

# Multidimensional analysis of diversification and sustainability of agricultural production

## *Análise multidimensional da diversificação e sustentabilidade da produção agrícola*

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### Abstract

Agricultural diversification is an important strategy in promoting sustainable rural development, but its purely economic analysis overlooks significant issues such as environmental and social aspects. In this context, there is a need to analyze agricultural diversification from more than one dimension. This paper, therefore, conducts a systematic literature review with the aim of building the state of the art of agricultural diversification within the multidimensional framework. It was possible to conclude that specialization is economically beneficial in the short term. Still, diversification brings long-term sustainability, considering the economic, social, and environmental pillars, as it allows for the respect of agroecosystem limits. Additionally, the diversification process is heterogeneous and complex, requiring respect for the specificities of each case.

**Keywords:** agricultural diversification, resilience, rural development, sustainability.

### Resumo

A diversificação agrícola é uma estratégia importante na promoção do desenvolvimento rural sustentável, mas sua análise puramente econômica ignora questões importantes, como as ambientais e sociais. É nesse sentido que existe a necessidade de se analisar a diversificação agrícola com mais de uma dimensão. Este artigo, portanto, realiza uma revisão sistemática de literatura com o objetivo de construir o estado da arte da diversificação agrícola sob o recorte multidimensional. Foi possível concluir que a especialização é economicamente benéfica no curto prazo, mas é a diversificação que traz sustentabilidade no longo prazo, considerando o tripé econômico, social e ambiental, uma vez que permite o respeito aos limites do agroecossistema. Além disso, o processo de diversificação é heterogêneo e complexo, devendo-se respeitar as particularidades de cada caso.

**Palavras-chave:** diversificação agrícola; resiliência; desenvolvimento rural; sustentabilidade.

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## 1 Introduction

Agricultural diversification and concern for food security are not new. Fausto (2006) explains that even during the colonial period, the Portuguese Crown expressed concern about diversifying agricultural production in Brazil to ensure the availability of foodstuffs. Therefore, in addition to large producers, there was a peasantry with smallholdings. This concern remains relevant today: the diversification of production systems provides a path to deal with complexity and uncertainty, particularly valuable during global shocks such as pandemics and prolonged droughts (Petersen-Rockney et al., 2021).

The trend, therefore, is to replace simplified or monoculture systems with diversified ones. The importance of integration between animal and plant production also comes into play. It is worth noting that each agroecosystem has its own specificities, and there is no one-size-fits-all solution. Therefore, it is necessary to understand them and adopt suitable forms of diversification (Ministry of the Environment [MMA], 2000).

Riquinho and Hennington (2014), starting from the premise that diversification requires the modification of certain structures such as access to credit, existing markets, and technical assistance, conclude that it is essential to restore the autonomy and knowledge of farmers. Additionally, they advocate for promoting cooperative practices and revitalizing structural public policies, citing examples such as agrarian reform and access to credit.

Agricultural diversification allows us to achieve objectives in various dimensions (Petersen-Rockney et al., 2021). In this context, it is considered that cultural legacies should not be disregarded, as they can define appropriate alternatives for agricultural diversification. Finally, the dependency on agrochemicals should also be reduced (Spangler, Schumacher, Bean & Burchfield, 2022).

It is worth mentioning, however, that agricultural diversification is a strategy not used by conventional crop production systems (Revoyron et al., 2022), since these adopt a productivist (productivity) and economic (profit) logic. On the other hand, it is known that diversification promotes greater adaptability and resilience, making it possible to resist the shocks and stresses of the previously mentioned threats (Petersen-Rockney et al., 2021).

Sustainable agricultural systems rely on a vision that considers local and regional development, emphasizing the use of local varieties and crops to increase agrobiodiversity, while balancing economic growth, environmental preservation, and social justice (Assis, 2006). Therefore, the replacement of simplified systems with diversified ones is crucial (MMA, 2000). In this context, production diversification contributes to the sustainability of agricultural production. Costabeber and Caporal (2003) support this concept and advocate for the importance of multifunctionality and polycultures.

As a promoter of agricultural diversification, the Food and Agriculture Organization of the United Nations (FAO, 2012) is based on the premise that it is an effective strategy for addressing food and nutrition security, sustainable rural development, job creation, poverty reduction, and environmental and ecological preservation and conservation.

The scientific literature provides various pieces of evidence that support agricultural diversification. Examples can be found in Garbelini et al. (2022), Mzyece and Ng'ombe (2021), Antonelli, Coromaldi, and Pallante (2022), Hao et al. (2022), Yan et al. (2022), Gogoi et al. (2022), among many others. Considering the scientific debate surrounding agricultural diversification, public policies can be made more efficient and effective. This has the potential to benefit rural communities, especially those most vulnerable to economic, environmental, and social changes. As scientific literature informs us, this strategy is crucial for enhancing resilience and does not disregard the future, preserving natural resources in the long term.



From the perspective of food security, agricultural diversification is considered an important strategy. In the long term, it leads to the preservation and conservation of natural resources. In the short term, there is an economic aspect related to the access of neighboring communities to diversified food production. In other words, local production can impact food prices by increasing supply and shortening distances (short food supply chain).

In this regard, this work is based on the following research question: What is the current state of the art regarding the diversification strategy for the sustainability of agricultural production? Therefore, the aim of this article is to analyze the multidimensionality of the productive diversification strategy in agriculture.

To achieve this objective, this work is divided into four sections: Introduction, which discusses agricultural diversification; Methodology, which describes the research methods; Results and Discussion, which presents the findings, and finally, Conclusions, which conclude the work.

## **2 Methodology**

This article adopts a qualitative approach, as defined by Gerhardt and Silveira (2009), which seeks to understand the reasons behind a phenomenon without necessarily obtaining statistical values. It also follows an applied nature, which, according to the same authors, aims to produce practical knowledge. The nature of the methodological objectives is exploratory, which, according to Gil (2002), aims to gain familiarity with the problem in order to refine ideas or intuitions. Finally, there is a literature review, which relies on the consultation of previously published theoretical references, analyzing and discussing scientific contributions, as explained by Boccato (2006).

Galvão and Ricarte (2020) define literature review as a generic term encompassing all research that analyzes specific subjects, employing various approaches and stages of development. The same authors also differentiate between convenience review and systematic literature review. The first involves gathering and discussing a set of scientific research that the researcher believes to be important. The second involves following protocols in conducting the research, establishing criteria for including or excluding articles to achieve a higher degree of reproducibility

This research employs both forms of literature review in separate sections. The first, presented in the Introduction of this paper, used the unsystematic technique known as the 'snowball' method, which, according to Ridley (2012), involves analyzing references from other articles. The second, presented in the third section of the paper, adopted the technique called Systematic Literature Review (SLR), which allowed for the construction of the state of the art on 'agricultural diversification'. Table 1 provides the methodological characterization of the work.



Table 1  
Methodological Characterization

Type of Research	Classification
Approach	Qualitative
Nature	Applied
Objective	Exploratory
Procedure	Bibliographic
Literature Review	Unsystematic and Systematic

Table 2, on the other hand, highlights the model for conducting the Systematic Literature Review. According to Tranfield, Denyer, and Smart (2003), adapted by Thorpe, Holt, Macpherson, and Pittaway (2005), the model comprises three stages: Review Planning; Review Execution; Review Reporting.

Table 2  
Model for Conducting Systematic Literature Review

Review Planning	Review Execution	Review Reporting
Definition of Objectives Proposal Preparation Protocol Development	Research Identification Article Selection Assessment of Article Quality Data Extraction and Process Monitoring Data Synthesis	Descriptive Reporting of Citations Thematic Reporting of Articles

Source: Tranfield, Denyer, and Smart, 2003. Adapted by Thorpe, Holt, Macpherson, and Pittaway, 2005.

The searches were conducted in the Web of Science and Scopus databases in October 2021. The objective adopted for the SLR is to determine the state of the art of productive diversification in agricultural production. Table 3 presents the details of the search conducted. Strings were tested until a satisfactory result was achieved, after which filters were applied, and the export to the StArt software was done in BibTeX format.<sup>1</sup>

This research adopted the following restrictions for the selection of articles used in the SLR: only articles published in scientific journals, in the English, Portuguese, and Spanish languages; a time frame from 2010 to 2021, aiming for contemporaneity of publications; categorized within knowledge areas deemed relevant to agricultural diversification.

<sup>1</sup> State of the Art through Systematic Review – [http://lapes.dc.ufscar.br/tools/start\\_tool](http://lapes.dc.ufscar.br/tools/start_tool)

Table 3  
 Database Search with Respective Filters

Data base	Web of Science	Scopus
Date of collection	09/10/2021	09/10/2021
Descriptors	productive diversification, productive concentration, agriculture	productive diversification, productive concentration, agriculture
Search Strings (with Boolean Operators)	((TS=(productive diversification)) OR TS=(productive concentration)) AND TS=(agriculture)	((TITLE-ABS-KEY(productive AND diversification) OR TITLE-ABS-KEY(productive AND concentration)) AND TITLE-ABS-KEY(agriculture))
1st result	322	541
Filter 1: Publication Type	Only articles published in scientific journals.	Only articles published in scientific journals.
Result 1	278	430
Filter 2: Temporality	2010 to 2021	2010 to 2021
Result 2	229	329
Filter 3: Language	Articles in English, Spanish, and Portuguese.	Articles in English, Spanish, and Portuguese.
Result 3	225	321
Filter 4: Database Knowledge Areas	Environmental Sciences. Agriculture Multidisciplinary. Agronomy. Development Studies. Multidisciplinary Sciences. Agricultural Economics Policy. Sociology. Economics. Social Sciences Interdisciplinary.	Agricultural and Biological Sciences. Environmental Science. Social Sciences. Economics, Econometrics and Finance. Multidisciplinary. Business, Management and Accounting.
Result 4	136	301
Partial Selection Criteria	Reading of Titles and Abstracts	Reading of Titles and Abstracts
Result 5	41	29
Final Selection Criteria	Reading of Articles	Reading of Articles
Result 6	15	15

### 3 Results and Discussion

It was possible to identify that the scientific debate about agricultural production diversification is multidimensional. Thus, the discussion on agricultural diversification can be classified under social, economic, and environmental aspects, as per the Triple Bottom Line (TBL) framework defined by Elkington (1997).

It is worth mentioning that science is complex and always seeks to simplify reality for a better understanding of phenomena. Therefore, the 'social, economic, and environmental' tripod was chosen to group the results.

Table 4 initiates the discussion of agricultural diversification from the social dimension perspective. It is important to note that in a single publication, there may be multidimensional analyses, so some articles are repeated in the following tables. This happens because it is sometimes difficult to dissociate environmental, social, and economic issues, as they affect each other.



Table 4  
 Social Dimension of Agricultural Diversification

Author	Year	Contribution
Grammont	2010	The author treats diversification as a strategy for peasants to escape poverty, but concludes that it is actually just a defensive strategy arising from the inability to specialize. Furthermore, this strategy has proven ineffective in lifting them out of poverty.
Gazolla and Schneider	2013	It addresses the dual logic of Pronaf: financing of usual activities (grains and commodities) and financing of agricultural diversification (small livestock and basic food)
Lydecker and Forman	2013	The authors analyzed the implementation of diversified cropping around highways in the United States as a means of obtaining environmental, economic, and cultural benefits
Scheidel, Farrell, Ramos-Martin, Giampietro and Mayumi	2014	With the decline in the availability of land for small-scale farmers, subsistence diversification plays an important role at the family level.
Laurenti, Pellini and Telles	2015	It is necessary to readjust sustainable rural development policies: promote agricultural diversification; encourage the expansion of subsistence production (food and nutritional security) and diversify non-agricultural income.
Rover, Boeira, Birochi and Follmann	2017	The authors analyzed the possibility of diversifying tobacco production areas in Brazil and concluded that proper socio-environmental and territorial management is necessary.
Chapagain et al.	2018	The authors analyzed agricultural production diversification in Nepal and concluded that it is advantageous.
Mekuria and Mekonnen	2018	Diversification between agriculture and livestock is the best subsistence strategy for small-scale farming in Ethiopia.
Sène-Harper, Camara and Matarrita-Cascante	2019	The authors assessed the effects of diversifying the livelihoods of fishing families, in this case, combining fishing with agricultural production, and concluded that while it reduced poverty among the families, this form of diversification did not necessarily lead to secure livelihoods. The authors believe that interventions such as providing credit, land, and agricultural technology would likely increase security.
Galeana-Pizaña, Couturier, Figueroa and Jiménez	2021	Among the authors' conclusions, small-scale multi-crop agricultural properties in dry regions of Mexico have the potential to address food security issues in the country.
Njira, Semu, Mrema and Nalivata	2021	In the authors' analysis, the diversification of agricultural production is crucial in maintaining a system dominated by small-scale producers.
Venus, Bilgram, Sauer and Khatri-Chettri	2021	To improve the adaptive capacity of small landowners, policymakers should promote the expansion of training and technology aimed at diversification.



Agricultural diversification can be seen as a strategy to escape poverty, but the literature is not definitive on this matter. However, there is convergence regarding the need for public policies that facilitate access to credit, land, technology, and technical knowledge, as the lack of these elements poses obstacles to diversification (Grammont, 2010; Laurenti; Pellini; Telles, 2015; Sène-Harper; Camara; Matarrita-Cascante, 2019; Venus; Bilgram; Sauer; Khatri-Chettri, 2021).

The social specificities of different countries have an impact on research outcomes. Therefore, social aspects, including cultural factors, should be considered to facilitate the reproducibility of research, as the same diversification model may not necessarily be replicable in another region (Lydecker; Forman, 2013; Spangler, Schumacher, Bean & Burchfield, 2022).

It is important to note that family farming and small-scale producers play a key role in agricultural diversification. This is because subsistence activities alone may not necessarily be effective in poverty reduction, which reinforces the need for public policies to create a conducive environment for these stakeholders (Grammont, 2010; Gazolla; Schneider, 2013; Scheidel; Farrell; Ramos-Martin; Giampietro; Mayumi, 2014; Laurenti; Pellini; Telles, 2015; Mekuria; Mekonnen, 2018; Njira; Semu; Mrema; Nalivata, 2021).

They are the biggest beneficiaries of agricultural diversification, as it is not just a matter of economic viability for them. The impacts go beyond income and also affect their identity, culture, and the environment. It is important to note, however, that providing credit alone is not sufficient; training and education are also essential so that small farmers can make informed decisions and thrive (Grammont, 2010; Scheidel; Farrell; Ramos-Martin; Giampietro; Mayumi, 2014; Laurenti; Pellini; Telles, 2015; Venus; Bilgram; Sauer; Katri-Chettri, 2021).

Resilience is a crucial aspect here: it is essential to reduce the vulnerability of small-scale farmers and enhance their ability to cope with stressors and shocks while ensuring food security. There is potential for development in this direction, even in regions that may not be ideal for cultivation but are still arable (Lydecker; Forman, 2013; Galeana-Pizaña; Couturier; Figueroa; Jiménez, 2021). The social dimension often interacts with the economic one, as poverty is a direct consequence of the economic/financial condition, and education level and culture also have their impacts on this condition. In this context, Table 5 presents the debate on agricultural diversification from the perspective of the economic dimension.





Table 5  
 Economic Dimension of Agricultural Diversification

(Continues)

Author	Year	Contribution
Schneider and Niederle	2010	Agricultural producers diversified through the production of resources for self-consumption, pluriactivity, reduced production of commodities, and adoption of alternative markets, indicating heterogeneous agricultural practices.
Rao, Shahid and Shahid	2010	The authors analyzed potential crops for diversifying agricultural production in the Arabian Peninsula.
Abson, Fraser and Benton	2013	Landscape specialization is associated with maximizing returns but greater volatility in those returns, whereas land use diversification is positively correlated with stability in returns but negatively correlated with expected returns. There is also scale dependence in the relationships between land use diversity and the resilience of agricultural returns.
Lydecker and Forman	2013	The authors analyzed the implementation of diversified cropping around highways in the United States as a means to achieve environmental, economic, and cultural benefits.
Ceceñas-Jacquez and Morales-Carrillo	2015	Crop diversification leads to higher yields in the long term compared to monoculture.
Laurenti, Pellini and Telles	2015	There was diversification in the occupational composition of the Brazilian rural population of working age in the last decade of the twentieth century: a decline in the rural labor force (PEA) in commercial agriculture; an expansion of the labor force engaged in non-agricultural occupations; and a reduction in economic inequality and informality.
Lal et al.	2017	Varietal and cultural diversification of rice-based production systems can increase profitability, as evidenced in Eastern India.
Meraner, Pölling and Finger	2018	In the Ruhr metropolitan region, a significant portion of rural properties is diversified. The intensity of diversification is positively influenced by proximity to urban areas, as well as specialization in high-value crops.
Pacheco, Ochoa-Moreno, Ordoñez and Izquierdo-Montoya	2018	Gross value added in agriculture, average household income, and the economically active population had a positive influence on agricultural diversification, while overall value added, education level, unemployment rate, and credit volume had a negative influence.
Chapagain et al.	2018	The authors analyzed agricultural production diversification in Nepal and concluded that it is advantageous.
Vázquez	2019	The diversification of agricultural production in Mendoza, Argentina, has led to the emergence and consolidation of new industries, in addition to fruit production. This has helped to offset the adverse effects of crises that affected the region's main wine production.
Nera et al.	2020	In central Italy, mechanization has positively impacted the resilience of the system, but future improvements should involve strengthening the local hazelnut value chain, collective strategies, and diversification.
Loch, Celentano, Cardozo and Rousseau	2021	Families with higher incomes from other sources tend to diversify less.



Table 6  
Economic Dimension of Agricultural Diversification

		(Conclusion)
Maggio and Sitko	2021	The article emphasizes the importance of considering the heterogeneity of cropping systems when conducting empirical analyses, in order to provide insights for diversification policies. The authors mention the case of Malawi and Zambia, where diversification of maize-based systems is not associated with income volatility reduction. However, when disaggregating the impact of diversification by cropping system, variations related to the attributes of each crop and their combinations become apparent. The spectrum of drivers leading to diversification is numerous and complex.
Liu, Shankar and Li	2021	Specialization increases technical efficiency, but the sample of small rural properties analyzed has low technical efficiency due to a lack of qualified labor.
Suresh, Wilson, Khanal, Managi and Santhirakumar	2021	Varietal diversification significantly reduces production efficiency.

In general, specialization in agricultural production increases returns but exposes producers to market fluctuations due to higher volatility. Diversification, on the other hand, enhances return stability but at the cost of lower returns (Abson; Fraser; Benton, 2013; Liu; Shankar; Li, 2021; Suresh; Wilson; Khanal; Managi; Santhirakuman, 2021).

The literature suggests that in the long term, diversified agricultural production can yield higher returns compared to monoculture. There are cases in various countries where diversified farming has brought economic benefits, such as increased profitability. It is even possible that the effects of economic crises can be reversed, and new industries associated with local production may emerge (Ceceñas-Jacquez; Morales-Carrillo, 2015; Lal et al., Chapagain et al., 2018; Vázquez, 2019; Nera et al., 2020).

The heterogeneity of regional economic variables also influences the strategy of productive diversification. Different results can be observed in the analysis of production systems. This is because agricultural diversification depends on numerous and complex variables, such as access to credit, technology, labor, etc. (Schneider; Niederle, 2010; Pacheco; Ochoa-Moreno; Ordoñez; Izquierdo-Montoya, 2018; Loch; Celentano; Cardozo; Rosseau, 2021; Maggio; Sitko, 2021).

Resilience should be both social and economic. In case of reduced returns, it should be compensated by other factors, such as stability in earnings. This means that the producer will not suffer from abrupt market fluctuations and will be able to absorb economic impacts since they are not dependent on the production of just one item, and the chances of a significant impact on all items are low (Abson; Fraser; Benton, 2013; Vázquez; 2019; Nera et al., 2020).

It is true that those who specialize in the production of just one agricultural item increase technical efficiency and yields through economies of scale, but it is also true that they are more vulnerable to market fluctuations as mentioned earlier. That is why diversification is seen as an important strategy for gaining scope (Abson; Fraser; Benton, 2013; Liu; Shankar; Li, 2021; Suresh; Wilson; Khanal; Managi; Santhirakuman, 2021).

The impacts are not only economic. Natural events can also be dangerous to production systems, which shows that there is a dialogue between the socio-economic and environmental dimensions. Table 6 presents the debate on the environmental dimension of agricultural diversification.

Table 7  
 Environmental Dimension of Agricultural Diversification

Author	Year	Contribution
Lydecker and Forman	2013	The authors analyze the implementation of diversified cultivation around highways in the United States as a way to achieve environmental, economic, and cultural benefits.
Ceceñas-Jacquez and Morales-Carrillo	2015	Crop diversification reduces climate risks.
Rover, Boeira, Birochi and Follmann	2017	The authors analyzed the possibility of diversifying tobacco production areas in Brazil and concluded that appropriate socio-environmental and territorial management is necessary.
Monteleone, Cammerino and Libutti	2018	They concluded that environmental constraints strongly influenced the choice of crops, and converting certain portions of land to agroenergy production could significantly increase agricultural diversity. Diversification is a signal of a shift in agriculture towards multifunctional activities that combine food quality, rural subsistence maintenance, and landscape preservation, while also promoting environmental conservation, thereby establishing a more sustainable agro-ecosystem.
Meynard et al.	2018	The authors analyzed the obstacles to diversification, a necessary step in transitioning to agroecology, and concluded that these obstacles favor dominant crop species. Examples include a lack of improved varieties, insufficient plant protection methods, a shortage of crop rotation references, the complexity of knowledge to be acquired by farmers, logistical limitations, and difficulties in coordinating with value chains. The authors also state that these obstacles are systemic and require the involvement of many stakeholders in driving change. They also emphasize the importance of interdisciplinary collaboration between agronomists and economists, which allows for a holistic understanding of this issue.
Chapagain et al.	2018	The authors analyzed agricultural production diversification in Nepal and concluded that it is advantageous.
Grahmann, Dellepiane, Terra and Quincke	2020	The authors analyzed the effect of conventional agriculture and diversified agriculture on the soil, concluding that diversification leads to higher soil fertility.
Loch et al.	2021	The agroecological transition towards more resilient models that increase biodiversity in rural communities is urgent. The agroecological transition in Alcântara, eastern Amazonia, increased the diversity of cultivated species but was not related to formal education.
Palomo-Campesino, García-Llorente and Gonzáles	2021	Producers who adhere to agroecology adopt more sustainable practices with greater diversification of productive activities compared to conventional producers.
Juventia, Rossing, Ditzler and Apeldoorn	2021	The authors conclude that diversification of agricultural production systems reduces the magnitude of plant injuries caused by pests. They also explain that these results are an initial step in promoting synergies between ecosystem services in a transition to agroecology, which supports production and regulates the ecosystem service of pest control.

Diversification of agricultural production offers potential benefits for environmental preservation and conservation, aligning with the principles of sustainable development. The



literature has shown that there is a good capacity to reduce climate risks through productive diversification. However, there is a need for environmentally sound management tailored to the specific context in which the production system operates (Lydecker; Forman, 2013; Ceceñas-Jacquez; Morales-Carrillo, 2015; Rover; Boeira; Birochi; Follmann, 2017).

There is evidence that agroecological production systems are advantageous and contribute to the preservation and conservation of natural resources, such as soil fertility and pest control. Promoting the transition to agroecology supports the sustainability of production systems, but there are still many obstacles to overcome in this process. Overcoming these challenges requires public policies that consider not only the social and economic dimensions, as previously discussed, but also the environmental dimension. Working with this three-pronged approach can lead to a truly sustainable production system (Meynard et al., 2018; Loch et al., 2021; Palomo-Campesino; García-Llorente; Gonzáles, 2021; Juventia; Rossing; Ditzler; Apeldoorn, 2021).

In conventional agriculture, the ecosystem is simplified, leading to significant environmental disruption. In a productive agroecosystem, the level of simplification is lower than that of a conventional agroecosystem. In other words, its degree of complexity is considerable to make the agroecosystem less harmful to the biotic and abiotic factors within it (Assis, 2006; Gliessman, 2000).

In the long term, the benefits are challenging to calculate because environmental preservation means maintaining the productive system under the conditions it needs to continue producing. Therefore, multidimensional analysis provides insights that would not be available through a unidimensional perspective, whether it is economic, social, or environmental. With a holistic view, you have more and higher-quality information to make decision-making and the formulation of public policies more reliable.

Sustainable development goes beyond the agricultural aspect, also encompassing livestock and affecting other sectors of society, such as industries, households, etc. However, the scope of this work has been delimited with a focus on the need for humanity to sustain food production and ensure access for all.

Agricultural diversification has its advantages and disadvantages. From a purely productivity-focused perspective, it may be considered negative as it does not maximize returns. However, when considering a multidimensional analysis, other factors come into play, particularly the social, economic, and environmental aspects. Naturally, no rural producer wants to forgo their production gains, but it is essential to think about the long term. Therefore, agricultural diversification becomes advantageous, considering factors that purely economic logic may overlook.

The productivist logic must then be overcome. Obviously, production should not be neglected, as this affects food security or profits, as they are incentives for producers and allow reinvestment, in addition to, if well managed and accumulated, serve as emergency reserves to deal with stresses and shocks. The point is that one must produce responsibly, without depleting natural resources. This assumes that resources can be restored, provided appropriate techniques are used.

In other words, sustainable rural development acknowledges the limits of nature and provides us with the means to operate within those limits, ensuring our needs are met both today and in the future.

Public policies must then be well grounded in scientific knowledge, as they impact the lives of millions of people. A political and global agenda cannot be based on dubious knowledge. Therefore, research on agricultural diversification as a strategy for sustainable rural development should be encouraged



It is important to note that specialized or commercial agricultural producers can coexist with diversified and family agricultural producers. The former will be integrated into the market and benefit from technical efficiency and economies of scale through monoculture. As a result, they will need to conduct risk analysis and engage in proper management for decision-making, while still considering practices related to the ESG (Environmental, Social, and Governance) framework. It is true that scientific literature indicates the need for a transition to agroecology in order to respect the limits of agricultural systems, but this is a long journey ahead. To achieve this, practices that minimize negative externalities and maximize positive externalities are welcome.

In the second case, producers will have a certain degree of integration into the market, but their scope of gains relates to subsistence and local supply. Here, the application of ecological principles to agricultural systems and the reinforcement of food security are emphasized, which can have a positive impact on local prices, provided that regional vocations are respected.

Table 7 provides a summary of the results.

Table 8  
 Summary of the results.

Dimensions/Contributions	Social	Economic	Environmental
Potential	<ul style="list-style-type: none"> <li>- Agricultural diversification could be important for eliminating poverty</li> <li>- Family farming is the biggest beneficiary of this strategy.</li> </ul>	<ul style="list-style-type: none"> <li>- Specialization increases returns, but they are volatile.</li> <li>- Diversification reduces returns, but they are stable.</li> <li>- Returns can be higher in the long term.</li> </ul>	<ul style="list-style-type: none"> <li>- Potential for environmental preservation and conservation.</li> <li>- Potential for reducing climate risks.</li> <li>- Lower degree of simplification of the system.</li> </ul>
Challenges	<ul style="list-style-type: none"> <li>- There is a need for public policies focusing on credit, land, training, etc.</li> </ul>	<ul style="list-style-type: none"> <li>- Heterogeneity of economic variables should be considered in public policies and research.</li> </ul>	<ul style="list-style-type: none"> <li>- Need for adequate environmental management tailored to the local context.</li> </ul>
Resilience	<ul style="list-style-type: none"> <li>- Social resilience helps to resist and recover from stresses and shocks.</li> </ul>	<ul style="list-style-type: none"> <li>- Economic resilience helps with subsistence and reduces the farmer's exposure to market fluctuations.</li> </ul>	<ul style="list-style-type: none"> <li>- Environmental resilience helps with environmental preservation and conservation and meets the sustainability premise.</li> </ul>

Therefore, the social, economic, and environmental aspects can be understood according to their potential, challenges, and what they represent in terms of resilience. The social potential is related to poverty reduction and the promotion of family farming. The economic potential involves the stability of returns and the possibility of achieving superior long-term returns. The environmental potential, on the other hand, is related to environmental preservation and conservation, reducing climate risks, and minimizing the simplification of the production system.



Regarding the challenges, in the same order, there is a need for public policies aligned with the needs of agricultural producers, considering the various variables that impact the results and adequate environmental management, always with a focus on the local dimension.

Finally, resilience can manifest itself in the social aspect through the ability to resist and recover from stresses and shocks, in the economic aspect through the ability to maintain subsistence and face market variations, and, finally, in the environmental aspect through the capacity for environmental preservation and conservation, aligning with the concept of sustainability.

Intertwining these three dimensions with their potentials, challenges, and the concept of resilience allows for a deeper understanding of the importance of agricultural diversification as a strategy for sustainable rural development.

#### 4 Final Remarks

The guiding question of this work is to understand the state of the art of agricultural production diversification. The objective, based on this question, was to analyze the multidimensionality of this strategy.

In general, it is understood that agricultural diversification is an important strategy to achieve objectives in the three dimensions discussed - social, economic, and environmental. In the first case, there is potential in combating poverty, but it is necessary for appropriate public policies to be implemented, with a focus on family farming, aiming to provide it with resilience.

In the second case, it is understood that diversification of production reduces short-term returns, but they are more stable, and in the long term, they can be advantageous. The major challenge here is the heterogeneity of economic variables, which need to be carefully analyzed and tailored for more effective results.

In the third case, there is the potential for environmental preservation and conservation, as well as a reduction in climate-related risks, since the system is less simplified than conventional agriculture. However, proper management is required.

It is understood, then, that the diversification of agricultural production is interesting in the aspect of sustainability. However, specialization remains a reality and the strategy adopted by several sectors that fail to diversify. Therefore, this research presents a limitation, which suggests a path for future research: to understand how to work specialized production systems in order to make them more sustainable.

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