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Como citar: SILVA, Bruce Wellington Amorin da *et al*. Agricultural Diversification and Productive Resilience. *In:* LOURENZANI, Ana Elisa Bressan Smith *et al*. (org.). **Agribusiness, development and the 2030 agenda:** interdisciplinary contributions. Marília: Oficina Universitária; São Paulo: Cultura Acadêmica, 2025. p.155-171. DOI: https://doi.org/10.36311/2025.978-65-5954-620-6.p155-171

Chapter 7

Agricultural Diversification and Productive Resilience

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https://doi.org/10.36311/2025.978-65-5954-620-6.p155-171

Introduction

The classic definition for the concept of sustainable development, established by the United Nations (UN), is the pursuit of meeting the needs of the present without compromising the ability of future generations to meet their own needs.

It is known, however, that this has not always been the concept of sustainability. The first perspective focused on the economy and had a developmental bias, disregarding environmental and social issues. After World War II, the focus was solely on economic growth, and the unrestrained consumption of natural resources was seen as a way for developing countries to prosper, just as the already developed ones did (Costabeber; Caporal, 2003; Pasqualotto; Stasiak, 2012; SMA, 2011).

This concept evolved, came to consider other dimensions, and was addressed in various international events. In 1968, at the Club of Rome, the limits of growth based on the finitude of natural resources were established. In 1972, at the Stockholm Conference, the divergences between industrialized and non-industrialized countries became evident, and the concept of environmental degradation expanded. In 1987, we have the classic definition of sustainable development mentioned earlier. Then, in 1992, at the Rio Conference, it was determined that the responsibility for environmental degradation is greater in developed countries than in developing ones (SMA, 2011).

The first perspective of sustainability presented is called ecotechnocratic, while the second is called ecosocial. The major difference is that the latter seeks a balance between the environment, economic growth, and society (Pasqualotto; Kaufmann; Wizniewsky, 2019). The current concept of sustainability is based on its multidimensionality (Box 1). The six dimensions adopted clearly highlight the need to holistically address its concept.

Box 1 – Multidimensionality of sustainability

Dimension	Description
Ecological	To ensure continuity, natural resources must be preserved and conserved.
Social	The product must be appropriately and equitably enjoyed by society.
Economic	Focus not only on obtaining profit but also on subsistence, sovereignty, and food security.
Cultural	Local knowledge and values must not be disregarded.
Political	Segments of the rural population must have participation, and their interests and needs must be heard.
Ethical	Responsibility between generations regarding environmental preservation and conservation.

Source: Costabeber and Caporal, 2003.

In the ecological dimension, the focus is on the preservation and conservation of natural resources. In the social dimension, the emphasis is on societal benefits. The economic dimension includes not only profit but also subsistence and other issues such as food sovereignty and security. The cultural dimension respects the local cultural reality. The political dimension concerns listening to the interests and needs of the local community, and finally, the ethical dimension refers to generational responsibility, emphasizing the importance of sustainability for future generations.

From this perspective and considering the context of the 2030 Agenda, the Sustainable Development Goals (SDGs) were formulated. The SDGs comprise 17 major objectives for the world to aim to end poverty, protect the environment and climate, and ensure peace and prosperity for people (UN, 2015). They represent a global action plan based on the commitments of UN member states to protect the planet and promote peaceful and inclusive societies.

Among the global goals is SDG 2 – Zero Hunger and Sustainable Agriculture, which specifically addresses sustainable agricultural development and food security. Item 2.4 provides more details on this.

> By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather conditions, droughts, floods, and other disasters, and that progressively improve soil and land quality (UN, 2015, p. 19).

As a strategy to achieve sustainable food production systems and contribute to resilient agricultural practices, the strategy of productive diversification has been an important topic. As Michler and Josephson (2017) highlight, in the past, development agencies promoted the production of some key crops for food security, but the focus has shifted towards diversification.

As a promoter of agricultural diversification, the Food and Agriculture Organization of the United Nations (FAO, 2012) posits that this is an effective strategy to address food and nutrition security, sustainable rural development, job creation, poverty reduction, and environmental and ecological preservation and conservation.

In this context, this chapter aims to discuss the strategy of diversifying agricultural production systems to contribute to achieving SDG 2. Additionally, this debate has the potential to foster the formulation of public policies and benefit rural communities, especially those most vulnerable to economic, environmental, and social changes, as this strategy contributes to resilience and the preservation of natural resources.

Threats to agricultural systems

The major threat to agricultural systems is termed the "Triple Threat of the Anthropocene to Humanity," which comprises Climate Change; Biodiversity Loss; and Food Insecurity (Kremen; Merenlender, 2018; Petersen-Rockney *et al.*, 2021).

Climate change has been a significant source of concern. In extreme situations such as heatwaves, droughts, cyclones, and floods, there is severe negative interference with agricultural productivity and food security. This impacts, consequently, rural poverty, promotes a reduction in demand for goods and services, and induces overexploitation of water, land, forests, and other natural resources (Birthal; Hazrana, 2019). Box 2 illustrates this type of situation concerning agricultural production.

Box 2 – Environmental effects of agricultural production activity

Aspect of productive activities[5]	Effect	Resource or phenomenon
Positive	Improves the productivity of renewable resources	Air
		River water
		Soil
		Organic fertility of soils and trees
Negative	Worsens the productivity of renewable resources	Desertification
		Deforestation
		Erosion
		Among others.

Source: Chambers and Conway, 1992.

The positive activities mean that there are benefits to renewable natural resources, which allow the sustainability of agricultural processes. The negative activities, on the other hand, worsen productivity and disrupt sustainability. In the long term, agricultural production tends to become unviable, and socioeconomic problems arise or deteriorate. There is a perceived link here between environmental and socioeconomic problems, with the latter being a consequence of the former. The threats in social aspects occur in the form of stresses and shocks, highlighted in Box 3.

[5] Productive activities refer to what producers do to produce food and their impacts on the environment.

Box 3 – Stresses and shocks

Stresses	Reduction of labor
	Real wage decreases
	Decrease in soil yield
Shocks	Wars
	Persecution
	Civil violence
	Droughts
	Storms
	Floods
	Burns

Source: Chambers and Conway, 1992.

Stress refers, therefore, to the reduction of labor, real wage decreases, and decreases in soil yield. These are negative interferences in the productive activity of agriculture that do not promote immediate collapse but wear it down in the long term.

Shocks refer to wars, persecution, civil violence, droughts, storms, floods, and fires. These are of greater severity, and the farmer's reaction capacity is even lower.

Regarding future problems in agricultural production, there are proactive and reactive aspects. In the first case, adaptation, the generation of changes, and continuity are considered. In the second case, it is considered to deal with stresses and shocks. The difference between the aspects is that in the first case, prevention occurs, while in the second, the problem is expected to arise and then action is taken (Chambers; Conway, 1992). This is illustrated in Box 4.

By relying on chemical agents, financial incentives, and being less resilient, conventional agriculture degrades natural resources and is not considered sustainable in the long term. This process can lead to serious consequences: soil degradation; waste and excessive use of water;

environmental pollution; dependence on external inputs; loss of genetic diversity; loss of local control over agricultural production and global inequality (Gliessman, 2000; Kremen; Merenlender, 2018). The basic practices of conventional agriculture are described in Box 5.

Box 4 – Social Effects of Agricultural Production Activity

Dimension	Aspect	Attitude
Positive	Proactive	Improve capacity to adapt
		Generate changes
		Ensure continuity
Negative	Reactive	Deal with stresses and shocks

Source: Chambers and Conway, 1992.

Box 5 – Risks Associated with Conventional Agricultural Practices

Practice	Description
Intensive soil cultivation	Regular cultivation leaves the soil without plant cover for a long time. Reduces organic matter and consequently fertility. Increases the probability of soil compaction and increases erosion rates.
Monoculture	Cultivation of a single crop aiming at the efficiency of agricultural processes and the use of machinery. Economy of scale. Industrialization of agriculture. Requires chemical protection.
Application of synthetic fertilizers	Significantly increases production. Provide more nutrients to plants. Farmers ignore long-term soil fertility. Nutrient leaching ease. Eutrophication of rivers and groundwater. Public health impacts. Dependence on oil prices.
Irrigation	Increases leaching and eutrophication. Increases soil erosion rate. Alters regional hydrography. Excessive water use.
Chemical pest and weed control	Significantly reduce pest populations. Populations can recover, however, demanding more chemical control. Human health impact. Chemicals are leached and enter the food chain of animals. Persist for decades.
Plant genome manipulation	Obtaining hybrid crops, unable to produce seeds, are more productive but makes the farmer more dependent on commercial producers.

Source: Gliessman, 2000.

Agricultural Diversity as a Productive Strategy

Agricultural diversification and concern for food security are not new. Already in the colonial period, there was concern by the Portuguese Crown with the diversification of agricultural production in Brazil, aiming to ensure the consumption of foodstuffs. There was, therefore, besides large producers, a peasantry, owner of small properties (Fausto, 2006).

The diversification of production systems is considered one of the ways to deal with the complexity and uncertainty of agricultural activity. Strategy suitable especially in global shocks, such as pandemics and prolonged droughts (Petersen-Rockney *et al*., 2021).

The central idea is to replace simplified or monoculture systems with diversified production systems. In this context, the importance of integration between animal and plant production is also inserted. It is worth noting, however, that each agro-system has its particularities and there is no recipe valid for all cases. Thus, they must be known and appropriate forms of diversification adopted (MMA, 2000).

Agricultural diversification allows for achieving goals in different dimensions. It is considered, in this sense, that cultural legacies must also be considered so that they define suitable alternatives for this productive strategy. Finally, the dependence on agrochemicals must also be reduced (Petersen-Rockney *et al*., 2021; Spangler *et al*., 2022).

It is recognized that the productive diversification strategy faces strong competition from conventional crop production systems since it does not present immediate benefits. On the other hand, however, it must be considered that diversification results in greater adaptation and resilience, being able to withstand the shocks and stresses of the threats. Diversification, then, constitutes a virtuous cycle. Considering climate change and sociopolitical inequality, diversified agricultural systems demand a change in the productivity paradigm. Thus, biophysical factors, such as climate variability, must be considered in agricultural policies, from the local to the federal level, prioritizing, then, climate adaptation to

agricultural systems (Petersen-Rockney *et al.*, 2021; Revoyron *et al.*, 2022; Spangler *et al.*, 2022).

The scientific literature exposes positive results regarding the diversification strategy. In general, this practice is seen as promoting resilience and helping in mitigating and adapting to climate change. It has been reported that the reduction of pesticides, energy consumption, water, and greenhouse gases. In the economic aspect, however, the literature indicates that higher returns are associated with specialization, but with greater volatility; while diversification, although lower, is associated with greater stability in returns (Abson; Fraser; Benton, 2013; Birthal; Harazna, 2019; Alletto; Vanderwale; Debaeke, 2022; Spangler *et al.*, 2022).

Furthermore, there is much scientific evidence that agrees with agricultural diversification[6] in various countries, such as Germany, Argentina, the United States, Ethiopia, India, Malawi, Nepal, the Arabian Peninsula, and Zambia[7].

Opportunities and Challenges of Agricultural Diversification

Diversification is a sign of the reorientation of agriculture towards multifunctional activities that combine food quality, rural subsistence, landscape maintenance, environmental preservation, and the establishment of a better agro-ecosystem (Monteleone; Cammerino; Libutti, 2018).

Some research states that crop diversification allows better long-term yields compared to monoculture. Others say that it does not necessarily lead to stable livelihoods. It is argued that this strategy contributes to poverty reduction, but the provision of credit, land, and technology is important. Overall, diversification can help consolidate new industries and

6 Antonelli, Coromaldi, and Pallante (2022), Garbelini *et al.* (2022), Godoi *et al.* (2022), Hao *et al.* (2022), Mzyece and Ng'ombe (2021), Yan *et al.* (2022).

7 Chapagain *et al.* (2018), Lal *et al.* (2017), Lydecker and Forman (2013), Maggio and Sitko (2021), Mekuria and Mekonnen (2018), Meraner, Pölling and Finger (2018), Rao, Shahid and Shahid (2010), Vázquez (2019).

help offset the adverse effects of crises (Ceceñas-Jacquez; Morales-Carrillo, 2015; Sène-Harper; Camara; Matarrita-Cascante, 2019; Vázques, 2019).

However, there are several barriers to crop diversification, such as lack of improved varieties; lack of phytosanitary protection methods; lack of crop rotation references; complexity of knowledge to be acquired by farmers; logistical limitations, and difficulty in coordinating with value chains. These are systemic obstacles and need many stakeholders to change (Meynard *et al*., 2018).

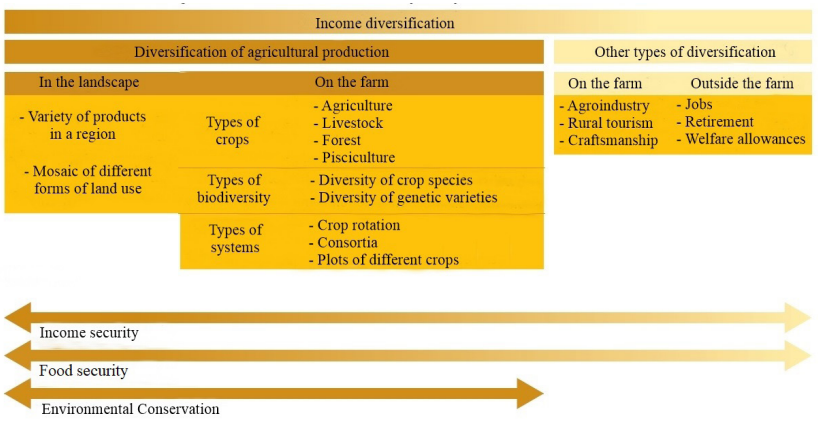
Research indicates that average household income, economically active population, and gross added value of agriculture have a positive influence on crop diversification; while the level of education (people with more years of study), inequality in credit volume, unemployment rate, and overall gross added value has a negative impact (Pacheco *et al*., 2018).

Related to this, it is important to consider the heterogeneity of cropping systems when making empirical analyses aimed at providing data for diversification policies. The spectrum of factors leading to crop diversification is numerous and complex. Diversification can occur, for example, with the promotion of subsistence, pluriactivity, reduction of commodity production, adoption of alternative markets, and even with the intensification of mechanization, but collective strategies must be associated (Maggio; Sitko, 2021; Nera *et al*., 2020; Schneider; Niederle, 2010).

Small farms practicing polyculture can help solve problems related to food security, even in arid regions. Crop diversification is, therefore, essential in maintaining a system dominated by small producers. Improving the adaptive capacity of these farmers involves formulating public policies aimed at expanding technologies related to diversification, encouraging the expansion of subsistence production, and diversifying non-agricultural income (Galeana-Pizaña *et al*., 2021; Laurenti; Pellini; Telles, 2015; Njira *et al*., 2021; Venus *et al*., 2021).

Figure 1 systematizes the issue of agricultural diversification in its various possibilities. The literature suggests benefits in income security, food security, and environmental conservation. This occurs through the diversification of income, but also brings important issues such as resilience.

Figure 1 – Forms of income diversification in rural areas and main benefits



Source: Sambuichi *et al.* (2014).

Case study: the evolution of Brazilian agricultural concentration

A survey conducted by the authors of this chapter allows us to visualize the evolution of the level of agricultural concentration in Brazil. By establishing, per mesoregion, the percentage of occupation of the three main crops in relation to the total agricultural area, it is possible to observe this phenomenon over time. Figure 2 presents the dynamics of this process geographically and temporally.

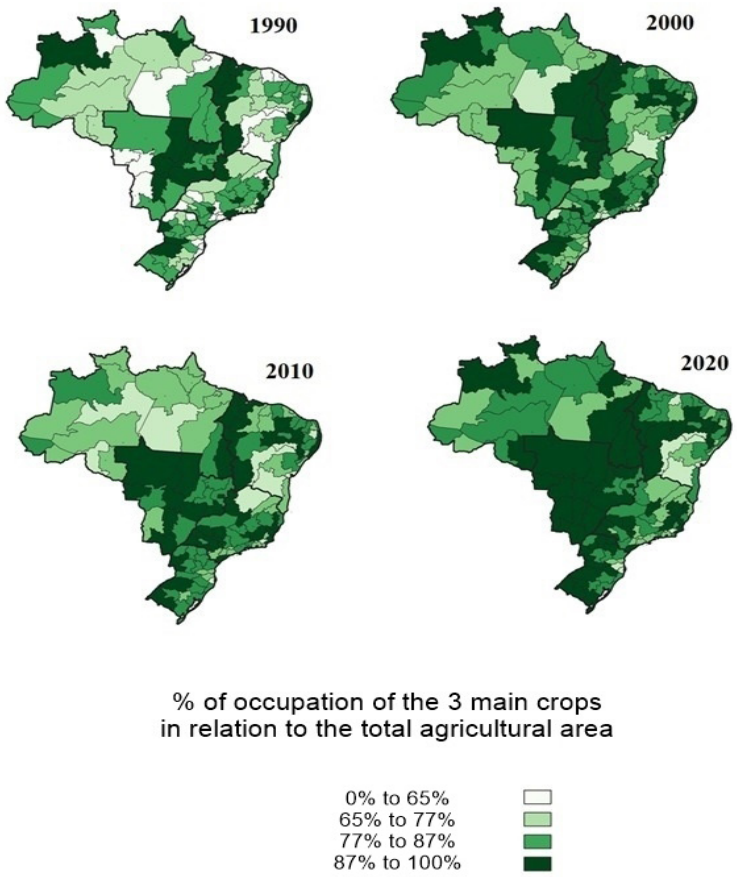
Despite the relative simplicity of measuring the evolution of agricultural concentration in the country over time, and considering the so-called "Triple Threat of the Anthropocene to Humanity," the following questions are posed to the reader:

a) What are the consequences of the evolution of agricultural concentration for the climate?

b) What are the consequences of the evolution of agricultural concentration for biodiversity?

c) What are the consequences of the evolution of agricultural concentration for food security?

Figure 2 – Evolution of agricultural concentration in Brazil, by Mesoregion



Source: Elaborated by the authors (2024).

Final considerations

The challenges and opportunities of agricultural diversification are diverse, but the literature converges on the idea that this is one of the strategies to promote sustainable development.

From a productive perspective, diversification is considered negative because it does not maximize returns. However, in a multidimensional analysis of sustainability, other factors must be considered. Here comes the social, economic, and environmental tripod. Obviously, no rural producer wants to give up the gains from their production, but it is necessary to think in the long term. Thus, agricultural diversification becomes advantageous and considers factors that purely economic logic disregards, such as food security, subsistence, and resilience. The latter is especially increasingly relevant concerning existing threats and those that may arise.

Finally, it is perceived that agricultural diversification, based on literature and UN policy, allows progress towards what is sought with item 2.4 of SDG 2. Thus, agricultural systems can increase their resilience, becoming more capable of adapting to natural and anthropogenic events, besides being able to positively impact food security.

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