

Resilience levels in fruit producers in southern Uruguay: a case study

Niveles de resiliencia en productores frutícolas del sur de Uruguay: un estudio de caso

Níveis de resiliência em produtores de frutas no sul do Uruguai: um estudo de caso

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Abstract

Fruit production in Uruguay faces the challenge of maintaining food production and promoting sustainability in a context of decreasing number of producers and increasing uncertainty. It is necessary to identify the response strategies of producers that shape their resilience and their relationship with Agroecology. The objective of this study was to evaluate the resilience levels of fruit producers in southern Uruguay through the Holistic Risk Index (IHR), which combines indicators of threat, vulnerability and responsiveness, and the analysis of the relationship between its components. The average IHR was low and the values were similar among producers. Resilience levels were medium to high. Threats were mainly climatic and vulnerability responds mainly to economic factors. The responsiveness is linked to experience, knowledge and intergenerational transmission of knowledge.

Key-words: Risk, vulnerability, responsiveness, Agroecology.

Resumen

La fruticultura en Uruguay enfrenta el desafío de mantener la producción de alimentos y promover la sustentabilidad en un contexto de disminución del número de productores e incertidumbre creciente. Se requiere identificar las estrategias de respuesta de los productores que configuran su resiliencia y su relación con la Agroecología. El objetivo del trabajo fue evaluar los niveles de resiliencia de productores frutícolas del sur de Uruguay a través del Índice Holístico de Riesgo (IHR) que combina amenaza, vulnerabilidad y capacidad de respuesta y el análisis de la relación entre sus componentes. El IHR promedio fue bajo y los valores similares entre productores. Los niveles de resiliencia fueron medio a alto. Las amenazas fueron fundamentalmente climáticas y la vulnerabilidad responde principalmente a factores económicos. La capacidad de respuesta se vincula con la experiencia, el conocimiento y la transmisión intergeneracional de saberes.

Palabras-clave: Riesgo, vulnerabilidad, respuesta, Agroecología.

Resumo

A fruticultura no Uruguai enfrenta o desafio de manter a produção de alimentos e promover a sustentabilidade num contexto de diminuição do número de produtores e crescente incerteza. É necessário identificar quais estratégias de resposta dos produtores moldam a sua resiliência e qual é sua relação com a Agroecologia. O objetivo do trabalho foi estimar os níveis de resiliência de um conjunto de produtores de frutas do sul do Uruguai por meio da aplicação do Índice Holístico de Risco (IHR) que combina indicadores de ameaça, vulnerabilidade e capacidade de resposta e analisar a relação entre seus componentes. Os valores do IHR foram semelhantes entre os produtores e os níveis de resiliência foram de médio a alto. Com base na percepção dos produtores, as ameaças são fundamentalmente climáticas, a vulnerabilidade responde a fatores econômicos e a capacidade de resposta está conectada com a experiência, ao conhecimento e à transmissão intergeracional de saberes.

Palavras-chave: Risco, vulnerabilidade, resposta, Agroecologia.

INTRODUCTION

Fruit production in Uruguay significantly contributes to food sovereignty and, due to its intrinsic characteristics, generates a strong link between producers and the environment that promotes the permanence of the rural population and access to rights, basic aspects in the construction of an identity that distinguishes it from other productions (Piñeiro and Cardeillac, 2014; Carámbula Pareja, 2015).

Between 2002 and 2020 the number of fruit producers was reduced in half (MGAP DIEA, 2003; Escanda, 2021). Cardeillac and Piñeiro (2017) attribute this to an inability to adjust to adverse contexts, including the impacts of climate change and variability, costs and profitability, difficulties with workforce and generational replacement (Fúster Rebellato *et al.*, 2011; Caputi and Canessa, 2012; Ferrer *et al.*, 2013; Malán, 2016; Zoppolo *et al.*, 2018; INIA, 2019).

The challenge of maintaining food production and promoting the sustainability of fruit production requires knowledge of the behaviours and diverse response strategies that allow producers to face changing and uncertain contexts (Piñeiro, n.d.), in order to promote agroecological transition processes towards resilient systems.

Resilience can be understood as the ability to learn to live in and with uncertainty (Folke, 2006). It emerges as a result of the interdependence between the components of complex systems that determine their capacity for adaptation, transformation, reorganization and recovery, both in the face of specific impacts and continuous changes in the environment (Walker *et al.*, 2004; Casimiro Rodríguez, 2016; Bocco, 2019).

Resilience depends on the context and the particular characteristics of each system (Cabell and Oelofse, 2012), permeated by socio-cultural, historical and political conditions that make its evaluation relatively difficult. There are several research precedents in agroecology that validate the use of the Holistic Risk Index (IHR, according to its Spanish acronym) adapted from Barrera *et al.* (2007) as a device to assess resilience levels (Altieri and Nicholls, 2013; Henao Salazar, 2013; Montalba *et al.*, 2013; 2015; Altieri *et al.*, 2015; Gazzano *et al.*, 2015); it is assumed that low risk values correspond to

high resilience values. The IHR calculation combines hazard, vulnerability and responsiveness variables.

Threat and vulnerability are interdependent and mutually conditioning components. While threat is understood as the probability of occurrence of a destabilizing event, vulnerability is an intrinsic predisposition to suffer damage due to the manifestation of the threat. Risk is configured when the threat becomes operational under certain conditions of vulnerability (Wilches Chaux, 1993; Cardona, 2001).

Vulnerability is a dynamic and multidimensional condition that involves biophysical, technological, economic, sociocultural and political components specific to each system (Adger, 2000; 2006; Walker *et al.*, 2004; Folke, 2006) and can be reduced through responsiveness. This response implies the ability to transform, adjust and adapt to environmental changes (Walker *et al.*, 2004); it includes the applied attributes, strategies and management by producers to reduce risk and recover from damage caused by adverse events (Altieri *et al.*, 2015). The agroecological approach promotes organizational and technical-productive response strategies related to the dimensions of agroecology (Ottmann and Sevilla Guzmán, 2004) that lead to reducing risk levels and consequently increasing resilience levels.

The objective of the research was to estimate the resilience levels of fruit producers in southern Uruguay through the application of the IHR and the analysis of the relationship between its components to identify aspects that contribute to increasing the sustainability of deciduous fruit from an agroecological perspective.

METHODOLOGY

The research is based on a local case study methodology. The study area is located in the south of Uruguay, in part of the departments of Montevideo and Canelones, in the main fruit production area at the national level (Figure 1). It was defined based on a selection of 27 farms with different degrees of hail damage according to a previous study (Linari *et al.*, 2020), using stratified random sampling.



Figure 1. Study area.
Source: Authors, 2023.

In the selected farms, a survey form was applied with a series of questions that allowed a broad socio-productive characterization of the study units, including aspects related to the design and management of fruit systems, as well as commercial and associative strategies, from which the threat, vulnerability and responsiveness variables that comprise the risk were identified and evaluated. Data was collected in May 2019. To estimate resilience, the Holistic Risk Index (IHR) adapted from Barrera *et al.* (2007) was applied, which integrates threat (A), vulnerability (V) and responsiveness (CR) indicators, according to the following formula:

$$IHR = \frac{A * V}{CR}$$

The indicators were defined based on responses of the producers to the survey, supported by a bibliographic review and consultation with experts in fruit production about variables that constitute the risk.

To characterize the threat, we considered the climatic variables that affect annual production (winter cold and water deficit), and hail as a punctual adverse effect that can cause significant damage (Zoppolo *et al.*, 2018; Linari *et al.*, 2020). We also considered the opinion of producers on sociocultural variables related to farm management and the environment that can negatively affect the production system.

The definition of vulnerability indicators was based on the characteristic attributes of producers and their production systems that can condition the predisposition to suffer damage, both due to the manifestation of a punctual threat and due to the continuous physical and socioeconomic changes of the environment (Cardona, 2001; Córdoba Vargas *et al.*, 2017).

The responsiveness sought to reflect the knowledge, experience and capacity of producers to apply strategies to confront risk. It was configured by indicators of agronomic management and economic and sociocultural strategies aimed at reducing vulnerability levels, resisting and recovering from environmental impacts (Henao Salazar, 2013; Altieri *et al.*, 2015).

Following the methodology of the IHR, the indicators were evaluated on a scale of 1 to 4, where 1 is the worst and 4 is the best value according to the assessed component. The IHR was calculated by averaging the indicators for each component (A, V and CR) and the formula was applied to each producer.

To analyze similarities and differences between producers in terms of risk levels, a hierarchical agglomerative clustering was performed using Euclidean distance and the complete clustering method. The `hclust` instruction from the `Vegan` library (Oksanen *et al.*, 2022) available in R (R Core Team 2023) was used.

In order to evaluate the presence of a spatial pattern of threat, vulnerability, responsiveness and risk, the spatial autocorrelation of each of these variables was analyzed, trying to identify whether there is an association in which the values of each variable are similar to the values in nearby properties. To evaluate the spatial autocorrelation (AE), Moran's I (Moran, 1948) was used, which is essentially the Pearson correlation coefficient with a weighting matrix of spatial location of each case studied. To analyze the AE, we worked with the inverse distance, taking into account all the elements that influence each entity; we worked with the software ArcGIS 10.4.

RESULTS AND DISCUSSION

A total of 27 male fruit producers were surveyed, with an average age of 53 years, who live with their families on the farm where they carry out their activity (or at a distance less than 5 km from it). The 52% percent of the surveyed manage areas between 10 and 40 fruit-growing hectares, coinciding with national averages (Escanda, 2021), and 67% are members of the National Register of Family Producers (as defined by MGAP DGDR, 2016). Those producers who do not integrate the Register claim their status as family producers (van der Ploeg, 2014; Piñeiro, n/d) based on their experience of more than 20 years in fruit growing, inherited tradition and taste for the activity. The cultivated species also coincide with the national fruit-growing reality (Escanda, 2021): all producers grow apples, 26 grow peaches, 16 grow pears and 13 grow plums; the 50% of the producers manage a richness of 3 to 4 species, in different combinations.

The analysis of the responses of the producers allowed to define 21 indicators: 5 of threat, 8 of vulnerability and 8 of responsiveness, which are presented in Table 1.

The IHR takes values between 1.29 and 3.92; producers cover a wide range of IHR, with a uniform distribution within the range.

Within the clustering analysis using only risk, four groups were differentiated and subsequently similarities and differences of the components in the formed groups were analyzed (Figure 2 and Table 2).

The threat was similar for all producers and the indicators with the greatest weight are those that respond to “potential risk of hail”, “affectation due to lack of winter cold” and “water deficit affectation”. Since climatic variables have a different impact on each system depending on their intrinsic characteristics, it was decided to assess them through the degree of impact perceived by the producers over a 10-year period. The surveyed producers mention climate as the main factor affecting yields, particularly the lack of winter cold, and perceive that the negative effects of climate variability will increase in the coming years. The application of practices based on agroecological principles, such as diversification and soil management (Nicholls *et al.*, 2015), according to the

particularities of each fruit system, can promote adaptation and response strategies in the face of increasing climate variability conditions.

Table 1. Threat, vulnerability and responsiveness indicators for fruit producers in southern Uruguay.

Component	Indicator	Average value
Threat (A)	- Potential risk of hail (AGR)	3.70
	- Affection due to lack of winter cold (AHF)	3.44
	- Water deficit affection (ADH)	2.67
	- Hive use and pesticide pressure (ACP)	2.11
	- Management style conflicts (AEM)	2.00
Vulnerability (V)	- Yield instability (VRE)	2.26
	- Demand behavior (VCD)	2.93
	- Flexibility to adapt to consumer demands (VFX)	2.52
	- Cost and profitability variation (VRT)	3.63
	- Work capacity (VMO)	2.00
	- Degree of compliance with the activity (VCA)	2.22
	- Intention and possibilities to continue with the activity (VIP)	1.81
Responsiveness (CR)	- Income derived from the activity (VFI)	1.07
	- Fruit trees diversity (RDP)	3.04
	- Soil cover (RMS)	2.85
	- Proportion of irrigated area (RRG)	2.81
	- Vulnerability preparedness (RPV)	2.78
	- Technical assistance (RAT)	2.07
	- Membership in organizations (RPO)	2.11
	- Commercial channels (RCO)	2.30
- Production expertise (RCE)	3.85	
	Threat (A)	2.79
	Vulnerability (V)	2.31
	Responsiveness (CR)	2.73
	Risk (IHR)	2.36

Source: authors, 2023.

The threat indicators related to possible conflicts with neighbors due to differences in management styles and difficulties with the use of hives present low average values (2 and 2.11 respectively). With the exception of one certified agroecological producer according to the standards of the Uruguayan Agroecology Network (RAU), the rest of the producer practice integrated production and it is expected that no conflicts related to management will occur.

Group 1 is the most resilient, with an average risk value of 1.46. It consists of 5 producers whose main activity is fruit growing, with low vulnerability and high responsiveness, with average values of 1.95 and 3.18 respectively (Figure 3).

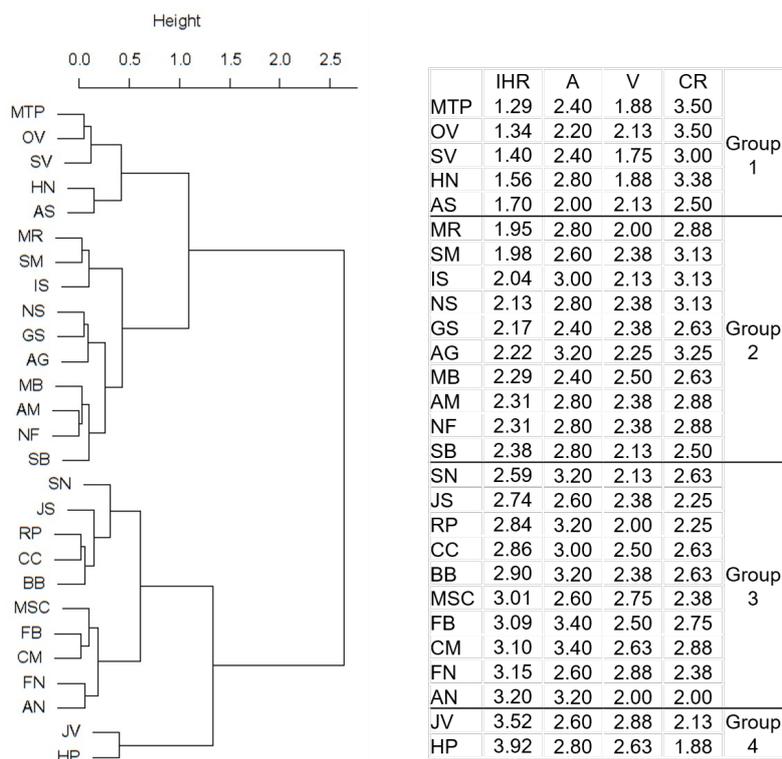


Figure 2. Dendrogram of clustering of fruit producers in southern Uruguay according to risk (IHR) and mean values of its components (A: threat; V: vulnerability; CR: responsiveness). In the left column, producers are located according to their identification code.
Source: Authors, 2023.

Table 2. Comparison of means of risk groups of fruit producers in southern Uruguay. Means followed by different letters are significantly different ($p < 0.05$).

Group	IHR	A	V	CR
1	1.46 d	2.36 b	1.95 b	3.18 a
2	2.18 c	2.76 a	2.29 b	2.90 ab
3	2.95 b	3.04 a	2.41 a	2.48 b
4	3.72 a	2.70 a	2.75 a	2.00 b

IHR: risk; A: threat; V: vulnerability; CR: responsiveness.

Source: Authors, 2023.

In this group, vulnerability is explained by aspects related to the perception of producers regarding the variation in costs and profitability in the last 10 years and the degree of flexibility to adapt to consumer demands. Regarding this indicator, producers state that consumers demand “perfection” without taking into account the particularities of the production process. Agroecological strategies based on socioeconomic principles as those mentioned by Dumont *et al.* (2021), such as the development of local markets and short

marketing circuits can bring consumers closer to producers and production processes and thus contribute to reducing the vulnerability values mentioned in this indicator.

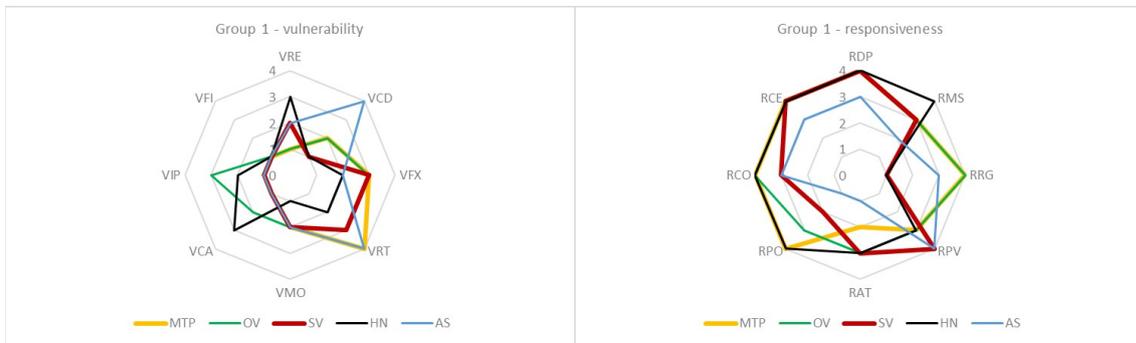


Figure 3: Vulnerability and responsiveness of highly resilient fruit producers in southern Uruguay.
Source: Authors, 2023.

In terms of responsiveness, producers in this group develop technical-productive, commercial and sociocultural strategies in accordance with the agroecological approach and principles that allow them to face adverse conditions, such as those cited by Nicholls *et al.* (2015), Dumont *et al.* (2021) and Parmentier (2014). According to the surveys, in technical-productive aspects they maintain soil cover between rows with spontaneous vegetation or green manure planting and cultivate between 3 and 4 deciduous fruit species, while in commercial terms they manage more than three commercial channels, strategies that aim at diversification, adaptation and autonomy. From a sociocultural point of view, they state that they have been in production “all their lives” and due to their experience and knowledge they feel prepared to face adversity and have strong intentions to continue in the activity; they count with individual and group technical assistance, they exchange between peers and integrate networks and organizations, except for the producer AS, the one at the highest risk within the group.

On the opposite side, group 4 is the least resilient, with an average IHR of 3.72. It consists of two producers with an average vulnerability of 2.76 and relatively low responsiveness , 2.01 on average (Figure 4).

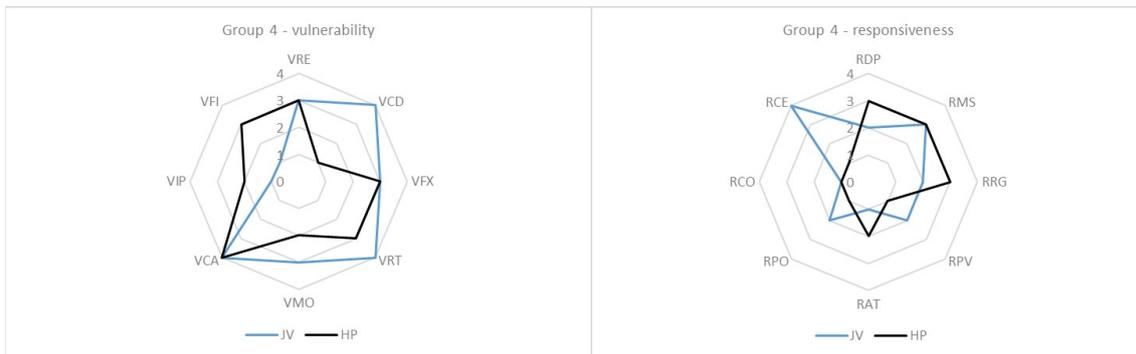


Figure 4. Vulnerability and responsiveness of low-resilience fruit producers in southern Uruguay.
Source: Authors, 2023.

Both producers manage a production area of 5 hectares, which for the reality of national fruit growing is considered low; they receive sporadic individual technical assistance, do not belong to organizations, and market their production exclusively through commission agents (third parties who take charge of the sale for a commission). Both producers state that they feel unprepared to face vulnerability and that it is difficult for them to recover from negative impacts on their systems. HP, the highest risk producer, expressed that he could not fully recover from the damage caused by a hailstorm in 2013, feels completely dissatisfied with the activity and expresses few intentions to continue, mainly due to the difficulties in facing production costs. According to producer JV, vulnerability responds to economic aspects, such as cost variations and the behavior of demand, which condition his degree of compliance with the activity.

Most of the producers fall into two groups with medium levels of resilience, each consisting of 10 producers. They are producers with more than 20 years of experience in production and with a family tradition, fruit production is the main source of income and they show knowledge of the sector in productive and commercial aspects; they are quite satisfied with the results of the activity and express their intention to continue in the sector, despite the uncertainty regarding generational replacement (an aspect shared by family production in general).

Group 2 can be considered as having medium-high resilience, with lower vulnerability (2.76 on average) and higher responsiveness (3.19 on average). According to the

perception of producers about the variables that shape the risk, vulnerability is fundamentally due to the increase in costs and the reduction in demand that negatively affects profitability, added to the relative difficulty in adapting to consumer demands. Regarding responsiveness, the trajectory and experience in the sector is highlighted, they manage a good productive diversity with more than 3 cultivated fruit species, they have irrigation in at least 50% of the cultivated surface and they use more than one commercial channel.

Group 3 shows medium-low resilience, due to greater vulnerability and lower responsiveness, with average values of 3.19 and 2.48 respectively. These producers are vulnerable to economic issues, since in the last 10 years they perceive increased costs, decreased profitability and decreased demand. They also express difficulties in adapting to consumer demands and, lied to this, they feel moderately satisfied with the results of the activity. Responsiveness is made up of the trajectory and experience in production, the degree to which they feel prepared to face vulnerability and the capacity to recover with external and family support.

In general terms and according to the perception of the surveyed producers, vulnerability is fundamentally related due to economic factors due to costs and profitability; other factors mentioned in the literature, such as difficulties with work capacity or uncertainty regarding generational change, do not appear as important in this study. The producers highlight as positive aspects the experience and intergenerational transmission of knowledge, the love for the activity, the lifestyle and the specific knowledge that allows them to feel relatively prepared to face vulnerability and with the capacity to recover, where the support of the family stands out. Belonging to organizations as an agroecological strategy only appears as important in four of the producers of the group with the greatest resilience (group 1), which reflects the general opinion they express in the survey about individualism and the lack of organization in the sector.

With respect to spatial autocorrelation, working at a 0.95 confidence level, there was no evidence of patterns in the spatial configuration of risk or its component variables in the study area. Threat and vulnerability are fundamentally responsive to variables common to all producers, and responsiveness is strongly linked to the life history of each producer.

Consequently, for this particular study, the location of the producer in the study area did not play an important role in explaining the distribution of risk.

CONCLUSIONS

For the producers included in this case study, risk takes medium to low values, which means medium to high levels of resilience, and is explained by vulnerability and responsiveness. Although the risk values are similar among producers, the cluster analysis allowed differentiating four risk groups; only two producers are located in the high risk group (low resilience).

Threat was similar for all producers, with an average value of 2.79 and explained by the climatic variables that condition production: hail, winter cold and water deficit. The results are consistent with the importance given to climate change in the referenced literature on resilience, and support the conclusion that it is essential to promote agroecological design and management strategies for production systems capable of facing conditions of increasing climatic variability.

According to the perception of the producers, vulnerability is linked to economic and productive aspects: they state that in the last 10 years the situation has been one of increasing costs, decreasing demand and profitability, and instability of yields. It is also relatively difficult to adapt to consumer demands.

Within responsiveness, aspects that stand out regarding farm design, such as spatial and temporal diversification of species and cultivars of deciduous fruit trees and soil management, are associated with key agroecological principles in resilience (Nicholls *et al.*, 2015). On the other hand, sociocultural aspects were identified that coincide with other studies (Gazzano *et al.*, 2015); experience in production, specific knowledge, lifestyle and intergenerational transmission of knowledge provide producers with skills for managing their systems. As an emerging aspect of the work, it can be noted the identification of response elements related to the sociocultural dimension that is generally not considered by public policies focused on the sector.

Although in this study the estimation of resilience based on the perception of the producers implies an important degree of subjectivity, the results are considered to be the starting point for a more detailed analysis of the relevance of each of the aspects that make up risk and their importance for the generation of agroecological strategies for building resilience.

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