



# Beliefs underlying preservation of native vegetation beyond legal requirements: an elicitation study among landowners in Cerrado

João Augusto Rossi Borges<sup>1</sup> · Artur Henrique Leite Falcette<sup>1</sup>

Received: 19 June 2023 / Accepted: 9 February 2024 / Published online: 19 February 2024  
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2024

## Abstract

The Brazilian Cerrado is one of the most biodiverse hotspots in the world, the birthplace of major rivers, and plays a crucial role in climate stability. Despite ongoing efforts to conserve the native vegetation within this biome, a significant amount of land remains legally available for conversion. This situation raises concerns, as landowners are likely to continue clearing areas for agricultural production due to its legality and the substantial economic incentives involved. This poses a direct threat to the ecosystem services provided by the Cerrado. To delve into the beliefs of landowners regarding the preservation of native vegetation beyond legal requirements on their properties, we adopted a theory-based approach, specifically the Theory of Planned Behavior. These beliefs serve as the foundation for designing and implementing effective conservation initiatives. A qualitative survey was conducted with a convenience sample of 21 landowners in Mato Grosso do Sul, Cerrado, Brazil. Through content analysis, we identified a total of 30 salient behavioral, normative, and control beliefs. Behavioral beliefs underscored the environmental benefits of preserving more than legally required, while acknowledging existing economic constraints. Normative beliefs revealed the expectation for approval for preservation from groups historically in disagreement or conflict with landowners. Control beliefs highlighted economic incentives as facilitators for preservation; however, landowners fear losing rights over land, and fear being watched by the state through surveillance and monitoring systems. The implications of these findings for conservation initiatives are thoroughly discussed, recognizing the delicate balance between environmental preservation and the economic considerations that influence landowners in the Cerrado region.

**Keywords** Belief elicitation · Conservation policy · Deforestation · Forest Code · Savannah · Reasoned action

## Introduction

The Brazilian Cerrado stands as one of the world's most biodiverse savannas, hosting over 12,000 plant and 1000 vertebrate species, with 4800 of them exclusive to this region (Joly et al. 2019; Strassburg et al. 2017). Additionally, the Cerrado serves as the origin of major rivers, nourishing vital national and international basins, including the Rio da Prata and São Francisco. Its native vegetation plays a pivotal role

in maintaining carbon and water balance, contributing significantly to regional and global climate stability (Arantes et al. 2016; Spera et al. 2016, 2020; Rodrigues et al. 2022). Despite its environmental importance, 46% of the original native vegetation cover in the Cerrado has been cleared for agricultural purposes, posing a threat to the biome's crucial environmental services (Strassburg et al. 2017; Rodrigues et al. 2022). Preserving the Cerrado and mitigating the adverse environmental impacts of conversion hinge on the conservation of private properties, given that 62% of the remaining native Cerrado exists within these properties (Bispo et al. 2023; Colman et al. 2022; de Marco Jr et al. 2023; Mapbiomas 2023).

Brazil's Forest Code, the primary legislation governing land use in the country, permits the clearance of 65–80% of native vegetation on a property in the Cerrado. Consequently, 40% of the remaining land in this biome is legally available for conversion, much of which is suitable for agricultural activities such as soybean and sugarcane cultivation

---

Communicated by Kathleen Hermans.

✉ João Augusto Rossi Borges  
joaoborges@ufgd.edu.br

Artur Henrique Leite Falcette  
artur.falcette@outlook.com

<sup>1</sup> Agribusiness Program, Federal University of Grande Dourados, Rodovia Dourados-Itahum, Km 12, Dourados, MS, Brazil

(Soares-Filho et al. 2014; Rudorff et al. 2015). Given the legality and substantial economic incentives, landowners are likely to continue converting these areas for agricultural purposes, despite the unsustainability of large-scale conversion. Projections indicate that large-scale conversion in the Cerrado will result in significant biodiversity loss, a notable decrease in freshwater provision, and a substantial release of greenhouse gases (Bispo et al. 2023; Colman et al. 2022; de Marco Jr et al. 2023; Rodrigues et al. 2022; Strassburg et al. 2017).

In response to this scenario, the Cerrado has seen conservation initiatives aimed at preventing further clearing, including legal frameworks, policy instruments, and multi-stakeholder agreements. However, these initiatives need to be scaled up for effective impact (Strassburg et al. 2017; Garrett et al. 2022). Conservation initiatives could potentially influence landowners to preserve more than mandated by Brazil's Forest Code, using mechanisms such as payment for ecosystem services or market exclusion. We contend that the success of such initiatives lies in understanding the beliefs that underlie landowners' decisions to preserve native vegetation beyond legal requirements<sup>1</sup> on their properties.

The Theory of Planned Behavior (TPB) provides a suitable framework for comprehending landowners' behaviors in an agricultural context (Sok et al. 2021). According to the TPB, intention is the primary predictor of behavior, influenced by attitude, perceived norms, and perceived behavioral control, which, in turn, are shaped by behavioral, normative, and control beliefs, respectively (Ajzen 1991).

A comprehensive study based on the TPB framework typically involves two main steps. In the initial step, a qualitative pilot study is conducted with a small sample of individuals representing the research population. This aims to extract accessible behavioral, normative, and control beliefs (Fishbein and Ajzen 2011). The beliefs identified in the pilot study are then subjected to content analysis and utilized to develop a quantitative survey. This survey also includes measures of intention, attitude, perceived norms, perceived behavioral control, and sometimes behavior. In the second step, the quantitative survey is administered to a large representative sample of the population. The subsequent quantitative analysis, often employing methods such as structural equation modeling and MIMIC models, allows the identification of the relative impact of attitude, perceived norms, and perceived behavioral control on intention. It also helps

in identifying the most influential beliefs that explain their respective TPB constructs (Sok et al. 2021). This sequential process is crucial, especially when the results are employed in developing interventions to modify behavior (Schmidt and Ajzen, 2020). This importance stems from the fact that, to motivate the desired behavior through interventions like conservation initiatives, there is a need to influence beliefs, given that beliefs form the foundation of people's behaviors (Schmidt and Ajzen, 2020).

While recognizing the importance of a comprehensive TPB study, this research chooses to concentrate on the initial step of the TPB, specifically conducting a qualitative study to elicit beliefs. Two primary justifications support this decision. First, in a prior attempt to carry out a full TPB study, we encountered reluctance among landowners in the region to participate in the qualitative study. Although we have not probed their reasons extensively, we speculate that landowners are increasingly feeling pressured to conserve native vegetation beyond legal requirements without apparent benefits, leading them to avoid the topic. Anecdotal evidence also indicates that landowners are hesitant to share their views on the preservation of native vegetation due to substantial fines for non-compliance with the Brazilian Forest Code. Consequently, the topic of preserving native vegetation appears to be sensitive to them. For topics of environmental sensitivity, qualitative research approaches, such as the one employed in this study, can unveil crucial insights (Bercht 2021; Burney et al. 2023). Second, once the pilot study is executed effectively, there is confidence that all beliefs within the population have been identified (Fishbein and Ajzen 2011; Stenius and Eriksson 2023). Past research has undertaken belief elicitation studies exploring various themes, including beliefs about fruit and vegetable consumption (Jung et al. 2017), beliefs guiding decisions to purchase groceries online (Stenius and Eriksson 2023), nurses' beliefs regarding the use of physical restraints (Via-Clavero et al. 2019), and students' beliefs underpinning stress reduction and depression help-seeking behaviors (Yzer and Gilashevitch 2019). Employing thematic analysis and frequency analysis methodologies, these studies adeptly pinpoint salient beliefs—those most frequently mentioned by participants. Recognized as informative for intervention design, these identified beliefs hold promise for future TPB-based surveys, facilitating a deeper exploration of their relative importance in explaining their respective constructs.

In the light of the foregoing, the aim of this study is to identify the beliefs that landowners have about preserving native vegetation beyond legal requirements on their properties. In the realm of conservation agriculture research, the TPB has been employed to comprehend the adoption of sustainable agricultural practices (Borges et al. 2016; Lokhorst et al. 2011; Zeweld et al. 2017), soil conservation practices (Wauters et al. 2010), the reduction of pesticide use (Bakker

<sup>1</sup> The Forest Code outlines the minimum percentage of native vegetation that must be conserved on a property, known as the legal reserve (LR). Additionally, it designates environmentally sensitive areas, such as riversides and hilltops, as areas of permanent preservation (APP) (Sotteroni et al. 2018). In the context of this study, preserving more than legal requirements implies conserving a greater amount of native vegetation than mandated by Brazil's Forest Code.

et al. 2021), and the adoption of nutrient best management practices (Daxini et al. 2019, Doran et al. 2021). In the Cerrado region, the TPB has been utilized to understand landowners' intentions to restore native areas (Lima and Bastos 2020). To the best of our knowledge, this is the first attempt to explore landowners' beliefs underlying preservation of native vegetation beyond legal requirements in the Cerrado.

## Research methods

### Data collection and questionnaire

The Cerrado region is situated in central Brazil, spanning across the states of Goiás, Mato Grosso, Tocantins, Maranhão, Piauí, Bahia, Minas Gerais, São Paulo, Paraná, the Federal District, and Mato Grosso do Sul (MS). This research specifically targets the Cerrado area within MS. MS encompasses a total area of approximately 35 million hectares (Mha), with Cerrado covering 62.2%, Pantanal 27.3%, and Atlantic Forest 10.5% of this land. Since 1985, around 6.7 Mha of native vegetation in MS has been converted for agricultural purposes, with 4.2 Mha attributed to the Cerrado alone (Mapbiomas 2023). Nevertheless, about 34.6% (approximately 12.4 Mha) of the total area of MS remains under native vegetation (Mapbiomas 2023). Notably, nearly 2 Mha are legally available for conversion in the Cerrado portion of MS (Stefanes et al. 2018).

A qualitative survey was conducted, from September 2022 to January 2023, involving a convenience sample of landowners in MS. According to data from the Brazilian Institute of Geography and Statistics (IBGE 2020), there are 71,164 farm properties in MS, with approximately 11% exceeding 1000 hectares. These larger properties concentrate more than 70% of the land in the region (IBGE 2020). The sample specifically focuses on landowners with large properties (> 500 hectares), as larger properties are more likely than smaller ones to possess legally available land for conversion (Stefanes et al. 2018).

Landowners were chosen through the authors' contact networks. This sampling procedure was employed to address the challenge of finding landowners willing to participate in research focusing on what appears to be a sensitive topic. The second author, who was a well-connected landowner in the study region at the time of the survey, invited peers to participate in the research. The surveys were conducted face-to-face upon acceptance. Data collection concluded with new landowners when beliefs became repetitive, indicating saturation, and no further beliefs could be identified through additional data collection. This point was apparently reached after surveying 18 landowners, a conclusion confirmed by surveying 3 additional landowners. As a result, the final sample consisted of 21 landowners ( $n=21$ ).

**Table 1** Demographic characteristics of the sample ( $n=21$ )

Variable	Categories	%
Age	18–35 years	19.1
	36–45 years	38.1
	46–60 years	33.3
	> 60 years	9.5
Gender	Male	85.7
	Female	14.3
Educational attainment	Incomplete high school	9.52
	Complete high school	19.05
	Incomplete bachelor's degree	9.52
	Complete bachelor's degree	47.62
	Postgraduate studies	14.29
Municipalities	Antônio João	4.76
	Bonito	9.52
	Campo Grande	9.52
	Dourados	14.29
	Maracaju	33.33
	Ponta Porã	4.76
	Ribas do Rio Pardo	4.76
	Rio Brillhante	4.76
	Sidrolândia	14.29
	Ponta Porã	4.76
Property size	501–1000 hectares	19.05
	1001–3000 hectares	38.10
	3001–5000 hectares	33.33
	> 5000 hectares	9.52
Farm product	Only cattle	19.05
	Only crops	47.62
	Mixed farm	33.33

The survey comprised two sections. The first section covered demographic characteristics (Table 1). Seventeen landowners reported that approximately 20% of their properties were designated as legal reserves, while 4 reported having less than 20%. The second section involved questions to elicit beliefs, developed following established procedures (Fishbein and Ajzen 2011). To elicit behavioral beliefs, we asked: “What are the advantages that might happen if you preserve native vegetation in your property beyond legal requirements?” and “What are the disadvantages that might happen if you preserve native vegetation in your property beyond legal requirements?” To elicit normative beliefs, we asked: “Are there any groups or people who would approve if you would preserve native vegetation in your property beyond legal requirements?” and “Are there any groups or people who would disapprove if you would preserve native vegetation in your property beyond legal requirements?” Last, for control beliefs we asked: “What factors or circumstances would make it easier for you to preserve native vegetation in your property beyond legal requirements?”

**Table 2** Behavioral beliefs: salient perceived advantages and disadvantages of preserving native vegetation beyond legal requirements

Advantages	<i>n</i>	%	Disadvantages	<i>n</i>	%
Repurpose unproductive land	15	71.4	Reduce agricultural production	15	71.4
Alleviate public concern about agriculture's environmental impact	2	9.52	Diminish farm income	21	100
Protect natural resources (e.g., water, biodiversity)	20	95.2	Decline in land value	18	85.68
Improve microclimate	11	52.36	Be accountable for an area without clear benefits	10	47.6
Improve soil conservation	11	52.36			
Preserve natural landscape	1	4.76			
Save the costs for clearing this land	20	95.2			

and “What factors or circumstances would make it difficult or impossible for you to preserve native vegetation in your property beyond legal requirements?”. The questions were translated into Portuguese.

### Data analyses

In line with Fishbein and Ajzen's (2011) suggestion that beliefs readily coming to mind for many respondents in an elicitation study are likely to be reiterated in the data, the appropriate method for analyzing such data is inductive thematic analysis (Stenius and Eriksson 2023). Therefore, in the initial phase of analysis, the open-ended responses to the belief elicitation questions underwent content analysis by the second author, resulting in themes that encapsulated distinct behavioral, normative, and control beliefs. Subsequently, in a second round of analysis, the themes identified in the first round were scrutinized by the first author, who possesses over 8 years of experience in reasoned action elicitation research. In a third and concluding round, the authors meticulously reviewed all themes to ensure logical coherence, engaged in discussions about each theme, and resolved any discrepancies. The authors reached a unanimous agreement on the final coded beliefs. Distinct beliefs underwent a comprehensive count analysis to illustrate the frequency with which participants mentioned them.

## Results

### Behavioral beliefs

Table 2 shows behavioral beliefs regarding the preservation of native vegetation on properties beyond legal requirements, encompassing beliefs about potential advantages and disadvantages of such preservation. A total of 11 salient behavioral beliefs emerged, comprising 7 advantages and 4 disadvantages. The advantages were

predominantly linked to environmental considerations, including the protection of natural resources, improvement of microclimate, soil conservation, and preservation of the natural landscape. Intriguingly, landowners also perceived that surpassing legal requirements would alleviate public concerns regarding agriculture's environmental impact. The advantage of repurposing unproductive land suggests that landowners are inclined to preserve primarily native vegetation on land deemed unproductive or with low agricultural potential. The sole direct economic advantage was saving costs for clearing land, but this seems related only to land with low agricultural potential. The disadvantages, in turn, were mainly associated with economic constraints, such as reduced agricultural production, diminished farm income, and a decline in land value. Landowners also expressed concerns about being held accountable for environmental damage in the future, even if the land is not designated for preservation.

### Normative beliefs

Table 3 shows salient normative beliefs, which are beliefs about who in landowner's view would approve or disapprove of the landowner preserving native vegetation in his/her property beyond legal requirements. A total of 10 salient normative beliefs were identified: 6 would approve and 4 disapprove. Disapproval was expected from groups closely associated with landowners, including other landowners, farmers' associations, farm suppliers, and farm advisors. Conversely, approval was expected from groups that historically held differing perspectives or conflicts with landowners in the region, such as the urban population, environmentalists, non-governmental organizations (NGOs), indigenous people and their associations, and social movements. While government approval was expected, landowners associated it with left-wing political parties, citing the names of prominent left-wing politicians.

**Table 3** Normative beliefs: salient referents for preserving native vegetation beyond legal requirements

	Approve		Disapprove		
	<i>n</i>	%	<i>n</i>	%	
Urban population	15	71.4	Other landowners	12	57.12
Environmentalists	21	100	Farmers' associations	12	57.12
NGOs	11	52.36	Farm suppliers	3	14.28
Indigenous people and their associations	13	61.88	Farm advisors	5	23.8
Social movements (e.g., landless workers movement)	13	61.88			
Government (Federal, state, and local level)	18	85.68			

**Table 4** Control beliefs: salient facilitators or barriers for preserving native vegetation beyond legal requirements

Facilitators	<i>n</i>	%	Barriers	<i>n</i>	%
Tax property cuts	16	76.16	Increase land value	18	85.68
Payment for ecosystem services provided by the surplus of native vegetation	21	100	Uncertainty regarding land tenure	6	28.56
Lower interest rates for farm loans	16	76.16	Concern about state surveillance and monitoring systems	17	80.92
Development of public policies to support preservation of surplus of native vegetation	21	100			
Companies' programs to support preservation of surplus of native vegetation	16	76.16			
Financial compensation for refraining from agricultural production on designated land	21	100			

## Control beliefs

Table 4 shows salient control beliefs, which are beliefs about which factors would make it easier and which factors would make it more difficult to preserve native vegetation in properties beyond legal requirements. A total of 9 salient control beliefs were identified: 6 facilitators and 3 barriers. Facilitators were predominantly associated with economic incentives, including tax cuts, payment for ecosystem services, lower interest rates for farm loans, and financial compensation for refraining from agricultural production on designated land. Public policies and corporate programs were also seen as facilitators, presumably offering additional economic incentives. Notably, landowners expressed apprehension about potentially losing rights over this land, particularly concerning the occupation of unproductive land by social movements or government entities. An increase in land value emerged as a barrier, as higher land value raised the opportunity cost of using it for agricultural production or selling it. Additionally, landowners expressed concerns about state surveillance and monitoring systems, perceiving them as potential barriers to the preservation effort.

## Discussion and concluding comments

The aim of this study was to identify the beliefs that landowners have about preserving native vegetation beyond legal requirements on their properties. A survey based on the TPB guidelines was developed and applied to a convenience

sample of landowners in MS, Cerrado, Brazil. A total of 30 salient behavioral, normative, and control beliefs were identified, offering insights with implications for conservation initiatives. Despite the pivotal role of landowners in protecting the Cerrado, given that most of the remaining native vegetation resides within private properties, the success of conservation efforts relies on collaborative actions involving various stakeholders (Bispo et al. 2023; Colman et al. 2022; Strassburg et al. 2017). We, therefore, reflect on the interconnection between our findings and the actions of other actors dedicated to safeguarding the Cerrado.

Behavioral beliefs concerning perceived disadvantages of preservation strongly suggest that economic constraints are viewed as a significant impediment to preserving more than legally required. This finding is not novel; Azevedo et al. (2017) similarly found that landowners in other regions of Brazil (Mato Grosso and Para states) perceive few economic incentives to comply with the Forest Code. Control beliefs regarding facilitators pointed to various perceived initiatives aimed at overcoming these economic constraints. Notably, all facilitators were linked to economic incentives. Therefore, our results clearly indicate that landowners expect financial compensation to preserve native vegetation beyond legal requirements. From landowners' perspective, this expectation seems legitimate as conversion is legal and economic incentives are large. These results are likely tied to a private sector discourse that increasingly supports the idea that landowners must receive financial compensation for not clearing the surplus of native vegetation (Garrett et al. 2022; TFA 2020).



Under this scenario, government entities and agricultural companies could, in theory, develop programs to financially compensate landowners with a surplus of native vegetation. However, this approach faces several challenges. First, financing such programs would require a considerable amount of cash (Garrett et al. 2022), prompting the question of who will finance it. Given the need for a substantial cash influx, it is likely that multiple sources, such as agricultural companies, government at different levels, and international climate funds, should provide funding. Second, the behavioral belief about the perceived advantage of repurposing unproductive land indicates that landowners are inclined to designate unproductive land or land with low agricultural potential for preservation. Therefore, it is likely that landowners operating rural establishments in regions with suitable land for agricultural production will desire a high amount of compensation for not clearing this land (i.e., the opportunity cost for not clearing is very high). Consequently, only landowners with land of low agricultural suitability are likely to participate in financing schemes unless the payments are exceptionally high (Garrett et al. 2022). Although financial compensation approaches align with our main results, we concur with Garrett et al. (2022) in emphasizing that economic incentives must be used with great care, as they might generate spillover effects, such as additional clearing in other areas facilitated by cash incentives, and they might incentivize wealthy landowners to capture most of the economic benefits. Perhaps, the government might provide small tax cuts (e.g., waive the Rural Land Tax) or lower interest rates for farm loans provided by the government for landowners with surplus of native vegetation. These strategies might resonate particularly with owners of unproductive/low agricultural potential land, as economic incentives for conversion are not substantial, and landowners perceive the advantage of saving costs for clearing this area. In addition, a price bonus for agricultural production could be offered to landowners with a surplus of native vegetation. Ideally, this would increase farm income and encourage the adoption of more sustainable agricultural practices.

Alternatively, market exclusion mechanisms could be employed to prevent the legal clearing of native vegetation. In this context, initiatives already established in the Amazon could be extended to the Cerrado (Gibbs et al. 2015, 2016), or jurisdictional approaches might be formulated (Brandão et al. 2020; Garrett et al. 2022). While market exclusion mechanisms are likely to reduce legal clearing, it is important to note that these mechanisms might result in the exclusion of landowners from the markets. Therefore, it is unlikely that they and their representatives will readily accept such mechanisms. For instance, the recent EUDR 1115/2023, which halts the commercialization of commodities from deforested areas, even if legal in the country of origin, and could potentially extend to non-forest ecosystems

like the Cerrado, has been criticized as discriminatory and unfair by Brazilian authorities (MRE 2023). Additionally, compliance with this legislation is likely to incur significant costs, raising the question of who will bear these expenses. If the costs are borne by landowners, this might lead to the exclusion of smallholders from the market. Another evident side effect of this legislation is that compliant products would be exported to the EU, while non-compliant products might either be sold in local markets or exported to other countries with looser environmental requirements.

Control beliefs about barriers indicate two landowners' fears: losing rights over preserved land and being watched by the state through surveillance and monitoring systems. The former seems associated with land occupation, which has increasingly generated conflicts among landowners, indigenous groups, and other social movements (e.g., landless workers movement) in MS (de Almeida 2021). This fear might explain landowners' perceptions that indigenous people and their associations, and social movements would approve preservation of native vegetation beyond legal requirements. The fear of being watched by the state was also found by Azevedo et al. (2017), working with small landowners in other regions in Brazil. These authors argue that landowners registered in the Rural Environmental Registry (CAR, Portuguese acronym) fear being watched, which might improve enforcement, but this perception decreases over time. For preservation beyond legal requirements, it is necessary to establish reliable and continuous monitoring systems for the land. However, it is equally crucial to inform landowners clearly about the system's purpose to alleviate concerns regarding constant surveillance. This measure seems also essential to ensure compliance with contractual agreements when using financial incentives to compensate landowners.

Normative beliefs suggest that approval for preservation beyond legal requirements was expected from groups historically in conflict with landowners in the region, such as environmentalists, NGOs, and indigenous people. Conversely, disapproval was expected from groups typically supportive of landowners. In other words, landowners seem to believe that preserving more than legally required would garner approval from those with a traditional focus on environmental protection, while disapproval would come from those aligned with agricultural production. We speculate that these results might be influenced by political position. While we did not collect landowners' political preferences, anecdotal evidence suggests that landowners with large properties in the region usually support right-wing parties. Given that landowners in our sample have large properties, it is reasonable to assume that they predominantly are supporters of right-wing parties. Traditionally, left-wing parties in Brazil align more to environmental and indigenous protection, while right-wing

parties focus on production-oriented discourse (Motta and Hauber 2022). Therefore, landowners presumably supporting right-wing parties might associate preservation beyond legal requirements with approval from environmentalists, NGOs, and indigenous people. In fact, landowners indicated that government would approve preservation, but only from left-wing parties, supporting our speculation. This result poses a challenge to the formulation and implementation of conservation initiatives, as landowners might feel excluded along with their representatives. Hence, we agree with Garrett et al. (2022) that the design of conservation initiatives should encompass multiple stakeholders, including representatives of landowners, environmentalists, and indigenous groups.

Preserving native vegetation beyond legal requirements was associated not only with environmental benefits but also with a belief in alleviating public concern about agriculture's environmental impact. This suggests that preserving more than required may serve a dual purpose for landowners, or at least different purposes for different landowners. This insight broadens the scope of conservation initiatives, indicating that the focus need not solely be on economic incentives to encourage landowners to preserve. Environmental NGOs, for instance, could tailor messages for strategic integration into public campaigns, highlighting the positive environmental outcomes of native vegetation preservation. These campaigns could promote landowners with a surplus of native vegetation and address concerns regarding the environmental impact of agriculture.

Finally, we align with Bispo et al. (2023) in recognizing that there is no straightforward solution to prevent the loss of native vegetation in the Cerrado. In addition to the discussed conservation initiatives, other measures are necessary. The Brazilian government must cease delaying the deadline for the Rural Environmental Registry (CAR) declaration (Poli- zel et al. 2021). As of April 2023, nearly 7 million properties have completed the CAR declaration in Brazil according to official data (SICAR 2023). However, until all the data is collected and validated by the government, it is impossible to determine the extent of land still available for legal conversion and which properties will need to purchase, restore, or rent land to offset existing deficits. According to the Forest Code, it is mandatory for landowners with a deficit of native vegetation to participate in the Environmental Regularization Program. However, the implementation of this program in the Cerrado is contingent upon the completion and validation of the CAR declaration. Additionally, it is crucial to extend credit and technical support to encourage the sustainable intensification of production systems in already cleared areas (Strassburg et al. 2017). Furthermore, supporting the restoration of degraded land on private properties is imperative (Strassburg et al. 2017; de Marco Jr et al. 2023).

This study has some limitations that might be considered in future research. First, the sampling method and the qualitative belief elicitation study do not permit the generalization of findings beyond our small sample. However, we contend that this study has engaged individuals who reasonably represent the population of landowners with large properties in MS, and thus, the identified beliefs may not be exclusive to the investigated sample. Additionally, given the qualitative nature of this study, the identified beliefs were treated as equally important, with a greater emphasis on those most frequently mentioned by participants, in the discussion and recommendations for the design and implementation of conservation initiatives. However, this approach may be debatable, as certain beliefs may prevail in the population and exert more influence in explaining attitude, perceived norms, and perceived behavioral control. Our frequency analysis indeed revealed variations in the common mention of distinct beliefs among participants. It is therefore recommended that future studies use the identified beliefs to construct a complete TPB questionnaire and apply it to a more representative sample of landowners (e.g., in other regions of the Cerrado). This approach can then guide the selection of specific beliefs to be targeted in the design and implementation of conservation initiatives. Second, in the TPB, a distinction exists between injunctive and descriptive normative beliefs. The former pertain to group(s) of people who would approve or disapprove of the preservation of native vegetation beyond legal requirements on properties, while the latter refer to group(s) of people who would or would not preserve native vegetation beyond legal requirements on properties. The questions used in this research only assessed injunctive normative beliefs, as the only descriptive normative group that would preserve or not preserve native vegetation on properties comprises the landowners. However, this is a broad group. Future research could explore within the descriptive normative group of landowners to identify those more or less likely to preserve native vegetation beyond legal requirements. Third, the behavior under study and the questions used to measure beliefs were not explicitly defined in terms of a time element. Although landowners did not appear confused about the questions during the survey, there might be uncertainty about the period during which they were asked to preserve native vegetation beyond legal requirements on their properties. Future studies could employ more precise measures based on a specific time frame.

**Data availability** The dataset generated analyzed during the current study is available from the corresponding author on reasonable request.

## Declarations

**Conflict of interest** The authors declare no competing interests.

## References

- Ajzen I (1991) The theory of planned behavior. *Organ Behav Hum Decis Process* 50(2):179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Arantes AE, Ferreira LG, Coe MT (2016) The seasonal carbon and water balances of the Cerrado environment of Brazil: past, present, and future influences of land cover and land use. *ISPRS J Photogramm Remote Sens* 117:66–78. <https://doi.org/10.1016/j.isprsjprs.2016.02.008>
- Azevedo AA, Rajão R, Costa MA, Stabile MC, Macedo MN, et al. (2017) Limits of Brazil's Forest Code as a means to end illegal deforestation. *Proc Natl Acad Sci* 114(29):7653–7658. <https://doi.org/10.1073/pnas.1604768114>
- Bakker L, Sok J, Van Der Werf W, Bianchi FJJA (2021) Kicking the habit: what makes and breaks farmers' intentions to reduce pesticide use? *Ecol Econ* 180:106868. <https://doi.org/10.1016/j.ecolecon.2020.106868>
- Bercht AL (2021) How qualitative approaches matter in climate and ocean change research: uncovering contradictions about climate concern. *Glob Environ Chang* 70:102326. <https://doi.org/10.1016/j.gloenvcha.2021.102326>
- Borges JAR, Tauer LW, Lansink AGO (2016) Using the theory of planned behavior to identify key beliefs underlying Brazilian cattle farmers' intention to use improved natural grassland: a MIMIC modelling approach. *Land Use Policy* 55:193–203. <https://doi.org/10.1016/j.landusepol.2016.04.004>
- Brandão F, Piketty M-G, Poccard-Chapuis R, Brito B, Pacheco P, Garcia E, Duchelle AE, Drigo I, Peçanha JC (2020). Lessons for jurisdictional approaches from municipal-level initiatives to halt deforestation in the Brazilian Amazon. *Front For Glob Change* 3:96 <https://doi.org/10.3389/ffgc.2020.00096>
- Burney V, Arnold-Saritepe A, McCann CM (2023) Rethinking the place of qualitative methods in behavior analysis. *Perspectives on Behavior Science* 46(1):185–200. <https://doi.org/10.1007/s40614-022-00362-x>
- Colman CB, Guerra A, de Oliveira Roque F, Rosa IM, de Oliveira PTS (2022) Identifying priority regions and territorial planning strategies for conserving native vegetation in the Cerrado (Brazil) under different scenarios of land use changes. *Sci Total Environ* 807:150998. <https://doi.org/10.1016/j.scitotenv.2021.150998>
- de Marco Jr P, de Souza RA, Andrade AFA, Villén-Pérez S, Nóbrega CC, et al. (2023) The value of private properties for the conservation of biodiversity in the Brazilian Cerrado. *Science* 380(6642):298–301. <https://doi.org/10.1126/science.abq7768>
- IBGE (2020) Instituto Brasileiro de Geografia e Estatística. Atlas do espaço rural brasileiro. IBGE
- Joly CA, Scarano FR, Seixas CS, Metzger JP, Ometto JP, et al. (2019) 1º Diagnóstico Brasileiro de Biodiversidade e Serviços Ecossistêmicos. Editora Cubo. <https://doi.org/10.4322/978-85-60064-88-5>
- Fishbein M, Ajzen I (2011) Predicting and changing behavior: the reasoned action approach. Taylor & Francis
- Garrett RD, Grabs J, Cammelli F, Gollnow F, Levy SA (2022) Should payments for environmental services be used to implement zero-deforestation supply chain policies? The case of soy in the Brazilian Cerrado. *World Dev* 152:105814. <https://doi.org/10.1016/j.worlddev.2022.105814>
- Gibbs HK, Munger J, L'Roe J, Barreto P, Pereira R, et al. (2016) Did ranchers and slaughterhouses respond to zero deforestation agreements in the Brazilian Amazon? *Conserv Lett* 9:32–42. <https://doi.org/10.1111/conl.12175>
- Gibbs HK, Rausch L, Munger J, Schelly I, Morton DC, et al. (2015) Brazil's soy moratorium. *Science* 347(6220):377–378. <https://doi.org/10.1126/science.aaa0181>
- Jung SE, Shin YH, Kim S, Hermann J, Bice C (2017) Identifying underlying beliefs about fruit and vegetable consumption among low-income older adults: an elicitation study based on the theory of planned behavior. *J Nutr Educ Behav* 49(9):717–723. <https://doi.org/10.1016/j.jneb.2017.05.343>
- Lima FP, Bastos RP (2020) Understanding landowners' intention to restore native areas: the role of ecosystem services. *Ecosyst Serv* 44:101121. <https://doi.org/10.1016/j.ecoser.2020.101121>
- Lokhorst AM, Staats H, van Dijk J, van Dijk E, de Snoo G (2011) What's in it for me? Motivational differences between farmers' subsidised and non-subsidised conservation practices. *Appl Psychol* 60(3):337–353. <https://doi.org/10.1111/j.1464-0597.2011.00438.x>
- MapBiomias (2023) Mapbiomas Brasil. Available at: <https://mapbiomas.org/noticias>. Accessed 7.11.23
- MRE (2023) Ministério das Relações Exteriores Carta de países em desenvolvimento a autoridades europeias sobre a entrada em vigor da chamada “lei antidesmatamento” da União Europeia Available at: [https://www.gov.br/mre/pt-br/canais\\_atendimento/imprensa/notas-a-imprensa/carta-de-paises-em-desenvolvimento-a-autoridades-europeias-sobre-a-entrada-em-vigor-da-chamada-201clei-antidesmatamento201d-da-uniao-europeia](https://www.gov.br/mre/pt-br/canais_atendimento/imprensa/notas-a-imprensa/carta-de-paises-em-desenvolvimento-a-autoridades-europeias-sobre-a-entrada-em-vigor-da-chamada-201clei-antidesmatamento201d-da-uniao-europeia). Accessed 16 Nov 23
- Motta FM, Hauber G (2022) Anti-environmentalism and proto-authoritarian populism in Brazil: Bolsonaro and the defence of global agri-business. *Environmental Politics*. <https://doi.org/10.1080/09644016.2022.2123993>
- Polizel SP, Vieira RMDSP, Pompeu J, da Cruz FY, de Sousa-Neto ER, et al. (2021) Analysing the dynamics of land use in the context of current conservation policies and land tenure in the Cerrado–MATOPIBA region (Brazil). *Land Use Policy* 109:105713. <https://doi.org/10.1016/j.landusepol.2021.105713>
- Rodrigues AA, Macedo MN, Silvério DV, Maracahipes L, Coe MT, et al. (2022) Cerrado deforestation threatens regional climate and water availability for agriculture and ecosystems. *Glob Change Biol* 28(22):6807–6822. <https://doi.org/10.1111/gcb.16386>
- Rudorff B, Risso J, Aguiar D, Gonçalves F, Salgado M, Perrut J, Oliveira L, Virtuoso M, Montibeller B, Baldi C, Rabaça G, de Paula H, Gerente J, Almeida M, Bernardo R, Cúrcio S, Lopes V, Chagas V (2015) Análise Geoespacial da Dinâmica das Culturas Anuais no Bioma Cerrado: 2000 a 2014. In *Agrosatélite*. Agrosatélite Geotecnologia Aplicada Ltda. <https://agrosatelite.com.br/cases#cases>
- SICAR (2023) Sistema Nacional de Cadastro Ambiental Rural. Regularização ambiental: Boletim informativo Abril 2023. Available at: [https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/boletim-informativo-car/BoletimCAR\\_ABR06\\_20231.pdf](https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/boletim-informativo-car/BoletimCAR_ABR06_20231.pdf)
- Soares-Filho B, Rajão R, Macedo M, Carneiro A, Costa W, et al. (2014) Cracking Brazil's forest code. *Science* 344(6182):363–364. <https://doi.org/10.1126/science.1246663>
- Sok J, Borges JR, Schmidt P, Ajzen I (2021) Farmer behaviour as reasoned action: a critical review of research with the theory of planned behaviour. *J Agric Econ* 72(2):388–412. <https://doi.org/10.1111/1477-9552.12408>
- Soterroni AC, Mosnier A, Carvalho AX, Câmara G, Obersteiner M, et al. (2018) Future environmental and agricultural impacts of Brazil's Forest Code. *Environ Res Lett* 13(7):074021. <https://doi.org/10.1088/1748-9326/aaccbb>
- Spera SA, Galford GL, Coe MT, Macedo MN, Mustard JF (2016) Land-use change affects water recycling in Brazil's last agricultural frontier. *Glob Change Biol* 22(10):3405–3413. <https://doi.org/10.1111/gcb.13298>
- Spera SA, Winter JM, Partridge TF (2020) Brazilian maize yields negatively affected by climate after land clearing. *Nature Sustainability* 3(10):845–852. <https://doi.org/10.1038/s41893-020-0560-3>



- Stefanes M, de Oliveira RF, Lourival R, Melo I, Renaud PC, et al. (2018) Property size drives differences in forest code compliance in the Brazilian Cerrado. *Land Use Policy* 75:43–49. <https://doi.org/10.1016/j.landusepol.2018.03.022>
- Stenius M, Eriksson N (2023) What beliefs underlie decisions to buy groceries online? *Int J Consum Stud* 47(3):922–935. <https://doi.org/10.1111/ijcs.12874>
- Strassburg BB, Brooks T, Feltran-Barbieri R, Iribarrem A, Crouzeilles R, Loyola R, Latawiec AE, Oliveira Filho FJB, Scaramuzza CAM, Scarano FR, Soares-Filho B, Balmford A (2017) Moment of truth for the Cerrado hotspot. *Nat Ecol Evol* 1.4:0099 <https://doi.org/10.1038/s41559-017-0099>
- TFA (2020). Press Release: Payment for environmental services can unite agribusiness, environmentalists and government around the same purpose say sector leaders. Tropicalforestalliance.Org. <https://www.tropicalforestalliance.org/en/news-and-events/news/press-release-payment-for-environmentalservices-can-unite-agribusiness-environmentalists-and-government-around-the-same-purpose-say-sector-leaders>
- Via-Clavero G, Sanjuán-Naváis M, Romero-García M, de la Cueva-Ariza L, Martínez-Estalella G, et al. (2019) Eliciting critical care nurses' beliefs regarding physical restraint use. *Nurs Ethics* 26(5):1458–1472. <https://doi.org/10.1177/0969733017752547>
- Wauters E, Biolders C, Poesen J, Govers G, Mathijs E (2010) Adoption of soil conservation practices in Belgium: an examination of the theory of planned behaviour in the agri-environmental domain. *Land Use Policy* 27(1):86–94. <https://doi.org/10.1016/j.landusepol.2009.02.009>
- Yzer M, Gilasevitch J (2019) Beliefs underlying stress reduction and depression help-seeking among college students: an elicitation study. *Journal of American College Health* 67(2):153–160. <https://doi.org/10.1080/07448481.2018.1462828>
- Zeweld W, Van Huylbroeck G, Tesfay G, Speelman S (2017) Small-holder farmers' behavioural intentions towards sustainable agricultural practices. *J Environ Manage* 187:71–81. <https://doi.org/10.1016/j.jenvman.2016.11.014>

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.