

## Risk Management Applied to Brazilian Family Agriculture

Gestão de riscos de negócios aplicados à Agricultura Familiar Brasileira

Rafael Castro Tavares<sup>1\*</sup>; Cassia Renata Pinheiro<sup>2</sup>

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<sup>1\*</sup> Instituto Interamericano de Cooperação para Agricultura – Consultant – SHIS WI 05, chácara 16, Lago Sul – 71600-530 – Brasília, DF, Brazil <[rafaelcastro.adm@gmail.com](mailto:rafaelcastro.adm@gmail.com)>

<sup>2</sup> Escola de Agricultura “Luiz de Queiroz” – Doctor in Science, Genetics and Plant Breeding – Av. Pádua Dias, 11 – Cx. Postal 9 – 13418-900 – Piracicaba, SP, Brazil

**Abstract:** Although hazards exist in all agricultural settings—particularly for the family farmer—uncertainties related to production place food security and family subsistence at risk. The objective of this study was therefore to analyze the components of risk management applied to family farming. To this end, we performed an exploratory study using data from a statistical survey of the 2018 Agricultural Census. Our results showed risks that were classified between medium and high. We observed that 45.8% of producers received retirement funds, implying they tend to be an older population. As a result, family succession work aimed at strengthening agricultural activities through technical assistance and rural extension (ATER) are necessary, since 80.1% of properties do not receive specialized guidance. We also found that 59% of the producers are not registered with the Declaration of Aptitude to Pronaf (DAP), which is an instrument used to access differentiated public programs. In this case, we observed that 52.2% of credit comes from government programs, with Pronaf accounting for the highest volume of credit (40.2% of resources). Using these data, we find that integrated risk management contributes to the daily activities of the rural producer, promotes the continuous improvement of the family business, assists in decision-making, and ultimately results in a reduction of losses and increases family income.

**Keywords:** Family subsistence, Farming, Food security, Rural business, Rural producer.



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**Resumo:** Embora os riscos existam em todos os ambientes da agricultura, em especial para o agricultor familiar, as incertezas relacionadas aos objetivos da unidade produtiva são geralmente críticas, pois colocam sob vulnerabilidade a segurança alimentar e subsistência da família. O objetivo do estudo consistiu-se em analisar os componentes da gestão de riscos aplicados à agricultura familiar. Para isto, realizou-se estudo exploratório por meio de levantamento estatístico do último Censo Agropecuário 2018. Os resultados mostraram que os riscos foram classificados entre médio e alto. Observou-se que 45,8% dos produtores rurais recebem de recursos de aposentadoria, o que indica ser são uma população mais idosa. Nesse sentido, faz-se necessário um trabalho de sucessão familiar visando o fortalecimento das atividades agrícolas por meio da Assistência Técnica e Extensão Rural (ATER), uma vez que 80,1% das propriedades não recebem orientação especializada. Verificou-se ainda, que 59% dos produtores não possuem registro na Declaração de Aptidão ao Pronaf (DAP), que é um instrumento utilizado para acesso às políticas públicas diferenciadas. Neste caso, observou-se que 52,2% dos créditos advêm de programas governamentais, sendo o maior volume de crédito destinado ao Pronaf, com 40,2% dos recursos. Através destes dados, é notável que a gestão integrada de riscos contribui para as atividades diárias do produtor rural, bem como promove uma melhoria contínua do empreendimento familiar e auxilia no processo de tomada de decisão, redução de perdas e aumento da renda familiar.

**Palavras-chave:** Subsistência Familiar, Produtor rural, Segurança Alimentar, Empreendimento rural, Agropecuária.

## Introduction

Family agriculture has become a topic of great importance in the Brazilian economy, particularly with its potential for growth and its share in agricultural production. In the past—roughly three or four decades ago—the term “family agriculture” was essentially nonexistent. When it began to be used, it was characterized as agriculture of small scale, of low income, and of subsistence, which in turn hurt the future evolution of this segment of agriculture, as shown by the decreasing economic importance of this segment in census numbers over the years (Torres and Silva, 2016).

This characteristic of small-scale agriculture was partly derived from the way in which the literature presented statistical data (Bittencourt and Sabbato, 2000). However, a pioneering studying began in 1995 by the Brazilian Institute for Geography and Statistics (IBGE) and through the Agricultural Census, made possible the use of microdata and changed the perception of family farming.

Family farming became viewed as professional businesses that generate revenue and jobs, and that distribute income to those involved in the production chain (IICA, 2013). Torres and Silva (2016) also agreed that family agriculture gained a new prominence given new metrics and public policies for the sector.

According to preliminary results by IBGE (2018), Brazil has 5,072,152 agricultural “establishments”, classified as follows: 27.48% as associations, consortia, or groups of individuals; 0.02% as cooperatives; 0.01% belonging to federal, state, or municipal governments; 0.01% belonging to public utility institutions; 72.01%, individual producers (individual and sole person responsible for the establishment); 0.25%, corporations or limited liability companies; 0.19% other conditions; and 0.02% do not apply.

In 1975, Brazil had 20,345,692 rural workers, and by 2017, the number of people engaged in rural activities reached its lowest level to date, at 15,036,978 rural workers, with 10,958,787 who were family farmers and 4,078,191 who were workers with no family ties to the rural producer (IBGE, 2018). These data underline the important role of family agriculture in the agriculture sector and its production capacity.

Law No. 11,326 from the 24th of July, 2006 (Brazil, 2006) defines the rural producer as being he or she who practices rural activities, who owns an area of up to four “fiscal modules”, and who uses manual labor primarily of the family in the economic activities of the establishment or rural development (IICA, 2015).

We highlight that for the family farmer to access public programs such as the National Program to Strengthen Family Agriculture (PRONAF), Technical Assistance and Rural Extension (ATER), Family Agriculture Insurance (SEAF), and Crop Guarantees (Garantia-Safra), among others, the Declaration of Aptitude to Pronaf (DAP) must first be issued to identify the individual producer and his or her family (FNDE, 2016).

Risk management serves as an indispensable tool for rural producers, who regardless of their size, legal classification, and location (urban or rural), are susceptible to uncertainties and challenges related to marketing, credit, agricultural practices, and other aspects, all of which interfere with or contribute to producers realizing their earnings or subsistence (Banco Mundial, 2015).

Risks in agriculture have the potential to multiply quickly along the entire production chain, generating impact and innumerable losses in many sectors (Buainain and Silveria, 2017). Risk is understood as the relationship between a combination of consequences and the likelihood that a final result differs positively or negatively (or both) from what is expected, particularly due to the interference of unforeseen and random factors (ABNT, 2018).

In this scenario, the Federal Court of Accounts (TCU, 2018a) highlighted that risk management seeks to achieve objectives established from analyzing the environment, either via strong management practices or through internal control measures that assist in identifying the potential risks of maintaining such risk at levels compatible with the management of the business.

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<sup>1</sup>Paragraph IV in article 2 of Decree No. 9,064, from May 31st, 2017, defines the fiscal module as an agrarian measurement for the land tenure classification of a property. It is expressed in hectares and may vary according to municipality. It is calculated by the National Institute for Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária - Incra).

To identify the different types of business risks inherent in family agriculture, we can analyze the preliminary results of the 2018 Agricultural Census, specifically regarding rural producer decisions, which can indicate possible risks associated with marketing, characteristics of the family farm, loans and financing, business expenditures, income, technical assistance, and whether the farm is following good agricultural practices (boas práticas agrícolas – BPA).

However, our objective is to analyze the components of business risk associated with Brazilian family agriculture, to allow rural producers more sustainable agricultural practices through actions necessary to mitigate, respond to, or transfer the risks that render uncertain their income and their ability to grow and remain in business.

## Material and Methods

To develop this study, we propose an exploratory analysis using certain variables from the agricultural census survey, conducted by IBGE (2018) between October 1st, 2016 and September 30th, 2017. Using secondary data, we sought to determine the main decisions of rural producers regarding their business risk.

Exploratory research proposes an empirical investigation with the objective of formulating questions that increase the researcher's familiarity with an environment, a fact, or a phenomenon, and lends insight into related concepts to then conduct a study with greater precision. Therefore, the research must conceptualize the interrelationships between the properties of the observed phenomenon or environment (Marconi and Lakatos, 2017).

We developed this study by first defining our primary objective, which is to analyze the management of business risks involved in the daily activities of the family farmer. These business risks arise from the practices within the farm and can therefore be characterized as actions relative to marketing, financing, cost management, and production management, among others (Buainain and Silveira, 2017, Embrapa, 2018).

Risk can be defined as the effect of a deviation from the expected, and can be positive, negative, or both, and can address, create, or result from opportunities and threats. Risk is normally expressed in terms of sources of risk, potential events, consequences, and probabilities (ABNT, 2018).

Risk is a future identified event, to which we can associate a probability of occurrence. Meanwhile, uncertainty is a future identified event to which we cannot associate any probability of occurrence (IBGC, 2007).

To define the treatment to address a risk, we must proceed with the second step of the study, which consists of determining the potential effect of the risk for each variable analyzed, considering the probability and the impact of the risk, classified as follows: very low, low, medium, high, and very high (ABNT, 2018).

Likewise, we apply the concepts and definitions recommended by subjective probability to quantify the risks that Rifo (2017) defined as being personal and thus characterized as a subjective evaluation that includes the individual's perception of the world, experiences, and information available to express the uncertainty of the event in qualitative terms.

In general terms, subjective probability arises from daily evaluations, or periodic decisions associated with the behavior of the individual. In this context, subjective evaluation includes other factors that are difficult to measure, to represent by perception, belief, ideological bias, values, experience, knowledge, or the interaction of these factors.

The arrangement of trajectories and events is an important component in evaluating risk, but does not necessarily translate or indicate the degree of vulnerability or exposure to risk (Oliveira and Cunha, 2015). Similarly, Oliveira and Cunha (2015) notes that the process of characterizing risk aims to obtain prior knowledge of the risk factors that affect the particular area, and their probability of occurrence.

To provide an overview of possible risk, based on the definitions from subjective analysis, we propose the use of two scales: first, of risk probability, and second, of risk consequences of impact (Table 1).

**Table 1.** Risk probability and risk impact scale

Probability	Probability Description	Impact	Impact Description	Weight
Very Low	Unlikely	Very Low	Minimum	1
Low	Rare	Low	Small	2
Medium	Possible	Medium	Moderate	5
High	Likely	High	Significant	8
Very High	Nearly Certain	Very High	Catastrophic	10

Source: TCU (2018b)

The level of risk results from multiplying the probability of risk and the impact of exposure to risk. This then represents the level of probability, in percentage terms of occurrence, expressed in the following equation (1).

$$R = P \times I \tag{01}$$

where, R is risk, P is the probability of occurrence, and I is the impact or consequence of the risk. The multiplication of P and I determines the level of risk.

Specifically, we note that we measured risk by collecting information, by estimating probability (occurrence of an event), and by evaluating impacts. We then evaluated these impacts through three lenses: financial impacts, impacts to the business, and impacts to reputation. We therefore assessed impacts and probabilities using category scales (BC, 2017).

Then, to pragmatically quantify risk, we used a method of quantitative analysis that employs a scale of risk levels, since such a scale establishes numerical values for defining risk (Table 2).

**Table 2.** Risk classification scale

Classification	Range
Low Risk	0–9.99
Medium Risk	10–39.99
High Risk	40–79.99
Extreme Risk	80–100

Source: TCU (2018b)

For example, we suggest that, a priori, variable A has the following distributions: a “nearly certain” probability of occurrence, represented by a weight of ten (Table 1), and a degree of impact classified as “moderate” and represented by a weight of five. Therefore, multiplying probability and impact, we find that variable A has a risk equal to 50, or is high risk (Table 2).

Risk exposure refers to the probability of an event occurring (horizontal axis) and the risk impact refers to the consequences of an event as a function of vulnerability (vertical axis) of the producers. According to IBGC (2007), different tones denote the level of importance that should be given to each of the events (Figure 1).

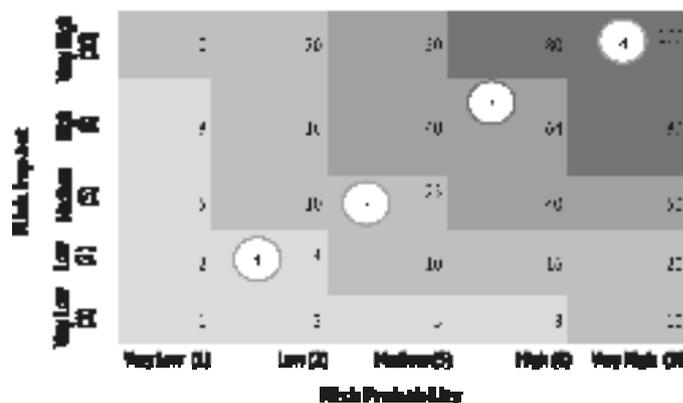


Figure 1. Risk Matrix  
Source: TCU (2018b)

An event of type 1, classified as having a low impact and low probability, implies a low, intangible impact. An event of type 2 is classified as medium importance (located in the central area of Figure 1). An event of type 3 is classified as having an intangible, high impact and therefore is found within the darker region of Figure 1, as the exposure and impact of this type of risk are considered high. Meanwhile, an event of type 4 is classified as having a very high impact and very high likelihood of occurrence.

In this context, we propose the third step of our study, which consists of elaborating the typology of risk. This is found in Table 3, which contains the qualitative variables to be analyzed, the degree of probability and impact, and the risk classification, which can result in the assigned criteria of low, medium, high, or extreme (Table 3).

**Table 3.** Risk typology

Thematic Dimension	Evaluated Objectives	Probability (P)	Impact (I)	(P x I)	Risk Evaluation	Treatment
Marketing	Destination of production is family subsistence and to guarantee food security of producer, placement of producers in cooperatives	10	5	(10 x 5)	50-high	reduce
Farm Characteristics	Weak access to public programs due to a lack of registration with DAP and access to electricity on the rural property.					
Loans and Financing	Availability of credit by financial agents and dedicated use for particular purpose.					
Expenses	Vulnerability in primary business expenses.					
Income	Instability (regularity) and financial loss.					
Technical Assistance	Vulnerability regarding access to technical assistance and use of soil correctives.					
Good agricultural Practices	Practices to control for pests or disease					

Source: Souza (2011)

The Brazilian Company for Agricultural Research - Embrapa (Embrapa, 2018) clarified that risks can be divided into three categories: first, by frequent risks, which cause small losses. These include normal business risks generally assumed by the producers themselves, who manage their business using the tools available to them on their farms or by accessing programs implemented through public policy. Second, are risks with a frequency and impact that can neither be neglected by nor assumed by producers themselves. Rather, these risks require certain instruments in order to be transferred from the producer. The third category of risk, according to Embrapa, involves risks that despite their low occurrence, generate large losses. Such risks are therefore classified as extreme and cannot be assumed by the producer, and therefore justify government action.

After identifying, evaluating, and measuring the impact and probability of the risk, we moved to the fourth step of the study, which comprised the treatment to be given to the identified risk (Oliveira and Cunha, 2015). In practice, while the total elimination of risk was impossible, certain sustained actions could serve to reduce or eliminate risk over the long term (IBGC, 2007). In this context, we established options for addressing risk (Table 4).

**Table 4.** Options for risk treatment

Component	Subcomponent	Detail
Avoid the Risk	-	Decision to not become involved in the risk or instead act in a way to remove oneself from the risk situation.
Accept the Risk	Retain	Maintain the risk at current level of impact and probability
	Reduce	Actions are taken to minimize the probability and/or the impact of the risk.
	Transfer/Share	Activities that seek to reduce the impact and/or the probability of risk occurrence by transferring or, in certain cases, by sharing a portion of the risk.
	Take Advantage	Increase the degree of risk exposure as to facilitate competitive advantages.
Prevention, Reduction, and Damage	Inherent Risk	Natural risk; absence of any action that management can take to change the probability of occurrence or the risk impact.
	Residual Risk	Resulting from taking actions and applying best practices of internal controls or of the organization's response to risk.
Capacitation	-	Consideration should be given to training teams to address possible risk, specifically, to be able to identify, anticipate, measure, monitor, and if necessary, mitigate risk.

Source: IBGC (2007)

Based on our data, we proposed responding to risk after analyzing the problem in a logical manner, to allow for the best decision possible to be made based on the available information.

Using our data and findings, the family farmer will have a better understanding of the consequences of future events, for short-, medium-, and long-term planning of his or her rural business, ultimately generating new opportunities and alternatives for the family nucleus (Panno and Machado, 2016).

In a fifth step of our study, we sought to identify our target audience. In 2017, Brazil registered a total of 3,652,446 rural “establishments” linked to the individual producer (IBGE, 2018), which represented 72.01% of total rural establishments, and which we defined as our target for the study. We acquired our statistical tables from the IBGE website.

In this context, given the need to know the decision-making patterns of farmers, we used an equation to calculate probability, expressed as follows in Equation (2):

$$P(A) = \frac{n(A)}{n(E)} \quad (02)$$

where  $P(A)$  is the probability of the occurrence of an event;  $n(A)$  is the number of responses referring to the sampling of event A; and  $n(E)$  is the number of elements in the sample space represented by the number of rural businesses that answered a particular question.

According to Costa (2015), the field of statistics establishes techniques that allow us to evaluate decisions based on an obtained estimate, in relation to the sample and the population, which can be better understood from the illustration in Figure 2.

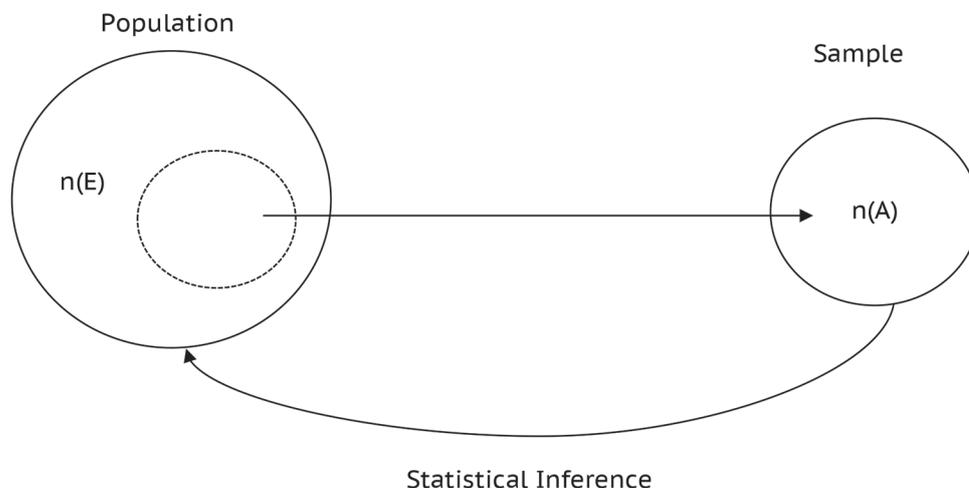


Figure 2. Schematic Summary of a Statistical Study  
Source: Costa (2015)

To better understand Tables 5 through 19 and their results, we have defined the following abbreviations:  $P.s^1$  represents subjective probability (the probability that an event occurs and has a positive or negative impact) and  $I.s^2$ , which represents the subjective impact (impact on finances, business, and reputation), and we use both to define risk based on the concept of subjective analysis.

Meanwhile, we proposed using a statistical treatment of the data to define the arithmetic mean (the most frequently used measure of central tendency), which was used to distribute the analyzed values of each variable and was represented by the ratio between the sum of observed values and the number of observed values, as follows:

$$\bar{X} = \frac{\sum X}{n} \quad (03)$$

where  $n$  is the total number of observed data and,  $X$  is the mean (the sum of all the data ( $X^1$ ;  $X^2$ ;  $X^3$ ; ...  $X_n$ ), divided by the quantity of data.

## Results and Discussion

Management assists in the day-to-day activities of rural producers, who need to make important decisions to guarantee their subsistence and that of their families. Thus, the concept of management can be perfectly applied to the activities of family agriculture, and in particular, to offer support to rural activities to achieve better financial results and reduce the risks to the family business.

Meanwhile, we must remember that risk management consists of identifying, evaluating, administrating, and controlling the events that can adversely impact the realization of certain objectives. Therefore, rural producers must practice risk management by first adopting conscious measures that reduce the probability and the impact of risk events. In addition, the rural producer should recall any significant events occurring in recent years that negatively impacted his or her agricultural activities and produced any negative results for the family nucleus, and remain proactive and reactive regarding such risk events.

In the case in question, we propose an analysis of data and information that allows us a holistic perspective, or rather, that seeks to understand certain phenomena in their entirety and in the context of various types of risk, so that rural producers may reevaluate their work or simply maintain good management practices using new knowledge and information relative to their businesses.

The rural producer continues to have a leading role in Brazilian agriculture. Thus, with the support of ATER, producers will be able to increasingly reduce risk in their rural businesses, not only through training, knowledge transfers, and good management practices, but through other actions that assist in the proper treatment of events (risks and opportunities), to improve the productive capacity of the family unit and add value to its various processes. Observing the family agriculture scenario can be to evaluate in the coming years, the number of rural establishments and individuals employed in agriculture—in particular rural producers—will demonstrate an accentuated decrease. This will occur as a result of high production costs, a fall in family incomes, greater risk inherent in farming activities, an increasing complexity of management for agricultural activities, and difficulty in adapting to technological changes.

We must remember that family agriculture is without a doubt the key to improving food security for the Brazilian population, and a vector for sustainable growth and the fight against rural inequalities.

### Marketing

Family agriculture is of great importance in food production, particularly for family consumption for the producing household, for contributing to reducing rural exodus, and for significantly contributing to the generation of capital, the reduction of hunger, and to jobs, among other benefits (IICA, 2017). In this context, our objective was to determine the share of production for family subsistence and the guarantee of food security, and the degree of rural producer participation in cooperatives.

Specifically regarding the destination for production, we note that 60% (Table 5) of production is marketed (sold) or bartered for inputs, which has been strengthened by government support such as that given through the Program for Food Acquisition (Programa de Aquisição de Alimentos-PAA), developed under the Zero Hunger Program, and allows the government to acquire food from family farmers and provide a portion of the food to those in food insecurity and also the National School Food Program (PNAE). For many family farms, marketing through the PAA plays a significant role in family subsistence. Furthermore, the programs has provided small producers incentives to face existing difficulties, which in turn adds value to production and provides new perspectives for staying in the field (Agapto et al., 2012).

**Table 5.** Number of agricultural establishments, by agricultural purpose

Primary purpose of agricultural establishment <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
Consumption by producer and producer's relatives	2,049,579	40	5	5	25-Medium
Marketing or barter of production	3,021,777	60	5	5	25-Medium
Total	5,071,356				

\*Note: <sup>1</sup>IBGE Question 6649; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact

Source: IBGE (2018)

However, we note that only rural producers who are registered with DAP or part of a formal organization (associations or cooperatives) can participate in PNAE. Therefore, producer registration with DAP and a rural producer's participation/membership in a formal network of small producers allows the establishment of new marketing models (Batalha et al., 2005).

Likewise, we found that 40% of production is for the subsistence of the family (Table 5). Due to the possibility of an even more marked reduction in the share of production for family subsistence, which would result in a lack of food for consumption by the family nucleus, the likelihood of an event occurring was considered medium. Similarly, the degree of impact was also classified as medium, especially because families could complement their income with other activities, within the scope of the family business, and provide for the family's subsistence.

Collective marketing is an important means of bringing gains to small, rural producers, notably due to the high production costs, technological requirements, price negotiation, production diversification, and existing difficulties of joint buying and selling faced by such producers (Hespanhol, 2013).

The organization of rural producers into cooperatives or associations represents a structuring that contributes to meeting demands, transferring knowledge, and enhancing production value in increasingly competitive, dynamic, and demanding markets. The cooperative presents itself as a prominent element, given that it offers the rural producer a new type of security for strengthening the family unit, similar to technical assistance, which reduces the effect of little formal and technical education among rural businesses (Marschal, 2009).

In this context, the actions and activities of ATER serve to encourage cooperation among rural producers and partner associations, and benefit the production of family farms.

Regarding cooperatives, we found that 60.8% of rural producers are not part of any cooperative or association, while 39.2% of rural producers are affiliated with cooperatives (Table 6).

**Table 6.** Number of agricultural establishments, whether a producer is associated with rural cooperative or association

Association with cooperative or association <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
Associated	1,988,071	39.2	2	5	25-Medium
Not associated	3,083,261	60.8	5	5	25-Medium
Total	5,071,332				

<sup>1</sup>IBGE Question 6707; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

With regard to the participation of the rural producer in cooperatives or associations, we proposed classifying their risk probability as low, since the rural producer could independently return to work and leave the cooperative. Here, we classified the degree of impact as medium, since leaving the cooperative could eventually generate marketing losses for the rural producer.

Meanwhile, for producers who were not yet part of a cooperative, we classified their risk probability as medium, since such affiliation were possible and would therefore change the producer's scenario through the benefits a cooperative could bring to the family nucleus. We also classified their degree of impact as medium, since the producer could have been proactive and become associated with a cooperative. Therefore, the degree of risk for the marketing variable was classified as medium risk, based on a weighted average.

### Characteristics of the Farm

The objective of analyzing the characteristics of the agricultural establishment was to identify the degree of fragility of rural producers regarding their access to public policies, and specifically, regarding rural producers who failed to register with the Pronaf program via registration with DAP, which is intended to aid rural businesses. We additionally analyzed the percentage of producers with electricity on their property.

We note that on May 31st, 2017, Decree No. 9,064 was approved (Brazil, 2017) to implement the New Register for Family Agriculture (CAF) and replace DAP. However, the systematized data from IBGE (2018) refers to DAP, which is the focus of this analysis.

Using the data from IBGE (2018), we note that 59.2% (Table 7) of rural producers were not registered with DAP, and their risk probability was therefore classified as medium, due to the expressive number of producers therefore without access to differentiated public programs. We also classified their risk impact as medium (moderate), since most of these families are composed of family farmers and would not have access to credit from Pronaf since they were not registered with DAP.

**Table 7.** Number of agricultural establishments, by DAP registration

Declaration of Aptitude to PRONAF (DAP) <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
Not registered	3,000,445	59.2	5	5	25-Medium
Registered	1,667,235	32.9	2	5	10-Medium
Does not know	387,170	7.6	5	5	25-Medium
Not applicable	17,302	0.3	1	1	1-Low
Total	5,072,152				

<sup>1</sup>IBGE Question 6707; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

We classified families with DAP registration as having a low probability of suffering changes in public policies that would result in the cancellation of the program. Similarly, we classified their risk impact as medium, given that the low transfer of resources for Pronaf could increase the difficulty of accessing credit and impact the objectives of the family business (Table 7).

Likewise, we analyzed the vulnerability of rural producers regarding the use and existence of electricity in their rural establishment. We found that 83.5% of the rural establishments had electricity, which is essential for running equipment, obtaining information, marketing, and exchanging experiences with other producers (Table 8). Therefore, we classified the risk probability that these producers would not have electricity access as low. Similarly, we classified their risk impact of no electricity as medium.

We classified the rural properties without electricity, which accounted for 16.5% of rural establishments, as having a medium risk probability, due to the potential for losses in communication, sales, and technology, among others (Table 8). We classified the risk impact of such properties as moderate (medium), since they could suffer lost opportunities and lost value for the family unit (Table 8). Therefore, we classified the degree of risk for these rural establishments as medium, using a weighted average.

**Table 8.** Number of agricultural establishments, whether a producer is associated with rural cooperative or association

Use of electricity <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No	830,328	16.5	5	5	25-Medium
Yes	4,215,799	83.5	2	5	10-Medium
Total	5,046,127				

Note: <sup>1</sup>IBGE Question 6651; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

### Loans and Financing

Most of the loans and financing to rural producers are the only way for farmers to generate leverage in the production of their rural business. The resources from governmental programs such as Pronaf were of great importance in strengthening and modernizing rural businesses and in incentivizing innovation in production. We therefore analyzed the availability of credit with financial agents and the purpose of the financing.

We noted that 52.2% of credit came from government programs, with the largest volume of credit (40.2%) for Pronaf (Table 9). Therefore, we considered the probability that producers would not have access to resources for loans and financing to be low (rare). We classified their impact level as high (significant), since a lack of such resources would compromise the objectives of the family business.

Meanwhile, 47.5% of producers reported that they received credit from other, non-governmental sources (Table 9). In this case, we classified their risk probability as low and their risk impact as small (low), since according to Assaf Neto et al. (2008), every investment decision that promotes a return on its capital cost

creates value (wealth) for its owners, known in the literature as the weighted average cost of capital (WACC). The authors highlight the substitution principle, where no investor would decide to invest in a given asset if identifying another, more attractive asset (a substitute). Therefore, the investments made did not affect the objectives of the rural business. Instead, they generate opportunities, add value, and increase income.

**Table 9.** Number of agricultural establishments, by loan or financing source

Declaration of Aptitude to PRONAF (DAP) <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No, without financing or loan	377,812	47.5	2	2	4-Low
Yes, Proinf	1,481	0.2	2	8	16-Medium
Yes, Pronaf	319,818	40.2	2	8	16-Medium
Yes, Pronamp	19,730	2.5	2	8	16-Medium
Yes, settlements (INCRA)	1,529	0.2	2	8	16-Medium
Yes, Fomento Rural	3,412	0.4	2	8	16-Medium
Yes, Terra Forte and Terra Sol	307	0.0	2	8	16-Medium
Yes, other program (federal, state, or municipal)	70,855	8.9	2	8	16-Medium
Total	794,944				

<sup>1</sup>IBGE Question 6707; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

In the same context, we studied the purpose of the financing, and observed that 48.7% was for investment (in machinery, equipment, or infrastructure), 38% for general expenses, 11.8% for farm maintenance, and 1.6% for marketing (Table 10).

**Table 10.** Number of agricultural establishments, by financing purpose

Financing purpose <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
Not registered	3,000,445	59.2	5	5	25-Medium
Registered	1,667,235	32.9	2	5	10-Medium
Does not know	387,170	7.6	5	5	25-Medium
Not applicable	17,302	0.3	1	1	1-Low
Total	5,072,152				

<sup>1</sup>IBGE Question 6707; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

Financing resources for investment, specifically, were for the purchase of durable goods for agricultural activities, and can be used to purchase land, construct buildings, construct permanent installations and make improvements, purchase machinery and equipment, to install irrigation, forest or deforest, install electricity or rural telephone lines, protect, correct, or recover soil, and purchase semi-trucks, pickup trucks, and motorcycles, among other uses. However, with this type of financing, the risk of the operation was that of the financial institution (IBGE, 2018).

Credit for general expenses was used for everyday purchases related to production and could be used to buy seeds or seedlings, fertilizers, agricultural chemicals, fuel, silage, hay, vaccines, and to maintain fencing and buildings, among other uses. For this type of financing, the rural producer must follow certain steps: soil preparation, planting, crop treatment, agricultural chemical applications, and harvest. We note the obligation by the financing party to use agricultural chemicals to protect the crop from pests, without giving the producer the opportunity to use other strategies to protect his or her crop (CNA, 2017).

Credit for marketing is used to help producers sell their production and therefore prevents the producer from being pressured into selling his or her crop for a low price to fulfill obligations (CNA, 2017). Credit allocated for maintenance of the rural property was applied to maintain buildings, facilities, machinery, and equipment.

Therefore, we classified the risk probability for all financing items (Table 10) as low, due to their balanced distribution and capacity of financing for all purposes to improve producer businesses. Meanwhile, we classified their impact as high for all financing categories, as a lack of such financing resources could negatively impact the family business and result in opportunity losses, missed

maintenance on the property, a lack of investment, producer difficulties to purchase seed, and poor product marketing, among other negative effects. As a result, we classified the degree of risk for the variable of loans and financing as medium, using a weighted average.

### Expenditures

Rural producers must know well the production costs and operating costs of their farms, as such knowledge affords the family nucleus the most power in product negotiation, purchasing, and marketing (IICA, 2013). We therefore analyzed the vulnerability of the expenditures of the rural producer regarding the primary activities of the family business, which can directly reduce the income of the producer due to elevated costs of salaries, inputs, the establishment of permanent crops, pasture, planted forest, necessary infrastructure, and the purchase of seed, from preparation to planting, among others (IBGE, 2018).

One of the primary expenses for the rural producer is related to the high costs of electricity (15.9% of expenditure), following by expenditures for purchasing salt, feed, and other supplements (13.5%), the purchase of medication (12.5%), and the purchase of fuel and lubricants (11.3%), which were determinant factors in reducing profit margin and decreasing the competitiveness of the producer, due to high costs (Table 11).

**Table 11.** Number of agricultural establishments, by type of expenditure

Total expenditure by the establishment <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
-- % --					
Rent	421,023	1.6	2	5	10-Medium
Salaries	1,580,498	6.1	2	8	16-Medium
Contracting of services	604,894	2.3	2	5	10-Medium
Fertilizer and correctives	1,782,834	6.8	5	5	25-Medium
Agricultural chemicals	1,661,522	6.4	5	5	25-Medium
Transport of production	527,431	2.0	5	5	25-Medium
Medications	3,264,045	12.5	8	8	64-High
Salt, feed, and other supplements	3,522,966	13.5	8	8	64-High
Seed and seedlings	1,579,559	6.1	5	5	25-Medium
Electricity	4,141,013	15.9	5	8	40-High
Purchase of animals	1,523,960	5.8	5	8	40-High
Purchase of machinery and vehicles	157,969	0.6	2	5	10-Medium
Fuel and lubricants	2,947,076	11.3	5	8	40-High
New permanent crops and forestry	39,726	0.2	2	5	10-Medium
Creation of pasture	315,503	1.2	2	5	10-Medium
Other expenses	2,008,070	7.7	2	5	10-Medium
Total	26,078,089				

<sup>1</sup>IBGE Question 6791; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

Therefore, in terms of risk probability, we note the possibility of increasing expenditure on such items, causing operational and managerial difficulties for the family nucleus. Likewise, to classify impact, we took into consideration the income losses that such expenditures could serve to reduce. As a result, we classified the degree of risk for the variable expenditure as medium, using a weighted average.

### Income

In relation to income, our objective was to identify any instability (regularity) of the resources of rural producers in the management of their rural establishments. In this context, we note that the activities of the farm represent the main source of income for only 41.8% of producers, while 58.2% of producers declared having off-farm jobs to complement their incomes (Table 12). These different income situations reflect activities that demand seasonal work and should, at some point, produce effects on production and yield (Buainain and Dedecca, 2010).

Thus, to classify probability in relation to off-farm activities of the rural business, we considered the possibility that the producer would have to increase his or her share of off-farm work to complement family income, therefore leaving the family business at risk. Consequently, the probability of this event occurring would be high, given the difficulty of resources for family survival and the payment of expenses.

In this case, the risk impact would be classified as high, since such a situation would put the activities of the family production at risk and could generate income losses from rural activities (Table 12).

**Table 12.** Number of rural establishments, by income source

Activities of rural establishment that constitute main income source <sup>1</sup>	Sample	P(A), <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No	2,941,389	58.2	8	8	64-High
Yes	2,113,464	41.8	5	8	40-High
Total	5,054,853				

<sup>1</sup>IBGE Question 6649; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

Thus, to classify probability in relation to off-farm activities of the rural business, we considered the possibility that the producer would have to increase his or her share of off-farm work to complement family income, therefore leaving the family business at risk. Consequently, the probability of this event occurring would be high, given the difficulty of resources for family survival and the payment of expenses. In this case, the risk impact would be classified as high, since such a situation would put the activities of the family production at risk and could generate income losses from rural activities (Table 12).

An additional aspect that we analyzed concerns the resources generated by the rural property, which in this case represent 41.8% (Table 12). We classified this particular component as medium risk probability, since the family could develop new practices within the family farm to increase income. In the same sense, we classified the risk impact as high, since members of the family could devote themselves entirely to off-farm activities to improve incomes, and meanwhile put at risk the primary source of labor on the farm—the family.

For the producer to obtain differentiated credit, he or she must have a minimum of 50% of gross family income originating from the agricultural and non-agricultural activities of the farm, and have the work of the family, specifically, be the predominant work of the rural establishment (BC, 2018). We verified the extent of credit granted by the Pronaf program to the rural producers and found that the data showed a reduction in revenue from the rural establishment as the main source of family income.

It is important to mention that the composition of income from agricultural families originating predominantly from the activities carried out within the rural establishment, represented in 2017 the equivalent to 41.8%, that is, -8.2% of the minimum requirement established by the Pronaf Program for eligibility to the differentiated credit. Therefore, new approaches to Pronaf will be fundamental, in view of the change in the behavior of the primary income of rural families and the need to adapt the policies for granting agricultural credit in exchange for social cohesion in small and medium rural establishments (Favareto, 2010).

When analyzing the other sources of income of the rural producer, we found that 45.8% receive retirement funds (Table 13), which implies an older population. Therefore, seeking off-farm activities to complement the family income would be even more demanding on the producer.

**Table 13.** Number of agricultural establishments, by producer's external income source

Other income received by producer <sup>1</sup>	Sample	P(A), <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
Retirement or pension	1,956,260	45.8	8	8	64-High
Income from off-farm activities	1,143,824	26.8	8	8	64-High
Receives funds from crop guarantee program (Programa Garantia Safra)	234,179	5.5	5	8	40-High
Receives funds from Farm Activity Guarantee Program for Smallholders (Programa Garantia da Atividade Agropecuária da Agricultura Familiar - PROAGRO Mais)	8,410	0.2	5	8	40-High
Receives funds from National Rural Housing Program (Programa Nacional de Habitação Rural-Minha Casa Minha Vida)	8,136	0.2	5	8	40-High
Receives funds for environmental services (Bolsa Verde and state programs)	15,351	0.4	5	8	40-High
Receives funds from government programs (federal, state, or municipal)	908,653	21.3	5	8	40-High
Total	4,274,813				

<sup>1</sup>IBGE Question 6792; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

Meanwhile, 21.3% of producers claimed they received income from government programs (federal, state, or municipal), and we therefore analyzed vulnerability indices in relation to the incomes of rural producers (Table 13). The income received by producers was largely composed of retirement income and salaries obtained from off-farm activities (Favareto, 2010). We therefore classified risk for the income variable as high, using a weighted average.

**Technical Assistance**

We then sought to analyze producer vulnerability regarding access to technical assistance and the use of soil correctives. We must highlight the fundamental role of the ATER network in Brazil, which aids producer families gain access to technology instruments and good management practices to develop their rural establishments, including the conservation of natural resources and community development.

Technical assistance provides education in which the smallholder gains access to formerly unfamiliar concepts and practices related to management and soil treatment, and learns the importance of crop rotation and the adequate use of agricultural chemicals, all of which serve to meet the development potential of each family farm (Marschall, 2009).

In this context, we highlight that 80.1% of producers received no specialized technical assistance (Table 14). Therefore, we classified the probability of a risk event occurring and the producer having no technical preparation as high and the risk impact for the property as also high, given that a lack of technical assistance jeopardizes the subsistence and food security of the family. Thus, we can conclude that these producers suffer a great lack of managerial support, despite most producers having considerable tacit knowledge.

**Table 14.** Number of agricultural establishments and whether they receive technical assistance

The establishment receives technical orientation and assistance specialized in agriculture <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No	4,064,296	80.1	8	8	64-High
Yes	1,007,036	19.9	5	8	25-Medium
Total	5,071,332				

<sup>1</sup>IBGE Question 6651; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

One of the main factors contributing to the low rate of technical assistance was related to the low rate of registration of rural producers with DAP (59.2%), which was essential in providing technical assistance to the rural producer (Table 16). The lack of technical assistance was further exacerbated by the low level of formal education among producers and their low rate of adoption of new technology, which could serve to mitigate incorrect practices in production and production losses (Castro and Pereira, 2017).

For producers who received technical assistance, we classified their risk probability and impact as medium, given the low number of technicians available to cover the demand for technical assistance and the resulting losses in knowledge transfer to the rural producer. Therefore, we suggest that producers register with an association or cooperative to further reduce their risk of not receiving technical assistance.

We additionally analyzed the use of lime and other soil correctives and found that Embrapa (2018) stresses that correctives and fertilizers are agricultural inputs with a large impact on yield, particularly in areas where soil is naturally acidic and not very fertile, justifying the need for the systematic replacement of nutrients to guarantee sustainable production.

Thus, we found that only 14.4% of producers applied lime or other soil correctives on their farms (Table 15). Meanwhile, 85.6% of rural producers instead chose to reduce their dependence on fertilizers and correctives, mitigating the risk of silting and contaminating water bodies, soil surfaces, and ground below the surface (Embrapa, 2018).

For the producers that use other correctives on their farm, we classified their risk probability as medium, in the case they receive no technical assistance. Similarly, we classified the risk impact of the property generating losses as medium.

**Table 15.** Number of agricultural establishments and practice of fertilizer, lime, and agricultural chemical application

The establishment receives technical orientation and assistance specialized in agriculture <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No	4,064,296	80.1	8	8	64-High
Yes	1,007,036	19.9	5	5	25-Medium
Total	5,071,332				

<sup>1</sup>IBGE Question 6651; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

However, for producers not using correctives, we decreased their probability of losses to low, since we assume that their lack of corrective use was guided by a soil analysis and overseen by a rural extension agent. We also classified their risk impact as low, as the non-use of correctives implies less dependence on fertilizer and soil correctives, and suggests financial gains in other areas such as the certification of organic or ecological products and good production practices, among others.

One of the main factors contributing to the low rate of technical assistance was related to the low rate of registration of rural producers with DAP (59.2%), which was essential in providing technical assistance to the rural producer (Table 16). The lack of technical assistance was further exacerbated by the low level of formal education among producers and their low rate of adoption of new technology, which could serve to mitigate incorrect practices in production and production losses (Castro and Pereira, 2017).

For producers who received technical assistance, we classified their risk probability and impact as medium, given the low number of technicians available to cover the demand for technical assistance and the resulting losses in knowledge transfer to the rural producer. Therefore, we suggest that producers register with an association or cooperative to further reduce their risk of not receiving technical assistance.

We additionally analyzed the use of lime and other soil correctives and found that Embrapa (2018) stresses that correctives and fertilizers are agricultural inputs with a large impact on yield, particularly in areas where soil is naturally acidic and not very fertile, justifying the need for the systematic replacement of nutrients to guarantee sustainable production.

Thus, we found that only 14.4% of producers applied lime or other soil correctives on their farms (Table 16). Meanwhile, 85.6% of rural producers instead chose to reduce their dependence on fertilizers and correctives, mitigating the risk of silting and contaminating water bodies, soil surfaces, and ground below the surface (Embrapa, 2018).

**Table 16.** Number of agricultural establishments and practice of fertilizer, lime, and agricultural chemical application.

Establishment applies lime or other pH correctives to the soil <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s <sup>3</sup>	I.s <sup>4</sup>	Risk
		-- % --			
No	4,317,505	85.6	2	2	4-Low
Yes	728,043	14.4	5	5	25-Medium
Total	5,045,548				

<sup>1</sup>IBGE Question 6651; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

For the producers that use other correctives on their farm, we classified their risk probability as medium, in the case they receive no technical assistance. Similarly, we classified the risk impact of the property generating losses as medium.

However, for producers not using correctives, we decreased their probability of losses to low, since we assume that their lack of corrective use was guided by a soil analysis and overseen by a rural extension agent. We also classified their risk impact as low, as the non-use of correctives implies less dependence on fertilizer and soil correctives, and suggests financial gains in other areas such as the certification of organic or ecological products and good production practices, among others.

According to a study by the International Policy Center for Inclusive Growth [IPC-IG] (2016), the reduction in fertilizer application allowed for considerable cost savings among rural producers,

encouraged soil fertility, prevented soil erosion and degradation, and added value to the products to be sold. Therefore, we classified the level of risk for the technical assistance variable as medium, using a weighted average.

### Good agricultural practices

In analyzing good agricultural practices, our objective was to study the practices for pest and disease control of the rural establishments.

The integrated management and biological control of pests and disease in agriculture have become more widespread, aiming to minimize current levels of pesticide use—particularly to reduce environmental impacts and minimize food waste—and have thereby improved the quality of life of rural producers and of consumers and resulted in a set of innovative practices and processes (Embrapa, 2018).

In this context, we note that since 64% of rural establishments did not use agricultural chemicals to control for pests and disease, the risk probability of production losses would be low (Table 17). Similarly, we classified the risk impact as low, given that producers can use natural pesticides to mitigate risk.

**Table 17.** Number of rural establishments and use of agricultural chemicals

Agricultural chemical use to control pests or disease <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s. <sup>3</sup>	I.s. <sup>4</sup>	Risk
		-- % --			
No	3,230,186	85.6	2	2	4-Low
Yes	1,681,001	14.4	5	5	25-Medium
Yes, but did not need to use during the period	134,360				
Total	5,045,547				

<sup>1</sup>IBGE Question 6653; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

The rural producers who used agricultural chemicals to control pests are likely to have an event occur that alters their business objectives, especially due to the potential excessive use of pesticides. Therefore, we classified their risk probability as medium. Similarly, we classified their risk impact as medium, since the increased use of pesticides could also result in increased family income and food security for the family. However, the decision to use agricultural chemicals must always be made under the guidance of a professional and taking into account the product specifications and the degree of risk exposure.

The use of biological controls with small animals such as chickens, ducks, quail, and others, is an important tool for the prevention and control of diseases in family farming. This type of management has many advantages, since it represents a new option for family subsistence, particularly because it is cheaper than using insecticides and does not harm the environment or consumers (IPC-IG, 2016).

In this context, we note that 76.9% of rural producers control for animal diseases or parasites, and thus, the probability of an event occurring that would generate losses would be low (Table 18). We also classified the impact level as low, since these producers adopt measures for risk mitigation.

**Table 18.** Number of agricultural establishments and disease and/or parasite control

Agricultural chemical use to control pests or disease <sup>1</sup>	Sample	P(A). <sup>2</sup>	P.s. <sup>3</sup>	I.s. <sup>4</sup>	Risk
		-- % --			
No	944,614	23.1	5	5	25-Medium
Yes	3,137,889	76.9	2	2	4-Low
Yes, but did not need to use during the period	4,082,503				
Total	5,045,547				

<sup>1</sup>IBGE Question 6600; <sup>2</sup>P(A): probability of event occurring; <sup>3</sup>P.s: subjective probability; <sup>4</sup>I.s: subjective impact  
Source: IBGE (2018)

However, 23.1% producers stated that they do not control for animal parasites (Table 19), and we therefore classified the probability of a risk event occurring that would generate losses for these producers as medium. We similarly classified their financial risk impact as medium. Overall, we classified the degree of risk for good agricultural practices as medium, using a weighted average.

### Graphic representation

The exploratory data analysis limited us to calculating certain measures of position such as average and variance. Yet, graphical techniques are more useful due to their strong visual appeal, and their dynamic is generally easier to understand (Bussab and Morettin, 2013). Figure 3 therefore presents the distributions of the thematic dimensions of the risks classified in Table 3.

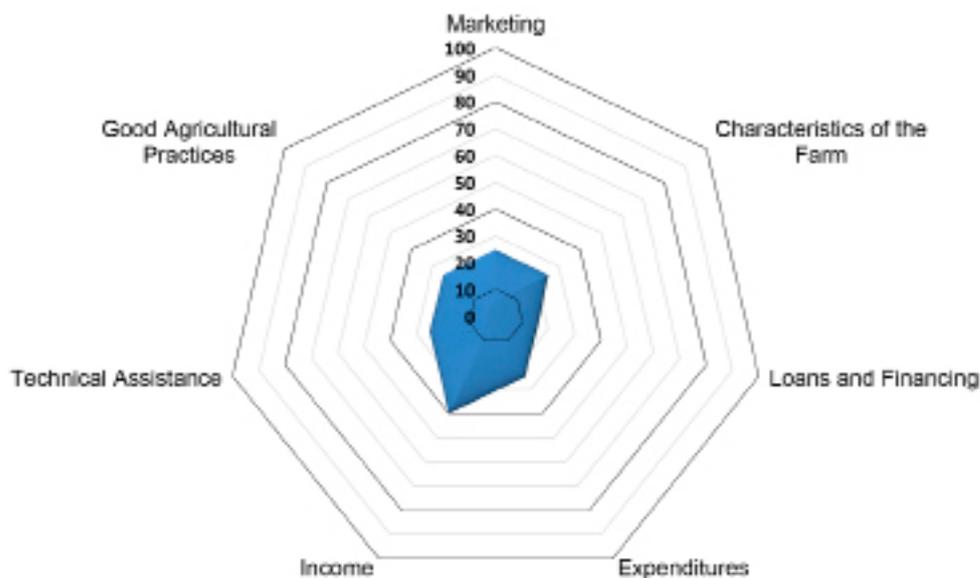


Figure 3. Thematic dimensions and degree of risk  
Source: Study results

We constructed Figure 3 using four points: 0-9 (low risk); 10-39 (medium risk); 40-79 (high risk); and 80-100 (extreme risk), which reflect degrees of vulnerability. A situation of higher risk is represented by the external region of the graph and a situation of least risk is closest to the center of the graph. Our results showed a predominance of risk in the central region of the graph, where we identified the average degree of risk from the variables analyzed.

### Conclusion

Analyzing and identifying the components of business risk management of the rural producer and their various sources of risk, we found that the factors with the greatest impact on the income of the producer were related to rural business expenditures and the availability of financial resources. We therefore suggest, as a means of mitigating these risks, a debate regarding new public policies in the sector that include, for example, the purchase of animal medications and vaccines, the cost of electricity, improving income distribution in the field, and expanding ATER.

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