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PRODUÇÃO INTEGRADA EM SISTEMAS AGROPECUÁRIOS: UTILIZAÇÃO DA FERRAMENTA SAFA/FAO

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Orientador: Prof. Dr. Paulo César de Faccio Carvalho

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PRODUÇÃO INTEGRADA EM SISTEMAS AGROPECUÁRIOS: UTILIZAÇÃO DA FERRAMENTA SAFA/FAO[1]

Autora: Luísa Cardoso de Mello
Orientador: Prof. Dr. Paulo Cesar de Faccio Carvalho

Resumo: O crescimento da população mundial e o abastecimento de alimentos necessário para tal, desencadeiam preocupações relacionadas às demandas de intensificação do setor agrícola versus a conservação dos recursos naturais. Sendo assim, a Agenda 2030, estabelecida pela FAO, propõe diretrizes a fim de estreitar a conexão entre o meio ambiente e as pessoas, que possam se tornar em ações para garantir produção, segurança alimentar, nutrição, consumo e agricultura sustentável. A Produção Integrada em Sistemas Agropecuários (PISA) consiste em um programa que reúne um conjunto de tecnologias e ferramentas voltadas para a construção de sistemas agrícolas sustentáveis. Nossa hipótese é que as propriedades rurais participantes do PISA são sustentáveis ao final do programa. Nesse sentido, este estudo teve como objetivo realizar uma avaliação da sustentabilidade, de acordo com a Avaliação de Sustentabilidade de Sistemas Agrícolas e Alimentares - SAFA / FAO, em todas as fazendas do projeto do PISA Missões no Estado do Rio Grande do Sul. As entrevistas conduzidas a partir de questionário composto de 100 perguntas do App SAFA SmallHolders, foram realizadas em 65 propriedades leiteiras no final do Projeto PISA Missões, e os dados foram compilados para calcular o índice de sustentabilidade para cada tema dentro das quatro dimensões estabelecidas no SAFA. Todos os 21 temas alcançaram o "Ótimo" nível de sustentabilidade na escala SAFA. Indicando assim, que os pilares do PISA - visão holística da propriedade, adoção do conceito do pastoreio rotatínuo de pastagens, práticas conservacionistas de manejo de solo, uso eficiente e racional de insumo e energia, bem-estar animal, além de gestão financeira - são capazes de desenvolver e/ou potencializar um sistema de produção leiteira sustentável.

Palavras chave: serviços de assessoria rural; agricultura familiar; desenvolvimento sustentável; produção de leite; avaliação de sustentabilidade.

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INTEGRATED CROP-LIVESTOCK SYSTEMS: USE OF THE SAFA / FAO TOOL[2]

Author: Luísa Cardoso de Mello
Advisor: Prof. Dr. Paulo Cesar de Faccio Carvalho

Abstract: The growth of the world population and the supply of food necessary for this, trigger concerns related to the demands of intensification of the agricultural sector versus the conservation of natural resources. Thus, the 2030 Agenda, established by FAO, proposes guidelines in order to strengthen the connection between the environment and people, which can become actions to guarantee production, food security, nutrition, consumption and sustainable agriculture. PISA consists of a program that brings together a set of technologies and tools aimed at building sustainable agricultural systems. Our hypothesis is that the farms participating in PISA are sustainable at the end of the program. In this sense, this study aimed to carry out a sustainability assessment, according to the Sustainability Assessment of Agricultural and Food Systems - SAFA / FAO, on all farms of the PISA Missões in the State of Rio Grande do Sul. The interviews conducted using a questionnaire composed of 100 questions from the App SAFA SmallHolders, were performed in 65 dairy farms at the end of the PISA Missões Project, and the data were compiled to calculate the sustainability index for each theme within the four dimensions established in the SAFA. All 21 themes reached the "Best" level of sustainability on the SAFA scale. Thus, indicating that the pillars of PISA - holistic view of property, adoption of the Rotatinuous pasture management concept, conservationist soil management practices, efficient and rational use of input and energy, animal welfare, as well as financial management - are capable of develop and/or enhance a sustainable dairy production system.

Key words: rural advisory services; family farming; sustainable development; dairy production; sustainability assessment.

[2]Master of Science dissertation in Animal Sciense, Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, (81p.) March, 2021.

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LISTA DE ABREVIATIRAS E SÍMBOLOS

ACV – Análise do ciclo de vida

ANE – Análise de redes ecológicas

EMERGY – Eficiência energética integral

FAO – Organização para a Alimentação e Agricultura das Nações Unidas

FARSUL – Federação da Agricultura do Estado do Rio Grande do Sul

PISA – Produção Integrada em Sistemas Agropecuários

MAPA – Ministério da Agricultura, Pecuária e Abastecimento

SAFA – Avaliação de Sustentabilidade de Alimentos e Agricultura

SEBRAE – Serviço Brasileiro de Apoio às Micro e Pequenas Empresas

SENAR – Serviço Nacional de Aprendizagem Rural

SIPA – Sistema Integrado de Produção Agropecuário

UFPR – Universidade Federal do Paraná

UFRGS – Universidade Federal do Rio Grande do Sul

CAPÍTULO I

1. INTRODUÇÃO

Sustentabilidade não é algo facilmente estipulado ou mensurado em sistemas agropecuários, pois não existem padrões bem definidos para cada empreendimento, além de parâmetros específicos que devam ser levados em consideração de acordo com cada situação estudada. Com o aumento da população e do consumo, o setor agropecuário está em evidência, pois cabe a ele fazer o melhor uso da tecnologia disponível para atender a demanda populacional e preservar recursos naturais para evitar o seu esgotamento. A intensificação via especialização na agricultura gera impactos negativos ao meio ambiente, sendo indesejável à sociedade (LEMAIRE et al., 2014). Tais impactos são exemplificados pela contaminação da água, aumento das concentrações atmosféricas de gases causadores do efeito estufa, erosão e desequilíbrio do solo, e perda de diversidade (FRANZLUEBBERS, et al., 2011).

Para avaliação de sustentabilidade de propriedades rurais, a FAO (Organização para a Alimentação e Agricultura das Nações Unidas) criou a metodologia SAFA (Avaliação de Sustentabilidade de Alimentos e Agricultura), construindo assim um quadro holístico (considerando a propriedade como um todo) para avaliar a sustentabilidade ao longo da cadeia de alimentos e de valor da agricultura. SAFA é uma referência global para avaliação de sustentabilidade, e aponta pontos fortes e vulnerabilidades dos sistemas de produção, que a partir de índices gerados resulta em um polígono de sustentabilidade (FAO, 2014).

Nos últimos anos, o Sistema Integrado de Produção Agropecuário (SIPA) foi reconhecido pela FAO como alternativa para intensificação sustentável do setor agropecuário, já que agrupa peculiaridades importantes para os futuros sistemas de produção de alimentos (CARVALHO et al., 2014). O SIPA é um dos pilares do projeto Produção Integrada em Sistemas Agropecuários (PISA), que foi institucionalizado pelo Ministério da Agricultura, Pecuária e Abastecimento (MAPA). O PISA tem como objetivo principal "*promover o desenvolvimento agropecuário sustentável no âmbito da microbacia hidrográfica como unidade básica de planejamento, por meio de difusão de tecnologias sustentáveis e transformação do processo produtivo na busca da obtenção de alimentos seguros, com qualidade, agregação de valor, competitividade e geração de emprego e renda*" (BRASIL, 2009).

Segundo a FAO, o consumo de carnes, leites e ovos mais que triplicou nos últimos 30 anos em países classificados como sendo de baixa e média renda, que somando-se ao aumento da população, à urbanização, aumento da renda e globalização, cria oportunidades de emprego (FAO, 2018a). Sendo o leite identificado como a *commoditie* agrícola mais valiosa, com produção mundial em 2013 de 770 bilhões de litros, o setor movimenta 328 bilhões de dólares, correspondendo a aproximadamente 6% do comércio ligado a agricultura (FAO, 2018a).

Nesse contexto, o Rio Grande do Sul é apresentado como modelo de nosso estudo, que busca propriedades rurais leiteiras mais sustentáveis, já que a produção de leite faz parte da rotina de pelo menos 494 dos 497 municípios presentes no Estado (EMATER/RS-ASCAR, 2019), classificado em terceiro lugar como maior produtor de leite em 2018 (ROCHA & CARVALHO, 2019) Dessa forma, esse projeto visa avaliar indicadores de sustentabilidade de propriedades rurais leiteiras, a partir da metodologia SAFA.

2. REVISÃO BIBLIOGRÁFICA

2.1. Serviços Ecossistêmicos e Sustentabilidade

O crescimento da população mundial, juntamente com a necessidade de alimentos requerida para tal, aciona preocupações relacionadas a demandas para o setor agropecuário e para a conservação de recursos naturais. Apesar da produtividade atual, uma em cada sete pessoas não consegue ter acesso à comida ou estão em estado de desnutrição, devido a um nível constante de pobreza e aumento dos preços de alimentos (FAO, 2009; Thurow & Kilman, 2009). Há estudos sugerindo que para a sobrevivência da futura população, a agricultura teria que dobrar sua produtividade. Para atender a demanda de crescimento populacional, deveríamos propor modificações no consumo de alimentos, aumentar o uso de bioenergia, além de preservar o meio ambiente (Foley et al., 2011).

Impactos ambientais ocasionados pela agricultura estão relacionados a sua expansão e intensificação. O primeiro acontece quando áreas agrícolas avançam tomando o lugar de ecossistemas naturais, enquanto a segunda acontece quando áreas agrícolas são manejadas a fim aumentar sua produtividade, principalmente por meio da utilização elevada de insumos (Foley et al., 2011).

É estimado que 11% da área da do nosso planeta é ocupada por lavouras, somando-se ainda aproximadamente 30% a mais de áreas utilizadas para pastagem (Raven & Wagner, 2021). A expansão da agricultura foi estimada em 80% na área tropical do globo, áreas para cultivo tomam o lugar de florestas tropicais, que são consideradas os maiores reservatórios de biodiversidade e serviços ecossistêmicos (Foley et al., 2007; Gibbs et al., 2010)

Os serviços ecossistêmicos devem ser considerados de suma importância para o equilíbrio e manutenção do ecossistema, pois representam o elo entre a funcionalidade da biodiversidade/ecossistema e o bem-estar humano (WHO, 2005). Tais serviços referem-se a todo e qualquer benefício que nos é entregue pela biodiversidade e pela estrutura e funcionalidade dos ecossistemas de pastagens, tais como produtos, recursos e meio ambiente, de forma que atendam a demanda para nossas vidas e bem-estar (Sala & Paruelo, 1997). Mesmo que a pastagens nos forneçam serviços ligados ao setor agropecuário (alimentos), devemos ter em mente que a partir dela também obtemos fibras, medicamentos, energia, além de outros produtos de valor econômico direto. Não menos importante para o nosso bem-estar, as pastagens fazem parte da manutenção do equilíbrio do nosso planeta, pois nos fornecem serviços de regulação do clima, ciclagem de nutrientes, controle da erosão, lazer, turismo, fazem parte da nossa cultura nacional juntamente com a riqueza de sua biodiversidade (Sala & Paruelo 1997; Havstad et al. 2007; Sala et al. 2017).

Dessa forma, elementos que constituem as pastagens atuam direta ou indiretamente na formação da estrutura e dinâmica do ecossistema interferindo, assim, nos produtos e serviços ecossistêmicos (Fig. 1) (Zhao et al., 2020).

Figura 1. Principais serviços ecossistêmicos de pastagens e suas interações.

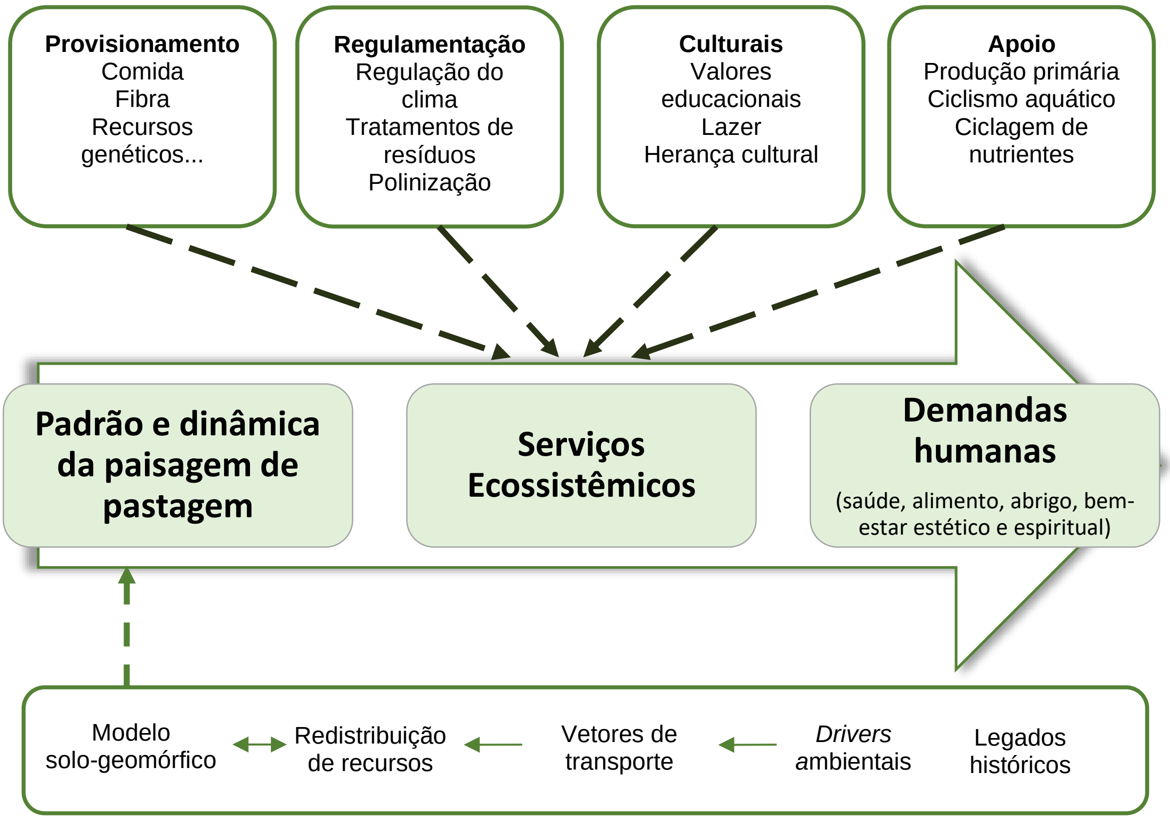

Figura 1 - Principais serviços ecossistêmicos de pastagens e suas interações com padrões e dinâmicas da paisagem e demandas da população. Adaptado de Zhao et al., 2020.

3. Sustentabilidade em Sistemas Agropecuários

Devido ao avanço e mudanças das tecnologias relacionadas aos sistemas de produção ao longo dos anos, é fundamental que tenhamos ferramentas metodológicas que possam ser utilizadas para a avaliação certeira dos processos implícitos e suas dinâmicas, facilitando assim o acompanhamento dos processos de intervenção tecnológica (Stark et al., 2016a). Tais processos de intervenção constituem um conjunto de tecnologias que, quando empregadas no sistema, podem ou não alterar positivamente a produção, que a longo prazo interferem em toda a dinâmica familiar do produtor. Dessa forma, se faz necessária uma análise prévia da metodologia a ser aplicada, comparando suas vantagens, desvantagens e modificações que possam acarretar o ambiente pretendido (Stark et al., 2016a).

Foram criadas diversas metodologias a fim de avaliar sistemas de produção, com diferentes abordagens, aplicações e objetivos. Stark et al. (2016b) citaram algumas, tais como: análise do ciclo de vida (ACV), análise de redes ecológicas (ANE) e eficiência energética integral (EMERGY), bem como a trajetória do sistema (Stark et al., 2016b).

Para que uma propriedade rural se torne sustentável ou avance seu nível de sustentabilidade, diversas ferramentas foram desenvolvidas para que tenhamos uma ampla visão a respeito do desenvolvimento de sustentabilidade dos sistemas agropecuários (Olde et al., 2016). Essas ferramentas, baseadas em indicadores, divergem de acordo com o setor (geográfico e setorial), grupo alvo (produtores, decisores de políticas), indicadores selecionados, formulação e tempo requerido para implementação (Binder et al., 2010; Marchand et al., 2014; Schader et al., 2014).

Visto que sistemas agropecuários têm suas complexidades e particularidades que devem ser analisadas para implantar e mensurar a sustentabilidade ao longo de sua cadeia de produção, foi possível encontrar na literatura outras ferramentas de avaliação de sustentabilidade baseada em indicadores. Essas ferramentas são geralmente constituídas de uma estrutura que possui três ou quatro níveis hierárquicos, que ainda pode divergir em sua terminologia (Fig. 2) (Olde et al., 2016).

No estudo realizado por Olde et al. (2016) foram comparadas outras ferramentas de avaliação de sustentabilidade a fim de obter um panorama dos requisitos práticos de cada metodologia, procedimentos, bem como as complexidades que envolvem a aplicação de cada ferramenta (Olde et al., 2016). Dessa forma, ferramentas de avaliação de sustentabilidade auxiliam na tomada de decisões na propriedade, causando impactos significativos acerca do seu desenvolvimento sustentável (Le gal et al., 2011; Marchand et al., 2014).

Figura 2. Níveis utilizados em ferramentas de avaliação de sustentabilidade.

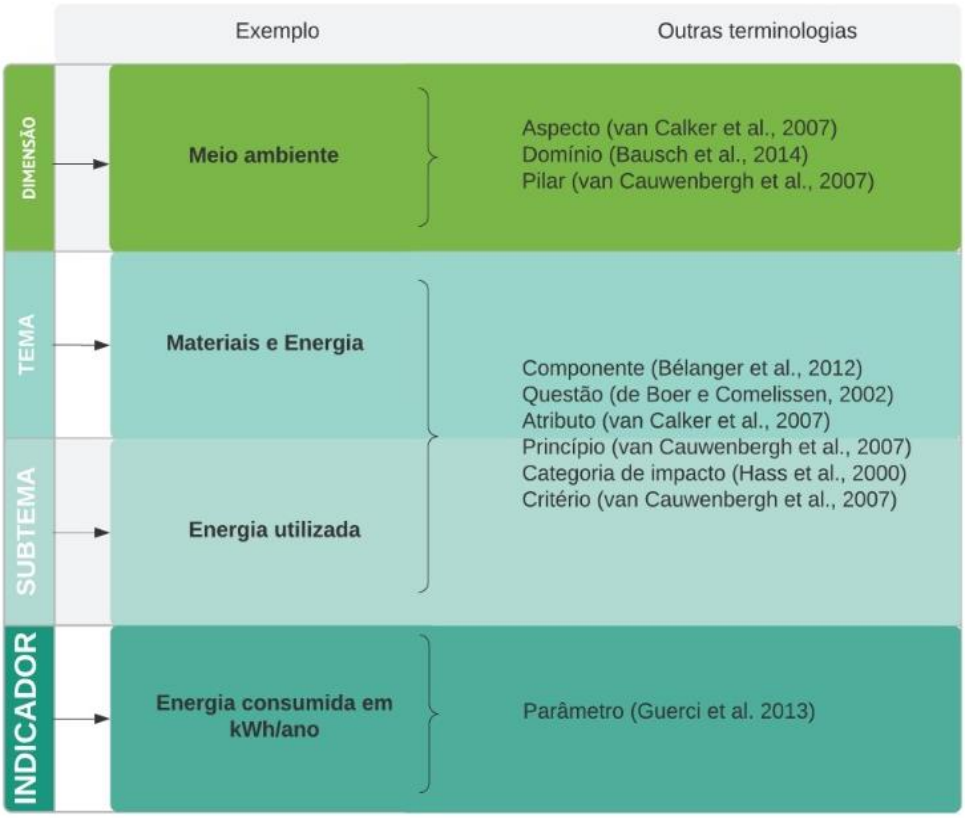

Figura 2 - Níveis de avaliação de sustentabilidade baseados no SAFA, juntamente com outras terminologias desenvolvidas. Adaptado de Olde et al., 2016.

Para a criação de uma ferramenta de sustentabilidade, é preciso levar em conta o que significa ser sustentável, o que significa um determinado nível de sustentabilidade, quais indicadores devem ser utilizados em cada caso, como mensurar o nível de sustentabilidade, qual valor cada indicador terá e como eles serão atrelados (Gasparatos, 2010).

Atualmente existem distintas estruturas genéricas de avaliação, que surgiram devido a necessidade de governar fatores externos e internacionais, bens públicos globais (clima, biodiversidade, estabilidade financeira, segurança alimentar, etc), somando ao avanço da globalização (Gasso, 2015). Contudo, para cumprir seu objetivo, essas estruturas buscam a padronização, credenciamento, avaliação de desempenho em relação à concorrentes, bem como entre regiões ou nações, além de conseguir abranger diversos usuários e situações distintas (Mineur, 2007; Ness et al., 2007; Van zeijl-rozema et al., 2011).

No contexto de avaliação de sustentabilidade, algumas indagações começam a surgir sobre o que é ser sustentável, de que forma, em qual escala, assim como quais os limites do sistema. Não obstante a avaliação, relações temporais também são levadas em consideração e levantam questões a respeito do período de tempo avaliado e seu nível de certeza. O fator social incorporado engloba quais processos? Quem está envolvido e como se dão as relações de troca quando se encontra objetivos diferentes? (Lélé & Norgaard, 1996; Briassoulis, 1999). Tais questões apresentadas não possuem uma resposta comum a todas as situações que forem avaliadas. Avaliar a sustentabilidade se torna uma ferramenta não somente empírica, mas também funcionará como normativa a fim de definir processos e objetivos para o desenvolvimento sustentável (Gasso, 2015).

As ferramentas de avaliação de sustentabilidade, quando aplicadas em propriedades rurais, geram resultados que podem ser utilizados para mensurar e monitorar práticas de gestão agrícola, não somente relacionadas à interação produto e consumidor, como também frente a questão de regulação e certificação em mercados de âmbito local e global (Olde et al., 2018). Relacionado ao agronegócio especificamente, algumas características são consideradas ações ambientalmente sustentáveis, tais como redução no consumo de água e energia, que resulta na diminuição do uso de insumos, bem como outras despesas para algumas empresas. Sendo relevante para a empresa, o produtor pode obter incentivos financeiros para implementação de práticas sustentáveis, além de colocar em pauta questões relacionadas à gestão ambiental ou bem-estar animal (Peterson et al., 2017).

Em “*Toward sustainable agricultural systems in the 21st century*” é considerado um sistema sustentável aquele que for capaz de seguir cumprindo seus objetivos diante de imprevistos que possam impactar a produção, podendo assim adaptar-se e evoluir. São quatro os objetivos utilizados como guias para atingir a sustentabilidade planejada: (1) satisfazer as necessidades humanas de alimentos, fibras, rações, além de contribuir na demanda de biocombustíveis; (2) melhorar a qualidade do meio ambiente e a base de recursos; (3) ser capaz de sustentar a viabilidade da agricultura economicamente; (4) melhorar a qualidade de vida de produtores rurais, trabalhadores agrícolas, bem como a sociedade. Além de ser capaz de se manter, sendo produtivo o suficiente, a produção deve fazer uso dos recursos necessários de forma eficiente, equilibrando os quatro objetivos citados anteriormente. Dessa forma, na busca desses objetivos, pode haver compensações ou sinergias que quando entrelaçadas, direcionam a sustentabilidade (Fig 3) (NRC, 2010).

Figura 3. Metas de sustentabilidade de acordo com o National Research Council.

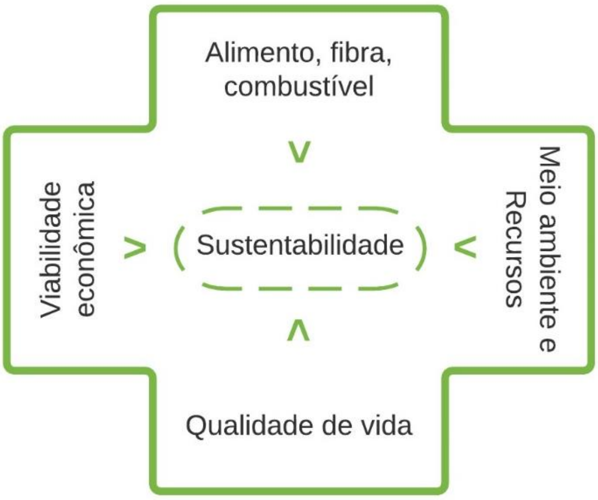

Figura 3 - Convergência de metas de sustentabilidade para atingir seu maior nível. Adaptado de (National Research Council, 2010).

4. Avaliação de Sustentabilidade de Alimentos e Agricultura (SAFA)

Tendo em vista as considerações anteriores, a sustentabilidade se tornou tema recorrente na sociedade atual, sendo a base dos Objetivos de Desenvolvimento Sustentável (ODS), que foram adotados por todos os Estados Membros das Nações Unidas no ano de 2015, na construção da Agenda 2030 (UN, 2012). Caracterizam-se como a principal conexão entre seres humanos e o planeta, alimentos e agricultura (FAO, 2018b). A finalidade do desenvolvimento sustentável é melhorar a qualidade de vida da população, sem a necessidade de ultrapassar os limites de exploração de recursos naturais fornecidos pelo meio ambiente (Merico, 1997). Para alcançar um desenvolvimento sustentável no setor agropecuário, estratégias estão sendo pensadas, analisadas e postas em prática, com bases mais ambientalistas, pela necessidade de mudar o modelo dominante de produção agrícola (Altieri & Nicholls, 2002). Para que isso aconteça, a agricultura deve ser produtiva o suficiente, economicamente viável, além de preservar traços culturais e sociais, sendo aceitável e ecologicamente apropriada (Sarandón, 2002). Portanto, uma agricultura sustentável preserva a biodiversidade, melhora os recursos do solo, protege ambientes aquáticos, entrega alimentos saudáveis e de qualidade, reduz a necessidade de uso de insumos, deixando o produtor mais livre de mercados externos, além de se tornar uma fonte de renda confiável para os agricultores (Zaldivar, 2006).

Uma das estratégias elaboradas para mensurar níveis de sustentabilidade é a ferramenta Avaliação de Sustentabilidade de Alimentos e Agricultura (SAFA) desenvolvida pela Organização das Nações Unidas para Alimentação e Agricultura (FAO). Foi desenvolvida para avaliar o impacto de operações alimentares e da agricultura no meio ambiente e nas pessoas. As diretrizes da SAFA possuem a visão orientadora de que os sistemas alimentares e agrícolas são caracterizados por quatro dimensões de sustentabilidade: boa governança, integridade ambiental, resiliência econômica e bem-estar social (FAO, 2014).

A FAO define desenvolvimento sustentável como:

> "Gestão e conservação da base de recursos naturais, e a orientação de tecnologias e mudança institucional de forma a garantir a obtenção e continuidade satisfatória das necessidades humanas para as gerações presentes e futuras. Tal desenvolvimento sustentável (nos setores da agricultura, silvicultura e pesca) conserva terra, água, recursos vegetais e animais, é ambientalmente não-degradante, tecnicamente apropriado, economicamente viável e socialmente aceitável" (FAO COUNCIL, 1989).

Portanto, SAFA é um quadro de referência global holístico, utilizado para avaliar a sustentabilidade por toda a extensão das cadeias de valor da agricultura, silvicultura e pesca. Constitui, assim, uma referência capaz de definir elementos de sustentabilidade, com estrutura consistente para avaliar sinergias e antagonismos entre as dimensões de sustentabilidade, possuindo níveis aninhados, a fim de aumentar a parcimônia entre todos os níveis (Fig. 4) (FAO, 2014).

Figura 4. Estrutura da ferramenta SAFA.

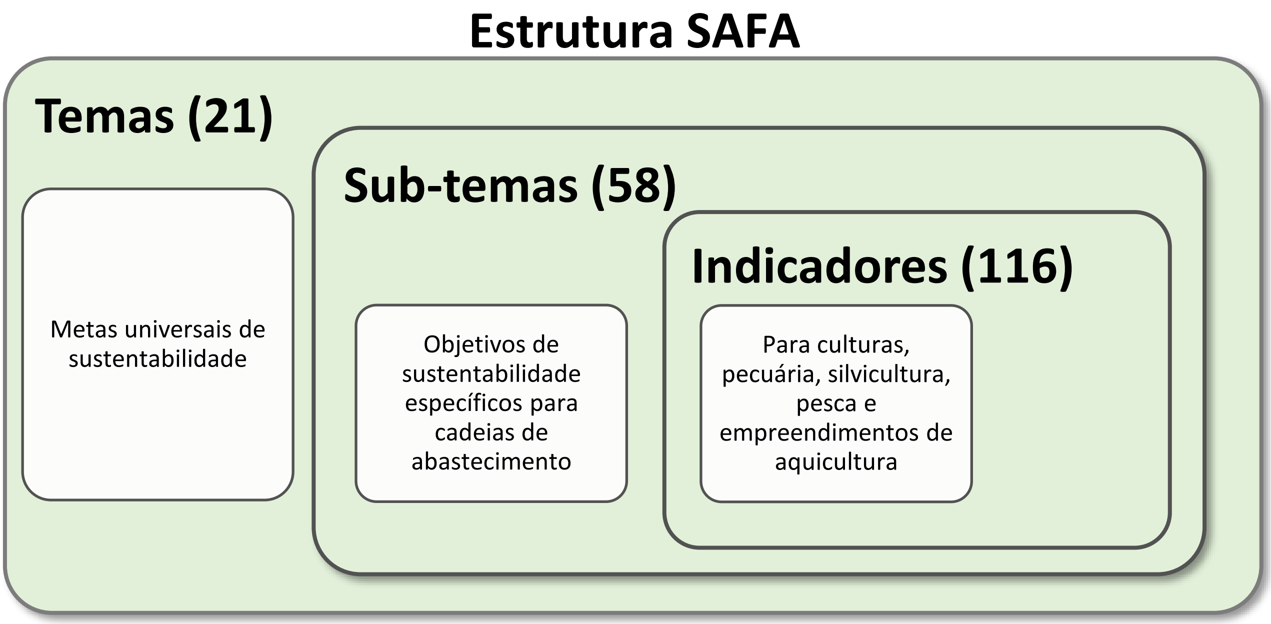

Figura 4 - Estrutura SAFA com seus níveis e possíveis aplicabilidades.

5. Sistemas Integrados de Produção Agropecuária – SIPA

Sistemas Integrados de Produção Agropecuária (SIPA), são constituídos como alternativas a fim de atingir as metas de produção de alimentos, mas levando em consideração a sustentabilidade do sistema. Para a consolidação de um SIPA, é necessário um conhecimento multidisciplinar para a integração adequada dos componentes envolvidos na produção, para que as relações sinérgicas sejam potencializadas e gerem resultados sociais, econômicos e ambientais (Carvalho et al., 2014).

Cientificamente, os SIPA são definidos como sistemas que exploram e potencializam sinergias e propriedades emergentes, que são resultantes de interações entre os componentes solo-planta-animal-atmosfera, que fazem parte tanto da produção agrícola, quanto da pecuária (Moraes et al., 2014).

No Brasil, o SIPA está associado ao manejo de rotação de cultivos e pastagens e alocação de ruminantes em pastejo direto, ainda estando conectado a recuperação de pastagens degradadas (Carvalho et al., 2014). Nesse contexto, esse sistema se torna interessante, pois produtores rurais enfrentam dificuldades em relação ao manejo eficiente e adequado das pastagens. Pois a produção de leite em sistemas a base de pastagem permite um aumento na renda dos produtores a partir da redução dos custos de produção (Dillon et al., 2005) devido a utilização das pastagens como principal fonte de alimento do rebanho. Mas ainda, caso o sistema leiteiro seja baseado na utilização de pastagens, acredita-se que se alcance um maior potencial para aumento da sustentabilidade ambiental pelo uso otimizado dos recursos (Capper et al., 2009).

No âmbito social, os SIPA auxiliam na sucessão familiar e integração social devido ao aumento da geração de emprego e da renda provinda do trabalho rural, juntamente com a ampliação da oferta de alimentos de qualidade, maior oferta de mão de obra, bem como especialização e aumento da qualidade de vida do produtor rural e de sua família, dentro dos padrões de sustentabilidade do sistema (Balbino et al., 2011). Dessa forma, o aumento da produtividade e a sustentabilidade do sistema não podem estar em direções opostas no planejamento rural, mas sim estarem lado a lado buscando maior eficiência e reduzindo impactos negativos ao meio ambiente (Godfray et al., 2010).

6. Produção Integrada de Sistemas Agropecuários – PISA

O programa PISA (Produção Integrada de Sistemas Agropecuários) foi institucionalizado em 2007 pelo Ministério da Agricultura, Pecuária e Abastecimento (MAPA), em conjunto com as Universidades Federais do Paraná (UFPR) e do Rio Grande do Sul (UFRGS). Desde 2008 o projeto é realizado no Sul do Brasil e, no Rio Grande do Sul, é conduzido pela parceria SEBRAE / SENAR / FARSUL desde 2011 por meio de ações do Programa Juntos para Competir.

O PISA tem como objetivo principal é disseminar a tecnologia necessária à adaptação do processo produtivo das propriedades rurais, em direção a uma produção mais sustentável de alimentos seguros e de qualidade, além de reduzir os custos de produção e aumentar o retorno econômico da propriedade (Brasil, 2009). A base do PISA é o Sistema Integrado de Produção Agropecuária (SIPA), que teve sua qualidade reconhecida pela FAO (Carvalho et al., 2014). Os SIPA estão representados no cenário internacional em 25 milhões de km², ocupando aproximadamente 50% da produção de alimentos no mundo (Bell & Moeere, 2012). A distribuição dessa produção corresponde a 65% de bovinos, 75% de leite e 55% de cordeiros presentes em países em desenvolvimento (Herrero et al., 2010). Assim, é possível observar que o Sistema possui forte representação no cenário mundial, se fazendo indispensável em questões de segurança alimentar (Eloy et al, 2020). Além disso, outras tecnologias de boas práticas na agricultura também são adotadas pelo PISA, tais como o plantio direto, a rotação de culturas e sua diversificação, o pastoreio Rotatínuo, entre outros (Eloy et al, 2020).

De acordo com Lemaire et al. (2011), o manejo da pastagem é o fator principal para o equilíbrio do ecossistema pastoril (Lemaire el al., 2011). Para obter maior sucesso na taxa de ingestão dos animais, de forma a potencializar a produtividade, a altura de entrada e saída, juntamente com a proporção de pastejo consumida pelos animais, irão determinar a excelência do sistema (Mezzalira et al., 2011). Nesse contexto, o PISA tem como sua principal ferramenta, o pastoreio Rotatínuo, que baseia-se na resposta comportamental do animal, frente à estrutura de pasto, utilizando a altura ideal do pasto pré-pastejo, bem como a intensidade de desfolha, para potencializar a ingestão de forragem por unidade de tempo de pastejo (Schons et al., 2021).

7. Características da Produção Leiteira no Sul do Brasil

De acordo com a FAO (2010), aproximadamente 150 milhões de famílias agrícolas, o correspondente a cerca de 750 milhões pessoas atuam na cadeia produtiva do leite, ocupando em sua maioria países que estão em desenvolvimento (FAO, 2010). Sendo assim, é preciso buscar alternativas que, a longo prazo, assegurem a segurança alimentar e o crescimento econômico do setor pecuário, englobando a pecuária de leite, buscando aumentar a eficiência da utilização dos recursos (FAO, 2010). A produção leiteira é uma importante atividade para o Brasil, tanto no âmbito econômico quando social, gerando renda regular a pequenos produtores, contribuindo para sua manutenção do campo (Matte júnior & Jung, 2017). Em 2013, o país produziu aproximadamente 24 bilhões de litros de leite, resultando em um aumento 31% em sua produção, quando comparado à década de 2000 (IBGE, 2018). Contudo, a demanda do produto pode fazer com que a produção de leite aumente em até 58% até 2050 (Gaitán et al., 2016; Rojas-downing et al., 2017).

O Brasil produziu 33 milhões de toneladas de leite em 2018, ocupando o quarto lugar dentre maiores produtores mundiais (Zoccal, 2020). A região Sul do Brasil é a maior produtora de leite do país (Costa et al., 2018). Em 2018, o Estado do Rio Grande do Sul produziu 4.242.293 litros de leite, se enquadrando como terceiro maior produtor de leite (IBGE, 2018). No RS, a produção de leite é caracterizada por ser de agricultura familiar, com propriedades de em média 18,3 hectares, com sistemas de produção à base de pasto (94,5%), semiconfinamento (3,7%) e confinamento total (1,8%) (EMATER/RS-ASCAR, 2019).A produtividade das propriedades que comercializam leite cru para indústrias e cooperativas, atingiu em 2019, 213 litros de leite/dia, produzindo em média 13,90 litros de leite/vaca/dia.(EMATER/RS-ASCAR, 2019). A pecuária leiteira é tradicionalmente caracterizada pela alimentação do gado baseada em silagem e concentrado, além da pastagem. Apenas 2.4% da produção total de leite do país é realizada a partir de um sistema de confinamento (intensivo) (Ruviaro et al., 2020).

No Rio Grande do Sul, a produção de leite está presente de alguma forma em 99,4% dos municípios, englobando principalmente produtores que atuam na agricultura familiar (EMATER/RS-ASCAR, 2019). Composta principalmente de produtores de pequena escala de produção, o rebanho leiteiro é alimentado principalmente com silagem + concentrado de milho e, pastagens temperadas anuais (*Lolium mutiflorum* e *Avena strigosa*) ou pastagens tropicais (*Sorghum bicolor*, *Pennisetum glaucum* e *Cynodon* spp.) (Carvalho, 2013). São sistemas considerados de baixa sustentabilidade, principalmente devido ao uso excessivo de insumos (Beukes et al., 2012; Foote et al., 2015; Macdonald et al., 2017). O PISA procura reverter a baixa sustentabilidade do sistema, pois uma das principais ferramentas do projeto é a implementação do pastoreio Rotatínuo, o qual se baseia no manejo da estrutura ideal do pasto, otimizando a ingestão de matéria seca e nutrientes, minimizando o tempo de pastejo e a necessidade de suplementação. Além de ser eficiente na produção de pasto (Schons et al., 2021), também promove a redução de impactos ambientais (redução da intensidade CH_4 , redução da intensidade de produção) (Savian et al., 2021).

Levando em consideração o tema em questão, essa Dissertação tem como objetivo analisar indicadores de sustentabilidade em propriedades rurais leiteiras, integrantes do programa Produção Integrada de Sistemas Agropecuários (PISA) Missões, a partir do uso da ferramenta SAFA. Por conseguinte, espera-se analisar as ações de intervenção tecnológica do programa PISA na implementação de estratégias viáveis que aumentem a sustentabilidade de tais propriedades, além de buscar possíveis padrões de sustentabilidade presentes.

8. HIPÓTESES E OBJETIVOS

A hipótese deste estudo é:

Ao final do programa PISA, as propriedades participantes, são sustentáveis, de acordo com a ferramenta SAFA.

O objetivo foi:

Avaliar indicadores das quatro dimensões de sustentabilidade pela ferramenta SAFA, aplicada em propriedades leiteiras participantes do projeto PISA ao final de três anos de atuação.

CAPÍTULO II

Article

9. ARE SMALLHOLDER DAIRY FARMS SUSTAINABLE? A CASE STUDY FROM SOUTHERN BRAZIL

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Abstract
The growth of the world population and the demand for food is a subject that directly relates the agricultural sector and the conservation of natural resources. The PISA program consists of a methodology that aimed at sustainable intensification of agricultural systems. In this sense, this study aimed to carry out a sustainability assessment, according to the *Sustainability Assessment of Food and Agriculture Systems* – SAFA/FAO, on farms from one of the PISA's projects in State of Rio Grande do Sul, the PISA Missões project. Interviews with the 100-question survey from the SAFA SmallHolders App were performed in 65 dairy farms at the end of the PISA Missões project, and data were compiled to calculate sustainability index for each theme within the four dimensions established in SAFA. All 21 themes reached the "Best" level of sustainability on the SAFA scale. It indicates that the blend of technical pillars of PISA, such as the holistic view of the small farm, adoption of Rotatinous stocking as a concept of grazing management, conservationist soil management practices, efficient and rational use of inputs and energy, animal welfare, as well as financial management, are capable of enhance a sustainable dairy production system.

Keywords: rural advisory services; family farming; sustainable development; dairy production; sustainability assessment.

9.1. Introduction

With the increase in population and consumption, the agricultural sector stands out, being responsible for the best use of available technology to meet the population's demand and preserve natural resources to avoid depletion. There are studies suggesting that for the future population to survive, agriculture would have to double its productivity [1–6]. The intensification via specialization in agriculture generates negative impacts on the environment (e.g., water contamination, increased atmospheric concentrations of greenhouse gases, erosion and soil imbalance, and loss of diversity [7], being undesirable to society [8]. Thus, sustainability has become a trend topic, being the basis of the Sustainable Development Goals (SDGs), a set of actions that design a path to achieve human well-being, together with the sustainability of the environment [9–11].

Due to the advances and changes in technologies related to agriculture systems over the years, methodological tools are essential to accurate assess implicit processes and their dynamics, thus facilitating the monitoring of technological intervention processes [12]. Such intervention processes constitute a set of technologies that, when used in the system, may or may not positively impact production, which in the short-term interfere with the entire family dynamics of the farmer [13]. Recently, the Integrated crop-livestock systems (ICLS) has been recognized by FAO as an alternative for sustainable intensification of the agricultural sector, since it presents important characteristics (e.g. nutrient cycling, soil improvement, reduction of production costs, sustaining high levels of productivity, providing ecosystem services) for future food production systems [14]. ICLS is one of the pillars of the (Produção Integrada de Sistemas Agropecuários-PISA), which was institutionalized by the Ministry of Agriculture, Cattle and Food Supply (MAPA) in 2007. The PISA initiative aims to promote sustainable agricultural development in general [15], and in Southern Brazil, in the State of Rio Grande do Sul, it is related the dairy sector.

Brazil is the 5th largest milk producer in the world, accounting for 33,954 thousand tons in 2020 [16]. July 2020, the agricultural sector increased by 1.26%, with accumulated growth of 6.75% in the period from January to July. All other segments (inputs, primary sector, agri-services) increased in gross domestic product, except the sector of agroindustry, which closed the accumulated until July with 0.37%, corresponding to the segment most affected by the Covid-19 pandemic [17]. In 2018, Rio Grande do Sul (RS) was the second in the ranking of milk production among Brazilian states. Its production increased by 21.8% in 10 years, from 3,315 to 4,242 million liters [18]. In 2020, RS was the third among the largest industrial producers in the country, with 4.27 billion liters/year, with an average productivity of 3.76 thousand liters/cow/year [19]. However, dairy cattle farming is still unsustainable, due to the increased use of inputs in animal feeding and crop farming, such as concentrates and nitrogen fertilizers [20–22]. Thus, sound pasture management that enhance the use of forage gathered by dairy cows grazing pastures is considered a way forward sustainability [23,24] by improving land use, in addition to mitigating environmental impacts in dairy systems [23,24].

Although there are some productive practices that contribute to sustainability (organic agriculture, crop-livestock integration, moderate grazing, integrated low-confine swine systems, perennial agriculture), further studies are still needed to build a well-established scientific , which together with the necessary data, will improve the sustainability of the agricultural system [25]. There are a few specific parameters that must be taken into account according to each situation studied. One of the strategies designed to measure levels of sustainability is the Food and Agriculture Sustainability Assessment (SAFA) tool developed by the Food and Agriculture Organization (FAO) of the United Nations. It was created to assess the impact of food operations and agriculture on the environment and people. SAFA's guidelines have the guiding/oriented view that food and agricultural systems are characterized by four dimensions of sustainability: good governance, environmental integrity, economic resilience and social well-being [26]. Therefore, SAFA is a holistic global reference framework, used to assess sustainability across the entire value chain of agriculture, forestry and fisheries. Thus, it constitutes a reference capable of defining elements of sustainability, with a consistent structure to assess synergies and antagonisms between the dimensions of sustainability, having nested levels, in order to increase parsimony among all levels [26]. Considering the importance of the dairy sector, this study aimed to analyze sustainability indicators for dairy farms that participated of the PISA Missões project, based on SAFA SmallHolders App methodology. Thus, the sustainability assessment was carried out to validate the technological intervention actions of the PISA project, in the implementation of viable strategies that promote the sustainability of milk production.

9.2. Materials and Methods

9.2.1. Integrated Production in Agricultural Systems (PISA)

The Integrated Production in Agricultural Systems Program initiative, referred to as PISA, is a concept for sustainable production developed and institutionalized in 2007 by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA) under the technical coordination of the Federal University of Paraná (UFPR) and the Federal University of Rio Grande do Sul (UFRGS).

PISA aims to promote the development of sustainable agricultural systems, based on the diffusion of sustainable technologies and improvements in the production processes, aiming at the production of safe, quality food, adding value, promoting competitiveness and income generation in the farm [15].

Since 2012, PISA has been executed/operated as an agricultural extension initiative in the South Region of Brazil. In the State of Rio Grande do Sul, under the guidance and articulation of the Federal University of Rio Grande do Sul (UFRGS), it is performed by a public-private partnership, comprising the Brazilian Micro and Small Business Support Service (SEBRAE), National Rural Apprenticeship Service (SENAR) and Agriculture Federation of Rio Grande do Sul (FARSUL), as part of the *Juntos Para Competir* Program.

9.2.1.1. How the PISA group is formed

For the initialization of the project, network structures are constituted for the implementation and execution of actions, these are: Technical Management Committee (TMC), Executing Entity (rural advisory services) and claimants (producers). TMC counts on the participation of government agencies, private institutions (SEBRAE-RS, SENAR-RS e FARSUL-RS), associations, representatives of the civil community, adding representatives from UFRGS and Federal University of Paraná (UFPR). This committee conducts the survey of local demands, technologies and resources available in the region.

9.2.1.2. Project participating farms

Local actors, such as municipal departments, Technical Assistance and Rural Extension Companies (EMATER), rural union or associations, indicate/invite producers to take part on a project. The incentive for the participation of producers occurs through meetings, in which the proposal and the PISA methodology are proposed, as well as the results obtained in other places where it was implemented, in order to stimulate voluntary candidacy in the project.

9.2.1.3. Technological Diffusion Unit (UDT) and Productive Units (UPs)

In the PISA project the participating farms are divided into two groups: technological diffusion units (UDT) and productive units (UPs). The UDT constitutes a model unit to share the methodology and tools to all PISA farms from a local group, where the farmer is willing to host meetings, trainings, and exchanges of experiences. In the UDT, then, the project's progress is monitored, regarding alternative actions or peculiarities, as well as the impact of the implementation of the technologies and tools implemented in the farms. The UPs are constituted as participating units, in which actions can be replicated, but always according to the specific situation of each farmer. In this way, UDTs are provided with monthly agricultural and financial advisory services, while UP’s from 45 to 60 days, over the 3 years of the project's duration.

9.2.1.4. Executing Entity (ATER)

Based on TMC's initiative, executing entities provide technical assistance services that are defined through integrated training actions with producers. Equipped with technical and operational training consistent with PISA concepts and tools, as agricultural and financial advisory services, perform actions covering a systematic view of the farm, being able to dialogue and establish a good relationship with the producer [27].

9.2.2. Characterization of dairy farms in RS

According to the Socioeconomic Report of the Milk Production Chain in RS, prepared by EMATER/RS in 2019, milk production is somehow present in a total of 152,489 farms, in 494 of the 497 municipalities [28]. In 457 municipalities (91.95%) producers were identified who sell raw milk to industries, cooperatives or cheese makers, or even to producers who process milk in their own legalized agribusiness, [28].

The annual production of milk by producers who sell raw milk to industries or cooperatives corresponds to 91.86% liters of milk, comprising 90.95% of the municipalities. Producers who sell raw milk as a formal activity (88.76%), produce up to 500L of milk per day. These producers account for 81.94% in formal activity, with 33.10% linked to industries, cooperatives or cheese makers, and 0.12% process milk in their own agro-industry. The farms have an average of 18 dairy cows in total each and, of the total of 50,664 producers, 94.5% adopt a pasture-based system and 97.5% are classified as family farmers [28], thus inserting itself in the context of the PISA Project.

9.2.3. Description of the PISA Missões Project

The PISA Missões Project was executed in the State of RS, Brazil, from 2015 to 2018**,** assisting farms where the main activity was milk production. The project served the municipalities of Campinas das Missões, São Miguel das Missões and São Pedro do Butiá, with groups of 30, 18 and 17 farmers, respectively, accounting for a total of 65 supported farms. Thus, dairy farms have, on average, of 37.4 ± 29.0 ha, and an area ranging from 5.0 to 550.0 ha, and 77% of the farms had up to 50 ha.

In 2010, Campina das Missões had a total population of 6,117 inhabitants, in an area of 225.76 km², of which 3,292 correspond to the rural population, representing 64.23% of the total. 1,223 family farming establishments were registered, with 3,374 people working in the agricultural sector in this field [29]. São Miguel das Missões registered in 2010 a total population of 7,421 inhabitants, of which 3,694 corresponded to the rural population, 965 family farming establishments, with 2,644 personnel working. São Pedro do Butiá, in 2010, registered a total of 2,873 inhabitants, with 1,664 corresponding to the rural population, in addition to 482 family farming establishments and 1,254 people working in this branch [30]. According to Köppen (1918), the three municipalities have a climate classified as Cfa, and an average annual temperature between 19°C and 20°C and a rainfall index between 1700mm and 1800mm. Campina das Missões presents a Nitisols soil type, while São Pedro do Butiá and São Miguel das Missões have soil type Oxisols [31–33].

9.2.4. Sustainability assessment of dairy farms from PISA Missões Project

The dairy farms participating in the PISA Missões Project were subjected to evaluation at the end of the project, after three years of technological intervention. The present research adopts - as a sustainability assessment methodology - the Sustainability Assessment of Food and Agriculture Systems (SAFA) Smallholders App. The SAFA use the criteria based on the dimensions of sustainability, with the objective of evaluating the sustainability and effectiveness of the project.

9.4.2. *Description of SAFA Smallholders App*

The SAFA Smallholders App (version 2.0) was meant to be a free, easy-to-use, open-source software offered by FAO to implement the SAFA Guidelines (version 3.0) indicated for the assessment of the sustainability of small-scale properties focused on requirements of subsistence or commercialization agricultural crops or livestock. This methodology for sustainability assessment consist in a 100-question survey, that answer to 44 sustainability indicators, distributed in 21 themes and 4 dimensions of sustainability [34].

9.4.3. *Sustainability assessment on farm*

The questions in the SAFA Smallholders App were translated into Portuguese, and organized in an Excel spreadsheet for data collection and further data analysis. For the purpose of standardizing the understanding of the situation of the property, and in order not to create a bias in the interview, previous training of interviewers was carried out on a pilot farm. Then, three interviewers went to the field to collect the data, randomly distributed in the 65 farms visited. These interviewers were professionals from the field of agricultural sciences, familiar with technical terms and dairy farming, which facilitated the communication with the farmer. Farmers were contacted by phone to schedule the interviews.

9.4.4. *Data Management*

Each farmer had his/her answer sheet. For each answer, a score was assigned according to the sustainability performance - good (green), limited (yellow), unacceptable (red) - indicated in the guidelines proposed by the SAFA app tool. Afterwards, the results were transformed in indexes, where the colors red, yellow and green were attributed the values 1, 3 and 5 respectively. Then, data from all producers were compiled and an average index was calculated from the result of that compilation. The index, ranging from 1 to 5, was next used to evaluate the sustainability in the farms as follows: 1- unacceptable (red), 2 - limited (orange), 3 - moderate (yellow), 4 - good (light green), 5 - best (dark green). From the indexes of the questions, the mean indexes of the 21 themes within the 4 dimensions of sustainability were calculated in order to generate the sustainability polygon.

9.3. Results

The average sustainability index, which considers the result compiled from all PISA Missões dairy farms project, reached the "Best" level for all 21 themes, distributed in the 4 dimensions of sustainability (Figure 1). In the sequence, the results for each dimension of sustainability will be presented, in addition to presenting the index for each theme (Table 2).

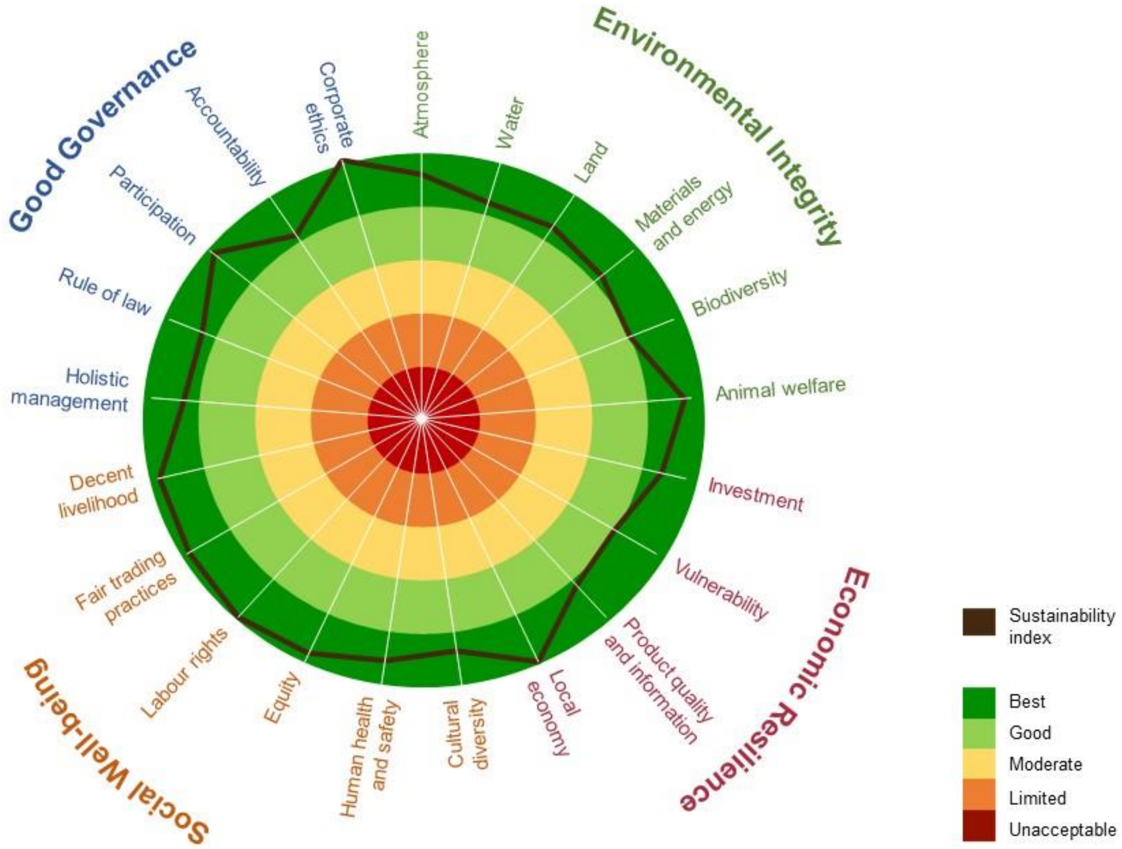

Figure 1. SAFA sustainability chart of the index of all compiled dairy farms.

Table 2. Sustainability dimensions and themes according to the SAFA Smallholders App, along with information analyzed from the PISA Missões project.

Theme	Analyzed PISA information	Sustainability indicator
	SUSTAINABILITY DIMENSION: GOOD GOVERNANCE	
Corporate Ethics	Understanding and engagement of sustainable practices, together with values and goals of the PISA project.	5.00
Holistic Management	Production risk minimization plan.	4.42
Participation	Join associations and farmers organizations.	4.92
Accountability	Perform records of rural property production processes.	4.11
Rule of Law	Regulate the right of ownership of rural property.	4.33
	SUSTAINABILITY DIMENSION: ENVIRONMENTAL INTEGRITY	
Atmosphere	Minimize air pollution.	4.01
Water	Water conservation actions.	4.18
Land	Soil management for conservation.	4.30
Biodiversity	Biodiversity conservation actions.	4.15
Materials & Energy	Better use of energy and recycling materials.	4.25
Animal Welfare	Provide animal welfare conditions.	4.88

SUSTAINABILITY DIMENSION: ECONOMIC RESILIENCE		
Investment	The development of sustainable practices, reflected in the local and regional community.	4.56
Vulnerability	Adding value to the product while maintaining productivity levels.	4.12
Product Quality and Information	Prioritize product food safety avoiding the use of pesticides.	4.20
Local Economy	Collaboration with the local economy.	5.00
SUSTAINABILITY DIMENSION: SOCIAL WELBEING		
Decent Livelihood	Increase social welfare.	4.99
Fair Tranding Practices	Understanding your product's supply and demand.	4.95
Labour Rights	Regulation of their workers.	4.88
Equity	Gender equality in decision-making.	4.47
Human Health & Safety	Adequate working conditions.	4.52
Cultural Diversity	Adequate nutrition and little traditional and cultural knowledge.	4.75

9.3.1. Good Governance

The dairy farms have reached the "best" level of sustainability. In the "*Corporate Ethics*" theme, 100% of farmer, as well as everyone on their farms, understood the values and goals of the PISA Project. "*Participation*" theme, 98% of farmers participate in an organization, enabling greater access to market information, prices, and services, helping to add value to the dairy farm. All these farmers believe that being part of this group adds value to their farm. When considering the conflict resolution indicator, most farmers (94%) are able to solve problems peacefully, if they occur, with input suppliers, workers, buyers, etc.

As an expressive result, 63% of farmers kept records of the production processes of their farms, contributing to "*Accountability*". This theme includes the frequency and detail that farmers keep records of the productive processes on the farm, such as information on planting and harvesting, use of inputs, animal health control, among others.

Most farms (98%) were able to adopt a farm management plan, as an action to be implemented from the "*Holistic Management*". Thus, ensuring long-term production and the resilience of the production system. 57% of producers reported that the plan was successful and 69% of the plans include more than three elements of the SAFA App, such as finance, soil fertility, environmental management, health and safety, quality, as well as forage planning, pasture management, animal production and nutrition plan, which are well-worked points in the PISA Project.

The theme "*Rule of Law*" is composed of three questions: legitimacy, tenure rights and tenure constraints. Thus, relating to milk - the main product marketed by PISA producers - we identify its sale is carried out within a quality standard, regulated by federal laws and its quality is often verified by buyers, ensuring the legal compliance of the product.

9.3.2. Environmental Integrity

In general, the dairy farms that reached the "best" level of sustainability, performed two soil improvement practices ("*Atmosphere" and "Land*") - cover crops and crop rotation, while the rest did not perform crop rotation. Besides, in relation to the two themes mentioned above, 86% of dairy farms used no-tillage as their main cultivation method, and 14% performed minimum tillage. A combination of natural and synthetic fertilizers was performed by 98% of dairy farms and in the recommended dosage. Within the *"Land"* theme, at least two methods for land conservation and rehabilitation practices were performed, such as maintenance of permanent soil cover, terracing or level planting. In addition, in all farms the native area was conserved (*"Land" and "Biodiversity")*.

Related to the theme *"Atmosphere"*, all farmers reported that 20% or more of the area of their farms is covered by trees and, during the project, the number of trees on the farms has not changed. Complementing that only 17% of the farmers manage the manure by means of a composting system or biodigester, the rest applied directly to the cultivation areas, or left on the pasture. None of the producers use burning as a management tool ("*Biodiversity" and "Atmosphere*").

For the genetic conservation of seeds and breeds, locally adapted species are used, however 51% of farmers stated that they depend totally on external sources for such acquisitions, included in the theme *"Biodiversity"*. The farming system is composed of 70% of farms that have a diversified production system with more than four crops and/or livestock creations. Among the farms included in the project, 85% maintain permanent set-aside areas, rehabilitated or restored natural areas and, 15% or have buffer zones. The use of synthetic pesticides was carried out properly, according to the specific crop and / or pest, following the manufacturer's recommendations (*"Biodiversity" and "Product quality and information"*)

Related to the *"Water"* theme, the use of synthetic pesticides identified in 85% of the farms was in accordance with the recommendations for water conservation practices. The adoption of practices with potential for water pollution has not been identified in any dairy farms.

A better use of energy and inputs were noticed as the reuse of residues from cultivation, processing and organic matter, recycling of materials, determining greater care with the equipment of the property, as a practice related to the theme *"Materials and Energy"*. Over 60% of farmers applied fertilizers based on recommendations according to soil analysis and crops requirements. In all farms, plastic containers and bags were properly sent for recycling or were reused. Although not implemented in most farms, efforts have been made to reduce the consumption of electricity. The farms do not have "renewable energy sources", but in Brazil the main energy matrix is hydroelectric, therefore considered a clean source. When used, the main source of wood or charcoal for energy is through natural managed forest with limited extraction, managed plantations or planted woodlots, and tree pruning. Preventive measures are taken, however in a lesser or greater extend, since 63% farms presented crop losses from 10 to 30% during the last year.

Related to the *"Animal Welfare"* theme, the animals were total free from hunger, thirst, discomfort, pain or any disease or anguish, according to the five freedoms of animals. The animals had access to quality veterinary care when needed, and farmers were able to follow treatment recommendations of the animals on the farm itself.

9.3.3. Economic Resilience

Greater care was taken with the financial management of the property, estimating expenses with inputs, fertilizers, pesticides, seeds, animal feed and veterinary care, which started with the field advisors, contributing to better results within the "I*nvestment"* theme. Besides, at the end of the three years of the project, 65% of the producers reported that the revenues were greater than the costs, contributing to the result of the index. Still related to the theme *"Investment"*, the farmers participate within the community, thus contributing to their development through the exchange of knowledge, skills and abilities, or simply through the supply of their product.

Farmers became safer and more aware of their financial situation, which helped them in farm management and decision making, affecting the theme *"Vulnerability"*. The vast majority of PISA properties sell more than two or three products. More than three options or locations for marketing the products enable consistent relationship with the main buyers. In this way, farmers have the power to choose where to sell their products. The financial health of the dairy farm influences the farmers' capacity to form a financial reserve, interconnecting the theme *"Vulnerability"* to *"Investment"*. In addition, 66% of the farms had crop-related insurance, 74% had a risk reduction plan in case of crop loss and 55% implemented measures on the farm to reduce the risk of climatic variability

In terms of "Product quality and information", 95% of dairy farms produce crops, animals or products that meet or are certified by a standard. Some of the farms (40% - 80%) have the main products sold as certified. Most of the pesticides used in the farms are not classified as red labels, and farmers follow the recommended dosage and safety instructions. All farmers carry out measures (hygiene, adequate storage, classification), to maintain the high quality of their products and cultivation, as well as receive technical quality checks. In addition, most farms manufacture products within some standard of commercialization or certification (between 40 and 80% of the products).

9.3.4. Social Well-Being

In relation to the theme *"Decent Livelihood"*, rural farmers reported positive impacts on their lives, which include healthy eating, safe housing, time available for the family to be together, to maintain a healthy relationship, to have time for leisure. In addition, farmers participated in training/courses, such as good agricultural practices or product processing, information management and records, as well as activities to support commercialization, contributing to the capacity development indicator.

Regarding the *"Human Health and Safety"* theme, vulnerable groups or untrained personnel do not apply pesticides on PISA farms, and for the application of such products, most farmers (80%) use PPE (Personal Protective Equipment). No occupational accidents requiring medical attention have been reported in the past year. Medical treatment is free or cheap, accessible to farmers and their families.

In the topic *"Fair Trading Practices"*, a good understanding by farmers of the pricing of their products was identified, coupled with knowledge of market information, such as supply and demand and price fluctuations.

Decision-making in the farm and in the production system as a whole was carried out on all property jointly by men and women, respecting gender equality and respecting the issues of *"Equity"*.

Most farmers had no ties to indigenous / traditional communities, nor knowledge of techniques, use of seeds and medicinal plants, these being practices covered by the theme *"Cultural Diversity"*. Regarding food sovereignty, 66% of farmers reported that not all family members have access to culturally appropriate food. But it was never necessary to decrease the size or skip meals due to lack of food. In almost all farms, connection with the indigenous community was reported, either by being part of it or through formal ties.

9.4. Discussion

9.4.1. Good Governance

PISA is a methodology that aims to optimize production based on the use of available resources on property, land, labor, capital, and increase production. It is characterized by being a tool for the dissemination of technological intensification, with the objective of increasing food production, based on sustainable production. That stated, we understand that the new guiding vision brought by the PISA project contributed to guide the planning / organization of the dairy farm. On the theme *"Holistic Management"*, the adoption of a management plan and its monitoring by rural advisors is critical to project success. Some improvement elements worked by these rural advisors and proposed to farmers are pasture management, forage planning, animal nutrition, fertilization management, financial management, genetic improvement of the herd, sanitary management, expansion, etc. Results suggest that such practices are capable of guiding the management of the farm. As pointed out in the study carried out by Hanisch et al. (2019) in the

State of Santa Catarina, farms participating in the research project for the development of techniques in order to improve production obtained high levels in the sustainability assessment [35]. Related to the theme *"Accountability"*, production data records serve as a management tool for decision making. In the analysis of agricultural systems, the planning techniques developed are mainly directed to the management of pasture. From that point on, the farmer will be able to trace his actions, which involve, for example, animal supplementation programs or herd sales [36].The group of farmers analyzed had a good participation in associations and cooperatives (*"Participation"*). Cooperatives that include family farming works the interaction between social and economic elements [37]. In addition to encompassing "socioeconomic" factors, social and environmental components, which if interconnected, constitute "eco-social" factors [38]. Such participation becomes an important element, as it is a place where knowledge exchanges, dialogues, information about services, markets, and technological diffusion. In this way, cooperatives play a key role in maintaining employment and economic viability in local communities in rural areas [37].

9.4.2. *Environmental Integrity*

The main practice implemented by the PISA project, responsible for the success, was the innovative grazing management, the "*Rotatinuous*" stocking [39]. Pasture management has a multifunctional function directed to the entire pasture ecosystem, thus addressing the processes involved in the production, use and sustainability of the pasture (LEMAIRE, GILLES & HODGSON, JOHN & CHABBI, 2011). Thus, the implementation of "*Rotatinuous*" stocking results in positive outcomes in the short term, as the system is based on flexible rest periods due to fluctuation in pasture growth, benefiting the accumulation of pasture, together with definitions for occupation and density of stocking, thus increasing the harvest efficiency and the benefit of the forage in the cows diet [39]. To obtain greater success in the rate of animal ingestion, increasing productivity, the pre-grazing and post-grazing sward height, as well as the proportion of grazed biomass, determine the excellence of the system [41]. The method enhanced the management of pasture, increasing the consumption of nutrients by the animals per unit of grazing time.

Related to the theme *"Materials and energy"*, pasture management in this system is able to achieve a good potential for increasing environmental sustainability through the optimized use of available resources, contributing to soil conservation [42] by reducing the need for inputs, and efficient use of natural resources. The implemented no-tillage method is seen as an essential method that is part of conservation agriculture that works to enhance biodiversity, as well as the biological processes that act on the soil surface, contributing to the preservation of soil and water resources, nutrients availability, optimizing and maintaining crop production [43]. This is because no-till is a method that relates the physical, chemical and biological dimensions of the soil, such as density, infiltration and retention capacities, acting in favor to the conservation of the biodiversity of the entire agroecosystem, bringing benefits to both the producer and the environment [44].

Conservation agriculture is such an important technology, encompassing tools and practices such as preventing loss of arable land, and at the same time regenerating degraded land (*"Land" and "Biodiversity")*. As a way of mitigating greenhouse gases, "*Rotatinuous*" stocking stands out again, since the intake rate has a strong positive correlation with live weight gain, which in turn is negatively related to the methane intensity (CH_4). This compound corresponds to 65% of greenhouse gas emissions from livestock worldwide, thus contributing to the carbon footprint of ruminants. That said, definitions of pre-grazing and post-grazing sward height, promoted by the "*Rotatinuous*" grazing, optimize daily consumption by offering a highly nutritious herbage , reducing the production of CH_4 [45].

9.4.3. *Economic Resilience*

With the reduction of production costs, due to the implementation of the *"Rotatinuous"* stocking - less demand for silage, less demand for supplementation with high protein content, in addition to pasture being of a lower cost feed - farmers were able to increase investment in their property by increasing the number of animals in production, thus increasing productivity. This aspect was highlighted by farmers, as it made possible to improve the financial management of their production system, fitting into the *"Investment"* theme. This aspect can also be analyzed from an economic and social point of view, since the practice of family farming, together with local cooperatives, depends on the natural resources available in the region. This is due to the common sense of the place and interest in the shared common assets of natural resources, as they depend on the health of the community and the local environment. Thus, farmers and the community, together, contribute to the sustainable development, ensuring and enhancing their own sustainability [46]. In the *"Vulnerability"* theme, the PISA project stood out for increasing economic resilience, which also contributes to reducing the vulnerability of the production system. Because, together with good financial management and a good management plan adopted on the farms, it makes the property less susceptible to risks that may be related to production instability, instability of the market and price fluctuations, animal dieses and food self-sufficiency [47]. In addition, farmers can access financial loans if necessary, from banks and credit unions, which is a characteristic of the PISA Missões region. National public policies that were developed with a focus on family farming. Such policies emerged in the 1990s, namely the National Family Farming Strengthening Program (PRONAF), Family Farming Insurance (SEAF), Family Farming Price Guarantee Program (PFPAF) and Crop Guarantee Program, which were of paramount importance for the development and transformation of the quality of life of people who depend on agriculture for their livelihood [48].

Practices that aim to profit the ecosystem resources available through biodiversity, instead of overloading them, such as avoiding the use of external inputs, are some of the strategies in the development of more sustainable agricultural production. Such strategies are supported by global initiatives such as the United Nations (UN) 2030 Agenda for Sustainable Development and the Intergovernmental Platform for Biodiversity and Ecosystem Services [49]. As noted, the dairy farms deliver quality and certified products, since the adoption of good agricultural practices to maintain high milk quality is reinforced in the PISA Missões project. Having a certified product adds value to the product, granting a higher financial return and increasing competition in the market [34].

9.4.4. *Social Well-Being*

The project positively affected all aspects of the lives of the participating families. In addition, farmers were motivated through training, in order to develop their skills and increase their knowledge, so to improve their production system. These issues affect the whole dynamics for quality of life, enhancing the contentment of doing a good job and maintaining good working conditions, which as a consequence opens the way to quality markets for the product delivered [35]. In addition, there is financial improvement, and reduced workload due to the implementation of *"Rotatinuous"* stocking, that facilitates the daily management of the dairy farm. In the *"Fair Trading Practices"* theme farmers participating in the PISA project, showed knowledge of the commercialization prices of their products. During the course of the project, most farms did not usually hire employees and, when a child under the age of 16 is part of the family, they have direct and access to education, in addition to not exercising a risky function on the property. We can link this to the fact that in family farming, most of the work is done by the family itself, making production become a form of autonomous work and linked to the development of the family, as the members can actually see their dedication and passion placed at work, resulting in improved family property and livelihood [50]. In relation to the theme *"Equity"*, the farms proved to be equal in relation to the participation of women in decision making. Regarding the theme *"Human safety and health"*, no weaknesses were found due to the fact that the farmers have good quality of life, and good access to health services present in the PISA Missões region. However, we must take into account the various public policies that were created in Brazil in order to address issues of health and food security. Some of them are: Bolsa Família Program, Program for Food Purchase from Family farming, National Program for Land Credit, National Policy on Food and Nutritional Security, National Plan on Food and Nutritional Security [48]. In the theme *"Cultural Diversity"*, the results found were contrary to those of Hanish et al. (2019), suggesting that in the PISA Missões project family farming is not related to any indigenous/traditional knowledge [35]. However, we emphasize that the integration of traditional and indigenous knowledge should be encouraged and valued in a participatory manner, as it is a factor that can raise the level of sustainability resulting from the project even further.

PISA Missões Project can be molded according to each farm context. This is a project with a well-founded methodology and action plan, but with flexible strategies, which can be adapted to the demands of each producer and his/her family. The project is executed through a public-private partnership, showing the importance that an action of this size can promote changes in people's lives.

9.5. Conclusions

In general, the technological intervention implemented by the PISA project after three years of operation ensured/promoted dairy farming sustainability. The importance of the connection between Research and Extension is clear during the project. The PISA Missões project, through the institutional arrangement, contributes to the achievement of the project's objectives. Bringing together a management approach characterized by demonstrating the benefits of collective work, in which farmers and study and research entities, through the Juntos Para Competir partnership, work together for the success of the project. When thinking about the transition from a system of conventional to sustainable practices, a series of understandings about the dynamics that compose it are necessary. The conjunction between theory, techniques and social aspects, aiming at a better dissemination of knowledge in a clear, didactic and objective way, enables and stimulates readjustments within a family farming system. One of the main points that promote the success of the PISA project, and which reflected on the issue, is the management of pastures, based on "*Rotatinuous*" stocking, as it implies several changes within the context of the environmental sustainability of farms, proving to be a sustainable management strategy and rapid implementation. PISA is an example of climate-smart livestock system production, enhancing production and reducing methane emissions per hectare. Thus, the production system can be understood holistically, encompassing environmental, social and economic aspects, among decisions to be made and, actions implemented, about the family farming system. Therefore, throughout the analysis of the project as a whole, it is clear that all the sustainability dimensions advocated by the SAFA tool are related to each other. Thus, demanding a holistic view of the property framework, in which farmers and their families must exercise, modifying their routine of dairy farming management practices, through sustainable methods, strengthening their production and reducing their vulnerabilities.

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10. CONSIDERAÇÕES FINAIS

A contribuição do presente estudo foi mostrar a efetividade da intervenção tecnológica do Projeto PISA, em propriedades rurais leiteiras, localizadas no Rio Grande do Sul, Brasil, cujo objetivo principal é a disseminação de tecnologias de intensificação agrícola sustentáveis. Sendo possível, por meio da utilização de uma ferramenta de avaliação de sustentabilidade SAFA Smallholders App, reconhecida internacionalmente, foi possível avaliar a sustentabilidade das propriedades rurais leiteiras, nas quatro dimensões de sustentabilidade.

De acordo com a ferramenta SAFA, as propriedades rurais leiteiras alcançaram o nível “ótimo” em todos os 21 temas de sustentabilidade, indicando que as metodologias propostas pelo PISA, como a prática do manejo rotatínuo de pastagens, práticas conservacionistas de manejo do solo, utilização eficiente e racional de insumos e energia, bem-estar animal, gestão financeira, além de uma visão holística da propriedade, conseguem elevar a produtividade do sistema, otimizando a produção leiteira de uma maneira sustentável.

A adoção de práticas agrícolas sustentáveis propostas pelo PISA, ainda impactam positivamente a qualidade de vida dos produtores e seus familiares, pois além do melhor retorno financeiro devido ao aumento da produtividade, a carga de trabalho é reduzida, já que as propriedades são caracterizadas no âmbito da agricultura familiar.

Este estudo ressalta a importância da implementação de práticas agrícolas sustentáveis em propriedades leiteiras, que contribuem para o melhor desenvolvimento da gestão da propriedade, do meio ambiente, da gestão financeira e, da qualidade de vida dos produtores.

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APÊNDICES

Apêndice 1 – Normas utilizadas para a preparação do capítulo II

Instructions for Authors: Sustainability

Submission Checklist

Please:

1. read the **Aims & Scope** to gain an overview and assess if your manuscript is suitable for this journal;
2. use the **Microsoft Word template** or, **LaTeX template** to prepare your manuscript;
3. make sure that issues about **publication ethics, research ethics, copyright, authorship, figure formats, data** and **references format** have been appropriately considered;
4. Ensure that all authors have approved the content of the submitted manuscript.
5. Authors are encouraged to add a **biography** (optional) to the submission and publish it.

Manuscript Submission Overview

Types of Publications

Sustainability has no restrictions on the length of manuscripts, provided that the text is concise and comprehensive. Full experimental details must be provided so that the results can be reproduced. *Sustainability* requires that authors publish all experimental controls and make full datasets available where possible (see the guidelines on **Supplementary Materials** and references to unpublished data).

Manuscripts submitted to *Sustainability* should neither be published previously nor be under consideration for publication in another journal. The main article types are as follows:

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- *Reviews:* These provide concise and precise updates on the latest progress made in a given area of research. Systematic reviews should follow the PRISMA **guidelines.**

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Authors must use the **Microsoft Word template** or **LaTeX template** to prepare their manuscript. Using the template file will substantially shorten the time to complete copy-editing and publication of accepted manuscripts. The total amount of data for all files must not exceed 120 MB. If this is a problem, please contact the Editorial Office **sustainability@mdpi.com**. Accepted file formats are:

- *Microsoft Word:* Manuscripts prepared in Microsoft Word must be converted into a single file before submission. When preparing manuscripts in Microsoft Word, the ***Sustainability*** **Microsoft Word template file** must be used. Please insert your graphics (schemes, figures, *etc.*) in the main text after the paragraph of its first citation.
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- We do not have strict formatting requirements, but all manuscripts must contain the required sections: Author Information, Abstract, Keywords, Introduction, Materials & Methods, Results, Conclusions, Figures and Tables with Captions, Funding Information, Author Contributions, Conflict of Interest and other Ethics Statements. Check the Journal ***Instructions for Authors*** for more details.

- Your references may be in any style, provided that you use the consistent formatting throughout. It is essential to include author(s) name(s), journal or book title, article or chapter title (where required), year of publication, volume and issue (where appropriate) and pagination. DOI numbers (Digital Object Identifier) are not mandatory but highly encouraged. The bibliography software package *EndNote*, ***Zotero***, *Mendeley*, *Reference Manager* are recommended.

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A cover letter must be included with each manuscript submission. It should be concise and explain why the content of the paper is significant, placing the findings in the context of existing work and why it fits the scope of the journal. Confirm that neither the manuscript nor any parts of its content are currently under consideration or published in another journal. Any prior submissions of the manuscript to MDPI journals must be acknowledged. The names of proposed and excluded reviewers should be provided in the submission system, not in the cover letter.

Author Biography

Authors are encouraged to add a biography (maximum 150 words) to the submission and publish it. This should be a single paragraph and should contain the following points:

1. Authors’ full names followed by current positions;
2. Education background including institution information and year of graduation (type and level of degree received);
3. Work experience;
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Manuscript Preparation

General Considerations

Research manuscripts should comprise:

- **Front matter**: Title, Author list, Affiliations, Abstract, Keywords

- **Research manuscript sections**: Introduction, Materials and Methods, Results, Discussion, Conclusions (optional).
- **Back matter**: Supplementary Materials, Acknowledgments, Author Contributions, Conflicts of Interest, **References**.
- **Review manuscripts** should comprise the **front matter**, literature review sections and the **back matter**. The template file can also be used to prepare the front and back matter of your review manuscript. It is not necessary to follow the remaining structure. Structured reviews and meta-analyses should use the same structure as research articles and ensure they conform to the **PRISMA** guidelines.

- **Graphical Abstract:**
- A graphical abstract (GA) is an image that appears alongside the text abstract in the Table of Contents. In addition to summarizing content, it should represent the topic of the article in an attention-grabbing way.

The GA should be a high-quality illustration or diagram in any of the following formats: PNG, JPEG, EPS, SVG, PSD or AI. Written text in a GA should be clear and easy to read, using one of the following fonts: Times, Arial, Courier, Helvetica, Ubuntu or Calibri.

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- **Abbreviations** should be defined in parentheses the first time they appear in the abstract, main text, and in figure or table captions and used consistently thereafter.
- **SI Units** (International System of Units) should be used. Imperial, US customary and other units should be converted to SI units whenever possible.
- **Accession numbers** of RNA, DNA and protein sequences used in the manuscript should be provided in the Materials and Methods section. Also see the section on **Deposition of Sequences and of Expression Data**.

- **Equations:** If you are using Word, please use either the Microsoft Equation Editor or the MathType add-on. Equations should be editable by the editorial office and not appear in a picture format.
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Front Matter

These sections should appear in all manuscript types

- **Title:** The title of your manuscript should be concise, specific and relevant. It should identify if the study reports (human or animal) trial data, or is a systematic review, meta-analysis or replication study. When gene or protein names are included, the abbreviated name rather than full name should be used.
- **Author List and Affiliations:** Authors' full first and last names must be provided. The initials of any middle names can be added. The PubMed/MEDLINE standard format is used for affiliations: complete address information including city, zip code, state/province, and country. At least one author should be designated as corresponding author, and his or her email address and other details should be included at the end of the affiliation section. Please read the **criteria to qualify for authorship**.
- **Abstract:** The abstract should be a total of about 200 words maximum. The abstract should be a single paragraph and should follow the style of structured

abstracts, but without headings: 1) Background: Place the question addressed in a broad context and highlight the purpose of the study; 2) Methods: Describe briefly the main methods or treatments applied. Include any relevant preregistration numbers, and species and strains of any animals used. 3) Results: Summarize the article's main findings; and 4) Conclusion: Indicate the main conclusions or interpretations. The abstract should be an objective representation of the article: it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

- **Keywords:** Three to ten pertinent keywords need to be added after the abstract. We recommend that the keywords are specific to the article, yet reasonably common within the subject discipline.

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- **Introduction:** The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance, including specific hypotheses being tested. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the workand highlight the main conclusions. Keep the introduction comprehensible to scientists working outside the topic of the paper.

- **Materials and Methods:** They should be described with sufficient detail to allow others to replicate and build on published results. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited. Give the name and version of any software used and make clear whether computer code used is available. Include any pre-registration codes.

- **Results:** Provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

- **Discussion:** Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible and limitations of the work highlighted. Future research directions may also be mentioned. This section may be combined with Results.

- **Conclusions:** This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

- **Patents:** This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Back Matter

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- **Funding:** All sources of funding of the study should be disclosed. Clearly indicate grants that you have received in support of your research work and if you received funds to cover publication costs. Note that some funders will not refund article processing charges (APC) if the funder and grant number are not clearly and correctly identified in the paper. Funding information can be entered separately into the submission system by the authors during submission of their manuscript. Such funding information, if available, will be deposited to FundRef if the manuscript is finally published. Please add: “This research received no external funding” or “This research was funded by [name of funder] grant number [xxx]” and “The APC was funded by [XXX]” in this section. Check carefully that the details given are accurate and use the standard spelling of funding agency names at https://search.crossref.org/funding, any errors may affect your future funding.

- **Acknowledgments:** In this section you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

- **Author Contributions:** Each author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND has approved the submitted version (and version substantially edited by journal staff that involves the author's contribution to the study); AND agrees to be personally accountable for the author's own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature. For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; Methodology, X.X.; Software, X.X.; Validation, X.X., Y.Y. and Z.Z.; Formal Analysis, X.X.; Investigation, X.X.; Resources, X.X.; Data Curation, X.X.; Writing – Original Draft Preparation, X.X.; Writing – Review & Editing, X.X.; Visualization, X.X.; Supervision, X.X.; Project Administration, X.X.; Funding Acquisition, Y.Y.", please turn to the **CRediT taxonomy** for the term explanation. For more background on CRediT, see **here**. "**Authorship must include and be limited to those who have contributed substantially to the work. Please read the section concerning the criteria to qualify for authorship carefully**".

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In the text, reference numbers should be placed in square brackets [ ], and placed before the punctuation; for example [1], [1–3] or [1,3]. For embedded citations in the text with pagination, use both parentheses and brackets to indicate the reference number and page numbers; for example [5] (p. 10). or [6] (pp. 101–105). The reference list should include the full title, as recommended by the ACS style guide. Style files for **Endnote** and **Zotero** are available.

References should be described as follows, depending on the type of work:

1. Journal Articles:1. Author 1, A.B.; Author 2, C.D. Title of the article. *Abbreviated Journal Name* **Year**, *Volume*, page range.
2. Books and Book Chapters:2. Author 1, A.; Author 2, B. *Book Title*, 3rd ed.; Publisher: Publisher Location, Country, Year; pp. 154–196.
3. Author 1, A.; Author 2, B. Title of the chapter. In *Book Title*, 2nd ed.; Editor 1, A., Editor 2, B., Eds.; Publisher: Publisher Location, Country, Year; Volume 3, pp. 154–196.

- Unpublished work, submitted work, personal communication:

4. Author 1, A.B.; Author 2, C. Title of Unpublished Work. status (unpublished; manuscript in preparation).
5. Author 1, A.B.; Author 2, C. Title of Unpublished Work. *Abbreviated Journal Name* stage of publication (under review; accepted; in press).
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- Conference Proceedings:

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- Thesis:

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9. Title of Site. Available online: URL (accessed on Day Month Year). Unlike published works, websites may change over time or disappear, so we encourage you create an archive of the cited website using a service such as **WebCite**. Archived websites should be cited using the link provided as follows:
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See the **Reference List and Citations Guide** for more detailed information.

Preparing Figures, Schemes and Tables

- File for Figures and Schemes must be provided during submission in a single zip archive and at a sufficiently high resolution (minimum 1000 pixels width/height, or a resolution of 300 dpi or higher). Common formats are accepted, however, TIFF, JPEG, EPS and PDF are preferred.

- *Sustainability* can publish multimedia files in articles or as supplementary materials. Please contact the editorial office for further information.

- All Figures, Schemes and Tables should be inserted into the main text close to their first citation and must be numbered following their number of appearance (Figure 1, Scheme I, Figure 2, Scheme II, Table 1, *etc.*).

- All Figures, Schemes and Tables should have a short explanatory title and caption.

- All table columns should have an explanatory heading. To facilitate the copy-editing of larger tables, smaller fonts may be used, but no less than 8 pt. in size. Authors should use the Table option of Microsoft Word to create tables.

- Authors are encouraged to prepare figures and schemes in color (RGB at 8-bit per channel). There is no additional cost for publishing full color graphics.

Supplementary Materials, Data Deposit and Software Source Code

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MDPI is committed to supporting open scientific exchange and enabling our authors to achieve best practices in sharing and archiving research data. We encourage all authors of articles published in MDPI journals to share their research data. Individual journal guidelines can be found at the journal ‘Instructions for Authors’ page. Data sharing policies concern the minimal dataset that supports the central findings of a published study. Generated data should be publicly available and cited in accordance with journal guidelines.

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- Data available in a publicly accessible repository The data presented in this study are openly available in [repository name e.g., FigShare] at [**doi**], reference number [reference number].

- Data available in a publicly accessible repository that does not issue DOIs Publicly available datasets were analyzed in this study. This data can be found here: [link/accession number].

- Data available on request due to restrictions eg privacy or ethicalThe data presented in this study are available on request from the corresponding author. The data are not publicly available due to [insert reason here].

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Data citation:

[dataset] Authors. Year. Dataset title; Data repository or archive; Version (if any); Persistent identifier (e.g., DOI).

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For work where novel computer code was developed, authors should release the code either by depositing in a recognized, public repository such as **GitHub** or uploading as supplementary information to the publication. The name, version, corporation and location information for all software used should be clearly indicated. Please include all the parameters used to run software/programs analyses.

Supplementary Material

Additional data and files can be uploaded as "Supplementary Files" during the manuscript submission process. The supplementary files will also be available to the referees as part of the peer-review process. Any file format is acceptable; however, we recommend that common, non-proprietary formats are used where possible.

References in Supplementary Files

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Restrictions on data availability should be noted during submission and in the manuscript. "Data not shown" should be avoided: authors are encouraged to publish all observations related to the submitted manuscript as Supplementary Material. "Unpublished data" intended for publication in a manuscript that is either planned, "in preparation" or "submitted" but not yet accepted, should be cited in the text and a reference should be added in the References section. "Personal Communication" should also be cited in the text and reference added in the References section. (see also the MDPI reference list and citations style guide).

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New sequence information must be deposited to the appropriate database prior to submission of the manuscript. Accession numbers provided by the database should be included in the submitted manuscript. Manuscripts will not be published until the accession number is provided.

- *New nucleic acid sequences* must be deposited in one of the following databases: **GenBank**, **EMBL**, or **DDBJ**. Sequences should be submitted to only one database.

- *New high throughput sequencing (HTS) datasets* (RNA-seq, ChIP-Seq, degradome analysis, …) must be deposited either in the **GEO database** or in the NCBI's **Sequence Read Archive (SRA)**.

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Research and Publication Ethics

Research Ethics

Research Involving Human Subjects

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- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Those who contributed to the work but do not qualify for authorship should be listed in the acknowledgments. More detailed guidance on authorship is given by the **International Council of Medical Journal Editors (ICMJE)**.

Any change to the author list should be approved by all authors including any who have been removed from the list. The corresponding author should act as a point of contact between the editor and the other authors and should keep co-authors informed and involve them in major decisions about the publication. We reserve the right to request confirmation that all authors meet the authorship conditions.

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Editorial Procedures and Peer-Review

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All submitted manuscripts received by the Editorial Office will be checked by a professional in-house *Managing Editor* to determine whether they are properly prepared and whether they follow the ethical policies of the journal, including those for human and animal experimentation. Manuscripts that do not fit the journal's ethics policy or do not meet the standards of the journal will be rejected before peer-review. Manuscripts that are not properly prepared will be returned to the authors for revision and resubmission. After these checks, the *Managing Editor* will consult the journals' *Editor-in-Chief* or *Associate Editors* to determine whether the manuscript fits the scope of the journal and whether it is scientifically sound. No judgment on the potential impact of the work will be made at this stage. Reject decisions at this stage will be verified by the *Editor-in-Chief*.

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VITA

Luísa Cardoso de Mello é brasileira, nascida em 31 de março de 1992, em Porto Alegre/RS, filha de Angela Maria Borba Cardoso e José Luis Kuczynski de Mello. Realizou o seu ensino fundamental na Escola Estadual Professor Leopoldo Tietbohl. Cursou o Ensino Médio no Colégio Estadual Florinda Tubino Sampaio.

Em 2013 ingressou no curso de Bacharelado em Ciências Biológicas, na Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) e, em 2014 no curso de Zootecnia na Universidade Federal do Rio Grande do Sul (UFRGS). Concluiu sua graduação em Ciência Biológicas em 2017 e iniciou em 2019 o Mestrado Acadêmico. Sob orientação do Prof. Dr. Paulo Cesar de Faccio Carvalho, sendo a área de concentração Relação Clima-Solo-Planta e Animal.