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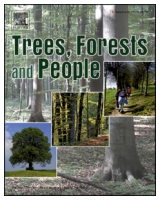

Deforestation fight in the sight of Brazilian Amazonas inhabitants

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ABSTRACT

Brazilian Amazon deforestation crystallizes numerous political, economic, and social issues. Recent empirical studies explore deforestation drivers by focusing on large-scale perspective but ignore the sight of the local populations. This article aims at providing an overview of deforestation perception among local populations defined as living within or near the Amazon biome. We have conducted 197 interviews in October 2021 in the Brazilian Amazonas region. On the basis of these interviews, we provide statistical analysis to explore 5 effects capable of driving the local perception of the deforestation processes: the gender, educational, generational, geographical and indigenous effects. Our results first highlight a very high and positive educational effect for the highest education level and a high indigenous effect, both in conformity with the intuition. Second, we observe a negative gender effect, contradicting some strands in the academic literature, and a high but ambiguous geographical effect. Finally, age does not appear to be neither a driver of interest nor an engagement in the fight against deforestation. In a context where the enforcement of environmental policy has become ineffective in recent years, we argue that characterizing local perceptions of deforestation processes might help to adjust the policy campaigns against deforestation, enhance their effectivenesses, and therefore participate to the restoration of Amazonian cover.

1. Introduction

The Amazon biome is fundamentally threatened by deforestation processes. At least 17 percent of the Amazon basin's primary forest is known to have been destroyed in the past 50 years, and this figure rises to 20 percent in Brazil. The coexistence of people with the Amazon forest crystallizes numerous political, economic, and social issues which determine the deforestation pressure. To better understand this trend, recent and various empirical studies have been developed to characterize the deforestation drivers and impacts. While some of them focus on public policies evaluation such as Assunção and Rocha (2019), some other focus on the private initiatives in the soy sector such as Heilmayr et al. (2020) and in the cattle sector such as Miranda and Oliveira (2023) or Levy et al. (2023). This in-depth scientific research however ignores the perspective of the local population. Yet, the perception of local inhabitants on the Amazon deforestation is far from trivial since the impact of forest cover change has contrasted local effects.

On the one hand, the impact of deforestation on local functions and services provided by Amazonian biome is clearly negative. First, it jeopardizes the unparalleled Amazonian biodiversity rich of more than 34,000 described species of plants, 1813 species of birds, 1022 amphibians, 648 mammals, and 814 reptiles. Consequently, the associated benefits for human societies such as water cycling, air filtration, or soil stabilization are destabilized by massive deforestation (Müller, 2020). Second, by affecting the largest basin river and rainforest on Earth with forests covering a surface ranging from 6 to 8 million square meters, the Brazilian deforestation directly impacts the role of the Amazonian forest as climate change mitigation (Müller, 2020). New models evidence that by 2050, deforestation combined with climate change and fire incidence could cause a decline of up to 58 percent in Amazon tree species richness (Marengo and Espinoza, 2016; Müller, 2020). More precisely, these combined threats could lead to a tipping point in the Amazon rainforest, *i.e.,* an abrupt change of state where the rainforest biome becomes unstable, and regions swiftly transform into dry scrubland and degraded savanna (Nobre et al., 2016; Pereira and Viola, 2019; Lovejoy and Nobre, 2018). Such a drastic forest cover change would be decisive for Amazonian inhabitants, their culture and their socioeconomic systems.

On the other hand, deforestation is usually associated with economic development as it allows for profitable agricultural exploitations, and infrastructure construction such as roads in remote areas. However, the

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literature on the economic effects of deforestation does not provide a policy consensus. There is one strand that has recently provided evidence against the bum-and-bust theory, namely timber extraction and the conversion of forests into cropland and pasture stimulate the economy in the first years of land use, which is then followed by an economic bust as forest resources and soil fertility are degraded. The narrative underlying this strand of the literature is that the last decade has been marked by an important decrease in deforestation rates in the Brazilian Amazon and a significant increase in the Human Development Index (HDI). Weinhold et al. (2015) showed that pre- and post-frontier municipalities in 2000 have experienced a similar increase in their Human Development Index (HDI) across the Amazon during the last decade. The findings of Caviglia-Harris et al. (2016) and Tritsch & Arvor (2016) suggest that socioeconomic welfare has become decoupled from the depletion of the Amazonian forest, notably by evidencing better socioeconomic indicators among post-frontier regions than pre-frontier and frontier regions. Nonetheless, another strand in the literature highlights recent evidence which calls for a more comprehensive understanding of relationships between 21st century deforestation and human development given their complex and dynamic nature (Norris et al., 2022). Indeed, it has been argued that agricultural expansions involving the use of monocultures, mechanization, and land concentration have resulted in the exclusion of local populations, social conflicts, and undermined access to resources traditionally belonging to the local population (Sauer, 2018).

With such ambiguous ecological-economic consequences, the opinion of local populations living near or within the Amazon regarding the deforestation processes merits dedicated empirical studies, in complement to the ones implemented at large scales. How do these local inhabitants relate to Amazon deforestation? To what extent are they engaged in the fight against deforestation? How do they perceive the involvement of international organizations regarding deforestation policies? Our study aims at identifying social determinants of deforestation processes by adopting the sight of the inhabitants living within the Amazon biome. We here aim at trying to map trends among different social groups in order to better capture the delineation of tensions regarding deforestation in local population. More precisely, we offer here a broad perspective of the Amazonian residents by going beyond the recurrent prism of the indigenous groups whose culture and habitat are fundamentally threatened by deforestation (Barbosa, 1996). In that respect, we consider residents of large cities within the Amazon forest such as Manaus beside residents from rural environment.

We argue that a better knowledge of local perceptions of deforestation processes might have decisive public policy impacts (Oliveira et al., 2023; Araujo et al., 2022). Indeed, Brazil's positioning on deforestation issues is deeply depending on political changes. Between 1985 and 1997, during the dictatorship, the rate of deforestation was high and reached 20 million square meters per year. In 2003, after the inauguration of President Lula's first administration and the appointment of Marina Silva as Environment Minister, international commitments as well as various internal policies to curb deforestation were made. The Action Plan to Prevent and Control Deforestation in the Brazilian Amazon (PPCDAM), created in 2004, has been a key public instrument to reduce deforestation rates in Brazil (Abranches, 2014; Nevez, 2016; Müller, 2020). Acknowledging the deep causes of deforestation such as cattle ranching, soybean production, illegal timber production or infrastructure works, the plan relied on three strategic axes: territorial and land tenure regularization, environmental monitoring and control, and incentives for sustainable productive activities. At the international level, this period corresponded to a radical shift of the Brazilian diplomatic stance, passing from a historic opponent to multilateral mechanisms to regulate the reduction of emissions arising from deforestation to an active contributor to the design of REDD+ in the UNFCCC. Furthermore, it negotiated a US dollar 1 billion agreement with the Government of Norway to finance the Amazon Fund signed in 2008. Unfortunately, this period of environmental pro-activity started to stagnate and decline under the presidency of Dilma Roussef, which was characterized by relative relaxation of environment policies and forest protection (Abranches, 2014). In December 2011, powerful political actors representing the interests of the agribusiness sector in the national congress managed to reform the Forest Code that largely reduced environmental protections and led the way to a new wave of deforestation (Pereira and Viola, 2019). Temer's presidency, followed by Bolsonaro, aligned with this trend by signing provisional acts, decrees, and laws that reduced the size of protected areas in the forest, suspended the ratification of indigenous lands, enabled land grabbers to legalize their holdings in the region, and forgave billions of dollars in environmental fines and debts that farmers and ranchers owed the government (Pereira and Viola, 2019). While deforestation in the Amazon in 2020 had the highest percentage increase in the last 10 years, the electoral victory of Lula last year offered some room for policy changes and a better control of deforestation rates. This encouraging political context is however weighted by recent empirical studies which highlight that the enforcement of environmental policy has become ineffective in recent years (Kuschnig et al., 2023). In the light of this policy context, knowing local perceptions of deforestation processes might help to adjust the policy campaigns against deforestation, enhance their effectivenesses, and therefore participate to the restoration of the Amazonian cover.

The rest of the paper is divided into three sections. The second section presents the data and the regression framework. The third section provides the results. The fourth section concludes with a discussion of the results while the fifth section provides policy recommendations from it.

2. Data and statistical analysis

2.1. Variable selections

Our research builds upon a limited qualitative research which has attempted to describe local social dynamics at play in the deforestation process. But a literature review on environmental issues in a broader sense helped us to identify relevant potential drivers. Some studies focus on the role of women in the preservation of the environment (Wan et al., 2011; Mohai, 1997; Badgett and Folbre, 1999), while some others dedicated on the capacity of education to foster environmental behaviors (McCRight, 2010; Kabir, 2016; Muttarak, 2016; Ortega-Egea, 2014; Poortinga, 2019). Beside this classical gender and education determinants, the literature has highlighted the vulnerability of relatively poor rural populations facing degraded and poorly productive crop lands, notably due to climate change and deforestation, and the negative consequences for living standards and poverty alleviation (Garrett et al., 2021; Russo Lopes et al., 2021; Barbier and Di Falco, 2021; Silva Junior et al., 2020). Finally, an extending literature has evidenced a generational fracture regarding environmental issues (Whitehead, 1991; Carlsson and Johansson-Stenman, 2000; Cohen, 2019). And because the first political movements against deforestation are mostly anchored around the defense of indigenous communities (Barbosa, 1996), we suspect that the ethnic background might also be a relevant explicative variable to understand the perception of deforestation among local residents.

In that respect, we propose to explore 5 effects on the local perception of the deforestation processes: the gender effect, the education effect, the generation effect, the geographical effect, and the indigenous effect. Because geographical and educational conditions might vary along life time, we have collected this information both for the interviewee now and for her parents. Eventually, we have selected 7 explanatory variables: gender, education, parents' education, age, living place, birthplace, and indigenous background.

To characterize the perception of deforestation process, we investigate two main outcome variables: the interest in the fight against deforestation and the engagement in the fight against deforestation. Engagement was presented in broad terms and entailed political,

associative, or economic activities. To deepen the analysis of these two main variables, we added three complementary variables which are somehow connected to them. The first one is related to the Brazil's right to deforest in its national territory and the second one concerns the reinforcement of the engagement of the international community in the fight against Amazon deforestation. These two questions are interesting to link the local perceptions (both interest and engagement of Amazonian residents) to the supra-regional issues, namely the national decision-makers which are determinant for the environmental policies (Kuschnig et al., 2023) and the international institutions which might impose supra-national norms or propose programs such as the popular REDD+ initiatives (Cromberg et al., 2014; Cooper and Kainer, 2018). The third secondary variable is related to the increase of the government support to Brazilian agriculture. This last variable helps to connect the local perception of deforestation to the main official *a priori* reason of this deforestation, the agriculture extension. For the whole set of outcome variables, respondents were asked to declare their level of interest and engagement on a scale from 0 to 10. In that respect, they are all declarative variables.

2.2. Survey

The survey was conducted in October 2021 in the Brazilian state of Amazonas. More specifically, interviews took place in the urban zones of Manaus, Téfé, and Manaquiri as well as in the rural areas of Téfé and Manaquiri. Interviewed persons were randomly selected in the streets. In urban and dense areas, the streets were defined according a gradient from the center to the periphery in different neighborhoods. The survey has been asked by a single native speaker interviewer and performed at different times of the day. Finally, a sample of 197 persons has been interviewed.

The table 1 presents a statistical overview of the collected data. There are missing values in the sample: 21 for both education and parents' education, 2 missing values for indigenous background, and 1 missing value for both living place and birthplace as well as age. Gender and geographic variables are quite balanced. There are 108 men and 89 women. There are 102 people living in urban areas and 87 in rural areas, while 83 persons were born in urban areas and 99 were born in rural ones. For indigenous background, it is more skewed towards non-indigenous persons as 139 respondents do not have indigenous origins and only 56 do. The education variables are divided into four levels: the first level corresponding to inferior or equal to 5th years (equivalent to elementary school), the second one stands from 6th to 9th year (equivalent to secondary school), the third one is highschool level (from 1rst to 3rd year), and the fourth level is related to university graduation. For the education level, it is skewed towards the lowest levels: 29 percent (51), 39 percent (69), 16 percent (28), and 16 percent (28). For the parents' education level, it is even more the case: 59 percent (104), 19 percent (34), 11 percent (20), and 10 percent (18). Finally, the average age in the sample is 37 years old. The youngest person in the sample is 15 years old and the oldest is 90 years old. 77 persons are below or equal 30 years old, 99 persons are above 30 and below or equal 60 years old, and 20 persons are above 60 years old.

Table 1
Statistical description of explicative variables.

Variable	Variable nature	Variable description
Age	Continuous	Min: 15 Max: 90 Mean: 37 St. deviation: 15.8
Gender	Binary	Men: 108 Women: 89
Education level	Ordered categorical	Lvl 1: 51 Lvl 2: 69 Lvl 3: 28 Lvl 4: 28 NA: 21
Parents' education level	Ordered categorical	Lvl 1: 104 Lvl 2: 34 Lvl 3: 20 Lvl 4: 18 NA: 21
Living area	Multinomial	Urban: 102 Periurban: 7 Rural: 89 NA: 1
Childhood living area	Multinomial	Urban: 83 Periurban: 14 Rural: 99 NA: 1
Indigenous background	Binary	Yes: 139 No: 56 Do not address: 2

2.2. Statistical analysis

First, we aim at exploring the correlations between the five outcome variables based on first-order linear regressions. Then *t*-test will be used to characterize the distribution of the two main outcome variables, the interest and the engagement in deforestation fight. Third, we explore correlations between the 5 outcomes variables and the 7 explanatory variables. To do so, we rely on two types of regression: a simple first-order linear regression and an ordered logistic regression to better fit with the typology of variables. The correlation coefficients are presented with significance p-value for the linear regressions, while the odd ratios with significance p-values characterize the ordered logistic regressions.

3. Results

3.1. Correlations between the interest and engagement in deforestation fight

Table 2 presents the correlation coefficients between the outcome variables from the linear regression with the associated p-value. We observe that a positive and significant correlation between the interest and the engagement among interviewees in the fight against deforestation. The value at 0.39*** suggests a partial non-alignment between the interest and the actions dedicated to the fight against deforestation among the sample. This result plaids in favor of exploring both variables to understand the sociological determinants of deforestation perception among local residents. Then Table 2 shows that the variable related to the Brazil right to deforest is poorly correlated and in non-significant way to the two main outcome variables. On the contrary, the variable related to the engagement of the international community into deforestation is positively correlated in a significant way with the interest and the engagement of interviewees in the fight against deforestation (cor = 0.19*** and cor = 0.19** resp.). Combining the results on those two variables highlights that national legitimacy is not a proxy of the local perception of deforestation on the contrary to the international one which appears more relevant. The international issue and the Brazil right to deforest are yet correlated, in a negative way as expected while it is not significant (cor = - 0.12). Eventually, the engagement in favor to Brazilian agricultural support is negatively correlated with the interest and the engagement into deforestation fight (cor = - 0.19* and cor = - 0.24*). This observation might suggest that the national level remains linked to local perception of deforestation process in a practical perspective (*i.e.* with the agriculture-forest trade-off to balance) instead

Table 2
Correlation coefficients between the different outcome variables (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Interest in fight against deforestation	Engagement in fight against deforestation	Brazil right to deforest	Increase of International community engagement
Engagement in fight against deforestation	0.39 ***	X	X	X
Brazil right to deforest	0.00	0.07	X	X
Increase of International community engagement	0.19 ***	0.19 **	- 0.12	X
Increase od Agricultural support	- 0.19 *	- 0.24 *	0.21 ‘	- 0.04

of a conceptual perspective (*i.e.* with the question of national legitimacy).

3.2. Distribution of interest and engagement for deforestation fight

Fig. 1 presents the distribution of the Amazonians' interest in the fight against deforestation. A *t*-test shows that this distribution is statistically different from a uniform distribution, centered on the value 5, with a 95 percent confidence interval ($t = 13.76$). More precisely, the average value is 7.68 (see red line in Fig. 1). The standard deviation is 2.53. Fig. 2 presents the Amazonians' engagement in the fight against deforestation. A *t*-test shows that this distribution is not statistically different from a uniform distribution, centered on a 5, with a 95 percent confidence interval ($t = 1.18$) highlighting that interviewed people are uniformly engaged in the fight against deforestation. More precisely, the average value is 5.29 (see red line in Fig. 2). We can note that all the levels, from 0 to 10, occur in the answers of our sample. As a consequence, we deduce that the interest stated by interviewed people for the fight against deforestation is higher than their declarative engagement. The standard deviation is 3.09.

3.3. Determinants of interest for deforestation fight

Table 3 summarizes the regression results for the outcome variable 'interest in the fight against deforestation'. When considering linear regression, we observe 3 statistically significant effects, two of them being positive while the last one being negative. More precisely, the coefficients for high education and indigenous background are positive while the one related to the gender is negative. The effect of being highly educated has high marginal impact since the coefficient at 1.95 stands for 78 % of the standard deviation of the variable. The indigenous background and the gender both play for 32 % of the standard deviation of the variable (coefficients equal to 0.80 in absolute way). On the contrary, age does not appear to play any role in the interest against deforestation. Finally, there are no significant differences between urban and rural inhabitants with respect to the interest in the fight against deforestation. The exploration of ordered logistic regression partially confirms this result since the odd ratios inform very high and significant effect of high education (odd ratio = 6.92***) and moderate effects for indigenous and gender variables. Assuming indigenous background increases by around two the probability of being interested in deforestation fight (odd ratio = 2.52*) while being a woman decreases it by around two (odd ratio = 0.44 ***). Interestingly, the ordered logistic regression shows a geographical effect linked to rural environment. However, this effect plays in an ambiguous way since living a rural environment increases the probability of being interested in deforestation fight by 2 (odd ratio = 2.41*) while being born in rural environment decreases it by 2 (odd ratio = 0.38*)

3.4. Determinants of engagement for deforestation fight

Table 4 summarizes the regression results for the outcome variable 'engagement in the fight against deforestation'. The engagement in the fight against deforestation is driven by similar sociological determinants as the 'interest' variable, but includes few notable differences. More precisely, we observed 2 similar statistically significant effects within a 95 percent confidence interval: the positive impacts of high-level education (coeff = 2.75***) and a gender negative effect (coeff = −0.83*). The coefficients are higher in absolute way than for the 'interest' outcome variable but comparatively to the standard deviation (3.09), the education effect stands for 90 % of the standard error and the gender 27 % of the standard error. Furthermore, an educational effect, with 90 percent confidence interval, occurs with parent's education and new insight emerges with the geographical effect. Indeed, being a rural citizen marginally increases the engagement in the fight against deforestation compared to the urban residents (coeff = 1.95** resp.). Finally, neither age nor the indigenous background appear to play a role in the engagement in the fight against deforestation. The ordered logistic regression confirms most of these results: a strong educational effect for the highest education level (odd ratio = 7.19***) and for high parent's education level (odd ratio = 2.77*). The negative gender effect is also confirmed with a decrease of a factor of 2 when the resident is a woman (odd ratio = 0.54 **) while a strong geographical is observed (odd ratio = 4.31***). However, an additional positive effect related to indigenous background occurs (odd ratio = 1.66 **).

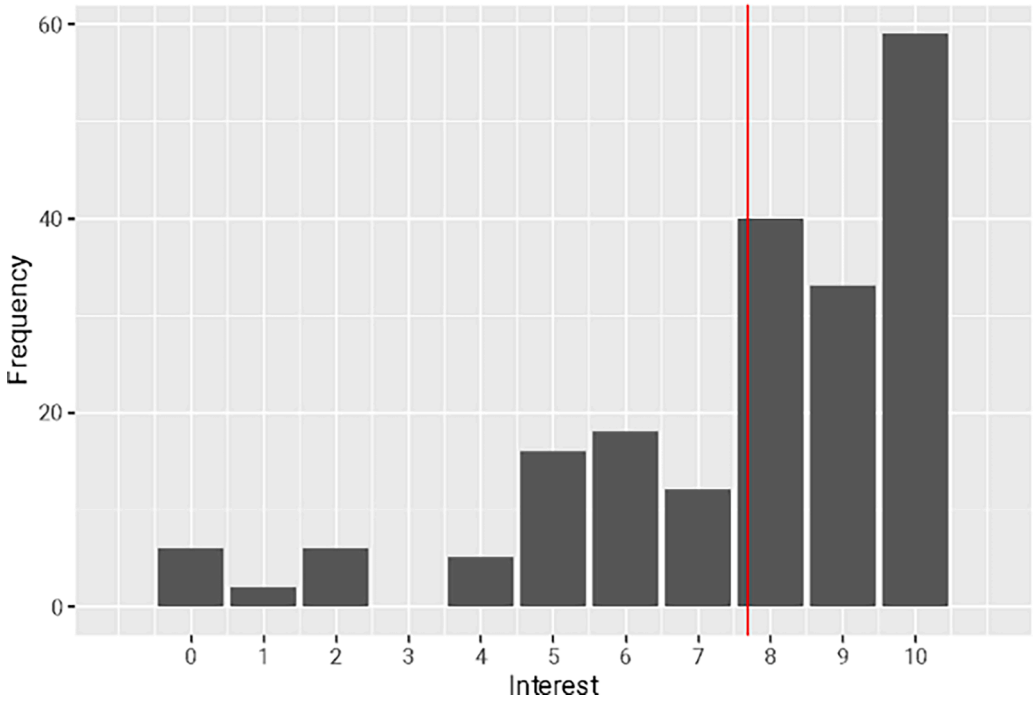

Fig. 1. Distribution of interest for the fight against deforestation among the 197 interviewed people on a ranking from 0 to 10.

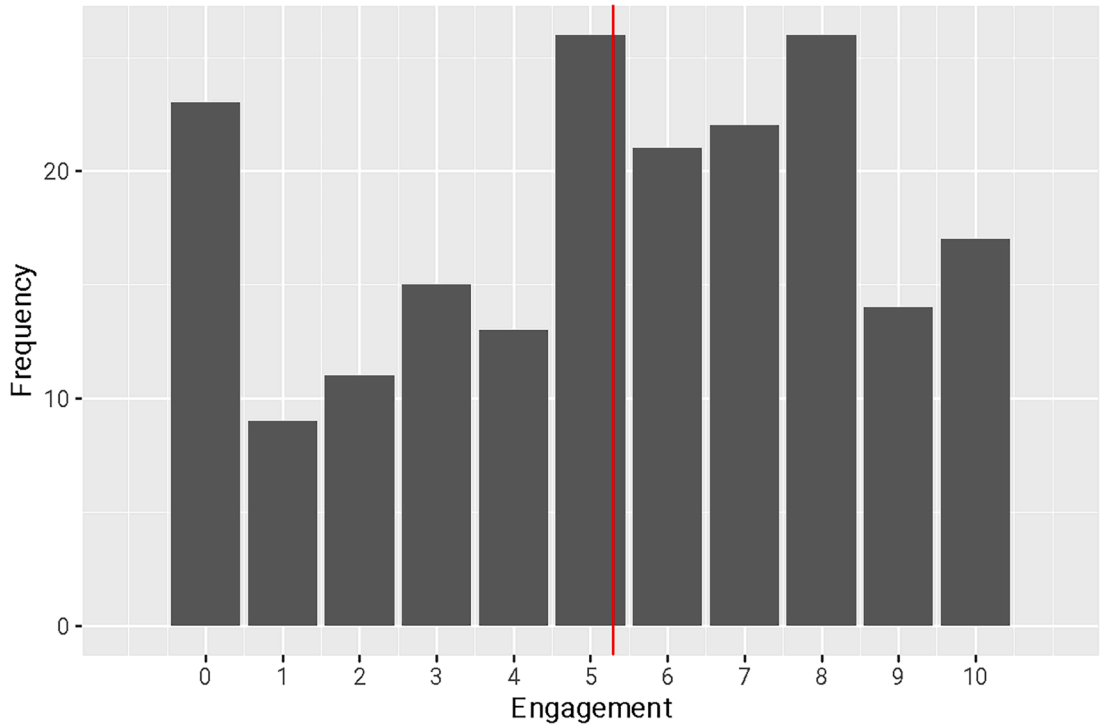

Fig. 2. Distribution of engagement for the fight against deforestation among the 197 interviewed people on a ranking from 0 to 10.

Table 3
Coefficients and odd ratios with associated p-value to explain the interest in the fight against deforestation (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Linear regression	Ordered logistic regression
	Coefficients	Odd ratios
Woman	−0.81 *	0.44 ***
Education (2)	−0.06	0.90
Education (3)	−0.17	1.23
Education (4)	1.95 **	6.92 ***
Parents’ education (2)	0.02	1.00
Parents’ education (3)	0.31	1.38
Parents’ education (4)	−0.47	0.64
Age	−0.01	1.00
Living place (Periurban)	0.76	1.39
Living place (Rural)	0.80	2.41 *
Birthplace (Periurban)	−0.40	0.71
Birthplace (Rural)	−0.76	0.38 *
Indigenous Background	0.80 ‘	2.52 *

Table 4
Coefficients and odd ratios with associated p-value to explain the engagement in the fight against deforestation (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Linear regression	Ordered logistic regression
	Coefficients	Odd ratios
Woman	−0.83 *	0.54 **
Education (2)	−0.34	0.80
Education (3)	0.47	1.45
Education (4)	2.75 ***	7.19 ***
Parents’ education (2)	0.79	1.54
Parents’ education (3)	1.33 ‘	2.77 *
Parents’ education (4)	0.02	0.98
Age	0.02	1.01
Living place (Periurban)	−0.33	1.07
Living place (Rural)	1.95 **	4.31 ***
Birthplace (Periurban)	−0.09	0.83
Birthplace (Rural)	−0.03	0.78
Indigenous Background	0.58	1.66 **

3.5. Determinants of the three complementary outcome variables

Table 5 summarizes the regression results for the outcome variable ‘support for Brazil’s right to deforest’. Linear and ordered logistic regressions outcomes are opposite to the previous ones , which is consistent in substance: a very high, positive and significative geographical effect linked the rural birthplace, a high negative educational effect from the highest level of education and a negative effect gender effect. Table 6 summarizes the regression results for the outcome variable regarding the involvement of international community. Here we observe a positive geographical effect regarding the rural birthplace and a negative gender effect. The positive geographical birthplace effect goes to the opposite to the geographical birthplace effect for the ‘interest’ variable suggesting a reserve between the association between local perception of deforestation fight and the local standpoint on international issues despite a certain correlation between the two variables (see Section 3.1.). Table 7 summarizes the regression results for the outcome variable regarding the support for Brazilian agriculture. The educational level is here particularly strong in a negative way. Indeed, the effect is observed with

Table 5
Coefficients and odd ratios with associated p-value to explain the Brazil’s right to deforest (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Linear regression	Ordered logistic regression
	Coefficients	Odd ratios
Woman	−0.94 ‘	0.57 ‘
Education (2)	−1.16	0.50
Education (3)	−1.34	0.56
Education (4)	−2.123211 *	0.33 *
Parents’ education (2)	−1.02	0.60
Parents’ education (3)	−1.05	0.37
Parents’ education (4)	−0.27	0.73
Age	−0.01	1.00
Living place (Periurban)	−0.58	0.68
Living place (Rural)	−0.89	0.59
Birthplace (Periurban)	1.17	2.18
Birthplace (Rural)	3.17 ***	6.13 ****
Indigenous Background	−0.59	0.71

Table 6
Coefficients and odd ratios with associated p-value to explain the variable related to the international community involvement (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Linear regression Coefficients	Ordered logistic regression Odd ratios
Woman	0.60	1.81 *
Education (2)	−0.05	0.71
Education (3)	−0.33	0.73
Education (4)	1.41	1.37
Parents’ education (2)	−0.01	0.97
Parents’ education (3)	−1.33	0.49
Parents’ education (4)	−1.37	0.54
Age	−0.02	0.99
Living place (Periurban)	−0.36	0.69
Living place (Rural)	0.37	1.42
Birthplace (Periurban)	0.28	1.51
Birthplace (Rural)	−1.26	0.35 *
Indigenous Background	0.34	1.21

Table 7
Coefficients and odd ratios with associated p-value to explain the variable related to the support to the Brazilian agricultural sector (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ‘ $p < 0.1$).

	Linear regression Coefficients	Ordered logistic regression Odd ratios
Woman	0.26	1.43
Education (2)	−0.40	0.42
Education (3)	−1.47 *	0.15 ***
Education (4)	−2.78 ***	0 .06 ***
Parents’ education (2)	−0.22	0.76
Parents’ education (3)	−0.17	0.71
Parents’ education (4)	−0.03	1.21
Age	−0.01	0.99
Living place (Periurban)	0.69	5.33
Living place (Rural)	−0.90	0.40
Birthplace (Periurban)	−0.32	0.52
Birthplace (Rural)	0.32	0.82
Indigenous Background	0.14	1.21

high significance for the educational level 3 and 4. In conclusion, two effects on these complementary are consistent with the ones for the two main outcome variables: the gender determinant, in favor of a higher positive perception of Amazonian deforestation for men than for women, and the educational background which is also a positive determinant on local deforestation perception. On the contrary, the geographical effect differs regarding the birthplace and no indigenous effect has been detected.

4. Discussion

4.1. Education, a positive determinant for the fight against deforestation

In this study, we evidence that education plays a positive role in the fight against deforestation. Indeed, we highlighted that Amazonians with the highest level of education in the sample exhibit higher probability to be interested and engaged in the fight against deforestation. Furthermore, education is negatively associated with support for more pro-agricultural sector policies and Brazil’s right to conduct deforestation policies in its national territory. All these coherent results suggest a strong positive correlation between ecological concerns and education level of Amazonians people. This conclusion is consistent with results which have been shown for another environmental issue, climate change. Indeed, there is empirical evidence that highly educated individuals have better knowledge about climate change compared to their less educated peers (McCRight, 2010; Kabir, 2016). Moreover, it has been shown that people with higher education express higher levels of concern about climate change (Poortinga, 2019), and are hence more prone to engage in pro-environmental behavior (Muttarak, 2016; Ortega-Egea, 2014). In that perspective, our study allows us to extend these conclusions to a broader environmental viewpoint, by including the issue of deforestation.

It is interesting to note it might exist a negative association with high-level parents’ education and local perception of deforestation fight. This observation, which is not significant in our sample but merit more investigations in larger sample, might contradict the general positive effect of education on environmental concern and action. In that respect, a potential extension of this study could focus on potential divergent effects between parents’ education and one’s own level of education on environmental concern and action. In our sample, these two variables are solely correlated to 0.31, suggesting the existence of many complex educational patterns among Amazonian residents. More generally, it would be interesting to investigate whether education, in this case parents’ education, can be a driver of political conservatism. This research question is relevant considering the relatively recent democratization of education in Brazil. Student enrollment in higher education increased by 141 percent between 2000 and 2014 (Fachinetti, 2020).

4.2. Geography, an ambiguous impact on the fight against deforestation among amazonian inhabitants

Geographical effect plays an ambiguous role in our study. On one hand, people living in rural areas have high probability to be engaged in the fight against deforestation than people living in urban areas. Furthermore, they tend to oppose public support for the Brazilian agricultural sector. On the other hand, people born in rural areas have more chances to support Brazil’s right to deforest in its national territory in comparison with people born in urban areas. In addition to this, they tend to oppose greater international involvement. This complex geographical effect can be connected to different scientific literature.

The positive association between people living in rural areas and environmental action can be linked to the reliance on Amazon’s services. Rural communities are more likely to suffer from negative deforestation consequences than urban populations. Indeed, regarding human dimensions, recent research on the effect of climate change points out that it has caused severe impacts on rural communities all over the world (Moftakhari et al., 2021). Furthermore, rural and indigenous communities in developing regions are identified as being among the most vulnerable due to their direct dependence on natural resources, limited economic capital (Moftakhari et al., 2021), marginalization in decision-making, as well as limited property rights (Nakashima, 2012). Recent research documented the severe impacts of repeated floodings on rural communities in the Brazilian Amazon (Almudi and Sinclair, 2022). Furthermore, this result is also in line with examples of rural communities in the Amazon region engaging in conservation movements. For instance, the Brazilian federal government created a 5.6 million-hectares reserve, including indigenous lands, in the Terra do Meio after intense activism of the Movement for the Development of the Transamazon and Xingu, mainly composed of small farmers and colonist organizations (Schwartzman et al., 2010).

On the other hand, the study shows that rurality is also positively associated with pro-deforestation stances. This association might be driven, for instance, by owners of large rural properties which are important drivers of deforestation. For instance, researchers from Brown University revealed in an article in 2015 through satellite data that a large proportion of deforestation in Mato Grosso, as well as remaining forest cover, was driven by large property owners.[1] Therefore, more information is required to disentangle the various actors and sociological groups composing rural communities in the Amazon region. Furthermore, the results dissociate people living in rural areas and people born in rural areas. The latter group might include citizens who

[1] https://news.brown.edu/articles/2015/11/brazil

do not live in rural areas anymore and thus reduce the exposure of this group to the climate-induced degradation of rural living conditions in the Amazon region over the last decade.

4.3. Gender and indigenous background: social determinants in line with amazonian historical pathway

Our analysis shows that being a woman decreases the probability of being interested and engaged in the fight against deforestation. Regarding the fundamental role of women in care and its link to environmental protection (Wan et al., 2011; Mohai, 1997; Badgett and Folbre, 1999), it could have been expected that women would show more interest and engagement than men in the preservation of the Amazon forest. These results could be interpreted as a consequence of women's marginalization in the Amazon region (Schmink and García, 2015). Indeed, Amazonian women disproportionately lack access to land tenure, technical and financial assistance to mitigate and adapt to climate change. In rural areas of Latin America in general, only 30 percent of rural women own agricultural land and just 5 percent of them have access to technical assistance for agriculture. Furthermore, deforestation and forest degradation have also disproportionately negatively impacted women, by reducing opportunities for the gathering of medicinal plants (Garrett et al., 2021). In addition to this economic exclusion, the Amazon features high rates of gender-based violence, reinforcing women's marginalization. In 2019, the Brazilian Amazon state of Acre recorded the highest femicide rate in the country, with the state of Amazonas recording the fourth highest. Therefore, these results might translate a relative disenfranchisement with respect to men from political issues such as deforestation. In this regard, recent studies have shown the positive role of microenterprises to empower women in the Amazon region as these initiatives allow to adopt more sustainable practices of resource management, develop more knowledge about the environment, and increase participation in household and community decisions about resource use (Mello and Shmink, 2017).

Finally, assuming an indigenous background increases the probability of being interested and engaged in the fight against deforestation. This result could be interpreted along the lines of political socialization at the end of the 20th century when the first political movements against deforestation were mostly anchored around the defense of indigenous communities (Barbosa, 1996). This political context could have forged an activist generation among the indigenous community. Furthermore, as mentioned above, indigenous communities in developing countries are part of the most vulnerable groups in the face of climate change, notably due to their dependence on natural resources. It has been recently confirmed in a review study concerning the future prospects of sustainable development in Brazilian amazon (Garrett et al., 2021). It should be noted that no relevant effects have been found for the explanatory variable *age*, contradicting to some extent the literature evidencing a generational fracture regarding environmental issues (Whitehead, 1991; Carlsson and Johansson-Stenman, 2000; Cohen, 2019).

4.4. Limitations and methodological perspectives

The paper presents different limitations on different research aspects. First, the paper relies on declarative data which could potentially undermine the research validity. This concern is further compounded by the political nature of the main interview questions. Furthermore, additional analytical categories would be ideal to better identify sociological trends with respect to the interest and engagement in the fight against deforestation. For instance, income information and proxy of the job or work activity would be relevant to better understand the correlations obtained throughout the study. Voting behavior could be valuable information as well to identify the intersection of deforestation issues and the broader political agenda. From a qualitative perspective, more in-depth interviews could be very useful to better understand the drivers of interest and engagement in the fight against deforestation in the Amazonas region. As presented in the literature review, deforestation issues are complex and are characterized by various interests which call for a thorough analysis. Finally, from a methodological perspective, the regression analysis framework while combining linear and ordered logistic forms remains simple and could be extended. One potential addition would include interaction terms in the regression analysis and allow for more accurate social categories such as educated urban populations or rural women.

5. Policy perspectives

The period of Bolsonaro presidency has highlighted the crucial need for a strong civil society attuned to the ecological threats underlying deforestation processes. More importantly, civil society's capacity to cohesively act on deforestation issues is key to ensure policy continuity in the preservation of the Amazon (Araujo et al., 2022). The results of this paper highlight a general interest in the fight against deforestation among the surveyed population, while the engagement is rather limited. Thus, there is definitely room for improvement in terms of engagement intensity among communities living in or nearby the Amazon forest. The development of an effective civil society able to hold deforestation dynamics in check lies in the alignment of declarative interests with concrete actions. In this regard, our study identifies different areas for policy action. As shown in the policy summary (Table 8), education appears as an important vector for interest and engagement in the fight against deforestation. Institutions such as international organizations or advocacy groups should primarily promote education as an important tool to foster environmental protection dynamics. It should be added that women are negatively associated with interest and engagement in the fight against deforestation, which reinforces the need for policies focused on women empowerment in the Amazon such as microcredit initiatives. Finally, the empirical results provided in this analysis suggest the salient character geographical dimensions of interest and engagement in the fight against deforestation. In a broader perspective, our study emphasizes the policy relevance of approaching the population of the Amazonas region in its complexity and developing tailor-made policies. The results offer a preliminary framework for institutions such as international organizations which aim to build adapted strategies for the development of resilient civil societies living in key regions threatened by deforestation dynamics and climate change.

CRediT authorship contribution statement

Alessandro Ferrante: Methodology, Writing – original draft. **Lauriane Mouysset:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Supervision, Validation, Writing –

Table 8
Policy sum up of 5 sociological effects and their associated intensity levels.

Policy summary Effect Type	Description	Intensity
Educational effect	Education is a very highly significant and positive determinant of the local perception of Amazonian deforestation.	Very high
Geographical effect	Living in rural communities is a highly significant and positive determinant of the local perception of Amazonian deforestation fight while rural birthplace negatively affects it.	High but to be precised
Gender effect	Being a woman decreases the probability of being interested and engaged in the fight against deforestation.	Moderate
Indigenous effect	Assuming an indigenous background increases the probability of being interested and engaged in the fight against deforestation.	Low
Generational effect	Age does not impact the local perception of Amazonian deforestation.	None

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Abranches, S., 2014. The political economy of deforestation in Brazil and payment-for-performance finance. Center Global Development, CGD Climate Forest Paper Ser. 10, 52.

Araujo, R., Costa, F.J.M., & Garg, T. (2022, August 11). Going viral: public attention and environmental action in the Amazon. https://doi.org/10.31235/osf.io/xj3f6.

Almudi, T., Sinclair, A.J., 2022. Extreme hydroclimatic events in rural communities of the Brazilian Amazon: local perceptions of change, impacts, and adaptation. Reg Environ Change 22, 27. https://doi.org/10.1007/s10113-021-01857-0.

Assunção, J., Rocha, R., 2019. Getting greener by going black: the effect of blacklisting municipalities on Amazon deforestation. Environ. Dev. Econ. 24 (2), 115–137.

Badgett, L., & Folbre, N. (1999). Assigning care: gender norms and economic outcomes. 138, 311–326.

Barbier, E.B., Di Falco, S., 2021. Rural populations, land degradation, and living standards in developing countries. Rev. Environ. Econ. Policy. 15 (1), 115–133. https://doi.org/10.1086/7131.

Barbosa, L.C., 1996. The people of the forest against international capitalism: systemic and anti-systemic forces in the battle for the preservation of the Brazilian Amazon Rainforest. Sociolog.l Perspect. 39, 317–331.

Carlsson, F., Johansson-Stenman, O., 2000. Willingness to pay for improved air quality in Sweden. Appl. Econ. 32, 661–669.

Caviglia-Harris, J., Sills, E., Bell, A., Harris, D., Mullan, K., Roberts, D., 2016. Busting the boom–bust pattern of development in the Brazilian Amazon. World Dev. 79, 82–96.

Cohen, S. (2019). *The age gap in environmental politics*.

Cromberg, M., Duchelle, A.E., de Oliveira Rocha, I, 2014. Local participation in REDD+: lessons from the Eastern Brazilian Amazon. Forests. 5 (4), 579–598.

Cooper, N., Kainer, K., 2018. To log or not to log: local perceptions of timber management and its implications for well-being within a sustainable-use protected area. Ecol. Soc. 23 (2).

Fachinetti, T.A., 2020. A democratização do acesso à educação superior brasileira: realidade e desafios. DOXA: Revista Brasileira de Psicologia e Educação 22 (1), 83–95.

Garrett, R.D., Cammelli, F., Ferreira, J., Levy, S.A., Valentim, J., Vieira, I., 2021. Forests and sustainable development in the Brazilian Amazon: history, trends, and future prospects. Annu Rev. Environ. Resour. 46 (1), 625–652. https://doi.org/10.1146/annurev-environ-012220-010228.

Heilmayr, R., Rausch, L.L., Munger, J., Gibbs, H.K., 2020. Brazil's Amazon soy moratorium reduced deforestation. Nat. Food 1 (12), 801–810.

Kabir, M.I., M, R., 2016. Knowledge and perception about climate change and human health: findings from a baseline survey among vulnerable communities in Bangladesh, 16. MC Public Health, pp. 266–275.

Kuschnig, N., Vashold, L., Soterroni, A.C., Obersteiner, M., 2023. Eroding resilience of deforestation interventions—Evidence from Brazil's lost decade. Environ. Res. Lett.

Levy, S.A., Cammelli, F., Munger, J., Gibbs, H.K., Garrett, R.D., 2023. Deforestation in the Brazilian Amazon could be halved by scaling up the implementation of zero-deforestation cattle commitments. Global Environm. Change 80, 102671.

Lovejoy, T.E., Nobre C., 2018. Amazon tipping point. Sci. Adv. 4 (2). /10.1126/sciadv.aat2340.

Marengo, J.A., Espinoza, J.C., 2016. Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. International J. Climatology 36 (3), 1033–1050.

McCRight, A.M., 2010. The effects of gender on climate change knowledge and concern in the American public. Populat. Environ. 32, 66–87.

Mello, D., Schmink, M., 2017. Amazon entrepreneurs: women's economic empowerment and the potential for more sustainable land use practices. In: Women's Studies International Forum, 65, pp. 28–36. Pergamon.

Miranda, B.V., Oliveira, G.M., 2023. Assessing the performance of voluntary environmental agreements under high monitoring costs: evidence from the Brazilian Amazon. Ecolog. Econ. 214, 107982.

Mohai, P., 1997. Gender differences in the perception of most important environmental problems. Race, Gender Class 5, 153–169.

Moftakhari, H., Shao, W., Moradkhani, H., AghaKouchak, A., Sanders, B., Matthew, R., Jones, S., Orbinski, J., 2021. Enabling incremental adaptation in disadvantaged communities: polycentric governance with a focus on non-financial capital. Climate Policy 21 (3), 396–405. https://doi.org/10.1080/14693062.2020.1833824.

Müller, C.R., Brazil and the Amazon rainforest – deforestation, biodiversity and cooperation with the EU and international forums, in-depth analysis for the committee on the environment, public health and food safety of the European parliament, policy department for economic, scientific and quality of life policies, european parliament, luxembourg, 2020.

Muttarak, 2016. Who is concerned and does something about climate change? Gender and education divide among Thais. Vienna Yearbook Population Res 13, 193–220.

Nakashima, D., 2012. *Weathering uncertainty: traditional knowledge for climate change assessment and adaptation; 2012*, Adaptation to Climate Change Team, Simon Fraser University. Canada. Retrieved from https://policycommons.net/artifacts/2102482/weathering-uncertainty/2857780/ on 05 Mar 2024. CID: 20.500.12592/qgjk6q.

Nobre, C.A., Sampaio, G., Borma, L.S., Castilla-Rubio, J.C., Silva, J.S., Cardoso, M., 2016. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc. Natl. Acad. Sci. 113 (39), 10759–10768.

Norris, D., Sabadini Carvalho, T., Guerrero, A.M., Sobral Escada, M.I., Alencar, A., Kimbrough, L., Butler, R.A, 2022. Cutting down trees does not build prosperity: on the continued decoupling of amazon deforestation and economic development in 21st century Brazil. Trop Conserv Sci 15, 19400829221132193.

Oliveira, G.M., Sellare, J., Börner, J., 2023. Mind your language: political discourse affects deforestation in the Brazilian Amazon. ZEF-Discussion Papers on Development Policy (326), 34.

Ortega-Egea J M, G.-d.-F.N.-L., 2014. Why do some people do 'more' to mitigate climate change than others? Exploring heterogeneity in psycho-social associations. PLoS. One.

Pereira, J.C., Viola, E., 2019. Catastrophic climate risk and Brazilian Amazonian politics and policies: a new research agenda. Glob. Environ. Polit. 19 (2), 93–103.

Poortinga, W., L, W., 2019. Climate change perceptions and their individual-level determinants: a cross-European analysis. Global Environmental Change 55, 25–35.

Russo Lopes, G., Bastos Lima, M.G., Reis, T.N.P.d., 2021. Maldevelopment revisited: inclusiveness and social impacts of soy expansion over Brazil's. Cerrado in Matopiba. World De- velopment 139, 105316. https://doi.org/10.1016/j.worlddev.2020.105316.

Sauer, S., 2018. Soy expansion into the agricultural frontiers of the Brazilian Amazon: the agribusiness economy and its social and environmental conflicts. Land. use policy. 79, 326–338. https://doi.org/10.1016/j.landusepol.2018.08.030.

Schmink, M, García, MAG, 2015. Under the canopy: Gender and forests in Amazonia. In: Occasional Paper, 121. CIFOR, Bogor, Indonesia.

Schwartzman, S., Alencar, A., Zarin, H., Santos Souza, A.P., 2010. Social movements and large-scale tropical forest protection on the Amazon Frontier: Conservation from chaos. J. Environ. Dev 19 (3), 274–299. https://doi.org/10.1177/1070496510367627.

Silva Junior, C.H.L., Celentano, D., Rousseau, G.X., de Moura, E.G., Varga, I.v.D., Martinez, C., Martins, M.B., 2020. Amazon forest on the edge of collapse in the Maranhão State. Brazil. Land Policy 97, 104806. https://doi.org/10.1016/j.landusepol.2020.104806.

Tritsch, I., Arvor, D., 2016. Transition in environmental governance in the Brazilian Amazon: emergence of a new pattern of socio-economic development and deforestation. Land. use policy. 59, 446–455.

Wan, M., Colfer, C., Powell, B., 2011. Forests, women and health: opportunities and challenges for conservation. Internat. Forestry Rev. 13, 370–387.

Weinhold, D., Reis, E.J., Vale, P.M., 2015. Boom-bust patterns in the Brazilian Amazon. Global Environ.l Change 35, 391–399.

Whitehead, J., 1991. Environmental interest group behaviour and self-selection bias in contingent valuation mail surveys. Growth Change 22, 10–21.