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Papers

Technology and degradation of pastures in livestock in the brazilian Cerrado

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Abstract
In Brasil ranching has played a fundamental role in the occupation of rural land. This process results in a series of environmental impacts, such as the erosion and compaction of the soil, and the emission of greenhouse gases, in addition to the intensive use of the soil and water resources. In part of the properties, inadequate management resulted in pastures with degradation levels. The literature points out the importance of intensifying technology as a way to guarantee sustainable pastures. The present study aims to identify and analyze the relationships between the technological level level of cattle production and the degradation of pastures in the Vermelho River basin in Goiás, central Brazil. This area is considered to be representative of livestock in the Brazilian Cerrado. The sample consisted of 60 cattle ranches, selected from each of the three sectors of the Vermelho River basin. The data were analyzed using a Multiple Correspondence Analysis, cluster analysis, and Beta regression to obtain Pasture Degradation Indice (PDI). Bivariate associations were found between the Technological Index (TI) and three variables - the manager's income, topographic relief, and the size of the property. It was possible to verify the use of a higher technological level in the largest properties as well as in flatter areas. It was also found that the higher technological level provides higher remuneration to managers. However, there was no relationship between the technology used in the establishments and the cattle density, which can reduces profitability economic and animal welfare. There was also no association between TI and PDI, suggesting pasture degradation, even when using more intensive technologies in cattle production.

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INTRODUCTION

In developing countries, ranching has played a fundamental role in the occupation of rural land, supporting the systematic advance of agricultural frontiers. Typically, ranching is the first economic use of the land following deforestation, with the natural vegetation being converted into pasture, which is eventually replaced by plantations of crops and urban development (GIBBS et al., 2010; GOENER et al., 2007; GRIFFITH, 2016; PINHEIRO et al., 2016).

This process results in a series of environmental impacts, such as the erosion and compaction of the soil, and the emission of greenhouse gases, in addition to the intensive use of the soil and water resources. The inadequate management of pastures and the lack of adequate conservation measures, have resulted in considerable degradation (ARMENTERAS et al., 2013; DIAS et al., 2016).

In Brazil, cattle ranching is typically used to generate financial income, although it may also be used as a means of occupying land for property speculation or leisure activities (MARGULIS, 2003). The considerable variation in climate, topography, and soils, together with the developmental phase of the stock (raising, restocking, fattening) and local socio-economic conditions, require distinct technological solutions for the intensification of beef production across the country (DIAS et al., 2016; MCMANUS et al., 2016). The different technological solutions for the intensification of beef production include genetic improvement, investment in nutrition and animal health, and other management strategies.

The need to intensify beef production in Brazil is being reinforced by the ongoing exhaustion of the agricultural frontier, greater environmental controls, and the increasing demand for farmland and animal protein (ARMENTERAS, 2013; OECD-FAO, 2015). Given this, the intensification of this activity should result in the more rational exploitation of natural resources , including the preservation of natural habitats, such as forests, and a reduction in the emission of greenhouse gases, through the reduction of the productive cycle, as well as accelerating the flow of income (CARO et al., 2017).

Management decisions on the intensification of beef production may be influenced by the socio-economic profile of the ranch administrator, the production profile of the ranch and the development phase of the cattle, as well as the price of beef, the coordination of the different components of the productive chain, and the availability of the production factors (BOWMAN et al., 2012). The ranch manager needs to comprehend the complex interrelationships among topography, soils, climate, pasture, animals, and the market, which requires a multidisciplinary and systemic administrative approach.

The present study aimed to identify and analyze the relationships between the technological level and the degradation of pastures that influenced decision-making by the managers of the beef production systems within the Vermelho River basin in Goiás, central Brazil. Six questions were analyzed, based on the theoretical and empirical approaches adopted in this study: 1) Does the education level and income of the local ranch managers determine the technological level adopted by the productive unit, and does the technological level depend on the availability of rural credit? 2) Is the topographic relief perceived by the ranch manager correlated with the technological level adopted for the beef production system? 3) Do the properties with the most technologically-advanced beef production system have lower levels of pasture degradation? 4) Is the size of a property correlated with the level of technology adopted by its manager? 5) Is the level of pasture degradation correlated with the size of the property? 6) Is the density of cattle higher on more technologically-advanced ranches?

The Vermelho River basin in western Goiás, a state in central Brazil, covers an area of approximately 11,000 km² of the Brazilian Cerrado savanna biome. Land use within the Vermelho River basin is dominated by cattle pasture, used primarily for the production of beef, with some areas planted with crops, most based on central-pivot irrigation systems.

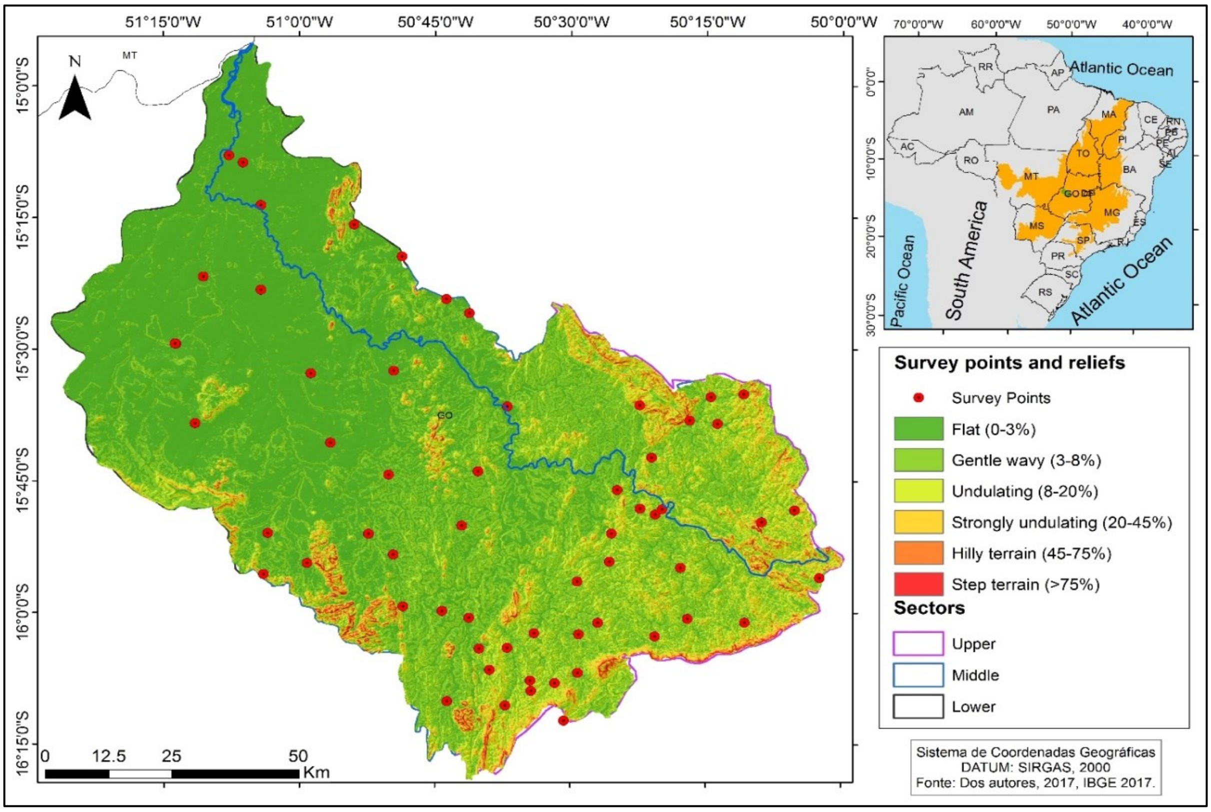
The predominant local cattle breed is the Nelore, which is well-adapted to tropical conditions, and is raised on *Brachiaria* pasture, which is also well-adapted to tropical climates and soils of low to medium fertility (KLINK; MACHADO, 2005; ROSA, et al., 2001).

MATERIAL AND METHODS

Data were collected using a standardized questionnaire, designed to provide the information necessary to test the hypotheses raised in the study. The questions were designed to provide data on three basic parameters: 1) The socioeconomic profile of the ranch manager; 2) The characteristics of the production system, and 3) The characteristics of the pasture management and other environmental conditions.

The Vermelho River basin was divided into three sectors, based on their slope and topographic profile. Slope varies considerably within the basin, declining from south to north, from relatively steep hillsides in the southern (upper) sector, with flatter, rolling plains to the north (Figure 1).

Figure 1 – Map of the three sectors of the Vermelho River basin, showing the reliefs and the points surveyed in the present study. Goiás, Brazil, 2016.



Source: IBGE (2017). Org. by authors, 2017.

The basin was divided into three sectors: (i) the upper basin, with altitudes of over 500 m a.s.l., and steeper slopes (20–45%), more diversified soils, and a highly vulnerable environment; (ii) the middle basin, with altitudes of 300–500 m a.s.l. and slope of 8–20%, and (iii) the lower basin, with altitudes of below 350 m a.s.l., and slope of less than 8% (MACHADO; LIMA, 2011).

The survey points were then distributed considering the greatest variability in slope and soils, with the aim of best representing the biophysical characteristics of the beef production systems, with 25 points in the upper basin, 24 in the middle basin, and 11 in the lower basin.

Data processing and analysis

The technological and pasture degradation indices were compiled for the evaluation of the association between these parameters and the other variables, as described here. The procedure followed for the calculation of the Technological Index (TI) is described in detail by Oliveira et al. (2018).

To compile the Index of Degradation of the Pastures, five indicator variables of the reduction of productivity and pasture degradation were selected (Table 1). These variables were based on previous studies, and included a total of 12 categories (LIMA et al., 2012; PERON; EVANGELISTA, 2004).

Table 1 – Variables used to generate the environmental degradation index.

Variable	Class
Exposed soil (Es)	(no = 0; yes = 1)
Erosive processes (Ep)	(no = 0; yes = 1)
Presence of termite mounds (Tm)	(no = 0; yes = 1)
Height of grass (Hg)	(< 12 cm = 0; > 12 cm = 1)
Presence of invasive plants (Ip)	Ip: 0 = no invasive plants; Ip: 1 = up to 15% invasive plant cover; Ip: 2 = over 15% invasive plant cover.

Org.: by the authors, 2017.

A Multiple Correspondence Analysis (MCA) was used to determine these indices, through the identification of the components that contributed most to the explanation of the variability in the data, generating a numerical index that represents the degradation of the pasture of each ranch (GUEDES et al., 2008; HAIR JR. et al., 2009; PAGÈS, 2014). This analysis was run in the R software, using the adjusted Burt matrix, as well as the complementary statistical treatments (GREENACRE, 2007).

Ward's hierarchical cluster analysis was then applied to the data to generate the clusters of the variables and the ranches (HAIR JR. et al., 2009; WARD JR., 1963). A Beta regression was also applied to replicate the index of degradation for application to the region's other ranches (OLIVEIRA et al., 2018).

The Moran Index was also applied to verify the spatial dependence of the data, that is, the possible existence of spatial autocorrelation in the PDI within the study area (LIMA et al., 2014; SHIRVANI et al, 2017; OLIVEIRA et al., 2018).

Possible correlations between the variables were verified by applying the nonparametric Spearman correlation coefficient (ρ_s) and Kendall's rank correlation coefficients, tau_b (τ_b) and tau_c (τ_c). These procedures were used to test the null hypothesis, i.e., with ρ_s or τ_b or τ_c = 0, or confirm the bilateral alternative (H_1) hypothesis, with ρ_s or τ_b or $\tau_c \neq 0$, together with Fisher's exact test.

RESULTS AND DISCUSSION

The TI was obtained from a Multiple Correspondence Analysis (MCA), cluster analysis, and Beta regression. Details on the approach are given in Oliveira et al. (2018).

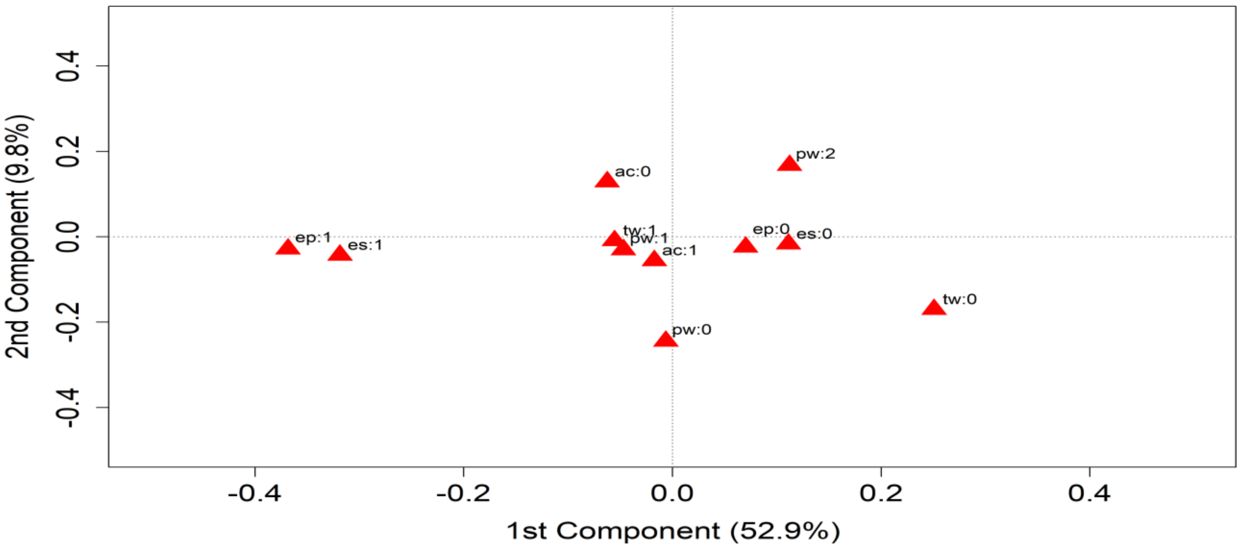
The combined MCA and cluster analysis of the set of indicators of the technological level of the ranches revealed two distinct strategies: (a) investment in the establishment and maintenance of pasture, including the application of fertilizers and lime, soil analyses, the bromatological analysis of the grass, and the use of powerful tractors (over 100 horsepower), and (b) investment in dietary supplementation, principally during the dry season, to compensate for the reduction in the volume and quality of the pasture, use of technical assistance and tractors of up to 100 horsepower. This strategy is dominated by variables related to supplementation, complemented by grazing, with cattle densities of up to two animals per hectare. High cattle densities (above two animals per hectare) are associated with the other variables related to a low technological level.

Each ranch was assigned to one of three categories of technological development: low, medium or high. Ranches with medium to high levels of technology predominated in the lower and middle basin, where properties were also of a larger size, in general (IBGE, 2006), reflecting the more favorable conditions (soils and topographic relief) for beef production found in these areas (OLIVEIRA et al., 2018).

Pasture Degradation Index (PDI)

Based on the analysis of the variables of degradation of the pasture (Table 1), the Multiple Correspondence Analysis (MCA) was used to determine two axes (components) that explained 62.7% of the total inertia in the variables analyzed. The first component (axis 1) explained 52.9% of the total inertia, while the second component explained 9.8% (Figure 2). The percentage contributions of the different variables indicated that exposed soil (es:1) and erosive processes (ep:1) contributed 32.54% and 30.45%, respectively.

Figure 2 – Plot of the Multiple Correspondence Analysis of the adjusted Burt matrix for the pasture degradation variables of the beef production systems of theVermelho River basin, Goiás, Brazil, analyzed in the present study.



Org.: by authors, 2017.

The first component reflected the possible loss of soil, and was thus identified as the dimension that represented soil degradation. The second component reflected the degradation of the biological conditions of the pasture, and was formed primarily by the maximum presence of weeds (pi:2), which contributed 27.73%, the absence of weeds (pi:0), with 27.75%, and grass less than 12 cm in height (ac:0), with a contribution of 25.35% to the total inertia of this axis.

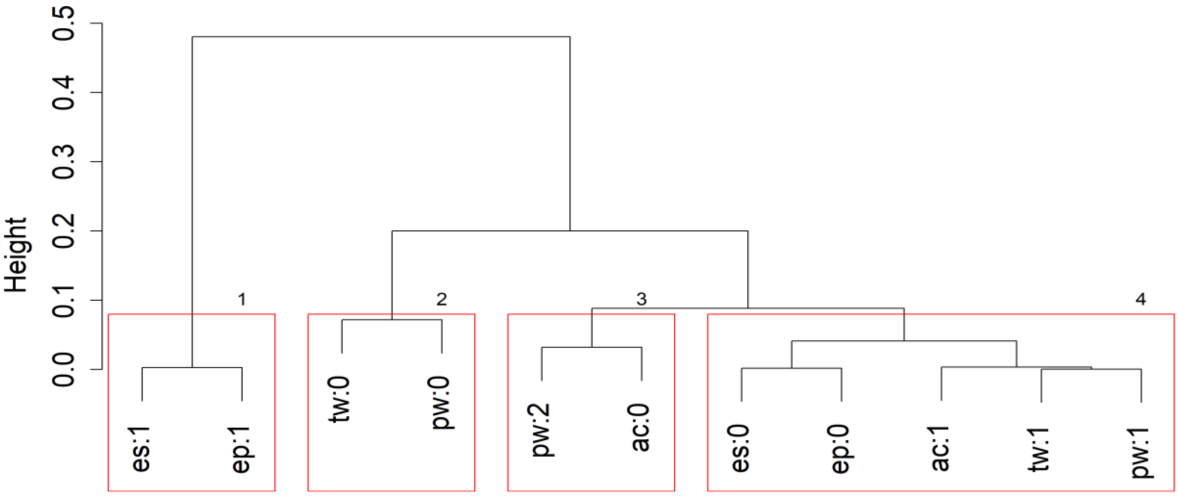
As the cluster analysis indicated that the inclusion of only a single dimension for the modelling of the Pasture Degradation Index (PDI) would result in a significant loss of information, the first two axes were included here, that is, a soil degradation index (SDI) (component 1) and a biological degradation index (BDI) (component 2), to provide an integrated PDI.

This analysis defined four groups of variables. The first group included the variables that indicate the degradation of the soil, based on the presence of erosive processes and exposed, that is, the worst level of degradation (Figure 3). The second group is composed by the variables that indicate a better management of the pasture, given the absence of termite mounds and invasive plants, which indicate a reduced level of biological degradation.

The third group represents the set of variables that reflect the most inadequate conditions for pasture management, due to the presence of weeds (> 15% of the pasture) and short grass (< 12 cm), which together reflect the worst level of biological degradation recorded in the region. The fourth group encompasses the variables that indicate moderate conditions of pasture management, included the presence of termite mounds, moderate weed cover (< 15%), tall grass (> 12 cm), and the absence of erosive processes or exposed soil. This group, which included the largest number of variables, was classified as median, in terms of the level of biological degradation.

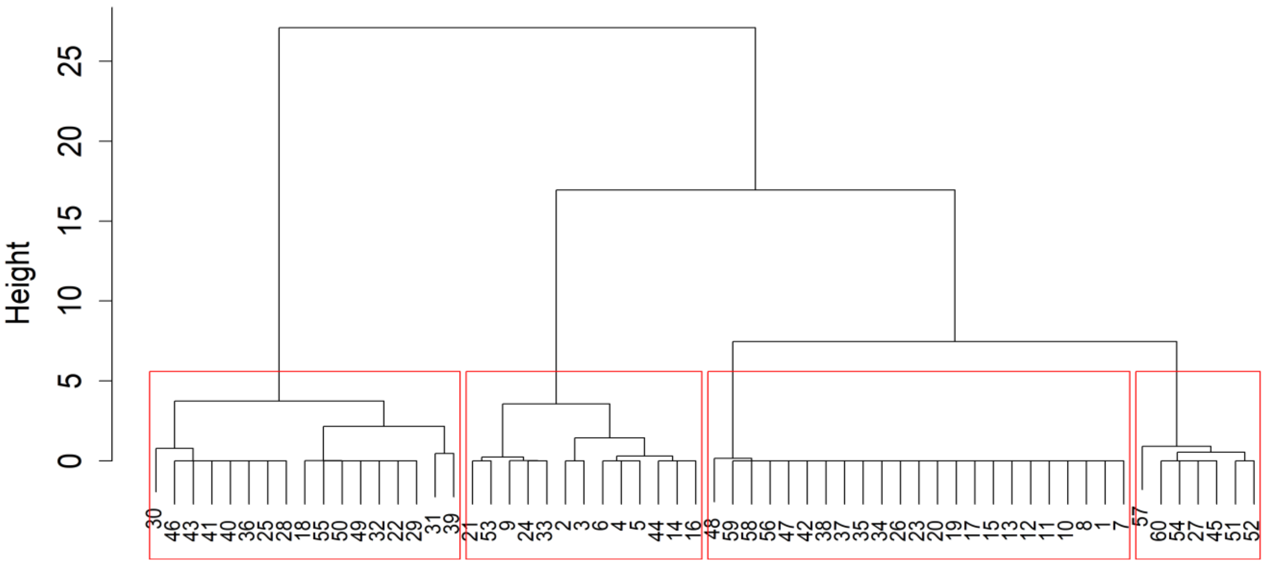
The cluster analysis of the pasture degradation levels in the sample units (ranches) also resulted in four principal groups (Figure 4).

Figure 3 – Dendrogram produced by the cluster analysis of the indicator variables of pasture degradation, based on components 1 and 2 of the MCA, for the beef production systems of the Vermelho River basin, Goiás, Brazil, 2016. Source: org. by authors, 2017.



Org.: by authors, 2017.

Figure 4 – Dendrogram produced by the cluster analysis of the ranches (numbers), in relation to their level of pasture degradation, based on components 1 and 2 of the MCA applied to the beef production systems of the Vermelho River basin, Goiás, Brazil, 2016.



Org.: by authors, 2017.

In the first group, 94.12% of the 17 ranches had exposed soil, 58.82% presented erosive processes, 100% had termite mounds, 88.24% had low weed cover (< 15%), and 94.12% had grass of over 12 cm in height. This is the group of ranches with the most critical pasture conditions, based on the level of soil degradation.

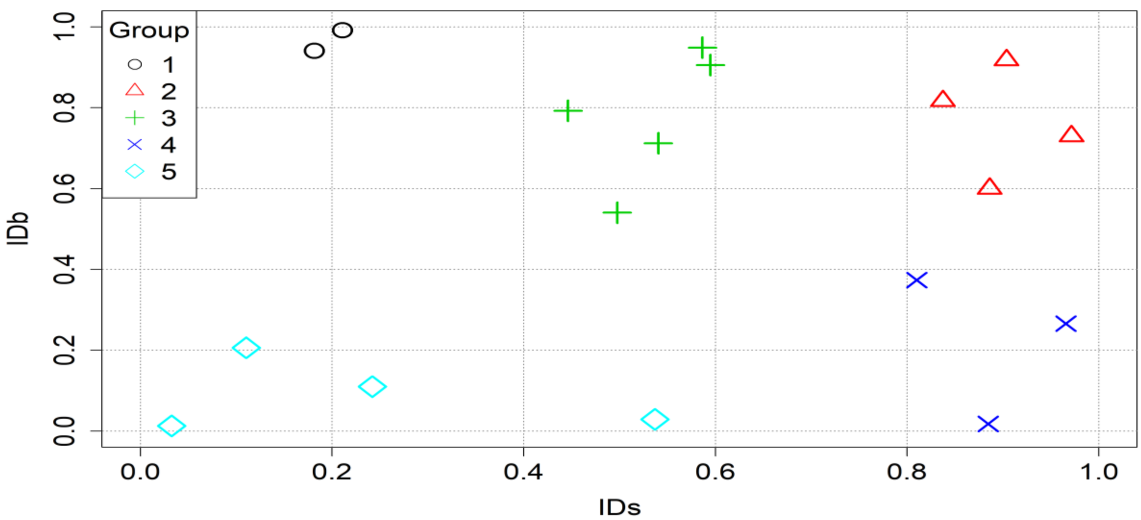
The second group is composed of 13 ranches, of which, 76.92% are characterized by the absence of exposed soil, and 84.62%, by a lack of erosive processes, in other words, with the low levels of soil degradation. However, the conditions for the maintenance and management of both the pastures and animals are favoring biological degradation, reflected in the presence of termite mounds on all the properties, and extensive weed cover (> 15%) in the pasture of more than half (53.85%) of the ranches. In addition, the grass was less than 12 cm in height on 61.54% of these ranches, which indicates overgrazing, a process that can impede the recuperation of the plant, and leave the soil more susceptible to erosive processes caused by rainfall. This analysis points to a reduced capacity of support of the pasture, leading to a decline in productivity, with less economic and environmental efficiency, which undermines the sustainability of the production system in the medium to long term, through the loss of soil.

The third group consists of 23 ranches with median management conditions (for both plants and animals), albeit slightly lower than the second group. This group is defined by the absence (100%) of exposed soil, and almost no (4.35%) erosive processes, although all (100%) the ranches have termite mounds and some weed cover (< 15%). However, the grass is more than 12 cm tall, reflecting a greater amount of leaf mass, and a better cattle support capacity and soil protection. The fourth group of ranches, which is the smallest of all, with only seven (11.67%) properties, has the lowest indices of biological and soil degradation. No exposed soil or erosive processes were recorded on any of the properties, indicating a lack of soil degradation.

The reduced incidence of termite mounds (28.57% of the properties) and weeds (57.14% of the properties with < 15% weeds), and the universal presence (100%) of tall grass (> 12 cm) indicate that these ranches were the best managed (both plants and animals) of the study region.

The Beta regression model was applied to obtain an expression for the calculation of indices of the degradation of soils and biological parameters. The estimate of the soil degradation index was composed of the variables that presented statistically significant ($p \leq 0.05$) parameters with almost all the variance being explained by the model ($R^2_{adjusted}$ = 97.43%). Similarly, the Beta regression model also explained almost all the variance ($R^2_{adjusted}$ = 96.06%) in the index of biological degradation, which was highly significant ($p < 0.01$). The two components estimated by the Beta regression models were combined to provide a single index of pasture degradation, through which the cluster analysis identified five distinct groups of ranches (Figura 5).

Figure 5 – Dispersal of the combined indices of degradation of the soil (Inds) and biological parameters (Indb), estimated by the Beta regression, Vermelho River basin, Goiás, Brazil, 2016.



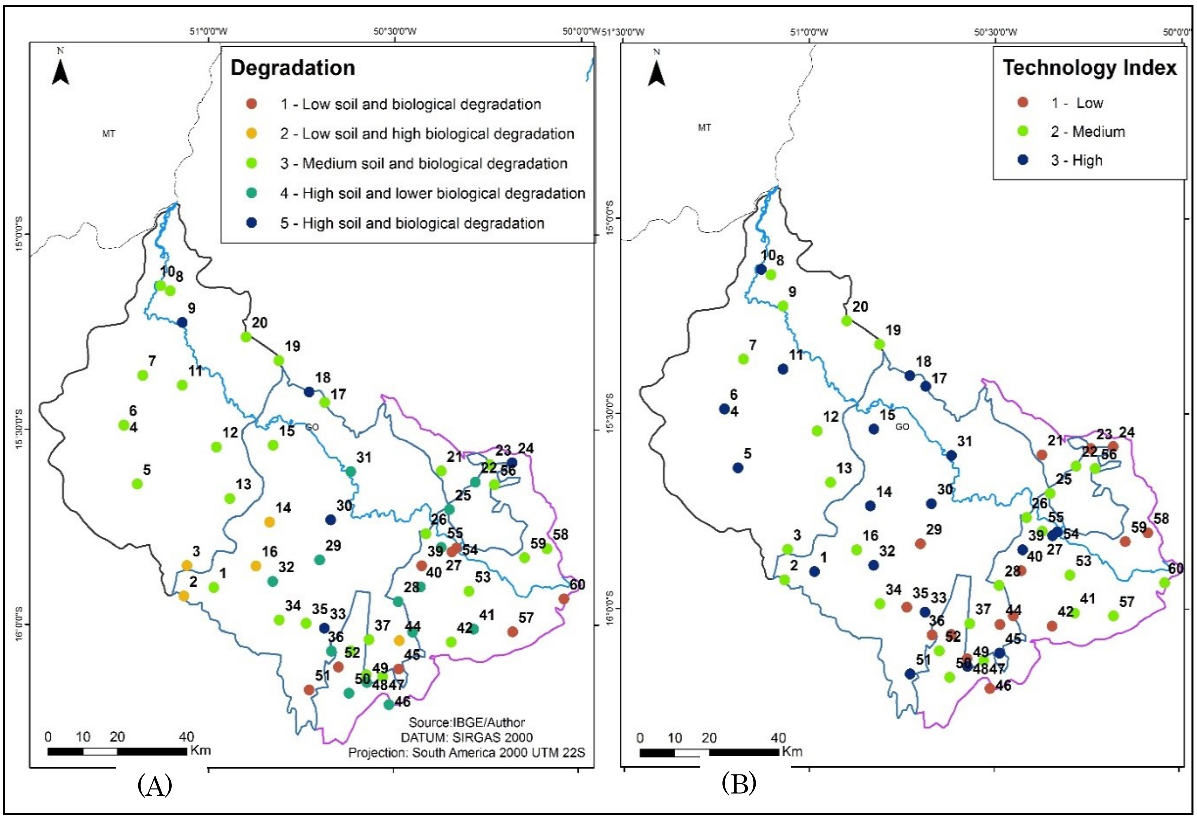
Org.: by authors, 2017.

The spatial distribution of the ranches according to their SDI includes 19 units with a high degree of degradation, indicating the loss of soil through the exposure of the substrate and sheet erosion of the pastures. The properties with the highest SDI are located predominantly (94.7%) in the upper and middle basins, where the terrain slopes more steeply. The opposite pattern was observed in the case of the biological index. In this case, the nine properties with the highest indices are concentrated (77.8%) in the lower and middle basins, while the lowest indices were recorded in the upper basin. These two indices highlight the need for distinct strategies of conservation to reduce the degradation of the soil in the different sectors of the basin.

The indices of pasture degradation (Figure

6A) and technology (Figure 6B) were related spatially. The analysis of the five categories resulting from the combined diagnosis of the conditions of pasture degradation, represented by the soil and biological degradation (Figure 6A) indices indicates that eight properties have the lowest indices of pasture degradation (Category 1), of which, seven are located in the upper basin. The 28 properties with a median level of pasture degradation (category 3) are distributed in all the sectors, while three of the five ranches with the lowest indices (Category 5) are located in the middle basin. Most (83.3%) of the 12 properties surveyed in the lower basin returned median indices of pasture degradation.

Figure 6 – Spatial distribution of the ranches surveyed in the present study according to their (A) soil and biological degradation indices; (B) Technological index – Vermelho River basin, Goiás, Brazil, 2016



Source: IBGE (2017). Oliveira et al. (2018). Org. by authors, 2017.

Overall, 46.7% of the ranches presented a medium (category 3) index of pasture degradation, while 23.3% had a high level of soil degradation combined with a low level of biological degradation (category 4). Almost a third (31.7%) of the properties presented a high technological level, with just over half (52.6%) of the cases being recorded in the middle basin (Figure 6B). None of the ranches in the lower basin returned a low TI, while the upper basin presented the greatest variation in pasture degradation and technology, with a greater contribution of properties with a low TI. It is important to note that this sector of the Vermelho River basin is where most of the government agrarian reform settlements are located.

The global Moran's index for pasture degradation was -0.01338 (p = 0.9507, α = 0.05), indicating a significant lack of spatial autocorrelation, i.e., that the level of degradation, like the technological level (OLIVEIRA et al., 2018), is not related to the spatial proximity of the properties.

Hypothesis testing

The technology and pasture degradation indices were used to test the operational hypotheses raised in this study. The results of the analyses are shown in Table 2.

Table 2. Results of the statistical procedures used to test the operational hypotheses raised in the present study in the Vermelho River basin, Goiás, Brazil, 2016. (na = not applicable).

Hypothesis tested	Fisher's exact test	Spearman (ρ_s) (d.f.:58)		Kendall (τ_b) (d.f.:58)		Kendall (τ_c) (d.f.:58)	
	p	ρ_s	*p*	*τ-b*	*p*	*τ-c*	*P*
H_0: TI and education level of the manager not associated.	0.8319	0.1791	0.1705	na	na	0.1575	0.1742
H_0: TI and income level of the manager not associated.	0.2889	0.2525	0.0519 (*)	na	na	0.2067	0.0314 (**)
H_0: TI and rural credit not associated.	0.3568	-0.1529	0.2428	na	na	-0.1533	0.2472
H_0: TI and topographic relief perceived by the ranch manager not associated.	-0.2976	-0.2195	0.0921 (*)	-0.2021	0.0860 (*)	na	Na
H_0: Pasture degradation and technological indices not correlated.	0.4000	-0.1390	0.2887	na	na	-0.1250	0.2969
H_0: TI and size of the property not associated.	0.0019 (***)	0.4491	0.0003 (***)	0.3966	0.0000 (***)	na	Na
H_0: PDI and size of the property not associated.	0.5469	-0.1026	0.4342	na	na	-0.0900	0.4266
H_0: Cattle density and TI not associated.	na	0.0875	0.5052	na	na	na	Na

(***) $p < 0.01$; (**) $p < 0.05$; and (*) $p < 0.10$.
The alternative bilateral hypothesis (H1: (ρs or τb or τc) ≠ 0) is that the two variables are not independent.
Org.: by authors, 2017.

The results of these analyses indicated that there was no systematic relationship between the TI of the ranch and the education level of the manager, which confirms that the level of technology applied to the region's ranches depends on other factors, that determine the acquisition of knowledge on production management techniques, including technical assistance. In support of this conclusion, whereas 78.9% of the properties with a high technological index use technical assistance, only 26.7% of those with a medium index do, falling to 13.3% in the case of the properties with a low index. The majority of the managers, irrespective of the TI of the property, had only an elementary school education. Even when the manager had a higher level of education, the property may have had a low TI, when it was used for leisure activities.

However, a degree of association was found between the income of the manager and the TI (ρ_s (58) = 0.2525, $p < 0.10$; τ_c (58) = 0.2067, $p < 0.10$), indicating that the manager's income influenced the technological level of the ranch, as expected. The modelling of this relationship by the Beta regression indicated that an income of 5–10 minimum wages (income 3) or above 10 salaries (income 4) provide a significant (p <

0.10) predictor of the technological level of the property.

Overall, 10 (52.6%) of the 19 ranches with the highest technological indices are administered directly by the owner of the property. These ranches have a mean area of 469.48 hectares, and only some employ a manager. Half of these ranch owners reside in urban areas and visit their properties regularly, and 60% live exclusively on the income derived from ranching.

Most (73.7%) of the ranches with higher TI are linked to the rural producers' union, and 60% of the owners depend exclusively on the income derived from ranching. Only 40% of the managers are registered in the federal social security system, which means that the majority are not covered for state pensions or other benefits. However, 13.3% of the 60 interviewees receive state pensions, and supplement their incomes with ranch work.

The properties surveyed in the Vermelho River basin were acquired through either inheritance (53.3%), purchase (40.0%) or settlement programs (6.7%). In contrast with the other groups, the group of ranches with the highest TI were mostly (52.6%) acquired through the purchase of the property, and almost half (47.4%) were administered by employees, with a business-based production profile.

No significant association was found between the TI and the use of rural credit, which is obtained through government programs, and amplifies the capacity for financial turnover and investment, which can help improve the technological level of the beef production systems. While the use of rural credit was negligible overall, it was even lower in the group with the highest TI (8.3%) than in the other groups (11.7%). This indicates that the ranches with the highest TI invest their own financial resources in the running of the beef production unit.

A significantly negative association was found between the technological level and the topographic relief perceived by the ranch managers (ρ_s (58) = -0.2195, $p < 0.10$; τ_b (58) = -0.2021, $p < 0.10$), which is consistent with the universal observation that flatter terrain is more appropriate for the application of technology, producing better results in terms of productivity, due both to the more favorable characteristics of the soil, such as the slope and the vulnerability to erosion, and the potential for mechanization (GOENER et al., 2007; GRIFFITH, 2016). This trend is reflected in a higher technological level, in general, on the properties located in the lower and middle basin, in comparison with the upper basin, where TI tended to be lower.

The relationship between the TI and relief, analyzed by the Beta regression, revealed that only the variable relief3 (highly undulating relief) had a significant ($p < 0.05$) association, primarily with the upper basin sector. The contribution of the highly undulating relief to the model is negative and decreasing, indicating that, the greater the undulation of the relief, the lower the estimated TI.

No systematic association whatsoever was found between the technological level and the degradation of the pasture, implying that this process may occur on any property, irrespective of the technology employed in its beef production system.

However, the technological level is highly significantly associated with the size of the property, as confirmed by all three analyses, i.e., Fisher's exact test ($p < 0.01$), and the Spearman (ρ_s (58) = 0.4491, $p < 0.01$) and Kendall (τ_b (58) = 0.3966, $p < 0.01$) correlations. In other words, large properties (> 675 hectares) tend to have a significantly higher technological level in comparison with smaller (< 180 hectares) properties. This association is consistent with the increasingly business-oriented model of beef production found throughout Brazil, which requires larger areas of pasture for grazing (ARMENTERAS et al., 2013; GIBBS et al., 2010).

The more detailed analysis of the relationship between property size and the TI indicated that the association with properties of medium (size 2: 180–675 hectares) and large (size 3: > 675 hectares) size was highly significant, returning p values of 0.01 and 0.001, respectively. Overall, then, the larger the size of the ranch, the higher the TI. Overall, 42.1% of the larger properties, and 31.6% of the medium-sized properties were classified with the highest TI, whereas most (86.7%) of the smallest properties returned the lowest TI.

By contrast, no evidence was found of any association between the size of the property and pasture degradation, indicating that the level of degradation is not dependent on the size of the property. In addition, no evidence was found of any association between the TI and cattle density.

High cattle densities in low technology systems tends to accelerate the degradation of the pasture, through processes such as overgrazing and intensive trampling, which reduces productivity and affects the welfare of the animals (OLIVEIRA et al, 2018).

FINAL CONSIDERATIONS

The socio-economic profile of the ranch managers and its influence on the technological level of the beef production systems, in relation to the education level and income of the manager, and the use of rural credit. No statistical evidence (considering the results of Fisher's exact test and the Spearman and Kendall τc correlations) was found of any association between education levels and technology, although in all cases, the manager had at least eight years of experience of beef production. By contrast, the technological level of the beef production system was associated with the income of the ranch manager, as shown by the Spearman and Kendall τc coefficients, which, together with the Beta regression, indicated a clear relationship between the technological level of the ranch and the income of the manager.

The analysis of the relationship between the topographic relief perceived by the ranch manager and the technological level of the beef production system found that the TI is associated negatively with relief, as indicated by both the Spearman and Kendall τb coefficients.

No association was found between cattle density and the TI, indicating that high cattle densities are found on properties with low TI, which may result in reduced zootechnical parameters and the degradation of pastures, affecting the wellbeing of the animals.

The TI is associated significantly with the size of the property, however, as shown by all three analytical approaches (Fisher, Spearman, and Kendall τb). This finding is consistent with large scale, grazing-based beef production systems, which demand a relatively large area of pasture.

The compilation of the PDI revealed two distinct dimensions, soil and biological degradation, that are relevant to the evaluation of this parameter. The combined analysis of these parameters found that 78.3% of the ranches surveyed presented medium to high levels of degradation.

However, no statistical evidence was found of any systematic association between the TI and the PDI, which indicates that the degradation of pastures is not determined by the technological level of the beef production system.

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