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Case Study on the Financial Viability of Forest Management on Public Lands in the Brazilian Amazon

Maisa Isabela Rodrigues [1,*], Álvaro Nogueira de Souza [2], Lucas José Mazzei de Freitas [3], José Natalino Macedo Silva [4], Maísa Santos Joaquim [1], Reginaldo Sérgio Pereira [2], Leonardo Job Biali [2], Jonas Inkotte [2], Juliana Baldan Costa Neves Araújo [2] and Renan Augusto Miranda Matias [5]

[1] Department of Agribusiness Management, University of Brasilia, Brasilia 70910-900, DF, Brazil; maisajoaquim@unb.br
[2] Department of Forest Engineering, University of Brasilia, Brasilia 70910-900, DF, Brazil; ansouza@unb.br (Á.N.d.S.); reginaldosp@unb.br (R.S.P.); ljbiali@unb.br (L.J.B.); jonasink@gmail.com (J.I.); juliana.bcneves@gmail.com (J.B.C.N.A.)
[3] Embrapa Eastern Amazon, Trav. Dr. Enéas Pinheiro s/n, Belem 66095-100, PA, Brazil; lucas.mazzei@embrapa.br
[4] Graduate Program in Forest Sciences, Federal Rural University of the Amazonia, 2501 Presidente Tancredo Neves Ave, Montese, Belem 66077-530, PA, Brazil; silvanatalino734@gmail.com
[5] Instituto Conexões Sustentáveis, 66 Praia do Flamengo St, Bl. B, 320, Rio de Janeiro 20040-006, RJ, Brazil; renanmatias@hotmail.com
* Correspondence: maisa.rodrigues@unb.br

Abstract: Brazil has a vast reserve of natural forests that belong to the state; hence, the state is responsible for supplying native wood to the market. However, the management in public forests has only begun recently; thus, much research is needed to know about its profitability. This study analyzed the financial feasibility of public forest management by addressing the following aspects: state concession, federal concession, and community forest management. We used the Net Present Value, Annual Equivalent Value, and Average Cost of Production methods to assess financial feasibility and applied the Monte Carlo simulation to estimate the probability of occurrence of NPV values. Community forest management showed profitability and a low occurrence of positive NPV values. The initial subsidies and the absence of royalty payments contributed to their good financial performance. The state and federal forest concessions showed financial unfeasibility and a low probability of profitability, which were justified by a low harvested volume of forest management, a high number of hollow individuals with small dimensions, poor volume estimates, and a high occurrence of species with low commercial values. Financial viability is a critical aspect of public forest management, and the achievement of good results depends on the consideration of several factors and aspects of public forests. Characteristics such as species composition, the distance between the managed areas, and the place of consumption must be considered. Areas that are not financially viable in the current period can be considered for future management and maintenance.

Keywords: forest concessions; forest economy; forest policy; public forest management

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1. Introduction

Brazil has approximately 488 million ha of natural forests, most of which belong to the state [1], a common characteristic for countries with high forest cover [2]. About 311 Mha of public forests are registered, and 286 Mha of forests are located in the Amazon [1,3]. Given the great extent of public forests, the government is responsible for providing native wood to the consumer market.

Public forests are classified as Conservation Units (Portuguese acronym UC) to ensure their full protection or sustainable use. Production activities are permitted within the sustainable use classification if they abide by the Brazilian environmental legislation. National (Portuguese acronym FLONA) and State Forests (Portuguese acronym FLOTA)

aim to achieve sustainable multiple use, with an emphasis on the methods of sustainable exploitation of natural forests [4].

Interested stakeholders choose to invest in timber leases and provide concessions for countries with vast stretches of public land, such as Canada, Indonesia, Russia, and Brazil [5]. The Public Forest Management Law allows for the exploration of timber and non-timber forest resources in public forests by regulating the exploration process through the mechanisms of forest concession, direct management by the state, or the allocation of public forests to local communities [6]. Thus, wood production, which is a crucial component of forest protection and biodiversity conservation, continues to take place, reducing the negative impact on forest values and contributing to increased income generation from natural forests [7], with extraction limits and yield levels being set for wood harvesting, along with other parameters being set to balance costs and investments [8].

For Brazil, cutting cycles of 30 and 35 years are adopted, with the maximum permitted harvested volume corresponding to 25.8 m^3/ha and 30 m^3/ha, respectively, based on an annual increment of 0.86 m^3/ha [9]. A few areas of natural forests in Brazil have been managed and subsequently monitored to understand their further development. Though the first studies began in the 1970s, we only have one experimental area that carried out a second cutting cycle [10], showing an annual increment of 1.47 m^3/ha after 32 years of exploration [11]. Since there is a lack of information, the forest management legislations adopted for the annual increment of forests in the Brazilian Amazon are inadequate.

The concession of national and state forests takes place through public bidding. Those with granting power (the federal government or states) issue a public notice, providing information about the areas that are being considered for concession; then, the bidder offering the highest amount of royalties is selected among the several companies that have the technical and economic ability to carry out forest management [6]. On the other hand, community forest management consists of allocating a forest to the traditional communities residing in the area [6], with the community being responsible for managing the exploitation of timber and non-timber forest products. It should be noted that community forest management does not require any payment of royalties. In most forest destinations in Brazil, wherein wood production is carried out on a large scale, the concession model is applied just in the Amazon, which is located in the country's northern region.

The management models promote forest management and protect the UCs from irregular occupation and predatory exploitation processes. Community forest management is a commonly adopted model worldwide aimed at conserving forests, recognizing community rights, and improving local livelihoods [12]. Brazil's forestry concession process shows satisfactory results, and less than 6% of invasions observed in the UCs are in the forest concession areas [13]. It is important to note that community forest management and forest concessions are recognized as governance instruments since they aim to manage forests, reduce environmental degradation, and bring about socio-economic benefits for the local population [14,15].

Millions of hectares of public forests are still eligible for concessions, but illegal resource extraction is currently taking place in those areas [16,17]. The policy that allows for forest management in public areas has only been recently adopted in Brazil, and it is understood that forest concessions are complex and challenging to implement. Despite many flaws, the Brazilian forest concession model is slowly and steadily developing [18].

Little is known about the financial viability of forest management on public and private lands. Forest management results in native forests have seldom been rigorously examined [7]. Important experimental research on forest management in the Brazilian Amazon was carried out, but it still needs to address the economic or financial aspects [19,20]. When considering forest concessions and allocating public forests as financial investments, they must be financially viable for the investor.

Management companies in the Brazilian Amazon are experiencing financial difficulties and defaults with the government, leading, in some cases, to the abandonment of forest

concession [17]. Financial difficulties can be understood as greater probabilities of financial unfeasibility and an abandonment of investments [21].

There are few studies on forest management, and our objective was to analyze the financial viability of investments in different forest management initiatives in public forests in the Brazilian Amazon. In this context, the paper is relevant as it addresses the financial viability of forest management in three categories: federal forest concession, state forest concession, and community forest management. Therefore, the results presented are important for investors and government managers of public forests in Brazil.

2. Materials and Methods

2.1. Study Sites

Para is a coastal eastern Amazonian state and the biggest producer of native wood in Brazil. The state's forests have easier access to markets, and forest management is more developed than in other Amazonian states. Within Para, we selected three management case studies: one federal forest concession, one state forest concession, and one community forest management (Figure 1):

- Saracá-Taquera federal forest concession, which has 32,000 ha Forest Management Unit (UMF) 2 of FLONA (01°41′58″ S and 56°14′05″ W);
- Paru state forest concession, which has 99,868.54 ha UMF 1 of FLOTA (01°12′07″ S and 53°18′54″ W);
- Tapajós community forest management, which has 30,063 ha of FLONA (02°50′50″ S and 54°54′40″ W).

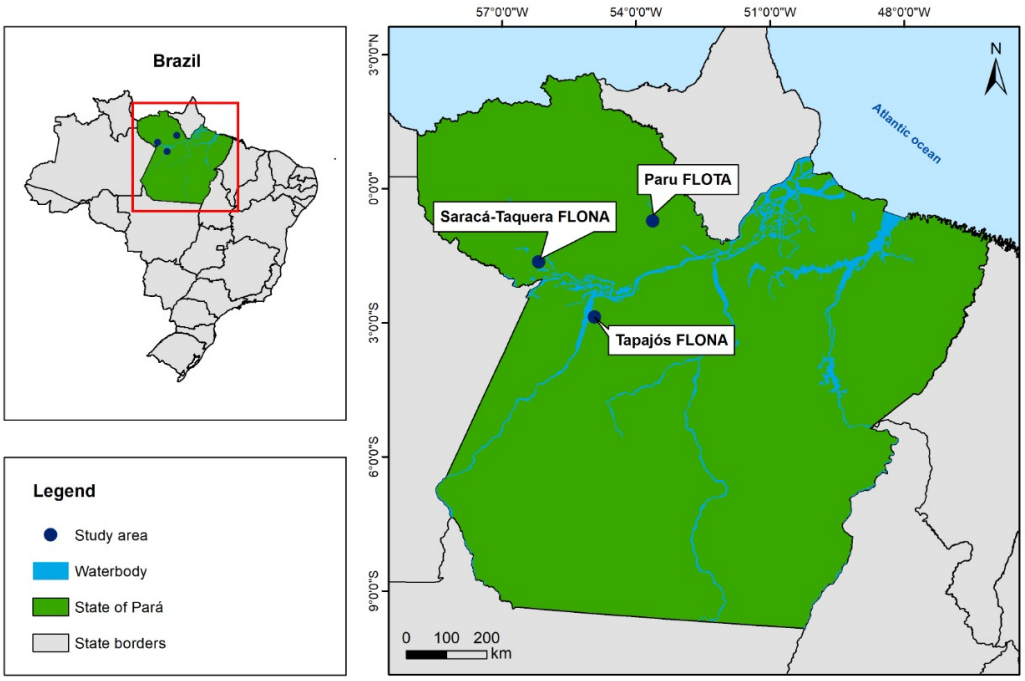

Figure 1. Location of the case studies in Para.

We chose Tapajós FLONA to present a successful model of community forest management, and we chose Saracá-Taquera FLONA and Paru FLOTA because the areas are among the oldest forestry concessions in Brazil.

2.2. Data

Table 1 summarizes the annual production and cash flow information collected from three management operations in 2019. These are historical data for the early years of forest management in each case. The data required to carry out the study related to costs and revenues were gathered through meetings held with the company's management and

accounting sectors and the cooperative. The volume handled in Saracá-Taquera FLONA and Paru FLOTA was collected in the Documents of Forest Origin, which is necessary for logs' transportation. The cooperative supplied the volume of Tapajós FLONA, measured in the company's yard.

Table 1. Costs and revenues from forest management carried out at Tapajós FLONA, and forest concessions from Paru FLOTA and Saracá-Taquera FLONA, Para, Brazil.

Local	Periods	Area (ha)	Volume (m^3)	Harvested Volume (m^3/ha)	Costs (USD)	Revenues (USD)
Saracá-Taquera FLONA (federal forest concession)	1	-	-	-	1,204,462.31	-
	2	-	-	-	134,286.45	-
	3	-	-	-	40,179.87	-
	4	1013.00	21,627.63	21.35	1,353,514.85	1,787,668.93
	5	971.42	13,683.56	14.09	995,289.41	1,151,056.55
	6	1321.00	22,179.23	16.79	1,513,637.81	1,946,827.30
	7	996.33	19,906.93	19.98	1,624,918.13	1,747,371.09
	8	929.33	19,377.00	20.85	1,656,256.11	1,743,377.62
	9–40	921.42	17,148.93	18.61	1,470,255.59	1,542,914.48
Paru FLOTA (state forest concession)	1	-	-	-	457,172.11	-
	2		3600.44		263,362.41	263,362.41
	3		50,106.74		2,776,782.79	2,780,615.54
	4	9258.53	29,744.85	14.99	2,199,552.97	2,192,328.47
	5		42,259.80		2,729,604.41	2,886,270.94
	6		13,035.27		932,526.70	932,526.70
	7–30	3140.72	47,066.35	14.99	3,357,595.17	3,367,066.24
Tapajós FLONA (community forest management)	1	100.00	1544.80	15.45	129,607.63	143,041.44
	2	300.00	3650.80	12.17	162,801.52	201,469.53
	3	521.00	7843.20	15.05	117,427.84	114,714.05
	4	700.00	13,452.00	19.22	249,967.67	337,266.26
	5	1000.00	14,884.90	14.88	360,506.71	390,978.46
	6	1000.00	15,845.70	15.85	433,913.30	550,744.90
	7	1000.00	19,981.70	19.98	621,717.01	646,944.57
	8	1000.00	22,027.90	22.03	618,849.66	730,407.17
	9	1600.00	37,563.50	23.48	970,110.11	1,054,430.57
	10	1600.00	38,090.40	23.81	1,309,122.05	1,547,243.60
	11	1600.00	28,628.65	17.89	983,932.72	1,162,904.27
	12	1600.00	28,628.65	17.89	983,932.72	1,162,904.27
	13	1436.74	21,421.00	14.91	964,030.76	1,372,990.36
	14–30	741.69	13,270.99	17.89	597,247.89	850,611.45

The costs presented refer to all forest management stages, such as administrative costs of pre-exploratory, exploratory, and post-exploratory activities. Revenues are managed wood commercialization, logs for community forest management and state forest concession, and sawn timber for the federal forest concession. The financial data were collected in Brazilian reais (BRL) and converted to USD in the proportion BRL 1.00 = USD 5.44, which is the exchange rate as of March 2023.

The federal and state concessions had been in operation for five years when we collected these data, while the Tapajos community management unit had been in operation for thirteen years. The managed areas are operating on 30-year cutting cycles. The federal concession began management in the third year of the contract. Hence, this concession completed its first harvest cycle in year 32, and the company will carry out forest management activities in the last 8 years of the contract in the second cycle areas. We estimated the harvested volumes, costs, and revenues for the projected future years of the contracted cutting cycles as the per-hectare averages of the harvested volumes, costs, and revenues from the early years' evidence projected over equal annual hectare segments of the remaining area.

2.3. Financial Evaluation

Our financial evaluation estimated standard deterministic measures of forest returns. Our measures of forest returns are Net Present Value (NPV; Equation (1)), Annualized Net Present Value (ANPV; Equation (2)), and Average Production Cost (APC; Equation (3)).

$$NPV = \sum_{j=0}^{n} R_j 1 + i^{-j} - \sum_{j=0}^{n} C_j (1+i)^{-j} \quad (1)$$

$$ANPV = \frac{NPVi(1+i)^n}{(1+i)^n - 1} \quad (2)$$

$$APC = \frac{PV_c}{V} \quad (3)$$

where Rj = revenue; Cj = costs; PVc = present value of costs; V = harvested volume; i = minimum attractiveness rate (%); j = period of time (years); and n = investment duration (years).

For the minimum attractiveness rate in Equations (1)–(3), we adopted an opportunity cost of 9%. The rate shown was determined based on a consultation with the forest sector. This value is usual for companies that work with forest management in Brazil, and it is also similar to what we find in scientific articles that address the subject [21,22].

Equations (1)–(3) are deterministic, but forest operations are risky because anticipated future harvested volume and wood product sale values are uncertain. We introduced Monte Carlo simulations [23] to estimate the probability of the occurrence of NPV values. The two uncertain inputs for these simulations are the harvested volume per ha and the average wood sale price. For small data samples with an unknown random variable, Samuelson [24] recommends a triangular distribution.

To employ this method, the three uncertain inputs adopted were the minimum, maximum, and probable values. Companies' annual reports' highest and lowest values as the minimal and maximal harvested volume values were utilized. Also, the average harvested volume for the known initial periods was used as the probable harvested volume variable. The minimal, maximal, and probable prices are similar measures that were taken from the revenue data for the known initial years for each of the three management operations. Table 2 records these values.

Table 2. Variables used for Monte Carlo simulation.

Forest Management	Inputs	Maximum	Probable	Minimum
Federal	Harvested volume (m^3/ha)	21.35	18.61	14.09
	Price (USD/m^3)	257.44	226.18	207.79
State	Harvested volume (m^3/ha)	18.95	14.99	11.61
	Price (USD/m^3)	74.11	71.94	55.80
Community	Harvested volume (m^3/ha)	23.81	17.89	12.17
	Price (USD/m^3)	77.34	64.45	25.21

The Monte Carlo simulation was performed using @Risk software version 8.2.0 separately for each forest management modality, and it was possible to obtain 100,000 NPV scenarios based on the probability distribution generated by interactions between the input and output variables.

3. Results

Different company cash flow components directly interfere with investments' profitability, making the financial returns different. The UMFs offer products with different characteristics marketed for other values. The community forest management sold the lot of wood in the company's yard at 64.45 USD/m^3, the state forest concession sold the logs in the port for an average price of 71.94 USD/m^3, and the federal concession sold sawn wood at 226.19 USD/m^3. The UMFs also have different exploitation arrangements, directly interfering in the cost structure (Figure 2).

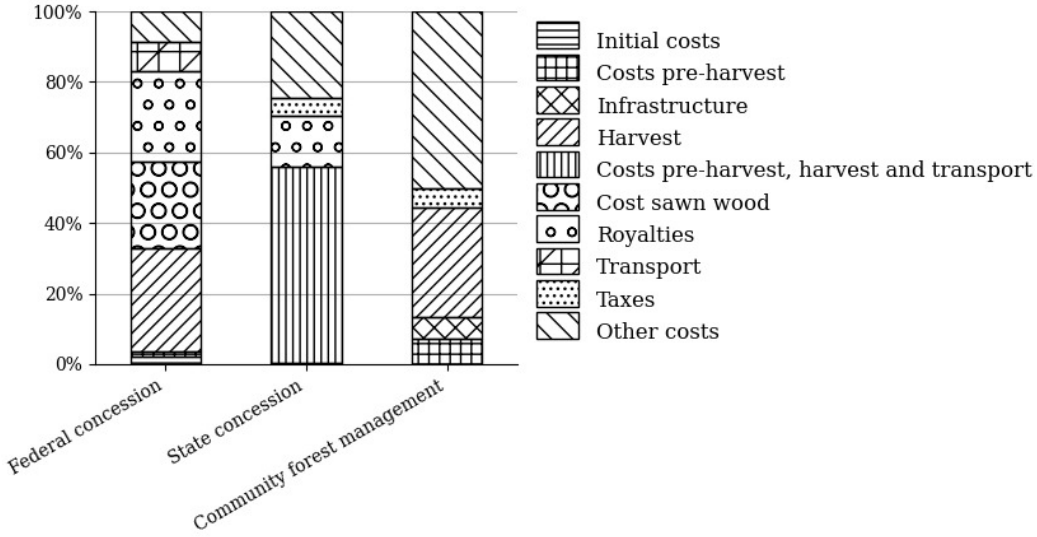

Figure 2. Costs presented by forest management initiatives.

As they present different organizations, the components characterized as other costs differ between companies. Thus, the items inserted in each area of study are as follows:

- Federal concession: The infrastructure cost, taxes, permanent plot monitoring, administrative sector employee payments, protective materials and clothing, and labor charges.
- State concession: Costs with the administrative sector, forest inventory, permanent plot monitoring, and profit sharing with the company's owners.
- Community forest management: The maintenance of machinery and equipment, labor rights, taxes, the payment of outsourced employees, administrative sector expenses, employee displacement, permanent plot monitoring, consulting, team training, protection materials and clothing, labor charges, and profit sharing with the members.

The federal concession forest management is carried out entirely by the management company. In the state forest concession, pre-exploratory activities, harvesting, yard operations, and transportation between the company's yard and the ferry are outsourced. In community forest management, there are costs for leasing trucks for the internal log transportation, machines, and tractors, and the other activities are carried out by cooperative members and the company's technical staff.

Only community forest management shows financial viability (Table 3), as the NPV and ANPV show positive results, and the APC is lower than the revenues obtained by the cooperative. Contrariwise, state and federal forest concessions are unfeasible via a deterministic analysis.

The NPV indicates that forest management in UMFs is financially unfeasible for state and federal concessions since the investment costs are higher than the revenues. Community forest management is viable, unlike concessions, since the revenues are higher than the investment costs, so it has a positive result. The ANPV indicates financial viability only for community forest management. Even when considering the annual return on investments with different durations, federal forest concession remains the least attractive financial investment. The APC projects are directly related to the added products' offered values.

The federal forest concession has the highest production cost because the concessionaire company sells sawn wood.

Table 3. Deterministic methods used to assess the financial viability of investments in different forest managements.

Indexes	Forest Management		
	Federal Concession	State Concession	Community
NPV (USD)	−468,574.14	−266,415.17	1,507,868.45
ANPV (USD)	−43,558.47	−25,931.88	146,770.41
APC (USD/m^3)	229.74	70.87	36.85

The Monte Carlo simulation showed favorable scenarios for community forest management (Figure 3a). According to the analysis, the investment has a 94.2% probability of presenting a positive NPV, with a 72.5% probability of return lower than the calculated NPV (USD 1,507,868.45). Despite being low, the investment is likely to have negative returns but is less subject to risks than the other investments analyzed.

The scenarios obtained for the state (Figure 3b) and federal (Figure 3c) forest concessions are pessimistic. State forest concession has a 3.7% chance of presenting an NPV > 0, with an 88.1% probability of offering a financial return lower than the calculated NPV (USD −266,415.17). In more favorable scenarios, the federal forest concession has a 21.9% chance of presenting an NPV > 0, with a 60.4% higher return probability than the calculated NPV (USD −468,574.14).

When analyzing the percentiles, federal concession has a 95% chance of loss and 5% financial viability. For state forest concession, none of the scenarios show financial viability (Table 4). Even with a small probability of financial viability, the percentiles do not show satisfactory results for state forest concession since less than 5% of the scenarios have an acceptable financial return. In contrast, almost all of the simulated scenarios for community forest management are financially viable.

Table 4. Statistical parameters of the Monte Carlo simulation for federal and state forest concessions and community forest management.

Statistic	Federal	State	Community
Minimum value	−1,199,617.99	−5,716,694.58	−1,035,406.39
Maximum value	968,317.57	457,145.53	3,593,054.16
Mean	−324,982.34	−1,549,512.54	1,575,260.33
Percentiles			
5%	−935,580.15	−3,683,364.60	−6,739,837.63
25%	−620,701.74	−2,331,880.42	940,017.95
50%	−363,212.39	−1,355,462.97	1,694,355.26
75%	−48,441.66	−607,297.18	2,273,273.90
95%	235,419.01	−55,458.75	2,870,419.48

The sensitivity analysis (Figure 4) points to a higher sensitivity of the NPV to the price of wood. The relevance of the value at which wood is traded is so important that fluctuations in this variable's values have caused a negative return for community forest management at the lower limit (USD −114,624.32) and a positive NPV for the federal forest concession at the upper limit (USD 390,149.84). The extreme values of the NPV of state concession that were obtained separately with the variation of the harvested volume and wood's selling price are negative, corresponding to USD −1,353,706.66 and USD −1,749,602.36 for the harvested volume and corresponding to USD −32,260.50 and USD −3,717,174.03 for the wood price.

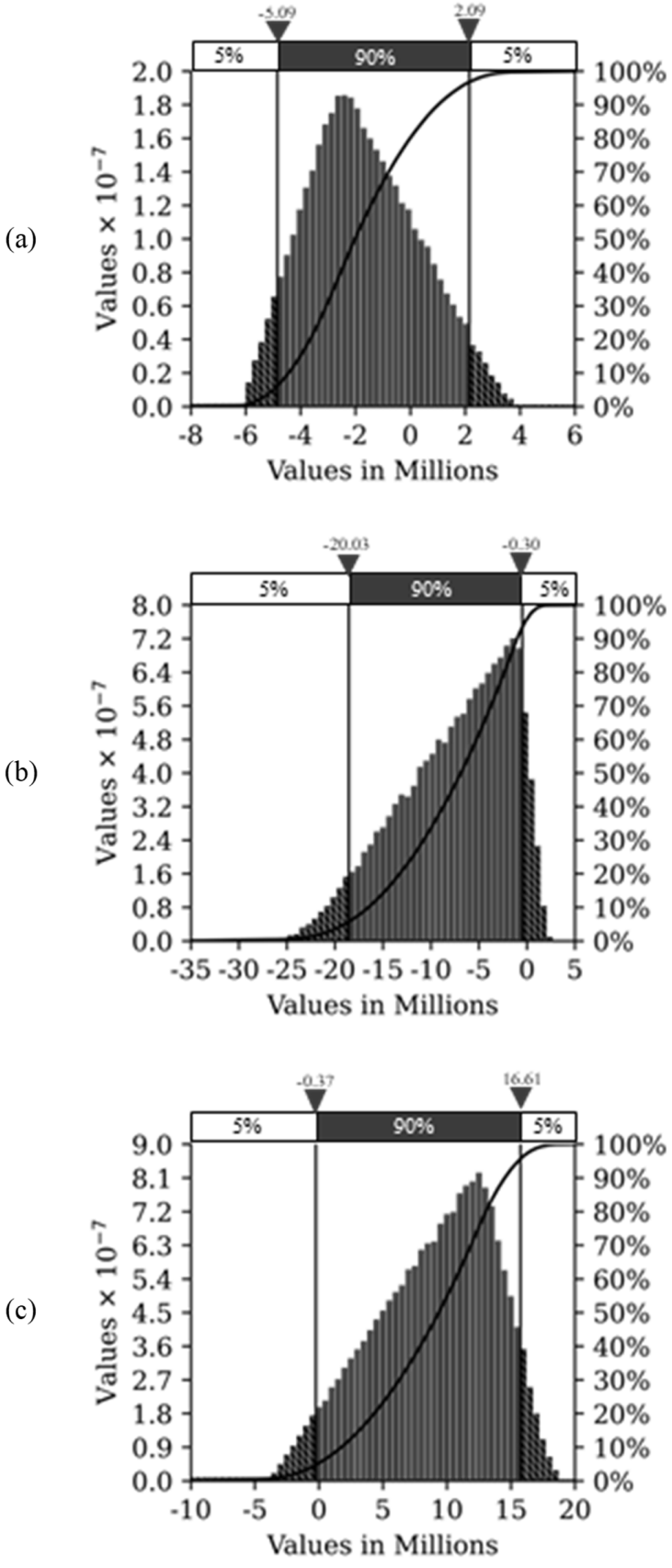

Figure 3. Distribution of frequency and cumulative frequency of NPV (BRL) for federal (**a**) and state (**b**) forest concessions and community forest management (**c**). USD 1.00 = BRL 5.44 in March 2023.

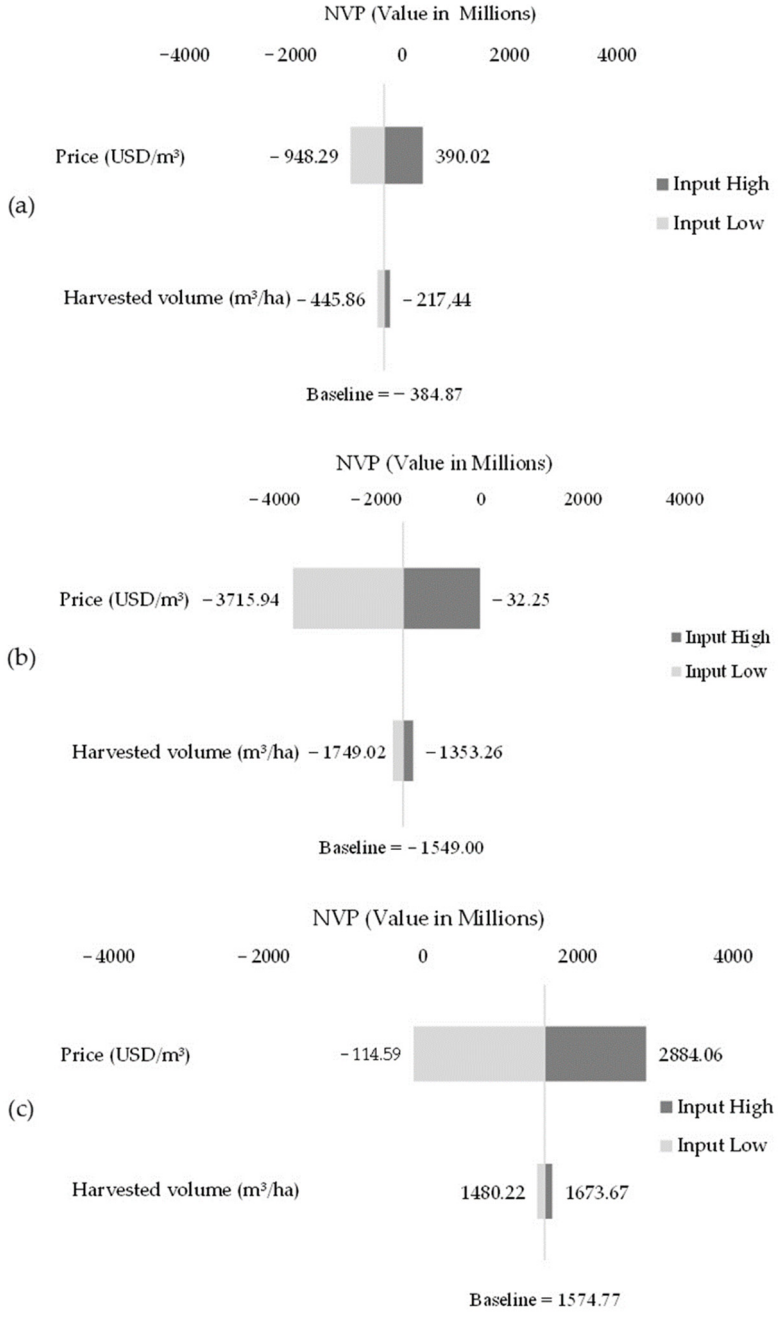

Figure 4. Sensitivity analysis of NPV to inputs for federal (**a**) and state (**b**) forest concessions and community forest management (**c**).

4. Discussion

The different strategies adopted in forest management determine the profitability of the investments. Due to the high costs of machinery and equipment that are necessary for forest management, a cooperative option for renting machinery and vehicles is an excellent alternative to reduce the initial investment and enable forest management in communities and small properties. Considering the commercialization value of products that companies offer, we observe that products with higher added values have higher market values. Still, the cost of added value is not remunerated by the sale price of sawn wood.

The unfeasibility of the understudy of forest concessions reflects the actual situation of the concessionaires. Several lawsuits, land problems, and setbacks are generated by the government agencies' lack of [25]. Between 2010 and 2022, twenty-four FLONA concession

contracts were signed. Three of them were terminated, one was temporarily suspended due to concessionary company debts with the Brazilian Forest Service (Portuguese acronym SFB), two were suspended in court via Public Civil Action, and four did not start forest management [3].

The logs' transformation into sawn wood is an expensive process with a low yield, declaring 40% of the logs' volume. The procedure used to obtain sawn wood contributes to making federal forest concession unfeasible, and the negative financial aspect of sawmill implementation is an essential finding since adding product value is one of the items evaluated by the FLONA's concession notices [17].

Forest management presents high initial costs, limited revenue opportunities, poor infrastructure, and market inefficiencies [26]. The costs include constructing roads and yards, forest management plan preparation, building the necessary structure for employees, and purchasing machinery, vehicles, and equipment, among others. These costs are required to start logging operations, and they occur before the beginning of the revenues since the management companies only sell wood. The initial cost of operations is an obstacle to forest management, requiring external investments for the initial high-risk phase [27–29].

The community forest management of Tapajós FLONA was subsidized in its initial phase. Partnerships with government agencies were essential to support community forest management in Tapajós FLONA at the start of the logging operation and maintain its financial resilience over time [30]. We emphasize that external funding is extremely important to structure community forest management [22,31,32]. Pokorny and Johnson [33] highlight that forest management has high initial costs, and without subsidies, few community forest management initiatives can cover the operational costs.

Tapajós FLONA's forest management has become a successful model for community forest management in the Brazilian Amazon and an important global reference [30,31]. The cooperative's support and the results it reflects must be considered when replicating its management model to other traditional communities, knowing that the long-term success of community forest management depends on the state and market support [29].

Since the activities are established in public areas, there are no costs associated with acquiring the property for the investments. However, it is necessary to pay royalties to the government depending on the volume of wood harvested. The amount paid to government agencies (Figure 2) represented 24.45% of the Saracá-Taquera FLONA forest concession costs and 14.43% of the Paru FLOTA costs. The exception for royalty payment is community forest management, which consists of a non-costly forest destination. The absence of this cost contributes to community forest management's profitability, minimizing the financial loss risk.

A low harvested volume is considered one of the limiting factors for forest management's viability [33,34], and it was observed in all of the UMFs analyzed. This scenario is a recurrent problem in managed forests in the Brazilian Amazon, as presented by Schuartz [35]. Considering the annual increment average of 0.86 m^3/ha and the maximum harvested volume of 25.8 m^3/ha for 30-year cycles [9], and based on the harvested volume presented by the study areas, federal forest concession showed the highest average harvested volume, which was equivalent to 72.14% of the maximum volume allowed, followed by community forest management with 69.35%, and state forest concession with 58.08%.

By considering the costs and revenues as fixed factors over the planning horizon, only community forest management has a harvested volume average that is higher than the minimum necessary to obtain financial viability. The investments are viable, with a minimum production of 12.87 m^3/ha for community forest management, 15.32 m^3/ha for state forest concession, and 23.91 m^3/ha for federal forest concession. All of the studied arrangements are financially viable when operating at the maximum cutting intensity (25.8 m^3/ha) and keep the cost–revenue ratio constant.

Some factors have contributed to the low harvested volume of UMFs. The management companies cited the high number of hollow and small-sized individuals, the poor estimated volume in the forest inventory procedures, and the high occurrence of non-tradable species.

The management agents point out the occurrence of hollow individuals as the leading cause of forest management's low cutting intensity. Hollow individuals harm the forest management harvested volume, even when substitution is possible. The remaining individuals, which could replace hollow individuals, usually have volumes that are lower than the trees selected for cutting. Large hollow trees will reduce the forest management harvested volume, and the exploitation of more trees to obtain the volume that was initially planned is not allowed.

The trees must have a minimum cut diameter of 50 cm at 1.30 m from the soil to be cut [36]. However, trees with a DBH (diameter at breast height) that is close to the minimum cut diameter are considered small in size for the market. As they are not in the sawn wood market's standards, wood that is classified as 'fine' has a lower market value. In large quantities, this characteristic can compromise the profitability of forest management.

It is necessary to correctly determine the volumetric stock of forest formations in forest management. A wrong volume estimate consists of an error in the forest inventory procedures or the volume measurement, and the inaccuracy of the estimation impacts the expected volume to be harvested. By analyzing the volumetric estimate in Tapajós FLONA, Gomes et al. [37] verified the efficiency of the equation used to estimate the volume but observed uncertainties in estimating the commercial heights of the individuals measured. To reduce that uncertainty, using lasers to measure trees in the Brazilian Amazon could avoid the overestimation or underestimation of their commercial heights [38].

Forest concessions have a range of species that can be managed, and there is an aim to insert new species into the market and minimize the species' pressure with the most significant demand. Despite the comprehensive list, companies explore approximately 25 species because several cataloged species have difficulty in commercialization since they are not considered as commercial species by the market. However, there are difficulties in inserting new species of native wood in the market, and similar physical characteristics do not mean there will be substitutions between them. Hence, companies focus on managing species that interest the market, limiting the area´s maximum harvested volume [39].

Community forest management presented a low financial risk as activities are carried out within the UC, which is responsible for training the cooperative members and the project's viability in its initial periods. In contrast, the risks that are inherent to state and federal forest concessions are considered high, with there are low probabilities of obtaining financial viability due to the wood's high initial costs and low commercialization values, adding to the low harvested volume of the UMFs. The results corroborate those of Medina and Pokorny [34], who evaluated forest management as an investment of modest incomes with high risks and limited financial viability.

Given the difficulty in optimizing costs and the high investment return sensitivity to variations in the wood sale value, marketing strategies should be drawn up for managed wood, aiming for better investment profitability. Planning must include gains in scale and added value to the products. Simpler requirements and shorter license processing times could reduce forest management's financial risk. This is because forestry operations are restricted to periods of drought, and licensing delays can make the annual harvest unfeasible [20]. Another possible measure would be to ensure market access and support for the marketing of wood, in addition to the establishment of minimum remunerative public prices [30], similar to what is carried out in agriculture.

There is an evident difficulty for forests managed by initial logging to reach the maximum logging intensity, a problem that may be accentuated in subsequent interventions. This factor can also be aggravated by the low density or absence of high commercial value species observed in initial explorations [35,40], resulting in lower forest management revenues. Wood stock and financial viability beyond the first cycle must be carefully analyzed [10]. We highlight that for federal forest concessions, the contracts provide for 40 years of exploitation, with forest management permitted in the second cycle, and little is known about the technical and financial feasibilities of forest management for future cycles.

Considerations on the Feasibility of Forest Management

The Amazon forest is extensive and heterogeneous, and forestry concessions were formulated while considering that the forest has similar characteristics throughout its area. Even though the three case studies are located in the same state, they have different characteristics. The financial viability of forest management depends on aspects such as the wood stock in the forest, the distance between the managed region and the consumer market, and anthropic actions in the areas that are common in managed forests.

Community forest management needs subsidies to present financial viability due to the high initial costs, the need for working capital of the communities, and the small scale on which forest management operates. Paru FLOTA presents geographical difficulties that hinder forest management's operationalization and anthropic action in the forest, compromising the wood stock. For Saracá-Taquera FLONA, the transformation of wood is expensive due to the low yield of sawmills. The viability of forest management depends on the better use of logs.

Given the forest's complexities, we believe that regardless of the forest management category in the area, UMFs should be treated as singular areas. This effort is vital to enable the production of legal wood and provide jobs and income for the population that resides in the forest.

Some areas are financially viable and do not require state support. Others, especially those that are located far from the commercial centers and with wood stock with less retail value, need help to obtain profit in logging activity. In these areas, subsidies are necessary for financially viable activity, or forest management must occur until future exploitation is financially feasible.

5. Conclusions

The community forest management at Tapajós FLONA showed viability, responding to the cooperative's technical and financial support. In addition to being considered financially unfeasible, the forestry concessions of UMF 1 of Paru FLOTA and UMF 2 of Saracá-Taquera FLONA presented low probabilities of a positive result. The results are for the case studies, and despite the important contribution to the sector, they can be used as indicators, but we cannot extrapolate them to forest concessions or community forest management in general.

A low harvested volume is a critical factor in forestry concessions' financial viability. By operating at the maximum cutting intensity, all of the management initiatives that were studied would have financial viability. It is worth mentioning that the financial viability of forest management depends on several factors. Aiming at the feasibility of forest management, and given the Amazon region's heterogeneity, forest management should not be treated equally in all of its extension. The financial viability of forest management in more remote areas or with wood stock with less commercial value depends on subsidies. In contrast, areas with valuable stocks close to the retail centers will present financial viability without the need for state interference.

As a financial investment, management in tropical forests must be studied more. These responses are important for the maturation of public forest management and are important tools that can support public policies. Thus, we emphasize the importance of continuing studies in countries that adopt forest concessions and destinations as public forest management modalities.

The distance between forest management areas and the consumer market, as well as the species composition of each area, must be considered when defining areas to be granted or destined for forest management. Areas that are not viable in the current period, either because of their distance from commercial centers or the low occurrence of species with high retail values, can be considered as stocks to be managed in the future.

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