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An outlook on the future of Brazilian agriculture: how farming students of Tocantins perceive sustainability in the *Cerrado*

Uma perspectiva para o futuro da agricultura brasileira: como estudantes camponeses de Tocantins percebem a sustentabilidade no Cerrado

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ABSTRACT

In the Brazilian *Cerrado*, the land-use change caused by the expansion and intensification of agribusiness farming has led to dramatic socio-environmental problems. To foster sustainable development, Brazilian farming students have to learn about land use according to the Sustainable Development Goals and how to implement them on their home farm and future workplace. Through a questionnaire-based survey, our study explored the perceptions of 128 students at the Family Farming High School of Porto Nacional on the sustainability of farming systems in the *Cerrado* of Tocantins. We analyzed the effectiveness of the school in teaching sustainability, the students' occupational preferences and perspectives, and their sentiment about three common farming systems in the *Cerrado* of Tocantins, i.e., agribusiness, family farming, and agroecological farming, and their opinion on the business relationships among the three systems. Even though our study confirmed the effectiveness of school-work alternation models in transferring sustainability practices from school to home farms, it also revealed farming students' poor understanding of the systemic definition of sustainability. Students defined sustainable and unsustainable farms with different perspectives and evaluation criteria, most of them referring to environmental indicators such as the way materials are used, whether the natural environment is protected, and whether biodiversity is preserved on the farm. There is a discrepancy between students' occupational preference and their prevalent sentiment about family farming, agribusiness, and agroecological farming. While more than half of them would accept

RESUMO

No Cerrado, a transformação do uso da terra causada pela expansão e intensificação da agricultura do agronegócio tem levado a problemas socioambientais dramáticos. Para promover o desenvolvimento sustentável, é fundamental ensinar aos estudantes brasileiros de agricultura os Objetivos de Desenvolvimento Sustentável relacionados ao uso da terra e como implementá-los em sua propriedade de origem e em seu futuro lugar de trabalho. Por meio de uma pesquisa baseada em questionários, nosso estudo explorou as percepções de 128 alunos da Escola Família Agrícola de Porto Nacional sobre a sustentabilidade dos sistemas agrícolas no Cerrado de Tocantins. Analisamos a eficácia da escola no ensino da sustentabilidade, as preferências e perspectivas profissionais dos alunos, seus sentimentos em relação a três sistemas agrícolas comuns no Cerrado de Tocantins — ou seja, agronegócio, agricultura familiar e agroecológica — e suas opiniões sobre as relações comerciais entre os três sistemas. Embora nosso estudo tenha confirmado a eficácia dos modelos de alternância entre escola e trabalho na transferência de práticas de sustentabilidade da escola às propriedades familiares, também revelou ser fraco o entendimento dos estudantes campesinos sobre a definição sistêmica de sustentabilidade. Eles definiram produções sustentáveis e insustentáveis com diferentes perspectivas e critérios de avaliação. A maioria deles referia-se a indicadores ambientais como a maneira pela qual os materiais são usados, como o ambiente natural é protegido e a biodiversidade é preservada na propriedade da fazenda. Existe uma discrepância entre a preferência ocupacional dos estudantes e seu sentimento prevalente para a agricultura familiar, agroindustrial e agroecológica. Apesar de mais da metade deles aceitarem trabalhar em

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to work on an agribusiness farm, significantly more students have a positive sentiment in favor of family farming and agroecological farming than agribusiness farming. The three farming systems, however, are not perceived as contending or isolated but as partnering businesses, featuring low competition and high cooperation rates. Our study contributes to a broader appreciation of the Brazilian students' perception of farming sustainability in the *Cerrado* of Tocantins and helps environmental education programs improve their effectiveness in transferring sustainability.

Keywords: agroecology; family farming; soy; environmental education; sentiment analysis; business cooperation.

uma empresa de agronegócios, significativamente mais estudantes têm um sentimento positivo para com a agricultura familiar e agroecológica do que para com a do agronegócio. Os três sistemas agrícolas, no entanto, não são vistos como concorrentes ou isolados, mas como empresas parceiras, caracterizadas por baixa concorrência e altas taxas de cooperação. Nosso estudo contribui para uma apreciação mais ampla da percepção dos estudantes brasileiros sobre a sustentabilidade agrícola no Cerrado do Estado de Tocantins e ajuda os programas de educação ambiental a melhorar sua eficácia na transferência da sustentabilidade.

Palavras-chave: agroecologia; agricultura familiar; soja; educação ambiental; análise de sentimentos; cooperação.

Introduction

There is no doubt that land-use change and farming intensification have had a dramatic impact on biodiversity, ecosystem functioning, and the provision of ecosystem services all over the world (IPBES, 2019). The expansion of monocultures (Ramankutty et al., 2018) and the increased use of synthetic pesticides and mineral fertilizers (Sharma et al., 2019) have caused major environmental damages, such as water pollution (Mateo-Sagasta et al., 2017), severe soil erosion (Borrelli et al., 2017), and an overall aggravation of land degradation (Gibbs and Salmon, 2015). Despite numerous national, international, and global policy initiatives during the past decades, the negative trend of these environmental crises could not be reversed. As a countermeasure, the United Nations (UN) recently announced that the 2021-2030 period would be the "Decade on Ecosystem Restoration" (United Nations Development Programme, 2020) to promote environmental policies that specifically target and promote the restoration of degraded lands.

Currently, land-use change and land degradation are particularly rapid in South America, especially in the *Cerrado*, a vast savannah located south and east of the Amazon rainforest (Ratter et al., 1997). Covering 150-220 million hectares, the *Cerrado* is the second largest biome in Latin America after the Amazon rainforest (Oliveira and Marquis, 2002) and is considered one of the most biodiverse tropical savannahs of the world due to its rich diversity of vascular plants (Eiten, 1994; Myers et al., 2000). Nonetheless, the natural vegetation cover has decreased dramatically in the last decades. From approximately 56% in 2002, it dropped to 52% in 2008 according to a Brazilian governmental survey (MMA et al., 2009). According to Beuchle et al. (2015), instead, the decrease went from approximately 53% in 1990 to 4% in 2010. In other words, 40-55% of the 150-220 million hectares of the *Cerrado* are now deforested and/or covered by croplands, pastures, and mono-species forest plantations (Sano et al., 2010).

Agribusiness as a whole (including supplies, industry, services, and agricultural production) contributed to approximately 20.5% of Brazil's Gross Domestic Product ("GDP"), in 2019 (CEPEA, 2020). With an estimated overall grain production and export of respectively 239 million and 123 million tons, Brazil is the fourth largest grain producer in the world and accounts for about 7.8% of the global production (Food and Agriculture Organization of the United Nations, 2020). The main grain cultivated in Brazil's *Cerrado* is soybean. The unprecedented expansion of soy farming in the *Cerrado* made Brazil the world's biggest soybean producer (approximately 121 million tons per year) and exporter (75 million tons per year) (United States Department of Agriculture, 2019). The increasing global demand for soybeans for human consumption, especially from China, the EU's cattle-feed soy flour imports, and India's soybean oil imports strongly contributed to Brazil's "soy supremacy escalation" (Sistema FIETO, 2018).

The dramatic landscape and land-use change of the *Cerrado* has endangered a substantial number of animal and plant species and put the whole biome under threat of degradation (Françoso et al., 2015; ICMBio, 2018). Besides deforestation and biodiversity loss, it has led to significant soil alteration (e.g., available phosphorus and potassium, and soil pH), nitrogen water pollution, and water shortages due to irrigation (Carvalho, 1999; Fearnside, 2001; Hunke et al., 2015).

These recent changes also had socio-economic impacts, such as governance changes, territorial conflicts between traditional and agribusiness land uses (e.g., in traditional and indigenous communities), and the transformation of traditional livelihood strategies (Carvalho, 1999; Fearnside, 2001). Additionally, the expansion of agribusiness farming competes with family farming traditions, thus determining conflicts within the Brazilian "dualistic" agrarian structure (i.e., the co-existence of agribusiness and family farming) (Pierri, 2013) and triggering land displacements. Indeed, agribusiness farming and particularly the expansion of soybean cultivation is coupled with cattle ranches relo-

cation and indirectly linked to land-use change in frontier areas, such as the northern *Cerrado* regions (Richards, 2015). Once unsuitable for crop production due to soil degradation (i.e., acidic, and nutrient-poor soils containing relevant concentrations of aluminum) (Ratter et al., 1997), the new frontier areas have been vastly occupied by soy agribusiness farms (Fearnside, 2001) and transformed into export-oriented corn-soybean fields based on heavy use of fertilizers, pesticides, and the introduction of GMO crops and grasses (Oliveira and Marquis, 2002).

The pressure of agribusiness production on smallholders may be directly linked to the decline of the Brazilian rural population from roughly 45% in 1970 to 19% in 2010 (IBGE, 2010). The decrease of under-29 individuals was even more dramatic, going from 46 to 16% (IBGE, 2010). The exodus of youth from rural areas translates into a lack of successors and threatens the continuity of rural communities and sustainable farming (Foguesatto et al., 2020). Family farm succession seems to depend on the farm size, a satisfactory rural income, and family farming state incentives (Pessotto et al., 2019; Foguesatto et al., 2020), whereas Brazilian agribusiness farms, especially those producing commodities such as soybeans, tend to fall under the control of multinational companies (Medina, 2022).

In response to these profound environmental and socio-economic changes, international awareness has increased, and so has the attention of academic research on the socio-environmental impact of Brazilian farming and, in general, on its sustainability (McKay and Nehring, 2014).

To embed sustainability in the "agribusiness vs. family farming" dualistic agrarian structure of Brazil, efforts must be made to promote and transfer sustainability practices to *Cerrado* farms (Miller et al., 2019). On one hand, agribusiness farms should increase their environmental sustainability by reducing their impact on the soil and climate, and their energy consumption. They should also improve their sustainable use of materials (e.g., consumables, machinery, infrastructure, feed, and fertilizers), incorporate clear sustainability goals in their farm vision, and enhance their social sustainability, for example, by increasing the employees' wages and cutting down dayworkers' overwork (Miller et al., 2019). On the other hand, family farms should focus on their social sustainability by upgrading working conditions — in particular, the low wages and the work overload — and their economic sustainability by increasing their liquidity and profitability and reducing their dependence on state credits. Following the example of agroecological farms, relying both on farm product sales and side or off-farm revenues may be a solution (Miller et al., 2019).

On the road to pursuing more sustainable agribusiness and family farms, environmental education is key because it teaches future farmers about the importance of sustainable farming and how to implement sustainability on their property or future workplace. The United Nations Development Programme (2020, p. 25) stressed that "education is one of the most powerful and proven vehicles for sustainable development". Specifically, SDG no. 4 "Quality Education" and SDG no. 12 "Responsible Consumption and Production" refer to environmental and sustainability education. The former thanks to its purpose of "[acquiring] knowledge and skills needed to promote sustainable development through, e.g., education for sustainable development and [..] lifestyles" (United Nations Development Programme, 2020, p. 19), the latter thanks to its purpose of "ensur[ing] that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature" (United Nations Development Programme, 2020, p. 25). In this respect, high schools and universities that teach farming, forestry, and environmental sciences have a particular responsibility in preparing students (i.e., future leaders and practitioners) to face global environmental problems and tackle the challenges that they bring at local and regional levels (Zerbe, 2020).

Materials and methods

Focusing on the State of Tocantins, in the northern region of the *Cerrado*, we conducted an environmental and sustainability education case study at the Farming High School of the city of Porto Nacional ("EFAPN"). Widely used in social sciences, especially psychology and education, as a qualitative research method, the case study approach allows in-depth, multi-faceted explorations of an issue in its real-life setting (Stake, 1995). The purpose of our case study was to understand the students' perception of sustainability in Tocantins and thus strengthen the existing knowledge on sustainability education in the *Cerrado*. Opting for a questionnaire-based case study, we were able to carry out a holistic review of the topic based on valid, factual data, that we could not have performed through a literature review only. It also reduced the potential bias of our European view towards a Brazilian problem, which was further eliminated by adding two national researchers to our research team, in the data analysis and manuscript drafting phases.

At the EFAPN, we conducted a questionnaire-based survey with farming students, the future generation of local farmers, to explore their perceptions of sustainability and sustainable farming in the *Cerrado* of Tocantins. Specifically, our research goal was to understand the school's effectiveness in teaching sustainability, the students' perceptions of sustainable farming, the students' occupational preferences and perspectives, and the students' opinions on the relationships between the farming systems; namely, agribusiness, family farming, and agroecological farming. All goals made up the sections of the questionnaire distributed to the students (Annex 1), which was completed in Portuguese and translated into English for further analysis.

Although our findings cannot be generalized to all farming schools in Brazil, they can be used to gain a broader appreciation of the Brazilian students' perception of farming sustainability and support a more detailed exploration of sustainability education in the *Cerrado*. The results should also support Brazilian educational institutions in formulating regional and national sustainability goals and policies, and applying them within study programs. This will help farming and environmental students, hence future farmers and environmental managers, to apply sustainability in the *Cerrado*.

Study area

The survey was conducted at the EFAPN, a farming high school located in the rural outskirts of Porto Nacional, about three kilometers from the city center (Figure 1). Porto Nacional is a city in the State of Tocantins, in the northern region of the *Cerrado*, the vast Brazilian savannah covering 150-220 million hectares south and east of the Amazon rainforest (Oliveira and Marquis, 2002).

Four land-cover types can be found in the *Cerrado*: The *Cerradão* (woodland with trees of 12-15 m high), the *Cerrado sensu strictu* (shrubland with shrubs and small trees of 2-8 m high), the *Campo Cerrado* (grassland), and the riparian forest (Eiten, 1982). The climate is seasonal, with the rainy season being from October to March and the dry season from April to September. The mean annual precipitation is between 800 and 2,000 mm (Ratter et al., 1997) and temperatures are, on average, between 22 and 27°C throughout the entire year (Klink and Machado, 2005). Soils are acidic and nutrient-poor and have significant concentrations of aluminum. Therefore, soils dedicated to crop agriculture and livestock farming must be fertilized (Ratter et al., 1997) and special modified crops and grasses must be used (Rada, 2013).

Established in 1994 to offer farming education to the children of Porto Nacional farmers, the EFAPN was created thanks to an interaction between the non-governmental organization "*Comunidade de Saúde, Desenvolvimento e Educação*" ("Health, Development, and Education Community"), the local rural and non-rural workers and their representative associations, the State of Tocantins, and the municipal government (Pereira, 2003; Bezerra et al., 2017; Chaves, 2017). We selected the EFAPN as the target school of the study because it advocates sustainable family farming and offers a distinctive rural educational approach based on school-work alternation pedagogy (Bezerra et al., 2017). Alternating between school weeks ("*Tempo Escola*"), used for teaching theoretical knowledge and technical/farming practices, and community weeks ("*Tempo Comunidade*"), used for field-based apprenticeships in farming establishments (Pereira, 2003), the EFAPN aims to bring adequate education to rural areas and promote the professionalization of rural workers.

Deriving from a worldwide attempt in the 1980s and 1990s to reverse the phenomenon of young people emigrating from the countryside to cities, principally due to land-use intensification (de Brauw, 2019), such an educational approach strives to encourage well-trained young farmers to remain on their farms (Chaves, 2017). First starting as an elementary school and later incorporating middle school and high school as well, the EFAPN eventually opened a professionalizing farming school program in 2003. In the following years, it opened two separate school programs, i.e., the *Agropecuária* ("Agriculture and livestock farming") and the *Agroindustrial* ("Agriculture and industrial food processing") curricula.

Both the *Agropecuária and Agroindustrial* school programs are linked to practical work but differ in the type of farming activity of focus and stage of the production chain. The *Agropecuária* curriculum focuses on agricultural production and animal farming. It aims to build professionals with knowledge and expertise related to soil and cultivation management, pest and disease control, crop growing and animal breeding, animal feed provision, animal and plant health, technical consultancy, and field expansion. The *Agroindustrial* curriculum, instead, focuses on the processing and marketing of raw farming products. It aims to build professionals with knowledge and know-how related to chemical, microbiological, and sensory food analysis, and the selection, classification, and storage of raw materials for animal and plant products. Students who take the *Agroindustrial* program are also taught to identify and apply techniques to market and distribute processed farming products, as well as elaborate, apply, and monitor preventive hygiene health tests on the production and processing of farming goods. According to the Brazilian education level scheme, students completing the study programs at EFAPN have a "technical level" of graduation.

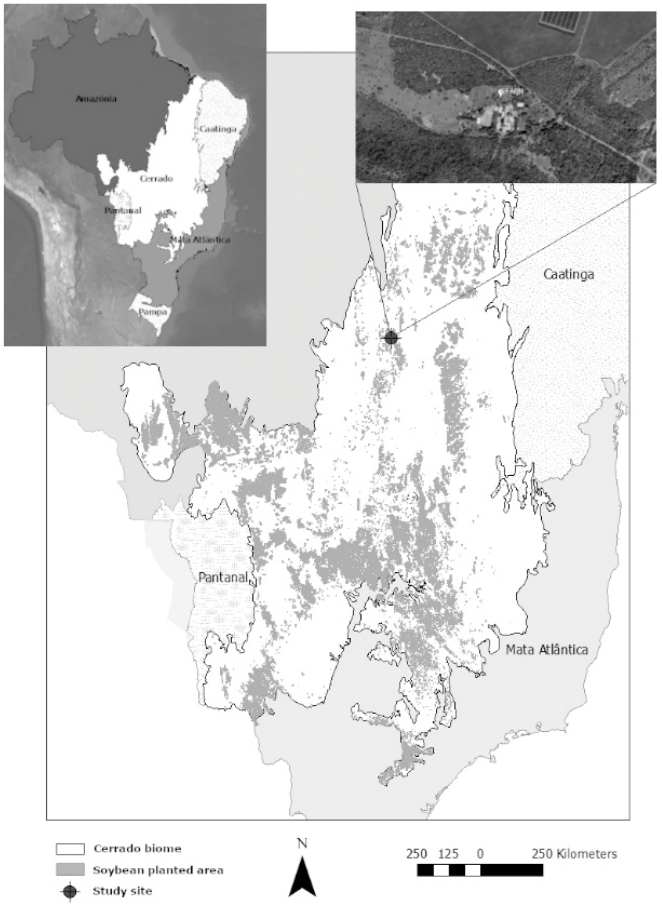

Figure 1 – The *Cerrado* biome. Dark grey areas show the soybean planted area as in 2019. The black dot shows the location of the EFAPN farming school, where the survey was conducted (Porto Nacional, State of Tocantins, northern region of the *Cerrado*).
Source: Miller et al. (2019).

Sample description

We surveyed 128 students of the EFAPN school which amounts to about 60% of the total number of enrolled students in 2019. Participating students belonged to farm families living in several municipalities of Tocantins, with a residence-to-school distance ranging from 10 to 260 km. According to an analysis by Chaves (2017), the 182 students enrolled at the EFAPN in 2016 came from more than twenty municipalities surrounding Porto Nacional. In July 2019, when we conducted the survey, the EFAPN had more than two hundred enrolled students and a total of 128 students took part in the survey. Of these, 89 (69.5%) were enrolled in the *Agropecuária* (i.e., agricultural and livestock farming) school program and 39 (30.5%) in the *Agroindustrial* (i.e., agriculture and industrial food processing) school program (Table 1). Male students were 80 (62.5%) and female students 48 (37.5%). The average student age was 16 years. Their enrollment period (i.e., total years at EFAPN) ranged from 8 weeks to 9 years, with an average of 2 years and 4 months. Females had on average a shorter enrollment period (2 years) than males (2 years and 6 months).

Data analysis

Six main analytical tools were used to analyze the questionnaire answers:

- Tool no. 1: the conceptual definition of "sustainable farming" by Robertson (2015);
- Tool no. 2: a simple impact matrix;
- Tool no. 3: the "Response-Inducing Sustainability Evaluation" (*"RISE"*) tool (Grenz, 2015);
- Tool no. 4: the three-sphere sustainability classification (Elkington, 1994);
- Tool no. 5: the Sentiment Analysis tool developed by Amazon Web Services ("AWS");
- Tool no. 6: Luo's (2007) coopetition analysis scheme.

Table 1 – Sample characterization (n = 128).

Category	Characteristic	%
Gender	male	62.5
	female	37.5
Age	=< 16	46.9
	>= 17, < 19	49.2
	> 19	3.1
	unknown	0.8
Total years at EFA	< 1	15.6
	>= 1, < 3	46.1
	>= 3, < 5	24.2
	>= 5	10.9
	unknown	3.1
School program	*Agropecuária*	69.5
	Agroindustrial	30.5

Tool no. 1

In line with the triple-bottom line concept and the widely accepted definition that sustainable farming systems must be economically viable, environmentally safe, and socially fair (Robertson, 2015), we rated the correctness of the students' definition of sustainable farming. It was marked as "correct" if it alluded to all three sustainability spheres, "partially correct" if it mentioned less than three spheres, and "incorrect" if it did not allude to any of the spheres. The analysis had to consider the open issues and challenges of clearly defining sustainable farming. In a broader sense, sustainable farming is depicted as the production of food and other agricultural products that protects the ability of future generations to do so, but narrowly defined, a single all-encompassing and absolute definition is doomed to fail (Velten et al., 2015). This is because sustainable farming includes a wide range of farming practices that combine different cropping systems, local environments, and social contexts, (Robertson, 2015) and can refer to agroecology, conservation agriculture, sustainable agricultural practices, sustainable land management, and climate smart agriculture. All of them, however, are intended to enhance human welfare while simultaneously ensuring the long-term potential of natural resources and their environmental services (IPCC, 2019). To reinforce our theory-informed research and analysis of the students' answers (Anibaldi et al., 2021), we also considered the two different approaches to measuring the sustainability of farming systems. The first considers the farming system as a closed area, and the second as intrinsically connected with the local or regional territory and its social communities (Lichtfouse et al., 2009).

Tool no. 2

A simple impact matrix was used to describe the impact of the students' home farms on the local community, and its environmental, social, and economic sustainability. We adopted a Likert scale from 1 (very negative impact) to 5 (very positive impact) and calculated the average rated level for each parameter.

Tool no. 3 & 4

We based part of our research on a study performed in the *Cerrado* by Miller et al. (2019) that analyzed the farming sustainability of soy farms, traditional family farms, and agroecological farms. Using the Response-Inducing Sustainability Evaluation (*"RISE"*), the study determined the degree of sustainability of each inspected farm. In other words, whether the farm individually fulfilled the triple-bottom line requirements (i.e., economic resilience, social well-being, and environmental integrity), both in the short and long-term (Bern University of Applied Sciences, 2022).

RISE is a hybrid method between a full and rapid sustainability assessment and is specifically tailored to farming enterprises (Bern University of Applied Sciences, 2022). In the present study, *RISE* was not used to perform a sustainability evaluation as it is originally meant for, but to classify information in a meaningful and schematic way.

Its 10 sustainability themes and 47 indicators were used to classify the farming-related teaching content of the two school programs, the type of farming practices adopted by students on their home farms, and the farming practices that they referred to when they had to describe a/an (un)sustainable farm in the *Cerrado*. Among the 10 *RISE* themes, six themes belong to the environmental sustainability sphere (e.g., "Soil use — SU", "Animal husbandry — AH", "Material use & Environmental protection — MU & EP", "Water use — WU", "Energy & Climate — E & C", "Biodiversity — B"), two to the social sphere (e.g., "Working conditions — WC" and "Quality of life — QOL"), and one to the economic sphere (e.g., "Economic viability — EV"). The 10th *RISE* theme "Farm management" referred to either the environmental, social, or economic sphere of sustainability depending on the context.

First, each student's answer was assigned to the *RISE* indicator that best comprised the content of the answer. Then, each indicator was attributed to the comprising *RISE* theme. Finally, each *RISE* theme was assigned to the correspondent sustainability sphere using the three-sphere sustainability classification scheme of Elkington (1994).

Tool no. 5

Sentiment analyses are powerful tools that are commonly used in questionnaires, feedback reviews, and other types of written assessments to determine the emotional behavior of online users. Among many other research fields, sentiment analyses are also applied in sustainability research (Serna et al., 2017; Song et al., 2018; Sánchez-Rada and Iglesias, 2019). The AWS Sentiment Analysis tool helped us understand the sentiment of the students about the two school programs and the three farming systems (agribusiness, family farming, and agroecological farming). The default algorithm behind the tool identifies "emotional" words and expressions contained in a written input query and classifies them into four categories, i.e., positive, negative, neutral, or mixed sentiment, with "neutral" indicating an impartial or indifferent feeling and "mixed" indicating the presence of both positive and negative feelings. For each category, the tool assigns a level of confidence that provides an estimate of the algorithm's accuracy in allocating the input data to that category. In our case, we uploaded every pertinent answer as a single input query. The output categories with a level of confidence ≥ 0.80 were considered statistically significant and labeled as dominant. For a level of confidence < 0.80, the input query (i.e., the student's answer) was discarded and labeled as "n.a.".

Tool no. 6

"Coopetition" indicates the combination between cooperation and competition. Luo's (2007) four-quadrants coopetition analysis scheme classifies the relationship between businesses in a very simple and practical way, which is by their level of cooperation and competition, either high or low. The four types of business relationships are:

- Contending (high competition, low cooperation);
- Adapting (high competition, high cooperation);
- Isolating (low competition, low cooperation);
- Partnering (low competition, high cooperation).

Luo's (2007) scheme was adopted here to analyze the opinion of the students on the business relationships between agribusiness, family farming, and agroecological farming.

When the student's answer was incomprehensive, disconnected from the asked question, or could not be classified with the above-listed analytical tools, it was labeled as "n.a." and excluded from further analysis. The titles of the tables and figures in the result section of this study explicit the number of accepted surveyed students ("n") or the number of answers ("no. of ans.") — when a student could provide more than one answer — and the number of discarded surveyed students or answers ("n.a."). Considering the variety of the sample ("n", "no. of ans.", and "n.a."), the outcomes of all tables and figures are expressed in percentages.

Results

School effectiveness in teaching sustainability

Nearly half of the students (48%) gave a partially correct definition of sustainability, but almost the same number of students gave an incorrect definition (42.5%). Only 9.4% could fully define a sustainable farm. The large majority of students (93.7%) affirmed to have taken school courses on "sustainable farming". The most quoted courses in that context were "Sustainable Development" and "Farming Production". Concerning the content of these "sustainability" courses, students referred to sustainability indicators mostly falling into three *RISE* themes, all of which belong to the environmental sustainability sphere, i.e., "Material use & Environmental protection" (30.1%), "Biodiversity" (24%), and "Soil use" (16.1%). Following the *RISE* classification scheme description (Bern University of Applied Sciences, 2022), "Material use & Environmental protection" refers to the sustainable use of consumables, machinery, infrastructure, feed and fertilizers, and the storage, use, and disposal of materials in a way that does not cause gas, liquid or soil emissions that can threaten the health of humans, animals, or the environment. The environmental sustainability sphere was alluded to 74.6% of the times, while the economic sphere reached 17.9% (Table 2). Concerning knowledge transfer, 85.7% of the students claim to apply the farming practices taught at EFAPN on their home farms.

Students' perceptions of sustainable farming

When describing a sustainable farm, the three most frequently mentioned *RISE* themes were "Material use & environmental protection" (33.8%), "Biodiversity" (26.9%), and "Economic viability" (17.4%). The environmental sustainability sphere was alluded to 68.3% of the times, while the economic sphere 25.5% (Table 3). Approximately 60.7% of the students declared to have seen or been to an unsustainable farm. The features of the unsustainable farm mainly referred to the *RISE* themes "Material use & environmental protection" (27.4%), "Biodiversity" (22.9%), and "Soil use" (11.7%). The environmental sustainability sphere was alluded to 60.2% of the times (Table 3).

Table 2 – Content of the sustainability courses classified according to the RISE tool (see Miller et al., 2019) and the three sustainability spheres scheme.

RISE themes (no. of ans. = 192; n.a. = 26)									
Soil Use	Animal Husbandry	Material Use & Environmental Protection	Water Use	Energy & Climate	Biodiversity	Working Conditions	Quality of Life	Economic Viability	Farm Management
15.1%	3.1%	30.2%	2.6%	5.7%	24.0%	2.6%	2.6%	10.9%	3.1%
Sustainability spheres (no. of ans. = 134; n.a. = 26)									
Environmental						**Social**		**Economic**	
74.6%						7.6%		17.9%	

Table 3 – Students' perception of the characteristics of a sustainable and unsustainable farm, and students' strategies to improve the sustainability of their home farms, according to the RISE tool and the three sustainability spheres scheme.

RISE themes	Soil Use (%)	Animal Husbandry (%)	Material Use & Environmental Protection (%)	Water Use (%)	Energy & Climate (%)	Biodiversity (%)	Working Conditions (%)	Quality of Life (%)	Economic Viability (%)	Farm Management (%)
Sustainable farm (no. of ans. = 204; n.a. = 17)	6.4	2	32.8	5.4	3.4	26.5	3.4	0.5	15.7	3.9
Unsustainable farm (no. of ans. = 228; n.a. = 42)	10.5	0.4	25.4	8.8	0	4.8	22.4	8.3	1.8	8.8
Strategies to improve farm sustainability (no. of ans. = 179; n.a. = 21)	9.5	3.4	33	2.8	6.1	28.5	7.8	2.8	6.1	11.7

Sustainability spheres	Environmental (%)	Social (%)	Economic (%)
Sustainable farm (no. of ans. = 145; n.a. = 17)	68.3	6.2	25.5
Unsustainable farm (no. of ans. = 128; n.a. = 42)	60.2	21.1	18.8
Strategies to improve farm sustainability (no. of ans. = 125; n.a. = 21)	77.6	12.8	9.6

On a 1 (very negative impact) to 5 (very positive impact) Likert scale, 28% of the students claimed that their home farms had a very positive impact (i.e., value = 5) on the local community. Approximately 28% declared that their farms had a positive impact (i.e., value = 4), and 31.4% that it had a neutral impact on the local community (i.e., value = 3). About 10.2% of the students claimed that it had a negative impact (i.e., value = 2) and only 2.5% a very negative impact (i.e., value = 1). The average rated value was 3.7.

Concerning the farm environmental sustainability, the outcomes revealed that 22.7% of the students believe that their farms have a very positive sustainability level, 39.5% a positive sustainability level, and 25.2% a neutral sustainability level. The average rated level was 3.7. As for the farm social sustainability, 18.7% of the students rated the sustainability level of their farms as very positive, 31.7% as positive, and 30.9% as neutral. The average rated level was 3.4. Concerning the farm economic sustainability, 19.2% of the students rated the sustainability level of their farms as very positive, 24.2% as positive, and 42.5% as neutral. The average rated level was 3.4 Finally, the average rated level of overall home farm sustainability was 3.5 (Figure 2).

Approximately 90.9% of the students would like to make their home farms more sustainable. The strategies and farming practices cited by the students to reach higher farm sustainability levels mainly alluded to the three following *RISE* themes "Material use & Environmental protection" (33%), "Biodiversity" (28.5%), and "Farm management" (11.7%). Accordingly, the environmental sustainability sphere was mentioned 77.6% of the times and the social sphere 12.8% of the times (Table 3).

Students' occupational preferences and perspectives

Approximately 90% of the total number of students (both school programs) confirmed that they want to continue with farming after their studies, whereas 10% claimed that they would like to change their area of work.

Concerning their preferred farming system as a future workplace, 41% of the students did not choose any specific type of farming system

and almost the same number (37%) specifically opted for agribusiness farming. Family farming was chosen by 12% of the students and agroecological farming by 10%. Nearly 60% (58.3%) of the students would like to work on a soy farm, 33.3% would not and 8.3% do not have any preference. These outcomes reflect the mainly positive (54.1%) or neutral (38.8%) sentiment of the students about agribusiness farming. Furthermore, most students have a positive sentiment about family farming (88.8%), as well as agroecological farming (78.4%) (Figure 3).

Students' opinions on the business relationship among farming systems

More than half of the students (54.1%) believe that agribusiness and family farming have a partnering relationship, with low competition and high cooperation levels (Figure 4). Although several students (37.7%) think that agribusiness and agroecological farming have a partnering relationship, many of them (29.5%) believe that they are isolated, with low competition and low cooperation levels. The majority of the students (68.4%) replied that family and agroecological farming have a partnering relationship.

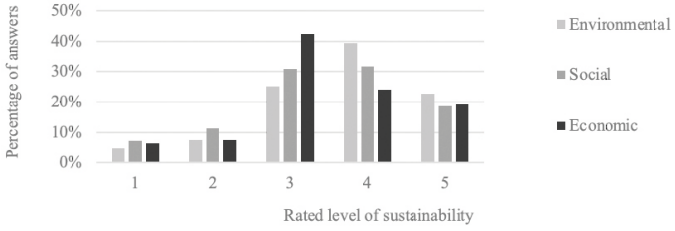

Figure 2 – Students' perception of the sustainability of their home farms given in percentage (%) ($n_{environmental}$ = 119; n.a.: 9 | n_{social} = 123; n.a. = 5 | $n_{economic}$ = 120; n.a. = 8).

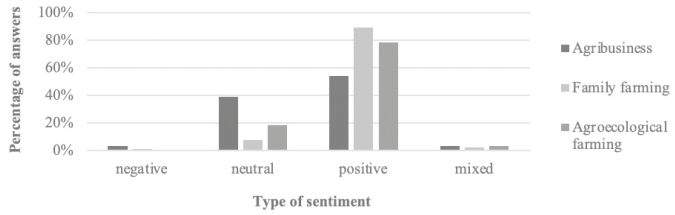

Figure 3 – Sentiment of the students about agribusiness, family farming, and agroecological farming ($n_{agribusiness}$ = 85; n.a. = 43 | n_{family} = 89; n.a. = 39 | $n_{agroecol.}$ = 88; n.a. = 40).

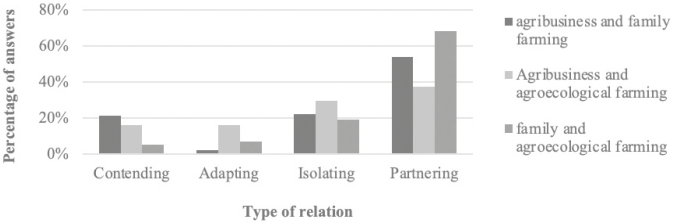

Figure 4 – Students' opinions on the relationships among farming systems ($n_{agribusiness\ \&\ family}$ = 85; n.a. = 43 | $n_{agribusiness\ \&\ agroecol.}$ = 61; n.a. = 67 | $n_{agribusiness\ \&\ agroecol.}$ = 57; n.a. = 71) based on Luo's (2007) business coopetition analysis scheme.

Discussion

Worldwide, half of all habitable land is used for farming (Ritchie and Roser, 2013). In Brazil, about one-third of the total land surface is covered by farming areas (Metzger et al., 2019), with farming still expanding at the cost of forests and natural areas (Food and Agriculture Organization of the United Nations, 2018), and thus of the local biodiversity and global climate. To tackle the global climate crisis, achieve and implement farming sustainability, and ensure biodiversity protection in the *Cerrado*, immediate actions must be taken. Following the triple-bottom line paradigm of sustainability, farming practices that not only are economically sound but also environmentally sustainable and socially just must be quickly developed and applied. Accordingly, educational centers where the farmers of tomorrow are tutored have a high responsibility to integrate effective education on environmental issues and sustainability concepts.

School effectiveness in teaching sustainability

According to EFAPN's statute, the school pursues local sustainable development by combining theoretical and practical classes and encouraging students to correlate their studies with their family dynamics, the communities where they reside, and the surrounding natural environment (Bezerra et al., 2017). Both EFAPN study programs offer courses linked to sustainability and its implementation within farming and land-use practices. With courses such as "Sustainable Farming" and "Sustainable Development", students learn how to protect the environment, preserve biodiversity, manage and preserve the soil, use materials (consumables, machinery, infrastructure, animal fodder, and fertilizers) efficiently, and avoid waste. Teaching sustainability in an explicit way and how to implement it has been revealed as an important basis in environmental education (Agbaje et al., 2001; Francis et al., 2011).

In contrast with other case studies in Brazilian schools, where sustainability teaching remains a declaration of good intentions (Gomes et al., 2022), sustainability is taught both in class and in the field at EFAPN. About 85% of the students confirmed that they apply the farming practices taught at EFAPN on their home farms, meaning that some conventional and sustainable knowledge is effectively transferred from school to real life. This also shows that the majority of the students perceive the importance of sustainability teaching as a means to solve and minimize environmental problems both at a global and farm level (Severo et al., 2019). Nonetheless, only 10% of the interviewed students were able to refer to all the three main spheres of sustainability (i.e., the environmental, social, and economic spheres). "It respects the natural environment, is fair from a social point of view, and is economically viable" stated one of the few students that could fully define sustainability according to the triple-bottom line. Evidently, students have understood how to practically apply sustainability on the farm level but have not been sufficiently taught about the background and holistic character of sustainability. This may be

strictly linked to the teaching skills and pedagogic approach of the teachers (Howlett et al., 2016) or their non-comprehensive understanding of the theoretical knowledge of sustainability (Agbaje et al., 2001).

Brazilian educators seem to hold a concept of sustainability that is mainly associated with the responsible use of environmental goods. This may be associated with the scarcity of teachers' training courses, the reduction of human resources and investments in education, and the devaluation of teaching (Silva, et al., 2019; Rodrigues da Silva and Antich, 2020; Vale and Silva, 2020).

Considering the EFAPN ineffectiveness in teaching the theoretical basis of sustainability, our research study reveals that study programs should put more effort into teaching the systems perspective of sustainability. This will enhance the students' consciousness of farming sustainability, help them correctly distinguish sustainable from unsustainable farming systems, and consolidate their reason for choosing, applying, and promoting sustainable farming practices on their properties. In this regard, school models that require both classroom time and worktime in farming establishments are advantaged (Parr and Trexler, 2011) because they can effectively transfer farming knowledge and know-how to home farms, and help turn students into "authors of local, sustainable development, striving to preserve the natural environment" (Bezerra et al., 2017, p. 70).

Students' perceptions of sustainable farming

Most students see their family farms as environmentally sustainable, half of them as socially sustainable — and with an overall positive impact on the local community — and less than half as economically sustainable. This is aligned with the Brazilians' historical perception that a "family farm is inherently sustainable and more respectful of nature than the agribusiness model" (Fuller et al., 2021, p. 9). However, according to Ebel (2020), most studies that support this argument do not provide evidence, and the very few that do, mainly refer to the important levels of agrobiodiversity on small farms, thus forgetting about the social and economic pillars of sustainability.

This general perception is also reflected in the teaching at EFAPN and thus in many students' answers, which show that the notion of sustainability is often reduced to the environmental sphere. Indeed, nearly all of the students would like to make their farms more sustainable, starting from environmental elements, such as the way materials are used on the farm, protection of the natural environment, and biodiversity preservation. One student claimed, "I would like to make my farm ecological, [by using] sustainable practices aimed at the well-being of nature." These measures, as well as the soil management practices, and economic viability are the key indicators that determine how students perceive and evaluate the sustainability of a farm, which is reflected by another student declaring that "I would like to turn my farm into a farm with plenty of production that doesn't harm nature." Especially, the preservation of biodiversity is seen as the essential element that a sustainable farm should take care of. Conversely, a farm that does not integrate measures to enhance biodiversity is perceived as unsustainable.

Sustainability courses have affected the students' perception of sustainable farming and their farms, showing that school programs integrating classroom and fieldwork solve the tension between abstract conceptualization and concrete experience, reflective observation, and experimentation (Parr and Trexler, 2011). Constructive and community-oriented teaching approaches, like the school-work alternation educational model of the EFAPN, foster students' sustainability knowledge (Segalas et al., 2010) and its application at home, and encourage students to yearn for a more socially fair development (Bezerra et al., 2017).

However, to increase the impact of sustainability teaching, teachers' pedagogic methods must combine collaborative activities, such as work groups and learning communities (Leal Filho et al., 2018). This can truly enhance awareness of the negative consequences of environmentally irresponsible behavior and thus help cease biodiversity loss and promote sustainable use of terrestrial ecosystems (Vicente-Molina et al., 2013; Abbasi et al., 2020; Eugenio-Gozalbo et al., 2021).

Approximately 60.7% of the students have already visited an unsustainable farm and defined it as such due to its "Material use & Environmental protection", "Biodiversity" and "Soil use" practices. Other equally notable features that students pointed out when defining an unsustainable farm are related to "Economic viability" and "Farm management". Some students considered to be unsustainable those farms that struggle to survive due to poor organization, lack of government subsidies and farming equipment, low profitability, or inadequate farming practices. This is reflected by a student stating, "The farm is unsustainable because of the lack of technological equipment and governmental subsidies" and "[because] they are not organized, they don't use much farming experience and don't have a good income." Other students, instead, considered to be unsustainable those farms that did not apply sustainability management practices and large-scale multinational agribusiness farms producing commodities such as soybeans that significantly altered the *Cerrado* landscape (Medina, 2022). "They are unsustainable because their vision includes income, heavy machinery, and pesticides only" and "They do not make efforts to help the natural environment; they only think about the income… they earn millions of reais and have more than one hundred workers", as two students denounced.

These two different perspectives on what farming students, and thus future farmers, consider "unsustainable" add further challenges to the work of the National Programme for Strengthening Family Farming ("*PRONAF*"). Indeed, the family farming policies and resources comprised in this program must be designed and allocated depending on which definition of "unsustainable farm" is chosen by the government (Sabourin et al., 2020). For over 20 years, the *PRON-*

AF has tended to provide incentives to family farms with already high-income levels, rather than those with the lowest income (Rufino de Aquino and Schneider, 2011). Hence, the economically more sustainable family farms are the ones benefiting most from governmental subsidies. This trend is equivalent to the incentives and the policy model adopted by the Ministry of Agrarian Development ("*MDA*") - the main political representation of agribusiness enterprises — where resources are allocated to the bigger and economically more profitable export-oriented companies (Sabourin et al., 2020).

The majority of the students (85.9%) would like to make their home farms more sustainable, focusing especially on topics associated with the environmental sphere of sustainability (72.6%). Specifically, the most alluded *RISE* themes were once again "Material use & Environmental protection", "Biodiversity", and "Farm management", corresponding to the themes mentioned in the description of (un) sustainable farming. The economic sustainability sphere was the second most mentioned sphere — referred to by 15.6% of the students. Increased productivity — counterbalanced by decreased environmental destruction — would make their home farms more economically sustainable, and support farm succession, which is proven to be linked to the farm size, a satisfactory rural income, and family incentives (Pessotto et al., 2019; Foguesatto et al., 2020).

To summarize, the way materials are used, whether the natural environment is protected, and whether biodiversity is preserved on a farm are the key indicators that determine how students perceive and assess (un)sustainability at the farm level. Present in other studies (Ebel, 2020), these indicators may not boost the effectiveness of sustainability teaching but may be used as an excellent baseline to start sustainability conversations with the students.

To some extent, poor farm management and low economic sustainability are also used to describe farm unsustainability if they threaten the survival of the farm. This additional finding completes our understanding of the sustainability perception of future *Cerrado* farmers of Tocantins and what their future and more sustainable farm will look like. That is, a farm that applies sound biodiversity practices, uses consumables, machinery, infrastructure, feed, and fertilizers sustainably; a farm that stores, uses, and disposes of materials without generating gas, liquid, or soil emissions that are hazardous to the health of humans, animals, or the environment; that embeds sustainability criteria in the farm management vision and provides good economic wealth. In this mental picture of a sustainable farm, future farmers clearly emphasize the environmental and economic spheres of sustainability but hardly mention the social sphere. Working conditions (e.g., fair work hours, compliance with safety at work standards, reasonable wages to employees, etc.) and quality of life elements (e.g., training experiences, health insurance, social relationships in the workplace, workers' personal freedom, etc.) are forgotten or not considered by the majority of farming students. Sustainability courses must therefore remind students that the social pillar of sustainability is also essential because a sustainable farm is, first of all, a place where people work and live. An economic enterprise that individually fulfills, both now and in the long-term, all three triple-bottom line requirements: environmental integrity, economic resilience, and, last but not least, social well-being (Bern University of Applied Sciences, 2022).

Students' occupational preferences and perspectives

Despite EFAPN being inclined toward family farming and the students' perception of a sustainable farm as an enterprise that uses materials in a non-polluting way, preserves biodiversity, and applies good management practices, a large number of students are attracted to agribusiness farming and economic sustainability.

Although raised and still working on family farms, 40% of the students would prefer to work within the agribusiness farming sector after completing their studies and 60% of them would accept to work on an industrial soy farm. This is particularly striking since many of them (40%) still do not have a clear idea of which specific farming system they would like to work with.

Even though it is true that agribusiness enterprises and soy farms are seen as potential workplaces and attract many students thanks to their economic appeal (Garrett and Rausch, 2016; Martinelli et al., 2017), family and agroecological farms are still more appreciated as a whole. This appreciation was confirmed by the sentiment analysis of the three different farming systems. About 90% of the students had a positive sentiment about family farming and 80% about agroecological farming. Instead, the percentage of students with a clear positive sentiment about agribusiness farming was significantly smaller. A little more than half of them clearly sympathized with it, and 40% of them had a neutral sentiment about it.

Considering the agribusiness farming and soybean cultivation expansion in the *Cerrado* and their increasing impact on the biome, the discrepancy between the students' occupational preferences and the sentiment analysis reinforces our finding that school courses do not seem to influence students' decisions about their future place of employment. When it comes to deciding about future employment, they often put aside their family and agroecological farming preferences in favor of agribusiness farming jobs that assure better prospects of wealth. Looking at this outcome from a different view, there is a certain distrust from students that family and agroecological farms can provide the same level of wealth that agribusiness farms guarantee.

The clear incongruence between students' work preferences and sentiments may be explained by the lack of attractive workplace alternative to agribusiness enterprises, factors affecting farm succession, e.g., low level of education of their parents, absence of a succession plan, off-farm employment, farm size, and family incentives (Foguesatto et al., 2020), or the poor understanding and implications of the systemic definition of sustainability. Fully grasping the theoretical and practical meaning of sustainability could raise more con-

cerns among students about the environmental impact of agribusiness and soy farms, and more resistance to choosing them as future workplaces when they offer an attractive prospect of wealth.

Students' opinions of the business relationships among farming systems

The business relationship between agribusiness and family farming is perceived as partnering, with low competition and high cooperation rates. Similarly, the relationship between agribusiness and agroecological farming is mostly seen as partnering. Fewer students see it as isolating, thus featuring low competition and low cooperation rates. Family farming and agroecological farming are seen as highly collaborative and lowly competitive farming systems. This is particularly striking because the collaboration between agribusiness and family farming, representing the two columns of the "dualistic" Brazilian agrarian structure (Pierri, 2013), has never been ideal. The expansion and intensification of monoculture crops promoted by agribusiness farming caused profound alterations to the socio-environmental wellbeing of many *Cerrado* regions and local communities dependent on traditional small-scale farming (Rekow, 2019). Also, the dialogue and collaboration among the two farming institutions representing agribusiness farming (i.e., the *MDA*) and family farming (i.e., the *PRONAF*), as well as their policy agendas, have always been conflictual or non-existent, thus reflecting the tension or indifference between the two farming systems (Zanella and Milhorance, 2016).

Conclusion

Considering the students' asymmetric understanding of sustainability, prevalently based on environmental elements and often lacking any reference to the social sphere, our study concludes that educational programs should put more effort into teaching the systems perspective of sustainability. This can occur by increasing the number of teachers' training courses on sustainability, promoting different pedagogic approaches, reversing human resources cuts, and increasing investments in education (Agbaje et al., 2001; Howlett et al., 2016; Silva et al., 2019; Rodrigues da Silva and Antich, 2020; Vale and Silva, 2020).

Nonetheless, farming school programs that adopt school-work alternation study models are effective in transferring sustainable farming practices. The educational approach of EFAPN reduces the gap between knowledge and know-how transfer and implementation (Parr and Trexler, 2011), and stimulates students to concretely apply sustainability on their home farms.

Students judge farms as sustainable or unsustainable using different evaluation criteria, mainly referring to environmental indicators, such as the use of materials by the farm, the application of environmental protection measures, and the presence of biodiversity conservation practices.

As far as the students' occupational preferences and perspectives are concerned, the main outcome of our study is the discrepancy between the prevalent occupational preference of students (i.e., at least half of the students would accept to work in an agribusiness enterprise or soy farm) and their predominant sentiment about the three different farming systems (i.e., significantly more students have a positive sentiment in favor of family farming and agroecological farming than agribusiness farming). This clear inner incongruence may derive from the better wealth prospects that agribusiness farming and off-farm opportunities provide (Foguesatto et al., 2020). Further research on reconciling strategies must be conducted and successful examples of family farming and agroecological farms in the country must be brought to the eyes of students. If farming schools better emphasized the link between unsustainable agribusiness farming features (e.g., deforestation, high-input cultivation, farm intensification, and large-scale change of land cover) and the environmental problems they cause (e.g., change of supra-regional rainfall patterns, extended drought periods, threatening of water security, increased public health problems associated with carcinogen-contaminated water and food sources) (Fearnside, 2001; Rausch et al., 2019; Rekow, 2019), the number of students choosing soy farms as a future workplace may decrease. The impartial but clear teaching of the social and environmental trade-offs of agribusiness farming will prevent skillful family and agroecological farmers of tomorrow from joining agribusiness farms and help their successful turnover.

In regard to the students' opinions on agribusiness, family farming, and agroecological farming, our study discovered that students perceive the business relationship between agribusiness and family farming, agribusiness and agroecological farming, and family farming and agroecological farming, as partnering, with low competition and high cooperation rates. If the perceived partnering relationship between family farming and agroecological farming is easily understood, the perceived partnering relationship between family farming and agribusiness farming is surprising and collides with the ongoing tension and indifference between the two farming systems and their governmental representative institutions (Rekow, 2019). An in-depth analysis of the students' rationale used to assess the degree of competition and cooperation between farming systems should be carried out. This will help us define how future farmers of the *Cerrado* will look at and shape farming business relationships, and therefore the business dynamics within the future Brazilian business landscape and agrarian structure.

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Annex 1 – Questionnaire delivered to 128 farming students of the EFAPN, divided into five sections.

Section	Question
1. Personal information	Gender, age, study years at EFAPN, school program (*Agropecuaria* or *Agroindustrial*)
2. School effectiveness at teaching sustainability	– Define "sustainable farming." – Have you attended courses on sustainability? What theory concepts and farming practices did you learn from them?
3. Students' perceptions on sustainable farming	– What does a sustainable farm look like for you? – What does your farm look like? – From 1 (very negative) to 5 (very positive), how would you rate the impact of your farm on the local community? – From 1 to 5, how would you rate the environmental sustainability level of your farm? – From 1 to 5, how would you rate the social sustainability level of your farm? – From 1 to 5, how would you rate the economic sustainability level of your farm? – Have you ever seen/been to an unsustainable farm? What does it look like? Why do you consider it unsustainable? – Would you like to make your farm more sustainable? Which farming practices would you apply to do so?
4. Students' occupational preferences and perspectives	– What do you think of family farming? – What do you think of agroecology and agroforestry farming? – What do you think of agrobusiness farming? – What would you like to do in your future? Would you like to work in the farming sector? – For which type of farming system would you like to work? – Would you like to work in a soybean enterprise in the future? Why / why not?
5. Students' opinions on the business relations between farming systems	– How is the relation between agrobusiness and family farming? – How is the relation between agrobusiness and agroecological farming? – How is the relation between family and agroecological farming?