Fighting Hunger and Educating Farmers with Regenerative Agriculture in Maputo's Green Horticultural Belt

Chapter 12 (SDG 2 & SDG 4). Fighting Hunger and Educating Farmers with Regenerative Agriculture in Maputo's Green Horticultural Belt

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The chapter analyses the Green Horticultural belt in Maputo, where Mozambican and Brazilian researchers jointly implemented demonstration plots and trained small-scale farmers in circular -ecologically regenerative- farming practices aimed to ameliorate food poverty. Sustainable farming practices also include direct planting, land rehabilitation, and water management. In the project, there is irrigation, rainwater collection, and the use of low-cost portable greenhouses. The adoption of greenhouses with water harvesters strongly reduces water use. The chapter uses resource-constrained innovation theory to analyze factors underpinning the success of this initiative.

Key-words: circular economy, sustainable agriculture, sustainable development goals.

1. Introduction

One of the biggest challenges in the world is food security. In 2020, between 720 and 811 million people faced hunger in the world. From 2019 to 2020, only in the African continent, there was an increase of 46 million more people undernourished. About 12% of the global population was living in food insecurity, which represents 928 million people (FAO, IFAD, UNICEF, WFP, and WHO, 2021). In the case of Mozambique in the African continent, according to the Organization for Economic Cooperation and Development, 80% of the population cannot afford an adequate diet, and 42.3% of children under five are stunted. According to Carrilho et al (2017) in the report about food security and nutrition challenges in Mozambique it also changes the eating habits of urban population which contributes to increase weight gain and obesity. According to the World Bank classification, Mozambique is also a low-income, and a food-deficit country.

Considering the many challenges for achieving food security, the implementation of sustainable farming practices could be an alternative for transferring knowledge to small producers about sustainable production techniques, also considering environmental and social benefits. In the case of Mozambique, this alternative is even more important considering that in 2020, 62,93% of the population is rural (World Bank, 2021). In these terms, a circular economy could be considered a promising strategy to support sustainable and regenerative agriculture (Velasco-Munoz, et al, 2021; Rhodes, 2017). The regenerative system is on the foundations of the circular economy approach. Regenerative agriculture is related to preserving and maintaining resources, considering

the interactions of agriculture with the natural system (Morseletto, 2020; Newton et al, 2020; Dahlbert, 1991). The farm is understood as a part of a large system. As stated by EMF *"the crops need insects to pollinate, surface and groundwater to irrigate, microbes to cycle nutrients, and soil to provide a strong and fertile growth medium"*. In this sense, regenerative agriculture comprises a group of techniques for producing high-quality food and improving the surrounding natural system. The techniques are embedded in this idea of changing from extractive to implementation of regeneration cycles and making things better. It is also important to consider the local conditions where the system is implemented. The regeneration techniques need to be tailored to local conditions. In this matter, we understand that it would be important to analyze the local conditions from the perspective of resources constraints theory. For this theory, constraints in resources are an incentive to innovate, for combining resources available creatively. The theory assumption is based on a resource-poor environment (Acar et al., 2019; Molina-Maturno et al., 2020; Sharmelly et al., 2021).

Taking this, his chapter analyses the implementation of the Green Horticultural belt in Maputo where Mozambican researchers, from the Institute for Agricultural Research of Mozambique (IIAM) and Brazilian researchers, from the Brazilian Agricultural Research Corporation (EMBRAPA) work together to mitigate food insecurity. The chapter is structured in five sections. After the introduction, a theoretical background is presented based on resources-constraints innovation theory and regenerative agriculture literature. Follow the methodology, the presentation of results, analysis, and conclusions.

2. Theoretical Background.

This section presents the main concepts related to resource-constrained innovation literature and regenerative agriculture. These concepts will support the discussion of results in this chapter.

Resource-constrained innovation literature.

Extant literature has widely explored the role of resource constraints on innovation and the nature of innovation (Garud & Karnøe, 2003). Along with its impact on incremental and cumulative innovations, resource constraints have been observed to promote rather than impede radical innovation, especially in the context of knowledge constraints compared to financial constraints (Klarin, 2019). It is notable that firms that can achieve innovation in the resource-constrained environment are likely to perform better than

their peers (Leifer, O'Connor & Rice, 2001). Although the earlier works emerged from developed countries focusing on firm-level differences in the resources and innovations, in a recent couple of decades, scholars have widely explored the origins, practices, and outcomes of resource-constrained innovations in developing countries (Bhatti, Barron & Ventresca, 2018; Devi & Kumar, 2018; Faris, 2015). These developing countries have several constraints prevalent in their business environment - poor access to domestic and international markets, inputs, services, information as well as limited infrastructure development including energy, transport, telecommunication, water (Ianchovichina & Lundström, 2009). Furthermore, in many cases, these countries experience fragile state functions including public safety and security, primary education, public health education, and public health (Ianchovichina & Lundström, 2009; Karnani, 2007). Also, firms might experience other issues like the lack of skilled human resources and high financial, monetary and fiscal instability (Ianchovichina & Lundström, 2008). At the same time, the rise of the emerging markets like India and China has led to greater research interest in the role of innovation in these countries as well as opportunities for context relevant innovations (George et al., 2012). Studies have highlighted that appropriate resource-constrained innovations have the capacity to generate local knowledge, improve access to infrastructure, develop business capacity and capabilities and alleviate poverty.

The importance of social, political and cultural skills has been acknowledged in the literature as some of the critical tenants for innovating in the resource-constrained environment, especially the developing countries (Khoury & Prasad, 2016; Bruton, Ketchen Jr, & Ireland, 2013; Wu & Si, 2018). In fact, authors note that in many developing countries these soft skills[1] are crucial for enabling innovations in the light of lack of appropriate resources, including the institutions. This is uniquely pertinent as the products and services need to be tailored to the local requirements while aligning with the resources available to the firms. In many cases, firms have to engage in bricolage to match the resources available to the opportunities available in their environment. Yet, in most resource acute stages, this typically calls for the firms to adopt more entrepreneurial position and leverage new and unique innovations leading to breakthrough innovations. Earlier works have observed that these radical or

[1] Examples of soft skills are constantly searching for new opportunities, being self-starting, learning from errors and feedback to overcome obstacles, creativity, perseverance, personal will, being innovative, among others (McKenzie, 2021; Ahadi and Kasraie, 2020).

breakthrough innovations are most notably present in products and services that address the needs of the local income consumers in the developing countries (Prahalad & Hart, 2002). Also, these studies highlight that for resource-constrained innovations to emerge there needs to be an active interface between various stakeholders and firms. Ausrød, Sinha, and Widding (2017) identify four elements relevant for resource-constraint innovations, namely, suitable value proposition, supply chain, customer interface, and finance.

Recent studies have explored the impact of origin and ownership of firms in resource-constrained innovations. Bu and Cuervo-Cazurra (2020) note that foreign firms and business groups are more inclined to induce innovativeness in this context, while state ownership leads to less innovativeness. Similarly, Onsongo (2019) highlight the role of multinational firms and foreign investment in these resource-constrained innovations. The study notes the role of both investments from the global north as well as south firms in the development of these innovations suitable for the resource-constrained context. Although much of the earlier works focused on the entrepreneurial and firms' led resource-constrained innovation, recent studies have noted the valuable role of the state in enabling some of the resource-constrained innovation (Kolk et al., 2014; Ramani & Mukherjee, 2014; Hietapuro & Halme, 2015; Hyvärinen et al., 2020).

Furthermore, studies have examined the nature and role of south-south collaborations (Abdenur, 2015; Chen, 2018). Adopting the perspective that examined the technical cooperation between Brazil and Africa, author notes that technical cooperation between these two contexts which themselves experience several resource constraints was driven by the work of national governments and policies adopted to encourage dialogue and innovative activities between the firms from these countries. Other studies have further highlighted the role of national governments in these engagements between the south-south partners (Thorsteinsdóttir et al., 2010). They suggest that developing countries innovation and knowledge transfer activities are greatly driven by the policies of the national government, and various bilateral, multilateral and regional agreements have emerged between partners from the south. Also, they suggest that these partnerships between the firms from the south are more likely to generate relevant model for innovations. In their study, they observe that more than a quarter of the health biotech firms engaged in the south-south collaboration and that Brazil was the leading country in the south-south collaborations. Such south-south collaborations have also been explored in the case of approaches to eradicating diseases and identifying new, more

resource-effective model of innovations (So & Ruiz-Esparza, 2012). Similarly, Chen (2018) explored the collaboration between the Chinese firm and Ethiopian wind farms, noting the higher level of knowledge transfer between the host and home firms and university scholars. Aerni et al. (2015) implore the use of agricultural innovation systems to build on the resources in the southern countries and develop suitable innovations in the context. In order to address the resource constraints in these developing countries, Agricultural Knowledge and Information Systems (AKIS) perspective enabled research in suitable areas, but over a period, this approach was found unsuitable since despite providing relevant technical knowledge it did not generate appropriate solutions and meet the needs of the local farmers. Thus, agricultural innovation systems emerged which considered the context of innovation as well as the technical innovation itself. Hence, these new innovation systems were able to generate relevant resource-constrained innovations to correspond to the needs of the farmers.

Regenerative Agriculture

According to FAO, agriculture is one of the main causes of biodiversity loss, the highest consumer of water in the world, and responsible for about 30% of greenhouse gas emissions. Besides, it is responsible for soil contamination in using herbicides, pesticides, and fertilizers (Velasco-Munoz et al., 2021). For facing these challenges, prior studies investigate the application of circular economy (CE) principles on food production.

Previous studies stress that CE in agriculture comprehends resource efficiency that refers to minimize resource use and avoid waste. It is also highlighted the essential role of agriculture in the conservation of biodiversity, to guarantee productivity over time, providing food security and eradicating poverty (Velasco-Munõz et al., 2021; Burgo-Bencomo et al., 2019). One of the main principles of CE is regenerating nature which implies that the concept of waste does not exist in nature. *"Everything is food for something else"* according to Ellen Macarthur Foundation. From this principle it comes the concept of regenerative agriculture which implies in keeping the ecosystem for guarantee balance with food production. Regenerative agriculture is also related to soil quality which need to be free of external synthetic input (as pesticide and fertilizer) (Rowntree et al., 2020). Soil quality also increases the capacity of water storage, and

generate their own fertility. As stated by an organic milk farmer in Brazil soil is the saving account in regenerative agriculture (Piao et al., 2021).

In a review conducted about regenerative agriculture Giller et al. (2021) highlighted that regenerative agriculture implies changes in the macro structure and social relevancy. As an example, the authors stress the connections of all parts of a farming system, as farmer and his family for promoting regenerative agriculture. Besides, regenerative agriculture also refers to increase levels of employment, integrated systems for promoting biological nitrogen fixation, and increase on soil productivity. Methods as no-tillage for avoiding soil erosion, intercropping, crop and livestock rotations, crop and livestock production system, agroecology techniques, and composting are largely adopted by the system (Giller et al., 2021; Food Security Report, 2021)

From the literature review the authors elaborated a conceptual framework for conducting the data analysis which is detailed in table 1.

Table 1 – Conceptual Framework.

Theoretical background	**dimensions**	**References**
Resource-constrained innovation literature.	• Encourage the adoption of general local knowledge; • improve access to infrastructure; • develop business capacity, develop capabilities to alleviate poverty, • develop soft skills • develop products and services tailored to local requirements; • promote active interface between various stakeholders and firms	Prahalad & Hart (2002) McKenzie (2021) Ahadi and Kasraie (2020) Duker et al. (2020)
Regenerative Agriculture	• No-tillage • Crop and livestock rotation • Crop and livestock production system • Composting • Water management • Soil management • Increase levels of employment • Connections of all parts of farming system • agroecology	Rowntree et al. (2020) Giller et al. (2021) Velasco-Munõz et al. (2021) Burgo-Bencomo et al. (2019) Food Security Report (2021)

Source: elaborated by authors.

3. Methodology

Four interviews were carried out to investigate the regenerative agriculture in Maputo´s green horticultural belt. The individuals selected were from EMBRAPA and IIAM organizations. They are two researchers from EMBRAPA, directly involved in the project in Mozambique, and two researchers from Mozambicam research organization. In addition, the research team had a day field research trip in the Umbuluzi agrarian station, in Mozambique, where the project was implemented. In this opportunity, the research team was able to observe and talk with researchers, technicians, and students working in the agrarian station. The pictures from this field research are in the end of this chapter.

The interviews were recorded on digital recorder and later transcribed verbatim in Portuguese or English and later translated into English language. A team of researchers were involved in the data collection in order to guarantee the reliability as suggested by Denzin (1978). The interviews in Mozambique were conducted in July 2019 and in Brazil, with EMBRAPA researchers, were in May 2019.

The interviews are detailed in Table 2.

Table 2 - List of Interviews

Organizations	**Details**
Institute for Agricultural Research of Mozambique (IARM)	• Technical Director (I1) • Researcher responsible for Umbuluzi Agrarian Station • One day field visit of Research Team, composed of three researchers, in the Umbuluzi agrarian station • Duration: 6 hours
EMBRAPA organization located in Brasilia, Brazil.	• 2 researchers directly involved in the project (I2 and I3) • Duration: 2 hours

Source: elaborated by authors.

4. Results

The case study of this paper is the Trilateral Project of Technical Support to the Programs of Nutrition and Food Security (PSAL) from 2011-2015. The PSAL project was a collaboration between Institute for Agricultural Research of Mozambique (IIAM), EMBRAPA, and two Universities from United States (University of Florida and the Michigan State University). The objectives of the project are focused in three areas: socio-economic production system, and post-harvest and agro-processing technologies for increasing the horticultural production and productivity. The main activities of the project are to test and adapt production, post-harvested, and processing practices and technologies, to contribute in the creation of infrastructure for research, extension and

processing, training of Mozambican researchers and extension technicians, and organized socioeconomic information about horticultural value chain (Schmink, et al., 2019).

One of the main locals of development the PSAL project is Umbuluzi, an agrarian station, where IIAM has an experimental unit. The research team had the opportunity to visit the Umbuluzi station for one day. In this day it was conducted interviews with the director of Umbuluzi agrarian unit, the Mozambicam research team leader who was the technical director of IIAM, and some students who are working on the station on that day. The technical director had a degree, and a Master and PhD in agronomic engineering from Federal University of Viçosa that is located at the Southeast of Brazil.

In the Umbuluzi agrarian station the researchers from EMBRAPA worked together with researchers from IIAM, technicians, and interns. The interns are students from different universities in Mozambique from the agronomic engineer degree. According to the interviews, interns want to stay in the Umbuluzi unit because they have the opportunity to learn by doing. Even in July, when no one was receiving the scholarship, interns are still there. Until the end of 2018, all interns are paid with the funding from the project. The interns received from 200 to 300 American Dollars per month, which is more than the salary paid to an agronomic engineer trained in Mozambique. According to I2 in the area of the project was trained from 300 to 500 students, and around 15 to 20 thousand small producers[2] .

One of the main pieces of knowledge transferred in this project from EMBRAPA to IIAM is the technic of building greenhouses. Because of the lack of water and the high intensity of sunlight, it is difficult to cultivate vegetables free of pest. The technic of building greenhouses, to develop the varieties and the production system is essential. The Mozambican team composed by IIAM leader of the project, students, and IIAM technicians, built with EMBRAPA researchers a greenhouse. So, in 2019, only students built a new greenhouse based on the knowledge acquired with EMBRAPA team.

The production system is agroecological and it was used some plant varieties for working as a barrier to pest. According to I1: "…*we work in agroecology. So you have a pest management plan that considerably reduces the need for pesticide use. This barrier is exactly the first model we designed to handle interference*".

[2] Small producers have production areas with less than 5 hectares (Haber et al., 2015).

According to a EMBRAPA researcher, they also use some techniques to maintain the water in the plant, such as straw mulch. According to I1, most of small farmers are illiterate and they can get knowledge through their children who gets formal education in the university. In his words: "…*It is very difficult to work with an illiterate but we reach them through their children, because the children of farmers are in the university to strengthen the production. So, this knowledge can be easy for the farmer to see via their children, because they believe on them. This is a model that fits more or less what we learn from our colleagues (EMBRAPA colleagues)"*

From EMBRAPA interviewees, they highlight the problems related to the production of vegetables such as contamination of soil and water by sewage sludge.

According to I3 *"…the production of vegetables is very precarious, there are many problems with contamination of soil, water, their water table is very dense and the cultural aspect itself did not help much for the production. They had no irrigation system. The water channel was already contaminated. So, we had to teach how to prepare the soil, the need to use a bed because it needed to be planted in beds because they could not use the soil itself, the spacing and in addition to working at the institute we also worked with the instructors with their own farmers."*

In terms of seeds, I2 mentioned: "…*the seeds we brought to Mozambique were tropical seeds, they were appropriated for tropical condition nations. So that's the reason the major success because all the varieties that we brought in were work. They adapted very well and very quickly*". He added: "*the good thing of this project the internalized the processes and the technologies and somehow there are using it with knowledge of whatever*". This fact leads the entry of Brazilian companies in Mozambique that work with seeds trade and irrigation equipment's.

Regarding the activities on the agrarian station, the EMBRAPA researchers detailed the importance of learning by doing process. According to them agronomic research in Brazil has a very important pillar based on the experience in the field. They pointed out that in Brazil PhD researchers, and technicians working together in the field learning from experience. In Africa Brazilian researcher brough this practice, which was not so usual.

The EMBRAPA Researcher I2 describe one of the field experiences in his words *"in one of experiments conducted we put all the researchers in the field. So, the ones that come as engineers, they are only spectators. They don't carry anything. So, one of the*

engineers say I'm an engineer, and refuses to work in the field, And I said: look at me I'm doing this and you should do the same.".

For EMBRAPA researchers, the leadership of Mozambican researcher was very important to transfer knowledge in the field and promote the engagement of researchers and students. According to EMBRAPA researcher I2 event after the end of the project, he visited the Umbuluzi agrarian station, he met about 50 students who were on practice. "*So, the leadership of Mozambicam researcher keeps moving with that project and making the difference"*.

5. Analysis

The analysis is based on the conceptual framework detailed previously. From the perspective of innovation constraint theory, the results indicate the importance of local knowledge and relationships (Aerni et al., 2015) for developing suitable innovation and alleviating poverty in contexts of extreme hardship. However, our analysis suggests that rather than looking at institutions or organizations, the key for successful knowledge transfers lies on the interactions between individuals. It is clear the importance of the soft skills of the technical director of IIAM in his close relationship with Mozambican and Brazilian researchers, technicians and students in the agrarian station. He used a cascading strategy where illiterate small farmers can get knowledge from their children who get formal education and training in the agrarian station. Thus, knowledge is transferred indirectly from the researcher to the farmers through a chain of personal bonds based in trust and respect. The students have already a family bond with their parents, that makes them more likely to be heard. In addition, the Director forged a relational bond with the students. It is also important that the research leader got his formal education in Brazil where he acquired also skills related to "learning by doing" in the agronomic engineer knowledge area. This contributes to stablish strong ties with Brazilian researchers. As a result, knowledge generated in Brazil is transferred to African farmers through a chain of personal, one-to-one bonds, where knowledge is reconfigured and its communication adapted to make it more appealing to the recipient.

All these micro-processes allow the dissemination of techniques from regenerative agriculture as soil and water management, natural control of pest disease in plantation, no-tillage and use of greenhouses which also reduces the use of water (FAO, IFAD, UNICEF, WFP and WHO, 2021). The other point related to regenerative agriculture is the use of Brazilian seed varieties, which are more adaptable to African local

conditions. This allows the production of vegetables with more productivity and address the problem of hunger in Mozambique.

The regenerative agriculture also details the importance of connections of all parts of farming system as stated by Giller et al. (2021). This element is pointed out when it is promoted in agrarian station the integration of researchers, and students for developing new skills and fighting hunger. It is also essential the relations of students with their parents who are part of farming system.

The soil management is another important dimension of regenerative agriculture. The adoption of agroecological techniques keep and enrich the fertility of the soil as stated by Rowntree et al. (2020).

The leadership of Mozambican researcher is recognized by Brazilian team from EMBRAPA as crucial for the development of the project and its continuity. As stated by the literature, soft skills are essential for enabling innovations in the lack of resources (Khoury & Prasad, 2016; Wu & Si, 2018).

The main outcomes are detailed on table 3.

Table 3 – Conceptual framework.

Theoretical background	**dimensions**	**Relations to the case**
Resource-constrained innovation literature.	General local knowledge; products and services tailored to local requirements	To develop seed varieties and infrastructure adapted to local conditions and resources constrains, as the building of greenhouse with materials available in Mozambique;
	improve access to infrastructure	To develop seed varieties and infrastructure adapted to local conditions and resources constrains, as the building of greenhouse with materials available in Mozambique;
	develop business capacity, develop capabilities to alleviate poverty	To transfer knowledge to engineers, technicians, and students and promote the culture of "learning by doing"
	soft skills	Soft skills from Mozambican research leader as personal will, perseverance, and overcome obstacles.
Regenerative Agriculture	No-tillage	To promote the learning skill of students who are going to transfer this knowledge to their parents who are farmers (social ties for promoting regenerative agriculture)
	Crop and livestock rotation	To promote the use of seeds adapted to local conditions
	Crop and livestock production system	To promote the use of seeds adapted to local conditions
	Composting	To promote the use of seeds adapted to local conditions
	Water management	To promote better management of soil and

	Soil management	water
	Natural control of pest disease	To promote the learning skill of students who are going to transfer this knowledge to their parents who are farmers (social ties for promoting regenerative agriculture)
	Increase levels of employment	To promote the learning skill of students who are going to transfer this knowledge to their parents who are farmers (social ties for promoting regenerative agriculture)
	Connections of all parts of farming system (social ties)	To promote the participation and "hands on" culture of all involved in the experiments (as engineers, technicians, and students) that promotes the transference of knowledge
	agroecology	To promote the learning skill of students who are going to transfer this knowledge to their parents who are farmers (social ties for promoting regenerative agriculture) To promote the dissemination of agroecology practices from Brazilian and Mozambicam researchers as natural pest barrier and soil fertility

Source: elaborated by authors.

6. Conclusions

The objective of this chapter was to analyse the implementation of the Green Horticultural belt in Maputo where Mozambican researchers and Brazilian researchers, work together for mitigating food insecurity.

The main outcomes indicate the importance of leadership, as soft skills, for promoting sustainable development in local context. Technical skills are fundamental for promoting the use of seeds and regenerative agriculture techniques adaptable to local context, but the leadership of technical director of IIAM was essential to the success of the project and its continuity. The charismatic leadership and strong relational ties between researchers in Brazil and Mozambique enabled a high level of knowledge exchange and trust that allowed the "regenerative agriculture elements" of the Brazilian model to be transferred. Also, the attention given to adapt the project to local needs and resources, resulting in the inclusion element. A green belt providing food for the more vulnerable but also acting as a practical school showing young volunteers how sustainable farming methods can be productive. Recall how these young students mentioned that they will convince their parents - traditional farmers- to try the new techniques. So, this effect of knowledge transfer from Brazil, knowledge adaptation to Mozambique needs and resources, and dissemination of such adapted knowledge among vulnerable farmers are among the main outcomes of this investigation.

The results indicated that some sustainable development goals are addressed as SDG1 (no poverty), SDG2 (zero hunger), SDG4 (quality education), and SDG6 (clean water and sanitation).

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Figures from the Umbuluzi Agrarian Station (July 2019).

Figure 1 – Research team with IIAM director in the field work in Umbuluzi: production of garlic new variety.

Figure 2 - Research team with IIAM director in the field work in Umbuluzi: greenhouse for production of fresh vegetables and local people working in the field.

Figure 3: Greenhouses build with EMBRAPA for producing fresh vegetables in Umbuluzi agrarian station.