Country case studies on pathways for innovation for SAI in Brazil
Inception Report

AGROICONE
conhecimento para uma nova economia

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Sumário

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1. Introduction

This Inception Report is the initial guiding document for the study to be performed within the Brazilian context by the Agroicone team, aiming to produce practical and evidence-based lessons on factors that influence success in pathways for innovation for Sustainable Agriculture Intensification (SAI) to support innovation investors and managers.

The first section addresses the background of agricultural and innovation systems in Brazil and presents a brief history and description of agricultural research, institutional structures, and main challenges.

The second section deals with the scope of the study and the respective delimiting criteria of the cases of interest to be addressed. The third part presents a preliminary version of the methodological approach to be used. The final version of the scope and methodology will be defined in the next product, from the conclusion of the common analytical framework and final selection of the cases to be studied.

In the fourth section, we present a list of possible cases, with a brief description and relevance in relation to the delimiting criteria.

In the last section, we present a ranking of cases, considering data availability and fitting criteria to support their final selection.

2. Evolution of agricultural systems and innovation systems in Brazil

Over the past four decades, Brazilian agricultural production has grown rapidly, 3.22% on average per year. Between the 2006 and 2017 censuses, growth rate was close to 4.3%, higher than in the United States (1.9%), China (3.3%), Chile (3.1%) and Argentina (2.7%). From 1995 to 2017, the Gross Production Value doubled and, according to Vieira Filho et al. (2021[1]), technology was responsible for more than 60% of this growth.

Brazil has emerged from a net food importer to one of the biggest agriculture exporters in less than 30 years, feeding approximately 1.5 billion people worldwide. Currently, the agribusiness sector accounts for 26.6% of the national GDP (CEPEA-USP/CNA, 2021), 19% of the jobs offered (CEPEA-USP, 2021) and 48% of the country's exports (MAPA, 2021). Also, agricultural technologies have an important role in food security and rural development, and in the last two decades, prevalence of undernourished persons was reduced from 11.9% in 1999-2001 to less than 2,5% of the total population (FAO, 2021[2]). According to IBGE (2017), the country uses 223 million hectares for agriculture and livestock, 63 million hectares of which are for agricultural activities and 159 million hectares are for livestock. Such development was triggered by many factors, including strong governmental investments in research and interventions that fostered significant internal migrations, and credit for modern inputs, in addition to a friendly scenario for agricultural agro-industrialization through cooperatives and private sector participation. Innovation and development of agricultural research in Brazil are at the base of this process, which resulted in a significant

[1] Filho, J. E. R. V., Gasques, J. G., & Ronsom, S. (2021) Inovação e Expansão Agropecuária Brasileira. in: Filho, J. E. R. V., Gasques, J. G., (orgs.). Uma jornada pelos contrastes do Brasil: Cem anos do Censo Agropecuário, IPEA, p. 121-134.

[2] FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO. https://doi.org/10.4060/ca9692en
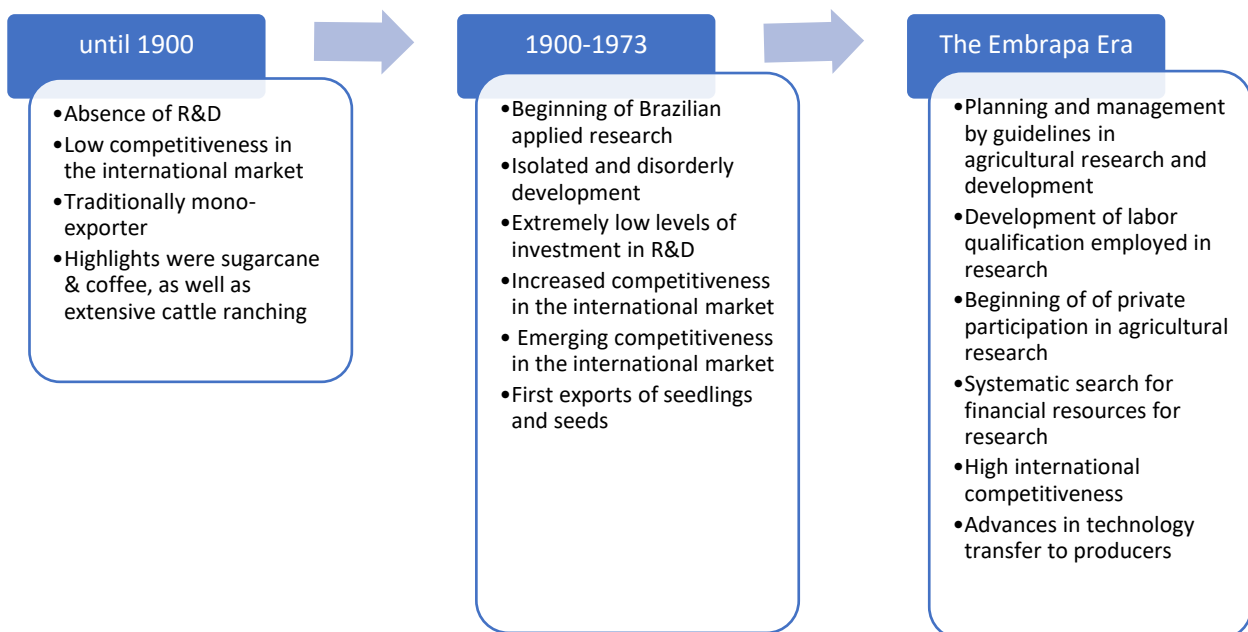
increase in agricultural production with a relatively smaller increase in the area used for agriculture and livestock, meaning growth in productivity in the country.

2.1. Development of agricultural Research in Brazil

Since colonial times, the agricultural sector has been a strategic one in Brazil. In the 1970s, there was an important change in agricultural systems, in addition to innovation that led to a modern and highly competitive agriculture in the following decades (the so-called "Green Revolution"). To a large extent, this pressure to modify the development model responded to the rapid industrialization process in Brazil between the 1960s and 1980s, which led to deep structural changes in the country. It set aside the focus on traditional agriculture based on extensive margin and continued expansion of land and moved towards a new agricultural model based on science, with intense use of technology (Martha Jr., 2015)[3].

According to Vieira Filho (2012[4]) the development of Brazilian agricultural research can be divided into three periods, based on the evolution of institutional infrastructure: (i) until 1900: a period characterized by absence of research and low competitiveness in Brazilian production; (ii) 1900-1973: the beginning of applied research, performed in a dispersed manner and with little articulation to a national project, focused on market interests and still with a low level of investment; (iii) 1973 to date: the creation of Embrapa marks the beginning of coordinated and planned applied agricultural research on a national scale.

Figure 1. Development phases of agricultural research in Brazil

until 1900
- Absence of R&D
- Low competitiveness in the international market
- Traditionally mono-exporter
- Highlights were sugarcane & coffee, as well as extensive cattle ranching

1900-1973
- Beginning of Brazilian applied research
- Isolated and disorderly development
- Extremely low levels of investment in R&D
- Increased competitiveness in the international market
- Emerging competitiveness in the international market
- First exports of seedlings and seeds

The Embrapa Era
- Planning and management by guidelines in agricultural research and development
- Development of labor qualification employed in research
- Beginning of of private participation in agricultural research
- Systematic search for financial resources for research
- High international competitiveness
- Advances in technology transfer to producers

Source: Instituto Inovação (2006[5]).

[3] Martha Jr, G. B. (2015). Pesquisa, desenvolvimento e inovação na agropecuária. *Revista de Política Agrícola*, *24*(2), 117-119.

[4] Vieira Filho. (2012)) Mudança tecnológica na agricultura: uma revisão crítica da literatura e o papel das economias de aprendizado. Revista de economia e sociologia rural, v. 50, n. 4, p. 717-738, out./dez. 2012.

[5] INSTITUTO INOVAÇÃO. Agronegócios: as oportunidades continuam. Radar inovação, Belo Horizonte, jun. 2006.

Agricultural research in Brazil began with the creation of state-level research centers and agriculture schools (universities), which led agricultural research in Brazil through the 1970´s. The Agronomic Institute of Campinas (IAC), founded in 1887, was one of the pioneering centers. Following its creation, other institutes were established, such as the Animal Science Institute (IZ) in 1905, the Agronomic Institute of Pernambuco (IPA) in 1935, the Rio Grande do Sul Rice Institute (IRGA) in 1940 the Agriculture Research Company of Minas Gerais (EPAMIG) in 1974. The leading universities in terms of research in this area are the University of São Paulo, through the Luiz de Queiroz College of Agriculture (ESALQ) founded in 1901, and the Federal University of Viçosa (UFV), which was established in 1927. In 1972, the Agronomic Institute of Paraná (IAPAR) was created and became one of the most respected agricultural research centers in Brazil. One year later, in 1973, Embrapa was created. It became the most important agricultural research institution in Brazil, with regional centers in almost all Brazilian states. Embrapa represented a very successful national agricultural research coordination vector, with soybeans being tropicalized in the 1980s and significant increases in the productivity of a number of agricultural products, fostering the technological development of tropical agriculture.

In 1992, the Brazilian government instituted the National Agriculture Research System (SNPA), formed by Embrapa, state centers and universities, and its main purpose is to work with farmers, organizations' value chains and civil society, as well as to support the development of public policies.

Currently, state research centers, as well as universities, are working in partnership with Embrapa on genetic improvement programs and other agriculture research and development projects. In addition, they focus on management practices or research niches, considering that Embrapa is leading the research on the country's most important crops and livestock. Currently, Embrapa has a 3.48 billion reais per year budget and a staff of 8,152, 2,244 of whom are researchers, 10.31% of which have a master's degree, and 88.91% are PhDs.

The National Agriculture Research System (SNPA) is formed by EMBRAPA, state centers and universities, and its main focus is to work with farmers, organizations' value chains and civil society, as well as to support the development of public policies (Figure 2). Research integration is supposed to occur through SNPA, which was formally established in 1992, however, its practical work is poor, according to Mendes (20096). One of the main vulnerabilities of the Innovation System lies in the articulation and interaction of the different agents that make up the basis of the science, technology and innovation productive structure.

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[6] MENDES, P. J. V. Organização da P&D agrícola no Brasil: evolução, experiências e perspectivas de um sistema de inovação para a agricultura. 2009. Tese (Doutorado) – Unicamp, Campinas, São Paulo, 2009.

Figure 2. National Agricultural Research System
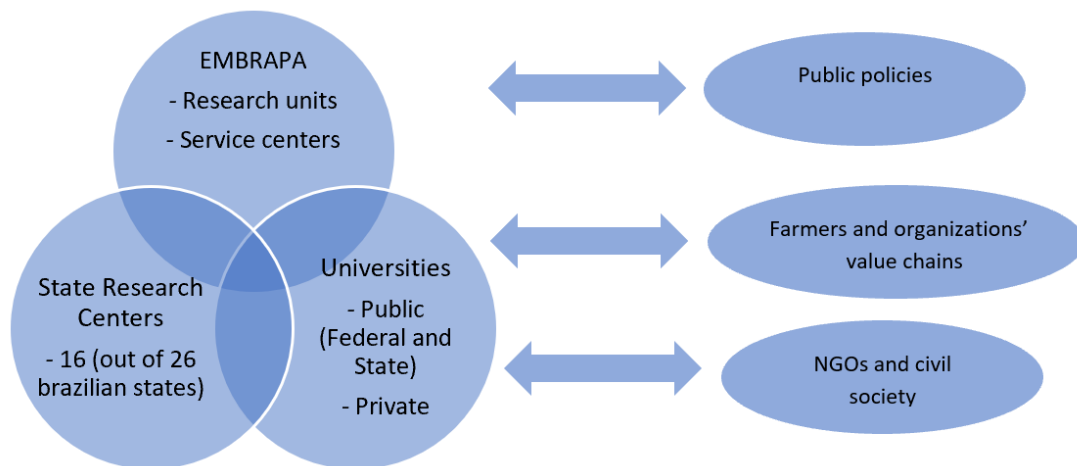
There is a low participation of the private sector in basic and managerial research, since the returns are not entirely appropriable. On the other hand, there is a lot of private participation in the machinery, chemical, crop and specific livestock sectors, where returns are subject to greater appropriability.

The current innovation system boosted the existence of a good inventory of available technologies for most staple crops, livestock and tropical agriculture in general. Developing and using several improved cultivars (with good agronomic characteristics, such as high yield, low production risk, and high nutritional value) for soybeans, corn, rice, beans, and cassava are essential for obtaining high yield and food security.

2.2. Agricultural Innovation Challenges in Brazil

Innovation in agriculture depends on an institutional framework that is capable of generating public knowledge and technological opportunities, as well as on the productive agents' capability to accumulate knowledge (Vieira Filho, 2014[7]). The greatest challenge continues to be accessing and adopting technology, which is the base of the innovation process and depends heavily on extension and technical assistance, as well as access to credit. It is much more indispensable for the small, poor and less educated farmers, who are the majority. From 1975 to 1990, Brazil had a national company for technical assistance and rural extension, which was called Brazilian Agricultural Technical Assistance Corporation (EMBRATER). Its goal was to facilitate implementing and adopting new technologies developed through research, and to provide technical assistance to farmers, supporting state extension services. After the extinction of EMBRATER, extension was passed on only to state governments, which work through EMATERs. Lack of support and fiscal crises in the states created a large gap in rural extension in some Brazilian states. The existence of a national body would therefore be necessary for equating efforts and coordinating actions across the country.

Farmer associations and NGOs have increasingly been taking on the governmental role of farmer assistance and have included goals in their agendas that go beyond yield improvement, such as environmental and social issues. The state-level extension agencies lack financial resources and there is no national-level organization to coordinate their efforts and actions. As can be seen in Table 1 below,

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[7] Vieira Filho, J. E. R. (2014). Políticas públicas de inovação no setor agropecuário: uma avaliação dos fundos setoriais. Revista brasileira de inovação, 13(1), 109-132.

0.5% of the farms in Brazil have access to technology and credit and produce more than half of the total gross agricultural production value (GPV). In contrast, 60% of the farms, which represent more than 3 million, produce around 3% of the agricultural GPV.

Table 1. Yield and Income Gap in Brazilian Agriculture

Income Classes (Thousand R$/year)	No. of Farms	% No. of Farms	GPV/year
Not declared	534,172	10.3	-
R$ 7,200	3,125,805	60.4	3.4
R$ 7,200 – R$ 36,000	1,012,038	19.6	10.2
R$ 36,000 – R$ 720,000	476,185	9.2	35.4
R$ 720,000	27,434	0.5	51.0
Total	5,175,636	100	100

Source: Brazilian Geography and Statistics Institute (IBGE)[8]. Prepared by: Eliseu Alves -EMBRAPA

There are different technology transfer models in agriculture, but in Brazil, generally, the model can be represented as a virtuous cycle where the key elements are research, extension and farmers (Figure 3).

Figure 3. Brazilian Technology Transfer Model in Agriculture
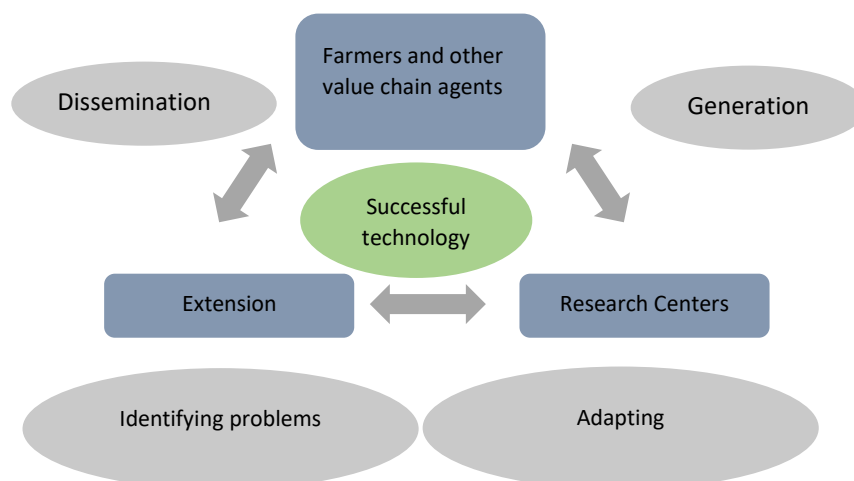
Technology development in agriculture production is deeply connected to market transformation, which goes beyond agriculture. Also, agriculture technologies and practices are always embedded in social institutions that must be considered for changing them. Therefore, articulation between technology transfer and strengthening the farmers' social organization is essential.

It is also important to emphasize the weight of the context of Brazilian social and economic inequality in the innovation process. According to Crestana and Silva (2006, p. ix), innovation in agriculture occurs "in

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[8] IBGE (2013). Brazilian Institute of Geography and Statistics. Available at www.ibge.gov.br/home/

a scenario where part of the country works with production relations that are still almost feudal, and other parts seek to build an information society from a classical industrial society with a still incomplete cycle". So, in addition to the productivity increase in Brazilian agriculture, small production scale has been facing difficulties in terms of insertion and economic viability. In Brazil, this has already been reflected in a 20% drop in the gross amount generated by family farming in 2006-2017 in the agricultural sector, concomitantly with the increase in production concentration (the small number of establishments that concentrate large areas and centralize production, mainly of agricultural commodities).

Furthermore, the advent of knowledge economy is intensifying the concentration trend. In the set of structural changes and socioeconomic processes experienced in converting an analogue world to a digital one, perhaps the main impact on the agricultural sector is linked to production scale. In a non-digital context, in many cases, small-scale has the competitive advantage of controlling and having full knowledge of the productive environment, which can be key to increasing productivity and efficiency. However, in the knowledge economy, the determining elements of efficiency are access to permanent innovation technologies and data processing capacity. The greater the data collection, storage and processing capacity, the greater the efficiency. That is, although the logic of economy of scale has been known for a long time, in a digital world, operating production processes gradually tend to be viable only in very large structures, concentrated in very few agents, accompanied by a trend for geographic segregation and production clustering. Thus, great inequality in productivity and income persists in the field, which, according to Alves et al (2016), can be attributed mainly to the fact that a portion of small and medium producers are not able to adopt available technologies, given the high cost of incorporating new technologies, market imperfections, and poor adequacy of public policies.

In addition, despite the transformations in recent decades that have enabled Brazil to change from an importer to an important food exporter, the levels of investment in research are still considered low in comparison with more developed countries. Finally, other no less important challenges for Brazilian agriculture's sustainability, which require investments in research, innovation and public policies, involve maintaining and increasing productivity in an environmentally sustainable way (nature friendly), that is, with soil conservation, ensuring the maintenance of the quality and availability of water resources and wildlife, reducing the use of agrichemicals, and controlling deforestation.

3. Scope

The scope of the study consists of six cases to be selected based on the criteria listed by CoSAI in the document *Invitation for expressions of interest for consultancy services to conduct a country case study on pathways for innovation for sustainable agriculture intensification: Brazil* and discussed collectively in the meetings during the project's Inception Phase. The criteria adopted for selecting the cases are:

> a. Cases of successful innovation at scale, from which lessons can be drawn.
> b. Time period: Lessons can be drawn from as far back as 20 years.
> c. At scale.
> d. Transformative and making progress towards at least one key SAI objective.
> e. Representing a variety of 'initiators',
> f. Representing a variety of innovations in policy, social institutions and finance as well as science and technology.
> g. Representation of a variety of interesting and important cases across the country (representation of small-scale agriculture, medium to large-scale agriculture, and urban and peri-urban agriculture and representation of important biomes/agroecological zones).

To ensure variety and representativeness of the situations analyzed according to CoSAI guidelines, in the six selected cases (short list), two cases of innovation aimed at small producers will be selected, as well as two cases involving medium and large producers, and two cases of urban and peri-urban agriculture.

Regarding the *At scale* criterion, it is noteworthy that, for meeting the other criteria and obtaining a broad variety of cases, it was not possible to adopt an absolute numerical reference. Therefore, the scale of each case must be evaluated considering the type of innovation and its representativeness within target audience or the value chain.

4. Methodological Approach

This section addresses some methodological components that will guide the case studies for obtaining practical lessons on implementing innovations for sustainable intensification of agriculture in the Brazilian context. The final detailing of the methodology will be the object of Product 2, from the conclusion of the collective construction of the common analytical framework.

The study will adopt an investigative approach to pathways of innovation in SAI, using a common analytical framework (under development) to test the following set of hypotheses that were reviewed and agreed to in the meetings with the teams (Brazil, Kenya and India) and CoSAI.

1. **To be successful, innovations must be 'bundled'**. (Policies, finance and institutional changes should be addressed at the same time as proposed technical changes, with a strategic analysis of constraints and lock-ins)
2. **Innovation must be a planned, inclusive process.** (bringing in all stakeholders from the start, with an agreement on collective shared responsibility).
3. **Innovation must be tailored to end users by involving them** in the design.
4. **Staff incentives in innovation organizations must be aligned with innovation goals** (This includes personal incentives for focus on outcomes and encouraging rapid iteration and learning from failure.)
5. **Personal leadership and networking are key elements of success**

The hypotheses will be test through a common set of questions about context, design and timeline, actors and their roles, activities, results and impacts to enable comparisons. The preliminary set of questions that can help in testing of the hypotheses are presented in Annex 1, however these are not exhaustive, and others can be added any time throughout the process.

The methodological approach will involve qualitative analyzes based on the Theory of Change framework, when possible, alongside with contribution analysis and process tracing tools (item 4.1) and the use of case studies (4.2), understand how change happened, producing a credible, evidence-based narrative of the innovation process rather than simply validating the Theory of Change.

The interviews made with key actors combined with document analysis will provide subsidies to test the initially established hypotheses.

4.1. Theory of Change, contribution analysis and process tracing

To make case studies of Brazilian experiences, the Theory of Change will be used as a methodology for preparing a map that structures and organizes how they work and points to recommended changes, facilitating their understanding and analysis. The logical model is made up of five components: inputs, processes, products, results and impacts - and displays a causal logic between them, explaining the mechanisms through which it aims to obtain the results and impacts indicated in the short, medium and long terms, as shown in Figure 4. This tool enables easy communication between stakeholders, consolidates a strategic assessment and relates its main impacts to activities related to the initiatives and their context. The theory of change will bring elements to understand the innovation process of different technologies, to test the selected hypotheses, and to draw lessons in pathways for innovation for SAI.

Figure 4. Theory of Change Approach

Inputs	Activities	Outputs	Outcomes	Impacts
Resources used to implementation: human resources, knowledge, skills, material and financial resoucres	The actions that are taken to carry out to implement the innovation	Direct effect of inputs and activities. Examples include: capacity building activities, training manuals, credit disbursed, inputs.	The intended and unintended effects of the outputs	Impacts refer to the long-term, sustainable changes in the livelihoods of farmers, the state of the environment and the conditions of rural poor, resulting from the spread or adoption of the innovations

As mentioned above, for a broad understanding of the problem being faced, the needs and the context of each experience, documental analyzes and interviews with key actors will be made, which will enable knowing and systematizing problems, objectives, activities, results and lessons learned from each innovation process. Each case study must be analyzed on a technically consistent basis, supported by proven social, political and economic assumptions, duly associated with the realities on which they were conducted, avoiding simplifications that could compromise conclusions.

In case there is no prior and adequately structured Theory of Change for the experience under analysis, its formulation will be based on a broad understanding of the problem and the reality on which it focused.

In order to produce a plausible, evidence-based narrative about the innovation process, contribution analysis and process tracing tools will be adapted to develop a theory of change showing how the innovation process might have come about, and establish whether, and how, a potential cause or causes influenced a specified change or set of changes (MAYNE, 2008[9]; OXFAM, 2011[10]; INTRAC, 2017[11]).

- Identify the assumptions underlying the theory of change;
- Consider other factors that may influence outcomes.

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[9] Mayne, J (2008). Contribution Analysis: An approach to exploring cause and effect. Brief 16, Institutional Learning and Change (ILAC) Initiative

[10] Oxfam (2011). Process Tracing: Draft protocol. Oxfam GB

[11] INTRAC 2017. Process tracing. Avaliable at: https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Process-tracing.pdf

- Consider alternative, competing explanations for the observed outcome(s) in question, until the explanation(s) most supported by the data remain (and determine which evidence support or question the alternative explanations).
- Determine how much the theory of change is contested;
- Gather the evidence to validate the theory of change in observed results, assumptions about the theory of change, and other influencing factors.
- Assess the links in the Theory of Change – if they are strong (good evidence available, strong logic, low risk, and/or wide acceptance) and which are weak (little evidence available, weak logic, high risk, and/or little agreement among stakeholders).

4.2. Case studies, triangulations and interactions

The case study is a methodological strategy that enables analyzing a chosen unit and not a population or a probabilistic sample of it, using it as an example for similar situations. In this study's case, what is expected is the formulation of objective lessons and practices from successful experiences in innovation for intensifying sustainable agriculture, where it is relevant to evaluate and/or describe the initiatives' contexts and design, as well as the results and impacts produced. Thus, case studies will be especially useful, as they will make it possible to apprehend the contours of certain situations and, through them, describe, understand and interpret the complexity of factors that conditioned the produced results, through an immersion in the delimited experience.

This methodology seeks to answer questions such as 'how?' and 'why?'. In it, the researchers will have no control over the events and situations under analysis, focusing on complex and contemporary environmental, economic and social phenomena inserted in the context of agriculture that shaped the case studies. For this purpose, it will make use of multiple sources of evidence, in the terms recommended by Yin (2004[12]), looking for each experience's causal links.

In these terms, as Yin (2004) points out, the case study will be understood as a methodological scientific investigation tool used for understanding successful experiences in complex situations, which is used as an example for similar situations. The methodology used will be guided by the Theory of Change (see item 4.1), which will be consolidated during the investigation, in cases where it will have to be built from the research findings.

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[12] YIN, Robert K. Estudo de Caso: planejamento e métodos. Tradução Daniel Grassi. 3ª ed.-Porto Alegre: Bookman. 2005.

A very common characteristic of case studies, according to Yin (2004), is that, in general, there are many more variables of interest to researchers than data provided in an objective and impartial way that can be used without bias prejudice in the analyzes. Likewise, the success of the investigation depends on the articulation of different sources of evidence, which need to converge, thus offering conditions to enhance the reliability and validity of the findings by triangulating and interacting information, data, evidence - even from different theories. The idea is to triangulate, articulate and interact different sources of information to extract lessons learned that are essential for the initiatives' success (Figure 5).
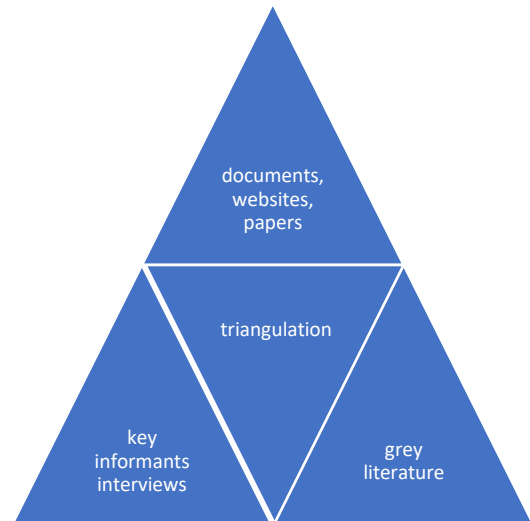

Figure 5. Triangulation of different information sources in building the Case Study.

Also, in order to ensure the reliability and validity of the findings the research team will critically examine their own role, potential bias and influence during formulation of the research questions, interviews and data collection. Preferably, the interviews questions should be open ended (as much as possible), clear and objective, formulated in different ways during the interviews (if necessary), and avoid words that could introduce bias. The answers should be investigated for additional information, evidence and examples when deemed necessary.

The work carried out based on these methodological steps of the Theory of Change and the Case Study will enable us to understand the assumptions on which the experience was based, its paths and developments for achieving the results, giving them tangible contours in order to meet the dimensions of interest recommended in this study's scope.

4.3. Limitations

Some limitations were previously identified and are listed below:

a) Diffuse innovations: In cases of diffuse innovation and widespread and gradual adoption, it is possible that the theory of change reflects the very technological progress of production systems, and not exactly the disruptions that are punctually associated with the researched innovations.
b) Programs and Projects with a pre-defined theory of change: The official theory of change developed by managers of a particular program or project (case study) can have the effect of directing the analysis of the cases, incurring an undesirable bias in exempt assessments.
c) Programs and Projects without a pre-defined theory of change: in these cases, the theory of change will be built ex-post and may not accurately reflect especially the main inputs of the case studies, making it difficult to analyze the activities' cause/effect relationship.
d) Although after an exhaustive survey and considering the team's experience in the context of Brazilian agriculture, relevant cases may have been disregarded due to lack of knowledge.
e) Some case studies are better documented than others, due to their nature, scale of coverage and elapsed time, and there could be a certain imbalance in deepening the analysis and in obtaining evidence that will establish cause/effect relationships.

f) Restrictions imposed by the Covid-19 pandemic may render field visits unfeasible and limit access to the audience benefitting from the projects.

4.4. Risks

g) Access to specific program data such as records, results, geolocation, schedules, budgets and others, is not previously secured and depends on requests whose results are not controllable by the deployment team. Similarly, access to the main actors (beneficiaries, decision makers, stakeholders) to be interviewed may also be limited by the counterpart. In both cases, the consequent risks are associated with loss in strength of the evidence, as well as in the breadth of the analyzes. To minimize this risk, the team will dedicate great effort in contacting, scheduling and conducting interviews in a virtual format, using their experience in conducting similar surveys.

h) Developing a common analysis methodology for three countries and different case studies is a challenge that requires a slow participatory process to mature and consolidate understanding. The kinetics of such a process can consume a large amount of time dedicated to the project and compromise the development of the operational part of the case studies and results analysis.

5. List of possible case studies (long list)

The long list of cases featured in Table 2 reflects the team's quest to meet the criteria defined by CoSAI (see item 3: Scope) and to provide a relevant number of possible alternatives for the subsequent choice of six case studies that would representatively reflect the innovation cases aimed at small, medium and large producers, as well as urban and peri-urban agriculture.

Table 2. Long list of case studies of innovation for sustainable intensification of agriculture in Brazil

CASES	CATEGORY	SCALE	INITIATOR	TYPE	BIOME
Full Bucket (Balde Cheio) Project	small scale and medium	In 2019, 1609 rural properties were served in 468 municipalities in 19 states	R&D institution	Innovation in agricultural extension advisory services and capacity building	all biomes
Integrated production system techniques - ILP (Integrated Livestock & Crops)	medium to large scale	9,5 Mha (2015/2016).	R&D institution	Investment in agricultural research and development	all biomes, except Semi-Arid
Associative formats in the sheep and goat farming chain	small-scale	<u>Goats</u>: 261,000 producers, equivalent to 80% of goat producers in Brazil <u>Sheep</u>: 362 thousand producers, equivalent to 71% of sheep producers in Brazil	farmers associations	Innovation in capacity building, institutions, agricultural extension advisory services and market strategy	Semi-Arid
One Land and Two Waters Program (Uma Terra e Duas Águas P1+2) – (Second Water Project – Cistern Program)	small-scale	By 2021, 104,000 water technologies for food production have been implemented	civil society, farmers associations and public sector	Innovation in agricultural and rural policy affecting production decisions including input and output markets	Semi-Arid
Brazil Without Extreme Poverty Plan	small-scale	National - 358 thousand families served by the Program for Stimulating Rural Productive Activities and the Technical Assistance & Rural Extension Program	public sector	Innovation in agricultural and rural policy, agricultural extension advisory services and capacity building	all
Armazém do Campo (MST) – urban agriculture	urban and peri-urban	20 producer cooperatives, currently there are 7 stores (São Paulo, Porto Alegre, Belo Horizonte, Rio de Janeiro, Recife, Caruaru and São Luís)	farmers associations	Innovation in market output strategy	Atlantic forest, Pampas
Rural credit cooperatives	small-scale, medium and large agriculture	In the 2020/2021 crop year, rural credit cooperatives turned over R$ 43 billion (20% of total rural credit) in 367 thousand contracts	producer associations	Innovation in financial instruments and approaches	all biomes
Multi-cropping (sequential cultivation and integrated production systems – Second Harvest)	medium to large scale	In 2017, 75 million tons of corn were produced in the second harvest, equivalent to 74% of corn production. 1.6 million corn farmers	Diffuse innovation	Investment in agricultural research and development and alternative approaches to technological innovation	Cerrado, Atlantic Forest
Food purchasing and control system for family farming in Paraná	urban, peri-urban and small-scale agriculture	In 2018, R$ 60 million were allocated for purchasing food to serve approximately 1.2 million students in more than 2,000 schools.	Public sector	Innovation in rural development policy and capacity building	Urban and Atlantic Forest
Connect the Dots Project (Projeto Ligue os Pontos)	urban and peri-urban agriculture	The project is being implemented since 2018, and operates in the rural south of SP, on 50 sq.km. of arable land.	Public-private partnership	Innovation in agricultural and rural policy, agricultural extension advisory services, and capacity building	Urban and peri-urban, Atlantic Forest
Cassava seed treatment - Mandi Plus	Small, medium, and large	the technology was developed, but has not yet been implemented or scaled up	public-private partnership	Investment in agricultural research and technological innovation	-

Agrosmart: Digital Platform for Climate Resilience and Sustainable Agriculture	Medium and large	Founded in 2014, the startup has today 4 thousand users covering an area of 800 thousand hectares. Recently Agrosmart acquired 100% of BoosterAgro, an Argentine startup that owns the main weather app focus on agribusiness in Latin America.	Private startup	Innovation in agricultural technology (decision support platform)	All biomes

5.1. Case studies - brief description

In this section we present a brief description of each possible case study and its relevance according to the criteria. We also included the case of the cassava seed treatment in the long list, as suggested by the CoSAI team.

5.1.1. Full Bucket (Balde Cheio) project

In Brazil, dairy farming is an activity with enormous capillarity in the territory and is practiced in more than one million establishments distributed across all biomes. In addition, the activity ensures income and is a resilience factor for a large number of small farmers. The Full Bucket (Balde Cheio) project is a successful case of technology transfer that advances dairy farming development. The project turns smallholder dairy farms into demonstration units, where the community learns sustainable techniques for increasing milk production. Its goal is to train extension workers and rural producers by fostering exchange of information on applied technologies on a regional basis, and monitoring social, economic and environmental impacts in production systems. The size of the assisted properties is mostly in the range of half a hectare to 50 hectares. Technology and good management enable family farmers to increase their income.

The program was created by Embrapa in 1998 and renewed in 2018 (Full Bucket Network) covering 70% of Brazilian states and serving more than 1,600 rural properties in 2019. The strategy's success can be attested to its scope and replication in other value chains. Technification and good management enabled family farmers to increase their income; obtain productivity gains; improve management of environmental impacts of production systems; and reduce rural migration.

5.1.2. Integrated production system techniques (Integrated Livestock and Crops)

Integrated agricultural systems have expanded by more than 10 Mha in the past decade and continue to expand. The Integrated Livestock and Crops (ILP - Crop-Livestock Integration) consists of plant and animal production in the same area, in consortium production, in succession or rotation, seeking synergistic effects among the agroecosystems' components, and its main objective is to intensify land use in a sustainable manner. The advantages of integrated livestock production include rationalizing the use of resources, the possibility of faster economic return, land optimization, and increased carbon inventory. In addition, the integrated system improves the soil with organic matter, water storage and improved soil cover quality for no-till.

5.1.3. Associative formats in the sheep and goat farming chain in the Semi-arid region

The sheep and goat production chain is strategic for increasing income and rural development in high social vulnerability areas with a strong presence of family farmers in Brazil. Currently, the number of sheep and goats in Brazil is mainly concentrated in the semi-arid region of the Northeast, a region marked by rural poverty, where 90% of establishments have less than 50 heads. In this context, two initiatives stand out: the producers' organization in Ascobetânia, in

Piauí State, and FrigBahia, an organization of cooperatives and rural family farmers that has a slaughterhouse that processes and sells special cuts of goats, sheep, swine and cattle, in addition to marketing other family farming products from partner cooperatives. These are two successful associative experiences as enablers of the chain and a factor of resilience for small producers in the semi-arid Northeast, overcoming the informality of the chain and the pulverized production with innovation in organizing supply and business management, advancing production intensification, access to markets, and income generation for small producers. These are consolidated and relevant experiences on a regional scale, from which several lessons can be learned – FrigBahia, for example, buys animals from producers within a radius of up to 500 kilometers and already accesses the national market.

5.1.4. One Land and Two Waters Program (Uma Terra e Duas Águas) – P1+2 (Second Water Project – Cistern Program)

The second water project (water for production) is an offshoot of the Cisterns Program and aims to manage water resources to enable agricultural production based on coexistence with the semi-arid region. Several technologies for capturing and storing water were disseminated and implemented (sidewalk and runoff cisterns, underground dams, stone tanks, trench barriers, roof cisterns). The program is being deployed since 2007 by Articulação do Semiárido Brasileiro (ASA), a network of civil society organizations that has been present in nine Brazilian states, and implemented 104 thousand water technologies for food production through May 2021. The technologies are primarily offered to families in poverty or social vulnerability situation in rural areas who are registered in the Cadastro Único. The project includes technical training actions in Water Management for Food Production and Simplified Water Management System for Production. In addition to technologies aimed at water management, families are provided with production kits for different production chains such as: Beef and Posture Poultry; Beekeeping; Beef sheep and goats and milk goats; Fruit and Horticulture. It is also a human resources training program that includes disseminating technologies and social mobilization for coexisting with the Brazilian semi-arid region, with relevant impacts on productivity increases for small producers, as well as strategies for adapting to climate conditions, and scarce resource (water) management.

5.1.5. Brazil Without Extreme Poverty plan

The Brasil sem Miséria plan, an innovative program for adopting a coordinated multidimensional strategy to fight extreme poverty, was launched in 2011 for removing 1.2 million people from extreme poverty (people who live on less than 70 reais a month). According to the 2010 Census, 25% of the rural population was in extreme poverty, with insufficient production, food insecurity, no access to electricity and precarious access to water. The Plan had three lines of action: ensuring income, urban and rural productive inclusion, and access to public services. Within the scope of the study for CoSAI, the focus would be given to actions aimed at rural productive inclusion. Standing out among the innovative strategies are the active search for families in extreme poverty and focusing its actions; intersectoral coordination, articulation between government agencies and programs at different scales, securing financial resources for structuring a family production system and a monitoring strategy. Approximately 358 thousand families benefited from rural productive inclusion actions: agricultural technicians performed

individual monitoring for preparing and implementing a production project, using non-reimbursable funds, distributing inputs and seeds, and facilitating sales to institutional markets.

5.1.6. Armazém do Campo (MST)

The Armazém do Campo initiative implemented by Brazil's Landless Workers Movement (MST) social movement, organized a short food supply chain in seven cities in Brazil, and is an example of success in the context of emerging quality food markets developed from re-establishing the relationship between growers and consumers (short supply food chain). The first store opened in 2016, to create a channel for selling organic and agro-ecological products from the Agrarian Reform, from landless settlements and cooperatives, and family farming. Armazém do Campo currently has seven stores and is also a political and cultural meeting point that seeks to bring the People's Agrarian Reform closer to the city's working class.

5.1.7. Rural credit cooperatives

Rural credit is an essential instrument for rural development and productive transformations. Credit cooperatives enable access to credit with increased capillarity compared to traditional financial institutions. In recent years, disbursements by rural credit cooperatives have doubled, exceeding R$ 27 billion in the 2018/19 cycle and surpassing the growth of other agents operating in this market. The growing importance given to the credit cooperative segment has attracted attention since 2003, when there was an official opening to cooperative credit implemented with two Central Bank of Brazil Resolutions. The farmers' growing economic organization process in credit cooperatives, mainly over the last decade, combined with the processes of improving cooperative management and expanding the availability of different types of financial services for diversified farmer profiles, are central elements that make this experience relevant for analysis, identifying lessons learned and systematization, aiming at its replicability, so that it could be possible to expand producers' access to rural credit, thus accelerating the modernization of production systems towards sustainability.

5.1.8. Multi-cropping (sequential cultivation and integrated production systems) (Second Harvest)

Multi-cropping is a land-saving strategy for dissociating agricultural production from deforestation in Brazil, in addition to increasing farmers' income. Multi-cropping can be defined as the practice of growing two or more crops simultaneously or sequentially in the same area and in the same year. The most common cases of multiple crops are sequential cultivation and integration of productive crops. The main crops that use sequential cultivation in Brazil are corn, peanuts, potatoes and beans. Sugarcane is usually integrated with soybeans or peanuts in the recovered areas, and corn is usually cultivated after soybeans in the same year/harvest season. Since 2012, second corn crop production has surpassed first crop production (IBGE, 2017). In the last 10 years, the total corn production in Brazil has doubled (a 96% increase) while the first corn crop area has decreased by 55% (from 9.2 to 4.1 Mha).

5.1.9. Food purchasing and control system for family farming in Paraná

Since 2009, the School Feeding Program - PNAE (Programa Nacional de Alimentação Escolar) establishes the allocation of at least 30% of the national fund for school meals to purchasing products from family farms and rural entrepreneur families or their organizations, prioritizing agrarian reform areas, traditional communities and *quilombos,* the communities of *quilombolas*, the descendants of runaway slaves during the Colonial Period. In Paraná, one of the main obstacles to making this policy viable was logistics for acquiring and delivering food to 1.2 million students enrolled in the state education system, according to the characteristics and factors that interfere in food production and distribution. The system developed in 2010 by the state's Education Secretariat together with Companhia de Tecnologia da Informação e Comunicação (Celepar) solved this bottleneck, organizing and classifying the cooperatives' proposals for food supply according to their production and distance to the schools. The technology also enabled the classification of organic producers, product seasonality and production by traditional communities, such as indigenous people and *quilombolas*. Since 2010, the electronic system has undergone several improvements and it is currently possible to search for information about each type of product offered in school meals across the state. In three years, the amount of food from family farming rose from 1,885 tons to 12,477 tons. The volume of organic food in the students' meals also increased from 9 tons to 2,537 tons.

5.1.10.   Connect the Dots Project (Projeto Ligue os Pontos – SP)

Ligue os Pontos is performed by the City of São Paulo for fostering sustainable development of the rural territory and improving its relations with the urban environment from the various different points involved in the Agriculture Chain. The innovative character of this proposal lies in facing the challenge of establishing a sustainable relationship between urban and rural areas, by strengthening the local agriculture's value chain using technology as a tool for integration and coordination between the initiatives and stakeholders associated with the chain - from the public sector and civil society - connecting the productive potential of the rural territory to the dynamics of the largest urban Brazilian economy, stimulating a consistent green economy, preventing arable areas from being taken over by urbanization and increasing the risk to the city's water security. The intervention, acting on a large scale (considering that urban sprawl threatens an area equivalent to 2.5 times the area of Manhattan) proves to be innovative in creating mechanisms that make local agriculture more profitable, encouraging farmers to stay on their land and even expand production. In addition, it fostered successful experiences in shared economy with technology, the success of open government practices, and the growing movement in favor of healthy eating and environmental preservation, establishing connections and synergies among the actions of public authorities and society's initiatives.

5.1.11.   Cassava seed treatment - Mandi Plus

Mandi Plus technology was developed by a public-private partnership between Syngenta Foundation and Embrapa. It involves coating the cassava seed part with a combination of

protectants and stimulants. According to Oliveira et al. (2020[13]) this technology enables producers to cut shorter seed stakes (8 centimeters), and thus significantly increase multiplication rates (up to 3) that enabled efficiency gains of 1 to 1.9 years compared to conventional five-year cycles. The technology is rather new, and its use has not yet been consolidated. Cassava is an important food security crop In Brazil and is mostly cultivated by smallholders' farmers in low-input and low-technology production systems. The development of the cassava technology is welcome, but it is important to be aligned with policies that ensure dissemination of innovations and consider any possible rebound effect of productivity increase in farmers' production scale, market concentration, and price depreciation due to increased supply.

5.1.12.   Agrosmart: digital Platform for Climate Resilience and Sustainable Agriculture

Agrosmart is a Brazilian startup founded in 2014, it offers a decision support platform that provide agronomic insights for the entire agribusiness supply chain with objective of helping farmers achieve a higher level of sustainability. The platform collects data from different sources, including soil sensors, drones, and satellite images to generate agronomic models based on the genetic material, soil type, and microclimate of each field. The data are sent to a digital platform where are analyzed by machine learning algorithms to make recommendations on everything from seed to be used to climate modeling. Agrosmart claims that its technology has helped farmers produce savings of up to 60% water and 20% energy. It has big-companies as clients, including Cargill, Syngenta, Coca-Cola, Corteva, Nestle, and AB InBev. In April 2021, Agrosmart acquired BoosterAgro, an Argentinian startup that has developed one of the most popular agrometeorological apps in the region. Following the acquisition, the companies now cover over 48 million hectares of farmland across nine countries.

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[13] Oliveira, E.J; Oliveira, S.A.S; Otto, C.; Alicai, T.; Freitas, J.P.X.; Cortes, D.F.M.; et al. (2020) A novel seed treatment-based multiplication approach for cassava planting material. PLoS ONE 15(3): e0229943. https://doi.org/10.1371/journal. pone.0229943

6. Short list of case studies

In this section, we present our choices for a short list of cases to be pursued in the Brazil's country study. The selection process considered the comments from CoSAI Secretariat and Oversight Group on the Inception's Report first version, the meetings discussions about the cases with the CoSAI and other country teams and also the recent pondering with the consultant Richard Kohl.

Following the recommendations, we include a new case to add more balance with a private sector initiative (Agrosmart), as in our first list there were a strong representation of public sector as well as civil society and NGOs initiatives.

We also took into consideration (i) the compliance with the CoSAI criteria; (ii) existence and ease of access to data and key actors and institutions – considering the restrictions imposed by the COVID-19 pandemic, which may the face-to-face surveys unfeasible in 2021 and (iii) the limited timeframe.

We suggest the following four cases:

1. Full Bucket (Balde Cheio) Project

2. Integrated production system techniques - ILP (Integrated Livestock & Crops)

3. One Land and Two Waters Program (Uma Terra e Duas Águas P1+2) – (Second Water Project – Cistern Program)

4. Agrosmart: Digital Platform for Climate Resilience and Sustainable Agriculture

All four cases sufficiently meet the key criteria, in terms of scale and representativeness (the initiative is financially sustainable and/or the project has reached a significant proportion of the potential market or need, in comparison to the size of the existing problem); promotion of a transformative change in at least one of CoSAI objectives; and encompass a diversity of innovations, initiators and scaling process:

- Different types of innovations: extension services strategies (Full Bucket); agricultural technology (iLP); technology for water management in the semiarid region in contexts of social vulnerability (P1+2); digital platform for decision support (Agrosmart system);
- Diverse initiators: public sector (P1+2, Full Bucket), private sector (Full Bucket, iLP, Agrosmart), civil society (P1+2. Full Bucket);
- Diverse beneficiaries: small (P1+2, Full Bucket), medium (Full Bucket, iLP and Agrosmart) and large farmer (iLP and Agrosmart)
- Diverse scaling process: commercial (Agrosmart); government projects/programs (P1+2 and Full Bucket); public, private and civil society partnership (Full Bucket, iLP);

The Table **3** systematizes more information about the four cases and the arguments for the relevance and adequacy to the study on pathways for innovation for SAI in Brazil.

Table 3. Shortlist of case studies

1. Full Bucket (Balde Cheio) Project					
Wow factor: this case is interesting because…	**Innovation package**	**Hypotheses**	**Sustainability**	**Numbers**	**Data availability**
It is a bottom-up organization of rural extension services (organization of producers, assignment of a technician for each family; demonstration units, multiplier units); Successful use of a family-owned dairy as a "practical classroom" for the purpose of recycling the knowledge of all the parties concerned. One of the main strategies of Full Bucket Program is the partnership between public institutions (technical assistance and rural extension agencies link to federal and state governments, university and research institutions) and private sector (cooperatives, associations, Sebrae, agricultural federations etc.)	The project's innovative methodology uses a family-owned dairy as a "practical classroom" for the purpose of recycling the knowledge of all the parties concerned: researchers, extension agents, and farmers	**CoSAI's** Innovation must be a planned, inclusive process. Innovation must be tailored to end users by involving them in the design. Networking is a key element of success **Others** Innovation in organizational processes tackles resource scarcity; The nature of the innovation itself (e.g. simple, easy to use, cost effective, requiring little change in behavior by farmers) was an important factor in the scaling up process.	There is no subsidy program. It is a partnership between public and private organizations	In 2019, 1609 rural properties were served in 468 municipalities in 19 states, 246 extension agents were trained, 293 demonstrative units were implemented. From 2014 until 2019, 9.558 rural properties served by the Full Bucket Program The state of Minas Gerais produces 27% of the milk in Brazil, the project is implemented in 225 municipalities. In 2019, participants produced 1.8 times the state production.	**Documents** The initiative is well documented (papers, impact evaluation, project reports). **Key informants/institutions** (Agroicone's team have access and contact with people in the organizations listed below) - MAPA - EMBRAPA - SEBRAE/SENAR - Local partners - Produtores

2. One Land and Two Waters Program (Uma Terra e Duas Águas P1+2) – (Second Water Project – Cistern Program)					
Wow factor: this case is interesting because…	**Innovation package**	**Hypotheses**	**Sustainability**	**Numbers**	**Data availability**
Application of low-cost irrigation technologies in agricultural areas that are cultivated during extended droughts for food production by small and vulnerable farmers	The P1+2 has a set of well-defined technologies. The application depends on the analysis of region condition, but the cistern-boardwalk is the flagship technology. Cistern-boardwalk, underground-dam, stone tank, popular water pump, "barreiro-trincheira", small dam, cistern-flood. Since it was launched in 2007 until March 2014, the P1+2 had already built 25,917 cisterns-boardwalk, 8,736 cisterns flood, 6,560 barreiro-trincheira, 1,053 underground-dams, 827 stone tanks, 1,813 small dams and 503 popular water pumps (ASA, 2014).	**CoSAI's** To be successful, innovations must be 'bundled'. Innovation must be a planned, inclusive process. Innovation must be tailored to end users by involving them in the design. Networking is a key element of success **Others** Collaborative institutional environment is a key factor to scale up low-cost solutions The development of local capacities is a key factor to the sustainability and scale up low-cost solutions	Although it had a government subsidy for implementation of technology, it has been supporting itself afterwards. The technology used is viable, accessible and low cost. It has been executed by the civil organization that integrate the Semi-Árido Articulation (ASA, in portuguese)	By 2021, 104,000 water technologies for food production have been implemented. There are 1.2 million smallholders' farms (with less than 50 hectares) in the semiarid region. (the average area of the participants is 25 hectares)	**Documents** The project is well documented (papers, evaluations, project reports, baseline report). **Key informants or institutions** (Agroicone' team has a good relationship and has developed other projects to MDS) - MDS - ASA - Local partners (NGOs and others) - producers

3. Integrated production system techniques - ILP (Integrated Livestock & Crops) and ILPF (Integrated Livestock, Crops and Forest

Wow factor: this case is interesting because...	Innovation package	Hypotheses	Sustainability	Numbers	Data availability
Integration of different productive systems (agricultural, livestock and forestry) within the same area. Increase of production and reduction of emission by product unit	The innovation is the integration of livestock crop system with no till system, with the inclusion of forages in the agricultural systems with competition control.	**CoSAI's** To be successful, innovations must be 'bundled'. **Others** The cost of technology transition is a barrier to scale sustainable innovations; Public policy and credit incentives are key factors in scaling up in technological transition; The environmental agenda generated important subsidies for the innovation scaling up process; The main drive of technological transition for the producers is economic.	There is no subsidy program, although it has public credit program to implement the technology. It is a sustainable business model It is a public-private partnership program	From 2005 until 2018, 15 Mha of integrated systems.	**Documents** The project is well documented (papers, assessments, reports). **Key informants or institutions** (Agroicone's team have a good relationship with the organizations) - Embrapa - Rede ILPF - Observatório ABC - Producers

4. Agrosmart: Digital Platform for Climate Resilience and Sustainable Agriculture

Wow factor: this case is interesting because…	Innovation package	Hypotheses	Sustainability	Numbers	Data availability
Digital monitoring solution that generates irrigation recommendations on when and how much to irrigate through the collection, control, monitoring and analysis of soil, plant and atmosphere data and agricultural operations.	Data collection through sensors installed in the field, which are analyzed to give solutions to support better decisions.	**CoSAI's** Staff incentives in innovation organizations must be aligned with innovation goals; Personal leadership and networking are key elements of success; **Others** Non-specific disruptive technologies (ag tech) are easily scalable.	A private technology developed and Implemented by Agrosmart	4 thousand users, 800 Mha monitored farms.	**Documents** There are little written data available online. We will ask for access to data in the in the interviews. The CEO is frequently **Key informants or institutions** (Agroicone's team have contact in Agrosmart, Raízen and Nestlé) - Agrosmart (CEO and team) - Big clients: Raízen and Nestlé - Producers - ESALQTec

ANNEX 1 - Country case studies: List of context questions to consider (preliminary version)

When
Construct a timeline of key events.
Include relevant context aspects (economic, political, social etc)

Where and who (target)
What was the geographic scope? How did this change over time?
How did the geographic location/scope affect the way the innovation package developed?
Did demand exist in advance, or was it developed? (How?)
Who were the intended users of the innovations?   Was there any disaggregation of users (e.g. by farming system/type, wealth, ethnicity, gender, age).
Was there a spillover(transbordamento) of target users/beneficiaries?
What were the innovation goals? Did the innovation aim to ensure established rights, meet basic needs or improve the productivity/profitability/quality of life beyond the basic (incremental)?

Who (involved)
List key players, characteristics and their roles through time.
Who initiated the innovation process, and what was their motivation?
What partners were brought in, why and how?
If different phases of the innovation were led by different groups, how did handover take place?
In the cases of institutional/organizational innovations without pre-defined geographic scope, what was the level of administrative management?
Include hypothesis questions: on individual leadership, coordination, capacities
Who financed the initiative?
Provide a detailed characterization of public or private roles and their scope of action.
Was there a leadership when the innovation process started? Was it essential to the success of the initiative?

How
(will partly depend on hypotheses tested)
How were intended users involved in the process? If so, through what mechanisms?
How were trade-offs addressed?   (a) between innovation objectives (e.g. social vs environmental) and (b) between interests of different actors.
What funding mechanisms were used? What phases were financed? How the financed phases were defined?
What business models were used?
How the innovation process was planned/designed? Has a Theory of Change been elaborated?
How the resources were controlled/monitored (e.g. transparency mechanisms)?

What: Outcomes and explanations
What changes took place?   in technology, policy/regulation, social institutions, financing?
What evidence is there on outcomes at scale?   Effects on different SAI objectives? (Environmental, social, human, productivity, profitability)
What were the costs and benefits?   (if any data exists)

Who were the winners and losers from innovation? What happened to different groups?   Any compensation or mitigation measures – who provided and how? Any spinoffs or unexpected benefits?

Was the innovation institutionalized through law or regulation?

Has the innovation been scaled up/appropriate by other actors/institutions/places?

What is the scale of results/impact in relation to the size of problem?

What were the leakages and spillover effects?

Lessons

Key success factors?

What factors helped or hindered involvement and uptake by different users/groups?

How were problems addressed?   What lessons can be learned for others?

Are there characteristics of innovation pathways that are likely to be more useful for specific types of innovations or users?

Key failure factors