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A Brazilian initiative for sustainable development of smallholder dairy farming: the PISA Program

P.C. de Faccio Carvalho[1], R. Dominschek[1], L.R. Eloy[1], T.R. Kunrath[2], D.R. Machado[1], V. Thénard[3], T. Calles[4], C. Bremm[5], D.T. dos Santos[6], A.C. Cittolin[7] and A. de Moraes[8]

[1]UFRGS, Av. Bento Gonçalves 771, Porto Alegre, RS (Brazil)
[2]Aliança SIPA, R. Dolores Duran 1584/11, Porto Alegre, R (Brazil)
[3]INRAE, BP 52627 – F 31326 Castanet Tolosan Cedex (France)
[4]FAO, Viale delle Terme di Caracalla, 00153 Rome (Italy)
[5]DDPA/SEAPDR, R. Gonçalves Dias 570, Porto Alegre, RS (Brazil)
[6]SIA, Av. Getúlio Vargas 1157, Porto Alegre, RS institution (Brazil)
[7]DC, Consultoria em alimentos. Rua dos Jacarandás, 378, apto 201, Lajeado, RS (Brazil)
[8]UFPR, R. dos Funcionários 1540, Curitiba, PR (Brazil)

Abstract. In the context of a growing demand for food in the near future, scarcity of natural resources and climate-change, the PISA program was designed to promote sustainable development of agricultural systems. In this article, we present a detailed description of PISA, as well as a case study of one of PISA's projects, in which we assessed sustainability. Ecological intensification is the base of PISA philosophy, comprising several tools and technologies on its conceptual framework. PISA execution methodology provides a context-specific and flexible-holistic approach. PISA is operated as an agricultural extension program, that has already served 1819 farmers in Southern Brazil. In the State of Rio Grande do Sul, PISA has been implemented in a more concrete way, through a public-private partnership aimed at smallholder dairy farming. In the case study of PISA Norte project, sustainability assessment by an international validated tool (SAFA) was performed in all supported farms. Smallholder dairy farmers, from the PISA Norte project, presented good performance in all sustainability dimensions. PISA principles, practices, and results addresses relevant sustainable development goals from the 2030 Agenda. Although PISA has been largely executed in smallholder dairy farms, its conceptual framework and institutional structure for operation can be replicable to any agrifood system.

Keywords. Agricultural development – Sustainable intensification – Ecological intensification – Rural advisory Services – Sustainability assessment.

Une initiative brésilienne pour le développement durable de la petite production laitière : le Programme PISA

Résumé. *Dans le contexte d'une demande alimentaire croissante dans les années à venir, de la rareté des ressources naturelles et du changement climatique, le programme PISA a été conçue pour promouvoir le développement durable des systèmes agricoles. Dans cet article, nous présentons une description détaillée du programme PISA, ainsi qu'une étude de cas d'un des projets de ce dispositif et pour lequel nous avons évalué la durabilité des fermes. L'intensification écologique est la base de la philosophie du programme PISA : cela comprend dans son cadre conceptuel plusieurs outils et technologies. La méthodologie d'exécution du programme PISA fournit une approche spécifique du contexte et une approche holistique flexible. Le programme PISA fonctionne comme un dispositif de vulgarisation agricole, qui a déjà impliqué 1819 agriculteurs dans le sud du Brésil. Dans l'État du Rio Grande do Sul, le programme PISA a été mis en œuvre de manière plus concrète à travers un partenariat public-privé visant les petits exploitants producteurs de lait. Dans l'étude de cas du projet PISA Norte, l'évaluation de la durabilité par un outil validé au niveau international (SAFA), a été réalisée dans toutes les exploitations agricoles suivies. Les petits producteurs de lait du projet PISA Norte ont présenté de bonnes performances dans tous les domaines de la durabilité. Les principes, les pratiques et les résultats du programme PISA, répondent aux objectifs de développement durable fixés dans l'Agenda 2030. Bien que le programme PISA ait été largement mis en œuvre dans les petites exploitations laitières, son cadre conceptuel et sa structure institutionnelle de fonctionnement peuvent être reproduits dans n'importe quel système agroalimentaire.*

Mots-clés. *Développement agricole – Intensification durable – Intensification écologique – Conseil agricole – Évaluation de la durabilité.*

I – Introduction

The process of agricultural modernization has led agrifood systems towards specialization and high input dependence, such as fertilizers and pesticides, resulting in side-effect environmental impacts. Considering the projection of population growth and increasing number of people without regular access to safe, nutritious, and sufficient food, there is a rising demand for food production through sustainable intensification, coupled with the creation of local strategies to tackle global food insecurity. According to Beltran-Peña *et al*. (2020), to meet this growing demand for food, besides sustainably increasing production, sustainability and resilience aims must be initiated to cope with the climate change scenario, added to scarce raw materials and economic instability. The alternative proposed to overcome these challenges, defined as "sustainable intensification", consists in increasing food supplies, without expanding land use for agricultural production, based on the improvement of the economic, social, and environmental pillars, which compose sustainability (Garnett *et al*., 2013; Thomson *et al*., 2019). However, the transition of agroecosystems in search of sustainability requires customized solutions, as agricultural systems management and planning, depending on site-specific environmental and socioeconomic conditions (Teixeira *et al*., 2018; Peltonen-Sainio *et al*., 2019; Titonell, 2020).

Diversified agrifood systems are essential in the process of transition towards practices promoting food security and sustainable intensification (Gaba *et al*., 2015). In this context, integrated crop-livestock systems (ICLS) were recognized as an alternative to achieve sustainable intensification (FAO, 2010), as these systems entail diversification. Additionally, many aspects of the ICLS are considered important features to the modern concept of sustainable intensified agricultural production (Moraes *et al*., 2014). For instance, on within-farm ICLS, proper grazing management maximizes both forage and animal production (Kunrath *et al*., 2020), while potentially reducing greenhouse gas emissions (de Souza Filho *et al*., 2019). The integration of crop and livestock provide positive modifications in the agroecosystem, such as enhancing soil physical, chemical, and biological attributes (Peterson *et al*., 2019), and improving nutrient cycling and resource-use efficiency (Szymczak *et al*., 2020).

In this context, the PISA program was designed, having the ICLS as a major conceptual pillar. Aiming to improve sustainability of agriculture, this initiative involves the development of crop-livestock integration along with the implementation of agricultural technologies and practices according to specific contexts and based on a holistic approach. PISA was introduced as an agricultural extension program, which has already served 1819 farms since its creation. In this article, we present a detailed description of the PISA initiative, as well as a case study of one of PISA's projects, in which we assessed sustainability by an international validated tool.

II – The PISA Program to support sustainable development of smallholders

1. PISA genesis and its scientific foundations

The Integrated Production in Agricultural Systems, hereinafter referred to as PISA (its Portuguese acronym for *Produção Integrada em Sistemas Agropecuários*), was conceived, developed, and institutionalized as a program in 2007 by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA, its Portuguese acronym). The program was technical and jointly coordinated by the Federal University of Paraná (UFPR) and the Federal University of Rio Grande do Sul (UFRGS). The objective of the program was officially presented as: "to promote sustainable development within the scope of the micro-watershed, as a basic planning unit, through the diffusion of sustainable technologies and transformation of the production process, to obtain safe, quality food, with competitiveness, and job and income generation" (BRASIL, 2009).

The philosophy of PISA was firstly based on the general concept of ecological intensification, meaning intensifying the functionalities of natural processes that agricultural ecosystems can offer (Doré *et al*., 2011). PISA aims to be as flexible as to adapt to any food production system in any part of the world. To accomplish parallel goals such as optimizing land use, saving smallholder farmers' workloads, enhancing farm productivity, or increasing farm profitability, different tools and practices must be combined in a holistic and flexible site-to-site approach. To this end, the program makes use of different technologies and processes, customized for different context-specific solutions, to build sustainable and competitive food production environments. The PISA management framework can draw on a variety of scientific approaches and technologies, such as ecological intensification, conservation agriculture, functional diversified farming, integrated crop-livestock systems, silvopastoral systems, animal welfare and health, climate smart-agriculture, rotatinuous stocking, farming system design; economic tools and controls; system fertilization approach; nutrient recycling; agricultural best management practices; circular economy.

Therefore, conceptual foundations of PISA, originated from the academic world, must be associated with governance led by MAPA to build a program aimed at diversifying and strengthening agricultural production and achieving food security. The mediation of public and private institutions, as well as representations of civil society, constitutes a collaboration strategy adopted in PISA, seeking convergence on the interests of food production and conservation of natural resources.

2. Running the PISA Program in Southern Brazil

In 2009, PISA philosophy and technical pillars were applied in a smallholder dairy farm in the state of Rio Grande do Sul to serve as a PISA implementation model, and furthermore, as a Technical Diffusion Unit (UDT) to other farmers. Since 2012, PISA has been operated as an agricultural extension initiative in the South Region of Brazil. Smallholders from 1819 farms, in 119 municipalities in the Southern States of Brazil (Paraná – PR, Santa Catarina – SC, and Rio Grande do Sul – RS), have already participated in the PISA program. In RS, the program has been more extensively executed, accounting for 95 municipalities, from 2012 to 2020 (Fig. 1).

The broader execution of PISA Program in RS was made possible due to its institutional arrangement, performed by a public-private partnership. In 2011, under the guidance of the UFRGS, the SEBRAE[1] joins PISA in the RS, by including PISA in the portfolio of a broader action aimed at the development of agricultural productive chains (JC program[2]).

JC performs PISA as local agricultural extension projects, aimed at smallholders' dairy farms. Projects are designed as a collective initiative, in which smallholders join voluntarily. Each PISA project is organized in steering committees with local actors, such as policy makers, NGOs, local associations, etc. The committee is responsible for guiding the implementation of the project. The rural advisory service for the projects is performed by an outsourced consultancy company hired by the JC. Therefore, the institutional arrangement of PISA projects is composed of the institutional founders, the institutional operators, the private consultancy company, and the local government.

Each PISA project covers a microregion of RS, comprising from 5 to 10 municipalities. In general, there are 15-20 beneficiaries in each municipality. Hence, projects' beneficiaries ranged from 60 to 150, depending on the local context, local demand, and farmers adherence.

1. Brazilian Micro and Small Business Support Service – private-sector institution.
2. The JC program, Portuguese acronym for *Juntos para Competir*, is a partnership among the Agriculture Federation, the National Rural Apprenticeship Service (SENAR) and SEBRAE-RS.

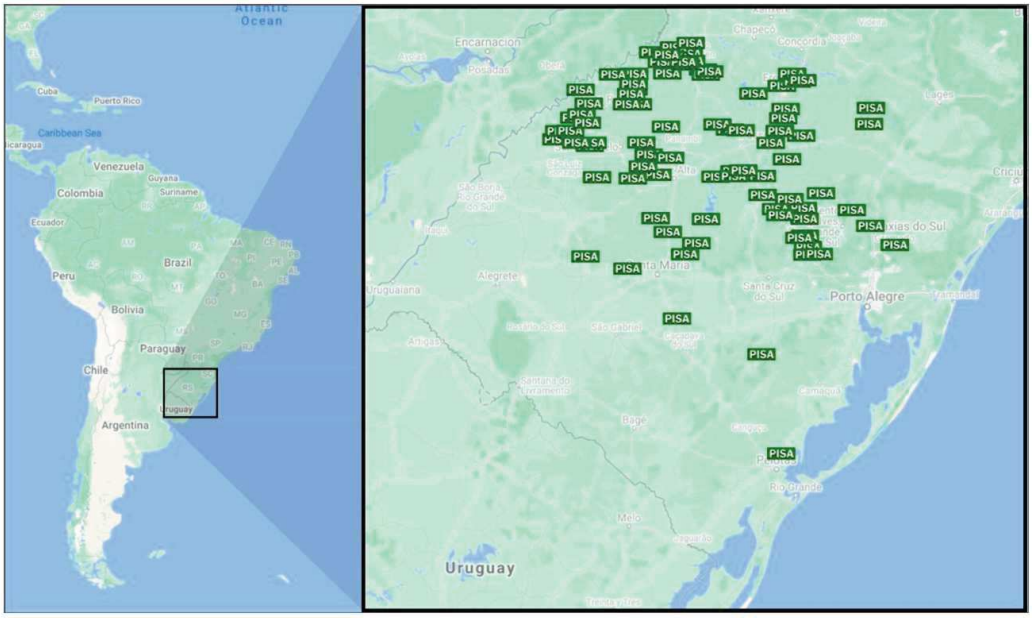

Fig. 1. Municipalities of the Rio Grande do Sul State where PISA has been executed, from 2012 to 2020.

A. PISA project execution plan

PISA projects are designed for a duration of 3 or 4 years. The PISA's rural advisory services include regular 4-hour technical monitoring service for farmers on the spot and group training activities. PISA execution methodology provides the implementation of a model unit called Technical Diffusion Unit (UDT) for every group of 15-20 farmers (generally one UDT per municipality). In the UDT, the application of PISA's concepts and tools can be demonstrated as practical results to all group. Considering UDTs' purpose, farmers receive monthly technical visits from field advisors. The other PISA farms, called "production units" (UP), are assisted every 45-60 days, throughout the progress of the project. Among the actions of collective training, farmers are encouraged to participate in the regular meetings, lectures and short courses that take place at the UDTs or local institutions facilities, in which they can build capacities and exchange ideas and experiences.

The implementation of a project is based on a request from a local actor, such as municipal departments, agents from the governmental company for agricultural extension (Technical Assistance and Rural Extension Company – EMATER), trade unions or farmer organizations, or dairy companies. From this request, the PISA project's committee is set. Farmers are invited to take part in the project by local actors, and the project's proposal is exposed to them. Thus, the groups of farmers that constitute a project are voluntarily formed, which is a prominent point for the rural extension process. The choice of the UDTs is also led by a participative and collective initiative since farmers and field advisors take part in the decision.

Regarding rural advisory services, field advisors from the hired consultancy company are trained to assure an even level of expertise in PISA's conceptual framework and philosophy. Advisory practice is performed in a participative approach, in which the field advisor works with farmers to establish a consistent and trust farmer-advisor relationship. In this context, advisors' recommendations, based on PISA's tools and practices, are adapted to each assisted farm reality, co-conceived with farmers, to empower farmers to make informed decisions and adopt suitable practices.

B. Target audience of PISA projects

In the State of Rio Grande do Sul (RS), milk production is an important economic activity, it is a formal economic activity in 90% of the state's municipalities. According to a recent report on the dairy production chain (EMATER-RS, 2019), more than 90% of milk produced in the RS State involving 50.500 dairy farmers, is sold as raw milk to official milk marketing channels. Among these dairy farmers, 97,5% are family farmers, with an average land area of 18 hectares. Milk is mainly produced in pasture-based systems (95% of farms), with an average herd size of 18 cows per farm. Most of the dairy herds (95%) comprise Holstein, Jersey and Holstein-Jersey crossbred cattle. Around 75% of those dairy farms produce up to 300 L of milk a day. These features are very consistent with the dairy smallholders observed in the PISA farms before technological intervention, i.e., before the implementation of a project.

Indeed, in accordance with this report, the PISA farms milk production is usually the main source of income for PISA farmers. Most of them are family farmers with forage-based dairy farms, where milk production is carried out in small production units. On average, the total land area is around 15-20 hectares with 6.5 hectares for grazing area. Farms present an average of 18 milking cows with a productivity of 18 litres per day. However, we highlight the wide diversity in PISA farms regarding soil characteristics, breeds of dairy cattle and crop diversity, family ethnical origins, farm structure, etc.

For instance, the PISA Norte project was designed to assist six municipalities from the North microregion of RS (Campinas do Sul, Erechim, Getúlio Vargas, Sertão, Três Arroios and Viadutos). The project was requested by local actors based on the regional importance of the milk production chain, the need of advisory services for dairy smallholders, and the increasing number of producers leaving dairy farming, which has turned into a low sustainability activity. From 2016 to 2020, the project was supporting 79 dairy farmers.

III – Sustainability assessment: Case study – PISA Norte Project

Considering that sustainable development is a driving goal of the PISA Program, in this case study, we assessed farms sustainability of one of PISA's projects, the PISA Norte project.

1. Methodology for assessment

We used an internationally validated assessment tool, the SAFA Smallholders App (version 2.0.) to assess sustainability of the PISA's farms. This tool was designed to support the applicability and implementation of SAFA Guidelines (FAO, 2014) at small-scale farms. SAFA Smallholders App consists in a 100-questions survey. That survey comprises a set of 44 indicators that are both highly relevant and practical to smallholder farmers, distributed in 21 SAFA themes and four dimensions of sustainability (good governance, environmental integrity, economic resilience, and social well-being).

For this study, SAFA Smallholders App survey was adapted since the app is no longer available. Questions were transcribed into a spreadsheet. The calculation of indicators and themes rating follows the same rules applied by SAFA Smallholders App. For each theme, a mean index was calculated based on all PISA Norte project's farms ratings. The SAFA sustainability polygon was created from the calculated mean index of the 21 SAFA themes.

In October 2020, at the end of the PISA Norte project, a two-hour interview was carried out on site by a trained interviewer in the 79 farms of the Norte project to apply the SAFA survey. The main farmer in charge of the milk production was surveyed. Interviewees could express themselves comfortably, with no interference or judgment from interviewers. During the interview, a farm tour was requested to interviewees, to understand the context of the farm.

2. Results from the sustainability assessment of the PISA Norte project

By the end of the project, PISA smallholder dairy farmers presented good performance in all sustainability dimensions (Fig. 2).

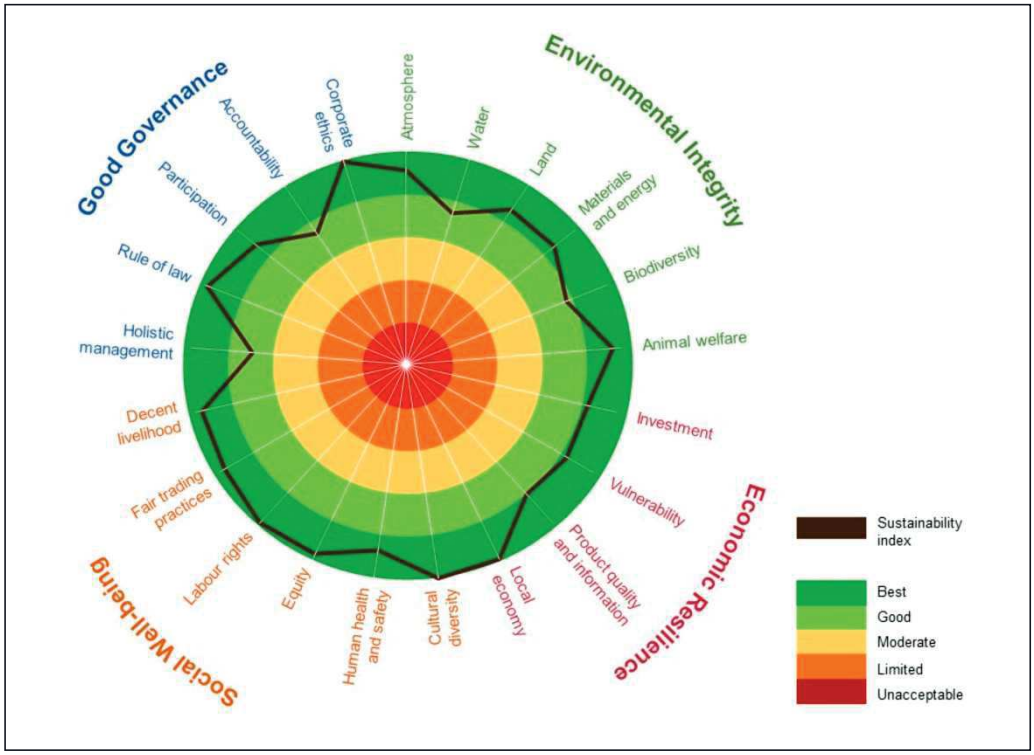

Fig. 2. SAFA sustainability polygon presenting the mean sustainability index of all farms of the PISA Norte project.

We observed an important impact of the PISA project on good governance. The SAFA tool has integrated this dimension in the sustainability analysis, considering governance as the process of organizing and implementing decisions, related to the other three pillars of sustainability. Thus, the project has provided to farmers a new holistic view of the farm and the dairy production system. This new guiding vision, understood in terms of values and goals of the PISA project, was assimilated by 95% of PISA farmers (corporate ethics theme). However, technical recommendations from field advisors and knowledge shared with farmers by the project initiatives were adopted, to a greater or lesser degree, among the assisted farms.

Regarding accountability, which is commonly overlooked in family farming, in 50% of PISA farms, producers have assiduously kept accurate production records. This activity has been also carried out in a lesser detailed and frequent way in 35% of the farms. Records represent a key tool for the holistic management.

Within the economic resilience dimension, we identified PISA project's contribution to enhance farms' profitability. More than 80% of PISA farmers reported that the farm revenues have often been greater than costs. This result is related to improvements in the dairy production system, that promoted increase in milk production, and / or reduction in milk production cost, assuring a higher profit margin to farmers. The new concept of grazing management, combined with adequate forage planning and animal nutrition, were pointed out by most PISA farmers as the main drivers of changes in their production systems. Another positive aspect related to cost reduction is that it allows farmers to face the fluctuation of milk prices with greater resilience.

For the vulnerability theme, the most prominent outcome is that 75% of PISA farmers have implemented on-farm measures to reduce risk due to PISA advisors' recommendations.

Considering the environmental dimension, in the atmosphere theme, we highlight as relevant practices for mitigating greenhouse gases, the adoption of rotatinuous stocking (Carvalho *et al*., 2013; de Souza Filho *et al*., 2019) and no-tillage as the main cultivation method, observed in most PISA farms. For animal welfare, in 95% of PISA farms best level of well-being and living conditions of animals were observed. Related to materials and energy theme, PISA farmers reported an improvement in soil fertility management. In 82% of PISA farms, fertilizers have been more efficiently used. In addition, most farms maintain a permanent soil cover. All PISA farms present a preserved natural vegetation area (permanent set-aside, defined by Brazilian legislation); and most farming systems produce multiple types of crops and pastures, along with livestock, justifying the good level for the biodiversity theme. We highlight that diversification, and the use of locally adapted crops and pastures are encouraged by PISA's field advisors.

Important impacts of the project were observed in the decent livelihood theme, within the social welfare dimension. The PISA project provided farmers with access to new knowledge, through trainings, meetings, lectures, and exchange of experiences with filed advisors and other farmers, favoring the development of PISA farmers' capacity. In 99% of the PISA farms, some degree of improvement on the producers' quality of life was reported.

IV – Final considerations

We identified that PISA stands out in terms of human resources. Farmers are supported by qualified field advisors, who are constantly being updated and can articulate multidisciplinary knowledge. In this sense, PISA advisors strengthen the link between research and farmers. To rural extension, these are desirable features in the context of more complex agricultural systems to deal with a challenging future scenario of climate change and economic instability. Additionally, we underline the combined actions of individual and group advising, performed in a participatory approach, as an important strategy towards the change of farmers mindset.

A new mindset opens to changing practices, so the transition to self-sufficiency can occur. The conversion from a specialized trajectory input driven to a diverse on-farm resources based on the PISA philosophy has proved sustainable in all dimensions by the SAFA tool.

The institutional arrangement of the PISA projects plays a prominent role in achieving goals. Each actor involved contributes to successfully implement a project, among the activities of promotion, financial support, management, theoretical-practical guidance, and execution. That explains the long-lasting and broad execution of PISA in the RS.

The PISA scope is aligned with the 2030 Agenda for sustainable development (UN, 2015). For instance, PISA principles and practices meet relevant sustainable development goals (SDGs), from promoting food security, social well-being, and sustainable economic growth to responding to climate change and sustaining our natural resources. PISA initiative actions are interconnected to address sustainable development, and hence, meet important SDGs.

At last, it is worth noting that, for the case of the RS, PISA is performed in smallholder dairy farms. However, PISA's conceptual framework and institutional structure for operation can be replicable to any agrifood system.

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