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Development of a tool to assess the rural sustainability of communities in the French region of Occitania[1]

Desenvolvimento de uma ferramenta para avaliar a sustentabilidade rural das comunidades da região francesa da Occitânia

Desarrollo de una herramienta para evaluar la sostenibilidad rural de las comunidades en la región francesa de Occitania

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Abstract: This article presents an analysis of rural sustainability in the Poles of Territorial and Rural Equilibrium (PETR) in Occitania, France, using the Rural Sustainability Index (RSI) as a statistical inference tool. It was constructed based on the dimensions of sustainable development: Social, Economic, Environmental, and Institutional. The methodology used in this research is quali-quantitative, bibliographical, and documental, based on secondary data provided by the French government. The results revealed that by the year 2022, half of the productive communities had a positive performance and half had to optimize efforts towards sustainability, with the best overall performances occurring in the Environmental, Social, and Institutional dimensions, with the Economic dimension showing the greatest potential for improvement. The RSI presents itself as a relevant tool to support the formulation of public policies for rural development, as it allows for reliable comparability between locations, regardless of their economic or population size.

Keywords: Rural Sustainability Index; Rural Sustainable Development; Rural Sustainability in Occitanie; Territorial and Rural Balance Pole; Development of Sustainability Index.

Resumo: Este artigo apresenta uma análise da sustentabilidade rural nos Polos de Equilíbrio Territorial e Rural (PETR) da Occitânia, França, utilizando o Índice de Sustentabilidade Rural (RSI) como ferramenta de inferência estatística. Foi construído com base nas dimensões do desenvolvimento sustentável: Social, Econômica, Ambiental e Institucional. A metodologia utilizada nesta pesquisa é qualiquantitativa, bibliográfica e documental, baseada em dados secundários fornecidos pelo governo francês. Os resultados revelaram que, até o ano de 2022, metade das comunidades produtivas teve um desempenho positivo e metade teve de otimizar esforços para a sustentabilidade, com os melhores desempenhos gerais ocorrendo nas dimensões Ambiental, Social e Institucional, com a dimensão Econômica apresentando o maior potencial de melhoria. O RSI apresenta-se como uma ferramenta relevante para apoiar a formulação de políticas públicas de desenvolvimento rural, pois permite uma comparabilidade confiável entre as localidades, independentemente de seu porte econômico ou populacional.

Palavras-chave: Índice de Sustentabilidade Rural; Desenvolvimento Rural Sustentável; Sustentabilidade Rural na Occitânia; Polo de Equilíbrio Territorial e Rural; Desenvolvimento do Índice de Sustentabilidade.

Resumen: Este artículo presenta un análisis de la sostenibilidad rural en los Polos de Equilibrio Rural y Territorial (PETR) en Occitania, Francia, utilizando el Índice de Sostenibilidad Rural (RSI) como herramienta de inferencia estadística. Se construyó con base en las dimensiones del desarrollo sostenible: Social, Económica, Ambiental e Institucional. La metodología utilizada en esta investigación es cualicuantitativa, bibliográfica y documental, basada en datos secundarios proporcionados por el gobierno francés. Los resultados revelaron que, para el año de 2022, la mitad de las comunidades productivas tuvieron un desempeño positivo y la otra mitad debió optimizar esfuerzos hacia la sustentabilidad, ocurriendo los mejores desempeños globales en las dimensiones Ambiental, Social e Institucional, siendo la Económica con mejor potencial de mejora. El RSI se presenta como una herramienta relevante para apoyar la formulación de políticas públicas de desarrollo rural, ya que permite una comparabilidad confiable entre localidades, independientemente de su tamaño económico o poblacional.

Palabras clave: Índice de Sostenibilidad Rural; Desarrollo Rural Sostenible; Sostenibilidad Rural en Occitania; Polo de Equilibrio Territorial y Rural; Desarrollo del Índice de Sostenibilidad.

1 INTRODUCTION

The issue of sustainable development, especially in rural areas, has been much debated in various global forums. Aspects such as food safety, environmental preservation, social responsibility, and institutional structure are the focus of concern for all countries – regardless of their economic size – which are now demanded by the local population and the international community regarding performance in relation to parameters such as food loss and waste, sustainable agriculture, and nutritional challenges.

Different countries face equally distinct challenges, as they have particular social and productive structures, which derive from their own historical process of formation. However, the essence of sustainability is common to all, constituting the set of efforts undertaken so that strategic development actions are sustainable. Different metrics are used to evaluate the results of strategic actions. But the inference on this form of development from the rural perspective needs to consider a complex configuration that involves large-scale commodity production, food quality and security and the transformation of rural communities.

The aim of this paper is to foster the discussion on the evaluation of sustainability in rural areas, based on the finding of the need to develop indexes that add the various variables and indicators available around dimensions that allow the evaluation of sustainable development in this sector. The established field of study encompassed the three largest productive centers in the French region of Occitania, applying the Rural Sustainability Index (RSI), which covers the dimensions of sustainable development: Economic, Environmental, Social and Institutional. The methodology used in this research is quali-quantitative, bibliographical, and documentary, based on secondary data provided by the French government. For timely research, it proved relevant to provide methodology and tooling applied to the evaluation of rural sustainable development, favoring the adoption of strategies for the sustainability of the communities involved.

In addition to the Introduction, the paper is divided into four sections, the first entitled "Relevance in the use of performance indexes to measure sustainability" (item 2), being subdivided into "Specific characteristics of

rural performance indexes" (item 2.1), and "Key elements of sustainability performance indexes" (item 2.2); the second, "Methodology" (item 3), being subdivided into "Definition of indicators" (item 3.1), and "Standardization and weighting of values" (item 3.2); the third "Results" (item 4), being subdivided into "Construction of the Rural Sustainability Index- RSI (item 4.1), and "Ranking of french PETR" (item 4.2); and the fourth “Discussion and Conclusions” (item 5).

2 RELEVANCE IN THE USE OF PERFORMANCE INDEXES TO MEASURE SUSTAINABILITY

Performance indexes, also known as synthetic indexes, or composite indicators (BECKER *et al*., 2017), are widely used to evaluate and compare countries, communities, or other local arrangements in various aspects, summarizing and explaining an observable set of data – what statistics call 'latent variables', or 'factors' (HAIR; BLACK; AL, 2009). These indexes show structural relationships and interaction mechanisms of different variables and phenomena, favoring the understanding of complex constructs such as sustainability. A set of composite indicators is the appropriate instrument to represent the multidimensionality of this type of concept, including delimiting the phenomenon observed in a precise historical clipping (BOGGIA; CORTINA, 2010; PEREIRA; SAUER; FAGUNDES, 2016).

The evaluation of sustainability demands the use of performance indexes that capture the different peculiarities and nuances of this complex construct. In the literature there are several possibilities. The Commission for Sustainable Development (UN, 2001) proposed key themes to test and validate composite indexes by grouping them into four major areas: social, environmental, economic, and institutional. The following table (Table 1) brings the proposed initial organization.

Table 1 - Key themes proposed for testing priorities in countries.

SOCIAL	ENVIRONMENTAL
Education, employment, health, housing, quality of life, income distribution, crime, population, ethical and moral values, role of women, access to land and resources, community structure, social exclusion.	Water resources, agriculture, coastal zone, marine environment, fishing, air pollution, global climate change, sustainable use of natural resources, sustainable tourism, land use.
ECONOMICAL	INSTITUTIONAL
Economic dependence, energy, consumption and production patterns, waste management, transportation, mining, economic structure and development, trade, productivity	Integration of decision-making, training, science and technology, awareness and public information, international conventions and cooperation, governance, institutional and legislative structures, disaster preparedness, public participation.

Source: Adapted from UN (2001, p. 14).

In the same way, the Organization for Economic Cooperation and Development (OECD) lists the following desirable characteristics for a sustainability index (OECD, 2004):

a. Synthesis of complex or multidimensional issues.

b. Highlight the performance of countries according to their public policies.

c. Possibility of a complete evaluation of the performance of countries.

d. Comparison the efficiency of countries.

e. Ease of communication with the average citizen.

f. Possibility of being used as benchmarking of better performing countries.

g. Identification of allocation priorities of improvement efforts.

h. Encouraging the search for better data and better analytical efforts.

i. Setting local priorities and seeking improvements in the performance dimension where earnings are most easily guaranteed.

On the other hand, the evaluation of sustainability in rural areas requires a systematic that considers performance indexes adjusted to the

manifestations of the reality of the field, especially due to their mixed character of biophysical, environmental, social, and economic elements (SCHULTINK, 2000).

2.1 Specific characteristics of rural performance indexes

The literature brings the essential elements that must be incorporated into the performance indexes of rural sustainability to adequately represent the plurality of elements that compose it. A systematic integrative literature review allowed us to investigate the existence of common characteristics and patterns and elements of analysis. The databases consulted were Web of Science, Scopus and Science Direct. The descriptors used were "Sustainability Index", "rural areas", and "Rural Sustainability Index", including the free translation of the same terms into English and Spanish. The results are summarized in Table 2.

Table 2 - Articles included. Keywords: "Sustainability Index", “AND” "rural areas" and "Rural Sustainability Index"

Year	Article Title	Author	Features
2021	Index system of sustainable rural development based on the concept of ecological livability	Li, X., Yang, H., Jia, J., Shen, Y., Liu, J.	1. Rural Sustainability Index 2. Deconstruction of the concept of Rural Sustainable Development (SRD), replacing its indicators with others with what the authors classified as 'universal value', and introducing the premises of ecological habitability 3. Two large dimensions: a. Rural ecological sustainability- green production and waste disposal b. Rural housing sustainability- public services and social convenience
2020	Scientific landscape of sustainable urban and rural areas research: A systematic scientometric analysis.	Sheikhnejad, Y., Yigitcanlar, T.	Fragility of sustainability between urban and rural areas

Year	Article Title	Author	Features
2020	Agricultural sustainability assessment framework integrating sustainable development goals and interlinked priorities of environmental, climate and agriculture policies	Streimikis, J., Balezentis, T.	New framework of indicators for assessing sustainability in agriculture, seeking to harmonise the european union's sustainable development, climate, and agricultural policies
2020	The "Eco-Effectiveness" of Agritourism Dynamics in Italy and Spain: A Tool for Evaluating Regional Sustainability	Belliggiano, A., Garcia, E.C., Labianca, M., Valverde, F.N., From Rubertis, S.	1. Index Decomposition Analysis (IDA) 2. Eco-effectiveness in agrotourism
2020	A New Livelihood Sustainability Index for Rural Revitalization Assessment-A Modelling Study on Smart Tourism Specialization in China	I read, H., Nijkamp, P., Xie, X., Liu, J.	1. Index for Rural Revitalization Assessment (IRRA) 2. Sustainability of livelihoods in rural tourism destinations Dimensions: subsistence capital and the interconnection between it and the environment
2017	A proposed Sustainable Rural Development Index (SRDI): lessons from Hajij village, Iran.	Hashemi, N., Ghaffary, G.	1. Sustainable Rural Development Index (SRDI) 2. Development of tourism in rural areas 3. Matrix of strengths, weaknesses, opportunities, and threats (SWOT)
2017	Malmquist index measurement for sustainability enhancement in Chinese municipalities and provinces	Sueyoshi, T., Goto, M., Wang, D.	1. Data Envelomycanalysis (DEA), including the Malmquist Index framework 2. The policies adopted for urban centres move to the rural environment
2016	Assessing urban sustainability of Chinese megacities: 35 years after the economic reform and open-door policy	Lu, H., Lijiao, Y; Jianguo, W.	Urban-rural income ratio in addition to indicators already used
2015	Monitoring socio-environmental change for sustainable development: Developing a Multidimensional Livelihoods Index (MLI)	Donohue, C., Biggs, E.	1. Multidimensional Livelihoods Index (MLI) 2. The index should use indicators of the dimensions: a. Human b. Physics c. Social d. Financial e. Natural

Year	Article Title	Author	Features
2015	Detecting the changes in rural communities in Taiwan by applying multiphase segmentation on FORMOSA-2 satellite imagery	Huang, Y.	1. Algorithm to optimize remote sensing by satellite image 2. Multiphase Approach: Normalized Difference Vegetation Index (NDVI)
2015	Towards sustainability in agro-forest systems? Grazing intensity, soil degradation and the socioeconomic profile of rural communities in Italy	Salvati, L. Carlucci, M.	The index should use indicators covering six thematic areas: a. Population dynamics and human settlement b. Labour market and human capital c. Economic specialization and competitiveness d. Quality of life e. Agriculture and rural development f. Territory and environment
2014	Assessing Rural Sustainable Development potentialities using a Dominance-based Rough Set Approach	Boggia, A., Rocchi, L., Paolotti, L., Musotti, F., Greco, S.	1. Dominance-based Rough Set Approach (DRSA) 2. Dimensions used in the index: 3. Quota of free residences 4. Quota of the population residing in smaller centers – as *a proxy* for a typical settlement in rural locations 5. Demographic density, measured according to residents in large centers, as a measure of productive social gravitation 6. Number of residents 7. Proportion of young farmers- under 40 years of age- and the rest of employers in the primary sector to assess turnover
2012	Can the Genuine Progress Indicator better inform sustainable regional progress?- A case study for Northeast Ohio	Bagstad, K.J., Shammin, M.R.	1. Spatial and temporal perspectives 2. Inter- and intra-regional dynamics: urban-suburban-rural
2009	Monitoring and guiding development in rural Egypt: Local sustainable development indicators and local human development indexes	Khalifa, M.A., Connelly, S.	1. The social and economic scopes of the index should reflect the relevant topics for the inhabitants of rural areas 2. Environmental and institutional factors should be given priority

Source: Dados of the research.

2.2 Key elements of sustainability performance indexes

For these characteristics to be achieved, the study also proposes a general scheme for the construction of indexes, described in Table 3.

Table 3 - General scheme for the construction of sustainability indexes

1. Theoretical framework	Ideally, a theoretical framework will allow indicators to be selected, combined, and weighted in a way that reflects the dimensions or structure of the phenomenon being measured	
2. Data selection	a) Political relevance b) Simplicity c) Validity d) Time series data (e) availability of accessible data f) Sensitivity g) Reliability	
3. Correlation analysis	Indicators are often chosen with little attention to the interrelations between them. Correlation analysis should: (a) identify the statistical dimensions in the dataset b) Eliminate highly correlated indicators	
4. Preliminary data processing	a) Make the variables comparable: for example, dividing by population / income / populated land area b) Adjustment- cleaning- of the data: for example, data deletion, averaging substitution, regression, multiple imputation, nearest neighbor c) Logarithms applied to highly distorted variables: e.g., measurement of asymmetry greater than 5 d) truncated distributions: for example, to consider the inaccuracy of data at extremes, to prevent extreme cases from becoming references for the entire population	
5. Data normalization	Method	Examples of Indexes
	Standard deviation of the mean	Environmental Sustainability Index Mother's Index Internal Market Index General Indicator of Science and Technology
	Distance from average	Economic Sentiment Indicator
	Distance from the best and worst performances	Human Development Index Health System Achievement Index Commitment to Development Index Human Tourism Index The Networked Readiness Index
	Categorical scale	Environmental Performance Index National Health Care Systems Performance Business climate indicator Index of Economic Freedom Summary Innovation Index

	Method	Examples of Indexes
6. Data weighting	Equal weights	Summary Innovation Index Environmental Sustainability Index Composite Leading Indicators
	Correlation analysis	Relative intensity of regional problems in the Community
	Unobserved component models	Internal Market Index General Indicator of Science and Technology Business climate indicator Governance indicators
	Data Envelopment Analysis (DEA)	Human Development Index Social Inclusion Unemployment
7. Data aggregation	$Y_c = \sum_{q=1}^{Q} (I_{q,c}^{p} \cdot w_q)^{1/p}$	Where: Y_c: Index for country 'c' $I_{q,c}^{p}$: Standard indicator w_q: Weight *1/p*: Compensation effects included
8. Robustness / sensitivity tests	Tests applied to verify the influence of point modifications on variables on the results – *ceteris paribus*	
9. Preview	Presentation of results	

Source: adapted from OECD (2004).

The United Nations (UN, 2015) began to set standards for the adoption of indicators and for the creation of a framework for monitoring the Sustainable Development Goals – SDGs. For these purposes, 10 criteria are proposed:

a. Limitation in number and overall harmonization.
b. Simple single-variable indicators with direct policy implications.
c. Possibility of high frequency monitoring.
d. Consensual indicators, in line with international standards and based on systems in training.
e. Construction of indicators from well-established data sources.
f. Disaggregation.
g. Universality.
h. Focus on results.
i. Indicators based on science and forward-looking.
j. Proxies for broader issues or conditions.

3 METHODOLOGY

The method used in this study is that of social research, within a positive conception of knowledge, and according to the methodological characterization proposed by Creswell (2013), Richardson (2017), Lakatos and Marconi (2019). Within this methodological perspective it is characterized in its different dimensions as follows:

a. As for the purpose: Basic Applied, where the research problem characterizes a material and concrete situation – the proposition of a rural sustainability index.

b. As for the objectives: Descriptive, whose objective is the maximum picture of the characteristics of the problem, identifying the relationships between the different variables of the study – the use of indicators that reflect different dimensions of the empirical field studied.

c. As for the methods: Inductive, where it is part of the private, collecting data that allow the observation of concrete representative cases, generalizing its results, finally generating a systematic analysis that can be replicated in other studies.

d. As for the approach: Mixed (quantitative-qualitative), where the researcher will interpret the data and information, bringing conclusions based on the theoretical framework and professional expertise of those involved in the research – the reconciliation of statistical inference, theory on sustainability, and planning and management of territorial planning.

e. As for the procedures: Bibliographic (books, articles, and other sources of scientific character) and Documentary (non-scientific).

The selection of indicators, the construction of the index, and the elaboration and use of dashboards to evaluate the field of study follows a peer-reviewed methodology (SCHMIDT-TRAUB *et al*., 2017), audited by the Joint Research Centre (PAPADIMITROU; NEVES; BECKER, 2019) as described in the following subsections.

3.1 Definition of indicators

This research used population, geographic and economic data from the Occitan region, an administrative region located in southeastern France, especially in the 31 Poles of Territorial and Rural Equilibrium (PETR), which involve 3.041 municipalities and more than 2 million inhabitants, as described in Table 4.

Table 4 - Poles of Territorial and Rural Balance - Occitanie. Population and Communes (2022)

Territorial and Rural Balance Poles - Occitanie	Population (2022)	Communes
PETR Cœur of Bigorre	34.823	51
PETR du Haut-Rouergue	34.083	38
PETR du Pays d'Auch	63.806	135
PETR du Pays de Lourdes et des Vallées des Gaves	37.360	85
PETR du Pays des Coteaux	17.950	103
PETR Garonne Quercy Gascogne	132.652	139
PETR Grand Quercy	91.830	148
PETR Hautes-Terres d'Oc	20.452	36
PETR Pays Portes de Gascogne	73.089	160
PETR Vallée de l'Aude	41.192	137
PETR Garrigues et Costières de Nîmes	288.959	44
PETR de l'Albigeois et des Bastides	288	2
PETR of l'Ariège	123.285	233
PETR du Pays of Cocagne	66.478	75
PETR du Pays des Nestes	31.956	146
PETR du Pays Tolosan	122.058	73
PETR du Pays Val d'Adour	43.209	157
PETR Uzège Pont du Gard	54.130	49
PETR Causses Cévennes	15.357	36
PETR du Pays Lauragais	105.655	167
PETR Pays d'Armagnac	43.351	102
PETR Vidourle Camargue	98.831	36
PETR Centre Ouest Aveyron	154.581	123
PETR du Lévézou	13.264	19
PETR du Sud Toulousain	98.037	99

Territorial and Rural Balance Poles - Occitanie	Population (2022)	Communes
PETR Figeac, Quercy, Vallées de la Dordogne	88.716	169
PETR Pyénées	77.654	235
PETR de l'Albigeois et des Bastides	57.571	95
PETR du Pays Gévaudan Lozère	33.358	64
PETR Pays Midi-Quercy	50.271	49
PETR Sud Lozère	11.957	36
Total	**2.126.203**	**3.041**

Source: Data.laregion.fr (2022).

The survey focused on the data published in 2022, using the indicators that are part of the Sustainable Development Goals – SDGs – provided by Préfet de la Region Occitanie, via picto stat system, which concentrates data on development and interministerial statistical mapping in Occitania (PICTOSTAT, 2022). The data are provided by different sources: Institut National de la Statistique et des Études Économiques (Insee), Fichier National des Professionnels de Santé (FNPS), Autorité de Régulation des Communications Électroniques, des Postes et de la Distribution de la Presse (ARCEP), Observatoire national de l'artificialisation, Geovélo, Service des Données et Études Statistiques (SDES), Portail Interministériel Cartographique (Picto), Corine Land Cover, and Schéma Directeur d'Aménagement et de Gestion des Aaux (SDAGE). Table 5 lists the indicators and their classification for the composition of the RSI.

Table 5 - Indicators of sustainable development, classified by SDGs and themes, used in the construction of the RSI

SOCIAL DIMENSION				
SDG	Theme	Indicators	Source	Period
SDG 1- Poverty eradication	1 - Combating inequalities and poverty	Median living standards	Insee	2018
		Poverty rate	Insee	2018

SOCIAL DIMENSION				
SDG	Theme	Indicators	Source	Period
SDG 3- Health and well-being	5 - Action for the health and well-being of all	Number of liberal general practitioners	FNPS	2019
		Density of medical doctors' lib. (for 10,000 inhabitants)	FNPS	2019
		Population sharing more than 20 minutes from at least one of the local health services	FNPS	2019
SDG 4- Quality education	4 - Adaptation of lifestyles and behaviors	Participation from 25 to 34 years of age, with a diploma in higher education	Insee	2017
		Participation of non-graduates between 20 and 24 years of age emerging from studies	Insee	2017
SDG 5- Gender equality	1 - Combating inequalities and poverty	Distribution of unemployed by sex	Insee	2018
		Difference due to higher grades among over 15 years of age, uneducated	Insee	2017
		Female unemployment rate	Insee	2018
		Male unemployment rate	Insee	2018
		Part of women's employment	Insee	2018
		Female activity rate	Insee	2018
SDG 7- Clean and affordable energy	3 - Climate action and carbon reduction	Heating mode of major fuel homes	Insee	2019
		Energy consumption by sectors	Pict	2019
		Energy consumption by energy type	Pict	2019
		Participation of production in energy consumption	Pict	2019
		Energy production by source	Pict	2019
		Plants installthem by sources	Pict	2019

SOCIAL DIMENSION				
SDG	Theme	Indicators	Source	Period
SDG 11- Sustainable cities and communities	6 - Strengthening territorial innovation	Moradia in situations of over occupation	Pict	2017
		Sharing artificial surfaces	Pict	2018
		Artificialisation evolution rate between 2010 and 2020	Observatoire national de l'artificialisation	2020
		M^2- Artificialized for housing by additional housing 2013- 2018	Observatoire national de l'artificialisation	2018
		Transport sharing- working outside your commune	Insee	2018
		Sharing public transport on business trips- home	Insee	2018
		Bike sharing on work trips - home	Insee	2018
		Safe lanes (bike paths and green roads)	Geovélo	2021
		Car sharing at work- home	Insee	2018
ECONOMIC DIMENSION				
Odd	Theme	Indicators	Source	Period
SDG 8- Decent work and economic growth	1 - Combating inequalities and poverty	Distribution of employee employment according to working time	Insee	2018
		Unemployment rate (unemployed na pop. Ativa)	Insee	2018
SDG 9 - Industry, innovation, and infrastructure	6 - Strengthening territorial innovation	Polluting cars (combustion)	SDES	2020
SDG 10 - Reducing inequalities	1 - Combating inequalities and poverty	Sharing the surface covered in 4G by at least one operator	ARCEP	2020
		Participation of families- Taxes	Insee	2018
		Report- standard of living	Insee	2018

SOCIAL DIMENSION				
SDG	Theme	Indicators	Source	Period
SDG 6- Drinking water and sanitation	2- Preservation of resources and biodiversity	Proportion of watercourses on the surface in good ecological condition or very good- inventory	Sdage	2019
		Number of treatment stations	Water agencies	2018
		Compliance rate of treatment plants	Water agencies	2018
		Eutrophication-sensitive zone: surface sharing	Pict	2010
SDG 13- Action against global climate change	3- Climate action and carbon reduction	GHG emissions per inhabitant	Pict	2019
		GHG emissions by type of pollutants	Pict	2019
SDG 15- Terrestrial life	2- Preservation of resources and biodiversity	Sharing of areas of agricultural territories	Corine Land Cover	2018
		Sharing the surfaces of artificial territories	Corine Land Cover	2018
		Sharing of water surface areas	Corine Land Cover	2018
		Part of the swamp area	Corine Land Cover	2018
		Part of the forest areas and semi-natural environments	Corine Land Cover	2018
INSTITUTIONAL DIMENSION				
Odd	Theme	Indicators	Source	Period
SDG 16- Peace, justice, and effective institutions	6- Strengthening territorial innovation	Participation rate in the 1st round of municipal elections	DataGouv	2020
		Participation rate 1st round of legislative elections	DataGouv	2017
		Participation rate 1st round of presidential elections- 1st round	DataGouv	2017

Source: PictOstat (2022).

Although the data source is not originally aggregated by dimensions, it will be carried out within the four dimensions of sustainability – social, environmental, economic, and environmental. To this, the internationally consolidated methodology was followed (UNESCO, 2006; UN, 2007), and adapted to the very set of data made available by the different spheres of

the French government, by the study of the Conseil National de L'information Statistique, which elaborated the French version of the indicators for the SDGs (CNIS, 2018).

3.2 Standardization and weighting of values

For the normalization and rescale of the values – in parameters ranging from 0 to 1 – the maximum and minimum method was used, which calculates a proportion of the displacement of an 'X' variable within the limits of the sample, as described in the equation (1) below (Figure 1).

Figure 1 - Equation for sample standardization

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)} \quad (1)$$

Where:

$x' = normalized\ value$

$x = value\ (data)$

$\max(x) = maximum\ sample\ value$

$\min(x) = minimum\ sample\ value$

Source: Elaborated by the authors.

After normalization and rescale of the data, there was a need to aggregate them so that there was better representativeness of the performance of each locality within a dimmension of sustainability, and an SDS. The literature on the elaboration of composite indexes is crystallized and agrees, for this purpose (BÉNÉ *et al*., 2019), that a simple arithmetic mean is sufficient for the calculation of aggregate scores of the index, in case one or more dimensions can be replaced by others. If the dimensions are not compensatory, other aggregation methods should be used. Thus, as the Economic, Environmental, Social, and Institutional dimensions of this study do not

have compensatory characteristics, we opted for the geometric arithmetic mean for the aggregation of scores. On the other hand, the aggregation of indicators in the same dimension was performed by the simple arithmetic mean, following the understanding that all have the same relevance to the objectives of the indicator (SCI, 2021).

The formula for calculating geometric means (2) is represented in Figure 2.

Figure 2 - Formula for calculating the geometric mean

$$\sqrt[n]{x1 * x2 * x3 * \ldots * xn} \quad (2)$$

Where:

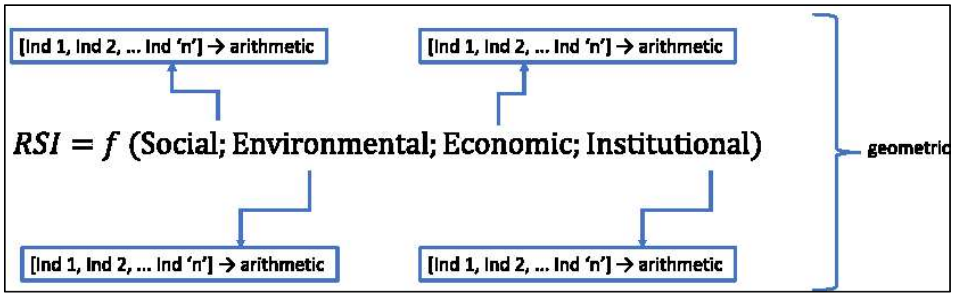
$n = number\ of\ sample\ elements$

$x1 * x2 * x3 * \ldots * xn = sample\ with\ 'n'\ elements$

Source: Elaborated by the authors.

For the aggregation of indicators with standardized values (scores), within the dimensions of sustainable development, the following formula was used for the composition of the RSI (Figure 3):

Figure 3 - Formula for the composition of the Rural Sustainability Index (RSI)



Source: Elaborated by the authors.

We chose to weight equally to all indicators within a dimension, and of all dimensions within the index because it is understood that there is equal relevance of each factor within the concept of sustainable development (SCI, 2021). Thus, localities must follow the index holistically, seeking the best interventions and strategies to achieve sustainability.

4 RESULTS

4.1 Construction of the Rural Sustainability Index – RSI

The construction of the RSI followed the methodology described in the study. In addition, it is reported that there was a result of members of the boards of two PETR in the discussion about the use of indicators and the RSI in the formulation and evaluation of public policies of the communes. They are PETR Pays D'Armagnac and PETR du Pays d'Auch. Thus, since the beginning of the development of the RSI, a tool was created that aggregated all the data, described the methodology, and allowed the consultation, generation of graphs and dashboards for monitoring of stakeholders. The application was developed from the proprietary Google Workspace package.

The construction of the RSI followed the steps:

a. Data collection for each indicator in Table 4, for each Community of Communes – which are administrative groupings between communes of the same region – of the 31 PETR.

b. Normalization of the data by the method of maximums and minimums, being rescaled into parameters ranging between 0 and 1.

c. Aggregation of indicators within the same ODS. For this aggregation, the simple arithmetic mean of all indicators belonging to the same SDGs was calculated.

d. Aggregation of SDS within the same dimension. For this aggregation, the geometric arithmetic mean of all SDGs belonging to the same dimension was calculated.

Consolidated statistical information – mean, standard deviation and percentiles – can be verified in Table 6.

The elaboration of the table that consolidates the statistical data of the Index allows us to infer about the development of french PETR and the distance they occupy from the average they establish from each other. Those with a greater distance from this parameter should make efforts with the member communes to identify weaknesses and establish adjustment strategies. Those who move positively away from this cut must reinforce the initiatives and disseminate them among the members, to continue the path of sustainability.

4.2 Ranking of the French PETR

From the calculation of the Index for PETR, it was possible to elaborate a ranking of the general index, also identifying the values obtained in each dimension of sustainable development. The column headings referring to the dimensions were abbreviated as follows: GS (General Score), ECO (Economic), ENV (Environmental), SOC (Social) and INS (Institutional). Table 7 brings this information.

Table 7 - RSI Ranking – PETR

Ranking	PETR	GS	SOC	ECO	ENV	INS
1	PETR du Lévézou	0.87	0.76	0.47	0.56	0.87
2	PETR du Pays of Cocagne	0.83	0.69	0.52	0.63	0.62
3	PETR Pays Portes de Gascogne	0.82	0.65	0.53	0.63	0.63
4	PETR du Pays Lauragais	0.80	0.60	0.51	0.70	0.57
5	PETR Grand Quercy	0.80	0.65	0.39	0.76	0.67
6	PETR Figeac, Quercy, Vallées de la Dordogne	0.79	0.64	0.43	0.69	0.62
7	PETR du Pays Gévaudan Lozère	0.78	0.65	0.37	0.62	0.74
8	PETR du Sud Toulousain	0.77	0.64	0.51	0.76	0.43
9	PETR du Haut-Rouergue	0.76	0.67	0.36	0.63	0.68
10	PETR Centre Ouest Aveyron	0.75	0.63	0.44	0.57	0.64
11	PETR de l'Albigeois et des Bastides	0.74	0.58	0.38	0.61	0.69
12	PETR de l'Albigeois et des Bastides	0.74	0.58	0.38	0.61	0.69
13	PETR du Pays des Coteaux	0.74	0.57	0.41	0.64	0.60
14	PETR du Pays Val d'Adour	0.74	0.53	0.38	0.72	0.62
15	PETR du Pays Tolosan	0.73	0.64	0.53	0.55	0.52

Ranking	PETR	GS	SOC	ECO	ENV	INS
16	PETR Uzège Pont du Gard	0.72	0.57	0.55	0.71	0.37
17	PETR of l'Ariège	0.71	0.53	0.35	0.92	0.51
18	PETR Hautes-Terres d'Oc	0.70	0.52	0.34	0.71	0.62
19	PETR Cœur of Bigorre	0.70	0.63	0.45	0.86	0.33
20	PETR Vidourle Camargue	0.69	0.58	0.58	0.73	0.29
21	PETR du Pays des Nestes	0.69	0.67	0.28	0.85	0.49
22	PETR Pyénées	0.67	0.57	0.38	0.75	0.41
23	PETR Garonne Quercy Gascogne	0.67	0.52	0.42	0.62	0.47
24	PETR Pays Midi-Quercy	0.66	0.49	0.39	0.60	0.51
25	PETR du Pays de Lourdes et des Vallées des Gaves	0.62	0.66	0.31	0.89	0.43
26	PETR du Pays d'Auch	0.58	0.50	0.36	0.43	0.63
27	PETR Pays d'Armagnac	0.57	0.44	0.31	0.48	0.64
28	PETR Vallée de l'Aude	0.54	0.43	0.16	0.89	0.53
29	PETR Sud Lozère	0.54	0.48	0.12	0.72	0.69
30	PETR Causses Cévennes	0.50	0.47	0.17	0.72	0.51
31	PETR Garrigues et Costières de Nîmes	0.42	0.54	0.57	0.58	0.13

Source: Research data.

5 DISCUSSION AND CONCLUSIONS

The table containing the Rural Sustainability Index (RSI) shows that approximately 55% of the PETR (17) are above the RSI average, and only two of them obtain the same value (0.70). The rest – 14 of them, or 45%) are below this cut. Thus, almost half of PETR need to optimize their strategic efforts to achieve median performance.

On the other hand, when analyzing the discrepancy between the indexes of the first and last placed in the Ranking, it is verified that the average of the five largest indexes (0.82) is 60.03% higher than the average of the five worst (0.51). The unequal performance in the indicators of the worst-placed PETR, and the most uniform of the former, explains this difference.

Unfolding the Index, it is verified that just over a third of the PETR (14) exceed the average in the Social Dimension (0.58), three equal the average and the rest have a performance below this line. Similar performance occurs

in the Economic Dimension, whose average of 0.40 represents the lowest among the dimensions of sustainable development, being exceeded by 14 PETR. The Environmental Dimension records the highest average among the dimensions (0.68), with 16 PETR exceeding this value. Finally, the Institutional Dimension is the one that more PETR exceeds the average, which is 0.55: there are 17 organizations with scores above this reference.

The measurement of sustainability from the RSI shows that there is a balance between the Polos of Territorial and Rural Equilibrium in the region of French Occitanie, practically equivalent to the number of those who have better average performance and those who need to optimize efforts in this sense. And, although the Environmental Dimension is the one with the best performance in the overall calculation, the RSI draws attention to the economic and institutional aspects receiving the strategic focus of public policies, seeking the most detailed analysis on the indicators individually, and the variables that influence their composition.

The study reports the structuring of the Rural Sustainability Index (RSI) to evaluate the sustainable development of the Territorial and Rural Balance Centers (PETR) of the French Occitany. The purpose of the Index is to allow the measurement of efforts towards rural sustainability, comparing the different sets of French communes. In general, the best performance of communities in the Environmental Dimension stood out, suggesting the relative success of its members' adhering to the principles of environmental preservation.

The Social Dimension is the second about the amount of above average PETR, highlighting the consolidation of the progress in this area, such as education, health, and social well-being. This dimension is followed by the Institutional, which, although it lacks a greater number of indicators – since they essentially reflect democratic participation in the PETR – shows that there is also a good performance of most communities.

The Economic Dimension represented the worst overall average performance, which may mean a greater focus on public policies for development not necessarily linked to the higher performance of economic, perhaps receiving more resources from the State – which could be verified in later studies.

The methodology used - qualitative-quantitative - associates the perspective of sustainability with mathematical principles to perform the aggregation of data in indicators, and these in a synthetic performance index. The Index applied to PETR allowed establishing a ranking where, more than classifying productive groups by performance, it evaluated the distance that each one was from a more consistent path to rural sustainability.

This study aimed to develop a tool, here constructed as a performance index, to serve as an additional resource for the public policy maker for rural development in the region of Occitanie in France. The expected contribution was the generation of an index that reflects a latent variable- rural sustainability- allowing the comparability between different productive arrangements over time, contributing as a planning tool and control function for the management of this sector of the economy.

A positive aspect of the generated Index is to allow comparability, among the communes themselves, their productive aggregates and other regions of France or other countries, including in historical series. As the reference was the grouping by Sustainable Development Goals (SDGs) and dimensions of sustainable development, one can make the choice of indicators and variables that better represent local manifestations, without losses in the essence of each item to be analyzed. This characterizes RSI as a tool to support the formulation of public policies and collaborates with the literature on sustainable development by providing empirical evidence.

Although the study brings data and generates information on the performance of rural sector organizations in this French region, it is suggested as a possibility for further studies the exploration of the spatial (co) relationship between them, which could indicate dependencies or synergies between the communes and regions, including evaluating the degree of dispersion/concentration of wealth, production, and well-being itself. Another limitation that could be explored in new research is performance by SDGs, since they were used in the present study only for the purpose of aggregating indicators within the dimensions of sustainable development.

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