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SUSTAINABILITY IN AGRICULTURE: ANALYSING THE ENVIRONMENTAL AND SOCIAL ASPECTS OF THE FAMILY FARMERS' ECONOMY

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Abstract: The impact of agricultural systems on the economy, environment and society should be monitored so that efficient and fair chains can be developed in the context of sustainable development objectives. Sustainability indicators can be used for this purpose and their applicability to regional realities should be assessed. The objective of the present research is to investigate the influence of environmental and social indicators on economic indicators from the perspective of the family farmers that participated in the Agroindustry Arrangement in southern Brazil. The study was based on surveys involving producers and managers of family farms associated with five cooperatives. The responses of 81 family farmers and cooperative managers to 30 indicators were assessed using the ordinary least squares regression. Fourteen of the indicators were economic (the dependent variable), 11 were environmental and five were social (the independent variables). Positive influences on the environmental indicators relating to water (the financial and operational aspects and productivity), air (the financial and operational aspects) and soil (the operational aspects) were identified. The social indicators relating to food health and safety (the financial aspects and productivity) and opportunities (the operational aspects) had a positive impact on the economy. Therefore, we concluded that there is a dependent relationship between the sustainability indicators which shows the importance of the social and environmental dimensions for the family farmers' economy. Such results indicated that producers from familiar agro-industry are aware of the importance of the environmental and social aspects to achieve success in the economic aspects and they can be important for the definition of new sustainability policies in regions, where agro-industrial production arrangements are relevant to the economy, as in southern Brazil.

Keywords: Sustainable development, family farming, key performance indicators, indicators, ordinary least square regression.

Introduction

Agricultural systems, in the context of sustainability, face several challenges. They have to satisfy the need for food (in terms of the quality and quantity of food), minimise their impact on the environment and society, and maximise economic gains (Galdeano-Gómez *et al.,* 2017). The intensification of food production in response to growing demand is essential but all activities in the rural environment have a powerful effect on ecosystems, requiring sustainable practices to improve the use of natural resources to ensure the economic viability of production systems and to care for the environment (Guenther *et al.,* 2016; Quintero-Angel & González-Acevedo, 2018; Scherer *et al.,* 2018).

Rural production based on family farming has been gaining importance in the current economic system because of its role in product diversification, its ability to produce healthier food, the face-to-face nature of its producer-consumer relationship, its support for the development of the agro-industrial sector and the generation of employment and income (Sili *et al.,* 2014; Lowder *et al.,* 2014). Cooperatives using family labour have been presented as an alternative way of evaluating and expanding profitable marketing channels and income generation opportunities, producing more goods, promoting management practices and helping the development of local economies (Figueiredo & Franco, 2018).

Studies that focus on a sustainability analysis of family farms, incorporating economic, environmental and social dimensions (which are recognised as the triple bottom line, or TBL) are scarce. Evaluating the family farmers' economy is difficult because of its magnitude, decentralisation and diversity (Gimenez *et al.,* 2012; Coteur *et al.,* 2018).

The use of sustainability assessment tools, however, makes this possible when short, medium and long term goals and a defined sequence of actions are laid down (Silvestre, 2013; Sabiha *et al.,* 2016). According to Sargani *et al.* (2020), the agrobusiness sector is growing and attaining a more sustainable level in terms of the TBL. Emerging entrepreneurship in a sustainable agricultural context and the importance of environmental and social requirements and obligations in value creation merits further study.

Kovacs *et al.* (2020) examined the complexity of dynamic drivers of sustainability such as energy and heat as well as chemical and biological transformations in soil, water and air. It is important that those involved in sustainability assessments internalise strategic objectives and maximise financial benefit without neglecting their environmental responsibilities (Guenther *et al.,* 2016).

Matzembacher and Meira (2019) studied production and consumption in Brazil as part of an attempt to understand sustainable agricultural strategies that involve the support of the community. In this model, producers receive social and environmental benefits such as having the sale of their products guaranteed by consumer organisations. The rural exodus of young people has been reduced as a result, and an interface between farmers and non-farmers has developed. The importance of evaluating a tripod-based system that includes sustainability is evident in the effects of environmental and social factors on the economy (Simas *et al.,* 2017). In Western Europe in the early 2000s, some farming survival strategies concentrated on structural diversification (new products or services) and income generation not related to agriculture (Meert *et al.,* 2005). 20 years later, the sustainability of small family farms such as Turkish tea farms (58% of which were highly sustainable) became more important. These small family farms use resources efficiently, tend to maximise human usefulness and provide a healthy environment for all species. The use of sustainability indicators was important in recognising the characteristics that reflected the farms' performance (Ul Haq & Boz, 2020).

Sustainability indicators can be environmental (e.g., air and water quality and energy consumption), social (e.g., quality of life, well-being and income distribution) or economic (e.g., consumption and production and liquidity) (Wohlenberg *et al.,* 2022). They can be integrated or used discretely. A good indicator notifies a potential problem before it becomes a feature of a system. This is helpful for decision-making. In communities in crises, these indicators help to highlight factors that deserve more attention and offer alternative solutions to such problems, thereby contributing to proactive decision-making and minimising the possibility of future negative consequences (Simas *et al.,* 2017).

Recently, a bibliometric study on the sustainability indicators in family farming was conducted (Wohlenberg *et al.,* 2022) which presented the similarities between environmental and economic indicators in works by several authors. It also showed that social indicators are more diversified and that the indicators of the three spheres of sustainability needed more exploration in the family farms, and sustainable agriculture needed the indicators' interrelations to contribute to decision-making.

So, understanding that the TBL operates in a systemic and interrelated way, the present study investigates the economic impact of sustainability on farmers using the environmental and social dimensions to illustrate the reality of family farming. Therefore, this study aims to investigate the influence of environmental and social indicators on economic indicators from the perspective of family farmers that participated in the Agroindustry Arrangement in southern Brazil.

Materials and Methods

Sampling and Measures

The study environment comprised 478 family farmers distributed amongst five agroindustry cooperatives belonging to the Local Productive Agroindustry Arrangement in southern Brazil, specifically Rio Pardo Valley, State of Rio Grande do Sul (Figure 1). Following the pilot study with managers from three cooperatives (C1, C2 and C3), a survey was carried out over eight months at fairs promoted by cooperatives and local fairs of family agricultural producers. The questionnaire — which consisted of Critical Success Factors (CSFs) and Key Performance Indicators (KPIs) in a model that enabled the measurement of sustainability indicators for family farming cooperatives — was sent to 81 farmers. In total, there were 30 KPIs divided among three CSFs. All items were measured on a scale from 1 (not important) to 5 (very important).

Selection of Variables

Since the main purpose of our analysis was to assess the impact of sustainability in economic terms on farmers using environmental and social indicators, we defined as independent variables the KPIs related to environmental and social CSFs. Our dependent variables included the KPIs of economic CSFs. So, our model investigated the effect of the environmental and social KPIs on economic KPIs. Table 1 describes the independent and dependent variables.

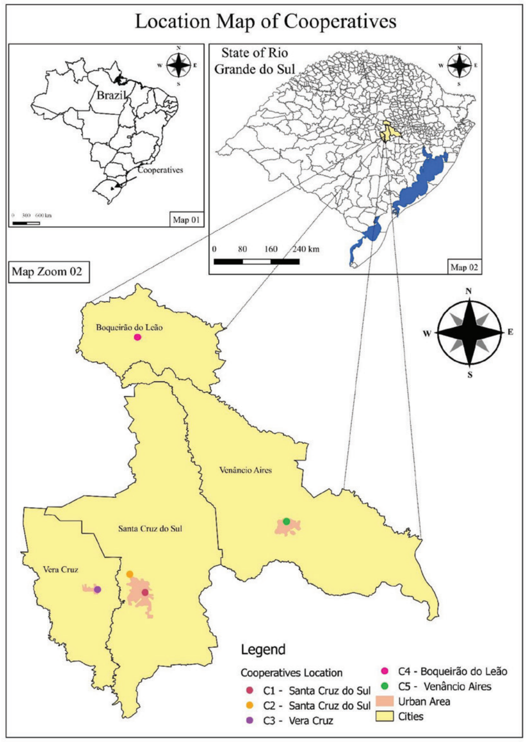

Figure 1: A map showing the cooperatives that participated in the study

Reducing the Number of Variables

Initially, we performed a bibliographic search and found 51 indicators related to sustainability; 24 were economic, 17 were environmental and 10 were social (Global Report Iniciative, 2013; Reytar *et al.,* 2014; Adelina & Roxana, 2016; Dočekalová & Kocmanová, 2016; Meneses-Jácome *et al.,* 2016; Carrasquer *et al.,* 2017; Galdeano-Gómez *et al.,* 2017; Nishitani *et al.,* 2017; Gonzalez-Garcia *et al.,* 2018; Haffar & Searcy, 2018; Karagiannis & Karagiannis, 2018; Liu *et al.,* 2018; Moghaddam *et al.,* 2018). These indicators which contained the definition and the form of monitoring were submitted for analysis to the managers of the cooperatives to identify those that applied to their cooperatives and whether any of them were already in use, most were not. The managers were unaware of the importance of monitoring decision-making processes. With the help of a group of experts, composed of two cooperative managers, the

Table 1: CSFs and KPIs considered in the research model based on Wohlenberg *et al.* (2022)

Economy (Dependent Variables)	**Environmental (Independent Variables)**	**Social (Independent Variables)**
KPI1: Financial planning of production revenues and expenses	KPI15: Water availability and quality (potable)	KPI26: Quality of life
KPI2: Debt control (how much of your capital is committed to the loans)	KPI16: Volume of water consumed in production	KPI27: Food safety: Quality and quantity of available food
KPI3: Profits	KPI17: Rainwater reuse	KPI28: Level of schooling
KPI4: Minimum quantity to be sold to cover production costs	KPI18: Treatment of sewers and effluents	KPI29: Qualification courses (technical or academic)
KPI5: Number of commercialized products	KPI19: Interference of weather variations (e.g., rains) in the business	KPI30: Rural evasion
KPI6: Production yield	KPI20: Air quality	
KPI7: Control of used materials	KPI21: Emission of unpleasant odors	
KPI8: Loss monitoring (amounts of leftovers or damaged product)	KPI22: Garbage collection	
KPI9: Consumers' feedback on offered products	KPI23: Erosion control and soil fertility	
KPI10: Product quality	KPI24: Alternative sources of energy generation	
KPI11: New product offer	KPI25: Reuse of waste "leftovers"	
KPI12: Using of different trade channels and development of cooperation networks		
KPI13: Maintain active membership in the cooperative		
KPI14: Farm investment		

manager of the Local Productive Agroindustry Arrangement and four university professors, the initial 51 indicators were reduced to 30, of which 14 were economic, 11 were environmental and five were social. They were structured in the form of topics to facilitate the understanding and participation of managers, associates and local farmers. Afterwards, the KPIs were categorised into 11 main constructs reflecting the opinions of the managers.

Data Analysis

Statistical analysis was carried out and skewness and kurtosis tests were conducted to verify data normality. We used the SPSS software (version 20) (IBM Corporation, 2011) to establish data correlations between the constructs and the ordinary least squares (OLS) regression. We expected to see a general relationship between the environmental and social indicators (independent variables) and the economic indicators (dependent variables).

The null hypothesis, H_0 was "There will be no statistically significant effect of the environmental and social indicators on the economic indicators in the distribution of responses of the family farmers and cooperative managers in the Agroindustry Arrangement in the studied region". The H1 hypothesis was "There will be a statistically significant difference in the distribution of responses that indicate a positive effect of the environmental and social indicators on the economic indicators from the family farmers in the Agroindustry Arrangement in the studied region".

Descriptive statistics were used for the assessment. The coefficient for assessing internal consistency was the Cronbach's alpha. The variance inflation factor (VIF) and statistical power of the partial coefficients using Cohen's f^2 estimation for the predictors $f^2 = \frac{sr^2}{(1-R^2)}$, where sr^2 represents a semi-partial correlation were used. For f^2, the range of effects suggested was: 0.02 = small effect, 0.15 = medium effect and 0.35 = large effect (Cohen *et al.,* 2014).

Results and Discussion

General KPI Analysis

Table 2 shows the reliability analysis of the three constructs using Cronbach's alpha. All were above the threshold value of 0.5 which is considered acceptable for preliminary research (Nunnally *et al.,* 1967; Hair *et al.,* 2009; Kottner & Streiner, 2010). Hence, the final constructs for the economic CSFs were financial (the profits and expenses of the farms and loans taken by the farmers), productivity (the costs associated with the production process), quality (of the products) and operational (investments and market strategies). In the case of the environmental CSFs, the final constructs were water (the way farmers managed water on their farms), air (the atmospheric conditions in the farms and how the farmers deal with problems related to weather and emissions), soil (the ways the farmers dealt with the soil and rubbish) and reuse/recycling (the ways the farmers reused their waste and generated alternative sources of energy). Finally, the three constructs for the social CFSs were health and food safety (quality of life and food safety), education (the level of the farmers' education) and opportunities (the rural exodus of those looking for new employment opportunities).

Table 3 shows the descriptive statistics such as the means and standard deviations and the results of the skewness and kurtosis tests. The skewness and kurtosis values reported suggested that the variables could be assumed to be normally distributed since their values were between the threshold of ± 2.58, represented in the z-distribution as $\alpha = 0.01$. We analysed collinearity by plotting the partial regressions for the independent variables and visually examined homoscedasticity using plots of standardised residuals against predicted values. All requirements were met by our dataset. We also tested the VIF among the independent variables (risk management) because multicollinearity can be a problem for ordinary least squares (OLS) regressions. All independent variables (environmental and social) resulted in a VIF < 3.0, that is they were below the threshold of VIF

Table 2: The constructs of our research model

Economy	Environmental	Social	Cronbach's Alpha
Financial aspects (KPI1, KPI2, KPI3, KPI4, KPI5)	Water (KPI15, KPI16, KPI17, KPI18)	Health and food safety (KPI26, KPI27)	0.846
Productivity (KPI6, KPI7, KPI8)	Air (KPI19, KPI20, KPI21)	Education (KPI28, KPI29)	0.822
Quality (KPI9, KPI10)	Soil (KPI22, KPI23)	Opportunities (KPI30)	0.577
Operational (KPI11, KPI12, KPI13, KPI14)	Reuse/recycling (KPI24, KPI25)		

= 10.0, so multicollinearity was not likely to be a concern in our regression model (Hair *et al.,* 2009). Ordinary least squares regression should not be used when certain standard requirements of a dataset are not met (e.g., normality, linearity and homoscedasticity) (Hair *et al.,* 2009). We were therefore able to use regression to achieve our objectives.

We performed four independent regression models, one for each of the economic components following the process of variable reduction (i.e., financial, productivity, quality and operational). The results of the regression models are presented in Table 4. Only one of our models was not statistically significant at $p > 0.1$; the others were at $p < 0.01$. Model 1 (Financial, F = 6.958, $p < 0.001$) explained 34.3% of the variance while Model 2 (Productivity, F = 8.997, $p < 0.001$) explained 46.3% of the variance. Model 3 (Quality) was not statistically significant (F = 0.784, $p = 0.603$) and had a negative variance percentage. Lastly, Model 4 (Operational, F = 9.426, $p < 0.001$) explained 42.4% of the variance. We used regression to explain the relationships between the independent and dependent variables and not to perform a prediction model, so the low R-squares and adjusted R-squares were not a concern (Cohen *et al.,* 2014).

The results from the regression models showed that Model 1 (Financial) had three significant effects, two on the environmental variables and one on the social variables. For environmental variables, the constructs water ($\beta = 0.402$, $p = 0.003$) and soil ($\beta = 0.240$, $p = 0.074$) had a positive effect on the financial aspects while the construct health and food safety ($\beta = 0.276$, $p = 0.020$) had a positive effect on the social variables.

The farming families need a level of welfare that comprises a healthy body, good interpersonal relationships and leisure time. The kind of work they do gives them the opportunity to achieve all of these (Gao *et al.,* 2019). Controlling water consumption and conserving the soil is essential if the quality of the farmers' agricultural products is to be guaranteed. A lack

Table 3: Correlation matrix and descriptive analysis

		Mean	S.D.	Skewness	Kurtosis	1	2	3	4	5	6	7	8	9	10	11
1	Financial aspects	4.229	0.687	-0.762	0.231	-										
2	Productivity	3.983	0.870	-0.868	0.563	0.623*	-									
3	Quality	4.709	0.446	-1.591	2.241	0.167	0.282*	-								
4	Operational	4.240	0.635	-0.945	0.357	0.353**	0.484**	0.409**	-							
5	Water	3.938	0.780	-0.716	0.007	0.563**	0.615**	0.109	0.514**	-						
6	Air	3.818	0.856	-0.130	-1.063	0.441**	0.363**	0.035	0.531**	0.616**	-					
7	Soil	0.501	0.229	-0.548	-0.578	0.217	0.184	0.161	0.498**	0.449**	0.530**	-				
8	Reuse/recycling	0.507	0.251	-0.268	-0.576	0.264*	0.327**	0.052	0.119	0.431**	0.376**	0.333**	-			
9	Health and food safety	0.506	0.246	-0.320	-0.623	0.323**	0.392**	0.077	0.200	0.311**	0.030	0.088	0.204	-		
10	Education	0.501	0.228	-0.553	-0.630	0.158	0.240*	0.178	0.283*	0.328**	0.258*	0.327**	0.419**	0.534**	-	
11	Opportunities	3.604	1.454	-0.700	-0.929	0.214	0.235*	0.139	0.385**	0.157	0.336**	0.331**	0.166	0.141	0.151	-

**$p < 0.01$, *$p < 0.05$

of efficient water management and poor soil will lead to a drop in the income (Fernandes & Woodhouse, 2008; Willers *et al.,* 2014).

Model 2 (Productivity) presented two significant effects, one on the environmental variables and one on the social variables. For environmental variables, the construct water ($\beta = 0.557$, $p < 0.001$) presented a positive effect as did health and food safety ($\beta = 0.238$, $p = 0.033$) on the social variables. Model 3 (Quality) was not statistically significant and did not present any significant effect. Finally, Model 4 (Operational) presented five significant effects, four on the environmental variables and one on the social variables. For the environmental variables, water ($\beta = 0.308$, $p = 0.014$), air ($\beta = 0.223$, $p = 0.076$) and soil ($\beta = 0.221$, $p = 0.043$) presented positive effects. Reuse/recycling ($\beta = -0.259$, $p = 0.012$), on the other hand, presented a negative effect on the operational aspect. For the social variables, only opportunities ($\beta = 0.209$, $p = 0.029$) presented a positive effect while the others were not statistically significant.

Sustainable and productive regionally integrated farms that depend on innovation seem to avoid the ecological problems ordinarily associated with agriculture. In fact, increased productivity and environmental sustainability can be combined in a socially sustainable way. Productivity can be the biggest impact factor and the family farmers recognise this (Juntti & Downward, 2017).

One aspect that needs to be analysed is the negative effect of reuse/recycling on operations. This is perhaps because recycling and reuse require more operational energy which costs more and does not yield short-term benefits, so respondents saw this as a negative operational impact. The main farm activities use energy in the form of electricity or fuel. Thus, the farmers may be aware that this has financial implications. On the other hand, cooperatives do not need packaging services, which reduces losses. They can produce on a small scale and deliver directly to the market via food supply chains (Dos Santos *et al.,* 2020).

We performed a statistical power analysis of our three significant models (Financial, Productivity and Operational) using Cohen's f^2. The statistically significant independent variable in Model 1 (Financial) showed a large effect on water (0.46) and a medium effect in air (0.26) and health and food safety (0.31). An analysis of the statistically significant independent variables in Model 2 (Productivity) revealed large effects (> 0.35) in both water and health and food safety. In Model 4 (Operational), four independent variables presented large effects: Water (0.49), soil (0.37), reuse/recycling (0.37) and opportunities (0.39) while air presented a medium effect (0.27). Therefore, we concluded that the significant effects had satisfactory statistical power in our sample.

Moreover, as noted in Table 4, the water factor was the most representative, having a strong impact on the financial, productivity and operational variables. Chouchane *et al.* (2015) who carried out a study in a Mediterranean country that required high levels of irrigation, examined the economic dimensions of water use and concluded that it is important to quantify and map water consumption and pollution in relation to production and consumption. The water footprint can be a determining factor in whether farms are successful.

Different agricultural systems are idiosyncratic in terms of monitoring and predicting financial demand, partly because factors such as the seasonality of production and the weather, are beyond human control. These are part of the production forecasting process and the generation of financial results related to liquidity and the availability of resources. Since economic productivity is affected by these non-economic factors in rural areas and monitoring tools must be adapted to this reality, adopting a holistic view to understand the process as a whole and its zones of inference is important (Quintero-Angel & González-Acevedo, 2018).

Lastly, the interrelation between indicators showed that certain economic activities are reflected socially and environmentally for instance, the adoption of technologies that are

Table 4: Results of the regression analysis

		Economy Variables			
		Financial Aspects	**Productivity**	**Quality**	**Operational**
Environmental variables	Water	0.402***	0.557***	0.134	0.308**
	Air	**0.240***	0.033	-0.175	**0.223***
	Soil	-0.096	-0.156	0.117	**0.221****
	Reuse/recycling	0.039	0.089	-0.065	**-0.259****
Social variables	Health and food safety	**0.276****	**0.238****	-0.076	0.045
	Education	-0.180	-0.088	0.188	0.105
	Opportunities	0.084	0.153	0.131	**0.209****
	F-value	6.958***	8.997***	0.784	9.426***
	R^2	0.400	0.681	0.070	0.475
	Adjusted R^2	0.343	0.463	-0.019	0.424

Notes: n=81 farmers. [2]Unstandardised regression coefficients are reported, *p<0.1, **p<0.05, ***p<0.01

more economically efficient can help reduce atmospheric emissions (Nishitani *et al.,* 2017; Simas *et al.,* 2017).

Conclusion

The use of KPIs helped us understand what was most important for the sustainability of family farms. The KPIs related to water and soil conservation had a more positive effect on economic constructs. Therefore, the environmental and social KPIs were of great relevance (particularly water and soil). This was because water had a strong impact on financial, productivity and operational variables. Other KPIs also showed that the economic dimensions of the farmers' activities were dependent on social and environmental factors.

It was clear that the family farmers and cooperative managers recognised the importance of the TBL. It is hoped that future researchers might work to help them achieve success in the social, environmental, and economic spheres because they are very aware of the importance of natural resources and the well-being of the family, as well as the financial benefits that can accrue with sustainable farming. They can be important for decision-making on new sustainability policies in regions where agro-industrial production arrangements are relevant to the economy, as in southern Brazil. These producers are receptive to innovation and will be accessible for the continuity of research focused on technology implementation. It is necessary to improve the quality of life (social dimension) and not to compromise the environment (environmental dimension) with a positive effect on the economy of the agroindustry.

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