is essential, as without it, no measures would be sustainable. It is therefore a priority to introduce a quarterly audit. Monitoring plots enable the damage rate to be measured. To make site managers accountable, a payment system based on the nature of the damage must be introduced, linking part of their bonus to the damage rate recorded. Finally, annual Health, Safety and Environment (HSE) training and refresher courses for all teams are essential to maintain a high level of awareness regarding the impact of every action on the forest. Following the closure of the logging site, two actions are a priority: the first is the closure of abandoned tracks and skid trails, and the second is the implementation of regeneration monitoring six months after logging. This monitoring enables the effectiveness of the measures to be assessed and allows them to be adjusted for the next cycle.

3. Discussion

Logging is the activity that causes the most damage, with a disturbance rate of 10.53 per cent on the soil of the sample plot; felling comes second with a disturbance rate of 10.15 per cent; road construction causes less damage than felling, with a rate of 9.24 per cent (main and secondary roads); operations in timber yards constitute the forestry activity causing the least damage to the ground, at just 6.2 per cent. This finding is similar to the conclusions of [3], which show that skidding and felling are the forestry activities causing the most soil damage, whilst land clearing for roads and unloading areas causes less damage. The rate of damage depends on the height and width of the tree. The larger the crown of the felled tree, the more

damage it will cause as it falls, and the more severe that damage is likely to be. This is particularly true when the tree is not felled in the correct direction or when delimbing has not been carried out to minimise damage to the stand. This finding is consistent with that of [4], who suggest that directed and controlled felling techniques help to limit the impact of a falling tree on the remaining stand. Whilst it is widely accepted that adopting felling practices in line with EFIR standards is not the sole criterion for obtaining certification for forest concessions, it remains one of the fundamental requirements. However, controlled felling must aim to minimise damage to surrounding trees. The forestry operations of BK Business Sarl require road infrastructure necessary for felling activities and timber transport [10]. Alongside the loss of forest cover caused by tree harvesting, the construction of road infrastructure further alters habitats, affecting the dynamics of forest ecosystems [8-17]. Furthermore, the indirect impacts associated with the development of forestry infrastructure (i. e. skid trails and forest roads) can lead to additional effects, including greater temperature fluctuations, the invasion of competing species, the creation of new aquatic habitats [1], and the clearing of ground vegetation [13]. The planning of training and assessment programmes for loggers is of paramount importance. Particular attention must also be paid to the reforestation and/or enrichment of felling clearings, as demonstrated by the work of [2] carried out in several forest concessions in Central Africa. Furthermore, the setting aside of seed trees containing dormant seeds and the application of techniques.

4. Conclusion

This study examined the environmental impact of logging and strategies for reducing damage: a case study of BK Business Sarl in Eastern Cameroon. It emerged that skidding is the forestry operation causing the most damage to the soil, with a disturbance rate of 10.53% on the soil of the sample plot; felling follows with a disturbance rate of 10.15 per cent; road construction causes less damage than felling, with a rate of 9.24 per cent; and clearing of logging yards is the forestry operation that causes the least damage to the soil, accounting for only 6.2 per cent. To limit or even reduce the environmental impact of forestry operations, various strategies have been considered. However, controlled felling should aim to reduce felling damage to surrounding trees. Planning training and assessment programmes for loggers would be essential for forestry operators. This would involve mapping the locations of trees to be felled, future tree species, seed trees, watercourses and steep-slope areas; placing particular emphasis on reforestation and/or enrichment of felling clearings; limiting the width of skid trails to 4-5 metres and the area of logging yards to a maximum of 0.5 hectares; implementing a quarterly audit to monitor the logging site; and holding site managers accountable by introducing a payment system based on the nature of the damage and their performance bonuses.

Abbreviations

UFE	Forest Management Unit
AAC	Annual Felling Quota
FCL	Lomie Communal Forest
DBH	Diameter at Breast Height
PGOA	Participatory, Goal-Oriented Approach
HSE	Health, Safety and the Environment
EFIR	Low-Impact Forestry

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Author Contributions

Christelle Dadem: Funding acquisition, Supervision
Jean Baurel Atchombou: Writing – review & editing
Donald Fofack: Conceptualization, Investigation

Conflicts of Interest

The authors declare no conflicts of interest.

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