A Comparative Study of the Use of Climate Information in Agriculture in the U.S. Midwest, Southern Brazil, and Argentine Pampas

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Abstract

The increased climate variability in recent years has driven the demand for climate information for decision-making and the interest in risk management tools. Although the effects of this variability on agricultural productivity have been extensively studied, there are few studies on how weather/climate forecasts affect agribusiness decisions, assisting farmers in making effective planning decisions. In a comparative study in the United States, Brazil, and Argentina, the major agricultural regions in the world, this research investigates the influence of weather and seasonal climate forecasts in farm decision-making. Primary data for this study is from a survey conducted with 510 farmers in the U.S. Midwest, Argentine Pampas, and Southern Brazil. There are strong similarities among the analyzed regions. In all three cases, survey responses indicate that climate information is a crucial input for agricultural producers. Applications on cell phones and websites have become the most popular tools for accessing climate information in all three regions, followed by television and radio. The perception of climate variability as a source of risk in farming varies within regions, with Brazilian and Argentinian farmers having a higher level of concern than American producers. In southern Brazil and the Argentine Pampas, it is common for farmers to adapt their crop choices and management practices based on El Niño/La Niña forecasts. Otherwise, a significant proportion of American producers do not make any changes based on phenomena forecasts, and the primary influence of these forecasts is on marketing strategies. A better understanding of farmers' current use of climate information is a first step in assessing opportunities for improving the provision of climate services in agriculture.

Keywords: Farm-Decision, Weather, Forecast, Risk Management, ENSO.

Introduction

Unfavorable weather events are identified as the main risk in extensive agriculture (Komarek et al., 2020). Droughts continue to be a significant natural hazard worldwide (Cai et al., 2017). Extreme weather outcomes have been linked to the El Niño Southern Oscillation (ENSO), which globally impacts agricultural production. Argentina and Southern Brazil were impacted by drought conditions caused by La Nina three years in a row, from 2020 to 2023, resulting in harvest failures for major cash crops such as soybean, first-season corn, and wheat. In 2012, the U.S. Midwest experienced a historical drought that was comparable to the drought of 1988.

While much research has been done on the impacts of climate variability on agricultural production, few studies have shown how weather/climate forecasts influence agribusiness decisions, helping producers plan efficiently. On the other hand, innovation in climate services for agriculture is occurring at great speed, so it is necessary to update studies on using these services in agriculture.

Mase and Prokopy (2014) reviewed perceptions and use of climate information, forecasts, and decision support tools in Australia, Canada, and the United States over a 30-year period. Farmers in some regions emphasize short-term forecasts, which are perceived to be more accurate and reliable compared to seasonal climate forecasts (SCF). Most producers use the SCF to plan activities in regions where livestock activity is more important.

Although seasonal climate forecasts are produced operationally at several centers worldwide, they are rarely integrated objectively in creating user-oriented forecast variables to help decision-making (Coelho and Costa, 2010). Other studies reported limited use and barriers to using available climate information, particularly by small farmers in less-developed countries (Hernández et al., 2015; Letson et al., 2001).

Several studies use Behavioral Science concepts to explain the heterogeneity in the use of climate information in agriculture (e.g., Lu et al., 2021). In the first place, the attitude towards climate information is identified, which depends on the perceived probability that the adaptation of agricultural planning to a climate forecast will improve the result, and on the assessment of the importance of the change in the result. The use of climate forecasts is also related to subjective norms, that is, the perception of how other actors would consider using this information. Finally, the use of climate information is associated with the perception of one's own ability to interpret and use this information in planning.

In turn, it is considered that the attitude, subjective norms and perception of the ability to use climate information are influenced by different characteristics of decision-makers and their farms. Previous studies have identified the following positive and negative relationships between these characteristics and the use of climate forecasts in decisions: concerns about climate variability (+), social pressure (+), farm size (+), gender (male+), educational level (+), perceptions about forecast inaccuracy (-), concerns about other sources of risk (-), inflexibility of the agricultural system, the role of advisors (+), age (- and +) (Lu et al., 2021; Mase and Prokopy, 2014; Letson et al., 2001)

In a comparative study in the U.S. Midwest, Argentine Pampas, and Southern Brazil, this research investigates the influence of weather and seasonal climate forecasts in farm decision-making. The United States, Brazil, and Argentina are major agricultural regions with relevant participation in the global market. These countries were responsible for almost 300 million metric tons of soybeans in the 2021/2022 crop season, 82% of world production. Regarding soybeans exports, these countries accounted for about 90% of the world market (USDA, 2023). In relation to corn production, the United States, Brazil, and Argentina produced around 45% of world production in the 2021/2022 crop season, while in wheat, the share of the three countries in the world market was 10% (USDA, 2023a).

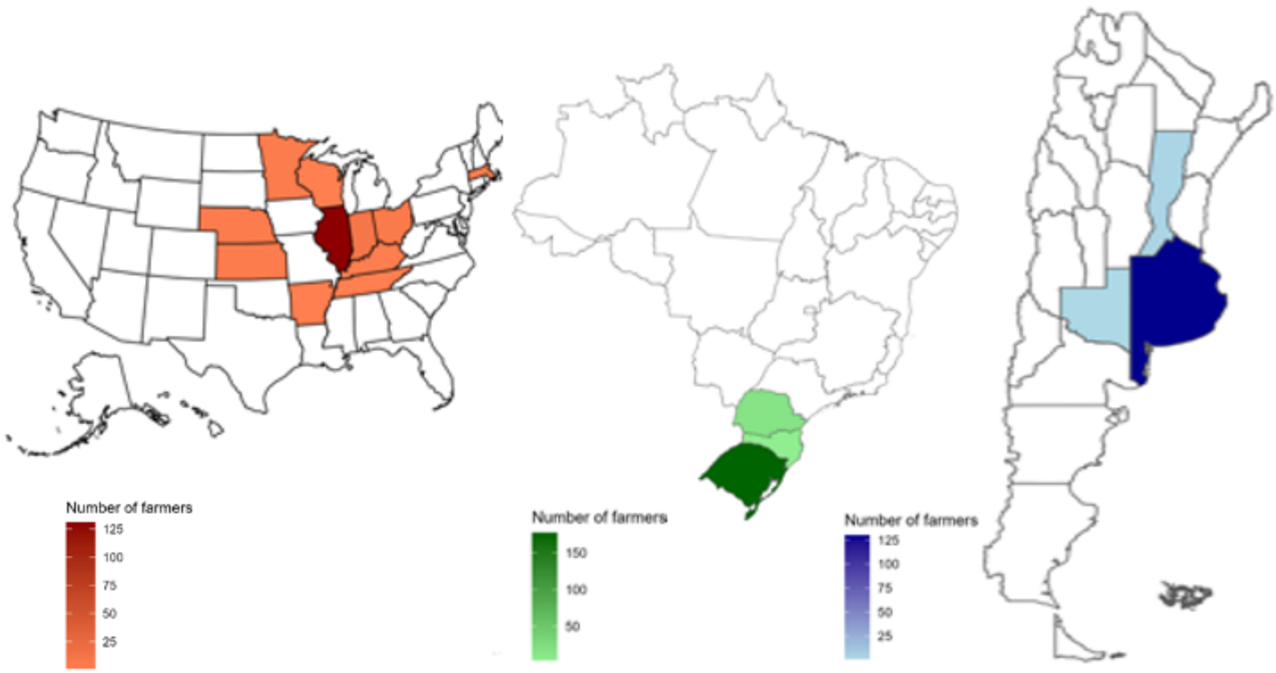
Extreme weather events generate, not only adverse effects for farmers, particularly small ones, but also affect all actors in the agricultural sector. In addition, there are sharp reductions in tax collection and investments. The increase in climate variability has driven the demand for climate information for decision-making and the interest in risk management tools. Therefore, the potential of using weather/climate information for agricultural risk reduction is of main importance (Solow et al., 1998). A better understanding of farmers' current use of climate information is a first step in assessing opportunities for improving the provision of climate services in agriculture.

Data and Methods

Study Region

This comparative study was conducted in the U.S. Midwest, Southern Brazil, and Argentina Central Pampas (Figure 1). These regions were chosen because they are the most important in rainfed grain production, and they share similar climatic variations in the seasons despite the specific characteristics of each area.

Figure 1: Maps of the study areas in the United States, Brazil, and Argentina



Most of the American farmers who participated in this study have their fields in Illinois, and some manage land in other states within the US Corn Belt (Figure 1). The U.S. Corn Belt region is known for its fertile land and agricultural prominence. The climate classifications for the area range from semi-arid steppe across far western sections to microthermal humid continental mild summer across northern sections to microthermal humid continental hot summer elsewhere. Average annual temperature varies by about 8 °C across the region (Haigh et al., 2015). With 75% of the area's cropland planted to corn and soybeans, the U.S. Midwest is one of the world's most intensive agricultural production areas, consistently impacting the global economy (USDA, 2020).

Unlike the rest of Brazil, the South of Brazil is in the subtropical region, characterized by a humid temperate climate, with hot summers in lowland areas (Barbieri et al., 2014). In higher altitude areas, the summer is mild, and the winter is harsh (average monthly temperature is below 10 °C), with constant frosts and occasional snowfalls (Barbieri et al., 2014). Agricultural production in Brazil originated in the southern states of Rio Grande do Sul, Paraná, and Santa Catarina. In the 2021/22 crop season, for example, these states accounted for about 24% of grain production in the country (Conab, 2023).

Surveyed farmers in Argentina have their farms in Buenos Aires State, and some of them also farm in neighboring states within the Argentine Central Pampas. A large proportion of Argentina's crop production originated in the Pampas region. Its economy is based on agriculture and livestock industrialization. The area is characterized by long periods of drought and floods, affecting water availability, agricultural systems' productivity, and other human activities. The Pampas is located within subtropical and mid-latitudes or temperate climates (Rolla et al., 2018; Aliaga, Ferrelli, & Piccolo, 2017).

Survey Instrument

The questionnaire survey employed in this study was based on a literature review and previous research focused on the use of climate and weather information in agribusiness decisions. The online survey was prepared in English, Spanish, and Portuguese, the official languages in the United States, Argentina, and Brazil, respectively. The questionnaire was implemented using Qualtrics software for the United States and Brazil and Google Forms for Argentina.

The survey is comprised of six main sections: (1) characteristics of the production system, scale, and land tenure, (2) primary sources of risk in farming. (3) the access to climate information, (4) the influence of climate information on decisions, (5) demand for climate services, and (6) farmers' sociodemographic characteristics. English, Spanish, and Portuguese surveys are available from the corresponding author upon request. Some surveys have missing answers. The results section reports the number of observations for each variable.

Data Collection

Primary data for this research is from a farmers' survey conducted in 2022 and 2023 in the U.S. Midwest, Argentine Pampas, and Southern Brazil. Total answers to the survey were 510, being 178 from American farmers, 202 from Brazilian farmers, and 130 from Argentine farmers. Members of the target population met specific criteria, such as easy accessibility, availability at a given time, or willingness to participate (Etikan, Musa, and Alkassim, 2016).

The online survey was distributed primarily among *Farmdoc* subscribers in the United States. *Farmdoc* is an extension program of the University of Illinois. In the last 20 years, it has become the premier online source of economic analysis and market information for commercial producers in the Midwestern United States. In Brazil, the online survey was distributed with help from the National Rural Learning Service in Rio Grande do Sul (Senar-RS, Portuguese acronym), Cooperative Technical Network (RTC, Portuguese acronym), and Agro Extension from the Federal University of Rio Grande do Sul (UFRGS, Portuguese acronym). In Argentina, a research team from National Institute of Agricultural Technology (INTA) and the National University of Northwestern Buenos Aires (UNNOBA) emailed the invitation for survey participation to farmers included in the registry of producers of the National Food Sanitation and Quality Service of Argentina (SENASA, Spanish acronym) for four counties in the North of Buenos Aires.

Data Analysis

All survey data was consolidated in a Qualtrics platform, and Google Form reports, were exported in CSV, and imported in R for statistical analysis. The results are presented as descriptive statistics for each region. A probit regression model is estimated to test for the relationship between the degree of influence of seasonal climate forecast in farmers' decisions and farm characteristics. The data was treated as probability sampling from an infinite population. The most critical requirement of probability sampling is that everyone in your population has a known and equal chance of getting selected.

Results and Discussion

This section presents and discusses a preliminary analysis regarding sample characteristics and the findings regarding the farmers' current use of climate information in the United States, Brazil, and Argentina. The sociodemographic characteristics considered in this study were age, experience in agriculture, educational degree, operated land, and percentage of rented land. The second part of the section presents and discusses the results regarding sources of risk in farming, access to climate/weather information, and farmers' decisions.

Sample Characteristics

Differences exist in the farmer's profile between the U.S. Midwest, Southern Brazil, and Argentine Pampas. According to the sample in this study, farmers in Brazil and Argentina tend to be younger than in the United States. Among the farmers who participated in the survey in Brazil and Argentina, the average age was 43 years old and 47 years old, respectively. Conversely, the average age in the United States was 61 years old. In Argentina, 82% of respondents have agricultural production as the primary source of income, whereas in Brazil, 69% and in the United States, only 48% (Table 1).

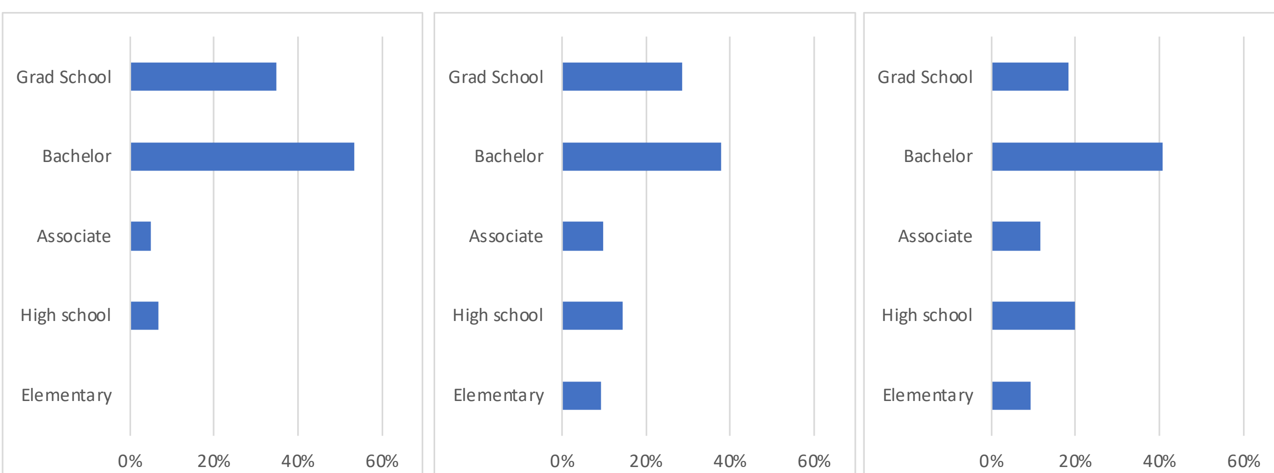
Table 1. Sociodemographic characteristics of survey's respondents in the United States, Brazil, and Argentina

		Median/percentage		
		US	Brazil	Argentina
Age	years	60.9	43.3	47.2
Experience in agriculture	years	37.2	24.5	24.2
Agricultural production as the main source of income	%	48%	69%	82%

The age difference is consistent with the average age of producers in the three countries. In the United States, 62% of farmers are older than 55 years old, according to the U.S. Census of Agriculture (USDA, 2017). In Brazil, the percentage of farmers more senior than 55 years old is 46%, according to data from the Census of Agriculture (IBGE, 2017). In Buenos Aires, Argentina, 50% of farmers are between 40-65 years old (INDEC, 2018).

Figure 2 shows the respondents' level of education in each country. The proportion of farmers with a bachelor's degree is similar in Southern Brazil and Argentine Pampas, around 40%. In the U.S. Midwest, the percentage is higher than 50%. Relative to the graduate school: almost 40% of the respondents in the United States have obtained that degree, while less than 30% have done so in Southern Brazil and less than 20% in the Argentine Pampas (Figure 1). So, in the three regions, the farm managers are highly educated. In approximately 60% of the surveys, the education degree is related to agriculture.

Figure 2. Education degree of respondents in the United States, Brazil, and Argentina



A. Midwest United States B. Southern Brazil C. Argentine Pampas

Note: In 56%, 53% and 82% of the surveys University education degree is related to agriculture in the United States, Brazil and Argentina, respectively

Figure 3 shows the respondents' farm size in three countries. The results are quite different. In Southern Brazil, about 60% of the respondents farm less than 495 acres. Meanwhile, in the US Midwest, 30% farm less than 495 acres. In Argentine Pampas, almost 40% farm less than 495 hectares. The percentage of respondents who farm more than 3,707 acres is lower in Brazil than in the United States and Argentina. The difference in farm size is consistent with the agriculture profile in the South of Brazil, characterized by small and medium properties. For example, in the state of Mato Grosso state, in the Center-West of Brazil, the average size of a soybean farm is 3,057 acres, while in the Rio Grande do Sul state, in the South, it is 133 acres (IBGE, 2017).

Figure 3. Operated land of survey's respondents in the United States, Brazil, and Argentina

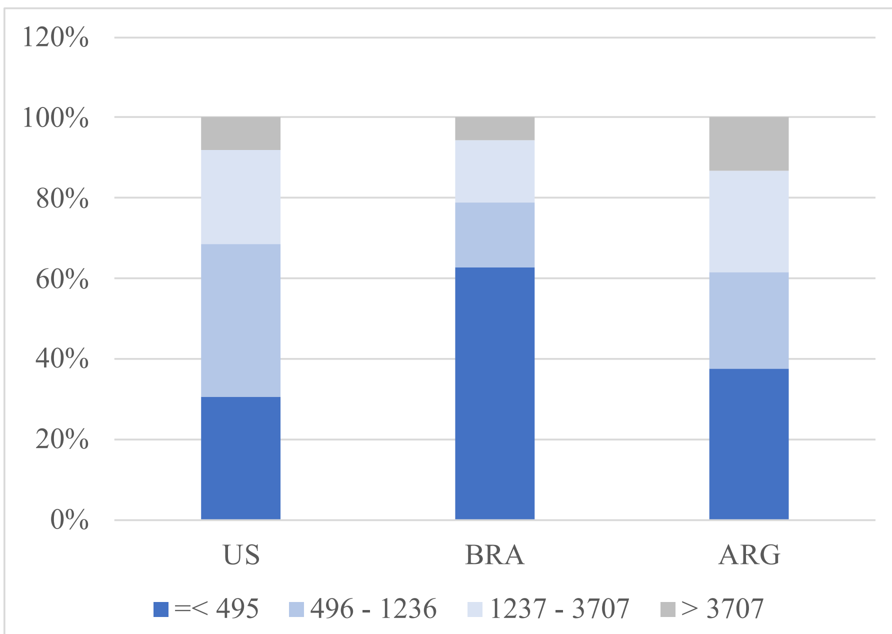
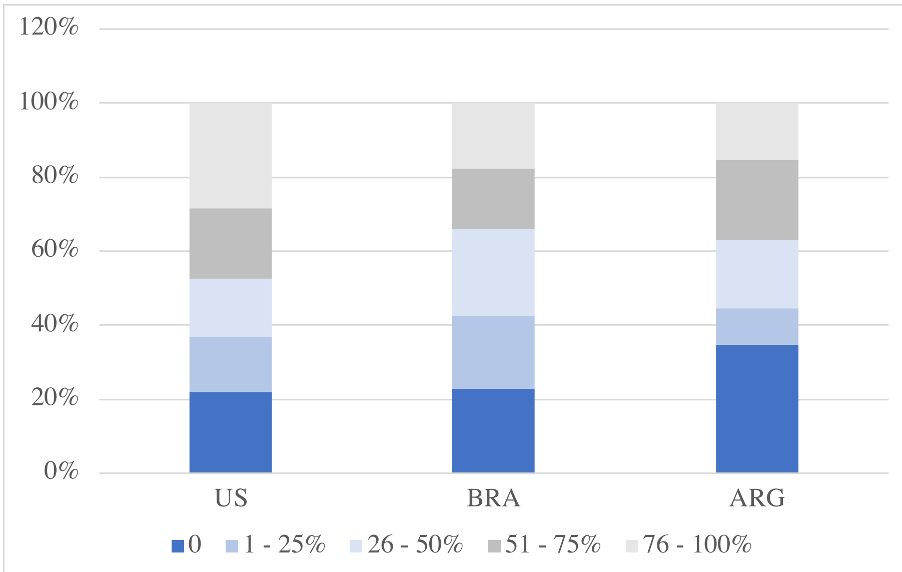


Figure 4 shows the respondents' percentage of rented land in the three countries. The Argentine Pampas had the highest rate of own area, with almost 40% of respondents with no rented land. The percentage of zero-rented land in the United States and Brazil was quite similar, around 20%. At the same time, the highest rate of rented land, from 76% to 100%, was registered among

U.S. Midwest respondents, with more than 20% of rented land. That percentage in Brazil and Argentina was less than 20%.

Figure 4. Percentage of rented land of survey's respondents in the United States, Brazil, and Argentina



Finally, in Brazil and Argentina, the percentage of integration between crops and livestock was quite similar: 60% and 64%, respectively. On the other hand, that percentage was lower among U.S. Midwest respondents, 27%. In most cases, livestock activity is less important than crop production.

Soybean and corn crops predominate in importance in the U.S. Midwest, Southern Brazil, and Argentine Pampa, followed by wheat in the winter season. The results are consistent with the land use occupation in the three regions. In Southern Brazil, for example, the soybean occupied 59% of the total cropland in the 2022/23 crop season, whereas the corn occupied 18% and the wheat 13% (Conab, 2023). In the U.S. Midwest, 75% of the area's cropland is planted with corn and soybeans (USDA, 2023). The most often rotation in the United States is a 50%-50% rotation between corn and soybeans. In Argentina Central Pampas, corn, soybeans, and wheat account for 80% of the planted area (SAGyP, 2023).

Sources of Risk in Farming

The weather was identified as the primary source of risk for most farmers surveyed in the U.S. Midwest, Southern Brazil, and Argentine Pampas. The result reinforces the relevance of the weather in crop production. Many studies have focused on the impacts of weather on yield variability (D'Agostino & Schlenker, 2016; Attavanich & McCarl, 2014) and the implications of climate on cropland production (Boyer, Park, & Yun, 2022; Cohn et al., 2016).

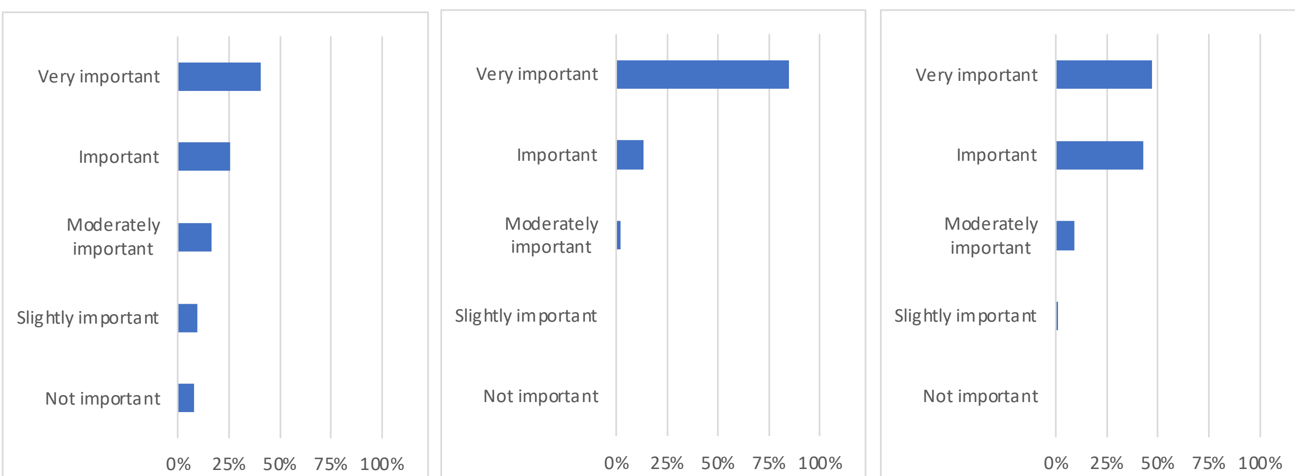
Other sources of risk mentioned by farmers are input prices/availability and output prices, government interventions, inflation, trade, yield, finance, and personal. Input costs are the operating costs for a farm that require upfront purchases necessary to begin production. These include fertilizer, pesticides, seeds, weaned animals, feed, and any other production input. For example, the Russian invasion of Ukraine substantially elevates the risk of disruptions in the global fertilizer trade. Russia is the world's largest exporter of fertilizers, accounting for 23% of ammonia exports, 14% of urea exports, 10% of processed phosphate exports, and 21% of potash exports (Colussi, Schnitkey, and Zulauf, 2022).

The output, or the producer prices index of agricultural products, represents the measure of transaction prices reflecting revenue received by the producer for goods and services sold to customers over a period. The war between Russia and Ukraine, preceded by the coronavirus pandemic, jolted commodity markets and caused a rise in the price of products such as wheat, soybean, and corn. The survey results in the three countries were probably influenced by these historical facts that shook up the world food market.

Another primary source of risk identified by farmers was government interventions. The most common form of government intervention in the agricultural sector is a form of incentive (subsidies). Restrictions on exports of products of strategic significance or restrictions on imports of any agricultural products may be referred to as restrictive intervention (Aliyeva et al. 2019). In Argentina, for example, there is a tax of 33% on soybean exports from Argentina and 31% on soybean oil and soybean meal. In the case of corn and wheat, the tax on their sales abroad is 12%. The tariffs are paid by export companies, which pass the cost down to farmers.

The perception of climate variability as a source of risk in farming varies within regions. In Southern Brazil and Argentine Pampas, around 90% of farmers answered that climate variability is very important or important. Meanwhile, that percentage was lower among U.S. farmers, approximately 70%. In the United States, almost 20% of respondents indicated that climate variability as a source of risk in farming is slightly important or not important (Figure 5).

Figure 5. Perception of the importance of climate variability as a source of risk in farming



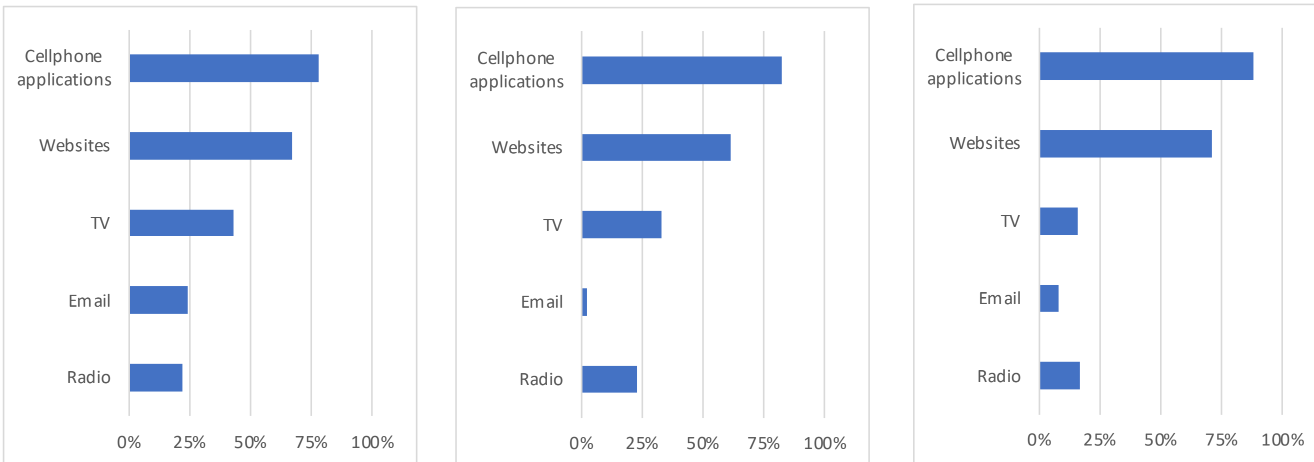
A. Midwest United States B. Southern Brazil C. Argentine Pampas

Note that the perceptions of the slightly and not important of climate variability as a source of risk in farming were almost null in Southern Brazil and Argentina. This reinforces how relevant climate/weather is in agriculture in South America, especially in the extreme south of the region where climate variability is more significant than in other areas. This result may be influenced by the data collection period in Argentine Pampas and Southern Brazil, in 2022 and 2023, respectively. Both regions suffered a severe drought caused by three La Niña in a row, drastically reducing agriculture yields. The phenomena favor increased rain across northern Brazil and decreased rainfall in extreme southern Brazil and Argentina.

Access to Climate/Weather Information

Farmers from the three regions farmers are highly attentive to climate information. Most of them check weather/climate information one or several times a day (97%, 92%, and 83% for the U.S. Midwest, Southern Brazil, and Argentine Pampas, respectively). Farmers access information mainly through cell phone applications and websites (Figure 7). Within the digital universe, the tool that has become the most popular is the cell phone (Kabbiri et al., 2018). Through it is possible to have access to several websites and applications that provide data and facilitate the exchange of information. The survey results regarding farmers' access to climate information through apps and websites are consistent with the rapid growth of the Internet, the ease of global communication, and the ability of news and information to spread with surprising speed and intensity (Easley and Kleinberg, 2010).

Figure 6. Farmers' access to climate information in the United States, Brazil, and Argentina



A. Midwest United States B. Southern Brazil C. Argentine Pampas

The farmers interviewed in the three countries also consulted climate information on TV (Figure 7). The relevance of TV could be attributed to the role played by this channel in enhancing the capacity of farmers by broadcasting different agricultural-related programs, including weather channels. Farmers can quickly get forecast information by watching TV agriculture-related programs (Chhachhar et al., 2014; Murty and Abhinov, 2012).

According to farmers interviewed in the three countries, radio is another way to access climate information. This result is consistent with the radio's immediacy and accessibility. This communication channel can be accessed in cars and trucks while operating agricultural equipment. The radio also usually brings local news, such as weather forecasts. Then, the results indicate that mass media channel communications, such as TV and Radio, remain relevant to the farmers to get information.

Most farmers identify public sources as a source of climate/weather information (Table 2). In the United States and Argentina, the National Oceanic and Atmospheric Administration (NOAA), and the Servicio Meteorológico Nacional (SMN), respectively, are ranked in first place among the sources most frequently mentioned by farmers. In Brazil, the Instituto Nacional de Meteorologia (INMET) is ranked in 5th place (Table 2).

Table 2: Main sources of climate information for farmers in the United States, Brazil, and Argentina

1	NOAA	CLIMATEMPO	Servicio Meteorológico Nacional
2	The Weather Channel	YR	BoosterAGRO
3	Weather Underground	Windy	Windguru
4	AccuWeather	Clic Tempo	INTA - Clima y Agua
5	Local news/radio TV	Instituto Nacional de Meteorologia / The Weather Channel / MET SUL Meteorologia	YR
6	Eric Snodgrass, Nutrien		AccuWeather
7	Weather Bug		Canal Rural
8	Climate Fieldview	Tempo AGORA	The Weather Channel
9	DTN	METEORED	Oficina de Riesgo Agropecuario
10	My radar - Agrible	caal	METEORED / Meteorólogo. Leo Benedictis

A. Midwest United States B. Southern Brazil C. Argentine Pampas

The Instituto Nacional de Tecnología Agropecuaria (INTA) is also a significant public source of information for Argentine farmers. Additionally, private services such as the Weather Channel are among the top 10 most frequently mentioned by farmers in all three countries, while YR and METEORED are popular in both South American countries." (Table 2).

Farm Decisions and ENSO

The El Niño-Southern Oscillation (ENSO) is a large-scale seasonal event that arises from atmosphere-ocean interactions and is characterized by sea surface temperature anomalies. Depending on the type of anomaly, the event is known as El Niño (warming) or La Niña (cooling). In the absence of an anomaly, it is classified as a neutral state (Trenberth, 1997; Adams et al., 1999).

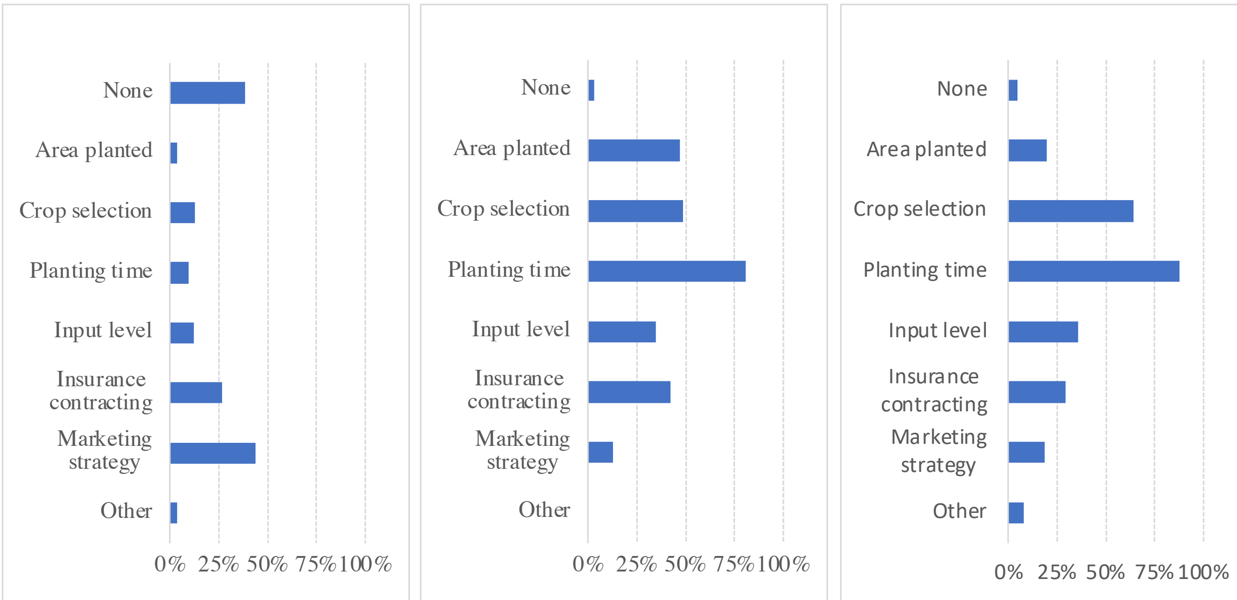
Significant impacts of the ENSO phenomenon on world agriculture have been identified, generating losses or gains in activity according to the region and phase of the phenomenon. Iizumi et al. (2014) estimated ENSO world-level effects on the yields of primary agricultural products.

They reported that El Niño is likely to improve the global soybeans average yield by 2% to 5%. On the contrary, in La Niña years, global average soybean yields tend to be lower than expected.

With respect to the use of ENSO-based forecasts in farming decisions, the answers were similar in Brazil and Argentine and quite different from the U.S. survey answers. Almost half of the surveyed farmers in the U.S. Midwest indicated that this forecast does not influence farm business decisions. In contrast, only 3% and 5% of farmers reported that the ENSO forecast does not influence farming decisions for Southern Brazil and Argentine Pampa, respectively. These differences in perceptions are consistent with published studies that show a weak relationship between ENSO episodes and soybean/corn yield levels in the United States. In contrast, there has been a strong relationship between grain yields and ENSO phases in Argentina and southern Brazil over the last 30 years (e.g., Cabrini, Colussi, and Schnitkey, 2022).

Within the farming decisions influenced by the ENSO-based forecast, *Marketing strategy* was selected with the higher frequency in the U.S. surveys. In contrast, *Marketing strategy* was the less selected option in South America's surveys. *Planting time* and *Crop selection* were the farm decisions selected for most farms in Brazil and Argentina (Figure 8). This result could be related to the common practice of double cropping in South America, where farmers in these regions usually plant soybean or corn during spring/summer and wheat during fall/winter. So, depending on the weather forecast for the year, it is possible to adjust the planting time and the crop selection to manage the weather risk.

Figure 7. Influence of ENSO forecast in farming decisions in the United States, Brazil, and Argentina



A. Midwest United States B. Southern Brazil C. Argentine Pampas

The insurance contracting was selected by farmers from the three regions, with a percentage around 25% in the U.S. Midwest and Argentina and more than 40% in Southern Brazil. Variables, such as precipitation, soil moisture, and solar radiation, gain more importance due to extreme weather events, such as ENSO. These impacts, for example, translate into economically meaningful effects on crop insurance premium rates (Tack and Ubilava, 2015).

Table 3 presents the estimated regression parameters in the probit model. The parameters with the highest magnitude and significance are the coefficient of the binary variable representing the country indicator for Brazil and Argentina. Other significant variables in the model are the manager's education level and the perceived importance of clime variability. Being a farmer in South America positively affects the influence use of ENSO forecast in farming practices. The Education level and the perceived importance of clime variability are positively related to the influence of ENSO forecast of farm decisions.

Table 3. Probit model estimation results. Factors affecting the use of ENSO forecasts in farm decision making in the United States, Brazil, and Argentina

Coefficients:

	Estimate	Std. Error	z	p-value	value
(Intercept)	-3.93273	1.2745116	-3.086	0.00203	**
ARG	2.44744	0.4607635	5.312	0.000000109	***
BRA	2.134068	0.4093237	5.214	0.000000185	***
age	-0.00022	0.014895	-0.015	0.98833	
exp	0.020167	0.0140941	1.431	0.15246	
educ_y	0.13371	0.0505947	2.643	0.00822	**
income	0.214316	0.2661644	0.805	0.4207	
livestock	-0.17265	0.2592581	-0.666	0.50544	
area_E2	0.299321	0.3302928	0.906	0.36482	
area_E3	0.251521	0.3700468	0.68	0.49669	
area_E4	-0.67722	0.4625976	-1.464	0.14321	
rent_E1	-0.25761	0.4221318	-0.61	0.54169	
rent_E2	0.590858	0.4501491	1.313	0.18932	
rent_E3	-0.28262	0.419713	-0.673	0.50072	
rent_E4	-0.39731	0.3612486	-1.1	0.27141	
risk_clime2	0.960663	0.4092388	2.347	0.0189	*

Signif. codes: '***'0.001, '**'0.01, '*'0.05 obs.: 287

Model

enso_influ ~ ARG+BRA+age+exp+educ_y+income+livestock+area_E2 + area_E3+area_E4+rent_E1+rent_E2+rent_E3+rent_E4+ +risk_clime2

variable	*unit*	*description*
enso_influ	binary	1 if ENSO forecast has influence on farm business decisions, 0 otherwise
ARG	binary	1 for Argentine farmers, 0 otherwise
BRA	binary	1 for Brazilian farmers, 0 otherwise
age	years	farmer's age
educ	years	farmer's education level
income	binary	1 if farming is the main source of income, 0 otherwise
livestock	binary	1 if the farm has livestock production, 0 otherwise
area_E2	binary	1 if operated land > 495 acres (200 ha), 0 otherwise
area_E3	binary	1 if operated land > 1237 acres (500 ha), 0 otherwise
area_E4	binary	1 if operated land > 3707 acres (1500 ha), 0 otherwise
rent_E1	binary	1 if rented land > 25%, 0 otherwise
rent_E2	binary	1 if rented land > 50%, 0 otherwise
rent_E3	binary	1 if' rented land > 75%, 0 otherwise
risk_clime2	binary	1 if climate variability is perceived as "moderately important, important or very important", 0 it is perceived as "slightly or not important"

Conclusions and Implications

This study provides information on the current use of climate information for agriculture in the United States, Brazil, and Argentina – the primary grain production area in the world. It is interesting to highlight the strong similarities among the analyzed regions. In all three cases, survey responses indicate that climate information is a crucial input for agricultural producers. Mobile phones and websites have become the most popular tools for accessing climate information in all three regions, followed by TV and Radio.

The perception of climate variability as a source of risk in farming varies within regions, with Brazilian and Argentinian farmers having a higher level of concern than American producers. The information generated and provided by public institutions is among the most consulted by farmers interviewed, especially in the United States and Argentina. This result highlights the value of this public good as a critical input for primary production. Additionally, the private sector, through services specifically developed for agriculture, plays a prominent role as a provider of climate information. Some of these private services are used in more than one region. These results suggest the potential for scalability in developing climate services that can be utilized in the different areas.

Regarding the influence of ENSO-based seasonal forecasts on decision-making in agricultural enterprises, there are significant differences between the responses of farmers in the U.S. Midwest and those in the two regions of South America. In southern Brazil and the Argentine Pampas, it is common for farmers to adapt their crop choices and management practices based on El Niño/La Niña forecasts. On the other hand, a significant proportion of American producers do not make any changes based on El Niño/La Niña forecasts, and the primary influence of these forecasts is on marketing strategies.

Drawing on concepts from behavioral sciences to interpret the factors affecting the use of climate information, these regional differences could be explained by differences in the perceived probability that adapting agricultural planning to a climate forecast will improve results (Lu et al., 2021). The professionalization of production in all three regions is likely a critical factor in the proper utilization of climate information in decision-making.

The theory also suggests that the use of climate information is associated with one's perception of their own ability to interpret and utilize this information in planning. This is consistent with the fact that education level has a positive effect on the use of seasonal forecasts in decision-making by agricultural enterprises.

Some limitations of the study related to the sampling method should be noted. Non-random selection in online surveys of farmers can lead to biases in the data since certain types of farmers are more likely to participate than others. However, while random sampling is the ideal method to secure sample representatives, this approach was not feasible in the current study. In particular, in our sample, farmers more adept at using digital information could be overrepresented. This issue should be taken into consideration when interpreting the results.

Finally, this paper presents a preliminary analysis of the collected data. Further statistical analysis will be conducted, and different models will be employed to understand better how farmers access and the incentives to utilize climate information in their decision-making processes.

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