Succession process in livestock farming systems in the Pampa biome of Brazil: a fuzzy logic analysis

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Abstract

Family succession trends have been growing in many Brazilian regions, especially in livestock systems in the far south, one of the main economic activities in Brazil's Pampa biome. This article aims to analyze the level of succession in livestock systems in Brazil's Pampa biome. The topic was approached using a mixed descriptive and explanatory approach, with a sample of 115 livestock farmers in the Pampa biome. A narrative study was carried out in the qualitative stage for data collection. In the quantitative stage, MatLab software was used, and Fuzzy Logic was applied to measure the level of the succession process. The findings of this study indicate that the livestock farmers in the sample studied have above-average levels of social sustainability, as well as high levels of possibility of making their succession processes effective. Thus, this study indicates that strengthening the succession process of livestock farming systems in Brazil's Pampa biome may be the way to generate better social indicators in the countryside and maintain the sustainable conditions of the Pampa Biome, ensuring the continuity of beef cattle.

Keywords: Sustainability; Livestock; Fuzzy logic; Pampa Biome

Introduction

One of the limiting and critical factors for the development of agricultural systems is succession. According to Scheffer (1995), this is a highly vulnerable stage, especially in family-run organizations. The process takes place after the decision-maker is unable to continue in charge, which generates uncertainties that impact organizational survival.

Family succession is an essential factor in discussing sustainability in livestock systems. Potrich et al. (2017) state that the succession process is a central element in discussions about rural sustainability. Succession is understood as the process by which the former manager passes on their duties to one or more people who will continue to manage the farm. According to Gilding et al. (2015), efforts are being made to understand the phenomenon of the succession process, but they still lack a better understanding of its many constituents. While in the urban environment, the issue of succession promotes uncertainty and risk of continuity for companies, in the rural environment, it has led to the discontinuity of a range of farms in Brazil. The aggravating factor is that in rural areas, according to Silvestro et al. (2001), succession decisions are made without professional guidance or planning, which determines their discontinuity.

However, the main bottlenecks that confront the rural succession process are the conflicts between young successors and their patriarchs, promoting uncertainty and risk of continuity for companies, the result of rudimentary work, the greater attractiveness of urban centres and gender inequality (Matte & Machado, 2016). This study focuses on livestock systems in the far south of Brazil, which are secularly linked to local traditions and customs (Viana et al., 2021). Livestock farming is one of the main economic activities in Brazil's Pampa biome. Among the factors that explain this territory's vocation for livestock farming is that the grasslands are made up of natural pastures that are excellent for raising cattle (Ibge, 2017).

The interruption of livestock activities, often caused by the breakdown of the succession process, leaves the rural environment open to commodity monoculture, which generates land concentration, profoundly modifies the conditions of the biome, and changes the social characterization of the countryside and the form of relations between agents (Schneider, 1994).

In this way, a well-conducted succession process that offers conditions for the quality of life of successors is aligned with a perspective of high social sustainability of livestock systems. In this context, this research aimed to analyze the level of succession in livestock systems in Brazil's Pampa biome.

Material and Methods

The study was descriptive and explanatory, using a mixed methods approach. The first stage consisted of qualitative data collection through a narrative study with six (6) farmers who are in the position of successors in their livestock systems. Three questions were asked to identify the succession process's critical success and failure factors. This stage aimed to subsidize questions that could help measure when there is a greater or lesser tendency for succession in a livestock system.

This stage gave rise to the questions shown in Chart 1, which were incorporated into a questionnaire to measure the level of the succession process in the fuzzy logic stage. The questionnaire included the sociodemographic and succession questions shown in Chart 1. In order to validate the questionnaire, a pre-test was carried out with two farmers and two experts to check for the need for adjustments. After the pre-test stage, the questionnaire was applied to a stratified sample of 115 livestock farming systems in Brazil's Pampa biome, as shown in Figure 1.

We then began the quantitative stage to measure the level of succession in livestock systems using fuzzy logic. According to Gomide & Gudwin (1994), Fuzzy Logic is suitable for measuring restricted reasoning models if analyzed from a binary perspective, i.e., by the classic model of belonging or not belonging to a given set. In this way, the authors point out that the fuzzy method controls qualitative data through modelling, which allows complex phenomena to be understood more clearly. Fuzzy logic includes a series of linguistic variables that allow values to be qualified in the modelling process. In this study, these linguistic variables assumed functions relating to the level of the succession process in livestock systems.

The input variables belonging to the sets in X were obtained through the narrative study previously carried out. Based on this, three input levels were stipulated for each of the alternative answers to the variables: bad, average, and good, as described in Chart 2. Sequentially, all the variables and their alternatives were analyzed by a specialist in the succession theme so that they could be classified into one of the three levels and ordered according to their degree of importance (where 1 is most important and 6 is least important), resulting in what is shown in Chart 2.

Once this stage was completed, we proceeded to create the rule base used to establish the decision logic. Three hundred and twenty-four (324) rules were created with all the possible combinations of the above variables to feed the decision logic. To classify the correspondence of each rule as

assertively as possible with the output sets, weights were assigned, starting from 0 (zero) to each of the possible answers for all the variables according to the importance established by the expert. The output criteria were then defined, as shown in Table 1.

Chart 1. Questions to measure the level of the succession process.

Questions	Measurement
Do successors usually take part in planning activities on the farm?	Nominal (Y/N)
Do successors usually participate in decisions on the property?	Likert 5 point
How often do the owner and successors meet to discuss the management of the farm?	Likert 5 point
How involved are successors in the day-to-day running of the property?	Likert 5 point
Do the successors intend to take on the role of owner in the future?	Nominal (Y/N)
Are the successors' suggestions implemented on the property?	Likert 5 point

Chart 2. Questions submitted for expert evaluation.

Variable	Alternatives and levels	Order of importance
A - Regarding the succession process	0 - No successors, owner aged 60 or over. Rating: Poor 1 - No successors, owner aged between 40 and 59. Rating: Poor 2 - o successors, owner under 40. Rating: Average 3 - There are successors with no interest in managing/working on the property. Rating: Average 4 - There are successors interested in managing/working on the property. Rating: Good	1
E - Successors intend to take on the role of the owner in the future	0 – No. Rating: Bad; 1 – Yes. Rating: Good	2
D - Degree of involvement of successors in the day-to-day running of the property.	0 - Very low. Rating: Bad; 1 - Low. Rating: Poor; 2 - Medium. Rating: Medium; 3 - High. Rating: Good; 4 - Very high. Rating: Good	3
F - Suggestions from successors are implemented on the property.	0 - Never. Rating: Bad; 1 - Few times. Rating: Bad; 2 - Sometimes. Rating: Average; 3 - Often. Rating: Good; 4 - Always. Rating: Good	4
B - Successors usually take part in planning activities on the property	0 - No. Rating: Bad; 1 - Yes. Rating: Good	5
C - Frequency of meetings between owner and successors to discuss property management	0 - Never. Rating: Bad; 1 - Rarely. Rating: Bad; 2 - Sometimes. Rating: Average; 3 - Often. Rating: Good; 4 - Always. Rating: Good	6

Table 1. Exit criteria for the level of the succession process.

Succession Process Level Ratings	Weight for classification	Possible combinations
Very Low	0 a 5	19
Low	6 a 11	89
Medium	12 a 17	134
High	18 a 23	73
Very High	24 a 27	9
Total		**324**

Table 2. Score for each level of the estimated succession process.

Level of the succession process	Score
Very Low	From 0.00 to 8.49
Low	From 8.50 to 27.50
Medium	From 27.51 to 52.50
High	From 52.51 to 77.50
Very High	From 77.51 to 100

Table 3. Existence of successors in livestock systems in Brazil's Pampa biome.

Existence of succession	Frequency (f)	Percentage (%)
No successors, owner aged 60 or over	2	1.74
No successors, owner aged between 40 and 59	5	4.35
No successors, owner under 40	8	6.96
There are successors with no interest in managing/working on the farm	15	13.04
There are successors with an interest in managing/working on the farm	85	73.91
Total	**115**	**100,0**

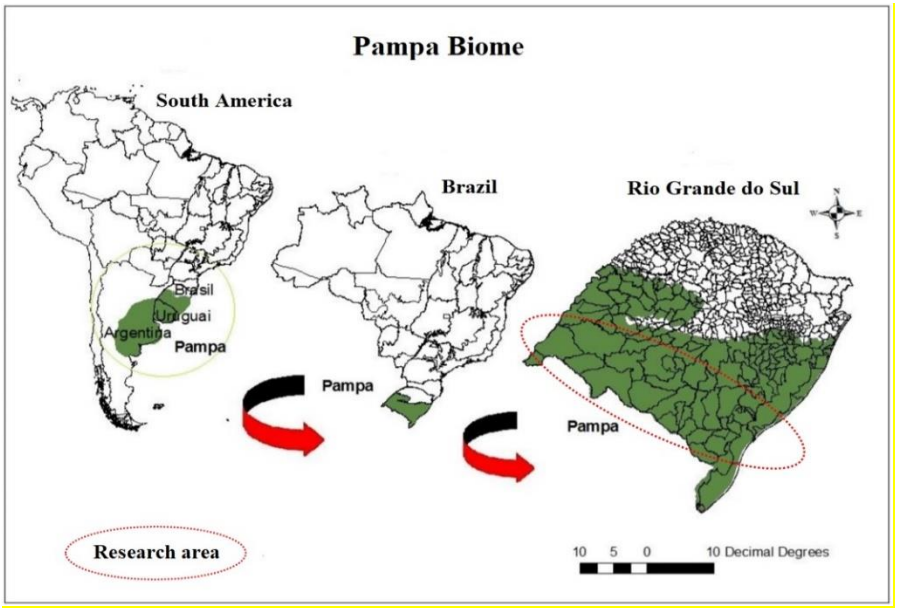

Fig 1. Location of the Pampa biome in South America and Brazil and the research area
Source: Adapted from Azevedo (2013).

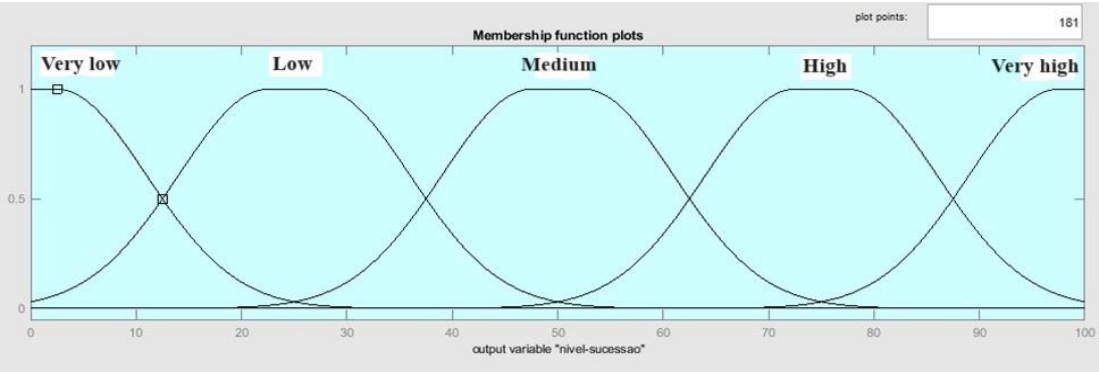

Fig 2. Representation of fuzzy outputs.

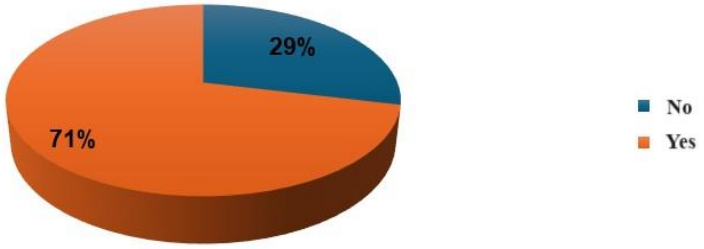

Fig 3. Successors' intention to work as farm managers.

We then went on to create the Y-sets, where we defined five outputs for the levels of the succession process, which represent a level scale from 0 (zero) to 100 (one hundred): very low, low, medium, high and very high, as shown in Figure 2. The levels of succession for the livestock systems and their respective values were defined, as shown in Table 2. To carry out these steps, MatLab software was used to build the fuzzy logic steps, from fuzzification of the input to defuzzification of the output. It is important to note that fuzzification is the moment in the fuzzy logic process when the linguistic variables and their respective pertinence functions are defined. Subsequently, in the decision logic stage, the rule

bases are established, whether or not they are conditional, to run the fuzzy logic. Finally, in the defuzzification stage, the fuzzy regions are linked to their corresponding values, thus transforming these regions into the system's output values.

Results and Discussion

Table 3 shows the results on the existence of successors in the livestock systems surveyed in Brazil's Pampa biome. It can be seen that approximately 73.91% of respondents report that there are successors who are interested in managing the livestock organization and/or working in it, which tends to reduce the possibility of discontinuity in the production system. This result may be linked to the fact that many respondents are on properties where the livestock culture has been ingrained in the family for decades, making it a natural process to pass on to descendants, who are often brought up in contact with the rural environment.

Figure 3 shows the successors' intention to work as managers on the farm. In line with the positive outlook for the existence of successors, 71% of respondents reported that the successors intend to exercise their function in the future, thus ensuring the existence of the succession process in these cases. At the same time, 39% of the farmers rated the degree of involvement of their successors as high or very high (Figure 4). Despite this, the results are still variable, as 39% of farmers answered the options of low or very low involvement. This indicator is relevant when discussing the succession process in livestock systems because with successors aware of the property's planning and activities, the transition of management tends to face fewer obstacles. In a study by Matte & Waquil (2013), the authors mentioned not only the importance of having successors who can participate in the succession process but also the need for involvement and interest to achieve this goal efficiently.

In this study, as shown in Figure 5, 66% of the farmers reported that their successors' suggestions are never, rarely, or only sometimes implemented in their livestock systems. This situation can result in successors' lack of interest in continuing to live the day-to-day life of the farm because they don't see their dedication and effort being turned into actions for the future of the place they will be managing.

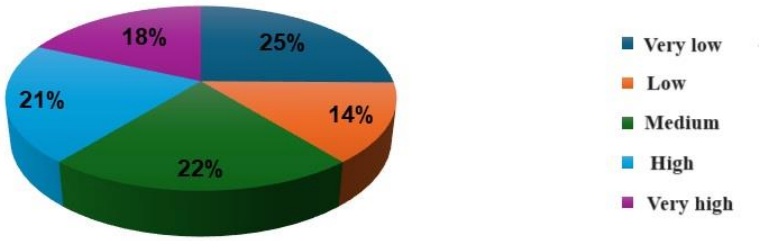

Fig 4. Degree of involvement of successors in the farm's activities.

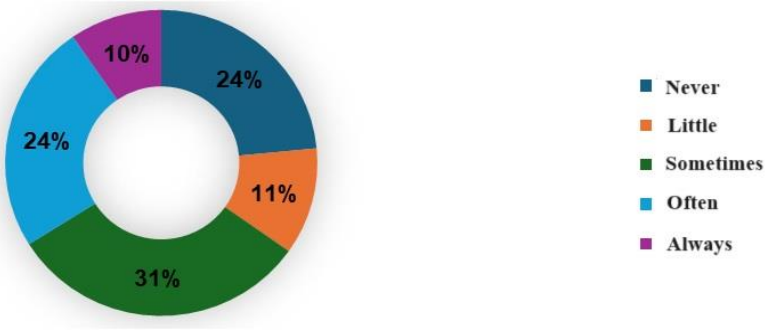

Fig 5. Degree of use of suggestions made by successors on the property.

Going deeper into the analysis, it has already been shown that 73.91% of farmers reported that their successors are interested in continuing the activities on the property; however, in 66% of the sample, the successors' suggestions are never, rarely or only sometimes implemented. This may help to explain a bottleneck that prevents the succession process from taking place in livestock systems because although

the basic elements for succession exist, the centralization of power in the hands of the person who has to pass on command of the farm ends up frustrating and discouraging their successors.

Determining the Level of the Succession Process using Fuzzy Logic

The result of applying fuzzy logic was to determine an indicator that would allow us to measure the level of succession in the livestock systems of Brazil's Pampa biome. In other words, to quantify the possibility of succession occurring (or not). Figure 6 shows the classification of the livestock systems surveyed according to their level of succession. This analysis highlights the high number of farms in the sample with a high or very high level of succession (60%). On the other hand, 40% of the systems are at a very low to medium level of uncertainty regarding succession. In addition, the average score obtained from all the succession levels of the farms in the sample was 62.41, indicating a high propensity to succession.

These positive results show a prospect of continuity for a large part of the livestock systems sampled in Brazil's Pampa biome, contrasting with the scenarios of adversity pointed out in other studies. One example is the study by Matte et al. (2015), which draws attention to the fact that the succession process is a limiting factor on livestock farms. In Chart 3, we try to demonstrate the construction of the succession indicator using fuzzy logic. Three different scenarios were constructed, emulating the characteristics of the succession variables in Brazil's Pampa biome.

As you can see, the lowest indicator represents farmers who are on the verge of having their organization discontinued due to a lack of successors (F1). The middle indicator represents the farmer who has successors, but they are distant from the reality of the farm and the chance of them continuing the livestock operation is uncertain (F2). Finally, the third indicator identifies the farmer with excellent synergy with his successors, who are adequately incorporated into the succession process (F3). Corroborating these findings, Hridoy et al. (2024) when examining the opportunities and challenges of fish farming in the northeastern region of Bangladesh, point out that there is a growing trend among young people to seek opportunities abroad, coupled with the aspirations of many parents to send their children abroad, represents a significant barrier to the advancement of aquaculture production.

However, Singh & Sonwani (2023) argue that the livestock sector contributes to the national economy, as well as promoting diversification and sustainable agricultural systems and, at the same time,

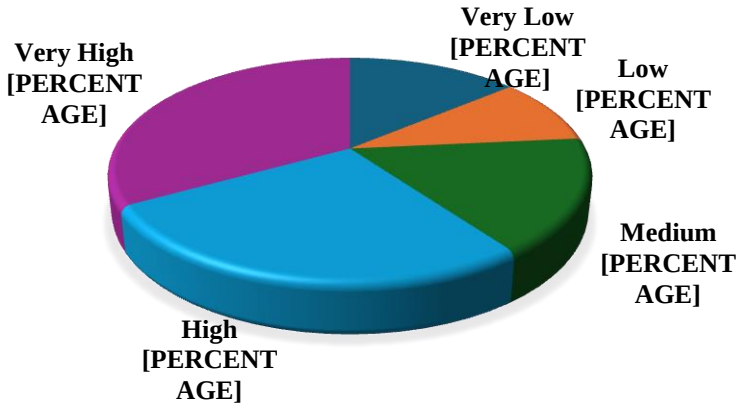

Fig 6. Classification of the succession process levels in the livestock systems surveyed using fuzzy logic.

Chart 3. Simulated scenarios with the inputs and outputs of the succession level using fuzzy logic.

	Scenarios		
Questions	**F1**	**F2**	**F3**
Succession process	No successors, owner aged 60 or over	Successor not interested in working on the property at present	With successor interested in working on the property at present
Participation of successors in estate planning.	No	No	Yes
Frequency of meetings	Never	Sometimes	Always
Degree of involvement of successors	Very low	Medium	Very High
Successors intend to take on the role of manager in the future	No	Yes	Yes
Successors' suggestions are implemented	Never	Sometimes	Always
Succession Process Level Score	7.46	50.00	92.54
Classification	**Very low**	**Medium**	**Very High**

contributes to extra incomes for the rural population and also to food and nutritional security (Radha & Kumar, 2022).

Conclusion

The aim of this article was to analyze the level of succession in livestock systems in Brazil's Pampa biome. To this end, we measured quantitative data from a sample of 115 livestock systems in a Brazilian state that is important in livestock production and has been suffering from a lack of farm business succession in recent decades.

Based on this, the results show that there is a low attractiveness of the rural environment, ranging from issues of quality of life and infrastructure to the very autonomy on the farm, which end up driving successors away from livestock farming. This finding is related to a lack of understanding about succession, which is not an isolated phenomenon, but rather a process that takes place over the medium and long term, bringing successors closer to the decision-making core. This situation was described as worrying, negatively affecting the continuity of livestock systems in Brazil's Pampa biome.

The effort to measure the level of succession in livestock systems stands out as a contribution to the field of knowledge. Although several studies have already addressed the importance of succession and its limiting factors, our study sought to quantify the level of the succession process using fuzzy logic.

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