

ADAPTA SERTÃO: IMPROVING SMALL FARMERS' ADAPTIVE CAPACITY IN SEMI-ARID BRAZIL THROUGH COMMUNITY BASED ADAPTATION (CBA)

Daniele Cesano (Adapta Sertão), Alexandre Maia (Universidade de Campinas), Jennifer Burney (University of California, San Diego), Igor César (Adapta Sertão), Thais Corral (Rede de Desenvolvimento Humano), Carlos Ravelo (consultant), José Luis Rueda (consultant).

Executive summary

The Brazilian semi-arid region, the Sertão, is the most populous semi-arid region of Latin America. Agriculture and pasture also represent the main source of income for about 15% of the population and an additional source of income for a much larger share of the population; however, farmers suffer from intensifying seasonal droughts, low yields and obsolete production practices. The Sertão of Bahia state, where the Adapta Sertão project is taking place, has experienced average temperature increases of about 2 °C while rainfall has decreased about 350 mm over a 50 years period, a 30% drop. Consequently, over the same time period, average milk productivity and staple food yields have also fallen sharply.

Adapta Sertão is a coalition of organizations helping small farmers in the Jacuipe Basin county, semi-arid region of Bahia state, Brazil, to making them more resilient in the face of a fast-changing climate. Adapta Sertão increases farmers' yields and productivity through access to micro-credit to buy productive technologies, organizing production and finding markets to sell their crops and aggregated value to products. The coalition has been able to do so through a Community Based Adaptation process (CBA). The latter, is a fairly new approach where communities are empowered to find their own adaptation solutions, without relying excessively on government interventions that may be too slow to address their quickly changing needs.

Through CBA, Adapta Sertão has been succeeding in identifying and overcoming key barriers through partnership building and diversified interventions to address the multiple needs of farmers. Adapta Sertão shows how climate change adaptive capacity in the semi-arid regions can be strengthened by changing farming methods and disseminating efficient and low-cost technologies. The most committed farmers have shown to increase productivity between 30% to 100% or more within a year. All this shows that climate change can be a common opportunity for improving obsolete practices and programs, and not only a common threat. Public policies promoting access to technology and finance, commercialization and technical assistance are still fragmented. By using partnerships and establishing links between these policies through local actions, a systematic approach to climate change adaptation can be achieved.

Context description - Socio-economic hardships in an increasingly dry area in Bahia state

The Brazilian semi-arid region (*sertão*) is Latin America's most densely populated semi-arid area of Latin America with approximately 900,000 km² and a population of 23 million people, 11 million of which are rural dwellers. Climate change studies point out that the likely medium- to long-term scenario for this region is increased rain variability and longer droughts, affecting river flow, water storage and irrigated production (Krol and Bronstert 2007; Silva et al. 2010) with a high possibility of substantial reduction in surface water availability (Montenegro and

Ragab, 2012) and increasing environmental dryness (Rodrigues da Silva 2004). This scenario is also backed up by more general scientific reviews such as IPCC (2014). Marengo (2008) suggest that this region had a water deficit in at least 60% of the time between 1970-1990. According to the same author, the maximum temperature in this region has increased by 1.5 to 2 ° C in 41 years. The local bioma Caatinga has decreased its land coverage over the past 50 years of about 65%-70% on average, contributing with a local climate change component (Burney et al, 2014). The study analysed the specific case of the Jacuípe Basin in the semi-arid region of the state of Bahia, where the Adapta Sertão project is taking place, and pointed out that between 1962 and 2011, the annual average of the minimum and maximum temperatures increased by approximately 2° C. In the same period, the average precipitation fell between 300 and 450 mm, which corresponds to a 30% reduction. These data have been supported by a recent analysis by Maia et al (2015) that analysed climate trend in the Jacuipe basin and in the semi-arid region of Bahia.

The implications for agricultural production can be fairly dramatic. Silva et al. (2010) estimated that, in an optimistic scenario, the loss of milk production in Bahia state can get up to 3.5 liters/day of milk during the colder months, and up to 5.25 liters /day of milk in the warmer months. In the pessimistic scenario, the loss may reach 7.0 liters /day in the warmer months and up to 5.25 liters /day in the colder months.

Burney et al. (2014) analysed the specific case of milk production in the Jacuípe Basin and found associations between annual changes in rainfall, temperature and milk productivity. In extreme cases, such as the drought in 1993, half of the cattle died and milk production fell 75%. Burney et al (2014) have also shown that milk productivity measured in litres/cow/day has been stagnant during the period 1974-2012 in the Jacuipe Basin, while in the Bahia state as a whole that includes also the Atlantic Forest and Savanna, milk productivity has increased about 40% in the same period.

All this indicates that climate change will aggravate a variety of existing problems such as food security, human health, economic underdevelopment and migration to urban areas. In semi-arid Brazil, farmers' vulnerability to climate change depends on a variety of factors, including the continuance of traditional, under-productive farming methods and inefficient use of scarce water resources. Top-down 'solutions' offered by the national government do not reflect these wide-ranging vulnerabilities and are often fragmented, focusing on just one challenge while leaving the rest unaddressed. They also often fail to engage with actors from various sectors. However, if properly developed and introduced, resilience strategies such as Adapta Sertão, can become a game changer and a business opportunity.

Case description - Adapta Sertão: a comprehensive strategy to improve family farmers' adaptive capacity

In year 2006, the NGO REDEH, in partnership with 6 local cooperatives and one local NGO, Rede Pintadas, created the Adapta Sertão coalition to identify possible adaptation strategies for semi-arid Brazil and go on to implement and disseminate them. The first step was to analyse and identify the technical and socio-economical barriers that prevented farmers from improving their production practices. The Adapta Sertao partners then began working together to understand which technologies, crops, cultures and production methods would be most appropriate for the local socio-economic and environmental conditions. The consultation

process went hand-in-hand with a period of testing of selected technologies in partnership with local farmers and technical assistance programs and funded by national and international research funds, foundation and development programs. Results were evaluated by the stakeholders to identify and select the most promising and adequate strategies and technologies based on their potential to be scaled-up and reach the largest number of farmers.

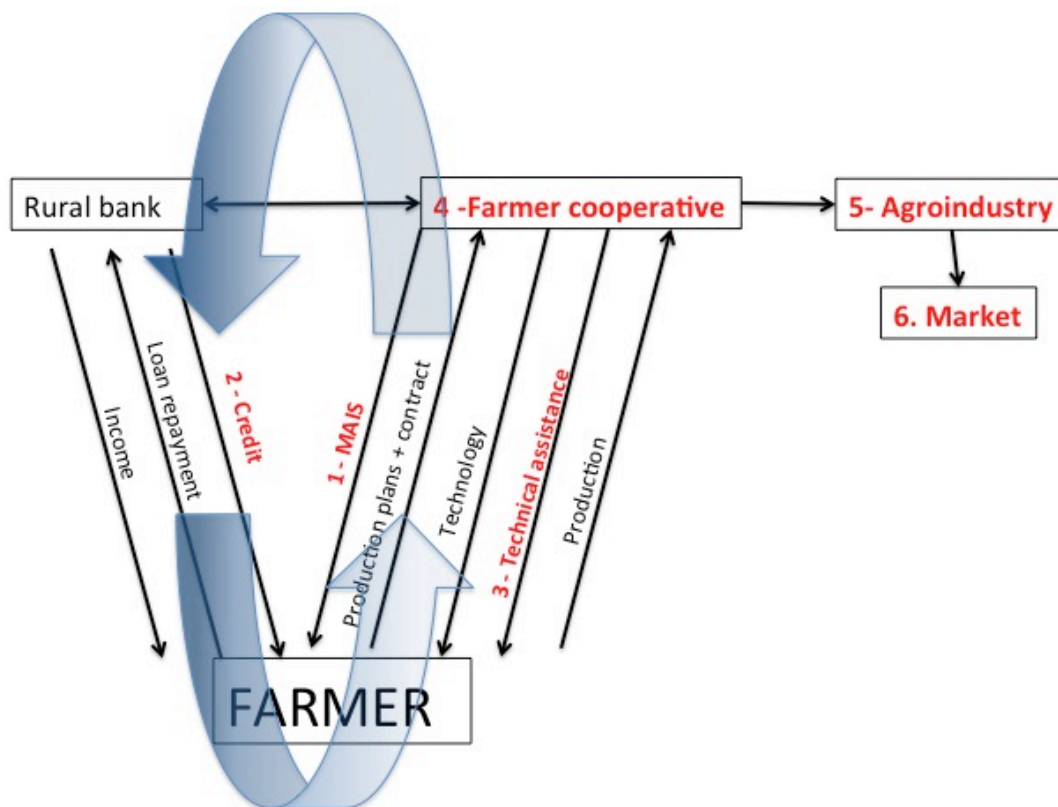


Figure 1 – The integration of the 8 pillars of the Adapta Sertão CBA strategy. Principles 7 (R&D) and 8 (public policy) are outside the value chain but are structuring actions to ensure its climate resilience and sustainability. In this system, the same amount of money is lent to the community indefinitely, creating more value and an economy that is based on climate resilience. Picture: Daniele Cesano

Based on this learning, Adapta Sertao developed gradually a Collaborative Development Framework for Appropriate CBA (Community Based Adaptation) Responses. The flow-diagram of *Figure 1* shows the links between the different stakeholders involved in the Adapta Sertão coalition that functions by creating a cycle of transferring from one stakeholder to another money, technology, products and knowledge. The flow works as follows. The farmers' cooperative identify the most suitable and committed farmers who start receiving technical assistance and training on a Climate Smart Agricultural Production system developed by the Adapta Sertão coalition called MAIS. Once farmers agree on production plans and supply contracts, the cooperatives indicate these farmers to the local rural bank to receive a loan to finance the MAIS system. The cooperatives can also sell technology to these farmers through specific partnerships with technology providers, *Figure 3*. Because of the MAIS, farmers' production is less susceptible to climate shocks and manage to supply more constant volumes of products to the cooperatives that then process them in small agro-industries and sell them to local, regional and institutional markets. Farmers are then able to pay back their

loan more easily and make a living exclusively on what they produce. Research programs help developing and systematizing the knowledge and improve the whole process. Dialogues with policy makers help creating a better framework for sustaining and disseminating the model. Adapta Sertão coalition is showing that climate change is not only a common threat but also a common opportunity for developing new business and improving existing programs.

The approach herein described here works around 8 pillars to sustain a proper CBA. These pillars and the partnership structure is shown in *Figures 1 and 2* and explained briefly below. It is important to mention that the incubation of the partnership is funded by the Interamerican Development Bank/Multilateral Investment Fund, through its “Proadapt” adaptation fund:

1. *Production system MAIS.* The climate smart agricultural system MAIS has been developed by the Adapta Sertao coalition, specifically for milk, goats, vegetables and fruits based on over 20 strategies and technologies, including land reclamation, to guarantee animal feed and water security for at least 3 very dry years. As result, MAIS milk, MAIS goats, MAIS vegetables amid climate change.
2. *Access to specific credit lines to finance the MAIS.* Generally the MAIS requires between R\$ 15k-35k (USD\$ 4k-15k) in investment. Adapta Sertao is negotiating a specific credit line with the two largest Brazilian lenders: Banco do Brasil and Banco do Nordeste.
3. *Technical assistance to ensure the correct implementation of the MAIS.* The Bahia technical assistance programs SENAR and CAR played a pivotal role. Adapta Sertao and SENAR’ technicians train farmers on how to implement the MAIS system correctly using the financial resources they have available.
4. *Strengthening cooperative as a measure to strengthening the farmers’ organization.* Strong and organized cooperatives are of fundamental importance to engage farmers and ease access to market.
5. *Industrialization of food through small processing units to add production value, diversify revenues and increase the life span of the products.* Small scale and functional processing units is key to aggregate value to the farmers’ products. In Brazil, CAR and BNDES play a big role and are entering the partnership now.
6. *Strengthening of the marketing and commercialization process to ensure the sale of products.* Access to market is a necessary step to guarantee a continuous flow of product.
7. *Scientific research to improve those components that are still lacking clear answers.* Research and development is an essential step to develop a whole value chain that is truly climate resilient, by analyzing and improving all of the 6 principles described above. The research is carried out by the University of Bahia, Federal Univesity of Rio de Janeiro/Centro Clima, Embrapa Semiarido, University of Sao Paolo/ESALq, University of Campinas, University of California San Diego/IR-PS
8. *Policy dialogue with government agencies to develop public policies that meet the needs of climate resilience.* Engagement with public policy institutions at local, state and federal levels is a necessary action to ensure that the proposed actions can be sustained through specific policies. The dialogue has been going on with the Brazilian Ministry of the Environment and the Secretary of Agriculture of Bahia state and local municipalities.

The partnership

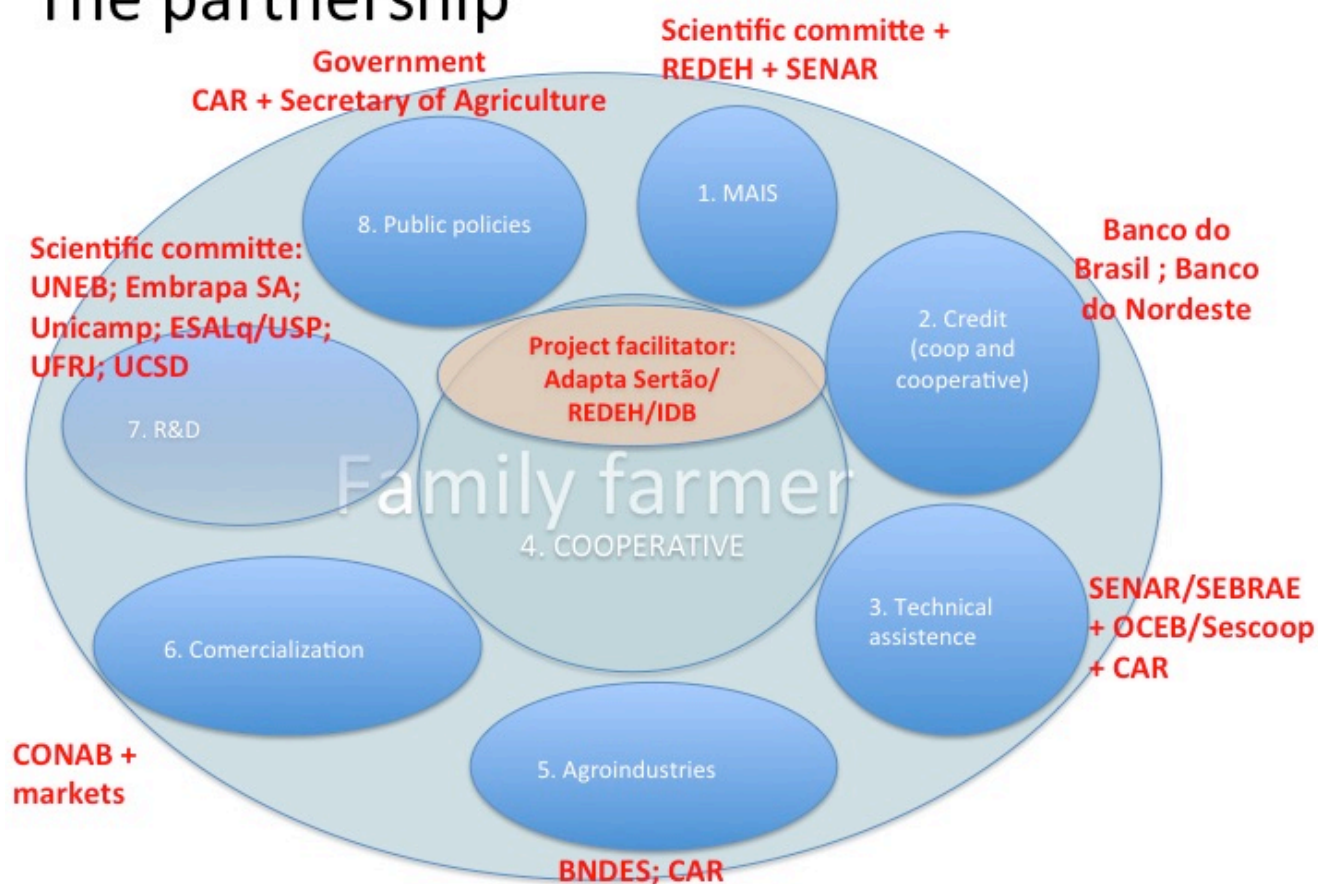


Figure 2 – The Adapta Sertão partnership. This picture shows the 8 Adapta Sertão CBA pillars in relation to the partners that are composing each pillar. The incubation of the partnership is funded by the Interamerican Development Bank/Multilateral Investment Fund, through its “Proadapt” adaptation fund. Picture: Daniele Cesano

Resultas and impacts

The first two results about Adapta Sertão have already been published in the peer-review paper of Burney et al (2014). The additional results have not been yet published.

Use of drip irrigation to sustain production

Constant sources of freshwater in semi-arid regions are scarce. Lack of reliable water access precludes its use. Therefore, irrigation is only a moderately effective adaptation strategy. By studying several farmers that relied on ephemeral water sources, Adapta Sertão found out that irrigation may not be economically viable during drier periods. However, if access to a stable water supply is secured, the data from Adapta Sertão’s irrigation projects show that this technology is very promising. The median net profit to date for all eight farmers surveyed was R\$ 1,361. The average system size was about 3,000 m², used to grow vegetables and corn, with an average investment around R\$ 3,500. Assuming variable costs remain similar, after payback of the initial capital investment, the median annual profit was over R\$ 3,300. The Net Present Value (NPV) of all of the systems (10 %, 5 years) was positive (median = R\$ 8,403),

and all systems had an Internal Rate of Return (IRR) over 10 %. However, it is important to mention that only a fraction of family farmers (<3%) have access to a stable source of freshwater suitable for irrigation. This result also showed the business opportunities that climate change can provide.

Balanced animal feed

Adapta Sertão has tested different animal feed with several farmers. Overall, these results heavily support the use of balanced and proper feeding practices, since they had profound impacts on productivity and profit. With proper balanced feed, at the end of one month, milk productivity increased, on average, by 52%. Net income from milk production also rose dramatically (49% average). The data for the lamb meat experiment showed that while pastured lambs typically gain less than 1 kg/month, at the end of 45 days farmers with lambs under the experiment had gained an average of 2.8 kgs of muscle mass (meat). The two farmers earned a net profit per animal between R\$ 129 and R\$ 148. This means that by supplying a balanced animal diet, farmers can decrease the number of animals while increasing their profits. This has huge implications for climate resilience because it saves feed that can last longer in periods of prolonged drought.

Physical water storage versus biophysical water storage: the case of palma forrageira

Adapta Sertão researched 60 farmers that constructed a 52 cubic meter rainwater collection tank to store water and use it to grow vegetables and 60 farmers that invested in one hectare of palma forrageira, *Figure 4*, a peculiar type of cactus which is an important animal feed that can store up to 80% of water. Palma forrageira can represent up to 70% of animal daily nutrition and 50% of the animal water intake. The cost of the two systems is very similar (around R\$ 9,000). The comparison was made to understand which system can generate more income for farmers and a better climate resilient strategy. The research showed that 1 Ha of palma costs on average R\$ 9,732 and generated a profit of R\$ 2,014 per year in milk, while the water cistern had an average net profit to the farmer of R\$ 789. In addition to this, palma forrageira can store up to 300 m³ of water per year in a biophysical form. The average cost of water was R\$ 100 per cubic meter in the case of palma and R\$ 190 in the case of the water cistern. This shows that palma forrageira can be a much better option for some farmers as it can also reduce the daily water consumption of cows. The description and result of the experiment are summarized in the video: <https://www.youtube.com/watch?v=04czm50dsy8>.

Use of small-scale technologies and mechanical equipment

Climate change is opening a wide window of (business) opportunities for developing efficient technologies and mechanisms for their dissemination over a large scale. Climate resilience requires a huge increase in farming efficiency, especially in the case of animal breeding. Farmers need to increase the speed in which they grow animal feed during the wet season or good rainy years, store additional feed and use it during the dry period or bad rainy years. If farmers use manual work and rudimental tools, they will be very limited in their actions. The use of small scale tractors, mechanical harvesters, mechanical milkers and feed cutters are very important tools to increase the efficiency of the production process of farmers, *Figure 5*. Adapta Sertão has estimated that a farmer with 6 cows spent about 4 hours per day to supply his animals with feed because of all the manual cutting he has to do. If he/she has a

mechanical harvester and a mechanical feeder, this time goes down to about 15 minutes per day.

The MAIS production system

All of this gained knowledge plus several other additional experiments brought the Adapta Sertão coalition to develop over time the MAIS production system that has already been described above and in *Figure 6*. The MAIS focus on milk, lamb and vegetable production, depending on the farmers' interests, and is formed by about 20 different technologies, innovations, equipment and strategies that when implemented correctly, they greatly improve the efficiency of farming practices and improve the farmer's climate resilience. The MAIS has been implemented in 100 pilot farms and currently there are 364 on-going MAIS projects in different development stages, aiming to reach 800 MAIS farms by 2018. The MAIS, properly implemented, can ensure a minimum of 2 minimum wages (R\$ 1,850/month) per farmer per month, which is double the amount people earn on average in the region. The Adapta Sertão coalition is aware that animal husbandry is the primary economic activity of millions of farmers in the region and the MAIS system has a strong land restoration and forestry-pasture integration component to try to revert this trend. The key results of the MAIS are:

- Milk production can increase at least 30% in each cow. Milk producers starting with 50 liters a day can reach more than 150 liters/day in about 1 year.
- Lamb breeding ensures a net income of R\$ 1,850 per month when the farmer manages to breed about 320 lambs/month.
- An area of fruits and vegetables of 3,000 m² can make farmers earn about R\$ 1,850/month if properly managed.

Obstacles and challenges

Environmental challenge

- Climate variability and lack of water. The data analyzed by the coalition shows a decreasing trend in precipitation has been surprisingly fast in the region. Climate resilience is built during average and good rainy years. The MAIS shall be fully implemented during 5 average rainy years but farmers could take more time due to the increasing climate variability and heavier droughts. Yet, implementing MAIS will provide better profitability.

Socioeconomic challenges

- Access to credit. The credit system for farmers in Brazil is very bureaucratic and has strict requirements, which limits farmers' access to the MAIS. Adapta Sertão is creating a specific credit line for the MAIS coupled with technical training and assistance by engaging Banco do Brasil, Banco do Nordeste and SENAR (Bahia leading technical assistance program) in the partnership.
- Poverty and illiteracy. Semi-arid Brazil is still a poor area with a low literacy level and poor infrastructures. This represents a challenge at all levels of the implementation of the Adapta Sertão strategy. Some farmers find it difficult to absorb all the new practical knowledge of the MAIS, especially the least literate. This is why the MAIS is implemented through steps and over up to 5 years through a specific technical training program.

- Expensive working capital for the cooperatives. There is no official government credit line that supports access to credit to the cooperatives that rely on commercial interest rates that are at about 25% per year. This undermines the viability of most of the farmers' businesses. Multilateral institutions and national or international development banks can play a role in creating a farmer credit mechanism are currently being engaged (BNDES).

Institutional challenge

- Existing government programs. Government programs have been in place for several years and are managed by officers who may have a very different view and in keeping business as usual.. Lack of dynamism, bureaucracy, and trickery represent the biggest barriers for change. Multilateral development agencies can play a very crucial and important role, as they can force change to happen by negotiating funding for new programs only if specific conditions are met based on clear rules, ethical principles, innovations, transparency and accountability.

Technical challenge

- Access to technology. Farmers need to buy some of the MAIS technologies through specialized retail stores that are inexistent in the region. Adapta Sertão has created a specialized retail store in one of the farmer's cooperatives in partnership with technology providers to supply farmers with specific technology, *Figure 3*.
- Poorly qualified field technicians. The technical assistance programs managed by the state usually do not have budgets to hire qualified field technicians. The result is that technical assistance programs managed by the state are very obsolete and lack the fundamental basis to provide farmers with specific knowledge. Adapta Sertão through its partners has trained the field technicians on all the aspects that are necessary for a correct implementation of the MAIS.



Figure 3 – The Adapta Sertão retail store. The specialized retail store has been created in the municipality of Pintadas and is affiliated to the Coopsertão cooperative. The store sells all MAIS technologies and operates in partnership with leading providers of small-scale machineries, irrigation technologies, seeds and other equipment. Pictures: Daniele Cesano

For its results, the Adapta Sertão coalition has already been recognized by the United Nations SEED Award (2008), the Award Celso Furtado of Territorial Development (2013) and the Mandacaru Award by the Environmental Institute of Sustainable Brazil (2013). In 2014, Adapta Sertao was one of 30 projects selected by the Millennium Development Goal Award (MDGs) coordinated by the Secretary General of the Brazilian Presidency, in partnership with the United Nations Development Programme (UNDP) and the National Movement for Citizenship and Solidarity. In 2015, it was one of the finalists for the Equator Prize of the United Nations Development Program.

Replicability and lessons learnt

Important steps for replicability:

1. Climate resilience, if properly framed, can be a common business opportunity to develop and disseminate new technologies and to restructure obsolete programs. Adapta Sertão shows that climate change is no longer a threat.
2. *Awareness raising on climate change impacts.* Our climate change analysis and related impacts clearly showed most stakeholders the threat that climate change was posing to small farmers' agricultural value chains. Studies were carried out by research institutions that partnered with the project. Then, raising awareness on climate change impacts among key stakeholders was the first step for building a strong coalition with a unified vision.
3. *Have a clear vision with a sustainability strategy, i.e. the 8 pillars.* The main objective of Adapta Sertão has always been to bring long-lasting and institutionalized changes. The identification of the strategy based on the 8 pillars took time and effort to develop. The analysis through multi-stakeholder dialogues to understand how to ensure and sustain change over a long timeframe was critical in this respect.
4. *Creation of a specialized retail store for the MAIS technologies.* The MAIS is based on the use of a set of consolidated technologies, but that are not available locally. Farmers would need to travel 100-150 miles to purchase them. Adapta Sertão has created a specialized retail store in partnership with main national technology providers to allow farmers' access to such innovations (*Figures 3, 4, 5, and 6.*). This becomes additional revenue streams to the cooperatives, but it also requires specific training and capacity building.
5. *Multi-stakeholder planning.* It is necessary to plan, through several meetings, all actions together with all direct beneficiaries, i.e. farmers' cooperatives, to ensure that goals and milestones are met and define activities and responsibilities. . *The engagement of different stakeholders over a 10 year process has been the key to develop a "single-minded" view on the key actions that should be developed and implemented.*
6. *Defining criteria for inclusion of cooperatives and additional stakeholders in the process.* It was necessary to define clear criteria to ensure the participation of cooperatives (direct beneficiaries) to ensure they have at least a minimum level of business management skills and coordination capacity. Cooperatives with little capacity and transparency can undermine the process.
7. *Credit and working capital.* Access to finance for farmers and cooperatives is key for implementing MAIS. Best if at preferred rates. Loans to cooperatives should include

working capital to buy the farmers' production and production inputs. Farmers' credit in Brazil has been subsidized for several decades now. However, working capital interest rates in Brazil are historically very high. Few initiatives help cooperatives access working capital with affordable terms. Banks and international financial institutions could develop an access to finance program to provide loans to these cooperatives.



Figure 4 – Palma forrageira is a very peculiar type of cactus that stores 80% water and can be used as animal feed. It can represent up to 70% of the nutritional value of the animal diet. Because of its high water content, animal water consumption is reduced by half, from 100 liters/day to 40 liters/day. Palma forrageira is a very smart way to store water in a biophysical form. It grows very fast and has a productivity of 300 tons/hectare/year, which is 10 times more than average grass. Pictures: Igor César



Figure 5 – Examples of a small-scale equipment used in the MAIS system. On the left side, a diesel powered mechanical feeder. The feeder cuts palma forrageira for 6 large animals in about 15 minutes while the hand cutting requires more than 2 hours of manual work per day. On the right side, we can see a micro tractor and on the back the cage of a mechanical harvesters. These are all equipment that makes farmers more independent and efficient. Resilience requires increasing farming's efficiency almost exponentially to be able to produce more and store as much feed as possible during the good wet season and years and that can be used during the dry periods. These equipment cost between R\$ 700 for the mechanical harvester to over R\$ 5000 for the micro tractor. Picture: Igor César.

MAIS

Modulo Agroclimático Inteligente e Sustentável (Sustainable Smart Agro-climatic Module)

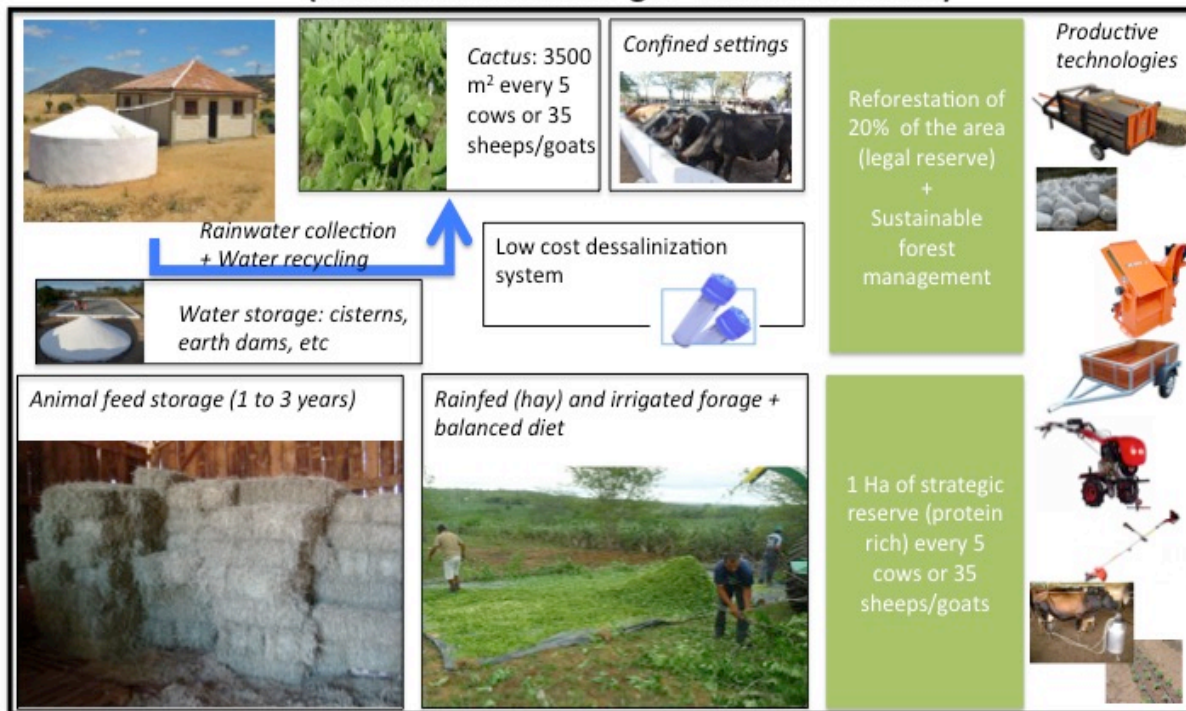


Figure 6 – A sketch of the MAIS production system in the property and some of its main strategies and technologies. Picture: Daniele Cesano

Scaling up: the necessary steps

A summary of the project results is provided in *Table 1*, while *Table 2* shows a brief history of the project and support. The following section summarizes how the coalition could take a regional dimension.

The one approach to scale up the climate resilience strategy developed by Adapta Sertão is that all key stakeholders are engaged with the objective of ensuring the conditions for CBA to flourish. Climate resilience based on a specific CBA approach, such as that proposed by Adapta Sertão through the 8 pillars, can be the leading policy objective of most agricultural state programs. The facilitation of this process could be made by local and state government in partnership with multilateral financial institutions such as IDB or the World Bank.

Several high level dialogues and forums would be necessary to ensure that the government and other key stakeholders take the proposition seriously to create the conditions for CBA projects to happen and further scale up. The development of a road map of specific actions with budgets would be required to ensure that local organizations access additional funding for implementing a larger CBA regional program. A massive undertaking requires a strong coalition of organizations, financial resources, combined with a very clear vision, technical

capacity and a strategy on the necessary steps towards resilience. The strategy for scaling up would be based on the following steps:

1. Identify a multilateral development agency and/or bank that is willing to bring the CBA Adapta Sertão proposition up to scale. This institution will be the leading agency for carrying this effort out in partnership with a local executing agency.
2. Define a specific area or a region for the scaling up, i.e. Bahia state for example.
3. Carry out a specific research analysis on climate change and potential impacts on the family farmers' value chain over the proposed area. Then organize several roundtable discussions engaging key stakeholders at all levels to present the results and propose a strategy based on the 8 pillars.
4. Engage all key stakeholders required to sustain the 8 pillars in high-level meetings. All these key partners have been already identified and engaged in Bahia state by Adapta Sertão. For scaling up in Bahia, it would be just a matter of defining the new areas with these partners and agree on the proposed strategy. Specific attention should be paid to the engagement of private sector actors and frame climate resilience as an opportunity to accelerating growth.
5. Negotiate the terms of the collaboration with all proposed partners. The partners for scaling this up in the Bahia state would be:
 - a. A multilateral financial or development institution to incubate the process – i.e. World Bank or IDB – together with a local Executing Agency, i.e. consulting company or NGO.
 - b. A number of selected farmers' cooperatives that are chosen based on specific criteria.
 - c. Banco do Brasil and Banco do Nordeste for launching a larger scale credit initiative to fund the MAIS and provide low interest rates for the selected cooperatives.
 - d. SENAR/SEBRAE to provide technical assistance to the farmers engaged through the farmers' cooperatives.
 - e. The Government and the Secretary of Agriculture and CAR/Bahia for launching a specific technical assistance and agroindustry support policy
 - f. OCEB/Sescoop, the Union of Bahia cooperatives, and business management consultants to help restructuring the cooperatives' operations and strengthening the management operations of the cooperatives.
 - g. Technology providers to help setting up a number of retailers for the dissemination of the MAIS technologies.
 - h. A scientific committee formed by national and international institutions and an independent monitoring strategy over time to understand how the project develops and the level of climate resilience achieved by the partners.
 - i. A permanent multi-stakeholder dialogue to discuss the project advancement and feed the climate adaptation policy process.

Table 1. Summary of key impacts achieved by the project

| Area | Baseline | Intervention | Result |
|-----------|--|--|---|
| Technical | Crop loss from rain-fed irrigation was on average 70%. Hand irrigation with buckets was used by women who spent 1 to 3 hours per day for fetching water and hand | Introduction of mechanical equipment and tools: water pumps, harvester, feeder, milker, etc. | <ul style="list-style-type: none"> Animal feeding went from 2 hours/day to about 15 minutes/day Milking went from 2 hours/day to about 30 minutes |

| | | | |
|----------------------|--|---|--|
| | irrigation. Most farming operations were manual and took several hours | | <ul style="list-style-type: none"> Women no longer fetch water or irrigate. Everything is automatic |
| Technical | <p>Technical assistance programs did not have any focus on climate resilience</p> <p>Climate resilience is not tackled by any program at any level</p> | <ul style="list-style-type: none"> Multistakeholder dialogue and development of the Adapta Sertao CBA Climate impact analysis on family farmers' value chain | <ul style="list-style-type: none"> Development of the climate smart agricultural production system MAIS Testing of new technical assistance programs based on resilience in partnership with local actors (SENAR and CAR) Several organizations at all levels start discussion climate resilience in their agenda |
| Technical-economical | Low productivity. Because of the time spent in manual operations, farmers' productivity was low. Farmers earned less than 1 minimum wage (< R\$ 750) and were relying on the cash transfer program from the government to secure their living. | Introduction of mechanical equipment and tools: water pumps, harvester, feeder, milker, etc. | <ul style="list-style-type: none"> If the MAIS system is applied correctly, farmers make more than 2 minimum wages per month, which is above average in the region. 30% of the farmers working with vegetable manage to increase their net income of about 30% The payback time of most of the equipment is between 1 and 3 years, showing full viability |
| Technical-economical | Farmers and their families suffering from climate change impacts, decreasing their wealth and health and migrating to rural areas | <ul style="list-style-type: none"> Integrating farmers in the the Adapta Sertao CBA (8 pillars) to improve livelihood Implementation of the MAIS system in 100 farms An additional 365 MAIS are in different implementation stage Objective by 2018: 800 MAIS fully implemented | We do not have final results. However, we see that about 30% of the farmers start showing very substantial improvements in their life. An additional 40% show some improvement. The remaining 30% show no improvement. The difference between farmers needs to be clearly understood yet. However, motivation, access to basic infrastructure and the level of education of the farmers are likely to be among the leading factors for success |
| Policy | Climate resilience is not included in any policy program in Bahia state. | <ul style="list-style-type: none"> Multistakeholder dialogue and development of the Adapta Sertao CBA Climate impact analysis on family farmers' value chain | Climate resilience start to be introduced the current agricultural policies |
| Economical | Cooperatives with unqualified management and outside of main value chains | <ul style="list-style-type: none"> Restructuring of cooperative management team Inclusion of farmers' cooperatives in value chain through CBA | <ul style="list-style-type: none"> Stronger cooperatives that show the potential to become fully viable Old unpaid loans and previous mistakes made by unqualified management teams slow down the process |
| Economical | Bureaucratic loans. Climate resilience is a concept not understood by banks | <ul style="list-style-type: none"> Multistakeholder dialogue and development of the Adapta Sertao CBA Climate impact analysis on family | <ul style="list-style-type: none"> Launching a specific credit mechanism for fund the MAIS (pilot) with the possibility of scaling up |

| | | | |
|--|--|--|--|
| | | farmers' value chain and impact on credit insolvency | |
|--|--|--|--|

Table 2. Summary of the most important stages of the project and financial support

| Phase of the project | Year | Intervention | Results | Funders |
|--|-----------|--|---|---|
| Phase 1 – efficient irrigation | 2006-2008 | Testing drip irrigation in 5 family farmers to see if efficient irrigation can be a climate resilient strategy (focus: fruits and vegetables) | Some encouraging results; difficult to have any final conclusion with such low number of families | <ul style="list-style-type: none"> • Cariplo Foundation • Dutch Ministry of Foreign Affairs |
| Phase 2 – scaling up efficient irrigation | 2008-2010 | Testing drip irrigation in 40 family farmers (fruits and vegetables). The project focus starts including other farmers' value chain, especially milk and lamb | It starts to be clear that efficient irrigation is not a long-lasting solution because only a very minority of farmers have access to stable freshwater resource. The key economic activity for local family farmers is milk and animal breeding. We start testing several improvements in the milk and lambs production chains. The project starts gathering several additional partners and takes the form of a coalition. One farmers' cooperative is created through the help of the partnership in Pintadas. | <ul style="list-style-type: none"> • German Environmental Agency • CNPq/Brazilian Academy of Science • Itau Foundation |
| Phase 3 – development of the MAIS and of a common vision | 2011-2014 | 6 farmers cooperatives join the partnership. They become the responsible for farmers' engagement. The focus of the project is making animal breeding and milk production more resilience to climate change. More partners are engaged. A clear vision and strategy arises around resilience. | The MAIS is conceived in partnership with several research institutions and tested in 100 farms through equipment that is subsidized by the funder. More than 300 farmers are engaged in the process. The 8 pillars are identified, discussed and framed. The framework for a resilience strategy also arises. Scientific studies shows the impact of climate change in the region and the viability of the MAIS system. | <ul style="list-style-type: none"> • Fundo Clima/Brazilian Ministry of the Environment |
| Phase 4 – Testing a local resilient economy | 2014-2018 | This phase is incubating a "resilience economy" based on the 8 pillars in the Jacuibe basin. All necessary partners for such incubation are identified and engaged | The MAIS is consolidated and implemented in 800 farms through the engagement of local cooperatives. Technical assistance programs use the MAIS as reference production model. Local cooperatives are strengthened in various ways. Banks and credit institutions join the partnership. | <ul style="list-style-type: none"> • IBD/MIF/Proadapt Fund • Petrobras • SENAR • CAR • BNDES (negotiation) |

Case description: Don Reginaldo Santana and how he overcame climate change

Reginaldo Santana, Farm Alto Bonito, Itaberaba - Ba

The property has 23 hectares, where Reginaldo kept more than 30 animals (cows, and young animals). Because of the great drought that was taking place in 2010/2011, Reginaldo was providing all the food in confined settings to avoid losses. He produced 50/60 liters of milk with only one milking in the morning. The property does not have electricity and water available is coming from the rainfall and then stored in surface tanks. Reginaldo started accumulating a lot of debts because his production practice was not paying all his costs.

Strategy and Innovations

The producer was buying 80% of his feed from suppliers. It required almost his full day of work and the help of an employee to feed the animals. He had to sell all his milk door to door in the city to maximize his revenues. Adapta Sertão helped Reginaldo develop a plan with priorities:

1. Identify all the unproductive or low productive activities and subsequently cut them and eliminate all the unnecessary costs, and
2. Become self-sustainable with animal feed.

Reginaldo's key strategies were:

- Selling his low-productive animals to get financial resources to pay off debts and even deploy a small area of palma. He sold 21 cows and kept only 9 animals.
- Resignation of the employee because now Reginaldo could take care of the 9 cows
- Start 2 milking per day on a more balanced and proper feed
- Pay off the debts with the money he got from the sales of the 21 animals.
- Use the little money left after paying off his debts to implement a 0.7 hectares of palma area. The size of the area was determined by the amount of money that was left from the sale of the animals.
- Selling milk to a local buyer (the farmer cooperative in Itaberaba is just working with fruits) to stop selling his milk door to door. Reginaldo started then also to have even more time to take care of the animals, as well as improve the quality of his life because he could now start having lunch at home again with his family.

From there we decided to go further and planned together with Reginaldo an expansion phase to reach 200 liters, and for that we needed to expand the area of palma and buy more productive cows. We filed for a bank loan, so we were able to expand the palm area to 2 hectares and acquire a few more cows.

Reginaldo got:

- A small scale tractor intended to facilitate soil management and bring feed and other products from one part of the property to the other
- Shredder machines power by diesel motor intended to cut palma and other feed. Reginaldo went from spending several hours to prepare feed to about 20-30 minutes.

Results

Before Adapta Sertão intervention, we had the following situation: producer with operating cost of R \$ 1.96 per liter of milk, and selling milk to R \$ 1.80, i.e., operating with a loss of

Principles of MAIS Leite

1. All voluminous fodder must be produced in the property and palma should represent 70% of animal nutrition.
2. The property must be intended to ensure food and water needs for the herds for up to 3 years of prolonged drought.
3. Farmers shall only acquire the protein concentrates (cotton, soy, etc..) that will serve as a protein supplement for animals
4. Maintain financial control, keeping the operating cost of production at a maximum of 50% of total revenue
5. Ensure an average production of lactating cows of 14 kg milk/day
6. Include land reclamation for pasture through an iFLF system (integration Farming Livestock Forest)
7. Use as much as possible small-scale low-cost machineries, especially those with a high aggregated labor value, i.e. the equipment that reduces substantially the manual work.

R\$ 0.16 per liter. Besides all this, he had some debts in the local market because he was selling milk at a loss but he still needed to purchase food for his animals because he wasn't supplying any feed coming from his property. After 7 months since the beginning of the intervention, we could already start cutting palma to supply the correct amount of feed to the animals, and stop purchasing most of the feed from outside sources. Reginaldo kept and is still keeping purchasing only the concentrated protein feed (soy and cotton meal) because high protein plants are much more difficult to produce in semiarid region and in quantity enough to fulfill all animals' needs. In addition, the time and amount of work needed for this activity often does not compensate the cost of buying ready-to-

use protein concentrates. All of this further lowered the production cost which reached R\$ 0.34 per liter and selling milk to R\$ 1.10. Initially the producer had an operating loss of R \$ 240.00 per month, i.e. he could not even pay his own work. Today he is assured of one minimum wage and R \$ 1,600.00 per month of operating profit.

After a year since embracing change, Reginaldo was now producing about 100 liters per day with his 9 cows. Milk productivity went from 3-5 liters/day/animal to over 12 liters/day/animal. He is aiming at reaching 200 liters in 2016.

Today we have a new Reginaldo. He is a proud professional milk producer and prepared to face the challenges of the business.



Reginaldo Santana cutting palma manually. The purchase of a mechanical harvester is in the list of his next purchase to increase his farm efficiency. Picture: Igor César.

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