8-2022

Impacts of Granite Quarrying: The Case of Subsistence Farmers in the São Pedro River Valley

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IMPACTS OF GRANITE QUARRYING: THE CASE OF SUBSISTENCE FARMERS IN THE SÃO PEDRO RIVER VALLEY

by

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A DISSERTATION

Presented to the Faculty of the University of the Incarnate Word
In partial fulfillment of the requirements
For the degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF THE INCARNATE WORD

August 2022

ACKNOWLEDGMENTS

I would like to thank extensively my committee, Dr. Guzman-Foster and Doctor Ortiz, for their expertise, and especially my dissertation Chair, Dr. Buck, for her relentless guidance and support.

Also, I thank Dr. St. Clair, who walked with me through a good portion of my journey.

Many thanks also to UIW's graduate grant division for cost-sharing expenses related to the logistics in this research project.

Thanks to Geologist Dr. Sergio Klein and my Research Associate (RA) Joana Rodrigues, who I am pleased to announce is now serving as project manager at Granite Grounds Rehabilitation Foundation (GGREF).

Isabelle Poupard Santizo

DEDICATION

I dedicate this work to the following:

The rural families of the São Pedro River Valley in Brazil—may their struggles also be ours.

Mario Santizo, Leah Grace Poupard Santizo, and Matteo Able Poupard Santizo for their unconditional support and sacrifices made during these 13 years.

Brazilian professor Dr. Poupard, who has been my biggest inspiration, supporter and contributor at all levels and in all my endeavors. She has taught me to care and to give and she introduced me very early to the teachings of her most influential figure: Paulo Freire.

IMPACTS OF GRANITE QUARRYING: THE CASE OF SUBSISTENCE FARMERS IN THE SÃO PEDRO RIVER VALLEY

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Granite quarrying constitutes an occupational hazard that compromises workers' health, destroys the environment, and negatively affects nearby communities (Azevedo et al., 2020; Ibrahim et al., 2019; Oktriani et al., 2017; Shaik et al., 2015). But the demand for granite and other decorative stones continues to grow (Gupta, 2018). Despite a decrease in imports/exports due to Covid-19 (Alves et al., 2020), today Brazil remains the number one granite exporter to the United States (U.S. Geological Survey, 2021). In the last 30 years, the extraction of granite in Brazil has been continuous, particularly in the states of Espírito Santo and Minas Gerais. In the Northeast of Minas Gerais, granite extraction comes from an impoverished rural area heavily affected by drought. The São Pedro River Valley is part of this rural area known as *sertão*. Environmentally, over the last decades, studies revealed factors that have severely altered and compromised this unique and fragile biome, called *Caatinga* (Quintão et al., 2017). Despite patent land destruction, water contamination and scarcity, and rural communities' distress, the effects of granite extraction in the São Pedro River Valley remain scientifically unknown. This case study addressed this research gap. Qualitative data originated from rural communities' testimonies. Participants were subsistence farmers whose livelihoods directly depended on local natural resources. The data emanated from content-based unstructured focus groups comprising 25-30 individuals. Data analysis used both Freire's pedagogical approach and In Vivo coding.

Qualitative data was cross-referenced with a geological report consisting of a soil analysis and interpretation. This study also gathered insights from a local Research Associate (RA), and recent images and video recordings of the area. To preserve the authenticity and integrity of participants' unique environment and circumvent limitations set by the current worldwide Covid-19 pandemic, data collection was conducted remotely. This case study provided an in-depth understanding of an economic activity that compromises the sustainability and equitability of the human-environmental balance in the São Pedro River Valley.

TABLE OF CONTENTS

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

LIST OF TABLES

LIST OF TABLES—Continued

LIST OF FIGURES

LIST OF FIGURES—Continued

Chapter 1: Overview of Granite Quarrying in the São Pedro Valley

Natural stones such as granite and marble have been used as construction materials since 4700 BC in Egypt (Alves et al., 2020). Initially, these expensive materials were used for temples, tombs, palaces, civic buildings, and major infrastructure, as well as for decoration and sculptures. Selection of granite was guided partly by suitability, but was also influenced by personal prestige and social and mystic beliefs (Pereira & Marker, 2016). Nowadays, the use of natural stone in residential and commercial areas is widespread, especially in the United States. The demand for granite and other decorative stones is increasing, with an annual growth of around 20% predicted (Gupta, 2018). The growing popularity and commercial value of granite continue to spur demand in the construction and remodeling industry today. As a result, the production and manufacture of granite products is continuously rising in the construction industries of developed countries (Peterson, 2015).

Granite is increasingly used for construction and remodeling to enhance the visual appeal and attractiveness of residential and commercial buildings and facilities. The benefits of granite in building architecture include durability, longevity, easy maintenance, permanence, and artistic elegance. Not surprisingly, the quarry industry is among the most important industries in developing countries, providing raw materials to the construction, building, and manufacturing sectors (Ibrahim et al., 2019). Amid the Covid-19 crisis, the global market for granite, marble and stone estimated at 20.1 trillion metric tons in the year 2020, is projected to reach a revised size of 28.1 trillion metric tons by 2027 (Global Industry Analytics, 2022). In the United States, the granite industry represents a profitable sector that generates hundreds of thousands of jobs.

Nonetheless, despite the undeniable economic benefits and continuous growth of granite trading and manufacturing worldwide, quarrying activities can be detrimental to people and

nature. Over recent years, scientific research has shown that granite quarrying in different countries can have severe implications (Ibrahim et al., 2019; Oktriani et al., 2017; Sasikala & Chandran, 2015; Shaik et al., 2015). An array of qualitative and quantitative studies conducted in countries such as Brazil, Canada, India, Nigeria, Turkey, and the United States concluded that granite quarrying can be extremely harmful. However, the extent of the effects caused by ongoing granite quarrying in the last 30 years remains scientifically unknown in the rural community located in the São Pedro River Valley in the Northeast region of Minas Gerais, Brazil.

In this semi-arid region known as *sertão*, granite production comes from an impoverished rural area heavily affected by drought. Northeastern Brazil faces recurrent long-lasting droughts that strongly affect regional livelihoods, due to limited water resources for drinking, agriculture, and cattle ranches (Pinheiro et al., 2017). The São Pedro River Valley is in this rural area. As part of the Jequitinhonha Basin, so-called the Valley of Misery (Souza, 2003), the São Pedro River is essential to an isolated and socially vulnerable community. Over the last decades, studies have revealed environmental factors that have severely altered and compromised the sertão's unique yet fragile ecosystem (Souza & Honório, 2020). According to testimonials gathered by the Granite Grounds Rehabilitation Foundation (GGREF) in 2018, subsistence farmers complained about their inability to cope with the nearby granite industry's open-pit quarries. The farmers described their difficulty in accessing clean water and their ability to plant crops and raise small animals for their personal use (GGREF, 2018). However, despite patent land destruction, water contamination and scarcity, and rural communities' distress, the extent of the impacts of granite extraction in the São Pedro River Valley are yet to be explored and understood.

This research sought to explore the effects of granite quarrying activities in the São Pedro Valley. Its purpose was to examine the consequences of granite quarrying on small-scale subsistence farming activities. Using a qualitative research design, data from local small farmers in the São Pedro River Valley was gathered and analyzed. By means of case studies, data was collected and analyzed from rural communities whose livelihoods directly depend on local natural resources. This study aimed to identify the affected rural communities and collect their experiences and views on the likely damage caused to their lands and water resources. The data originated from unstructured focus groups and was cross-referenced with a soil analysis, recent images and video recordings of the area, and the expertise of the Research Associate (RA). This case study also assessed the main issues and effects identified onsite through field observations with the support of a local RA. The data obtained was analyzed to provide an in-depth understanding of how granite quarries have impacted the livelihoods of impoverished rural communities. This study's aim was to answer the following research question: How have small farmers' livelihoods been affected by granite quarrying in the São Pedro Valley?

Theoretical Framework

Rural people are unlikely to perceive the problems that they face in everyday life as environmental (Redclift, 1992). This case study investigated how rural people's livelihoods have been affected by granite quarries in the São Pedro River Valley from a societal angle. It explored the views and perceptions of subsistence farmers whose livelihoods depend on the environment. By providing insights about their past and current farming activities, subsistence farmers could reveal environmental issues such as land degradation, water contamination, and scarcity, to mention just a few. This case study presented intrinsic social and environmental interrelatedness.

Based on humanistic theories that directly align with the educational field of this doctoral study, this research provided an in-depth understanding of a social and environmental issue focusing on a pedagogical approach. Such approach was built around vulnerable rural communities in Brazil, notably in the sertão region. To understand the problem, the focus of this case study was directed towards the perceptions of those individuals who are challenged by the issue. The search for an in-depth understanding of the rural community in the São Pedro Valley was planned and conceptualized using Paulo Freire's theoretical framework.

Freire was a Brazilian educator and philosopher who forged groundbreaking pedagogical theories founded, among others, on adult literacy in the context of vulnerable rural communities as a conduit to emancipation (Freire, 2000). According to Freire (2000), "when an illiterate peasant participates in an educational experience, he or she comes to a new awareness of self, a new sense of dignity, and is stirred by a new hope" (p. 33). Freire's framework has proven to be timeless, as recent research continues to explore his approach to education through awareness of emancipation. Such awareness has also been described as a social awakening marked by the acquisition of knowledge about one's reality. Freire's theories go beyond the educational sphere as they aim to promote a more just and humane world (Bolin, 2019).

The philosophical dimensions of education, when framed within the theories of Freire (2000) and applied to the culture of impoverished rural communities in Brazil, also referred to as a "culture of silence," materialize in the form of a better understanding of the human condition and role in society. Education in such a context, according to Freire, happens most effectively in informal settings. The construction of new knowledge emanates from participants through discussions and the sharing of similar experiences. Following this pedagogical approach through community discussions, this study facilitated the narration of small farmers' experiences and

perceptions of granite quarrying on their lands. This led to a better understanding of the problem, primarily for the benefit of those affected, and secondarily for the purpose of the completion of this research.

Freire's framework surpasses the level of the individual, focusing on a collectivistic approach (respectful of the community's culture) to present a full understanding of that group (Giroux, 2010). Several studies in a variety of fields have been carried out, based on Freire's educational theories. Notably, Araújo et al. (2018) considered Freire's theoretical and methodological framework important in the field of nursing because of how it approached dialogue and promoted people to reflect on their reality. Heidemann et al. (2010) applied Friere's theories in a health study and concluded that participants' reflections led to the transformation of their own practices. This study aimed to present the application of the method of Paulo Freire in a research with professionals of family health teams, users and community leaders about the use of the notion of health promotion.

Thus, *change* in Freire's framework is a recurrent theme that evokes transformation through the construction of collective knowledge. Change theory establishes that every human being is capable of looking critically at the world when in a dialectical encounter with others. According to Friere (2000), "[p]rovided with the proper tools for such encounter, individuals can gradually perceive personal and social reality as well as the contradictions in it, become conscious of their own perception of that reality, and deal critically with it" (p. 32). This study aimed to generate the knowledge necessary to answer the research question and promote social change among the impoverished rural community of the São Pedro River Valley. By following Freire's theories, this case study sought to stir social awareness, or awakening, based on a dialectical, collectivistic, and emancipatory approach.

Study Significance

Various scientific studies conducted in recent years indicate that granite quarrying is an issue that is worth investigating. Researchers have extensively studied granite quarrying through a variety of lenses, such as social (Ibrahim et al., 2019), medical (Olusegun et al., 2009; Shaik et al., 2015), economical (Peterson, 2015), environmental (Busnardo et al., 2017) and political (Yahya et al., 2018). There is notably a general scholarly consensus about the need to improve the current state of granite quarrying (Sari & Özcan, 2018). The relevance of assessing the effects of granite quarrying is especially noteworthy in Brazil, due to its predominant place in the world market as a granite exporter (Peterson, 2015). The state of Minas Gerais is the second largest producer of granite in the country.

In the north of Minas Gerais, the Vale do Jequitinhonha region has been marked by a remarkable plundering of mineral resources whose impact on agrarian people needs to be studied (Sulzbacher et al., 2020). Similarly, the effects of granite quarrying on nearby rural communities have been overlooked. Although the destruction caused by granite quarries is visible in the São Pedro River, the extent of the damage remains scientifically unknown. There is currently no research dedicated to the theme of exploration of minerals in the Jequitinhonha Valley taken from a social and, especially, an agrarian standpoint (Sulzbacher et al., 2020). In that regard, the São Pedro River Valley case study adds a significant scientific contribution because it helps to close a research gap.

In addition to robust scientific data corroborating damage caused by granite quarrying, this study was also based on empirical evidence. Over the last few years, informal observations gathered and views expressed by small farmers and their families in the São Pedro River Valley community have revealed significant societal and environmental issues. Small local subsistence

farmers have raised several concerns with respect to the deterioration of their lands, their water resources, and their subsequent inability to produce crops to feed their families. There have been continuous distressing claims from small farmers about their land, which had been previously used for granite quarrying. Within the last few years, subsistence farmers have been abandoning their small lands for lack of productivity. Small farmers complain that their lands have been destroyed, streams have been contaminated with granite dust, and the soil has turned into "cement" (GGREF, 2018).

In additional, there is a need to investigate granite quarrying in the São Pedro Valley to provide an understanding of how rural communities' subsistence has been affected from an ethical perspective. This case study addresses a meaningful need rooted in human rights. The São Pedro River Valley, rich in granite reserves, is paradoxically one of the poorest and most isolated rural regions in the state of Minas Gerais, also known as *Sertão Mineiro*. When a vulnerable community living in a fragile environment is impacted by an economic activity that only benefits one side, it becomes a matter of social justice. As Freire sought social change through self-awareness using a pedagogical approach, this study aimed to raise mindfulness and knowledge about the effects of granite quarrying in an isolated rural community. Raising awareness is key to understanding an issue, and thus to better cope with it. At the societal level, this research sought to give voice to a vulnerable culture, also known as a "culture of silence" (Freire, 2000, p. 58). Most importantly, this research gives this vulnerable community an opportunity to no longer be part of a "culture of silence" (Freire, 2000).

This research is important because it also investigated an environmental problem. Impoverished rural communities who are dependent on natural resources for their livelihoods usually try to use them sustainably (Barraclough et al., 1997). Over the last decades,

unprecedented humanitarian crises and environmental destruction have been ravaging this poorest and most isolated region of Brazil, the São Pedro River Valley in the state of Minas Gerais. Rural poor have the biggest stake of all in protecting their environment from harmful pollution and degradation (Barraclough et al., 1997). This case study's significance was grounded on the interconnectedness between subsistence farmers and the environment. Subsistence farmers depend on natural resources (land and water) to survive, so if the environment is affected, their ability to harvest crops becomes compromised. By investigating subsistence farmers' perceptions of their ability to feed their families, this study also examined the evolving interactions of man with the environment. This research sought not only to identify social issues but also to capture the degradation of the environment as perceived by those whose livelihood directly depends on it.

Economically, this study explored a sensitive matter that is relevant to consumers worldwide. The granite imported into the United States comes primarily from Brazil (U.S. Geological Survey, 2021). There is a general lack of information on the damage caused by granite quarrying and on ways to minimize that damage (Levytskyi & Tolkach, 2017). As almost half of the granite imports to the United States come from Brazil (U.S. Geological Survey, 2021), there is a need to know about this issue, particularly among those who purchase granite-derived products (e.g. kitchen and bathroom countertops). As the awareness of environmentally friendly products grows and the number of consumers in search of ethically produced goods increases, realization about the effects of purchasing a non-renewable commodity becomes a plausible necessity. Because granite is a widely used exhaustible natural resource, it is essential to study the impacts caused by its quarrying and manufacturing activities (Monteiro et al., 2018). Conscious consumers want to understand how their choices impact the environment, and granite

quarrying is no different. Increasing knowledge among consumers about the extraction of this rock can ultimately lead to changes in the rural community in the São Pedro River Valley and potentially elsewhere.

In practice, this case study is significant because it calls for action and promotes awareness through discussion among not only small subsistence farmers, but also other communities, such as researchers, granite consumers, human rights and environmental activists, government agencies, etc. Raising awareness among stakeholders about this issue is important because it can eventually translate into change and can open the doors to non-governmental organization (NGO) initiatives and other forms of assistance in the region. This case study can lead the way to facilitating the implementation of interventional plans, reaching out to local and federal authorities to stimulate humanitarian and environmental assistance. When it comes to a social justice activism approach, scholars have to engage collaboratively with oppressed communities and with activists in interventions to promote social justice (Frey & Hanan, 2020).

Finally, on a personal level, this research project presents itself as a moral responsibility to me as the Principal Investigator. Witnessing the community's struggle to access food and water, and thus dignity, added a unique significance to the present work. Because of my history with this region and decades of participation in charitable activities consisting of food, clothing, and first necessity item (such as basic food, hygiene products and clothing), I have developed a strong connection with the community and their causes. Additionally, I am the co-founder of an NGO, GGREF, that brings humanitarian and environmental assistance in the Valley. GGREF is an American family-owned and -operated non-profit foundation. This initiative, although not connected with this research study, greatly benefited from it. Thanks to the findings that emerged

from this study, the adapted solutions that GGREF provides now are more targeted and have greater success.

As a doctoral student in search of academic excellence and practical knowledge, it became also an ethical obligation to use available tools to contribute to a better society. Closely familiar with the region since childhood and observing the growing concerns about land and water in the 1990s, the granite quarrying issue became a personal matter to address and for which to seek solutions. This case study was also a responsibility towards the community, and towards subsistence farmers who need to understand what has happened to their lands and how they have been impacted by it so that they can better cope with the problem. Also, those who are yet to be affected by granite quarrying need to be informed so they can make better decisions about their lands.

Epistemological Assumptions

Generally speaking, "epistemology is theory of knowledge" (Carter & Little, 2007, p. 3). According to Collins and Stockton (2018), "the epistemological dispositions represent the architecture of how a researcher sees the world and the production of knowledge" (p. 5). In that sense, epistemological assumptions are founded in both the theory and practice of research. When combined, the theory and practice of epistemology translate into the source of cognition needed to answer a research question scientifically. This study aimed to investigate how subsistence farmers have been impacted by granite quarrying in the São Pedro River Valley. In that regard, the source of cognition was contextualized around the idea of subsistence, or the state of farmers' livelihoods near granite extraction sites. Thus, to address this issue, the production of knowledge was centered around the farmers' perceptions of their ability to plant and harvest crops for their own consumption in the São Pedro River Valley.

Taber (2019) established that constructivism is linked to general epistemological commitments or to approaches to research. “The label *constructivist* is also sometimes associated with a paradigm, or research tradition, within social research that collects and analyses qualitative data to explore peoples’ perceptions and experiences” (p. 9). Taber’s epistemological assumption is rooted in a constructivist approach because the creation of new knowledge to address the research question is generated from the critical views on perceptions and experiences of others among a community of subsistence farmers. In this constructivist approach, individuals interact with the material world and construct their own model of knowledge that is influenced by the ideas of others (Taber, 2019).

In this study, epistemology rises from a context of social injustice among vulnerable communities. To effectively respond to the multiple injustices and socioenvironmental crises that we face, it is essential to change our ways of relating to knowledge, to each other, and to the place we inhabit (Hensler & Merçon, 2020). In Freire's theories, humans can become actively conscious of both the conditions and their sources, and how to change these conditions through social intervention and action (Au, 2007). Freire is committed to a dialectical epistemology that asserts that we can know things as integrated totalities and that we learn through a dialectical process of breaking things down into parts and “re-totalizing” them yet again (Au, 2007). In that regard, this study’s epistemology is also surrounded by axiology, because the knowledge constructed by subsistence farmers is generated by a dialectical collective process that is evaluated and justified in relation to broader cultural values (Carter & Little, 2007).

Conclusion

Granite quarrying constitutes an occupational hazard that compromises workers’ health, destroys the environment, and negatively affects nearby communities (Ibrahim et al., 2019;

Oktriani et al., 2017; Sasikala & Chandran, 2015; Shaik et al., 2015). Despite initial empirical data emanating from rural communities in the Valley, the effects of granite extraction in the region have remained scientifically unknown. This study aimed to address this research gap qualitatively by collecting and analyzing data from rural communities whose livelihoods directly depend on local natural resources. Rooted in a dialectical constructivist approach, this study's epistemological assumptions are centered around the farmers' critical views and collective perceptions about their own subsistence near granite quarries. The search for an in-depth understanding of the rural community was conceptualized through Paulo Freire's pedagogical framework because it was built on a collectivist approach specifically designed to build knowledge by empowering rural communities in Brazil.

This study's significance has a broad reach. First, it contributed to the present literature by exploring an unknown and isolated region. Second, it shed light on the intrinsic social and environmental interrelatedness between small farmers and granite quarries. Third, it revealed a dilemma that juxtaposes social justice with economic benefits. Finally, it raised concern among granite consumers, which promotes environmental and humanitarian awareness in the region. At a personal level, this study combined two outcomes: it represented an academic accomplishment leading to a PhD in Education, and it fulfilled a personal and moral obligation to give voice to a silent and oppressed minority.

Chapter 2: Literature Review

To understand how subsistence farmers are impacted by granite quarrying activities in the São Pedro River Valley it is necessary to have a brief understanding of the significance of the granite industry in Brazil. This literature review provides an overview of the Brazilian granite industry and its economic weight internationally. This chapter also compiles research studies conducted in different countries, including Brazil, aimed at understanding the effects of granite extraction activities on the environment and in society. Researchers have conducted studies mainly to examine and understand workers' conditions in nearby communities. They have explored the granite industry by addressing the matter from a legal perspective, analyzing the laws and policies governing this economic sector. Since the present case study focused on a rural community living in the sertão region, it is relevant to present a general overview of this region. The focus then narrows down to a specific area in Minas Gerais forming part of the sertão called the São Pedro River Valley. Finally, this chapter explores the life and customs of subsistence farmers living in the São Pedro River Valley.

Brazilian Granite

The increasing demand for marble and granite as durable and attractive building materials worldwide has been particularly beneficial to the economies of middle-income countries like Brazil, China, India, and Turkey (Peterson, 2015). Rapid industrialization in developing economies that are rich in natural resources, such as Brazil and India, is one of the main factors driving the demand for granite. These two emerging countries have large and diverse deposits of granite reserves. In addition, Brazil has a relatively modern logistics infrastructure that allows for the extraction and transportation of the materials to their main metropolises and to ports for export (Peterson, 2015).

Research indicates that there are only a few countries on the face of the earth as rich in natural resources as Brazil. These natural resources, ranging from minerals beneath the ground to waters above ground, have paved the way for the rise of Brazil as an economic power within the region, as well as throughout the globe (Choudry, 2013). Brazil has thousands of different types of marble and granite deposits, with roughly 900 firms operating in 1,500 to 1,800 quarries. Brazilian stone extraction, particularly granite, is widespread across the country, with as many as 15 out of 27 states providing at least 100,000 tons of gross production in 2012 (Peterson, 2015).

The United States and Brazilian Granite

The granite, marble and stone market in the United States is estimated at 5.4 trillion metric tons in the year 2020 (Global Industry Analytics, 2022). The granite imported into the United States comes primarily from Brazil (U.S. Geological Survey, 2021). The primary destination of Brazilian polished granite slabs is North America, which imports more than 80% of the region's granite (Peterson, 2015). Between 2016 and 2019, 45% of imported granite in the United States was from Brazil (U.S. Geological Survey, 2021). Granite is a rock formed from the slow crystallization of magma. It is composed mainly of quartz and other minerals (King, 2018). Sawmills take the raw blocks from quarry operators and cut them into slabs that can be polished and exported for final transformation into consumer products (Peterson, 2015). The main granite quarries in Brazil are located in the Southeast region of the country, and the main producers are the states of Espirito Santo (largest granite producer in the country), the state of Minas Gerais (mainly in the Northeast region known as the Vale do Jequitinhonha), and Bahia. These states alone are responsible for 80% of Brazilian granite production (Mezadre & Bianco, 2014).

In Brazil, the export of ornamental rock from January to May 2019 generated a total of $407.5 million dollars (Azevedo et al., 2020). In the United States, before the Covid-19 pandemic, nearly half of all granite imports came from Brazil (Ober, 2018). Importers from the United States include large home improvement retailers such as Lowe's and Home Depot, or specialized stone retailers that produce countertops, construction tiles, and other products (Peterson, 2015). Brazilian ornamental rock exports to the United States increased by 9% between 2018 and 2019. Due to the Covid-19 pandemic, there was a significant drop of 18% from 2019 to 2020 (Alves et al., 2020).

The processing of raw blocks into slabs is much more concentrated in Espírito Santo, which was responsible for more than 70% of the industrial transformation in the sector, whereas in Minas Gerais and Bahia the production process mostly consists of granite extraction activities (Peterson, 2015). Back in 2012, Espírito Santo's quarries extracted 3.6 million tons of marble and granite, or 40% of the country's production (Peterson, 2015). The neighboring state of Minas Gerais produced 22% of the country's ornamental stones, and the state of Bahia produced 8% (Peterson, 2015). Nowadays, Espírito Santo continues to maintain its dominance in the industry. The main hub of ornamental rocks in Brazil is located in the municipality of Cachoeiro de Itapemirim, a town in Espírito Santo, where much of its production is destined for exports (Azevedo et al., 2020). In 2017, their production accounted for 65% by volume of total quantities of ornamental rocks in the country (Azevedo et al., 2020).

Brazil has been an important global player since the 1990s, particularly after deposits of high-quality granite were discovered throughout the country (Peterson, 2015). In 2012, China imported 60% of Brazilian concrete blocks, and Italy imported 76% of the marble. While China and Europe's interests are in granite raw blocks, other markets are interested in processed slabs

(Peterson, 2015). In 2017, Brazil was the third largest exporter of granite in the world, with the state of Espírito Santo producing 50% of Brazil's ornamental stones and responsible for more than 70% of Brazil's exports (Azevedo et al., 2019), including the granite production of Minas Gerais.

Unfortunately, the Brazilian granite industry's progress did not take place in an organized and systematic way. The sector experienced serious difficulties in modernizing itself, in being able to compete in a global economy, and in organizing itself in a professional and sustainable manner. Most importantly, Brazil has not been able to maintain its productivity in an environmentally sustainable way (Bacarji et al., 2013). Not surprisingly, granite quarry pollution has affected countries producing natural stone, such as Brazil, because it results in environmental pollution, negative conditions for health, and economic losses (Sarici & Ozdemir, 2018).

Granite and the Environment

Much of the granite produced in Brazil comes from small quarries that lack investment in technology (Santos Silva & Costa, 2019). Over the last decades, environmental sustainability has been at the top of international political agendas and has been recognized as a key driver of innovation (Dangelico & Vocalelli, 2017). Today, environmental awareness has become mainstream, impacting 83% of consumers among every generation in America. Sustainability now represents an important consumer need, and is an integral aspect of product quality (Ottman, 2011). A growing global consumer environmental awareness has led several manufacturers to offer eco-friendly products (Zhang et al., 2019) to adapt to consumers' new green demand. Consumer choices reflect not only price and quality preferences but also social and moral values, as witnessed in the remarkable growth of the global market for organic and environmentally friendly products (Mazar & Zhong, 2010).

In the stone industry, however, despite existing regulations geared towards cleaner production, there are deficiencies in adapting to a greener production process (Bai et al., 2016). This is the case particularly with respect to granite extraction activities, like granite quarrying. The literature continues to produce evidence of the impacts of granite extraction and manufacturing activities on nature. Systematic data show that granite extraction activities can significantly damage the environment (Busnardo et al., 2017; Oktriani et al., 2017). Notably, Sasikala and Chandran (2015) suggest that granite quarrying is one of the most environmentally unfriendly industries.

The granite production process in Brazil has led to serious environmental problems (Bacarji et al., 2013). The damage caused by quarries starts at the extraction phase. Granite quarries are normally utilized for extracting building materials like dimension stone, and are normally shallower than other kinds of open-pit mines (Sasikala & Chandran, 2015). Cutting the stones produces heat, slurry, rock fragments, and dust. The fine particles can cause more pollution than other forms of granite waste unless stored properly in sedimentation tanks and used for other purposes (Sasikala & Chandran, 2015). Quarrying activities severely alter landscape topography, soils, and vegetation. In some cases, the stability of soil or construction can have catastrophic effects (Busnardo et al., 2017). Granite quarry pollution consists mostly of waste formed during production, but also during the processing phase (Sarici & Ozdemir, 2018).

The sequence of events involved in the granite extraction process has not changed much since stone entered the homes of the ancient Greeks (Gupta, 2018). After extraction of the blocks, the primary processing—splitting, or sawing—of the plates happens, using equipment called looms. During sawing the plates (slabs), a slurry is generated that contains abrasive remains and consists of water, iron particles, lime, and ground rock. After passing through the

loom, about 20–30% of the extracted block is converted into sludge, which is drained by a sewage system where the water is recycled and the solid material removed and deposited in landfills or in areas reserved for companies (Bacarji et al., 2013). The granite industry generates a large amount of residue during the process of transforming raw blocks, extracted in blast processes, into slabs (Azevedo et al., 2019). In Brazil,190,000 tons of polluted mud is produced every year in the manufacture of granite and marble (Bacarji et al., 2013).

Societal Impacts of Granite Quarrying

When an environment is damaged, those who directly depend on it to survive are particularly impacted. Sasikala and Chandran (2015) collected data from households affected by granite quarries in Vellarada, India and their study revealed that, as a direct result of granite processing activities, individuals were affected by shortages of water, noise and dust pollution, vibration, health problems, and land degradation (Sasikala & Chandran, 2015). According to Sari and Özcan (2018), who carried out a recent study of 12 quarries in Turkey, quarrying activities that do not operate properly can result in significant land loss to small farmers, mostly due to dense dust particles suspended in the air. Granite quarrying can lead to irreversible changes in the environment and, consequently, to major societal issues (Baciu et al., 2011).

Granite quarrying also has a direct effect on water. Oktriani et al. (2017) investigated river pollution caused by the natural stone industry, focusing on wastewater treatment. The data collected from water quality tests indicated a high concentration of toxicity in a quarry located in Indonesia. Most businesses in the natural stone industry are located near the river because some parts of the production process need water. River water is utilized to reduce the heat of the machines and also to clean the dust created from the stonecutting activities. These kinds of activities near the river bank affect the quality of water. Rivers also become a dumping ground

for waste produced in the form of liquid industrial waste, which affects the quality of the river. According to Sasikala and Chandran (2015), "[q]uarrying activities are known to affect both the surface and groundwater regime. Shortage of water and pollution are the most severe problems faced by the people. The local topography and drainage pattern may considerably influence the severity of pollution" (p. 343).

Shaik et al. (2015) examined granite workers' health in India and concluded that exposure to granite particles, known as silica dust, produces changes in lung functions, leading to chronic, irreversible lung disease. Songmene, Kouam and Balhoul (2018) focused on ways to reduce workers' exposure to granite particles, especially during the process of polishing granite slabs. Olusegun et al. (2009) studied the impact of granite quarrying in Nigeria. Their study identified the presence of hazardous particulates generated onsite and concluded that granite quarries can cause respiratory ailments in quarry workers and negatively affect nearby residents' health.

Quarrying Laws and Policies

Developing countries, where traditional institutions regulating resource management still persist, may have little real power if outsiders, in alliance with local elites or with representatives of the national state, find it profitable to exploit their resources (Barraclough et al., 1997). In Brazil, as in the United States, states have autonomy to legislate on environmental issues. Monteiro and da Silva (2018) identified several failures regarding the reliability of the evaluation of environmental impacts and licensing in Brazil's crushed stone industries in Northern states. Their study found that there were delays in issuing licenses within the period established by law, and there were no periodic environmental inspections.

Mezadre and Bianco (2014) studied policies regarding workers in the marble and granite processing industry and its high risks to their health and safety, and underlined the importance of

formalizing policies and practices for managing people in this industry, as well as in other labor-intensive industries. Poorly regulated industrial activities represent a threat to the business's image, as it compromises workers' well-being, the environment, and nearby communities. With respect to environmental licensing in Brazil's industries, Monteiro and da Silva (2018) suggested that the population should contribute to environmental conservation, denouncing attitudes that negatively impact the environment..

Yahya et al. (2018) recently conducted a legislative analysis on quarry rehabilitation in Selangor, Malaysia. Researchers identified loopholes in the laws and policies leading to ineffective quarry rehabilitation, and concluded that the only way to sustain the granite industry and continue to benefit from it was through adequate legal frameworks and policies. Another recent study in Turkey concluded that if a quarry is opened on arable lands, it is of vital importance to properly excavate and store soil formed through chemical and physical processes under various conditions for many years, in order to ensure that the soil is reusable (Sari & Özcan, 2018).

When operations cease in a given granite quarry, the site is often in need of environmental restoration. In general, rehabilitation of inactive quarry pits is required by law. However, rehabilitation efforts rarely attempt to restore ecological function to a site, and even more rarely consider the ecological implications of landscape context (Corry et al, 2008). Recent research shows that there are major gaps among regulatory agencies aimed at helping to minimize quarry pollution, workers' health conditions, and environmental destruction (Ibrahim et al., 2019; Sari & Özcan, 2018; Yahya, 2018). With respect to quarry rehabilitation, Yahya et al. (2018) underlined the consequences of extraction sites that are left without proper restoration. Many exhausted quarries are abandoned without being rehabilitated. As a result, the industry

gains an unfavorable image while the vacuum in the legislative framework remains (Yahya et al., 2018).

A Region Called Sertão

The term sertão translates literally as *hinterlands*, which means an area behind a coast or the shoreline of a river. The concept itself can be perceived as derogatory, evoking a tributary region, the backcountry around a town, or the periphery of a larger and more important region. However, hinterland, or backcountry, is a relational concept, depending on the perspective of the speaker and activities. At first glance, Brazilians associate the term sertão to the inlands. However, a deeper analysis reveals a transformation of the meaning over time (Alcântara, 2018). It is referenced in the literature as colonial wilderness, portrayed as an empty and frightening land.

Vainfas (2019) explored the conquest of the hinterlands by Portuguese settlers, especially the search for gold, silver, and precious stones, as well as the enslavement of Indians. The term sertão has also been translated as *badlands* (Staff, 2004) and backlands. According to Moreira (2013), João Guimarães Rosa's famous literary piece, *Grande Sertão: Veredas*, one of the greatest novels in the Portuguese language in the 20th century that contains reflections on social conflicts and shifting identities in a vast isolated rural area in Brazil, translates the term sertão as *backlands*. The novel has inspired an enormous output of scholarly work that approaches it from every critical perspective: linguistic, historical, sociological, metaphysical, and even esoteric (Moreira, 2013).

During Portuguese colonization (17th to 19th centuries), the Brazilian coastline was dominated by the colonizer (Alcântara, 2018). The sertão was then a hostile and unknown inland region. References to the sertão appeared in the 18th century, with the history of the Bandeirante

Movement, which praised the adventurous and urban Paulistas hunters of Indians for slavery (Neves, 2018). Since the colonization of Brazilian territory, indigenous peoples have been going through diasporic processes, especially in the eastern part of the country. In the first three decades of the 20th century, the Paulistas were given responsibility for expanding national borders and discovering mines inland. These ideas were the foundation for the construction of São Paulo's cultural hegemony, when São Paulo assumed national economic supremacy (Neves, 2018). Indigenous cultures continue to be disregarded and not recognized or valued by a society that is unaware of the presence of indigenous villages in southeastern Brazil, notably in the Jequitinhonha and Mucuri Valleys (Silva, 2018).

In the sertao, the fabric of society was shaped by the history of feudalism. In the sertão, people lived in archaic social circumstances under the control of local delegates who acted upon phony democratic principles (Neves, 2018). The hinterland, without precise geographic specification, was considered the antithesis of the coastline areas. It was a vast and occupied area for the outcast culture and ways of life that often ignored laws and customs set by city values. According to these interpretations, the sertão was the opposite of civilization, and therefore the place of barbarism (Alcântara, 2018). In the second half of the 20th century, a strictly economic perspective of the sertão was outlined, with an emphasis on mining and livestock as primary factors in the colonizing occupation of the semiarid areas and, secondarily, the agricultural polycultures of cereals, cotton, and other small crops complementary to monocultures. The evolution of transport and the modernization of agricultural techniques extended monoculture activities to the semiarid region and incorporated new methods of livestock management (Neves, 2018).

A History of Fire Practices

Fires have been a common practice in Brazil for the creation of pasture lands or for large scale agricultural activities. The northeast of Minas Gerais has particularly been affected by indiscriminate fire practices. In fact, fire is one of the most important issues in rural Brazil, and indigenous and rural communities are seeking help to manage fires that have become increasingly difficult to control (Eloy et al., 2019). Since the beginning of colonization, intentional fires have been used for the preparation of areas for the planting of sugar cane, coffee, and soybeans. The use of careless field fires for agro-pastoral practices and for the opening of human habitation has been a reality in Brazil since its discovery (Tavares, 2018). In particular, *Caatinga* fire management issues are especially important because they have been seen as the "odd man out" in tropical development debates, in spite of their considerable complexity and the massive level of threat that they face from agro-industrial expansion (Oliveira & Hecht, 2016). Little is known about restoring these landscapes once they are destroyed, although subtle forms of fire management most certainly play a key role (Eloy et al., 2019).

Poverty

More than ten million people live in the sertão, on lands severely degraded by decades of deforestation, plowing, and goat herding. Rain, when it arrives between long periods of drought, comes in torrents, often providing as much devastation as sustenance. Up to 80% of it is lost to evaporation and non-absorption (Staff, 2004). Semiarid regions, home to hundreds of millions of smallholder farmers worldwide, are hotspots for food security and climate adaptation (Goldblatt et al., 2017). The Brazilian sertão, comprising the northeastern region of Brazil, is today the most populous semiarid region in the world. This extensive region also faces the highest rates of poverty, food insecurity, and climate risks in this country (Maia et al., 2018).

Rural families in the region face harsh socioeconomic conditions and depend on natural resources to survive (Souza & Honorio, 2020). The region has developed urban centers, and hinterlands have evolved to constitute symbolic spaces, explaining the Brazilian social duality presented by historiography and literature through the dialectic of progress and backwardness of the modern and archaic (Neves, 2018). There is also the sertão scenario of social conflicts, driven by the activities of bandits, colonels of the National Guard, messianic preachers, community leaders, or rural social movements struggling for land ownership; on the other hand, sertão is a reference for artistic expressions and cultural manifestations that have established themselves as a national heritage (Neves, 2018).

Increased Climatic Challenges

An Unbalanced Climate

Low annual precipitation levels alone were not the only cause of subsistence farmers' inability to plant and harvest their crops. The region presents a natural challenge marked by two distinct seasons: *mês da seca* (the dry months) and *mês das águas* (the rainy months). The semiarid climate is typically marked by irregular distribution of rain throughout the year (Lacerda et al., 2020). Thus, one of their main struggles consists in having access to water during the dry months, when the lack of rain can last several months, with an annual dry period lasting from seven (Mota & Martins, 2019) to nine months (Pinheiro et al., 2017). In the São Pedro River Valley, it rains heavily during a few months (mostly from December to February). December rainfall averages 167 mm, the highest precipitation month (Lacerda et al., 2020). It is during this period that rural communities normally have access to water for their own consumption and for their crops. To increase their chances of harvesting, they plan their planting so that the development stage of the plant, when it needs most water, coincides with the month of

December. This month is also the main period for replenishment of their water reserves (Lacerda et al., 2020).

Yet, even during the rainy months, subsistence farmers experience challenging climatic conditions such as erratic rainfall, which often results in flooding. Annual rainfall averages 773 mm, and 70% of this rain may fall in a single month (de Andrade, do Nascimento Aquino, Guerreiro Chaves & Bezerra Lopes, 2017). During the few months of heavy rain (from December to February), the area floods abruptly, but shortly after, the water has mostly vanished, leaving very little to no water for the days and months to follow. Another contradicting climatic irregularity during the rainy months, *veranicos,* is unexpected hot and dry days when typically there should be abundant rain. In 2019, there were 44 days of veranicos, which was one of the longest ones since 2015 (Lacerda et al., 2020). Finally, another climatic challenge to subsistence farmers' livelihoods is the high levels of evaporation, a common characteristic of droughts (Wu et al., 2020). This characteristic can be explained by the combination of two factors: increasing numbers of dry days during the *veranicos*/rainy months and the increase in temperatures.

Less Rain and Higher Temperatures

In this region, subsistence farmers are facing climatic challenges, with increasingly fewer days of rain and hotter temperatures. The number of days in the sertão without rain has increased over the years from an average of 254 in the 1970s to 275 in the 2010s (Maia et al., 2018). When compared to previous generations, subsistence farmers' livelihoods have been severely reduced over the past three decades. Recent studies corroborate this, indicating worsening climatic conditions marked by an increase in temperatures and a decrease in yearly levels of precipitation (Burney et al., 2014; Lacerda et al., 2020; Maia et al., 2018). Studies indicate a consistent increase in temperatures over the years, and rising temperatures have made it more difficult for

crops to survive. In the sertão region, average temperature has risen at a rate of 0.26 °C per decade, with the maximum temperature shifting from an average of 30.0 °C in the 1970s to 31.4 °C in the 2010s (Maia et al., 2018). Overall, climate records show that over the last 50 years, average daily temperature has increased by approximately 2 °C (Burney et al., 2014).

The severity of drought has been increasing over the years, making it nearly impossible for rural families to plant and harvest their crops. Subsistence farmers have been losing their ability to harvest. Between 2015 and 2019, both the irregular distribution of rainfall and the severity of the dry season resulted in the loss of grain production and decreased food security for families in the region (Lacerda et al., 2020). Global climatic changes and environmental degradation have been negatively impacting agriculture and livestock, especially in the sertão region, where the desertification process advances strongly (Guilhermino et al., 2019).

Recent research indicates that climate change in the sertão over the past 40 years is remarkable, confirming some of the most pessimistic scenarios for semiarid regions in the world (Maia et al., 2018). Subsistence farmers do not make a direct association between the changes in the environment that affect their crop production and climate change. However, by revealing the contrast between their crop productions from the past (30 years ago) and the present, clear environmental variations are underlined over the years. Climate models agree that semiarid regions around the world are likely to experience increased rainfall variability and longer droughts in the coming decades (Burney et al., 2014).

Deforestation

Deforestation in Brazil began in the 17th century, during the colonial period (Sousa & Honorio, 2020). According to the Brazilian Institute of Geography and Statistics, back in 1993 more than 200,000 km^2 of vegetation (almost 50 million acres) had already been wiped out

(Sousa & Honorio, 2020). Deforestation practices continue today (Sousa & Honorio, 2020) with more than 50% of the Caatinga's local vegetation destroyed (Guilhermino, 2019). Caatinga is the world's largest and most diverse seasonally dry tropical forest (Pinheiro et al., 2017). It is a complex subtropical water-limited ecosystem and the only exclusively Brazilian biome (Pinheiro et al., 2017). Pereira et al. (2020) assessed the vulnerability of the Caatinga and concluded that 15% of the studied territory faced severe susceptibility to desertification (Pereira et al., 2020).

Reasons Behind Deforestation

According to the Brazilian Ministry of Environment, deforestation of the Caatinga is mainly due to the illegal and unsustainable exploitation of native wood, as well as overgrazing for extensive cattle raising (Sousa & Honorio, 2020). Most importantly, the Caatinga biome has been rapidly deforested due to the indiscriminate exploitation of forest resources for industrial purposes and for large-scale agricultural development (Guilhermino, 2019). Deforestation has transformed the Caatinga into pasture, arable land, and other types of intensive land use (Sousa & Honorio, 2020). Contrary to subsistence farmers, who use naturally arable land and available water resources, large scale agro-industry and livestock production use widespread deforestation as part of their practice.

Fires have also been systematically used to remove trees on millions of acres. At this macro level, serious concerns are raised about what one might call "disappearing biomes" due to the expansion of commodities such as soy (Oliveira & Hecht, 2016). Most widely discussed is southern Amazon, but far more significant is the Cerrado and its transition into the Caatinga, the dry forests of northeastern Brazil which has lost more than half of its vegetation since colonial times (Oliveira & Hecht, 2016). In the words of subsistence farmers, not only plants and trees have been destroyed, but natural soil fertilizers are gone as a result of deforestation practices. In

the context of large-scale agricultural activities, studies suggest an increase in a process of desertification (Pereira et al., 2020).

Little is known about recuperating these landscapes once they are destroyed, although subtle forms of fire management most certainly play a key role (Eloy et al., 2019). Conceptually, subsistence farmers understand the level of threat, and in direct opposition, the little attention it has received. They claim that the destruction of their environment is not an issue of concern to the public in general. Indeed, "savanna management issues are especially important because they have been seen as the *odd man out* in tropical development debates" (Eloy et al., 2019, p. 6). Not surprisingly, deforestation has contributed, at an accelerated pace, to global social injustice, hunger, and poverty (Guilhermino et al., 2019).

Today, Brazil continues to witness the misuse of fire for deforestation and conversion of natural vegetation into intensified agriculture and pasture plantations (Eloy et al., 2019). Some industrial activities in the region in need of meeting their own energy demand are responsible for damaging a large quantity of hectares through deforestation practices (Souza & Honorio, 2020). Agro-industrial activities have fragmented the Caatinga, covering the soil with alternating crops and pastures (Pereira et al., 2020). In the sertão, some of the most harmful activities are coal, firewood extraction, livestock, and agriculture (de Brito Chaves et al., 2015).

Desertification

Fundamentally, desertification is the process of land degradation in arid, semiarid, and sub-humid natural environments (de Brito Chaves et al., 2015). Subsistence farmers are having their lands destroyed in great part due to deforestation that has been favoring large-scale economic activities. Since part of granite extraction activities involve deforestation, quarries

contribute to this process of land degradation in the region. Desertification is usually associated with the erosive effects of rain, aggravated by human activities (de Brito Chaves et al., 2015).

Drought and Poverty in the São Pedro River Valley

Despite Brazil's privileged income position in comparison to the rest of the world (about 80% of countries worldwide have a lower income per capita than Brazil), there continues to very high levels of inequality in terms of income distribution and poverty. In the country, the poorest areas are the north and northeast regions, while the richest regions are located in the south and southeast (Fahel & Teles, 2018). In the state of Minas Gerais, the poorest areas are the north and northeast regions, while the richest regions are located in the south and southeast (Fahel & Teles, 2018).

The higher indices of poverty in Minas Gerais are in the Rio Doce North and Jequitinhonha/Vale do Mucuri regions, which are also the highest indices of poverty in Brazil (Fahel & Teles, 2018). Since the 17th century, in the north of Minas Gerais where the lower portion of the Jequitinhonha Valley is found, the main activity was cattle raising, which reached the territory of Minas Gerais through the São Francisco Valley, also known as the "river of the corrals." Currently, there is a predominance of mining activity in the upper Jequitinhonha, a predominance of cattle raising in the lower Jequitinhonha, and mixed activity in the intermediate region (Souza, 2003). Nevertheless, it remains deficient on rural production, which explains its low Human Development Index rate (Santos, Ferreira & Campos, 2018).

The physical location of this case study takes place in the São Pedro River Valley. This Valley is found in the poorest area of Minas Gerais, in the northeast region known as the Sertão Mineiro, forming part of the Jequitinhonha Basin (Souza, 2003). The Jequitinhonha Valley occupies over 30 thousand square miles, and approximately one million people live there,

distributed in 80 municipalities. In recent years, the interest of researchers in the region has grown steadily, due to the widespread discourse according to which the Valley boasts social and economic indicators comparable to the worst in the world (Souza, 2003).

The São Pedro River is part of the Jequitinhonha Basin (Latitude: -16.500; Longitude: -41.333). In addition to high levels of poverty, communities face climatic challenges due to very low rates of precipitation, substantially increasing their vulnerability levels. Definitions of vulnerability vary among scholars. The most influential is probably that of the Intergovernmental Panel on Climate Change, which defines it as "characteristics of human or social-ecological systems exposed to hazardous climatic or non-climatic events and trends (Herwehe & Scott, 2017).

In the São Pedro River Valley, there is very little rainfall year-round. The average annual rainfall is 747 mm (29.4 inches). In favorable years, precipitation reaches its peak in December, with an average of 173 mm. Originally perennial, the São Pedro River is now an intermittent stream tributary of the Jequitinhonha River. Starting at an altitude of approximately 1100 m, near the town of Agua Branca, the river runs through a steppe climate with scarce vegetation, known as Caatinga. The semiarid region sits at the nexus of climate impacts, adaptation, food security, and economic development. Monitoring vegetation and biomass dynamics in these regions is critical for sustainable development (Goldblatt et al., 2017).

The dominant vegetation, the Caatinga, ranges from open scrublands to tall, dry forests. This type of vegetation, also called dry forest, comprises at least 135 geo-environmental units and nine distinctive ecoregions (Da Silva et al., 2018). The Caatinga lies inclined over crystalline rocks (gneisses, granites, and schists), which represent the predominant geological units in the eastern part of the northeast (de Andrade et al., 2017). Despite centuries of inadequate soil use

and uncontrolled exploration of its natural resources, the Caatinga has been neglected in terms of research efforts and conservation policies (Mesquita et al., 2017). The problem is even bigger if one takes into account that one-third of the Caatinga has a high potential for desertification (Da Silva et al., 2018).

The Caatinga is a savanna-like vegetation, a type of desert flora found in interior northeastern Brazil. Because of the semiarid climate, local farmers and isolated rural communities depend heavily on small nearby water streams. In fact, the climate in the northeast of Minas Gerais has been a major factor that increases local communities' inability to grow crops and feed their families. A recent study has shown high vulnerability of the human population in the northeastern part of the state of Minas Gerais, based on aggregating social, environmental, and epidemiological aspects to downscale climatic scenarios (Quintão et al., 2017). Small farmers indeed are particularly affected in the area because water is generally scarce due to a predominantly arid climate. In fact, drought seasons last for several months during which there is very little to no precipitation (Quintão et al., 2017).

Subsistence Farmers in the São Pedro River Valley

Subsistence farmers are people who grow what they eat, build their own houses, and live without regularly making purchases in the marketplace. Peasantry, or subsistence farming in Brazil, is considered a way of life, a culture (Silva, 2019). Present in Brazilian territory since colonization, peasantry has shaped the formation of the Brazilian agrarian space, even, in the majority of cases, as they are excluded from the main public policies and installed in precarious spaces of agricultural production (Silva, 2019). The population living in Brazilian semiarid areas consist primarily of subsistence farmers (Santos da Silva, 2017). Those farmers plant crops primarily to feed their families. They are smallholders, known as peasants, who often survive

from subsistence pastoralism, raising livestock for their own consumption. Because subsistence farmers' production is used for their own consumption, the crops can be produced on a few hectares of land at most (Santos da Silva, 2017).

Small subsistence farmers show a certain balance between consumption and the individuals who work and maintain the struggle for sustainability of the land. For these subsistence farmers, unity with the land is a fundamental condition for their existence through the production of food (Silva, 2019). According to Santos da Silva (2017), in the peasantry, the purpose of production is not accumulation (Santos da Silva, 2017). When a subsistence farmer goes to the local market and sells his crops, the money is used to buy crops from another small farmer. Thus, the small farming economy has its own dynamics of collaboration and organization (Santos da Silva, 2017). Anthropologist Flávia Galizoni (Galizoni et al., 2020) conducted research on rural families in the upper Jequitinhonha, seeking to understand the relationship of the population with its natural environment. Her research placed the rural family as the fundamental unit that manages natural resources and examined the labor of the rural population as the main form of land sustainability. Galizoni et al. (2020) revealed that the scarcity of resources, which was a result of fragmentation of properties, is avoided by differentiated management, based on the population's knowledge of the environment and local traditions.

For small subsistence farmers, crop production combined with products extracted from the environment (leaves, fruits, roots, and animals, among others) represent the main source of food for rural families (Ribeiro, 2014). As a deeply collectivistic society, the exploitation of these resources is commonly done in a community management scheme. Community members can exploit resources considered to be renewable (medicinal plants, cattle pasture, firewood,

etc.), taking care not to put too much pressure on their availability. These areas are hardly fenced, as they are in common use by families in the community (Ribeiro, 2014).

In the sertão region, the scarcity and distribution of rain generates the need for farmers to resort to the use of irrigation practices (Alves et. al., 2017). Smallholder family farmers are the most vulnerable group, who deserve more social and technical intervention because they lack basic social and technological resources that could greatly improve their productivities and overcome the impacts of decreasing precipitation (Maia et al., 2018). But in the São Pedro River Valley, the lack of resources, water supplies, and infrastructure makes it impractical for most producers to develop any type of irrigation system in the region. These populations, who are among the world's poorest, depend primarily on rain-fed agriculture for their livelihoods (Goldblatt et al., 2017).

Irrigation projects in the sertão have proved to be a viable adaptative measure only where perennial water sources are available, and not in the case of small and medium water reservoirs that dry up regularly, or during each prolonged drought (Maia et al., 2018). The São Pedro River, formally perennial, now has turned into an intermittent stream (GGREF, 2018). To sum up this dissonance, ground water is not a completely renewable resource and, in many situations, the rate of withdrawal surpasses the rate of recharge from precipitation (Maia et al., 2018). In the sertão, increasing water scarcity, driven by increased competition for available water supplies and climate-induced shifts in hydrologic systems, make rare the areas suitable for irrigation. Moreover, the region does not provide wells with high yields, being mostly smaller subsurface reservoirs and aquicludes. Most importantly, ground waters generally have high levels of salinity (Maia et al., 2018).

Sustainable Development in the Sertão

Historically, the sertão has played, and continues to play, an important role in the Brazilian socioeconomic formation (Neves, 2018). Since the 17th century, including during the dark centuries of Brazilian slavery, vast extents of lands belonged to a few influential landowners who dominated the agricultural industry, producing mainly coffee, cocoa, cotton, and tobacco. This period was followed by an extensive cattle-farming industry in the region, resulting in abusive deforestation and fire practices. According to Sulzbacher et al., (2020), "in the Jequitinhonha Valley, the history of three centuries of explorations of natural resources has unleashed several processes, but it has rarely involved a development connected with locals and regional issues, with the population and with equitable principles" (p. 8).

Sustainable development needs to be accompanied by public policies. However, throughout history, governments have overwhelmingly tended to prioritize the economy over environmental concerns. Herwehe and Scott (2017) studied the impact of Brazilian social policies aimed at ensuring successful and integrated sustainable development and concluded that aggressive government-funded social support programs, paired with economic growth and technological advancements, need to be implemented for successful and sustainable development to take place (Herwehe & Scott, 2017).

Aleixo et al. (2019) addressed social inequality in the northeast of Brazil by measuring communities' access to water. The importance of reducing diverse forms of inequality in access to water highlighted both the framework of the human right to water and the sustainable development goals. They assessed the conditions of access to water and related inequalities before and after the construction of a water supply system in a rural community of Brazil's

semiarid region. The study concluded that increasing access to water is an initiative that does reduce but does not solve social inequalities altogether (Aleixo et al., 2019).

Conclusion

The volume of Brazilian granite in the production and import/export industry is immense. Economically, granite is a profitable industry, a strongly desired commodity by consumers worldwide, especially in America where demand is continuously growing. This demand translates into increased extraction activity in developing countries. Conversely, this economic activity is detrimental to the environment and thus to those who depend on it directly to survive. There is an irrefutable consensus among scholars about the negative impacts of granite in communities and on the environment. Despite existing laws to regulate the industry, implementation initiatives in several countries, such as Turkey, Brazil, and India, are lacking. Several factors come into play as we consider empirically the impacts of the current granite quarrying activities in the São Pedro River Valley. Such impact is particularly severe in this rural region of Brazil because it is heavily affected by decades of drought, land appropriation, lack of infrastructure, and extreme poverty. Geographically, São Pedro River Valley forms part of the sertão, a culturally and historically rich region with intense folklore deeply rooted in tradition. Rural families in the region face harsh socioeconomic conditions and depend on natural resources to survive (Souza & Honorio, 2020). The livelihood of subsistence farmers in the São Pedro River Valley depends on their communal crop production, combined with products extracted from the environment. Thus, when the environment is destroyed, it directly affects their chances of survival.

Chapter 3: The Method

While scientific evidence corroborates various dangers to society and the environment caused by granite quarries, empirical data suggests those dangers have been particularly felt among an isolated community of subsistence farmers in the São Pedro River Valley. The following chapter presents and justifies the methods used to investigate the effects of quarrying in this region. Several implications and limitations are discussed in this section with regard to the design of the study, participant selection, and data collection. This chapter explains what guided the method for this study, and most importantly, why a case study was chosen as a method of inquiry. It is important to address how the study was designed with subsistence farmers in mind, notably with respect to participants' language, culture, and level of vulnerability. Thus, the method in this study was shaped to fit participants' conditions and needs. It aimed to promote discussion in search of a greater collective awareness geared towards action and change. Thus, the form of data collection was chosen to address the research question following Freire's pedagogical approach and in accordance with the nature of participants. The method reveals how this study's goal residing in addressing the research question is intertwined with participants' need for change. Such a dynamic established an interdependence between myself and the participants, through the RA. This chapter also provides an overview of how this study was shaped by the pandemic of Covid-19.

The Design

Epistemology Guided the Method

According to Collins and Stockton (2018), "[t]he central role of theory comes into greater clarity when the interdependence between epistemology and theory selection is made explicit. Then, the influence on the selection of a case and a framework for analysis flows naturally" (p.

6). Thus, epistemology guides methodological choices (Carter & Little, 2007). In the São Pedro River Valley case, subsistence farmers' critical thinking about their collective perceptions guided the study's constructivist theories. Constructivist theories suggest that knowledge cannot be simply transferred from one mind to another. Rather, individuals have to represent their ideas in a form that allows others to process those representations and so construct their own knowledge (Taber, 2019). In that sense, sharing of information alone is just communication. To reach new knowledge, individuals need to develop a new relationship with the information that was shared. Similar to learners who have to make their own sense of teaching based on the resources they already have to interpret it (Taber, 2019), participants in this study had to process the new information in relation to one another to constitute the creation of knowledge.

A Dialectical Approach

Conceptualized through Paulo Freire's pedagogical framework, the study followed a dialectical philosophy, where things can only be understood in relation to each other and cannot be analyzed as independently existing pieces (Au, 2007). A dialectical approach shaped this study with regard to its framework and design and contributed to new knowledge that went hand in hand with changes in practice, power relations, and future policies. In this way, it contributed to the merging of research, education, and action, as proposed by Freire (2000), with the potential for promoting significant individual, collective, and territorial transformation towards a more just and sustainable world (Hensler & Merçon, 2020). Freire's dialectical materialism provided a framework for analyzing objectively existing conditions in the world, for understanding that humans can become actively conscious of both the conditions themselves and their sources, and for changing these conditions through human intervention and action (Au, 2007).

Why a Case Study?

The case study form of inquiry involves understanding an issue (Creswell & Poth, 2016). Case study research is a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (Creswell et al., 2007). In the context of this research study, the issue to be explored was the impact of granite quarries. Subsistence farmers who have lived in the region continuously for the last 30 years delineated the bounded system in this case study, which was a single instrumental case because it explored one issue within one bounded base. In a single instrumental case study, the researcher focuses on an issue or concern, and then selects one bounded case to illustrate this issue (Creswell & Poth, 2016).

The fundamental goal of case study research is to conduct in-depth analysis of an issue within its own context in order to understand it from the perspective of participants (Mills et al., 2017). Case studies usually have multiple information sources, such as documents, archival records, interviews, direct observations, participant observations, and physical artifacts. Researchers may also videotape the interactions and record field notes about the process, and ask participants to write about their experiences in a journal and share their progress (Creswell & Poth, 2016). The sources of information in this case study primarily originated from subsistence farmers. Additional sources consisted of on-site observations, images, video recordings, and soil analysis. Case studies are used to describe a phenomenon and the real-life context in which it occurred (Baxter & Jack, 2008), and in this study, the phenomenon consisted of ongoing granite quarrying activities as experienced by subsistence farmers living in the São Pedro River Valley.

Because this study was framed within Freire's (2000) pedagogical theories, the data collection and analysis followed a contextualized dialectical structure that focused on

participants' interaction with each other's perceptions. The method was designed to fit the locals' culture within their own context. The focus in case study research is not predominantly on the individual (and their stories) but on the issue with the individual case selected (Creswell et al., 2007). This study revolved mainly around the participants because their perceptions could not be collected in dissociation from them. Since subsistence farmers framed the context surrounding the issue, the attention was primarily geared towards them. Researchers use the case study method because they deliberately want to cover contextual conditions—believing that they might be highly pertinent to their phenomenon of study (Creswell et al., 2007). The elements pertinent to this study were delineated by participants' perceptions of the impact of granite quarries on their livelihoods.

Unstructured Focus Groups

Focus group methodology uses groups as an integral element of the methodology (Jamieson & Williams, 2003) because the method shapes the overall format of the study. In focus groups, participants tend to answer questions more freely and accurately in an environment that creates shared experiences (Doherty, Ramsey, Ibbotson, Carcary & Conway, 2018). Using focus group methodology allows the researcher to gain authentic, quality data relying on the spontaneity of participants in an atmosphere of dynamic group interaction (Jamieson & Williams, 2003). In the São Pedro Valley, individuals' culture is deeply rooted in a communal identity. Communication happens collectively and effectively in a verbal, unstructured way, with individuals sharing ideas daily through very informal lively discussions, usually permeated with interferences that do not hinder their conversations. Freire's pedagogy enables students and teachers to be subjects who can look at reality, critically reflect upon that reality, and take transformative action to change that reality based upon the original critical reflection (Au, 2007).

To maintain the environment as authentically as possible, this case study was designed with an unstructured focus group approach to entice group discussion and place participants at the center of the study. Unstructured focus groups were designed to provide participants with a familiar and conducive setting, and so group discussions took place at the remote sites of the São Pedro River Valley, where subsistence farmers live and work (the land). With unstructured focus groups, this study aimed to observe natural interactions with very little disruption. The focus group approach has the potential to promote the development of data through group interaction that may not be possible by other means (Jamieson & Williams, 2003).

Reading and writing are not common forms of daily communication among subsistence farmers. Thus, unstructured focus group interactions were led through dialogue and semi-guided discussions. As Freire (2000) outlines, "[d]ialogue is the encounter between men, mediated by the world, in order to name the world" (p. 880). Case studies explore common issues experienced by a group of people who are bounded by time and space. In that regard, this form of inquiry allows the study to be conducted in a natural setting but, most importantly, at participants' own location. For subsistence farmers to express their opinions freely, they needed to be in a conducive and familiar environment.

Isolated communities are usually not comfortable with individuals outside of their group, even if they share the same language and a few similar traditions. In such settings, the presence of an outsider can be perceived as intimidating, or at the least bothersome. Thus, to preserve the integrity of participants' culture and space, I was represented by a local RA. Born and raised in the São Pedro River Valley, the RA was familiar with participants and the region. According to Mills et al. (2017), studies can opt for focus groups to reduce the attention on the researcher, who takes a peripheral position. The RA played a vital role because she helped move the attention

from me and instead, place the emphasis on the participants and the issue they were facing. By placing the focus on the participants, the unstructured focus group approach placed the impact of granite quarries on subsistence farmer's livelihoods at the center of this study.

The Research Associate

Freire (2000) established a clear approach to qualitative research in the context of adult education in the peasant area (more specifically, the sertão) in Brazil. In his pedagogical approach, he recommends that investigators begin their own visits to the area, never forcing themselves, but acting as sympathetic observers with an attitude of understanding towards what they see. While it is normal for investigators to come to the area with values that influence their perceptions, this does not mean that they may transform the thematic investigation into a means of imposing these values (Freire, 2000). To ensure the local environment and customs of the local community were not disrupted, my presence was completely removed from the field. I profoundly relied on the RA to complete this study.

Culturally, the RA was an essential player in this study because of her origin, level of awareness, and willingness to participate in this research. Part of the rural community, she grew up in the São Pedro River Valley and lives now in a nearby town. At the time of this case study, her parents still lived in the country, where they struggled as subsistence farmers themselves. At first, the RA invited participants she had personally known for years to an informal gathering. During this gathering she talked about the nature and purpose of the project. In this initial gathering, she explained the reason for the investigation, how it would be carried out, and what use it would have. Before data collection started, the RA further explained that the investigation would be impossible without a relationship of mutual understanding and trust (Freire, 2000). Most importantly, the RA was able to convey meaning in a respectful socially and culturally

appropriate way. In addition, she could use local language (idioms, accents, and expressions) that was familiar to subsistence farmers. This way, they were more engaged in the conversation and enticed to freely exchange their ideas and construct new knowledge. It was important that participants were aware that their voices were going to be recorded before they agreed to participate in the case study.

Selection of Participants

In case studies, participant selection is made through purposeful sampling. Because subsistence farmers in the São Pedro Valley are characterized as economically vulnerable and marginalized, they represent a sensitive population. To minimize those sensitivity barriers, this case study approached the small farmers in oral form using the Portuguese language only, and through the local RA, who was an integral part of sample selection. Sample selection in this case study took a few elements into consideration. The main criterion, first and foremost, was with regard to the geographic location. All participants in this study needed to be from the São Pedro Valley. They had to be living in the region for at least the last 30 years, which is when granite quarrying started in the Valley. Another important criterion for selection was to identify mainly those subsistence farmers whose lands had been used for granite quarrying. With respect to demographics, participants who were relevant to this study had to be males and females of older age (40 years old and up). These criteria allowed participants to provide a chronologic overview on the effects of quarrying activities in the area.

The sample represented empirically the communities most affected by granite quarries. Most members of the community in the São Pedro River Valley do not have available water and sewer systems in their homes. Thus, they are fully dependent on natural resources (land and water) to survive. They depend on rain/springs to irrigate their crops and for personal use. Some

had had their lands used for granite extraction whereas others had not. However, even those subsistence farmers whose lands were not used for granite extraction mentioned the impact of granite quarries on their lands (GGREF, 2018). They experienced water and land contamination, which is widely discussed in the literature and referred to as "silica dust" (Shaik et al., 2015).

Because this case study explored participants' views in detail, it was designed to work with a small sample size to address the research question. Information power indicates that the more information the sample holds, the lower the number of participants needed (Malterud et al., 2016). Although authors vary in their described optimal participant numbers, critical analysis of the available literature deduced that, ideally, a focus group consist of 5 to 12 relatively homogenous participants (Jamieson & Williams, 2003). Through the support of the RA, this case study was able to identify at least six subsistence farmers who fit the criteria and thus were part of the sample selection. The actual number of persons present during the unstructured focus groups ranged from 25 to 30 individuals from all households. Brayda and Boyce (2014) discuss the cultural aspects of purposeful sampling; in addition to selecting the right participants, successful participant selection has to be extremely aware of language and cultural barriers.

Peripheral Participants

This study also involved peripheral participants. Separating participants who fell under this study's criteria of purposeful sampling from other subsistence farmers who otherwise would be tightly connected was detrimental to the local culture. Thus, to address this dilemma, the unstructured focus groups also involved individuals close to the participants. Although the data collection consisted of pertinent information provided by subsistence farmers, it also contained peripheral participants outside of the purposeful sampling selection. Allowing those individuals to also voice their opinions and participate in the discussions, whether directly related to granite

quarrying or not, led to a more positive and realistic environment with receptive participants who consequently made more in-depth contributions to this study. Overall, the peripheral participants constituted another trigger of indirect data production. Combining the number of purposeful sample participants with peripheral participants, this study collected data from approximately 25-30 individuals (2 to 4 per household).

Data Collection

Research studies face ethical dilemmas when non-local researchers collect data from people with social and cultural contexts differing significantly from their own (Brittain et al, 2020). It is indeed becoming increasingly difficult to ignore the ethico-cultural and methodological challenges associated with applying universal ethical guidelines, principled on individualistic autonomy, in rural, more collectivistic, low literate communities (Appiah, 2021). When conducting research and collecting data from participants whose culture is so distinct, researchers are faced with a dilemma: how can research be conducted ethically without affecting participants' integrity and wellbeing?

This case study starts from the premise that, in the context of antagonistic cultures and extreme levels of vulnerability, the researcher's presence posed an obstacle to human subject protection and compromised the study's validity. When researching vulnerable populations, several ethical dilemmas exist in qualitative research methodology with regards to informed consent, confidentiality, and anonymity (Ngozwana, 2017). Researchers must go beyond formal ethical protocols to protect participants, researchers, and the integrity of research (Brittain et al, 2020). In an environment in which participants face hunger and lack of water in addition to very low levels of education, as in the São Pedro River Valley, the presence of an outsider creates a strong hierarchic relationship that affects their well-being. When conducting research, despite

IRB process implementation, researchers are perceived as superior individuals in the eyes of participants just for the fact of having access to water.

Finally, to minimize the risk of Covid-19 spread, data collection had to be adapted. In times of pandemic, just like social workers, researchers have to adhere to new ethical guidelines, especially regarding those who may be at higher risk due to accessibility of food and medical care (Farkas & Romaniuk 2020). Around the world, the priority now seems to be preventing transmission, protecting the vulnerable, and restarting work, commerce, and education (Flood et al., 2020). Thus, to protect participants' rights and health, I applied adapted ethical guidelines to data collection. These guidelines prevented me from physically entering the community. Thus, following IRB guidelines and approval, data collection was conducted by the RA, with participants' safety, health, and respect in mind. Remote data collection aimed to maintain the authenticity of the data and safeguard the cultural integrity of participants, respect their unique environment, and circumvent limitations set by the current worldwide Covid-19 pandemic.

Guiding Prompts

As previously seen, this case study's main form of data collection emanated from participants. In the São Pedro River Valley, local communication takes place very informally. Due to the highly collectivistic nature of the participants who live traditionally surrounded by family and friends as they accomplish their daily activities, interviews were not a suitable form of data collection. In fact, individually asking specific questions for data collection would be antagonistic to their way of life. In the sertão, members of the community express their ideas verbally among themselves without following a rigid dialogical protocol. Thus, during unstructured focus groups discussions, data collection took place through guiding prompts, which were written by me but verbally brought up to participants by the RA.

With unstructured focus groups, the moderator guides the discussion using open-ended questions to promote participant freedom in giving multi-dimensional responses (Jamieson & Williams, 2003). In this case study, at least two unstructured focus groups with the same participants took place, according to the outcome of each iteration, until saturation and time constraints were reached. Saturation occurs when the researcher no longer receives information that adds data to the research question. The focus groups elaborated on the prompts provided by the RA until the discussions ceased, which led to the next prompt. The prompts were written in the first person plural because the RA identified as one of them, and to maintain the focus on the group.

Guiding prompts were designed to be brought up to entice discussion covering three major areas, which were transposed to on-site observation criteria as well. A first set of prompts revolved around small farmers' current and past livelihoods, their ability to harvest crops within the last 30 years as well as their ability to raise farm animals or hunt and fish, and their accessibility to clean and natural water sources. The second set of prompts was geared towards granite quarrying activities in the area, if and how they had changed subsistence farmers' lives, and what those activities represent to them today. The final set of prompts addressed suggested solutions to the problems they face. Participants were invited to share their thoughts, how they overcame or coped with common issues. The discussions were designed to culminate with suggestions of other possible solutions that small farmers might find viable and beneficial to them. Freire's liberatory pedagogy revolves around the central idea of "praxis." He asserts that by deepening their consciousness of the world, individuals can change it for the better (Au, 2007).

Because I was not present during the data gathering, the present case study could not take place in a controlled environment. Participants were invited to interact with the RA and, most

importantly, among themselves. This approach was designed to ensure the focus stayed on the issue relevant to this case study through the guiding prompts designed by me and conveyed by the RA. Guiding prompts were designed for the RA to be able to freely capture any data, including those that did not fit into a priori categories. In such a setting, the research question served as a guide, not a mandate, and left room to address unexpected occurrences (Fetters & Rubinstein, 2019).

Peripheral Data

The focus group data collection captured the essence of participants' views and experiences which did not, at times, directly address this case study's research question. Allowing for peripheral participants, this case study was also designed to capture peripheral data. Communication happens effectively among groups in an unstructured form. In the context of a vulnerable rural community, the main purpose of using guiding prompts is to respect participants' culture and to allow them to voice their opinions and concerns as they would naturally. Thus, data collection gave room for digressions. The RA was able to redirect the group at times. At others, participants spoke freely, without the constraints imposed by structure or time. Following an unstructured focus group format with peripheral participants allowed the information to flow freely, without rigid guidelines, as in an authentic environment.

According to Freire (2000), "dialogue is the encounter in which the united reflection and action of the dialoguers are addressed to the world which is to be transformed and humanized" (p. 88). With this philosophical perspective in mind, data collection followed participants' pace and direction, allowing them to address each question, disregard others, and digress from them until speakers had exhausted their comments, whether directly relating to the questions or not.

Participants were not interrupted in order to maintain a harmonious interaction among speakers who would address the questions among themselves using their own words.

Freire (2000) suggests that "[d]ialogue cannot be reduced to the act of one person's *depositing* ideas in another, nor can it become a simple exchange of ideas to be *consumed* by the discussants" (p. 89). Due to the nature of unstructured focus groups, this case study anticipated the recurrence of data not apparently aligning with the research question. In fact, reference to drought-related comments would most likely be reported from these unstructured focus groups. To distinguish the impact of granite quarries from the drought that has been affecting the region for decades, the prompts designed to gather data from unstructured focus groups were directed towards the availability of spring water and the degradation of the land. Constructivists do not consider that learning of accepted knowledge is impossible, simply that it is not straightforward (as each learner has to make their own sense of teaching, based on the resources they already have to interpret it) and so requires careful pedagogy (Taber, 2019).

Despite the fact that the lack of precipitation is not the focus of the present case study, it was anticipated as a recurrent theme. It was captured during data collection as one of the recurrent themes that were relevant to subsistence farmers. Even though they did not address the research question at first, they were viewed as pertinent in this study, based on the fact that they mattered to the participants. Additionally, allowing data collection to digress gave participants a more realistic environment and made them more inclined to participate. It is important for the researcher to show participants that he or she cares about them and the problems they face. Researchers fail when participants cannot connect with them and establish a positive relationship, especially in a research project that seeks a better life for those who are vulnerable.

Data analysis was used subsequently to identify and separate the data that was relevant to the research question.

Content-Based Unstructured Focus Groups

The circumstances surrounding the 2020/2021 Covid-19 pandemic had a significant impact on the design of data collection. This study was built around Freire's humanistic philosophy and pedagogical theories to fit participants' environment. Paradoxically, the study could not physically implement live discussions or any type of interactions necessary to entice critical thinking to promote awareness and collective change. Data gathering was founded on a dialectical approach that had to abide by a strict quarantine protocol. To avoid traveling and gatherings with individuals from different households, I, with the assistance of the RA, conducted data collection remotely. To further minimize exposure of all those involved in the study, I was physically absent from the field.

Thus, I remained in the United States communicating with the RA, who collected data on the field. Special precautions were taken to minimize the risk of contaminating the RA and others. Despite the fact that the RA was already a regular member of the São Pedro River Valley community, with frequent contact with the population, she followed the Covid-19 guidelines during her visits to participants, ensuring maximum physical safety. All interactions between the RA and participants were conducted outside of each household for increased safety. This preventive measure was all the more suitable due to the small size of each household and people's general lifestyle of being outdoors year-round. Thus, the RA practiced safe social distancing at all times while collecting data.

Additional measures were taken to avoid the spreading of the virus from one household to another. To that end, members from different households could not have physical contact with

each other. The only face-to-face interaction conducted was between households and the RA. The RA visited each household separately, meeting with them outside for data collection. Data collection was conducted while avoiding participants from different households from interacting physically. However, subsistence farmers were able to interact with others through the RA. Participants could listen to others' perceptions, as gathered by the RA and condensed by me. The RA served as the data carrier during all iterations of data collection. Thus, the discussions in each household involved the recurrent data gathered from all participants. This way, I and the RA reproduced a content-based unstructured focus group in which the data was present but not the individuals who produced it. Lastly, since subsistence farmers were already physically secluded amongst themselves, they were not required to use masks or any face covering.

Cross Referencing the Data

Once analyzed, the data obtained from unstructured focus groups was cross-referenced with the insights of the RA in addition to the results of a soil analysis, and recent images and video recordings of the local area. The RA played a vital role in this study. She was able to review the raw data as well as the data analysis and provide her own perception on the results obtained. The use of recent photos and video recordings of the landscape complemented the insights provided by subsistence farmers and the RA. Cross-referencing the data was an important step in the data analysis. It allowed me to go back to the unstructured focus group for clarification, as many times as needed, whenever the data could not be satisfactorily validated. In other words, this fluid process ensured the correctness of the data analysis, which in return increased the study's validity. Additionally, this case study also conducted a soil analysis and interpretation as part of data collection.

Data Analysis

In case studies, the researcher interprets the meaning of the case, whether that meaning comes from learning about the issue of the case or from learning about an unusual situation (Creswell et al., 2007). Data analysis was set to identify and separate the data that was relevant to the research question. Various analysis techniques have been used to deal with focus group data, but the fundamental issue is to identify themes embedded in the many words of a text (Jamieson & Williams, 2003). The amount of data needed can represent a particular challenge in a case study. Malterud et al. (2016) recommends a shift in qualitative data collection from a numerical input of participants to the contribution of new knowledge from the analysis.

In cases where gatekeepers are involved, it is important that potential research respondents understand their right to refuse to participate at any stage in the research process, and that this refusal will not affect service provision or level of care (Clark-Kazak, 2017). In this case study, the RA, upon receiving consent from subsistence farmers, recorded all interactions during the unstructured focus groups. These recordings were then sent as raw data to me, who transcribed them verbatim. All colloquial expressions and regionalisms in the dialect were kept intact in the transcripts. Those terms would later be accounted for in the English translations of the data analysis followed by cultural footnotes, as needed. The data was transcribed and kept in Portuguese to be revisited several times for a wider range of data analysis.

Research indicates that informants, when invited to be co-inquirers in the process through reading and interpreting the researchers' result reports, individually and collaboratively can enrich the data further (Iivari, 2018). With this in mind, member checking was incorporated in this study, as I continuously sent data analysis to the RA. The final version of data analysis went through member checking to be at last translated into English. When

participants are presented the initial data analysis they "re-consider" through the "considerations" of others, their own previous "consideration." According to Freire (2000):

> the analysis of reality made by each individual decoder sends them all back, dialogically, to the disjoined whole which once more becomes a totality evoking a new analysis by the investigator, following which a new evaluative and critical meeting would be held. (p. 112)

Member Checking

The purpose of member checking was to give participants access to the raw data as well as the data interpretation. Freire (2000) recommends that after each data collection, the investigator draw up a brief report "to be discussed by the entire team, in order to evaluate the preliminary findings. The evaluation meetings should be held in the area itself" (p. 112). Subsequently, the recurring themes and subsequent assertions were read out loud to the group in a collective and familiar setting. Participants' comments were incorporated into the data analysis. Member checking was also an important form to minimize bias in this study, as participants' data was shared with the focus group for accuracy. Another reason to use member checking in this case study is the importance of trustworthiness in research. Rather than facilitating a specific research method, it was about sensitively engaging with a group and opening spaces for dialogical encounters (Hensler & Merçon, 2020).

Naidu and Prose (2018) indicate that in qualitative research, the results that researchers interpret might not always align with participants' views of the data in context. Thus, results must be returned to the community before they are presented to ensure that community members are aware of and agree with how they and their communities are represented by researchers. This way, member checking helps verify the accuracy of data once the researcher has completed collection and, possibly, analysis of the data. When researchers conduct member checking, they

allow participants to view themselves as part of a system in which they can reflect on how their thoughts, ideas, and activities are interpreted (Naidu & Prose, 2018).

Unite Word Analysis

Pedagogically, Freire advocates a process of problem posing, coding/decoding, and dialogue as a means of developing critical consciousness for social transformation, both in the classroom and in the world (Au, 2007). Consistent with the data collection approach, this case study conducted data analysis following Freire's (2000) pedagogical framework. Freire focuses on the meaningfulness of the word in data analysis. He suggests that as researchers attempt to analyze dialogue as a human phenomenon, they discover the word as the essence of dialogue itself. According to Freire, there are two dimensions in the word: reflection and action: "There is no true word that is not at the same time action and reflection. Thus, to speak a true word is to transform the world (p. 87). Freire focused on contextual unit words to teach syllabification to subsistence farmers in the region. Similarly, this case study focused on contextual unit words for me to extract authentic data and to understand the impact of granite quarrying in small farmers' lands.

Maintaining the authentic vocabulary as presented by the participants allowed the researcher to better understand and report small farmers' perceptions. Such an approach also provided more accuracy to this study and helped remove bias or misinterpretation. Thus, the data analysis focused on authentic units of information authentically produced by the participants. The data analysis was aimed at providing authentic formulation of ideas, as intended by subsistence farmers according to what they thought. According to Freire (2000), "[t]he investigation of thematics involves the investigation of the people's thinking – thinking which occurs only in and among people together seeking out reality" (p. 108).

In Vivo Coding

Freire's approach to data analysis brings the focus to authenticity of participants at the word level. Such method aligns directly with in vivo coding, a well-known qualitative method. Comparable to Freire's method, in vivo coding uses words or short phrases from the participants' own language in the data record as codes (Miles et al., 2020). In vivo coding was a suitable form of data analysis in this study because it reinforces the authenticity of the language, which also carries meaning, whether explicitly or implicitly. In vivo coding establishes that phrases that are used repeatedly by participants are good leads; they often point to regularities or patterns in the setting (Miles et al., 2020).

To capture the essence of the information shared by subsistence farmers, it is important to keep their language as is because their own local language, or dialect (colloquialisms and regionalisms), shapes their speech and contains important and unique content (meaning). It includes folk or indigenous terms for their particular culture, subculture, or microculture and suggests the existence of the group's cultural categories (Miles et al., 2020) and identities. In vivo coding allowed this case study to keep the essence of the meaning conveyed by subsistence farmers. Such essence could have been lost or misrepresented if participants' words and expressions were paraphrased. In vivo coding revealed the main codes found in the data, in addition to sub-codes, categories, and subcategories. In vivo coding was also appropriate for this case study from an ethical perspective, being a morally just approach towards vulnerable communities because it prioritized and honored participants' voice (Miles et al., 2020).

Food Baskets

Many researchers have started to conduct projects with vulnerable and marginalized people in a cross-cultural context. The need for culturally competent social and health care

requires knowledge of the social and cultural contexts of the people (Liamputtong, 2010). This case study was aimed towards engaging the community while maintaining its culture as intact as possible. One cannot expect positive results from an educational or political action program that fails to respect the particular view of the world held by the people; such a program constitutes cultural invasion, good intentions notwithstanding (Freire, 2000).

This case study conducted two sets of data collection, with initial prompts at first, followed by member checking. Each interaction followed the structure of a content-based unstructured focus group. This way, the RA visited separately each household twice. Culturally, the hospitality of Minas Gerais evokes food, chatting, and care (Lima & Oliveira, 2018). Reciprocally, it is common practice for guests to bring food or treats to the hosts. To respect this cultural norm, the RA was tasked with bringing food baskets to each household. A total of 19 food baskets were distributed: 10 for initial data collection and 9 during member checking. Food baskets in Brazil are widely known as part of government initiatives to provide assistance to families in financial hardship. In the São Pedro River Valley, food baskets are highly praised and thus well received.

The RA distributed food baskets containing similar items as the ones found in government social programs, such as rice, beans, oil, and dry meat, as well as cleaning products for the house and for personal usage. Food baskets were important in this case study because they maintained local tradition without influencing data collection because they were purposefully given prior to the beginning of the unstructured focus groups sessions. Thus, the purpose of the baskets was to show appreciation and respect towards the community and was dissociated from the data collection process.

Conclusion

Epistemological assumptions based on Freire's dialectical approach guided this study's methodological choices. The investigation of subsistence farmers' perceptions on the impact of granite quarrying in their livelihoods was conducted qualitatively using the case study method of inquiry. The selection of participants followed a purposeful sample approach. Subsistence farmers selected for this study represented empirically the communities most affected by granite quarries. Data consisted of subsistence farmers' perceptions, observations, images, video recordings, and soil analysis. To maintain the environment as authentically as possible, this case study was designed within an unstructured focus group approach to entice group discussions and to place participants at the center of the study. Data collection was conducted remotely. I and the RA produced a content-based unstructured focus group. This method of data collection preserved the authenticity and integrity of participants' unique environment and circumvented limitations set by the current worldwide Covid-19 pandemic. Data analysis involved member checking to increase the study's validity. Member checking was followed by Freire's pedagogical analysis focusing on participants' speech at the word level and using in vivo coding.

Chapter 4: Findings

Data collection was conducted with a purposeful sample of small subsistence farming households through unstructured focused groups. The data revealed the impact of granite quarrying activities in subsistence farmers' ability to feed themselves and provide for their families. Unstructured focus groups targeted participants' daily activities and perceptions relating to their subsistence. To capture this information, I designed guiding prompts (Appendix 1) and verbal prompts. The questionnaire focused on participants' ability to plant and harvest today when compared to 30 years ago, before the granite extraction activities started to develop in the Valley.

Data Collection

Initial data collection for this case study took place during the month of December 2020. I worked remotely with the RA on a daily basis. The RA conducted unstructured focus groups in person and, because reading and writing are not a common form of communication in the region, she presented the prompts verbally to participants. The prompts were presented in three sections: the first section aimed to address what had changed with regard to subsistence farmers' sources of food coming from both their crops and the environment; the second section was designed to gather participants' views on the granite extraction activity near their lands; and the last section focused on the future of subsistence farmers and sought to identify possible solutions to the problems brought up by the participants in the first two sections of the unstructured focus groups.

Setting

Data gathering was conducted in the field at each one of the participants' home sites (see Figure 1). Due to the limitations set by Covid-19 with respect to group gatherings, the RA travelled to the rural areas to visit each household separately. A total of 10 unstructured focus groups were conducted with 25 people, involving both male and female participants who had

been living in the Valley for the last 30 years. No households had running water and few had electricity (see Figure 2). The only source of water for participants consisted of creeks, dams, streams and natural water springs. One household had a cistern built for rainwater catchment, which allowed them to fill the cistern with rainwater during the rainy season (the months of December and January) and from the spring. In that particular household, the water catchment was rationed and intended to last throughout the year (until the next rainy season).

Figure 1

A Household From This Study, São Pedro River Valley

Note: All photographs in this study were taken by the RA

All 10 households were located within 3 km of a granite quarry. Each unstructured focus group comprised a household that ranged between 3-5 adults who participated in the study. Following the unstructured focus groups, the raw data was gathered by the RA and sent to me, which I transcribed and sent back to the RA for accuracy checking. Several reviews were needed before the final version of the raw data could be completed. The accuracy of the raw data

benefited greatly from the participation of a Brazilian professor who served as a language and culture consultant.

Unstructured Focus Groups' Initial Findings

Questionnaire prompts for data collection were designed with participants in mind in order to trigger group discussion without imposing preconceived themes. When working with subsistence farmers in the Sertão region of Brazil in the 1980s, Freire (2000) challenged educators and researchers to never merely discourse on the present situation, and to never provide the people with programs unrelated to their own preoccupations, doubts, hopes, and fears. According to Freire's pedagogic views, as educators and researchers "it is not our role to speak to the people about our own view of the world, nor to attempt to impose that view on them, but rather to dialogue with the people about their view and ours" (p. 96).

Subsistence farmers' collective constructive knowledge was at the center of this study's epistemology. I sought balance in presenting unbiased prompts that nevertheless reflected participants' reality. As a result, while some expressions were well received, other terms, such as "irrigation" and "elements from the environment," were not perceived as authentic and therefore were, at first, not fully conducive to participants' discussion. However, the RA naturally overcame this initial limitation. During the unstructured focus groups, the RA rephrased certain expressions using authentic, local, and relevant language, and changed the grammatical structures to facilitate communication. The RA also rephrased some words from the questionnaire to adjust to those spoken by the community during the discussions.

Subsistence

When first asked what had changed with regard to subsistence farmers' sources of food, 10 out of 10 households said that their ability to plant and harvest had decreased significantly in

comparison to the previous generation (approximately 30 years ago). Figure 2 is a picture taken of the area near one of the households. Details about participants' ability to plant and harvest will be discussed in depth in this chapter.

Figure 2

Backyard of a Household from this Study, São Pedro River Valley

Regarding their livelihoods, participants used a variety of explanations to describe the challenges involved in their farming activities (as shown in quotation marks below). There were recurrent (catch) phrases obtained from different households. Table 1 illustrates the five most recurrent phrases.

"**We Can Barely Feed our Families."** While all participants said that it had become increasingly difficult to provide for their families, they mentioned a variety of vanishing food and water sources. According to subsistence farmers, their main concern was that they could not harvest their crops to feed their families. The issue of water was mentioned side by side with their inability to harvest. While most participants mentioned changes in the soil, a majority also pointed out environmental issues in the context of their inability to feed their families.

Table 1

Participants' Most Repeated Responses to Study Question on Subsistence

Section 1: Subsistence	*"Our crops won't grow"*	*"The creeks have dried"*	*"There is no rain"*	*"The soil has changed"*	*"Most animals and plants have disappeared"*
Household #1	✓	✓	✓		✓
Household #2	✓	✓	✓	✓	✓
Household #3	✓	✓	✓	✓	✓
Household #4	✓	✓	✓		
Household #5	✓	✓	✓	✓	✓
Household #6	✓	✓	✓		
Household #7	✓	✓	✓	✓	✓
Household #8	✓	✓	✓	✓	✓
Household #9	✓	✓	✓		
Household #10	✓	✓	✓	✓	✓

"We Plant but We Cannot Harvest." All participants said that harvesting had become a major issue in the Valley. The main concern was their inability to harvest, despite working on the land and even watering their crops. One of the main recurrent expressions that subsistence farmers from different households used about their inability to harvest was that they planted a lot and harvested very little (see Figure 3).

"In the Past We Planted a Little and Harvested a lot; Today We Plant a lot and We Harvest Very Little." In this antithetical sentence, subsistence farmers established a chronology and voiced their concerns, indicating a change in the environment that was not related to their actions. Subsistence farmers used several other expressions that illustrated the dichotomy

between their ability to provide for their families in the past as opposed to today. Participants also made comments to further explain their inability to harvest and thus to feed their families. Table 2 serves as comparison between how subsistence farmers planted crops 30 years ago as compared to now.

Figure 3

Scarce Meal for a Household from this Study, São Pedro River Valley

"The Water is Running Away." All participants pointed out the increasing water shortage in the Valley. Subsistence farmers attributed the lack of water as the main cause of their inability to harvest crops. Their main concern was the absence of rain, even during the rainy season, and the disappearing streams and springs. One of the main recurrent expressions that subsistence farmers from different households used about the lack of water was that the rivers had dried and it no longer rained.

"The Rivers Have Dried and it Does Not Rain." Subsistence farmers used several other expressions that illustrated the lack of water to irrigate their crops in the past as opposed to today. Participants also made comments to further explain their inability to find water. Table 3

shows the comparison between how subsistence farmers' accessed water 30 years ago as compared to now.

Table 2

Comparison of Past and Present Planned Crops

In the Past (30 years ago)	Now
"Our grandparents lived off the land"	"We can't live off the land anymore"
"They planted and harvested a lot"	"We plant but we barely harvest"
"We could plant crops even during the drought"	"We depend on the rain"
"There was no problem to water the plants"	"There is no water for our crops"
"You could plant hay for the cattle"	"We can't feed our cattle"
"There was rice, beans and corn"	"We haven't been able to harvest corn in the last 3 years"
"We worked in harmony with nature"	"Even if we water our crops they don't grow"
"There was water to water our crops"	"Several farmers don't produce at all anymore"
"In the past you could plant even rice"	"Sometimes we will go three days without any water"
"This place was known for its watermelon"	"Last year I couldn't harvest anything"

"The Soil is Tormented." Participants from 8 out of 10 households described changes in the soil. The main concern was the temperature and the condition of the dirt. One of the main recurrent expressions that subsistence farmers from different households used about the changes in the soil preventing them from harvesting as before was that the dirt had changed.

"The Dirt has Changed." Subsistence farmers used several expressions that illustrated the change in dirt over the past 30 years. Participants also further explained their inability to

harvest due to the poor conditions of the soil. Table 4 illustrates how the soil has changed in the Valley within the last 30 years.

Table 3

Participants Comments on Access to Water Over Time

In the Past (30 years ago)	Now
"There was always water"	"There is very little rain"
"The streams rarely dried"	"Sometimes it is difficult to find water even to drink"
"There were a lot of springs"	"We suffer during the drought"
"There were marshes"	"The streams have dried"
"We could water our crops with the streams"	"Most springs are gone"
"Everyone would come and get water from here"	"The water disappeared into the ground"

"Nature is Disappearing" Participants from seven households explained that animals and plants cannot be found any more in nature, as they once could in the past. Subsistence farmers mentioned vanishing animals and plants, as well as their inability to fish for the lack of water and the laws forbidding hunting activities. Table 5 illustrates participants' perceptions on the disappearance of nature in the Valley within the last 30 years.

Impact of Granite Quarries

When initially asked about their views on the granite extraction activity near and/or on their lands, 7 out of 10 households responded that the quarries had caused damage to their lands and water sources. The details about impact of quarries on participants' subsistence will be discussed in depth in this chapter. Table 6 illustrates participants' responses in detail to Section 2 of the questionnaire, with the main phrases they used to describe the pits (granite quarries).

Table 4

Perceived Changes in Soil Quality Over Time

In the Past (30 years ago)	Now
"You could plant a garden right here"	"The dirt is tired" "The soil is more fragile" "The soil is hurting" "The dirt is drier" "The dirt is compact."
"There were a lot of leaves on the ground"	"The natural fertilizers are gone because of the deforestation"
"There were a lot of roots"	"The dirt is more sandy"
"The leaves and roots would rot and fertilize the dirt"	"The soil is not as fertile as in the past"
"Our soil was cool"	"The ground is hotter"

"The Quarries Have Destroyed our Soil and Water Sources." Most participants said that granite extraction quarries had destroyed their soil and water sources. According to subsistence farmers, the main impacts caused by granite quarries in their livelihoods were the destruction of nature, the contamination of water, and the damages caused to the dirt. The impacts caused to nature were mostly related to deforestation and the destruction of spring water.

The Future and Solutions

When asked about the future of subsistence farmers, participants from 6 out of 10 households said there was no future for them in the Valley. They stated that their lads had been destroyed (see Figures 4 and 5). Nevertheless, when questioned about ways to solve the subsistence problem in the community, participants from 10 out of 10 households suggested different solutions to restore their land and/or water sources. Those suggestions are discussed

shown below in Table 7 and further discussed under the recommendations provided in this case study.

Tables 7 and 8 illustrate participants responses in detail to Section 3 of the questionnaire.

Table 5

Participants' Perceptions of the Disappearance of Nature Over Time

In the Past (30 years ago)	Now
"You could feed your family by hunting"	"Hunting is forbidden today"
"You could feed your family by fishing"	"Only a few who have reservoirs can farm fish"
"We could find a tree full of jabuticaba fruit anywhere"	"Very rarely can you find a native fruit tree"
"You could find a gabiroba tree, oranges and other native fruits"	"You can barely find a gabiroba [fruit tree]"
"One could fish"	"We can't even find water to drink, how are we going to find fish?"
"You could find gray brockets, spotted pacas, armadillos, and other animals from this region"	"Most games do not exist anymore"
"You could find medicinal plants"	"One can no longer find medicinal plants"
"You could make medicine from roots"	"We don't know anymore how to make medicine from plants"
	"The trees that conserved the water are gone"
	"We only find a few native fruits when it rains"

Table 6

Participants' Descriptions of the Impact of Granite Quarries

Section 2: The Impact of Granite Quarries	"We saw when the pits arrived in the region"	"The pits have impacted our subsistence"	"The pits affected our water sources (creeks, streams, etc.)"	"The pits damaged our soil"
Household #1	✓		✓	
Household #2	✓	✓	✓	✓
Household #3	✓	✓	✓	✓
Household #4	✓	✓	✓	
Household #5	✓	✓	✓	✓
Household #6	✓			
Household #7	✓	✓	✓	✓
Household #8	✓	✓	✓	✓
Household #9	✓			
Household #10	✓	✓	✓	✓

Figure 4

Granite Block and Debris, São Pedro River Valley

Table 7

Participants' Perceptions of Their Future in The Valley

Section 3A: The Future	"There is no future here"	"The water springs cannot be recovered"	"Our children have to move out to the city"	"People are abandoning their lands"	"We are weak and helpless"
Household #1	✓		✓		✓
Household #2	✓		✓	✓	
Household #3	✓				✓
Household #4					
Household #5		✓	✓	✓	✓
Household #6	✓	✓	✓		
Household #7	✓	✓	✓	✓	✓
Household #8		✓	✓	✓	✓
Household #9		✓	✓		
Household #10	✓	✓	✓	✓	✓

Figure 5

Granite Rubble, São Pedro River Valley

Table 8

Participants' Perceptions of Solutions to Quarry Impacts in The Valley

Section 3B: Solutions	"Recover the water springs"	"Plant trees"	"Build an artesian well"	"Repair and fertilize the soil"	"De-clog the dam"
Household #1			✓		
Household #2	✓	✓			
Household #3		✓			
Household #4	✓		✓		
Household #5	✓		✓		
Household #6			✓	✓	
Household #7	✓	✓	✓	✓	✓
Household #8	✓	✓	✓	✓	✓
Household #9	✓	✓	✓		
Household #10	✓	✓	✓	✓	✓

Member Checking

Before conducting unit word analysis and in vivo coding, I proceeded to member checking. Because the meanings of words or phrases identified through in vivo coding can be specific to a particular culture, it was important that member checking or other forms of meaning-oriented validity be used to ensure my understanding of both the meaning and context specifics of words or phrases used by participants (Manning, 2017). To increase validity, the data gathered from the unstructured focus groups were transcribed, categorized, and condensed to be presented to participants. The use of member checking was an effective way to increase validity and gather further relevant data for this study. The new data gathering also helped provide

accuracy and further understanding of the original information previously collected. To prepare for member checking, the main information given by participants was categorized and synthesized, focusing on the authentic recurrent language produced during the unstructured focus groups.

According to Freire (2000), member checking is an integral part of data analysis. Freire refers to member checking as an "evaluation meeting" with participants. Freire established that "the evaluation meetings represent a second stage in the decoding of the unique living code" (p. 112). Due to the limitations set by the ongoing pandemic, I could not organize evaluation meetings with participants. Thus, to conduct the second stage in decoding the data, while effectively circumventing the threat of Covid-19, I tasked the RA to visit each household separately again and bring the synthesized data to all participants. The RA conducted member checking by sharing with each household the recurrent and relevant data previously gathered from all 25 participants. During member checking, participants validated others' comments and further shared deeper thoughts and perceptions on the matters addressed.

Seven Problems and Three Solutions

The RA conducted member checking during the month of January 2021, the rainy season in the Sertão region. To prepare the data for member checking, I followed the sequence of prompts as presented in the guiding prompts (Appendix A) that were addressed during the unstructured focus groups. Participants' input from all three sections was condensed into two categories: problems and solutions. There were seven problems and three solutions identified, and presented as ten statements. Each statement was followed by some of the participants' quotes (verbatim expressions) to probe and help illustrate the content of each problem or solution. I developed a selection of participants' quotes and suggested the RA share those with

participants during the second visit. Similar to initial data gathering, all member checks were recorded using Audacity, and saved as MP3 files.

The seven problems identified by participants were related to the lack of water, the conditions of the soil, the destruction of nature, and the effects of the quarries, referred to as "the pits." The three solutions suggested to these problems were geared towards addressing the problem of lack of water, the destruction of nature, and the conditions of the soil. I shared the statements with the RA, who conducted a total of nine member checks, one household being unavailable at the time. The RA recorded all interactions while conducting member checking in each of the participants' home sites. Member checking was presented to participants as shown in the RA introductory text (Appendix B) and in Tables 9 and 10 below:

> ***RA**: Good morning everyone. Thank you, once again, for participating in our work. In October, I spoke to you all, and about twenty other people here in the region, about the problem of our community's subsistence. We identified seven problems and three solutions. So, I wanted to ask for your help to see if I understood right each problem and each solution that you talked about. First, I will talk about the seven problems and then the three solutions. So, please tell me if it's right, and if there's anything missing. Is that ok?*

The 10 member-checking statements (seven problems and three solutions) provided were read out loud to participants by the RA. The RA then presented the most recurrent quotes provided by participants during initial data collection. The RA was asked to share the quotes as needed to probe and illustrate each statement, thus helping gather more accurate input from participants. The RA also had the freedom to pick the quotes she deemed relevant and conducive during the member checking. The RA presented more or fewer quotes as she perceived there was a need to further clarify, reinforce, or elaborate on each statement.

Table 9

Member Checking Problem Statements

Categories	Member Checking Statements	Probes: Participants' Quotes (Verbatim Expressions)
Problem #1: Harvesting	In the past we used to plant and harvest in abundance, but today our crops barely grow or do not grow at all even if we water them.	• "we plant a lot and harvest little" • "in the past even during the drought we could plant" • "now what we harvest is not enough to feed our families" • "sometimes even when you water your crops it does not make a difference" • "we were known for the watermelon in the region" • "today we can't even harvest corn"
Problem #2: Lack of Water	In the past there was water in creeks; today there is barely water sometimes even to drink.	• "in the past, we had a lot of water" • "today, the creeks have dried" • "the springs did not get dry in the past" • "today, there are no more springs, they are gone" • "there used to be marshes and dams in the past"
Problem #3: The Soil	In the past, we did not need to fertilize the soil, but today the dirt is damaged.	• "in the past there were natural fertilizers like leaves and roots" • "today the soil is tired and dry" • "deforestation has taken the natural fertilizers from the soil" • "the temperature in the ground is higher" • "the dirt is sandy"
Problem #4: Nature	We used to find all kinds of plants and animals but today nature is disappearing.	• "in the past we could fish and hunt to feed our families" • "today hunting is forbidden" • "there is barely water to drink, how are we going to fish?" • "in the past, we used to find fruit trees and medicinal herbs" • "very rarely we find native plants" • "the trees that used to keep the water are gone"
Problem #5: The effects of quarries on nature	The pits [granite quarries] destroyed the nature.	• "nature was destroyed by the pits" • "the pits took down the trees that keep the water" • "because of the destruction of the trees we have less water today" • "the pits released oil and wastes into nature"
Problem #6: The effects of quarries on the water	The quarries clogged the springs, dams and creeks	• "the granite debris buried everything" • "The pits fired some shots, then the spring water ran away." • "The ground dust, when it rains, goes down to the streams." • "The quarries' debris rolled down and clogged the dam."
Problem #7: The effects of quarries on the soil	The granite companies paid to use the land but destroyed the soil	• "my land is full of granite debris" • "the soil is worthless because of the pits" • "there is erosion because of the pits" • "to harvest yucca now I need a pickax" • "there are holes everywhere" • "The bad dirt covered the good dirt"

Table 10

Member Checking Solutions

Categories	Member Checking Statements	Probes: Participants' Quotes (Verbatim Expressions)
Solution #1: Water	Build an Artesian Well for the Community	• "all the community would benefit from an artesian well" • "there would be clean water to drink"
Solution #2: Nature	Recover the springs and plant trees	• "first, we need to plant trees" • "we need to try to recover some of what we had before" • "stop deforestation and preserve the springs" • "make sure the springs don't dry anymore"
Solution #3: the Soil	Fix the soil erosion and fertilize the dirt	• "we need to treat the soil" • "the dirt needs to be fertilized" • "we need to bring in an expert who knows those things" • "there would be some machines to stop the granite debris from coming down"

During member checking, participants were asked to review the information presented to them. The RA was instructed to let the conversations flow until participants had exhausted their responses. All input was relevant, even the information not directly related to the research question, because letting participants express themselves freely increased their involvement in the discussions. The more involved participants were, the more conducive to data gathering this study became. Thus, the RA asked subsistence farmers from each household to, in their own way, double check the statements and to add to or modify any of them, if needed. The RA followed up each statement and participants' quotes with an interrogative sentence such as "is this correct?" and "did I get this right?" At the end of member checking, the RA asked if participants would like to provide any other information, which four out of nine households did. The original statements and quotes presented to participants during the member check can be found in Appendix B.

Participants' Responses to Member Checking. The RA was asked to gather information on the distance of each household to the closest granite quarry. With regards to the

presentation of the statements (seven problems and three solutions), subsistence farmers had more information to provide than during the initial data collection through the unstructured focus groups. Participants reconsidered what had been said and what they had themselves originally expressed. According to Freire (2000),

> as each person, in his decoding essay, relates how he perceived or felt a certain occurrence or situation, his exposition challenges all the other decoders by re-presenting to them the same reality upon which they have themselves been intent. At this moment, they "re-consider," through the "considerations" of others, their own previous "consideration." (p. 112)

I also inquired about the possibility of getting a soil sample from each household. All nine households authorized the RA to obtain a sample of the soil.

Problem 1: Harvesting. Whereas the unstructured focus groups initially indicated the lack of rain to be the main cause of participants' inability to harvest their crops, the member checking revealed otherwise. When presented with the statement about harvesting their crops, followed by verbatim expressions, all participants agreed that in the past they used to plant and harvest in abundance, but that today their crops barely grew or did not grow at all, even if they watered them. Thus, two contradictory conclusions emerged: one from the unstructured focus groups and the other from the member checking, as follows:

1. "We can't harvest our crops because of the lack of water." (Unstructured focus groups.)
2. "We can't harvest our crops, even if we water them." (Member checking.)

Subsistence farmers made several references to rain and watering their crops and the more they discussed and pondered on the lack of water, the more additional pertinent comments they provided. They arrived to the conclusion that, even despite the rain, or despite their efforts in watering their crops, they could hardly harvest anything. According to subsistence farmers,

during the rainy season the water does not get retained into the ground. The table below illustrates several verbatim comments made by participants regarding their inability to harvest, despite rain and watering their crops. They explained that it does rain in the region during the rainy season, but shortly after the rain, the ground quickly dries up and crops die before they can fully grow and be harvested. During member checking participants made several comments about problem 1; the most recurrent ones are shown in Table 11.

Table 11

Participants' Responses to Harvesting Problems

Problem 1: In the past we used to plant and harvest in abundance, but today our crops barely grow or do not grow at all, even if we water them.	
Household #2	"Yes. Not even during the rainy season we are able to harvest now, the roots don't grow, the plants don't grow."
Household #3	"That's what I already said, you water, you water, you water, but nothing grows."
Household #4	"Today if you plant, it dies. I just lost all the corn I planted."
Household #5	"Yes. I lost all my beans and now I am watering my corn but it's like a rock. I have never seen anything like this."
Household #6	"Yes because the bad soil covered the good one and the dam is clogged."
Household #7	"Something is wrong with the soil because when it rains the ground dries up right away and our crops die."
Household #8	"When it rains, it rains a lot but then the water goes away and we lose our crops."
Household #9	"Yes, we are here struggling, we keep trying but we see no results."
Household #10	"It is true. In the past, I could plant anytime and I could harvest. And today there is no way, even in the water [rainy] season, we can't harvest almost anything because the water goes away and there are no more dams."

Problem 2: **Lack of Water.** When presented with the statement about the lack of water followed by verbatim expressions, all participants agreed that in the past, they could find water even during the drought season, but that today, at times, it was hard for them to find any water at all, even to drink. According to subsistence farmers, there has been a change to the water bodies' natural functioning. Table 12 illustrates several verbatim comments made by participants

regarding the environmental disruption leading to their inability to find water year-round. Subsistence farmers indicated that their water resources (natural water bodies) such as water springs, marshes, and river potholes, have disappeared and that the perennial streams have turned into intermittent creeks. Some of the most recurrent comments made during member checking about the lack of water are outlined in Table 12.

Table 12

Participants' Responses to Lack of Water Problems

Problem 2: In the past, even when there was no rain, there was water in the streams, but today there is hardly water sometimes to drink.	
Household #2	"Yes, it is just like that. In December the creeks are already dry. We can't find water to drink at times."
Household #3	"There is only water in the creeks when it rains, then the water goes away. We bring our drinking water in buckets from another farm."
Household #4	"When it rains it floods and then everything is gone. This here used to be a marsh and now it's all gone."
Household #5	"We are lacking drinking water and we don't talk about spring water anymore. I used to know 3 that were always full. Now they are gone."
Household #6	"Yes, in the past the creeks were deeper and they had river potholes with water where you could fish even during the drought."
Household #7	"I wanted to understand why the water is gone, we have to drink little by little so we don't run out completely."
Household #8	"Yes the rivers fill-up and then dry out. The ground cannot hold the water anymore as it used to. Out of 100 springs now we have only 20 left."
Household #9	"Yes because in the past there were stream sides along the creeks. The creeks were deep and it kept the water in."
Household #10	"Exactly, because now the creeks have dried, the springs are vanished, there are no more marshes."

Problem 3: The Soil. When presented with the statement about the condition of the soil followed by verbatim expressions, all participants agreed that, in the past, the land did not need to be fertilized, but today the soil is very damaged. There were two main problems described by participants regarding changes in the soil. According to them, on one hand, the soil had lost its natural elements (organic fertilizers or compost); and on the other hand, it had become hotter,

sandier, and less absorbent. Participants attributed the conditions of the soil to be caused mainly by deforestation and the use of chemicals in the environment. Table 13 illustrates the most common verbatim comments made by subsistence farmers about the soil.

Table 13

Participants' Responses to Condition of Soil

Problem 3: In the past, the land did not need to be fertilized, but today the soil is very damaged.	
Household #2	"We agree. The water disappears into the ground. Deforestation and fires have taken away the good fertile soil."
Household #3	"Just like that. The soil is so dry it cannot keep the water anymore even when it rains the water goes away."
Household #4	"The dirt has been washed off. The soil is dried and tired."
Household #5	"Yes, the dirt needs fertilizers because it is poor now."
Household #6	"In the past the soil had its natural fertilizers but the chemicals destroyed them. The soil is hot because of the deforestation."
Household #7	"The ground is now a sandy and hot dry dirt so we work really hard in the sun but you can see there are no crops to harvest here."
Household #8	"The ground was cooler in the 70s and 80s. Now there are no more plants to decompose and fertilize the soil."
Household #9	"The chemicals ruined the soil and the deforestation killed the natural fertilizers."
Household #10	"That's right, before you could plant anything, and today you have to fertilize a lot because you can see that the soil is very tired."

Problem 4: Nature. When presented with the statement about the destruction of nature followed by verbatim expressions, all participants agreed that in the past they used to find all kinds of plants and animals but that today nature is vanishing. The information about the environment was related to the community's ability to find food and nourish themselves from nature through fishing, hunting, and harvesting wildlife. According to participants, most native trees and animals had vanished from the region, hunting had become illegal, and fishing was impossible due to the disappearance of streams and creeks. Table 14 outlines recurrent verbatim comments provided by subsistence farmers about the destruction of nature.

Table 14

Participants' Responses to Destruction of Nature

Problem 4: We used to find all kinds of plants and animals but today nature is disappearing.	
Household #2	"Some trees still exist but they do not bear fruits anymore."
Household #3	"Everything is disappearing because there is no rain and the soil is so dry."
Household #4	"The animals that lived around here, we don't see them anymore. I used to fish but now not anymore."
Household #5	"Around here all is gone, you can't find a fruit tree anymore."
Household #6	"The fruit trees (even mango) and the animals are all gone so even if hunting was allowed we wouldn't find anything to hunt or fish."
Household #7	"The fish we used to find over there all die."
Household #8	"The trees that were along the river banks to hold the water up are gone so everything is gone."
Household #9	"We don't see fruit trees anymore and the animals are extinct."
Household #10	"Exactly, we could find all kinds of fruit trees. We can no longer see the same things that used to be abundant."

Problem 5: Impact of Granite Quarries. When presented with the statement about the effects of quarries on nature followed by verbatim expressions, all participants agreed that the granite quarries had destroyed nature and provided several additional comments. According to subsistence farmers, granite quarries had practiced deforestation and explosions, which had led to the main issues affecting nature in the area. Some of the most common verbatim comments made during member checking about the impact of granite quarries on nature are outlined in Table 15.

Table 15

Participants' Responses to Impact of Granite Quarries

Problem 5: The pits [granite quarries] destroyed nature.	
Household #2	"Before the pits, we had more rain and the air was cooler because there were trees to keep the moisture."
Household #3	"Yes indeed. The pits dried up our land, the soil popped and when it rains the bad dirt covers the good one."
Household #4	"Yes the pits took down the trees, especially along the creeks. We used to climb on trees and jump in the water, now it is all gone."
Household #5	"The pit dust came down into my property and killed my mango and my orange trees."
Household #6	"The pits hurt the environment also with dynamite and chemicals like mercury, diesel and nitrate."
Household #7	"Everything is destroyed, the trees are gone."
Household #8	"The pits exploded the rocks and the water springs disappeared."
Household #9	"The pit's explosions really hurt nature but also us because our house is full of cracks from the dynamites, very precarious conditions here now."
Household #10	"Yes, they took down the trees and the oil came down the creeks."

Problem 6: Effects of Quarries on Water. When presented with the statement about the effects of quarries on water followed by verbatim expressions, all participants agreed that granite quarries had wiped out their water sources. According to participants, granite extraction practices using dynamite near their lands had destroyed natural spring waters. Participants also explained that dams and ponds had been clogged with granite debris, marshes had been buried by debris and granite dust, and chemicals like fuel and mercury had polluted the creeks. Some of the most recurrent verbatim comments made during member checking about the effects of quarries on water supply are outlined in Table 16. Note that the distinction between Problems 2 and 6 is the presence of the quarries as responsible for their lack of water.

Table 16

Participants' Responses to the Effect of Quarries on Water Supply

Problem 6: The pits [granite quarries] wiped out our water sources.	
Household #2	"That's right. The pits sat high above our lands and the debris rolled down clogging the creeks. The pits fired the shots which softened the ground and a 50 year old spring water sank into it."
Household #3	"Yes. The debris and the bad dirt are drying up our marsh and our drinking water became salty and blurry."
Household #4	"There used to be a dam and we could see the oil floating on the surface. The pits clogged our water spring."
Household #5	"Right, there is a ton of sand coming down, I have never seen so much sand. It comes down and clogs everything."
Household #6	"For us it's a total loss because the community depended on the dam which now is clogged with granite rubble."
Household #7	"Yes it did. When they cut the rocks it spread out the dust into the water along with the chemicals they work with and it all rolled into the dam, now the dam needs to be cleaned. The water is yellow and filmy but we still use it because we don't have a choice."
Household #8	"All is left are abandoned pits, clogged creeks and buried dams. It was progress that turned into a disaster for this region."
Household #9	"We used to have river potholes where we could find water but the pits clogged them with a thin sand."
Household #10	"The debris clogged my neighbor's water spring."

Problem 7: Effects of Quarries on the Soil. When presented with the statement about the effects of quarries on the soil followed by verbatim expressions, all participants agreed with the information and provided additional details. According to subsistence farmers, the composition of their soil had been altered by granite waste, which they described as "bad dirt." They explained that the soil had become hard, hot, and sandy as a result of the granite rubble and dust released in the air. Participants referenced the "bad dirt" several times by saying that it had covered the "good dirt." Some of the most recurrent verbatim comments made during member checking about the effects of quarries on the soil are outlined in Table 17.

Table 17

Participants' Responses to the Effect of Quarries on the Soil

Problem 7: The pits [granite quarries] damaged the soil.	
Household #2	"Yes, the pits released a thin dust into the ground and it buried the good dirt. The walls of our house cracked because of all the dynamite explosion."
Household #3	"Now we have to dig deep to plant our crops on the good dirt that was buried by the debris."
Household #4	"The soil now is harder and full of rock debris. The bad dirt rolls down into our land and makes the soil sandy and dry."
Household #5	"We don't understand how but the pits dried-up our soil. There is so much debris and pit dust around here."
Household #6	"The ground does not absorb the water anymore. So you need to dig deep to find the good dirt to plant, but when it rains the water brings in the dust with rubble which compacts the soil and kills your crops even before they can grow."
Household #7	"The bad dirt that covered the good dirt does not allow the plant to grow, the roots can't develop."
Household #8	"Yes the debris comes down and spreads this sand all over our soil hardening it."
Household #9	"The pits released mercury and all types of fuel like diesel into the ground and that will take years for us to get rid of."
Household #10	"The stone dust hardened our soil so we have to dig a lot to find the old good dirt."

Solution 1: Build an Artesian Well for the Community. When presented with the suggestion to build an artesian well, all participants agreed that building an artesian well would be a viable solution to their challenges of finding water, because it would be a reliable source of clean water. See Table 18 for the verbatim comments made by subsistence farmers about building an artesian well.

Solution 2: Recover the Springs and Plant Trees. When presented with the suggestions to recover nature, all participants agreed that native trees needed to be planted, especially alongside the creeks, in order to maintain water and recover the water springs that had vanished. See Table 19 for the verbatim comments made by subsistence farmers about recovering nature.

Table 18

Participants' Responses to Solution 1, Build an Artesian Well for the Community

Solution 1: Build an artesian well for the community.	
Household #2	"Yes because the water from the well would not be contaminated."
Household #3	"That is what I said because we would have clean drinking water and so would the animals."
Household #4	"Yes because now we have to walk far to bring drinking water. We have to carry by hand the water we need for consumption and for our crops."
Household #5	"Yes because people need to drink clean water. This water here is salty and it is stagnated water and that's not good."
Household #6	"Yes because if we could drink water from artesian wells it would be water that hasn't been contaminated by the pits."
Household #7	"An artesian well would allow us to harvest the crops we plant again."
Household #8	"That is the only way. You only have water today if you have an artesian well."
Household #9	"Yes we need it [an artesian well] and if we could afford we would build one."
Household #10	"I think this well would help a lot, you know, especially to have water to drink because it would provide healthy water that could be used for everyday consumption"

Table 19

Participants' Responses to Solution 2, Recover Nature

Solution 2: Recover the water springs and plant trees again.	
Household #2	"We need to plant trees to keep the water in the ground."
Household #3	"Yes and stop taking down the trees that are still here so we can have water."
Household #4	"You have to plant trees by the creeks and isolate the area so the animals don't destroy the trees."
Household #5	"Yes because if you plant trees it will keep the water from running away."
Household #6	"Yes this is also a good idea and people need to think less about money because nature needs to be regenerated."
Household #7	"I agree because if you plant you have water and if you have water you have everything."
Household #8	"Yes that would be a good solution."
Household #9	"Yes if we recovered the springs we would have more people around here but now they all left, everything is abandoned."
Household #10	"Yeah, I think that would be a good idea because planting it would help more to try to keep at least some springs that still remain."

Solution 3: Fix Soil Erosion and Fertilize Dirt. When presented with the suggestions to fix the soil, followed by verbatim expressions, most participants agreed that the soil needed to undergo some type of treatment, even though they were not sure how viable it would be or if the resources were available. According to them, cleaning the rubble and granite debris would help recover their lands. Some participants brought up the need to build a containment wall to prevent the quarry waste from rolling down onto their land. Others also mentioned the need to clean the dam so they could have access to water again year-round. See Table 20 for the verbatim comments made by subsistence farmers about fixing the soil.

Table 20

Participants' Responses to Solution 3, Fix the Soil

Solution 3: Fix the destruction of the land and fertilize the soil.	
Household #2	"We need a containment wall to keep the tons of debris and oil from rolling down. I think we need a technician to teach us how to fix the problem."
Household #3	"Yes because the land is destroyed with holes and craters and when it rains the land, the water and the roads get destroyed."
Household #4	"Yes we have got to do that with someone who understands the problem so it can get done right."
Household #5	"If you fertilize the soil it is expensive but it will be good again for us to plant and harvest like we did before. But if it rains, the pit waste will roll down again and ruin the soil again."
Household #6	"I never had anyone come here to help with this situation but also it's so hard to get all the way down here."
Household #7	"Yes something has to be done to stop the bad dirt from rolling down into our lands and water."
Household #8	"We need machines to get rid of the rubble and make sure no more debris rolls down into our lands."
Household #9	"Yes, we need that and we need someone to tell us how we can plant and harvest now so we don't keep losing our crops anymore."
Household #10	"Yeah, I think that would also help a lot because then it would prevent the debris from continuing coming downwards, try to cover up a little bit of the erosions."

Outcomes of Member Checking

The unstructured focus groups revealed that subsistence farmers' ability to live off their lands had been impacted by granite quarries' activities in the region. Member checking served to increase validity to this assertion and further expand on detailed information about granite quarries' impact on subsistence farmers' livelihoods. Participants provided more details during member checking than during the initial data collection (unstructured focus groups). During member checking, participants interacted with the data as if they were in a face-to-face group discussion. All statements compiled from the unstructured focus groups and presented during member checking were not only validated but further developed by participants, in great part unanimously. Completing unstructured focus groups and member checking separately in each household helped remove group influence from participants' responses.

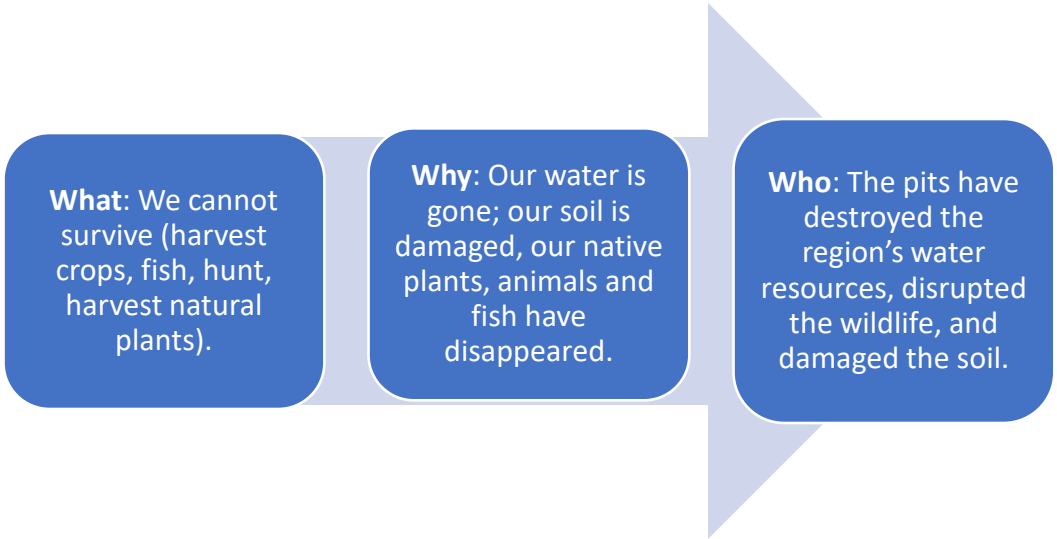
While the data emanating from the unstructured focus groups initially indicated that subsistence farmers' inability to harvest was primarily due to the lack of rain, the data obtained during member checking revealed other important factors. Seemingly, subsistence farmers' inability to feed their families was due to the disappearance of their natural water resources, vanishing wildlife, and changes to the soil. Participants indicated that the disappearance of water resources was indicated by vanishing water springs, marshes, river potholes, and perennial streams. The changes in the soil were indicated by a lack of natural fertilizers, an increase in ground temperature, and a noticeably sandier and less absorbent, unfertile soil. Subsistence farmers also believed that deforestation and the use of chemicals in the environment led to the disappearance of native trees and animals in the region. Member checking revealed that all households attributed some of their challenges to survival to past granite extraction activities in the area.

During member checking, participants reinforced the interrelatedness of their subsistence with the environment. Additionally, a relationship between the soil and the water became clear, as participants indicated how the soil could not retain water anymore. By combining the most recurrent problems faced by the community, as identified during member checking, the main focus turned towards granite quarrying activities. It was revealed that the quarries' activities of deforestation, granite waste release, and the use of chemicals and explosives in the environment had affected water resources, the soil, and wildlife in the region. Participants reached the conclusion that the main sources of subsistence (water, soil, and the environment) have been compromised by granite quarries' activities. The stating of these problems was followed by solutions to mitigate the lack of water by building artesian wells, resolve the damages caused to the environment by replanting trees, and fix the destruction of the soil by fertilizing the ground and building a containment wall.

Figure 6 illustrates the concluding findings during member checking, summarized into three essential elements of information identified by one of the Ws: what, why, and who.

Figure 6

Essential Elements of Information



Data Analysis

Unit Word Analysis

Consistent with the data collection approach, this case study conducted data analysis following Freire's (2000) pedagogical framework, focusing on the meaningfulness of authentic language. I analyzed participants' perceptions through their language at the word level, using the word-as-a-unit data analysis. The word-as-a-unit data analysis revealed essential themes encompassed within each unit word. From these unit words emerged sub-unit words and generative themes (see Figure 7). According to Freire (2000),

> [g]enerative themes can be located in concentric circles, moving from the general to the particular. The broadest epochal unit, which includes a diversified range of units and sub-units—continental, regional, national, and so forth—contains themes of a universal character. (p. 103)

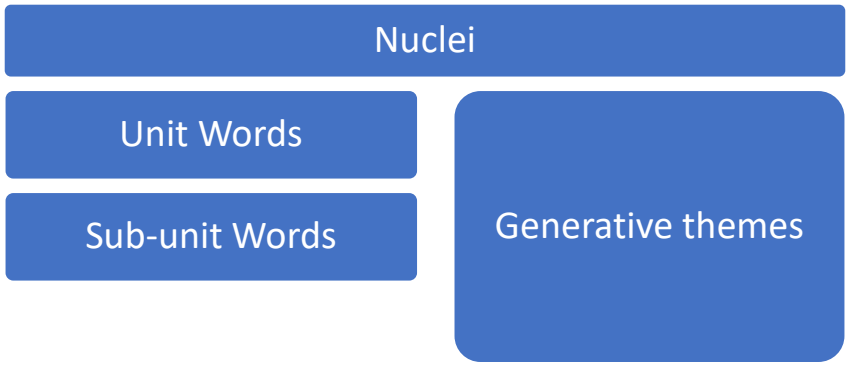
By using a pedagogical framework, I was able to maintain participants' essential vocabulary to depict their perceptions, as interpreted by them. The word-as-a-unit data analysis gave more accuracy to this study and helped remove preconceived ideas, bias or misinterpretations. It also provided the authentic formulation of ideas, as intended by subsistence farmers and according to what they perceived both individually and collectively. Freire (2000) defined authentic language as the essence of dialogue, saying that "human existence cannot be silent, nor can it be nourished by false words, but only by true words, with which men and women transform the world" (p. 88).

The pedagogical framework establishes that dialogue can only take place through the use of true words (Freire, 2000), which are words that have actual meaning to those who speak them and live them. In this case study, the true words were authentic because they emanated from participants to describe their own reality. Those words were also recurrent and thus meaningful to them. The authenticity of true words was conducive to communication, aligning with Freire's

(2000) dialogical theory that "[i]n the dialogical theory of action, subjects meet in cooperation in order to transform the world" (p. 167). The transformation in this case study consisted of participants' new awareness with regard to challenges they faced around their subsistence. Because of their collectivistic and insular culture, such awareness could only be achieved through a dialogical approach. Freire suggests that "[t]he methodology of the investigation must be dialogical, affording the opportunity both to discover generative themes and to stimulate people's awareness in regard to these themes" (p. 97).

Figure 7

Unit Word Analysis



Another important aspect of the unit word analysis is the role of participants in the study. Freire's (2000) methodology "requires that the investigators and the people (who would normally be considered objects of that investigation) should act as *co-investigators*" (p. 106). Because subsistence farmers' perceptions were at the center of this study, their collective and authentic contributions were the key to the investigation.

Participants initially responded to the verbal prompts from the questionnaire. Later, they provided their opinions during member checking, which was presented to them as a synthesis of what participants had originally stated as a group. In such fashion, the themes emerged from participants' words through dialogue. According to Freire (2000), "[t]he more active an attitude

men and women take in regard to the exploration of their thematics, the more they deepen their critical awareness of reality and, in spelling out those thematics, take possession of that reality" (p. 106).

The overall approach to the unit word analysis in this case study emerged from authentic single words used dialogically by participants in their own environment to describe, ponder about, and sometimes reconsider how they perceive and experience their own reality. The unstructured focus groups revealed four unit words, from which emerged the generative themes. Freire (2000) establishes that to investigate the generative theme is to investigate peoples' thinking about reality and peoples' action upon reality, which is their praxis. Starting from the word level, and focusing on participants' authentic language used collectively, the data analysis was able to identify the nuclei, or main theme. Each of the four unit words identified are presented with their respective sub-unit words and generative themes.

The Emergence of the Nuclei. The nuclei constituted the center of the problem faced by subsistence farmers. The nuclei was constructed from the most recurrent single words spoken by participants (unit words). These unit words were categorized to incorporate all deriving sub-unit words (see Figure 7). The generative themes emerged from recurrent language features that accompanied the unit words and the sub-unit words. This study identified four unit words, namely "water," "nourishment," "land," and "pits." There were two generative themes accompanying the four unit words, namely the language feature of negation, and terminology related to the concept of destruction.

Unit Word 1—Water. The first and most frequently used word among all households was water. Thus, water became the first and main theme, encompassing several sub-unit words (rain, creeks, spring, well, marsh, cistern, etc.). The word water was used on average 18-31 times

during each unstructured focus group. As I had not included the word water in the prompts, all initial reference to the word water emanated solely from participants' input. The high frequency and prevalence of the word water revealed, as expected, its relevance in subsistence farmers' lives. The verb "to water" was used instead of "to irrigate," which became the word choice also made by the RA during the data collection process. The prevalence of the unit word water was reinforced by its deriving sub-unit words. The most recurrent sub-unit words for water were rain, well, dam, ground water, and creeks.

Associated with the unit word water and its sub-unit words were generative themes consisting of negation, and terminology related to the concept of destruction.

The unit-word water, combined with its generative themes (no, no more, gone, ended, destroyed, contaminated), revealed the challenge of water scarcity and water quality in the community. The sub-unit words indicated that the lack of water was a systemic issue, because it affected all levels of subsistence farmers' life. During the unstructured focus groups, participants from all households stated that it did not rain any more as it used to (see Table 21). Participants from three households repeated the common phrase, Water is Life.

Table 21

Unit Word 1—Water: Sub-Unit Words, Generative Themes, and Most Recurrent Phrases

Unit Word	Sub-Unit Words	Generative Themes	Main phrases used in the context of unit word "water"	# Households Out of 10 Who Used Phrase
Water	creeks, dam, marsh, streams, rain, water springs, cistern, well	No, no more, gone, vanished, dried out, ended	There is no water / *Não tem água*	9
			It doesn't rain as it used to / *Não chove mais como antes*	10
			The creeks dried out / *Os rios secaram*	7
			Springs are vanishing / *As nascentes estão sumindo*	8

Unit Word 2—Nourishment. Participants were not familiar with the word subsistence (*subsistência* in Portuguese) and instead they used the word nourishment, food or sustenance (*sustento* in Portuguese). In Portuguese, the verb *sustentar* also translates as "to support." Participants used the word nourishment at the center of their discussions. The unit word nourishment had a wide range of definitions and uses, encompassing the meanings of sub-unit words such as feeding, sustenance, support, maintenance, and living. Associated with the unit word nourishment and its sub-unit words were a series of generative themes in the negative form relating to participants' inability to feed their families (see Table 22).

Table 22

Unit Word 2—Nourishment: Sub-Unit Words, Generative Themes, and Most Recurrent Phrases

Unit Word	Sub- Unit Words	Generative Themes	Main phrases used in the context of unit word "nourishment"	# Households Out of 10 Who Used Phrase
Nourish-ment	plants, animals, fish, fruit trees, feed, food, sustenance, grains	Can't, not possible, unable, no more, can't find	Unable to support / *Não dá para alimentar*	9
			Not really possible to survive / *Não tem quase como sobreviver*	7
			Can't provide sustenance anymore / *Não dá para tirar o sustento*	7

Unit Word 3—Land. The word land was used systematically as participants referenced their source of nourishment. Ironically, subsistence farmers did not use the expression subsistence farmers. Instead, they called themselves landowners (*donos da terra* in Portuguese). In Brazil, and especially in the state of Minas Gerais, the nouns farm and farmers denote economic and socially privileged status. The farmer in the area is usually a rich man who owns vast areas with cattle, who lives in a residence with running water, and has abundant resources on the land. In the case of participants in this study, they did not consider their lands to be a farm nor did they refer to themselves as farmers because of the small size and lack of resources on

their lands. With the expression landowner, the concept of ownership became limited to the physical terrain itself. This way, in their choice of words, participants further exposed their own lack of resources and sources of nourishment. Associated with the unit word land and its sub-unit words (production, dirt, soil crops, harvest, garden, planting) were a series of generative themes in the negative form to express the unproductivity of the land. During the unstructured focus groups, participants from 10 out of 10 households said their crops would not grow, while participants from 6 out of 10 households said the soil had changed. See Table 23.

Table 23

Unit Word 3—Land: Sub-Unit Words, Generative Themes, and Most Recurrent Phrases

Unit Word	Sub- Unit Words	Generative Themes	Main phrases used in the context of unit word "land"	# Households Out of 10 Who Used Phrase
Land	production, harvest, dirt, soil, crops, garden, planting, nature	no, no more, won't grow, can't, worthless	Crops won't grow / *Não dá nada*	10
			The land isn't productive / *A terra nao produz mais*	10
			The soil lost its natural fertilizers / *O adubo da terra ababou*	5
			The dirt is dry and hot / *A terra tá quente e seca*	5
			The dirt is damaged / *A terra tá judiada*	4

Unit Word 4—The Pit. When prompted to speak about granite extraction activities in the area, participants from 9 out of 10 households used the word pit (*pedreira* in Portuguese) to refer to the granite extraction sites and to granite related activities. The word pit was also used to describe granite entities in general. All participants used words associated with the pits that had a negative connotation. When discussing granite extraction, participants from 8 out of 10 households used the word destruction, and 7 out of 10 used the expression holes in the land. The unit word pit also had sub-unit words that were mentioned by participants to reference the presence of granite extraction in the area, such as machines, debris, waste, dust, and pollution.

Associated with the unit word pit and its sub-unit words were the generative themes, presented as an array of nouns, adjectives and verbs used to describe the effects of granite quarrying in the Valley. Some of these generative themes included destruction, carcass, explosion, worthless, obstruct, clog, and damage (see Table 24). These words were categorized as terminology related to the concept of destruction.

Table 24

Unit Word 4—The Pit: Sub-Unit Words, Generative Themes, and Most Recurrent Phrases

Unit Word	Sub- Unit Words	Generative Themes	Main phrases used in the context of unit words "The Pit"	# Households Out of 10 Who Used Phrase
The Pit	machines, rock, dynamite, mercury, oil, debris, rubble, waste, dust, sand, holes, carcass.	explode, destroy, release, deforest, pollute, contaminate, dry-up, clog, obstruct, bury, damage, end	The lands are full of holes / *Ficou só a buraqueira*	9
			The pits buried our lands with debris / *Deu rejeito e pó de pedra no nosso quintal*	8
			The pits clogged the creeks / *Entupiu os rios*	6
			The pits dried up our springs / *A pedreira afetou a nascente daqui*	5
			The pits damaged a lot of trees / *Desmatou muitas árvores*	7

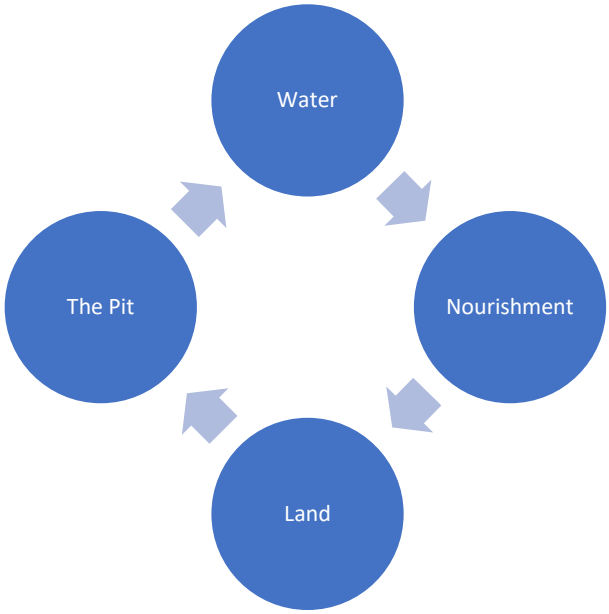
The Nuclei. Freire (2000) defines the nuclei as one general theme encompassing all unit words. In this study, the general theme, or nuclei, originated from the four unit words spoken by participants. According to Freire (2000), "the specialist looks for the fundamental nuclei which, comprising learning units and establishing a sequence, give a general view of the theme" (p. 120). The high frequency of the true words spoken by subsistence farmers revealed what really mattered to them, making them relevant and turning them into the center of this case study. Once the unit words were identified, I combined all unit words and generative themes to find the nuclei. According to Freire (2000), "[i]n all the stages of decoding, people exteriorize their view

of the world, and in the way they think about and face the world— fatalistically, dynamically, or statically—their generative themes may be found" (p. 106).

At the center of the unit word data analysis is the nuclei. According to Freire (2000), "[t]he more the group divide and reintegrate the whole, the more closely they approach the nuclei of the principal and secondary contradictions which involve the inhabitants of the area" (p. 112). The nuclei of the unit words identified in the study is "We lack water and the ability to nourish our families using our lands, which have been destroyed by the pits" (see Figure 8).

Figure 8

Unit Words Identified in the Study



Conclusion of Unit Word Analysis. To reach the reality as perceived and described by subsistence farmers, this study used their authentic words. Participants' words, also referred to as "true words," were used as units to identify the main themes. Freire (2000) explains in his pedagogical framework that

> the object of the investigation is not persons but rather the thought-language with which men and women refer to reality, the levels at which they perceive that reality, and their view of the world, in which their generative themes are found. (p. 97)

In this pedagogical analysis, four unit words were identified: Water, Nourishment, Land, and Pit. Each unit word had an expansive array of sub-unit words (semantic field). Two generative themes emerged. The first generative theme related to Water, Nourishment, and Land, and evoked negation. The second generative theme related to Pit, and evoked destruction.

However, according to Freire (2000), "the word is more than just an instrument which makes dialogue possible; accordingly, we must seek its constitutive elements" (p. 87). In this study, the constitutive elements consisted of sub-unit words emanating from each unit word. In breaking down the theme, I looked for the fundamental nuclei, which, combined with learning units and establishing a sequence, gave the following general theme: We are lacking water and the ability to nourish our families using our lands, which have been destroyed by the pits. Figure 9 illustrates how the nuclei emerged from the data and how it connects with each of the four unit words, followed by their sub-unit words and respective generative themes.

From this unit word analysis emerged the interchangeable group relationship among unit words, sub-unit words, and generative themes, as shown in these three suggested sub-nuclei samples:

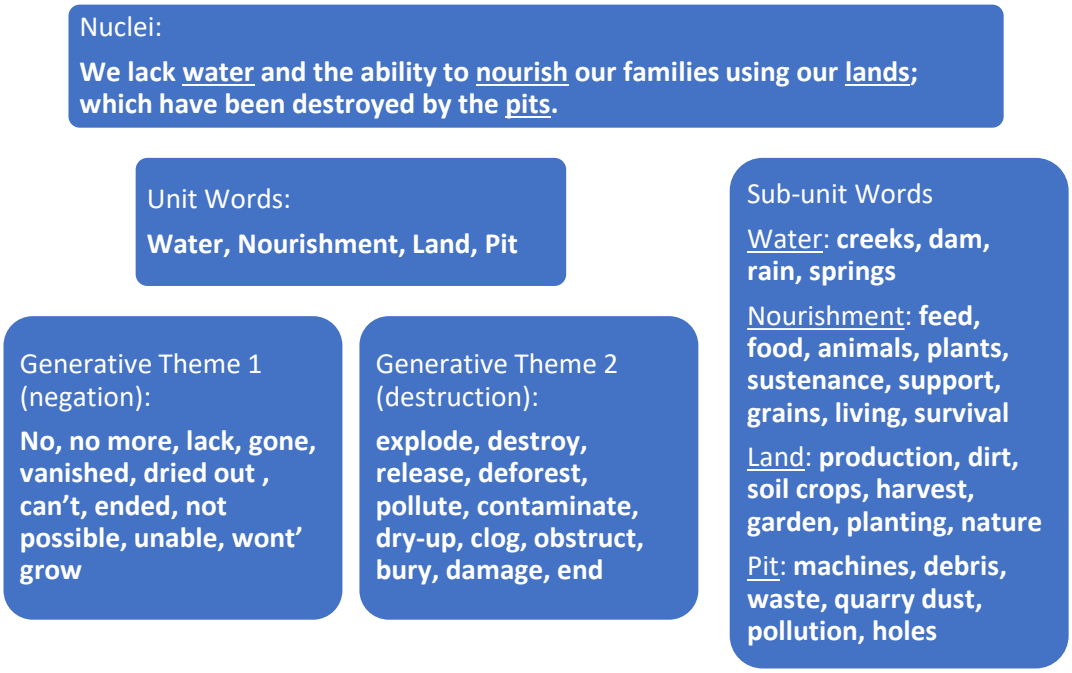
1. We are unable to harvest; the quarry dust buried our dam and contaminated our soil;
2. It's impossible to find food, the water springs dried out, and nature disappeared due to deforestation;
3. We cannot survive from our crops and have no more creeks, which have been clogged with debris.

This analysis also further confirmed the initial findings revealed during the unstructured focus groups. Seemingly, the four unit words confirmed the impact of granite quarries on subsistence farmers' livelihoods. These unit words also exposed the core of the reality lived by participants.

The word-as-a-unit analysis revealed that subsistence farmers' livelihoods had been affected in the São Pedro River Valley because their main sources of nourishment (water and land) had been compromised by granite extraction activities.

Figure 9

How the Nuclei Emerged From the Data and Connects With the Four Unit Words



Water and land are essential elements of life found in nature. The majority of participants established a clear connection with the environment and their subsistence. While the pedagogical analysis focused on participants' perception of their inability to live off the land as a result of granite activities on or near their lands, in vivo analysis focused on their perceptions on the impact of quarries on the environment. In vivo analysis of the data in this study complemented the word-as-a-unit analysis, providing further details and deeper understanding of the changes noticed by participants over the last 30 years and the extent of the quarrying destruction caused to the environment; notably, water sources and lands.

In Vivo Coding

Following Freire's (2000) approach to data analysis, in vivo coding is a form of qualitative data analysis that places emphasis on the actual spoken words of the participants. It can assess participants' routines, rituals, rules, roles, and relationships (Manning, 2017). I identified the themes and subthemes that emerged from the unstructured focus groups and member checking. The in vivo coding method was used in this study to capture the participant's language register and intensity as part of the data. This form of coding is especially helpful when researchers interact with participants from a particular culture or microculture to help highlight how those participants use specific words or phrases in their interactions that might not otherwise be understood when using other forms of coding (Manning, 2017).

In vivo coding allowed this case study to keep the essence of the meaning conveyed by subsistence farmers. Such essence could have been lost or misrepresented if participants' words and expressions were paraphrased. In vivo coding revealed the main codes found in the data in addition to sub-codes, categories, and subcategories. In vivo coding was appropriate for this case study also from an ethical perspective, being a morally just approach, especially towards vulnerable communities, because it prioritized and honored participants' voices (Miles et al., 2020). This type of data analysis also aligned with Freire's pedagogical framework. Freire's (2000) approach to data analysis brought the focus to the authenticity of participants at the word level, especially in the context of a vulnerable and isolated community.

While the initial data collection through unstructured focus groups, followed by member checking, revealed that farmers' livelihoods had been affected within the last 30 years because of quarries' activities, the pedagogical analysis reinforced and further provided details on subsistence farmers' ability to plant and harvest their crops. In vivo data analysis was used to

reach a deeper understanding of participants' perceptions of how granite quarries had affected the environment. In vivo data analysis was aimed at elaborating on the core issues revealed by participants. For instance, some of the main questions this analysis tried to answer were: How did the rivers dry? How did the springs disappear? How come there is less rain? Why is the soil temperature hotter? Why can't crops grow?

In Vivo Code 1: The Water is Nearly Gone. When describing the challenges faced due to the lack of water, participants gave extensive detail about different sources of water. The most recurrent reference to the lack of water was initially related to rain. However, as the group further discussed and analyzed others' perceptions, participants explained that all sources of water were vanishing. As initially revealed during the unstructured focus groups (which was later verified and further expanded during member checking), according to subsistence farmers granite quarries had had a direct impact on water bodies' natural functioning in the area. Participants repeatedly evoked the lack of water in a systemic way. According to them, not only was there less rain, but springs, creeks, dams, streams, and marshes were dry. Participants initially revealed that granite extraction activities had led to a decrease in the amount of rain. They also explained in detail how their other sources of water, from water springs, dams, streams, and creeks, had been affected. Participants indicated that these sources of water were vital to them, as they used water for their daily activities and survival (drinking, cooking, and cleaning) and for their crops and animals.

In Vivo Sub-code 1.1: The Rain. During the unstructured focus groups, where all participants stated that the lack of rain had affected their livelihoods, only three households made a connection between the lack of rain and the granite quarries' activities. However, during member checking all 10 households agreed unanimously with the fact that granite quarries'

activities had decreased the amount of rain in the area because of their deforestation practices. Household #3 made the following comment: “The pits came to take away the rain from us, because deforestation makes the rain run away.”

According to subsistence farmers, granite quarries led deforestation practices in order to open dirt roads for their trucks, allow them to access the rocks with heavy equipment, and provide access to the extraction process with machinery. Additionally, the quarries opened dirt roads for trucks to drive the raw material out. Although the vast majority of participants considered deforestation a negative practice in the area, a few subsistence farmers saw the positive side of having a dirt road on their property. The following are the main expressions used by participants when referencing deforestation practices carried out by the granite quarries in the area (see also Figures 10 and 11):

“The woodland is the health of the soil but many took the trees down and burnt them.”

“Deforestation made the river banks disappear, the riverbed is now dry because there are no more trees to protect it.”

“Slash and burn fires make nature sick.”

“Granite quarries arrived and started taking down the trees.”

“Without trees there is no rain.”

“Without trees the humidity of the ground is now gone.”

“Because of deforestation the animals and medicinal plants are gone.”

“The trees are the ones that keep the temperature cool.”

Figure 10

Deforestation Near a Granite Quarry, São Pedro River Valley

Figure 11

Abandoned Granite Quarry, São Pedro River Valley

In Vivo Sub-code 1.2: The Springs. Several participants claimed that granite quarries had had a direct impact on natural springs, primarily because the granite extraction process was carried out near a source of water. Some subsistence farmers quantified the disappearance of natural springs by comparing how many there used to be in the past (30 years ago) and how many were left now (2021). On some properties, where there used to be natural springs, participants explained that they all had vanished. Participants also explained that those springs

were a reliable source of water in the past, particularly important to their survival during the drought season. One household stated that a 50 -year-old spring vanished overnight. Although some participants expressed their astonishment and lack of understanding about the vanishing springs, others offered explanations. Many subsistence farmers believed there were three main reasons for the disappearance of water springs: deforestation along the creeks, the use of dynamite, and quarry debris and rubble.

1. Deforestation along the creeks: Similar to the lack of rain, subsistence farmers attributed the disappearance of springs to deforestation practices. Participants stated that deforestation along the creeks had led to the disappearance of natural springs in the area because the trees that were able to retain the water and keep the spring flowing were gone. Subsistence farmers indicated that vanishing springs were leading to the disappearance of creeks and streams because springs were the ones feeding the creeks. They explained that, in the past, the trees were able to keep the ground humid, which protected the natural springs throughout the year, even during the drought season. Participants indicated that natural springs used to be their main source of drinking water. They stated that spring water was a clean water that was safe to drink. According to participants, subsistence farmers had lost an important source of reliable water to drink due to deforestation practices along the creeks. The following are some of the main expressions used by participants when referencing the disappearance of natural water springs due to deforestation (see also Figure 12):

    "There used to be a ton of springs, I knew three of them that were full."

    "I can't understand why they dried up."

    "The trees kept the water into the ground."

"The quarries worked near the springs and that damaged them."

"In the past, we used to climb on trees and jump into the creek."

"The quarries take down the trees to access the rocks."

2. Dynamite blasts: Several participants indicated that the dynamite blasts used for rock extraction had led to the disappearance of most natural springs in the area. Indeed, they often mentioned the use of dynamite in the granite quarries near or on their lands by referencing shots, explosions, and detonations. They explained that the explosions had made the ground pop and crack. Others indicated that the shots had softened the ground, making the nearby natural spring sink and disappear into it. Participants attributed the lack of springs to the blasts by correlating the time the shots were fired with the springs' disappearance. Two households also indicated that the walls of their homes had cracked due to the blasts. One participant stated that the house had become a dangerous place to live after the blasts because the cracks were continuously growing bigger, creating concern that walls would come down. The following are some of the main expressions used by participants when referencing the disappearance of natural water springs due to dynamite explosions:

   "As soon as the pits fired the shots, the water spring that used to be here for 50 years disappeared overnight."

   "The ground shook, and the spring vanished."

   "I think that the explosions must have softened a rock and made the water vanish underground."

   "The ground popped and the spring was buried."

   "They [the quarries] fired some shots and the spring vanished."

   "The blasts cracked the walls of our house."

3. Quarry debris and rubble: Subsistence farmers explained how the quarries affected the natural springs with granite waste, rubble, and debris. They explained that, because granite quarries were located at elevation, the debris and rubble rolled down into their lands, clogging the springs. To find rock suitable for extraction, granite quarries had to break large amounts of rock. According to participants, more rocks had to be broken than what were actually extracted for commercialization. In the process of rock extraction, the quarries released rock residue, which was then spread onto their lands and into their waters. This rock residue was referenced in different ways. Participants described it at times as rock rubble, quarry debris, and sand, and so on. Participants explained that the rock residue resulted in the obstruction of natural springs by clogging and burying the source of water. The following are some of the main expressions used by participants when referencing the disappearance of natural water springs due to granite rock residue (quarry waste, debris, and rubble) (see Figure 13):

    "The quarries clogged the springs with rock rubble."

    "Those rocks keep closing down the spring."

    "The quarries buried our spring."

    "The rock rubble kept coming down."

    "The quarry debris sank the spring and then it disappeared."

    "The quarry dirt and rock closed down the spring."

    "The rocks rolled down into the spring and dried it."

Figure 12

Bottom of a Creek, São Pedro River Valley

Figure 13

Granite Rubble and Debris, São Pedro River Valley

In Vivo Sub-code 1.3: The Dam. Participants explained in detail how the granite quarries had affected the dam. The dam in the area used to be participants' main source of income and nourishment, as they used the water from it to irrigate their crops. Without their crops, subsistence farmers claimed not only that they could not sell their products at the market, but also that they could not feed their families. They stated that before the quarries arrived, the dam used to be full with water year-round, allowing them to grow and harvest their crops and even fish, at times. After the arrival of granite quarries in the area, the extraction of rocks led to obstruction, and eventually obliteration, of the dam. Subsistence farmers provided detailed information on how that process took place. According to them, the location of the rock extraction process was the main factor that led to the obstruction of the dam.

The granite quarries were situated where the rocks were found, rocks that sat high above the dam. Thus, when the quarries started to operate by extracting those rocks for processing, tons of granite residue was generated, which started to roll down into the dam, especially when it rained. The granite residue, consisting of rubble, debris, and dust, filled the dam to the point of clogging and burying it. When the dam was full of granite residue, no water could be stored in it. Some participants claimed that the dam now was dry, and gone for good. Others stated that the residue had been cleared from the dam in the past by local authorities and needed to be cleared again so it could be used by the community. However, in one household, participants said that clearing the residue from the dam was a useless initiative because, once cleared, all the rubble and debris would roll down and backfill the dam again. While all participants lamented what had happened to the dam and how it had affected the community's livelihood, one participant concluded that the investments made to build the dam and later to clean off the debris had been wasted. A participant from Household #6 made the following comment: "For us it's a total loss

because the community depended on the dam, which now is clogged with granite rubble" (see Figures 14 and 15). Others also commented on the obstruction of the dam:

"*This dam here had never dried before."*

"The dam is buried now."

"The rain brought down rubble into the dam clogging it."

"There is a thick dirt mixed with rock debris in the dam."

"The pits sit right above the dam so all the pit debris came rolling down."

"The dam used to be our source of income, but now it's gone."

"The dam got cleaned up from the debris once, but when it rains it clogs it back up."

"There is so much granite debris in the dam now that it is cracked."

"The dam that I used is dry now."

"The quarries filled the dam with rubble."

"The dam is backfilled."

"I can't water my beans anymore because the dam is dry now."

"The pits use the water to clean the rocks and that water rolls down into the dam."

"Before the pits arrived we had so much water in that dam."

"There used to be fish in this dam."

"The dam was a lost investment because now it's gone."

"There is no space for water in the dam because it's full of pit waste."

"We are going to fight to get the dam cleaned up because it's for the community."

Figure 14

Community Dam, São Pedro River Valley

Figure 15

Bottom of Community Dam, São Pedro River Valley

In Vivo Sub-code 1.4: The Streams and Creeks. Participants indicated that the streams and creeks had also been affected by granite quarrying activities. There was a consensus among subsistence farmers that perennial streams and creeks were something of the past. Now all sources of natural running water had become intermittent, only occurring during the rainy season. They explained that the streams and creeks were clogged or buried, and had subsequently dried out. The most recurrent reason given was the amount of granite residue, consisting of rock debris and rubble, which had been carried over into the streams and creeks.

Participants also repeated the word "sand" several times to refer to the material released from the granite quarries. They stated that the residues had affected the natural water flows and changed the depth of the water (see Figure 16). For instance, river potholes (*caldeirões*) used to be found along the creeks as a natural water reserve year-round. But granite residue, which had been carried by the water, had obstructed the river potholes and, without river potholes, subsistence farmers had lost an important source of water that was vital, especially during the drought season. The conditions of the river banks also changed, as now they had a sandy consistency, which made it impossible to retain water along the creeks. Such lack of water was defined by subsistence farmers as the "absence of mud." They explained that mud could not be found any more. At the bottom of the dried creeks, the dirt had cracked. Dynamite blasts and deforestation were also mentioned as reasons the streams and creeks had dried out. Participants commented:

"The pits buried the streams."
"After they fired [dynamite] shots this creek here dried out."
"When it rains, the granite waste rolls down into the streams."
"The debris keep on clogging down the streams and turn them into stone."
"The sand came down and buried the creeks."
"The creeks used to have potholes where we could find water year-round."
"The river potholes are gone because they are full of rubble."
"The creeks are shallow now, they lost their depth."
"I don't know of any perennial creek around here anymore."
"We used to climb on trees and jump into the river, now it's all gone."

"Along the river banks, there is no more mud, it's all just a sandy and dry soil."
"The bottom of the creek was so dried it cracked."
"There used to be puddles along the river banks, but now they are gone."
"My creek here is blocked with pit sand and debris that keeps rolling down from up above."

"When they took down the trees, this river dried up."

Figure 16

Along a Stream, São Pedro River Valley

In Vivo Sub-code 1.5: The Marshes. Marshlands were described by participants as another main source of subsistence. According to participants, previous generations used to have wetlands available to them throughout the year, planting a variety of crops in the marshes, including rice, which requires large amounts of water. The marshes were also a reliable source of life for native plants, including natural medicinal plants. Again, similar to when describing the obstruction, contamination, and disappearance of other water sources (springs, creeks, streams, and dams), participants described how the marshes had been affected by granite quarrying activities in the area. They said that marshes were all located on low ground, whereas the granite quarries were found up above, which resulted in all the chemicals and granite residues rolling down into the marshes.

Subsistence farmers indicated that granite quarries used chemicals (oil, gasoline, and mercury) in the process of rock extraction. Those chemicals had rolled down and polluted the marshes. Additionally, large amounts of granite residue had buried those marshes. The granite residue had also affected the soil's moisture, removing its ability to retain water. In essence,

participants explained that the marshes were gone, and an inhospitable and unsuitable surface for planting crops had replaced them. One participant explained that the marshland had become not only dry but also had turned into a hard surface. To describe the hard surface, one subsistence farmer from Household #7 said that "even the marshes that never dried before are now turning into a slab. Can you imagine that?" Others commented how the quarries destroyed the marshes:

"The marshes got sucked up."
"The marshes never dried before."
"They now have turned into a slab."
"We used to find medicinal plants in the marshes."
"The marshes can't keep the water in anymore."
"In this marsh here, is where I used to plant rice, now it's all gone."
"The marshes are located on low ground, the pits are located high up, so all the pit oil and chemicals come down and contaminate the marshes."

In Vivo Code 2: The Quarries Polluted the Water. Participants indicated that, although they knew the water available to them was improper for consumption, many subsistence farmers used it for their daily needs, such as drinking, cooking, and cleaning, because they had no other choice. They also gave water to their animals and they used it for irrigating their crops. They explained that the water was contaminated by the granite quarries, as granite quarries needed to use water to cut the rocks during the rock extraction process. By cutting the rock up above the hill, granite quarries released chemicals and residue down into the water. The contaminated water was released without going through any type of water treatment. When describing the pollution of the water, participants mentioned different chemicals, such as mercury and nitrate. The other form of contamination originated from the rock itself and was referred to as rock dust.

In Vivo Sub-code 2.1: The Chemicals. Several participants commented on the pollution caused by chemicals released into the water by the granite quarries (see Figure 17). They used

the word contamination to refer to the presence of five pollutants in the water: oil, gasoline, kerosene, nitrate and mercury. Those pollutants were used during rock extraction at the granite quarry sites. Although the extraction had ceased at the time of this study, the chemicals remained in the site. During the rainy season, those pollutants would spread because the torrents would wash them down into the creeks, streams, dams, and so on.

Participants explained that the floods had been washing down chemicals from the quarries into the ground, contaminating the waters at the subsoil level. For participants to access clean drinking water, they had to go several meters down into the layers of an aquifer, which they did not have the means to do. One household's water reservoir (cistern) was polluted by chemicals because it was connected to a stream uphill. Participants provided different characteristics to describe the polluted water. They explained the water was yellow and filmy, and tasted salty. Subsistence farmers said they were concerned for their health due to the contamination of the water they were drinking. They also explained that the chemicals were one of the reasons that fish had died in the creeks and streams. Participants also commented:

"We have no choice but to drink this polluted water."

"The water that comes from the creek into my cistern tastes salty,"

"You can still smell the oil where they used to wash their machines."

The oil that comes down from the pits killed the fish in the creeks."

"The water we use in our household is yellow."

"The water above the subsoil is contaminated".

"There is oil and mercury in the water."

"We can see the oil floating on what's left of the water puddles."

"The chemicals from the pit contaminated our water cistern."

"If we had treated water we would not use this one."

"When it rains it's worse because it spreads the oil even more."

Figure 17

Contaminated Creek, São Pedro River Valley

In Vivo Sub-code 2.2: The Rock Dust. When describing water contamination, in addition to chemicals, the great majority of households used the term rock dust (*pó de pedra*) to explain the effect on the quality of their water. Another recurrent word used was sand. Participants explained that granite quarries used water to cut down the rocks with a blade or cable. The water was used to cool off the cables, so they would not overheat. As the water was released from the quarries, it carried file granite rock particles into the creeks, streams, dams, and marshes. Subsistence farmers stated that the rock dust carried in that water led to the disappearance of creeks and streams; that the rock dust had buried them. One participant claimed that the rock dust had turned a creek into a paved road. The rock dust and sand also affected the water cistern of one household because it was carried over by a stream. Participants explained that they had to empty their reservoir to clean up the sand that had accumulated. The same cleaning process had been done to the dam but it had clogged up again. Participants further commented on the effect of rock dust on the water:

"When it rains, the rock dust rolls down into the creeks."

"The sand clogged the creek."

"When the pits cut the rocks they release a thin rock dust into the water."

"A ton of rock dust keeps coming down."

"We end up drinking water with rock dust because we have no choice."

"When the rain carries the rock dust down, it is so much sand that the soil dries up right away."

"The water is full of sand."

"My mango trees died because of rock dust in the water".

"Rock dust came into the creek and turned it into a paved road."

"The rock dust buried all river potholes."

"When it floods, it brings more rock dust and it clogs everything up: dams, springs, etc."

In Vivo Code 3: The Soil is Damaged. Participants from all households explained that the granite quarries had affected their soil in a variety of ways. When asked what had happened to the soil, they provided a description of the soil conditions, at times subjective, other times objective. Subsistence farmers illustrated changes to the land and ground through the choice of verbs in their narration. In the Portuguese language, similar to in Spanish, there are two forms of a verb that translate *to be*. By using the verb *estar* versus *ser*, participants removed permanent attributes in their descriptions. For example, instead of saying "the soil is hard," participants chose to say "the soil has become hard" or "the soil is hard now." Similarly, when describing water contamination, the great majority of households used the term rock dust (*pó de pedra*) to explain the changes in the soil. One of the most recurrent expressions when describing the soil was: *A terra tá só o pó de pedra* / the soil is now nothing but rock dust.

Participants made a distinct separation between good soil and bad soil. According to them, in addition to the rubble and debris, the rock dust (*pó de pedra*) had turned their good soil into bad soil. The great majority of households explained that they could not harvest on the bad soil. Subsistence farmers made a direct chronological correlation between the good soil in the

past and the bad soil of the present day. They explained that, over the years, a layer of the bad soil had covered the good soil. According to them, there were several characteristics related to the bad soil that contrasted it with the good soil. The main words used to describe the bad soil were hard, dry, hot, affected, and worthless.

In Vivo Sub-code 3.1: The Soil has Become Hard. According to subsistence farmers, the upper layers of the ground have been covered by a harder surface over the years. In addition to describing the effects of rock dust (*pó de pedra*) in the water, participants claimed that the same rock dust had infiltrated into the ground. In essence, they stated that the rock dust has hardened the soil, making it nearly impossible to harvest. Several participants compared their land to a hardened surface. In a compact soil, the crops cannot grow, they explained; the plants' roots can barely develop. Additionally, when subsistence farmers tried to harvest the yucca roots (one of their main sources of food), those would snap in the dense soil.

Participants explained that to be able to plant and harvest, they had developed a new farming practice to overcome the bad dirt. They started to dig deep holes into the ground to search for the good dirt, and had to use tools such as pickaxes and mattocks to perforate the hard surface. When digging deep into the ground, subsistence farmers found good dirt to plant yucca seedlings. However, once the rainy season came, it would flood the hole, pushing the seedlings further down. The floods would also carry quarry debris and sand into the hole, making the hole ashed off with the quarries' debris and sand. The crops located at the bottom of the hole would get buried and hardened over time and, while those crops would still grow a little, they could not be harvested because they would snap. One household explained that the crops they had planted at the bottom of the hole had yellow leaves and very thin twigs that could barely be pulled out. Subsistence farmers further clarified:

"The roots barely grow in this hard soil."

"There is no more mud, it's all just a sandy and dry soil."

"I have to use a pickax to harvest my yucca."

"The rock dust hardened the soil."

"To plant seedlings today, you have to dig 5-6 centimeters down."

"We have to dig deep to find softer soil to plant."

"I was afraid to snap my mattock while trying to harvest."

"When it rains, the water brings pit to the crops, hardening it."

In Vivo Sub-code 3.2: The Soil has Become Dry. Another noteworthy series of comments made was regarding the change in water retention in the soil. The majority of participants explained that the soil could not retain moisture any more. They said, over the years, that the ground had become drier and unable to absorb the humidity, even during the rainy season. Some participants pointed out that they could not see mud any more on the ground. Instead, they explained that the soil had a constant sandy texture. A number of factors were presented as explanations for this lack of humidity in the ground. The initial explanation provided during the unstructured focus groups was the lack of rain. During member checking other explanations surfaced and became recurrent. One of those was that, as previously mentioned, the ground had lost its natural fertilizers. These fertilizers were described as the grounds' natural compost, made up of decaying roots, branches, leaves and fruits. Without those fertilizers, subsistence farmers said that the ground could not retain moisture anymore. Another factor, also previously mentioned, was the presence of quarry residue in the ground. Participants stated that the debris produced during the rock extraction was making the ground dry. They further clarified about the dryness of the soil:

"When the rain carries the rock dust down, it is so much sand that the soil dries up right away."

"When you water the ground, it sucks all the water and gets dry right away."

"You don't see clay anymore, all you find is sand."
"The soil has dried-up."
"The soil does not keep the moisture anymore."

In Vivo Sub-code 3.3: The Soil is Hotter. When describing issues about the soil, participants also provided details about changes in the soil temperature. They stated that along the years, the temperature in the ground had increased. One household explained that in the 1970s and 1980s, the ground used to be cooler. To subsistence farmers, a hot soil translates into less water in the ground and less favorable conditions to plant and to harvest. They explained that not only had it become difficult for plants to develop and grow in the ground, but it was also difficult for farmers to physically stand the high temperatures while working the land. The main reasons given for this increase in the soil temperature were deforestation and the lack of water. Subsistence farmers explained that even when it flooded, the water quickly disappeared and the ground was dry again. They further clarified:

"The ground is hotter."
"The ground is so hot the water disappears right away."
"The ground is a lot hotter than in the 70s and 80s."
"Before the soil was cooler."
"The soil is so hot as soon as it rains it dries up."
"The soil is hotter because there is no water."

In Vivo Sub-code 3.4: The Soil is Unproductive. As a general concluding category of expressions, participants unanimously agreed that the soil could not produce any more. Several different expressions were used to describe the soil's lack of productivity, including some local expressions such as *cascabulho*/shabby and *bololo*/decrepit. Many referred to the ground as a carcass, whereas others used the term craters to describe what their lands looked like after the granite quarries had pulled out the rocks. Another recurrent word was *quebradeira*, a colloquial

noun deriving from the verb *quebrar*/to break. In this context, *quebradeira* had two meanings, relating to the breaking of the rocks and the fact that the subsistence farmers were financially broken since they did not have crops to sell at the marked any more. The vast majority of households said that the soil was worthless, using the expression *a terra não presta mais pra nada/*the soil is completely worthless. Finally, participants used descriptors that personified the ground, such as it is sick, tired, and hurting, and further stated on its lack of productivity:

"The mercury and the fuel used in the pits spread out throughout the ground.
"The pits released chemicals and oil into the soil."
"The pits released rock dust into the ground."
"The soil is full of rubble mixed with sand."
"The ground is full of holes, like craters"
"My property is full of rubble and pit debris."
"The ground lost its natural fertilizers."
"The ground is sandier."

Conclusion of In Vivo Coding. Several conclusions were reached from the initial unstructured focus groups using In Vivo Coding analysis. First and foremost, the following deductive conclusion can be drawn:

- Granite quarries affect the environment.
- Subsistence farmers depend on the environment to survive.

Granite quarries affect the environment that subsistence farmers depend on to survive; therefore, granite quarries affect subsistence farmers' ability to survive (see Figure 18).

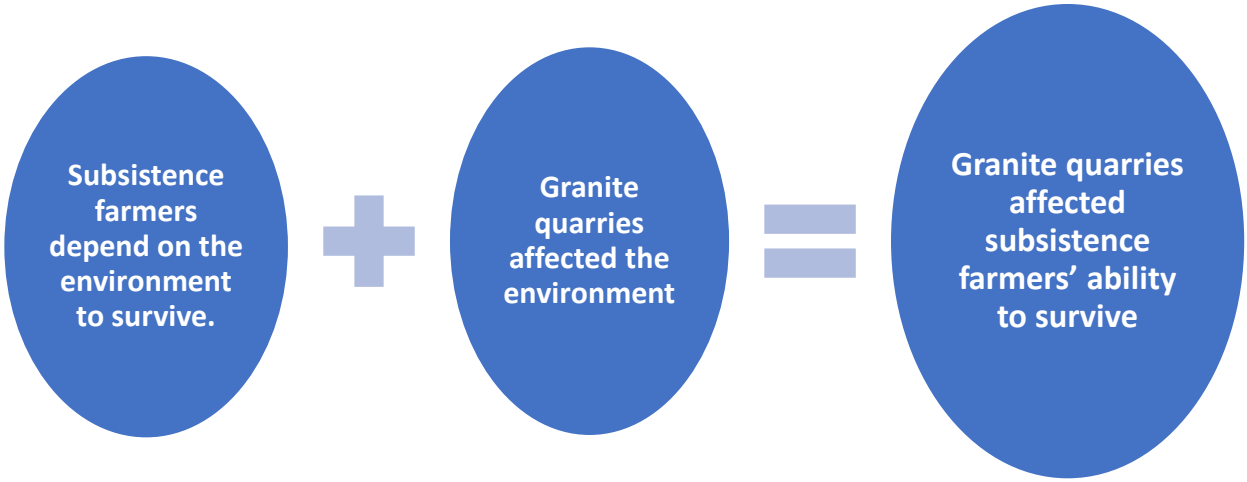
But how did the quarries affect the environment?

In vivo coding was used to reach a deeper understanding of participants' perceptions on how granite quarries had affected their livelihoods by destroying the environment. The data gathered revealed three main recurrent themes: The water is nearly gone; The water is

contaminated; and The soil is damaged. Participants' first explanation of the lack of water was that deforestation practices had led to the decrease in rain. The second explanation was that dynamite blasts used to extract rocks, along with subsequent granite residue (consisting or rock debris and ruble) released into the ground and water, had destroyed natural springs and obstructed and destroyed creeks, streams, marshes, and the dam.

Figure 18

Correlation Between Farmers, Quarries and the Environment



With respect to the contamination of the water, participants explained that chemicals and oils used in the quarries were released into the creeks and streams, polluting the water they depended on to live. Additionally, they revealed that the impacts of rock dust, a thin particle of granite powder released in the air and carried by water, contributed to the contamination of their water. Finally, subsistence farmers expressed their views on the damages made to their soil which, similar to the water sources, had been affected by granite residue and granite quarry pollutants. In essence, subsistence farmers had lost their ability to plant and harvest because the small amounts of water available were unreliable and improper for consumption, and the soil had become impracticable for crop production. Subsistence farmers recurrently referred to the word

sand to describe both the contamination of the water and the deterioration of the soil. They alluded to a sandy material, or rock dust, to describe the material that had been released from the quarries into their water sources (creeks, dams, and marshes), making it yellow. They also explained that the consistency of the soil on their property had turned sandier, making it less productive.

The more participants provided detailed information on how quarries damaged their livelihoods by destroying the environment, the more interconnected the problems they faced became. For instance, the soil was hotter because there were fewer trees and less water in the ground, which led to a less fertile dirt and fewer crops to harvest. In addition to the destruction of the environment by granite quarries, participants described how other aspects of their lives had been affected. Some explained that the walls to their houses had cracked from the dynamite blasts. Others were concerned for their health, as they were constantly exposed to chemicals and were drinking polluted water. Finally, participants also lamented the fact that granite quarries had only brought destruction to the region. They claimed there were no benefits because the quarries' presence in the region had not been translated into the creation of jobs, nor had they provided any type of compensation to those whose livelihoods had been affected.

Cross Referencing the Data

I used the RA's own perceptions and interpretations for cross referencing as, during the course of this research, the RA's perceptions became increasingly key in data analysis. Her views needed to be taken into consideration because she had implemented all the steps involved in data gathering by physically visiting all participants in remote areas. Therefore, in contrast to myself, she had been able to do on-site observations. Additionally, born and raised in the area, she is a native of the São Pedro River Valley region and, coming from a subsistence farming

community, she has her own understanding of the issues faced by the lack of water and food. Her views of participants' input, and her words, were necessary to add to this study for further validation. Thus, the results that emerged from the data analysis were presented to the RA for cross-referencing purposes in May of 2021.

The Main Issue

In order to obtain the RA's understanding of participants' perceptions on how granite quarries had affected their livelihoods, I condensed the findings that emerged from member checking and the data analysis section of this chapter. Initially, I asked the RA to provide, in her own words, her understanding of the main issue faced by subsistence farmers in the São Pedro River Valley. According to her, the main problem was the lack of food that resulted from the destruction of the springs carried out by granite extraction quarries. The RA stated that the quarries destroyed the natural springs and that was why the water was gone. According to her, there was no water in many of the small farms she visited. People were lacking water even to drink, and without rain to water their crops, subsistence farmers were not able to feed their children. According to the RA, "The quarries destroyed the natural springs and that is why the water is gone."

On-site Observations

When asked about her personal on-site observations regarding the condition of the soil, the RA stated that the quarries had indeed destroyed parts of the farms she had visited. She said the holes that were dug by the quarries were still visible. There was also abandoned equipment, rock blocks, and steel cables that had been used for the cranes. "With time, all this abandoned material damages the lands more and more," she said. However, she explained that there were still many portions of land that were in good condition and could be farmed. According to the

RA, if subsistence farmers could have access to a reliable and clean source of water year-round they could provide for their families. “All the holes that were dug by the quarries are still visible,” she said.

When questioned about the sand that participants repeatedly mentioned to describe the soil, the RA explained that they were referring to rock dust mixed with dirt. According to the RA, some subsistence farmers called the substance granite dust, while others called it sand. She explained that when the quarries cut the granite blocks, they use a machine known as a wire machine. Wire machines were used to saw the granite block with steel cables, using water. When the machines cut the rocks, they released granite dust into the water. That water then spread the granite dust to the farms. Subsistence farmers referred to the granite dust mixed with dirt as sand or sandy dirt. The RA described seeing the presence of sand in almost all the plains of the subsistence farmers’ community, sasying “I saw this sand in almost all the lower areas of the farms in the Valley.”

When asked to provide further details about how the granite rock was still spreading into subsistence farmers’ lands, even though the granite quarries had ceased their activities in the area, the RA explained that the small farms in the region were located in a valley with many hills. The activities of granite cutting and sawing had been carried out uphill. In these hills, when it rained, the left-over rock dust came down in the floods, contaminating the soil and water of the small streams located downhill. Thus, granite quarries in the São Pedro River Valley were up above where the rocks that had been extracted were found. Since quarries were located up high, their effects were felt downhill, even years after they had been abandoned.

Solutions' Feasibility

The RA was asked to give her opinion about the solutions suggested by participants, namely the rehabilitation of the springs and the dam, the constructions of cisterns and artesian wells, and the correction of the soil. The RA confirmed that rehabilitating the dam by de-clogging it would provide relief. She explained that the dam had been obstructed but if the granite debris were removed from the dam, it would allow the dam to fill back up again. However, she stated that this solution would solve the problem only for those who lived near the dam, who could use the water from the dam to water their crops. Cleaning the dam, she stated, would resolve the problem of five families only. When asked if the lack of water issue could be resolved in any way, the RA explained that subsistence farmers needed to have access to water again, that the soil should be restored with nutrients, and most importantly, the natural springs should be rehabilitated and protected. She said, "Through soil correction and the protection of natural springs, everything can get back to how it used to be."

With the main issue of the lack of clean water in mind, I asked the RA to provide her opinion on participants' suggestions regarding the construction of artesian wells for the community. According to the RA, an artesian well would help solve the problem because it would translate into a reliable source of clean water for subsistence farmers. Originally, subsistence farmers had explained that their soil had been ruined and therefore could not be used for crop production anymore. The RA reiterated that, according to her observations, there were in fact some areas of the land that had been destroyed with holes and contaminated with granite dust. However, some other parts of the land located higher up in the farms could still be used for planting crops, if there was water. She said, "I saw that there is still good dirt in the region; in my opinion what is missing is water to be able to produce in abundance."

Lastly, I asked the RA about any other type of work or solution that subsistence farmers could pursue as an alternative source of food to provide for their families. I asked if, instead of using the land, subsistence farmers could start a small production of animals. The RA explained that the São Pedro River Valley was part of the Jequitinhonha Valley, known for its high levels of poverty and lack of resources. “Everything is hard already as is,” she stated. Subsistence farmers are struggling to find food for their families and a very few animals for their own consumption, so there is no way they could raise chickens or pigs for sale, for example. This kind of activity is not an option for subsistence farmers in the São Pedro River Valley because it would require “larger quantities of food and water, which is already not enough.”

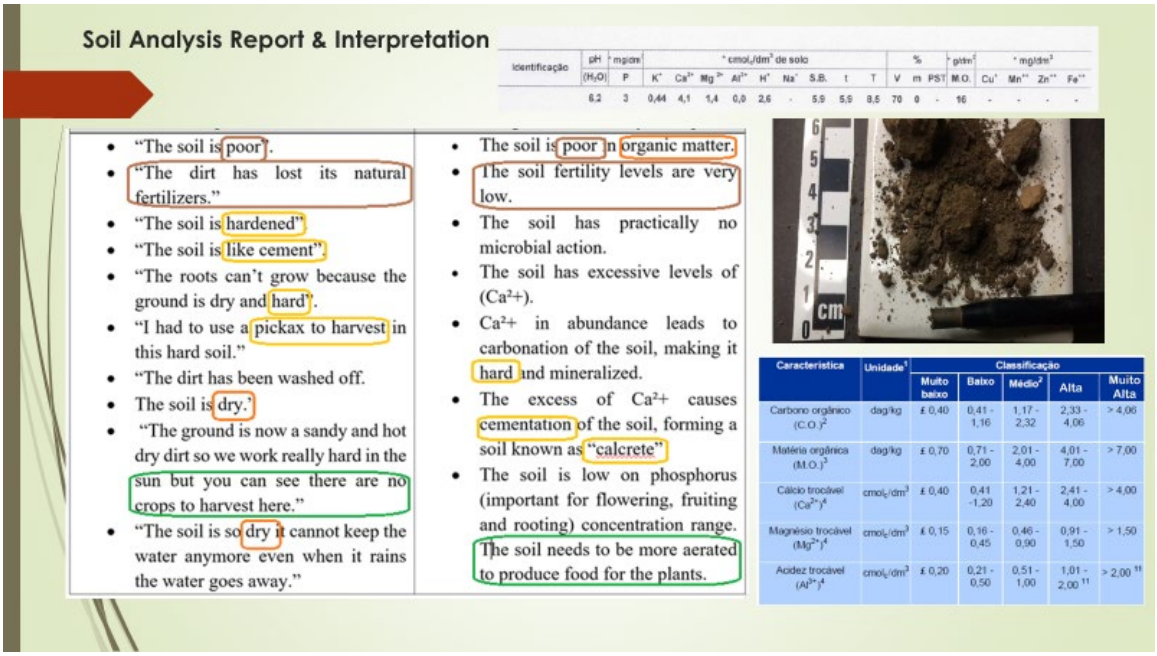
Soil Analysis

Based on subsistence farmers’ recurrent statement about the conditions of the dirt, this case study conducted soil analysis of nine samples collected from the land of participants (see Figure 19). The soil samples were collected from rural areas located between 300 meters and two kilometers of a granite quarry. Following their verbal consent and IRB ratification, the RA visited each household again to conduct dirt collection. The dirt samples were collected from the areas subsistence farmers normally used to plant their crops. The nine samples collected were each divided into two sets. One set of nine samples was taken to the laboratory at the University of Southern Bahia in Vitoria da Conquista for chemical and organic analysis. The other set of nine samples was shipped via mail to geologist Dr. Sergio Klein Rodriguez, in the state of São Paulo, for tactical analysis. Dr. Rodriguez served as consultant in this research. I forwarded the lab results from the university to the geologist and subsequently translated the results and the geologist’s analyses and interpretation ensuring all personal identifiable information was removed from the text. The interpretation of the soil analysis report revealed very low levels of

soil fertility and aeration, and high levels of potassium and calcium in addition to major deficiency in organic matter. The complete data from the soil analysis and interpretation are found in Appendix C.

Figure 19

Soil Analysis Report and Interpretation



Conclusion

The purpose of this case study was to answer the following research question: How have small farmers' livelihoods been affected by granite quarrying in the São Pedro Valley? To address this research question, this study gathered and analyzed data from local small farmers in the São Pedro River Valley living near granite quarries whose livelihoods directly depend on local natural resources. The data emanated from content-based unstructured focus groups and was cross-referenced with the insights of the RA, recent images and video recordings of the area, a chemical and organic soil analysis report, and field observations. The gathered data revealed the impact of granite quarrying activities on subsistence farmers' ability to feed themselves and

provide for their families. Unstructured focus groups, mediated by the RA, targeted participants' daily activities and perceptions related to their subsistence.

Seven main problems emerged from the initial data gathering, indicating that subsistence farmers could no longer live off their crops due to the lack of rain, the damages caused by quarries on nature, water resources, and the soil. Member checking confirmed that granite quarries' activities in the region were in great part responsible for the decrease in farmers' food security. Member checking also reinforced the initial data gathered and provided further details about subsistence farmers' decreasing access to food and water. The four unit words water, nourish, lands, and pits emerged from Freire's pedagogical analysis answering the question how? and revealed the nuclei of this study: subsistence farmers' inability to live off their crops is due to the lack of water and their ability to nourish their families using their lands, which have been destroyed by the pits. In vivo coding answered the question why? and provided details on the reasons quarries had impacted water resources and destroyed the lands. Photo images and video recordings, and field observations perceived by the RA, in addition to organic and chemical soil analysis collected in the field, confirmed subsistence farmers' claims about soil infertility. Table 25 summarizes overall data analysis of this case study.

Table 25

Overall Data Analysis of Study

Initial Data What?	Member Checking What?	Word as a Unit How?	In Vivo Why?
Subsistence farmers in the São Pedro River Valley can no longer live from their crops because of the lack of rain.	Subsistence farmers' food and water security has significantly decreased because of the overall lack of water supply and nearby granite extraction activities.	Subsistence farmers have lost access to clean, reliable water sources and their soil has been damaged by granite quarries.	The process of granite extraction and manufacturing has put a strain on water supply and released pollutants into the water and made the lands infertile.

Ethical Considerations

Some aspects of this case study need to be taken into consideration to enhance its level of trustworthiness, starting with the human subjects. Many researchers have conducted projects with vulnerable and marginalized people in a cross-cultural context. However, it is crucial that researchers ensure that their research is conducted ethically and that they take into account the cultural integrity of the participants (Liamputtong, 2010). Conducting research among isolated small farmers in the São Pedro Valley community could expose the study to social and economic dilemmas that are worth considering. On an economic level, this study contrasts the community's wellbeing with granite company's profits and progress. On a social level, it contrasts granite consumers with the community's ability to plant and harvest their crops. On an environmental level, this study places irregular granite extraction activities against sustainable practices that favor eco-friendly products.

To address these considerations while respecting and protecting human subjects, this study went through a methodical (full-board) IRB process. The main focus of this study was to remain transparent towards subsistence farmers and preserve their anonymity at all times. Thus, before collecting data, this study provided a verbal informed consent brief to participants clearly exposing and explaining the content of the study through full disclosure. The verbal prompts were clearly discussed with participants before each recording, which followed an interview protocol. To ensure protection of human subjects, it is important to raise the awareness that they can opt out at any moment during the study, including after the data is collected and analyzed. In this case, participants were given food baskets before the study was conducted. They had the option of taking the gift and not providing any data, thus ensuring that they would not feel obligated to participate in the study.

With respect to self-disclosure, Probst (2016) ponders the researcher's identity and history and suggests that some information already disclosed explicitly might also be exposed implicitly. With that in mind, the exact location of participants' lands remain undisclosed. Pseudonyms were given to participants and to the RA to preserve their anonymity and safety. Finally, the exact location of the rural community described in this study has been omitted. The name São Pedro River Valley has been given as an approximate region near the one where the data was collected for this study. The omission of the exact location was made as an attempt to further protect human subjects and avoid any potential retaliation to the findings revealed in this case study.

Chapter 5: Discussion

This case study explored the impact of granite quarrying on subsistence farmers' livelihoods in the São Pedro River Valley. Initial data collection indicated the main issue to be a severe lack of rain. Qualitative data analysis and recent photo images and videos revealed that rural communities had lost the ability to live off their crops because granite activities in the region had damaged their main sources of food, namely the water and the soil. As seen in the literature review section, the region is naturally characterized by a harsh historic climate (Lacerda et al., 2020). This chapter provides an in-depth interpretation and discussion of the data emanating from subsistence farmers' perceptions and from the RA's observations, in conjunction with the soil sample collected from nine households and the analysis interpretation provided by geologist Dr. Rodriguez. The findings are discussed and compared with theory and scientific evidence from the research field.

Restatement

The case study aimed to answer the following research question: How has small farmers' livelihood been affected by granite quarrying in the São Pedro Valley? Its purpose was to examine the consequences of granite quarrying on small-scale subsistence farming activities in a semi-arid region. The search for an in-depth understanding of the rural community in the São Pedro Valley was planned and conceptualized through Paulo Freire's pedagogical framework. This study aimed to generate necessary knowledge to answer the research question and promote social change among the impoverished rural community of the São Pedro River Valley. By following Freire's theories, this case study sought to stir social awareness, or awakening, based on a dialectical, collectivistic, and emancipatory approach.

Using a qualitative research design, this study gathered and analyzed data from local small farmers in the São Pedro River Valley, whose livelihoods directly depend on local natural resources. The data emanated from content-based unstructured focus groups and was cross-referenced with the insight of a RA, soil sample analysis, and recent images and video recordings of the area. This case study also integrated onsite observations, as perceived by the local RA. The word-as-a-unit analysis answered the question how? and exposed the nuclei of subsistence farmers' inability to live off their crops. In vivo coding answered the question why? and was aimed at providing an understanding of the reasons why subsistence farmers' food security had decreased.

The initial data revealed that subsistence farmers had lost their ability to plant and harvest crops due to the severe lack of rain. Farmers further stated that their inability to feed their families was due to the disappearance of their natural water resources, vanishing wildlife, and changes to the soil. Member checking provided insights about the impact of granite quarries on their livelihoods. The more that participants provided detailed information and shared their perceptions through the RA, the more they reached additional conclusions about reasons for the challenges to farming. The unit-word analysis revealed that subsistence farmers were lacking water and the ability to nourish their families using their lands, which had been destroyed by the pits. In vivo coding indicated details about how the quarries had increased the lack of water and destroyed the land. The lack of water, according to participants, was primarily due to a severe decrease in precipitation levels, followed by the use of water by the quarries and the pollution caused during their extraction and processing of rocks. The destruction of the lands also was a result of granite-related activities, resulting in rock debris, dust, and chemicals released into their lands.

Part I: Discerning the Impact of Granite Quarries

Lack of rain and deforestation minimally relate to granite quarrying (see Figure 20). The Brazilian Sertão is the largest semi-arid area in Latin America, in both size and population, at ~900,000 km^2 and more than 20 million people (Burney et al., 2014). Historically, the climate in the region has been widely known to affect subsistence farmers' livelihoods (Maia et al., 2018). It was established that local rural communities in general do not have access to running water in the São Pedro River Valley. Additionally, they can hardly depend on any source of natural water for drinking, planting crops, and for general household consumption.

In the Brazilian semi-arid region, the Sertão, farmers' vulnerability to climate—past, present, and future—stems from several factors, including low yielding production practices and reliance on scarce and seasonally variable water resources (Burney et al., 2014). Given the existing challenges in the region, how can the impact of granite activities on subsistence farmers be distinguished from climatic factors? In addition to natural climatic factors, the São Pedro River Valley has witnessed centuries of environmental destruction in order to favor various economic activities. To address these issues, this section discusses the origins and implications of the most recurrent factors described by participants as the cause of their inability to plant and harvest crops, namely the lack of rain, deforestation, vanishing natural water springs, the deterioration of the soil, and the obstruction of the dam. These recurrent factors, combined with soil interpretation, are then compared and transposed to findings from the current literature in their respective fields.

Lack of Rain

Subsistence farmers' lives in the São Pedro River Valley revolve around the availability of water. A popular expression in the region is "water is life." In that regard, lack of rain

translates into a lack of life because it has a direct impact not only on their crops and household consumption, but also their health and, ultimately, their survival. Several studies investigating precipitation levels in the Sertão strongly support claims about the lack of rain in the Sertão and its impact on rural families. In this region dependent on family agriculture, harsh environmental conditions threaten to aggravate existing food insecurity and economic underdevelopment, and to push migration to urban areas (Burney et al., 2014). This scenario is certainly reflected in the Valley where small farmers have been abandoning their unproductive lands in search of a better life in the cities. Those who remain face a debilitating drought marked by the absence of rain, which is undoubtedly affecting their ability to plant and harvest crops.

Subsistence farmers' claimed that the harsh climatic conditions (marked by record low levels of precipitation and higher temperatures over the years) are increasing. According to some of them, the progressive deterioration in the levels of precipitation and the increase in temperatures within the last 30 years were a consequence of the quarries' activities. However, while the granite extraction process is environmentally destructive (Ozcan et al., 2012), record low levels of precipitation cannot be linked to granite activities. Instead, the lack of rain can be attributed to two other factors: the natural challenging characteristics of the Sertão weather and the recent climate change indicators. On one hand, the unbalanced levels of rainfall resulting in months with very little or no rain has been a reality captured in several studies. On the other hand, lower yearly precipitation rates, higher number of days without rain, including during the rainy months (*veranicos*), and an increase in temperatures have been overwhelmingly observed throughout millions of acres within the last few decades.

Deforestation

To explain how important the vegetation in the Caatinga is to their survival, subsistence farmers described its dependence on water. They stated that "when the vegetation is removed, the water in the ground runs away." Thus, if water is life and the plants keep the water in the ground, the vegetation is also life to them. They claimed that deforestation posed a danger to the region. Thus, in addition to its semi-arid harsh climate with increasing temperatures and decreasing rainfall, the Sertão region also faces severe and indiscriminate deforestation practices. Subsistence farmers stated that the dry climate and unpredictable rainfall made deforestation all the more detrimental to their crops. More specifically, they claimed the lack of trees had a direct impact on water supply. Since this biome has been progressively destroyed, subsistence farmers are losing their water supply and food security.

Loss of Food, Water, and Income

The destruction of the native flora that produces fruits such as mango, jaca, umbú, and gabiroba has translated into the loss of a previously reliable food source, significantly decreasing subsistence farmers' food security. These fruit trees were largely referenced by subsistence farmers as a thing of the past, especially the fruit trees known as *gabiroba* and *jaboticaba*. Subsistence farmers claimed they did not find the native plants as they used to 30 years ago. Thus, other than water and food, deforestation translates into a loss of other types of plants that could provide an additional source of income (handicraft and folk art) or that could be used for medicinal purposes.

Granite Quarries and Deforestation

Deforestation is an activity that encompasses vast areas and has affected subsistence farmers for centuries. Granite quarries in the São Pedro River Valley have led deforestation

practices since the 1980s to facilitate the process of rock extraction and to open dirt roads to transport the blocks to the coastline of Brazil. Since deforestation is a reality that existed in the São Pedro River Valley long before the arrival of granite quarries, their activities cannot be solely attributed to subsistence farmers' decrease in crop production. However, by taking down the trees, quarries have made an impact on water supply and increased its scarcity. On the fragile soils of the Caatinga, when the vegetation is removed, the insulation is less, the evaporation of water from the soil is increased, and the impacts of the runoff rains are higher (Pereira et al., 2020).

Concomitantly, subsistence farmers indicated that the removal of trees has raised the temperature in the ground, because deforestation had led to less water retention in the soil. When farmers claim the ground is dryer and hotter, it is most likely related to the fact that the Caatinga forest develops shallow roots to enhance root water uptake from upper soil layers (Pinheiro et al., 2017). If most of those roots are removed, there is a lack of water retention that is noticeable within the upper layers of the ground, which is close to the level where subsistence farmers plant their crops.

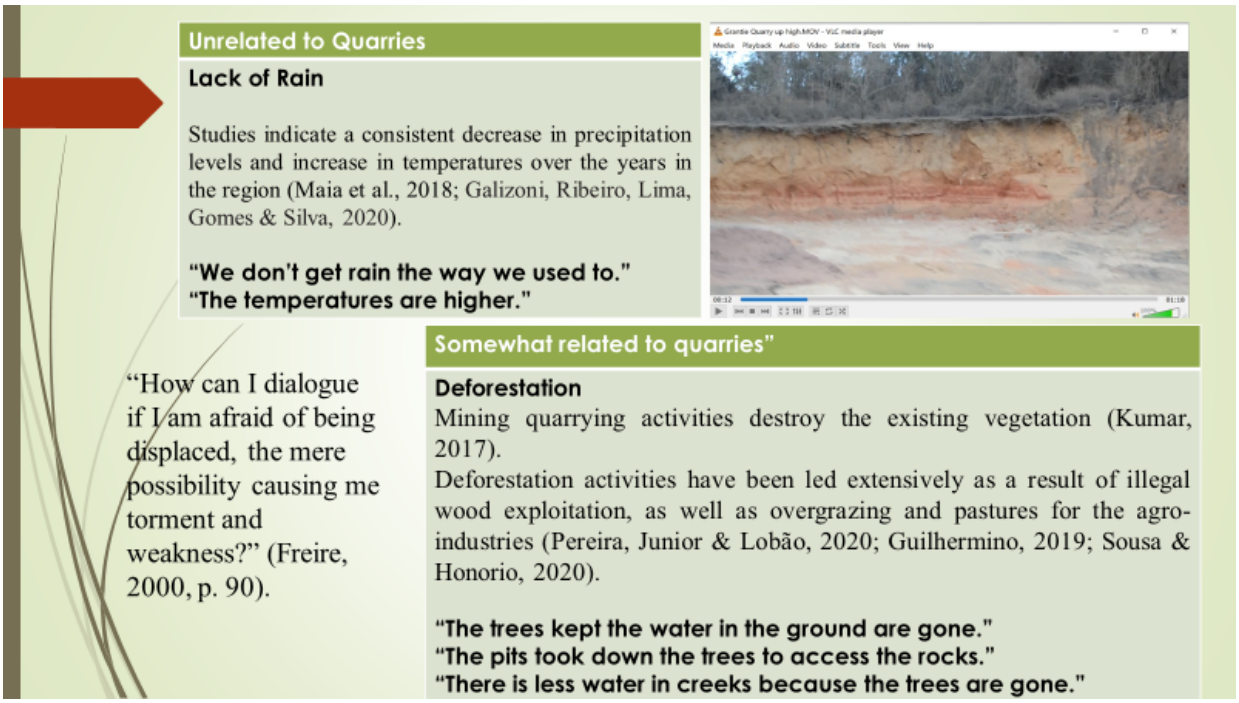
Participants revealed that one of the quarries' main activities involved cutting down trees. Consequently, granite quarries have increased the challenges set by previous deforestation practices by further reducing subsistence farmers' dependability on the vegetation. Beyond the role of being a shelter for several endemic species, the Caatinga biome provides essential services to society, such as timber, foraging, and watershed protection (Pinheiro et al., 2017). Deforestation practices have reduced subsistence farmers' ability to find water, especially during the dry season, because there is less vegetation to keep the moisture in the ground. This action

certainly affects the local environment, especially in the São Pedro River Valley, where trees are scarce and vital, as they help retain the water in the ground.

The evidence obtained from subsistence farmers' perceptions regarding deforestation practices strongly supports that their livelihoods have been directly affected by these activities. Deforestation practices deriving from granite quarries increased the ongoing environmental impact because they further intensified the drought in the area. The activities involved in the process of rock extraction accentuated the destruction of local vegetation, worsening food and water shortages in the rural community. Thus, granite quarries have increased the challenges set by previous deforestation practices by further reducing subsistence farmers' dependability on the Caatinga biome.

Figure 20

Lack of Rain and Deforestation in Relation to Quarrying



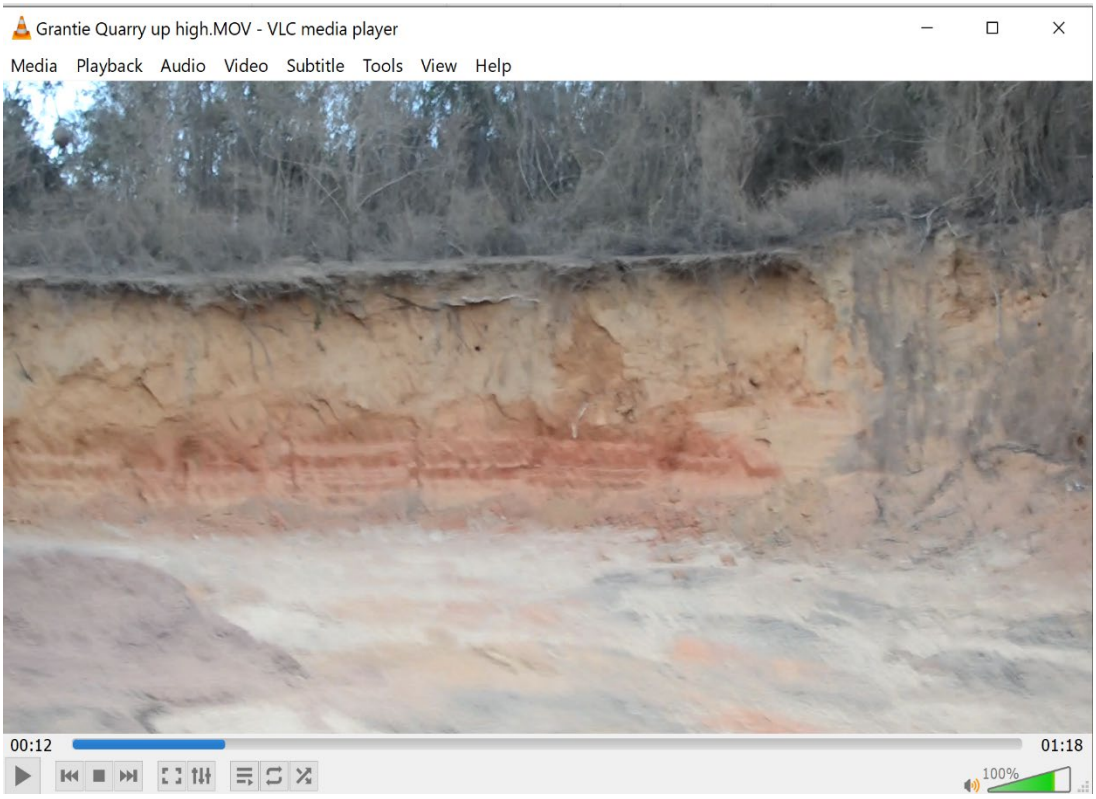
Water Resources

Dissipation of Water Resources

"We cannot find water anymore," the subsistence farmers said. Along with the disappearance of vegetation, water has been vanishing from the region. The tall, dry forests in the Caatinga were once the most dominant physiognomy along the rivers and mountain slopes (da Silva et al., 2018). Participants indicated that the disappearance of water resources was marked by vanishing water springs, marshes, river potholes, and perennial streams. Within the last 30 years, these water resources had been disappearing to the point that where there once was water, only mud could be found now. Marshes, which used to serve as natural water reservoirs, are gone.

Figure 21

A Vanished River (Still From Video Recording 1)



Subsistence farmers stated that these natural water resources were progressively vanishing (see Figure 21), leaving them sometimes with no water to drink for up to three days. In contrast, previous generations were able to plant and harvest even during the months without rain. During the dry months, parents and grandparents could find water in nearby springs, creeks, marshes, and streams, which allowed them to plant crops even during longer periods of drought. However, those sources of water have disappeared over the years. Participants claimed that the increasing lack of rain had led to the disappearance of creeks, marshes, and streams. Today's crops do not grow due to the lack of water that can be felt, even during the rainy months, most likely due to the increase in temperatures and the prevalence of *veranicos/*little summers. Along the major rivers, wetlands and seasonally flooded grasslands were once common (da Silva et al., 2018), which can explain in part why subsistence farmers could plant rice and watermelon in the past.

Why are Creeks and Streams Vanishing?

"The rivers have dried," the subsistence farmers said. Record low rainfall and deforestation have undoubtedly affected the Sertão's natural water resources. On the one hand, some specific issues remain uncertain regarding climate change and its effects on the Caatinga forest water cycle, such as the fact that the desertification processes may be enhanced as vegetation faces higher atmospheric demand in a drier soil (Pinheiro, Van Lier & Bezerra, 2017). On the other hand, manmade disruptions to water levels are largely attributed to the disappearance of rivers, creeks, and springs. The Caatinga's dense river network, composed of both perennial and intermittent rivers, has been strongly disturbed by human activities (da Silva et al., 2018). The state of Minas Gerais has witnessed extensive mineral extraction activities for centuries and the São Pedro River Valley has been particularly impacted by precious and semi-

precious stone-mining activity. The abusive extraction of resources and the privatization of nature have led to the disappearance of water sources in the Caatinga (Galizoni et al., 2020). Dams built by farmers and companies to irrigate coffee plantations in the upper Jequitinhonha have put a strain on the volume of water in streams and creeks in the Valley (Galizoni & Ribeiro, 2004).

Additionally, vast areas of eucalyptus plantation and agro-business activities have triggered a drastic process of watershed decimation (Galizoni et al., 2020). On the plateaus of Jequitinhonha and in the general fields of the São Francisco, for instance, springs were buried by the planting of massifs of eucalyptus trees by reforestation companies, or were devastated, along with native vegetation, by charcoaling companies (Galizoni & Ribeiro, 2004). Subsistence farmers explained that the trees that used to exist along the riverbanks to hold water have been removed by large-scale agricultural activities. The removal of those trees has weakened the rivers, leading to their disappearance, along with converging creeks and streams that used to be a reliable source of water to the rural community.

Granite Quarries and Water

Access to drinking water is the most significant issue faced by host communities near a quarry (Melodi, 2017). Subsistence farmers explained that, in addition to various economic activities detrimental to their water supply, granite quarries had also affected the nearby streams, creeks, and marshes (also known as surface water) commonly used by rural families. Contrary to underground rock exploration, granite quarrying is an open-pit activity. Despite the different procedures, their activities consist of extracting minerals from the ground (Ozcan, Musaoglu & Seker, 2012). According to Ukpong (2012) some of the environmental disturbance created by quarrying is caused directly by engineering activities during aggregate extraction and processing

of the rock. The environmental impact of mine-quarrying activities is very complex and it not only destroys the existing vegetation but also affects the surface and ground water quality (Kumar, 2017).

Quarrying basically destroys landscape, which leads to downstream movement, scouring, or accumulation of sediment while provoking erosion (Ozcan et al., 2012). In fact, environmental degradation accompanies mining operations and remains after they cease, leaving air pollution, scars on the landscape, and damaged surface and underground waters (Ukpong, 2012). Due to their proximity to one another, granite quarries' environmental impacts are closely felt by rural communities. Granite quarries generally use the same surface water that subsistence farmers depend on for their household consumption and to water their crops. The effects of granite quarrying on vanishing surface water are widely known, even in the Brazilian Serão. Indeed, along with intense agricultural techniques, exploration of granite rocks has drastically increased the processes of watershed dissipation in the Caatinga (Galizoni et al., 2020). In the São Pedro River Valley, granite quarries have had two major impacts on surface water: they have reduced the flow and polluted the water. In this fragile ecosystem, already facing vanishing surface water, it is necessary to understand those two impacts.

Quarrying and Surface Water Flow

Subsistence farmers explained that granite quarries had put a strain on their natural water resources. Indeed, haphazard quarrying activities may cause a rapid impact on riverbed configuration in response to the changes in flow (Ozcan et al., 2012). However, the most detrimental activity to surface water flow originates from the quarries' own needs. It is not viable to cut the granite rock without using water (Santos Silva & Costa, 2019). Natural stone industries are located near a source of surface water because some parts of the production process need

water (Oktriani et al., 2017; Sasikala & Chandran, 2015). Granite quarries take the blocks to the sawmill, which requires water to transform the blocks into polished slabs (Bacarji et al., 2013). These activities are conducted near water bodies, near farmland and human settlement (Ukpong, 2012). In the São Pedro River Valley, granite processing activities have an immediate and significant effect on surface water flow because they increase the water demand in a water-depleted region. On the one hand, granite quarries' water usage increases water scarcity in the vicinity. On the other, all 10 households interviewed in this study were located within fewer than 3 km of a granite quarry. Thus, the limited surface water flow has been severely reduced due to water demand originating from granite processing activities near the rock extraction sites.

Households that depend on surface water and live near granite facilities have been affected by the shortage of water (Sasikala & Chandran, 2015). Another aspect to be considered is the location of the granite processing sites. Granite quarries and processing facilities are usually found in higher altitudes. When granite sites are located uphill, the water used to process the rock directly impact the water supply downhill. This spatial distribution increases even more the impact of granite-related water demand on water deficit. Subsistence farmers' surface water has been depleted from the top down. In this sense, granite-related activities in the São Pedro River valley have exacerbated the dissipation of surface water resources and farmers' survival.

Impact of Granite on Surface Water Quality

Several studies corroborate the claims of water contamination as a direct result of granite quarrying. In the granite exploration process, waste is generated alongside causing serious environmental problems, either at the point of production or processing, or during extraction. (Azevedo et al., 2020; Ukpong, 2012). During the cutting operation, flush erosion of the tool occurs due to the flowing action of a fluid stream that carries hard abrasives of tiny rock detritus

(Gupta, 2018). In Brazil, the export of ornamental rock from January to May 2019 generated a total of $407.5 million dollars, and the production process generated 80% of waste from extraction to polishing (Azevedo et al., 2020). It is estimated that 2.2 tons of abrasive sludge is generated per cubic meter of sawed rock (Nascimento et al., 2020). Water samples with high turbidity may exhibit high metal concentrations (Kernen, 2010). Not surprisingly, subsistence farmers' surface water quality has been affected. In the process of granite quarrying and manufacturing, river water is utilized to reduce the heat of the machine and to clean the equipment needed for stonecutting activities (Sasikala & Chandran, 2015). These activities involve the release of different pollutants into the water.

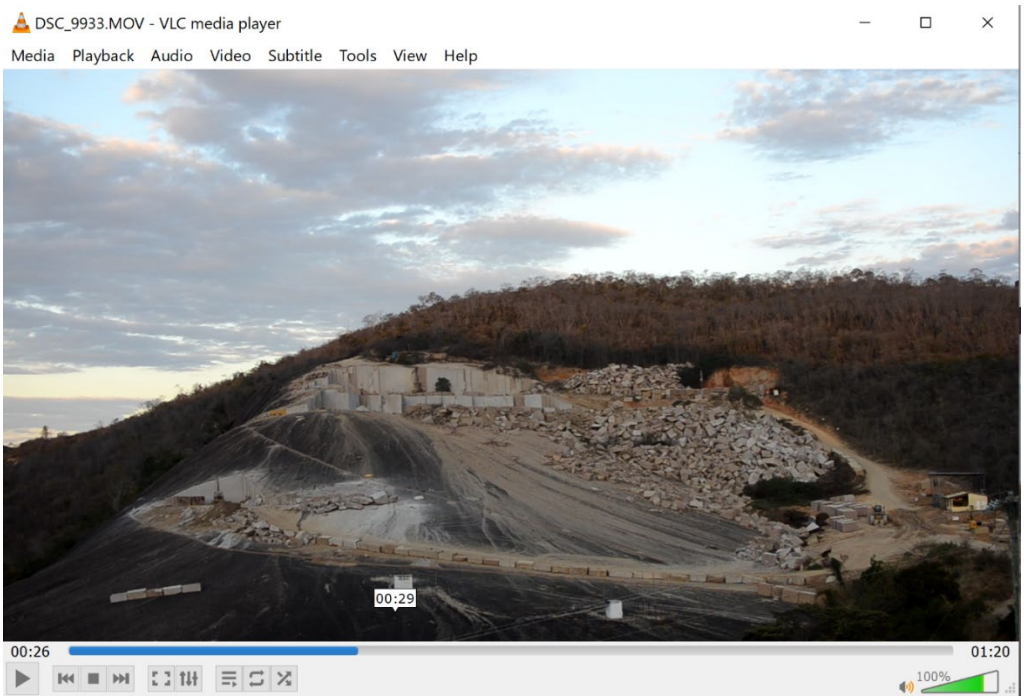
Subsistence farmers used the word contamination to refer to the presence of five pollutants in the water: oil, gasoline, kerosene, nitrate, and mercury. Studies on the impact of granite quarries on the environment indicate granite processing indeed releases harmful elements into the water (Azevedo et al., 2019; Bahloul et al., 2019; Songmene, Kouam & Balhoul, 2018). During sawing of granite slabs, a slurry containing abrasive elements such as iron particles and lime are released into the water (Bacarji et al., 2013). Rivers become a dumping ground for waste (Sasikala & Chandran, 2015). There is a need to regulate and control the waste produced from quarrying activities in order to prevent the introduction of excessive heavy metals into the surface water. (Ukpong, 2012). In the São Pedro River Valley, the contaminated water has been released without going through any type of water treatment.

Granite quarries are located on higher grounds (see Figure 22). Thus, in the context of water contamination by granite activities, spatial distribution plays an important role. Since subsistence farmers used marshes for planting, their crops were located on lower ground, whereas the quarries were high up. In that sense, the residue was directly carried down to the

lower levels. Subsistence farmers explained that “all the pit oil, chemicals and rock dust came down and contaminated our marshes.” Thus, the floods had been washing down chemicals and rock dust from the quarries into the ground, contaminating the waters in the subsoil level. For subsistence farmers to access clean drinking water, they had to dig several meters down into the lower layers of the aquifer. This could only be achieved through the construction of underground water wells, which they did not have the means to do for lack of resources.

Figure 22

A Quarry Location (Still From Video Recording 2)



Rock Dust in the Water

The ornamental stone processing industry has a considerable environmental liability related to residue generation during the cutting stages of granite blocks (Azevedo et al., 2019). When granite quarries cut the rock, cutting waste is produced in the initial phase of granite processing and, at this stage, an abrasive sludge is produced (Nascimento et al., 2020). The process of shaping dusty materials such as granite generates harmful dust (Songmene, Kouam &

Balhoul, 2018). The dust suspended in the air is especially harmful to the health and safety of local populations (Boutemedjet et al., 2019). The impact of rock dust on humans and the environment has been widely known. Rock dust severely affects the quality of the water (Sasikala & Chandran, 2015). Crystalline silica is a common component of rocks found in quarries, which affects rivers (Sasikala & Chandran, 2015).

Subsistence farmers described rock dust as an important pollutant present in the surface water. Despite the fact that the quarries have ceased their activities, granite dust continues to spread through air and water, polluting the nearby surface water. Rock dust is one of the most visible, invasive, and potentially irritating impacts associated with quarrying, and its visibility often raises concerns that are not directly proportional to its impact on human health and the environment (Ukpong, 2012). The presence of rock dust in the São Pedro River Valley has become part of subsistence farmers' daily lives. Often referred to as sand, rock dust has had a direct impact on the quality and flow of surface water. According to subsistence farmers, rock dust has been washed into nearby creeks and streams.

Stone cutting processes generate and release waste in large volumes, which causes pollution in the rivers (Azevedo et al., 2019; Bahloul et al., 2019; Songmene, Kouam & Balhoul, 2018). It is estimated that the sludge produced by granite quarries contains approximately 67% water and 30% rock dust (Nascimento et al., 2020). Despite their awareness about the presence and harmfulness of granite dust, subsistence farmers are still using the contaminated water from the rivers because it is their only source of drinking water. Exposure to the toxicity of granite dust can cause a disease called silicosis, a type of pulmonary fibrosis (Bahloul et al., 2019). Thus, water pollution resulting from granite processing activities has not only affected subsistence farmers' crops but has also posed a serious risk to their health.

Pollution of the Dam

Subsistence farmers have access to only one dam in the São Pedro River Valley, which was built in the 1990s to help rural communities survive during excessive periods of drought. Since then, this open-water manmade reservoir has represented a source of income and nourishment for households and for crop irrigation among the rural community. Subsistence farmers claim the water in the dam has been polluted by rock dust and other quarry related contaminants. They assert that, similar to the effects on nearby creeks and streams, rock debris, dust, and pollutants have been carried down through the water into the dam, altering and compromising its quality.

Previously described in the context of granite quarries' impact on surface water, evidence further corroborates the subsistence farmers' assertion regarding the pollution of the dam. Indeed, if granite quarries affect the quality of the water surface that feeds the dam, the water in the dam is also polluted with chemicals and rock dust. The water in the dam is reported to have a yellow and filmy appearance in addition to a strong smell. However, subsistence farmers still use the water from the dam because they do not have a choice. The dam is located within 500 meters (equivalent to 0.31 miles) downstream of a granite quarry, which highly increases the level of contamination.

Obstruction of the Dam

Not only has the release of pollutants and rock waste as a result of granite extraction activities contaminated the dam, it has also led to its obstruction. Subsistence farmers directly attribute the blockage of the dam to the quarry, claiming it has clogged the dam with granite waste. The obstruction of the dam is largely substantiated by photos taken by the RA (Chapter 4), which show the presence of granite waste in an empty dam. The obstruction of the dam by

granite waste is an issue that has also caught the attention of local government officials in the São Pedro Valley. Initiatives have been led to clear the obstruction by removing the granite debris from the dam. However, the granite waste continues to be released into the dam despite the ceasing of granite extraction operations. Evidence suggests that, over time, granite waste has been carried over by the streams and has blocked the dam. The obstruction of the dam is a lamentable reality that affects rural communities and local public spending as well. In fact, it reverses local government's endeavors because it no longer serves as a source of water for the local community, as originally planned. In terms of public capital, this represents a waste on two levels: the initial funding of the construction of the dam in the 1990s and, more recently, the loss of resources used to remove granite waste from the dam to unsuccessfully re-enable its use.

Granite waste is widespread in the region (see Figure 23). Other than the physical evidence in the field corroborating the blockage of the dam, studies offer further insights about the blockage of dams by granite waste. Granite waste property has been largely studied to benefit the construction industry and prevent environmental degradation (Savadkoohi & Reisi, 2020). In that sense, several researchers worldwide studied the use of granite waste in the production of building materials (Amin et al., 2020). Recently, it has been verified that cement and mortar can be made out of granite waste (Nascimento et al., 2020; Savadkoohi & Reisi, 2020). The adhesion resistance of a mortar depends mainly on the bond between the mortar and the substrate, which is highly affected by porosity (Nascimento et al., 2020). The abrasive sludge produced during the initial phase of granite processing has proven to have great sealant properties.

Thus, granite waste has the potential to be incorporated into concretes because granite dust improves the bond, thus increasing the adhesion strength (Nascimento et al., 2020). Granite dust can be used to replace sand in cement mortar. When mixed with water, granite dust results

in higher strength of the cement mortar (Amin et al., 2020). The substitution of natural sand with granite powder in mortars increases maximum adhesion strength by 30% (Nascimento et al., 2020). The introduction of granite dust into the concrete mixture led to a reduction of water absorption of 32–38%, and water penetration by 60–70% (Prokopski et al., 2020).

The aforementioned findings can hypothetically be compared to the outcomes observed in the dam at the São Pedro River Valley. An empirical correlation can be drawn between the physical properties of granite waste and the severity of the obstruction of the dam, as perceived by subsistence farmers. Although the findings in this study can only be empirically suggested, the observations with respect to the hardening property of granite waste to increase mortar adhesion closely reflect subsistence farmers' assertions about the presence of granite waste carried by the water. Thus, there are speculative indicators that granite waste mixed with water in the environment has the potential to react similarly, creating blockage in the form of a concrete-like substance.

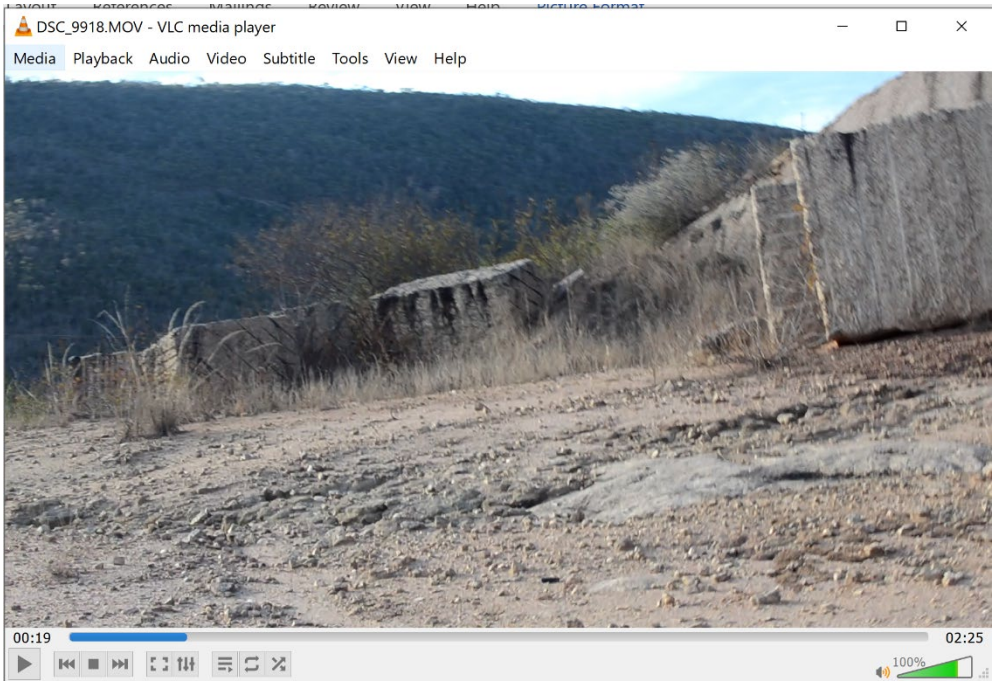
Granite Quarries and Groundwater

In general, all industrial activities have impacts on the environment, caused by the excessive use of non-renewable raw materials and the increased production of waste that is incorrectly disposed of in the environment (Azevedo et al., 2020). In general, environmental degradation accompanies mining operations, and remains after they cease, creating air pollution, scars on the landscape, and threatened surface and underground waters (Ukpong, 2012). Underground mining activities bring changes to surface landforms, ground water, and surface water (Blodgett & Kuipers 2002). Underground excavation leads to problems of decay of the physical and mechanical rock characteristics because of the water drainage in the quarry (Bruno

& Cherubini, 2005). Quarrying operations can adversely alter pre-existing ecosystems, and change hydrogeological and hydrological regimes (Ozcan et al., 2012).

Figure 23

Granite Blocks, Dust and Rubble (Still From Video Recording 3)



Studies confirm that the exploration of rock and stone has an impact on groundwater. Quarries' activities have harmful effects not only on surface water but on groundwater as well (Azevedo et al., 2020; Boutemedjet et al., 2019). In the São Pedro River Valley, the impact of granite quarrying on underground water is not visible, but the depletion of water by granite quarries can be seen in open-source geological imaging (Siagas, 2021). Siagas is an official groundwater information system, developed by the Geological Survey of Brazil, which provides an updated database of wells and developed modules capable of carrying out queries and research, and extraction and generation of reports. The current reports from Siagas reveal the existence of artesian wells built nearby quarries. This suggests granite quarries have dug wells to

provide water supply to the granite extraction activities of the São Pedro River Valley (Siagas, 2021). The artesian wells built by granite quarries have put an additional strain on the communities in this water-depleted region.

Groundwater is not as free flowing as surface water. Predicting and modeling how it flows is widely complex (Kumar, 2017). Nevertheless, several studies substantiate subsistence farmers' claims that granite quarries affect underground water quality and flow. According to them, granite quarries had polluted underground water and diminished the aquifer levels, leading to the disappearance of natural spring waters. Indeed, the pollution of aquifers is affected by industrial facilities, unauthorized solid waste landfills, fuel, pesticides and mineral fertilizers, long-term excessive water abstraction from wells, and migration of substances in closed areas (Koshliakov et al., 2020).

Subsistence Farmers' Dependence on Groundwater

Groundwater is a valuable resource used to provide the communities in the arid region with drinking water. In general, during dry seasons and drought periods, small underground watercourses in river headwater areas are the main source of downstream waters. In the Caatinga, the groundwater is located several meters below the river bed, restraining its connection to the root zone of plants (Pinheiro, Van Lier & Bezerra, 2017). The physical outlets of an aquifer are known as springs. During the drought season, underground water found in natural springs represents subsistence farmers' main source of water, a reliable source that is often safe for them and their animals to drink. Subsistence farmers know that, in contrast to surface water that is subject to run off from the land and, groundwater is covered by soils and sediments and is considered to be less vulnerable than surface water. These springs supply most

rural communities and families with water and are therefore crucial in the spatial and productive distribution of the rural population (Galizoni & Ribeiro 2004).

Explosives and Springs

Explosives and diamond wire are the most commonly used methods in Brazil to cut granite in small quarries, for their practical and economic advantages (Santos Silva & Costa, 2019). Excavation of rocks is proven to have a direct impact on water supply (Bruno & Cherubini, 2005). In the São Pedro River Valley, evidence suggests that the underground water flow has been directly impacted by granite extraction activities. According to subsistence farmers, the water level in the aquifer, or underground water reservoir, is decreasing. The main indicator of this phenomenon is the disappearance of spring water, which has been largely observed by the rural community within the last 30 years. Subsistence farmers attribute the disappearance of springs to the recurrent practice of rock excavation in the quarry sites.

Rock extraction in the São Pedro River Valley has been done through the use of dynamite. In the context of rock excavation and the use of explosives, ground vibration creates cracks in the surrounding rocks near the blast site and travels at different rates through soil, rocks, and water until the energy of the vibration is dissipated (Jug & Grabar, 2020). According to subsistence farmers, this vibration has travelled and even led to the cracking of walls in homes situated near the quarries. Along their way, blast vibration waves shake humans, animals, plants, and any man-made and other natural installations (Jug & Grabar, 2020). Evidence suggests that the blasts that travel as a result of dynamite use for rock extraction have led to the shifting of rocks, affecting the flow of perennial springs nearby. These types of natural water sources, which had been used for several generations, had vanished overnight following the rock blasts. The

explosions had been conducted by a quarry located less than 1 km from the spring. The proximity of the two events in space and time indicate a likely correlation between them.

Subsistence farmers explained that the explosions to extract rocks, along with subsequent granite residue (consisting or rock debris and rubble) released into the ground and water, have destroyed natural springs, and obstructed and destroyed creeks, streams, marshes, and the dam. When quarries used explosives in the São Pedro River Valley, the detonations were felt by nearby rural communities who witnessed not only the blast itself but also the subsequent flying of rocks and debris. Studies further substantiate these claims, strongly corroborating the correlation between groundwater depletion and the practice of rock explosion. Mass rock excavation with explosives affects the safety of aquifers in the vicinity of the blasting area (Jug & Grabar, 2020). Blasting may cause a shaking-loose of silt, sand and rock particles, and chemical precipitates that line fracture surfaces in the subsurface (Kernen, 2010). The fly-rock, or particular rock that flies beyond the blast site, causes damage to property and injuries to people, and can lead to fatalities (Jug & Grabar, 2020).

The dynamite blasts described by subsistence farmers for rock extraction can be empirically compared to a similar form of explosion called bombturbation. This practice results in a cratering phenomenon visually similar to the one observed in an open-pit quarry. Bombturbation leaves behind a pit that is variously excavated of soil with an accompanying rim of debris nearby (Hupy & Schaetzl 2006). Many soils and landscapes that have undergone bombturbation are largely altered, with long-lasting craters left behind that may have shifted onto a new pedogenic pathway (Hupy & Schaetzl 2006). Water regime is also affected by bombturbation. In some instances, impermeable bedrock and soil layers are breached by cratering, depriving the vegetation of its former source of shallow water. In other instances,

cratering exposes a preexisting shallow water table, limiting subsequent reforestation (Hupy & Schaetzl 2006).

In the context of underground mining, the phenomenon of subsidence is observed. This phenomenon can be closely compared to the effects of rock excavation by explosions on underground water flow. Subsidence occurs as a result of underground blasting. Subsidence can cause the formation of open cracks, fissures, or pits (Blodgett & Kuipers 2002). Subsidence impacts agricultural lands in ways that include the formation of surface fissures, change in ground slope, changes to surface drainage, disruption of ground water hydrology, and deterioration of surface and ground water quality (Blodgett & Kuipers 2002). Although subsidence is linked in this case to mining activities, which, contrary to quarries, take place underground, their effects can nevertheless be anecdotally associated with the observations revealed by subsistence farmers in the São Pedro River Valley.

Groundwater Pollution

Rock extraction or excavation is proven to affect not only the quantity but also the quality of groundwater. Indeed, in addition to water depletion, rock blasting can have extensive adverse environmental impacts, like vibrations, noise, dust, and chemical contamination (Jug & Grabar, 2020). Pollution may also occur in the form of fugitive dust from excavation, from haul roads, from blasting, or from point sources (Ukpong, 2012). Blasting may cause a shaking loose of silt and sand and rock particles (Kernen, 2010). This leads to chemical precipitation into line fracture surfaces in the subsurface, which can result in increased turbidity in water derived from a bedrock well (Kernen, 2010). Also, if commercial explosives are spilt on the ground or left undetonated at a blast site, ammonium and nitrate can reach into ground, surface, and groundwater (Jug & Grabar, 2020). In some instances, materials such as detonators and

explosives are not entirely combusted during blasting and result in the release of soluble substances into the groundwater (Kernen, 2010). Rock blasting can result in increased turbidity in water derived from a bedrock well (Kernen, 2010). Thus, blasting activities should be avoided near urban areas, protected animal habitats, water protection zones, and so on (Jug & Grabar, 2020).

Subsistence farmers described the effects of granite quarrying in ways comparable to the effects of coal quarrying. Along with the damage of water pollution by dust and combustion gases of blasting in coal quarrying, coal pits have a significant negative impact on water resources. Polluted quarry water worsens the ecological situation in a much larger area than covered by water pollution (Kumar, 2017). Rock blasting activities that will excavate more than 5,000 cubic yards of bedrock may impact drinking water supplies (Kernen, 2010). Additionally, the transfer of dust from the air to surface waters can result in contamination. Impacts generally relate to the presence of suspended solids, in addition to those arising from water erosion. In rare cases, physical impacts may be aggravated by the presence of chemically active minerals in the dust (e.g. limestone contains alkaline calcium carbonate and sulfides) that can alter water chemistry and suitability for the fauna and flora that it supports (Kumar, 2017).

Disappearance of Wildlife

With respect to the presence of wildlife, the majority of subsistence farmers explained that animals could not be found any more in nature as they once could. The meat of wild animals constitutes an important protein source for several rural and urban communities (Albuquerque et al., 2017). Thus, the disappearance of animals has another direct impact on their livelihoods because of the significance of the local fauna as a source of food. The large number of people living in the Caatinga and their economic conditions force many local communities to use plant

and animal resources to meet their needs (da Silva et al., 2018). Thirty years ago, rural people in the São Pedro River Valley used to hunt animals such as gray brockets, spotted pacas, and armadillos. One of the most fundamental uses of game animals in this region was to meet nutritional needs (da Silva, Leal & Tabarelli, 2018).

These resources are even more important during seasonal drought periods, especially the more prolonged periods when a good portion of the livestock herds die from hunger and thirst (da Silva et al., 2018). In other parts of the Caatinga, however, hunting continues to occur, and the people use animal resources in various ways, demonstrating the economic and cultural significance of local fauna to the people in this region (da Silva et al., 2018). However, in the São Pedro River Valley, due mainly to the dissipation of water resources and laws forbidding hunting activities, subsistence farmers can no longer find wildlife to hunt or fish. Indeed, the importance of fishing for local peoples has decreased in recent years due to environmental degradation (Albuquerque et al., 2017).

Although much of the disappearance of wildlife can be attributed to previous economic activities in the region, granite quarries also play an exacerbating role in the disappearance of wildlife. By putting a strain on the water demand and affecting the quality of the water and the soil, granite quarries directly affect the wildlife nearby. Indeed, in addition to pollution, quarrying activities cause groundwater seepage fluctuations and consequent natural habitat-induced geological disasters (Ozcan et al., 2012). Some impacts of those activities can be felt by subsistence farmers, and they mentioned the disappearance of animals that were directly affected. Others are affected indirectly. For example, in the context of mining activities, one species of aquatic insect may be unique to a particular hydrological system that is threatened. In

an indirect manner, any mammalian wildlife, which depends on that species of insect for food, would also be impacted (Blodgett & Kuipers 2002).

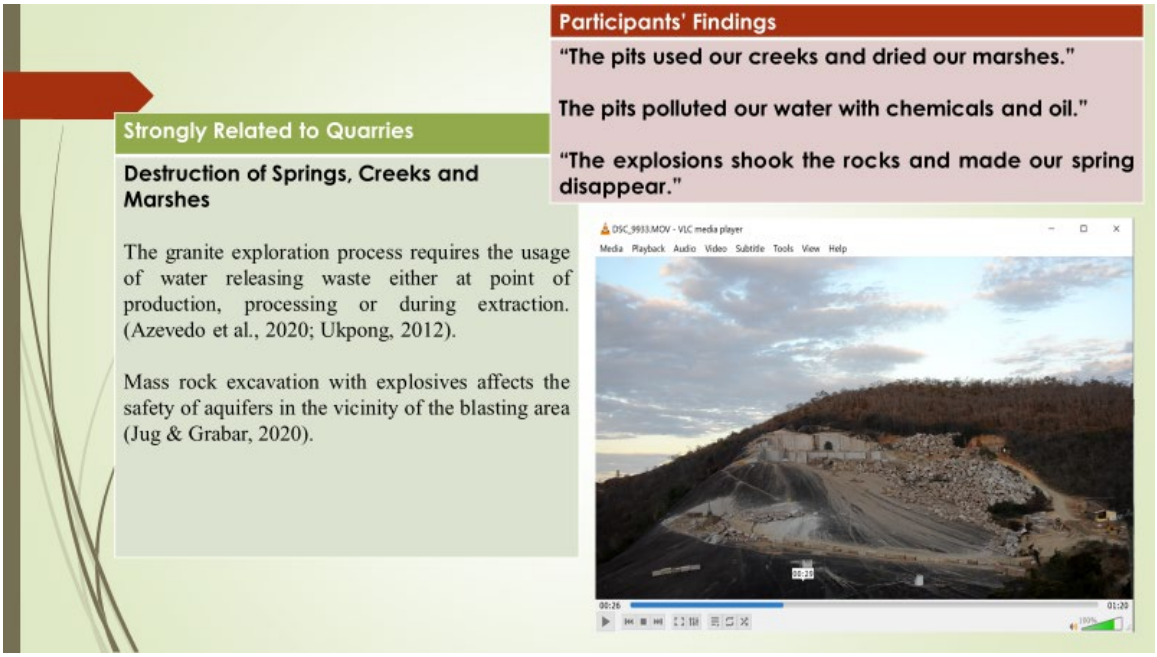
Conclusion of Water Resources

Subsistence farmers' significant dependence on natural surface and underground water resources is undeniable, especially during the drought season. At first sight, deterioration of water resources in the Valley can be attributed to the lack of rain, a history of systemic deforestation practices in the region, and climate change indicators. The findings in this case study revealed participants' inability to access the necessary amount of water to cover their daily needs. Subsistence farmers' claims about the impact of granite activities in vanishing water resources are also largely explained. Granite quarries have affected the water resources in many ways (see Figure 24).

First, quarrying activities have increased surface and underground water demand. Second, chemicals resulting from granite extraction and processing activities have adversely impacted the quality and flow of surface and groundwater. Third, rock excavation using dynamite has led to the depletion and the contamination of the aquifer, while granite dust has polluted nearby creeks and streams and obstructed the dam. In sum, granite quarries have exacerbated the water shortage and further polluted different sources of natural water supplies in a severely water-depleted region. As a result, the survival of those who solely depend on natural resources has been severely compromised. These actions have directly affected subsistence farmers' lives and crops, increased endangered wildlife decimation, and posed a serious threat to the health of the rural community in the Valley.

Figure 24

Destruction of Natural Water Resources in Relation to Quarrying



The Soil

The soil was one of the four main themes identified in the word-as-a-unit data analysis. During initial data collection, six out of ten households indicated an issue with regard to their soil. During member checking, all participants provided detailed information about the damages. This case study revealed that soil for subsistence farmers is as important as water. According to the farmers, the soil is interconnected with the water. To rural families, the land gives life to the water, which has channels where the water is in constant motion (Galizoni & Ribeiro 2004). Consequently, if the water supply is depleted or there is pollution in the water, the soil is directly affected. The main claim regarding the soil conditions in the São Pedro River Valley was that the land did not produce any more, as it used to in previous generations. During initial data collection, some households explained that one of the main reasons they could not plant and harvest as before was because the dirt had lost its fertility.

Participants stated that their soil was tormented. Member checking provided details of the condition of the soil, revealing it had lost its ability to produce, had become hotter, was less absorbent, and was sandier. According to subsistence farmers, their lands had become a dumping ground of granite rubble, which had made it useless for planting and harvesting crops. Recent photo images and video recordings showed rock debris spread out throughout the lands, as well as abandoned equipment, suggesting also the presence of chemicals. The main changes to the soil as reported in this study were related to the absence of natural fertilizers in the ground, the presence of granite residue in the form of rubble or debris, and the release of granite dust in the air, known in the literature as silica particles.

The opening of a granite quarry begins with the stripping of the deposit (the rock), removing the organic soil found on the deposit to expose it to the surface. When operating in accordance with environmental laws and guidelines, granite quarries reuse the surface removed in various construction projects (Santos Silva & Costa, 2019). But when quarries do not follow environmental regulations, the rock debris lies in the open indefinitely, along with abandoned machinery, once the quarry decides to shut down (see Figure 25). A study of 12 quarries in Turkey concluded that quarrying activities that did not operate properly could result in significant loss of soil. As Sari and Özcan (2018) pointed out, “If a quarry is opened on arable lands, it is of vital importance to properly excavate and store soil formed through chemical and physical processes under various conditions for many years in order to ensure that it is reusable” (p. 82).

Participants referred to silica particles (Shaik et al., 2015) as rock dust. They stated that over the years, granite dust released from quarries had affected the quality of their soil, damaging their crops and significantly reducing their productivity (see Figure 26). Jug and Grabar (2020)

recently suggested that not only the soil is affected by granite quarries, but also the air. Dust generated by blasting and suspended into the atmosphere greatly affects air quality. Similarly, Sari and Özcan (2018) concluded that quarrying activities released dense dust particles in the air. Participants claimed that the dirt had lost its natural fertilizers and was now poor, due to deforestation.

Figure 25

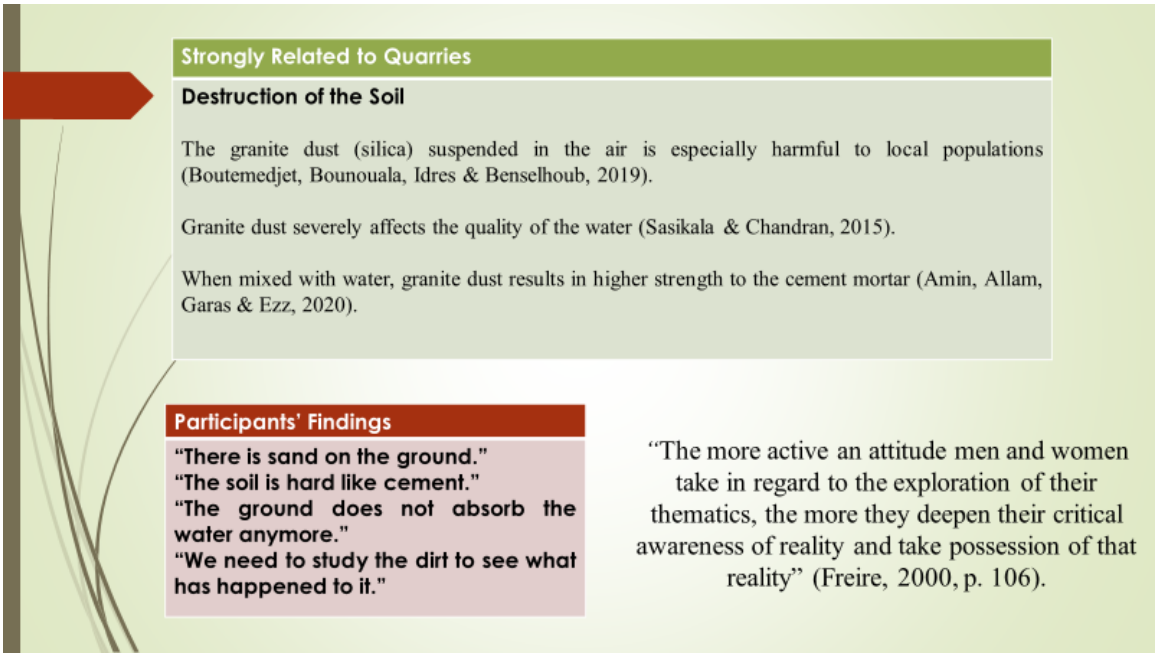
Rock Debris and Abandoned Equipment

Indeed, the claim regarding the lack of fertilizers in the ground can largely be substantiated by the prevalence of deforestation practices, led not only by granite quarries but also by other large-scale economic activities such as cattle raising and eucalyptus plantations (as discussed earlier in this chapter). The severity of the environmental problem depends on the characteristics of the mineral being extracted, the methods of mining, waste materials generated,

and the site characteristics. The effect is manifest in air, land, plants, and water associated with the mining process (Ukpong, 2012). If one of these elements is damaged, it has a chain reaction through other natural elements. In fact, water, soil, and vegetation act in a complementary way (da Silva et al., 2018).

Figure 26

Quarries Have Negatively Affected the Soil



When describing the hardening conditions of their soil, subsistence farmers indicated that, at times, they had to use pickaxes to dig the ground. Several studies mentioned earlier in this study (under the section Obstruction of the Dam) revealed that the use of granite dust in cement mixes significantly increases its adhesion property. Similarly, Prokopski et al. (2020) examined the possibility of significant improvement in the technical properties of concrete with the addition of granite dust. It was established that the addition of granite dust leads to an increase in the average density of concrete. Due to the partial replacement of sand with dust, the microstructure of the cement matrix is compacted, which is the main reason for increasing the

strength of concrete with dust. The strength of the concrete increased by 17–19%, compared to control samples without granite dust (Prokopski et al., 2020).

Soil Analysis

As indicated in Chapter 4, the interpretation of the soil analysis report revealed very low levels of soil fertility and aeration, and high levels of potassium and calcium in addition to major deficiency in organic matter. These results validated and further expanded participants' claim about the hardening of the soil. According to the soil analysis interpretation, calcium in abundance leads to carbonation of the soil, which makes it harder and mineralized. The excess of calcium causes cementation of the soil, forming a soil known as calcrete (Appendix C). Calcrete is used as a substitute raw material resource in cement industries (Velmayil & Alagaiah Venu, 2020).

It was observed in the samples and in the visual tactile analysis that the soil presents itself in clumps, with a total absence of organic matter. This indicated that the soil is very poor in terms of fertility. According to geologist Dr. Rodriguez, the soil needs to be more aerated, more loose and alive, to produce food for plants. The analytical results indicated that the region's soil is very poor in organic matter and has practically no microbial action, required for desirable fertility. With regard to pH range, the majority of samples had a good acidity range for agriculture.

Conclusion of The Soil

Participants claimed their soil had become unproductive because of granite debris and rock dust that had been carried over from the granite quarries. Several studies on rock dust corroborate the negative impact of granite particles on soil fertility. The soil analysis conducted at the University of Southern Bahia and interpreted by geologist Dr. Rodriguez confirmed

subsistence farmers' claim regarding the conditions of the soil. The results revealed that all analyzed samples were poor in organic matter, presented high to very high levels of calcium and potassium, and had poor soil fertility and aeration. Participants' claims aligned closely with the soil analysis report with respect to the dirt's condition, as shown in Table 26.

Table 26

Participants' Claims Compared to Geologist's Report

Participants' Claims	Dr. Rodriguez's Soil Analysis Report
• "The soil is poor." • "The dirt has lost its natural fertilizers." • "The soil is hardened." • "The soil is like cement." • "The roots can't grow because the ground is dry and hard." • "I had to use a pickax to harvest in this hard soil." • "The dirt has been washed off." • "The soil is dry." • "The ground is now a sandy and hot dry dirt so we work really hard in the sun but you can see there are no crops to harvest here." • "The soil is so dry it cannot keep the water anymore even when it rains the water goes away."	• The soil is poor in organic matter. • The soil fertility levels are very low. • The soil has practically no microbial action. • The soil has excessive levels of (Ca^{2+}). • Ca^{2+} in abundance leads to carbonation of the soil, making it hard and mineralized. • The excess of Ca^{2+} causes cementation of the soil, forming a soil known as calcrete • The soil is low on phosphorus (important for flowering, fruiting and rooting) concentration range. The soil needs to be more aerated to produce food for the plants.

Conclusion to Part I (Summation)

Understanding the effects of granite quarrying in the São Pedro River Valley is a complex task. There are a variety of factors that have severely impacted subsistence farmers' livelihoods within different timespans. The region has a naturally challenging climate that has been ravaged by a history of excessive exploitation of natural resources and environmental

destruction for centuries (e.g. lumber, deforestation, cattle rising, fires, mining, and precious stones quarrying). Additionally, the harsh semi-arid climate in Brazil has witnessed an increase in temperatures and a major drop in precipitation levels, with the occurrence of *veranicos/*mini-summers within the last decade.

All these manmade and environmental factors in the region undoubtedly make distinguishing the effects of granite quarrying on humans and nature more difficult to pinpoint. This research examined a societal issue through an environmental lens using a pedagogical approach to reveal how participants' livelihoods had been affected by granite quarrying. It revealed that the activities involved in the process of rock extraction in the São Pedro River Valley have considerably accentuated the ongoing destruction of local vegetation, worsening food and water shortages in the rural community. Quarries have depleted and polluted natural water resources as a result of rock extraction and polishing. Quarries have exacerbated surface and underground water demand and damaged the soil in a fragile ecosystem, released chemicals and rock dust, and obstructed subsistence farmers' dam.

The results found in this study revealed that granite extraction activities have increased subsistence farmers' food and water scarcity by further exacerbating the ongoing destruction of the Caatinga biome. Due to the interdependence of water, vegetation, and soil, when water scarcity increases, the vegetation is removed and the land is damaged; a destructive cycle sets in. By impacting the water supply and compromising the quality of the soil, granite quarries have also affected the fauna and the flora in the São Pedro River Valley.

Although not the main cause for the destruction of wildlife, granite quarries are a contributing factor to the disappearance of local plants and animals, because they also depend on the environment to survive. The lack of rain and previous environmentally detrimental activities

have been so severe that they obfuscate the impact of granite quarries on subsistence farmers' livelihoods. In this sense, the continuation of both natural environmental and manmade disasters of the Caatinga biome mask the effects of granite quarries on subsistence farmers' livelihoods.

Part II: Discussing the Method

Systematization of Experiences

In this study, although the encounters with participants did not take place in an overt educational setting, the dialogues were conducive to learning by reflecting and sharing. While Jara's (2018) and Freire's (2000) liberation came through the power of literacy, this case study provided a setting to promote liberation through participants' realization of their own condition as subsistence farmers trying to plant and harvest near granite quarries. In that sense, participants systematized their experiences by collectively and cognitively developing a critical view about their own condition. The systematization of subsistence farmers' experiences led them to understand the impact of granite quarries in their crop production. This realization echoed Freire's *conscientização/*awakening*,* because participants ceased to see themselves as weak and poor, and progressively started to seek explanations for the problems related to planting and haversting. The methodology of *conscientização*/awakening introduces women and men to a critical form of thinking about their world. As Freire (2000) says, "The perception and comprehension of reality are rectified and acquire new depth" (p. 104).

In the systematization process, experiences are perceived individually and collectively by those who lived through them (Jara, 2018). For participants, reaching a realization of how their livelihoods have been impacted by granite quarries was a process achieved solely by them and through them without interferences. Systematization of experiences provokes a critical look at the experience, which produces new knowledge (Jara, 2018). Thus, participants can only

systematize their own experiences, and for that to occur, the encounters cannot be charged with outsiders' experiences or distractions. Dialectical member checking favored the systematization because it brought to participants others' experiences without outside interference.

Experiences are complex dynamic processes in permanent movement, encompassing a set of objective and subjective dimensions of historical-social reality (Jara, 2018). Participants in this study could discuss their experiences without having to tailor them for purposes other than their own interests. Subsistence farmers were not asked to elaborate, clarify, or reach any conclusion. Instead, they had the freedom to discuss or not, diverge their focus, or make or change their perceptions without following any structured delivery. They were able to "develop their power to perceive critically the way they exist in the world with which and in which they find themselves" (Freire, 2000, p. 12).

The systematization of experiences cannot take place when there is banking, an education concept where knowledge is a "gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing" (Freire, 2000, p. 72). This case study presented general prompts as guiding topics for discussion, instead of directed questions. Guiding prompts were addressed according to subsistence farmers' interest and interactions with each other rather than according to the prompts themselves. This format of data collection was an effective approach to prevent both bias and banking.

In the banking concept of education, the encounters "become an act of depositing, in which the students are the depositories and the teacher is the depositor" (Freire, 2000, p. 72). "Instead of communicating, the teacher issues communiques and makes deposits, which the students patiently receive, memorize, and repeat…. When there is banking, the scope of action allowed to the students extends only as far as receiving, filing, and storing the deposits" (Freire,

2000, p. 72). In direct opposition, experiences are not static; they are fluid because the perception of those who live them evolves, making them living places of creation and production of knowledge (Jara, 2018).

Adapting Research Methods to Covid-19

The Absence of the Principal Investigator. As previously mentioned, to circumvent limitations set by the origin of the Covid-19 pandemic, the data collection in this case study was conducted by the RA. Due to travel constraints in 2020, I could not travel to the field. Instead, the RA visited all households, serving as my voice and guide during the unstructured focus groups. My physical absence strengthened the ethical considerations of this study for two main reasons: first, subsistence farmers' cultural and social environment was not disrupted by the presence of an outsider; second, their identity was not revealed even to me, increasing significantly their confidentiality and safety.

My absence also increased this study's validity by greatly removing the risk of banking. This approach preserved the authenticity and integrity of participants' unique environment and was conducive to genuine data production and sharing among participants. This way, the case study could be structured to fit participants' culture and setting, as intended. The offering of food baskets to each household was also an effective approach to ensure a socially just and ethical environment and it resulted in the production of reliable and authentic data.

Although my physical absence led to limitations with respect to data collection, mainly due to the lack of field observations, the benefits surpassed those limitations. The absence of an outsider maintained the unique environment as authentic as possible, closely mirroring a typical day in the lives of subsistence farmers. Participants were not put in a confrontational or unfamiliar situation, thanks to my absence. They were free from judgement or criticism. Their

inputs were not challenged by the RA. In that sense, my absence ensured a necessary detachment towards participants and the data.

The RA was not perceived as a visitor because she is from the São Pedro River Valley. Thus, subsistence farmers did not feel the need to please her as they would most likely have with me and, most importantly, they were not inclined to react in a certain way. When visitors come to meet rural communities in the São Pedro River Valley, their presence can highly influence locals' behavior. Usually, members of the community treat guests with the utmost respect. Such a cultural trait can lead to inaccurate responses to questions in order to please a visitor. Also, due to their level of poverty, subsistence farmers may not have much to offer to their guests, which can put them in an embarrassing position.

Applications of Content-Based Unstructured Focus Groups. Another important aspect of this case study's adaptation to Covid-19 was with respect to participants' interaction. The unstructured focus groups did not lead to any social gathering outside the boundaries of families that lived together. The content-based unstructured focus groups were designed to produce and combine knowledge data without physically gathering the participants. Thus, each household first interacted within itself with members of their own family, addressing prompts that had not been thought of before. Then the essence of the interaction was shared among all households during member checking with the RA. During initial data collection, members from the same household interacted with each other, following the prompts suggested by the RA. Whereas the first time around, the RA was my voice, during the second interaction (member checking), the RA was the combined voice of all subsistence farmers.

Originally planned to circumvent the limitations set by the pandemic, content-based unstructured focus groups revealed themselves to be very advantageous in this study. First, this

approach of data collection was favorable to a more balanced and accurate participation from all subsistence farmers. Indeed, more time was dedicated to each person without the influence of others through peer pressure or the dominance of one speaker over another, which could be favored by more spontaneous personalities than others. Second, content-based unstructured focus groups brought anonymity to participants not only with respect to me, but also to subsistence farmers themselves. In fact, the names of participants from other households were never mentioned to each other, even when the interest of a subsistence farmer was sparked. Third, it reduced the risk of confrontation among subsistence farmers from different households. Also, completing both unstructured focus groups and member checking separately in each household helped remove group influence from participants' responses. All these benefits greatly increased the validity of the data produced.

Highly collectivistic, participants were receptive to content-based unstructured focus groups because the gatherings were among family clusters. This way, subsistence farmers were still interacting collectively but only within the limits of their own households. They avoided gatherings involving different households. Instead, the information they provided travelled across freely through the RA, who carried their voices to me. Content-based unstructured focus groups were conducive to learning by sharing, with the focus on the content rather than the delivery. During member checking, participants interacted with the data as if they were in a face-to-face group discussion, each time progressively reinforcing the interrelatedness of their subsistence with the environment. Additionally, a new relationship was established between the soil and the water.

The focus of content-based unstructured focus groups was on data collection strongly intertwined with data production. Subsistence farmers felt comfortable to speak even though the

RA was recording them. The participants in this study constructed new knowledge that emerged from their own comments and from using their own words, without a distinction of who said what. Data collection and production were both taking place at the same time, spiraling the information presented. Participants' perceptions evolved significantly from initial data collection to member checking mostly because during the second unstructured focus groups they were presented with their own words and they knew what to expect.

Creators of Knowledge Through Group Info-Gap

In this case study, subsistence farmers took the role of co-researchers. Pedagogically, their level of knowledge placed them in a teaching rather than learning position. Their analysis of reality emerged from a cooperative info-gap approach. According to Freire (2000), "The analysis of reality made by each individual decoder sends them all back, dialogically, to the disjointed whole which once more becomes a totality evoking a new analysis by the investigators, following which a new evaluative and critical meeting will be held" (p. 112). In that sense, participants collectively and progressively became creators of knowledge. Analogically, subsistence farmers had the pieces needed for me to put the puzzle together. Initially, although some subsistence farmers were already aware of the damages caused by granite quarries in the area, by sharing and analyzing their views, they raised their level of consciousness with regard to the problem, becoming critically aware of it.

Thus, when listening to what others said about the impact on their subsistence, participants were able to fill major gaps. For example, some households focused more on the lack of rain. Others insisted more on the deterioration of the dirt. Other households pointed out the vanishing rivers, streams, and springs. When all perceptions were combined, condensed and presented to participants, they were able to connect their observations and reach their own

conclusions. This led to their realization of the problem holistically (see Figure 27). Even though a few participants had already established strong connections between granite quarries and their livelihoods, they were not aware of the extent of the damage caused to their lands and water resources. It is worth making a parallel here with the trees and the forest. If we consider each participant as an independent individual who was seeing some trees, the sharing of the participants' input helped the group view the forest. The visualization of the forest in this study emulates the participants' realization of their condition, translating to an in-depth understanding of their experiences and their lives.

In essence, only participants held the answers to the issues presented in this case study. But the subsistence farmers' experiences had to be first combined and organized to be then critically and collectively analyzed. The progression of participants' perceptions was key to their awakening. For instance, initial data collection revealed that the soil was hot and dry. As more elements were added and reflected upon during member checking, the main issue revolved around the fact that the soil was hard, which was why crops had become increasingly difficult to harvest. Another example was with regard to the quarries, which, during initial data collection, were claimed to have impacted the subsistence framers' lands by leaving holes and rock debris behind. During member checking, it was revealed that the quarries had affected subsistence farmers' ability to access water, use their soil for crop production, and find food in the natural environment. The increasing levels of understanding that emerged from participants' encounters were crucial to their awareness and, consequently, opened the door to their ability to act.

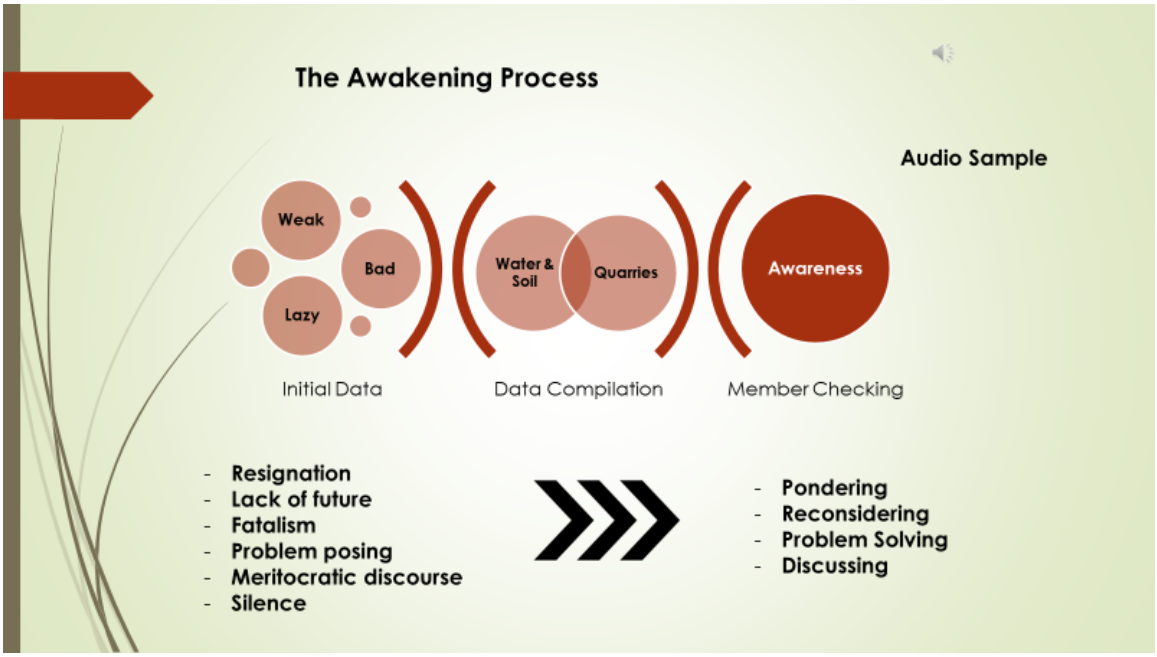
Participatory Perception of Power

Power and Oppression. As stated in Chapter 1, this research study was conceptualized through Paulo Freire's pedagogical framework, which is founded on the separation between

oppressors and oppressed. This distinction emanates from the universal imbalance of power distribution. In that manner, oppressors and oppressed cannot be dissociated. This study revealed that participants, although aware of their conditions as oppressed, were in general less aware of the concept of oppression. When a vulnerable community is faced with social injustice, it raises ethical issues to a higher level because of the steep unbalanced distribution of power. In the context of the São Pedro River Valley, power cannot be dissociated from oppression.

Figure 27

The Conscientização/Awakening Process



To subsistence farmers, power means freedom to plant and harvest. Because that power has been taken from them, they are oppressed. To be liberated from the oppression, participants in this study needed first to understand that they had been oppressed and why, so they could then take action towards gaining their power back to feed their families. As Freire (2000) says, "[t]he pedagogy of the oppressed, as a humanist and libertarian pedagogy, has two distinct stages" (p. 54). In the first stage, the oppressed unveil the world of oppression and through the praxis,

commit themselves to its transformation. During the second stage, in which the reality of oppression has already been transformed, this pedagogy ceases to belong to the oppressed and becomes a pedagogy of all people in the process of permanent liberation (Freire, 2000).

Although oppressors have the power, they do not necessarily see themselves as such. Most individuals who share humanistic theories or are well-intended often aim to reject oppression (Freire, 2000). To be an oppressor, in the context of this study, one does not need to claim such role. The simple fact of having running water and food security places individuals in a superior position compared to subsistence farmers in the São Pedro River Valley. Because food and water ensure dignity, the lack of them reduces dignity, putting human beings in an inferior position. In that sense, my absence undoubtedly removed an oppressive figure from this study. Subsistence farmers were then able to create knowledge in a setting in which the roles of oppressed and oppressor were not clearly defined. In that sense, and given the context of this case study, the absence of an authoritative figure was an additional instrument for participants to reach their awakening and liberation.

Human Rights and Environmental Justice. This case study raises a human rights and environmental justice issue. Human rights notions have been gaining influence in international water law, notably the human right to water, which has been recognized by the United Nations General Assembly and the Human Rights Council (Alsaadi et al., 2020). Indeed, the United Nations determines that access to water is a human right that is quantified as a minimum per capita consumption of 50 liters/day (Mota & Martins, 2019). Participants in this study claimed they often did not have enough water to drink during the drought season, or that they would at times drink from any source out of necessity. In that sense, the human rights violations in the São

Pedro River Valley is an undeniable fact. Not only do subsistence farmers lack the minimum daily amount of water, they are also faced with the consequences of drinking non-potable water.

As critical as the water issue is in the region, it goes well beyond the scope of this study. Although the human right to water exists under international law, the gap in implementation is widened by the steady growth in population and the unsustainable management of water resources worldwide (Alsaadi et al., 2020). Human rights are increasingly important in the context of individuals who depend on the environment to survive. Rural communities are the most vulnerable individuals because they are those who are the most affected by changes in natural resources. From the violation of subsistence farmers' human rights exposed in this study emerges the concept of social and environmental justice.

The global trend toward adopting environmental rights has been largely regarded as a positive development for both human rights and the natural environment (Gellers & Jeffords 2018). However, the impact of constitutional environmental rights must be systematically assessed using empirical data. According to Lata and Gupta (2020), environmental democracy sets a standard for how decisions should be made. At its core, environmental democracy involves three mutually reinforcing rights that, while independently important, operate best in combination: the ability for people to freely access information on environmental quality and problems, to participate meaningfully in decision-making, and to seek enforcement of environmental laws or compensation for damages (Lata & Gupta, 2020).

Participants from this case study had not received access to information regarding the effects of granite on their lands, nor any form of compensation due to the destruction of their crops or their water resources. As previously indicated in this study, Brazilian laws to address environmental issues do exist. However, when implemented, the environmental impact

assessments processes are done to fulfill legal obligations but with little motivation to protect community interests (Walteri et al., 2021). Additionally, the environment and justice of environmental justice are often defined through Western ways of thinking (Alvarez & Coolsaet, 2018). As a result, there is a tendency to transpose Western concepts and frameworks to other civilizations, running the risk of being ineffective and of producing additional injustices (Alvarez & Coolsaet, 2018).

Power in Religion. The participatory perception involved participants' views of the power found in the oppressors and in themselves. Subsistence farmers' perception of their own power evolved throughout this study as part of their awakening process. During the first encounters, participants repeatedly evoked their own lack of power. They used statements such as "we are powerless" and "we are so poor." Several households at first evoked religious reasons to explain their lack of power by saying "God has punished us" or "we might have done something really wrong." Many participants quoted Biblical parables that related very closely to their conditions and ways of life.

Traditional communities define themselves "far beyond physical forms of land use and occupation, to reach symbolic concerns, which are built by religion, customs, ways of being, identity conceptions of individuals" (Sulzbacher et al., 2020). Subsistence farmers at first spoke passively, accepting their fate as the will of God, who was punishing them. To some, poverty was also seen as a gift, because it brought them closer to their faith. In the New Testament, Jesus says, in Matthew 19:24, that "it is easier for a camel to go through the eye of a needle than for a rich person to enter the Kingdom of God," confirming the idea that the poor will be saved because, as they suffer, they become closer to divinity. Participants also referred to their lands several times as "a castigated land," closely relating to ancient rural communities who lived

similarly during Biblical times without access to running water in a desert-like environment similar to the semi-arid climate.

Fatalism and Meritocracy. Participants from six out of ten households said there was no future for them in the Valley. When pondering their situation, most participants at first consciously resigned themselves to fatalism. Freire (2000) says "Fatalism in the guise of docility is the fruit of a historical and sociological situation, not an essential characteristic of a people's behavior. It almost always is related to the power of destiny or fate or fortune—inevitable forces—or to a distorted view of God" (Freire, 2000, p. 61). Some subsistence farmers repeatedly stated "there is no rain because that's how it is" and "we were meant to suffer in this land." This fatalistic discourse is largely addressed by Freire (2000) who saw its anti-praxis roots. Indeed, fatalism goes against action because of the perception that a stronger power is acting upon those who are left helpless. While fatalism is a form of acceptance and passivity among subsistence farmers, it allows granite quarries to continue operating unaccountably in the São Pedro River Valley. Freire (2000) suggests that "[w]e need to say no to the neoliberal fatalism that we are witnessing at the end of this century, informed by the ethics of the market, an ethics in which a minority makes most profits against the lives of the majority" (p. 25).

Fatalism, or the upholding of the status quo, also finds its justification in the theories of meritocracy. Along with fatalism, subsistence farmers alluded to principles of meritocracy reinforcing the status quo in the São Pedro River Valley. At times they evoked their inability to harvest crops to be related to an act of God, and at others, they justified it by their lack of hard work which made them underserving individuals. In the meritocratic views, poverty is a consequence of lack of worth or talent. Several recent narratives indicate there are issues with the contemporary neoliberal meritocratic discourse (Littler, 2018). To better understand the concept

of meritocracy, Kim and Choi (2017) elaborated a literature review of 18 studies and concluded that contemporary meritocracy has largely disregarded non-meritocratic elements such as family background and social networks, which can cause severe inequalities within society such as limited access to social capital and resources. If non-meritocratic elements are ignored, meritocracy is more closely aligned with principles of the jungle law or a Darwinian approach to the survival of the fittest.

Meritocratic principles were also mentioned initially as the cause of their lack of water and food. In essence, subsistence farmers' understanding was heavily centered on the justification that those who were in the granite industry business were those who had succeeded because they had worked harder or they were more talented or smart. Therefore, they deserved to have a good life because they were simply better. Conversely, participants expressed their lack of power and motivation as due to the fact that they were perpetually destined to struggle as unsuccessful individuals. Pervasiveness of meritocratic policies in education threatens to crowd out need and equality as principles of justice. As such it may pose a barrier rather than a route to equality of opportunity. Meritocratic discourses legitimate societal inequalities as justly deserved, such as when misfortune is understood as personal failure (Mijs, 2015). Authoritative figures thus embody meritocracy and in that sense, my absence in the field helped dissipate those principles.

A Shift in Power for Liberation. Participants' understanding of the impacts of granite quarries on their lands and water resources evolved along with their perception of power. Their fatalistic and meritocratic views had been keeping power unattainable, conditioning them to inaction. But as the interactions in this study progressed, participants' participatory perception of power slowly evolved as they started to question it. Some of their critical thinking was expressed

through statements such as “I think there is something really wrong” or “there has to be a solution to this problem.” During member checking, some pondered the causes that had led to their loss of food and water security over the years. The more they discussed and reflected during the unstructured focus groups, the less they referenced fatalism and meritocracy. As Freire (2000) suggests, “The liberation of the oppressed is a liberation of women and men, not things. Accordingly, while no one liberates himself by his own efforts alone, neither is he liberated by others” (p. 66).

As fatalism slowly vanished, the door to action and change started to open. Because of what they started to reveal to each other and themselves, participants were no longer passive beings who were subjected to a higher power or the status quo. The justifications previously found within fatalism and meritocracy slowly dissipated as they became more and more aware, shifting their perception of power. As a result, power progressively transitioned from an unattainable force to one that could be found within participants’ reach. They collectively reached the conclusion that their inability to plant was not due to fate nor an unattainable power. Most importantly, participants started to see themselves as active individuals, because the cause of their problems had been transferred to the pits. As they started to grasp a different awareness, they started to liberate themselves. According to Freire (2000), in the process of oppression, someone oppresses someone else, but that is not the case in the process of revolution, because one cannot be liberated by someone else “nor does someone liberate himself, but rather that human beings in communion liberate each other” (p. 133).

Conclusion to Part II (Summation)

This case study 's research methods were adapted to the Covid-19 era. At first, what seemed to be an impediment favored this study, as the study undoubtedly benefited from the restrictions imposed by the pandemic. These restrictions allowed it to remain authentic, anonymous, and safe. It favored Freire's dialectical approach by encouraging participants to better systematize their experiences without restraints, interference, judgment, or fear. We could claim that the adaptations made around the restrictions became a method in itself. Member checking was effective mainly because it brought all participants' experiences to them—they were heard and they could hear others' voices and ideas and ponder them freely. Member checking was dialectical because it gave participants the opportunity to reflect, share their experiences, and rethink their views.

This case study led to an evolution of the participatory perception of power. This change in perception emerged initially from the fact that participants saw that somebody cared about them and wanted to hear what they had to say. There was change because subsistence farmers became progressive aware of an injustice and wanted to do something about it. This change was the core of the awakening process experienced by participants. This awakening was possible because of a change also in the perception of power through religion. It is understandable that participants would explain their distress through parables, because they live very similar to biblical times. Although participants changed their fatalistic discourse, they remained nevertheless very religious. In the São Pedro River Valley, the fatalistic and meritocratic discourses are socially and culturally ingrained. For participants to be able to move away from these perceptions was quite transformative.

Limitations in the Study

There were some inherent limitations to this study. First, with regard to its remote approach to data collection due to my absence from the physical site. The contact between myself and the RA was virtual, whereas the interactions between me and the participants were conducted indirectly, through the RA. Thus, despite the positive outcomes, the approach to data collection also had drawbacks. On the one hand, this study gained authenticity and increased validity thanks to the outsider's absence; on the other hand, it had limited additional insight and perceptions that could only have been captured on site by me. Despite the fact that the RA followed my directions and reported objective data factually (via MP3 files and images), her observations on-site could only be perceptual. Also, this study does not account for unpredicted on-site notes that could have been added to the data. Lastly, it does not include my subjective on-site observations about participants. For instance, I could not incorporate into the study non-verbal cues such as participants' facial expressions, gestures, and body language, which could have translated into additional insights.

Another limitation was raised in this study around participant selection. Participants might not have been willing to provide complete data, or even partial data, due to the fear of reprisal or retaliation from granite quarrying companies. In the region, the granite business has a strong economic and political influence. This reality might have made it difficult for subsistence farmers to reveal damages caused by the granite industry. In fact, some may have family members employed in a granite company. Others may still have ongoing explorations of granite on their own lands. There are also those subsistence farmers who might wish that granite quarries would come to explore their lands, despite the destruction they might cause, for the benefit of a monthly payment that would allow them to feed their families. Some small farmers still want

granite companies to explore their lands because they get compensation while the quarrying activities are taking place. Thus, there should be an important caveat to participant selection with regard to those whose lands might still be used by granite extraction companies. Collecting data from subsistence farmers who currently receive compensation while their lands are being used could compromise the data's accuracy. Thus, another criterion for participant selection would ideally be their land's inability to further produce granite. Nonetheless, such criteria would dramatically reduce the participants' numbers.

Yet another limitation resides in the fact that some participants simply could not be reached, either because their geographic location was too difficult to reach or because they were afraid of repercussions or simply afraid of the unknown. Accessing remote sites to implement unstructured focus groups also represented a limitation to this study. Since most subsistence farmers live in the country with very little or no road infrastructure, several sites had to be reached by foot. This limitation could translate into a smaller number of iterations, which could be detrimental to the overall results presented and analyzed in this case study. The more iterations that take place, the more likely the information would flow, as subsistence farmers would increasingly become comfortable with the presence of an outsider.

Fear of reprisal from the small farmers' perspective could impact the information provided. Thus, trust was an important challenge that could impact the quality and validity of the study. Creating trust through a personal relationship served as a means to efficiently obtain a disclosure of the interview subjects' world (Kvale, 2006). Not only that, Kvale (2006) explains the negative aspect of interviews that create a clear hierarchical power relationship between the interviewee and the interviewer. Once again, the promotion of trust took place through the presence of the RA, who was deeply familiar with participants and represented me. However, we

cannot exclude the possibility of certain participants not trusting the RA, which constitutes our last limitation to this study. Additionally, although not representative of the São Pedro River Valley due to its small number of samples, the soil analysis validated participants' claim that they could not produce on their lands. More studies are needed to better understand how granite affects planting and harvesting crops.

Although this study reveals evidence that subsistence farmers became progressively empowered through the unstructured focus groups, we cannot state that they reached liberation. Participants' views evolved regarding both the causes leading to their lack of food and water and their perception of power. Although several claims can be made attributing the awakening of subsistence farmers through this study, it does not constitute their transformation. The data collection approach was designed to place participants in their natural element and to give them a voice. Because of the freedom they had and the importance given to what they had to say, subsistence farmers felt empowered.

Member checking especially reinforced that empowerment by asking participants "is this what really happened?" or "did I get this right?" or "is this correct?" This approach placed subsistence farmers in a unique position, in which they had never been before. They were not used to being asked for their opinion or to correct any assertion. But generations of inculcated fatalistic and meritocratic thinking are still a definite challenge to their empowerment. Only subsistence farmers themselves can achieve their liberation and therefore, only they can reach the realization of such. After all, as Freire (2000) asks,

> who suffer the effects of oppression more than the oppressed? Who can better understand the necessity of liberation? They will not gain this liberation by chance but through the praxis of their quest for it, through their recognition of the necessity to fight for it. (p. 45)

Future Studies and Recommendations

Future Studies

This case study exposed the impact of granite quarries in the lives of subsistence farmers from one perspective. Through participants' examination, it has been verified and confirmed that quarries have affected subsistence farmers' livelihoods by damaging the environment in different ways. The impact on environmental rights, however, has yet to be systematically assessed using empirical data (Gellers & Jeffords, 2018). It is particularly important to expand on procedural environmental rights—legal provisions relating to access to information, participation, and justice in environmental matters—to provide fertile ground for analyzing how environmental rights directly interface with the conditions necessary for a functioning democracy (Gellers & Jeffords, 2018).

Additionally, there is an urgent need to proceed with environmental research to understand and potentially quantify the extent of the damage caused among species, in particular threatened animals and plants in the region. More detailed laboratory tests need to be conducted to potentially identify elements that were not detected in the present study, in particular in the soil analysis. Participants indicated that the water had been contaminated by granite quarries. Thus, other types of analysis need to be conducted to investigate the existence of granite residue in the water. Not only that, a thorough examination of subsistence farmers' health and their families' is needed to investigate their claim about the water pollution and to understand the impact of potential granite residue from a medical standpoint.

New research and policies need to be translated and reflected in the transformative and participatory role of the individual (Souza & Honorio, 2020). There is a need to investigate the effectiveness of future action aimed at addressing the social and environmental issues affecting

the São Pedro River Valley. The Brazilian government has undertaken several projects to construct water cisterns for farmers in the Sertão and elsewhere; an obvious departure point for future research would be to test the effectiveness of irrigation in conjunction with cisterns. It would be important to understand whether such cisterns outperform the dams (Burney et al., 2014). Future collaborative interventions in the São Pedro River Valley aimed towards bringing humanitarian or environmental aid to oppressed communities must be studied and reported (Frey & Hanan, 2020).

Especially in the context of vulnerable individuals, researchers need to question the universal relevance of their theoretical frameworks and develop a victim-centered justice (Alvarez & Coolsaet, 2018). Researchers need to question their physical presence in the field and make decisions based on participants' wellbeing rather than the validity of their study. If participants' rights and safety are not protected, the validity of the study is questionable. When researching vulnerable participants, it is important to understand the oppressor/oppressed relationship, include that hierarchy as part of the study, and act accordingly to fully understand and respect participants.

Recommendations to Subsistence Farmers

As stated during data collection, there were three main solutions to the problem subsistence farmers faced in order to plant and harvest their crops: build an artesian well, rehabilitate the springs, and recover the soil's fertility. According to participants, all the community would benefit from an artesian well because it would provide them with reliable and clean water to drink. Also, rehabilitating the springs would involve replanting of trees to preserve the water sources. Finally, the soil analysis would reveal the problems found in the ground and offer solutions to make it arable again, although they were not sure how viable it would be or if

the resources would be available. According to them, cleaning the rubble and granite debris would help recover their lands as well. Some participants brought up the need to build a containment wall to prevent the quarry waste from rolling down onto their land. Others also mentioned the need to clean the dam so they could have access to water again year-round.

Recommendations About the Water

Several studies have been aimed at addressing the water issue in rural areas of Brazil with limited rainfall. Some studies have concluded that the main solution to subsistence farmers' water scarcity is an irrigation project. Through irrigation, the water can be accessed year-round and effectively provide the necessary need to farming. Additionally, different and adapted measures to boost agricultural production and mitigate the impacts of more extreme climate conditions have been targeted to small, impoverished farmers in the region (Burney et al., 2014). The most commonly used adaptive strategies for the mitigation of droughts in the region are the use of wells, weirs, and cisterns (Maia et al., 2018).

Mechanical technologies adapted to the semi-arid region can be used for rainwater management and present positive impacts on all types of agricultural production. Technical guidance, which is still scarce, can help farmers manage their production more efficiently during long periods of drought (Maia et al., 2018). A recent study suggests that the problem is closely linked to the irregularity of precipitation levels rather than the lack of rain. Mota and Martins (2019) focused on the needs of rural communities and ways to face the natural erratic rainfall, and concluded that what the region lacked was an appropriate system to collect rainwater. They recommended the construction of a new system to collect rainwater, appropriately dimensioned to increase the collection area of rainwater. They suggested that, with a new water collecting system, rural communities could meet the minimum per capita consumption of 50 liters/day, as

established by the United Nations (Mota & Martins, 2019). Successful water strategies most often require work and investment to secure water access year-round through storage, access to groundwater, or construction of larger catchments (Burney et al., 2014).

For participants in this study, these recommendations on water shortage in the Sertão seem adapted to their needs and align with their own suggestions. However, most of these actions require resources that are not available in the region. Additionally, subsistence farmers need to learn how to integrate adaptive measures to their farming practices, whether the water scarcity is remediated by a cistern, a well, the rehabilitation of a spring source, etc. The protection of natural resources, mainly the water, can only be achieved through investment accompanied by sustainable development of subsistence farming (Guilhermino et al., 2019).

Subsistence farmers in the São Pedro River Valley face general rain irregularity and lack of water, as experienced by millions of individuals in the Sertao, in addition to an increased water shortage due to the quarries' water demand and pollution. In that sense, their participation in addressing the water issue is as important as the necessary resources needed. Subsistence farmers are at the center of the water shortage problem in the São Pedro River Valley and so they understand its intricacies in ways that are unknown to those who have not lived it. Freire (2000) says that "[t]he oppressed are not *marginals* nor people living *outside* society. They have always been *inside*. The solution is not to *integrate* them into the structure of oppression, but to transform that structure so that they can become beings for themselves" (p. 74). Thus, the lack of water among communities in the area needs to be addressed through a dialogical approach and include particularly adaptive measures with water shortage in mind.

Recommendations About the Soil

As some studies address the lack of water in the Sertão, others focus on the conditions of the soil for improved farming activities. There are conservation projects aimed at restoring the Caatinga biome using techniques to fight desertification in the region using low cost methods in a collective way (Guilhermino et al., 2019). Other projects focus on soil fertility to mitigate the soil aridification (Maia et al., 2018). As suggested by participants, this study conducted a soil analysis of nine households living near granite quarries. The analysis of nine soil samples collected from participants' lands revealed low fertility levels, lack of organic matter, poor aeration, and carbonation of the soil that made it hard and mineralized. The interpretation of the soil analysis conducted by geologist Dr. Rodriguez provided adapted recommendations to address the problems identified in all nine soil samples.

For the correction of soils, in relation to organic matter, the geologist recommended the introduction of effective microorganisms that aim to establish the balance of microbial flora and establishment of balance of soil life, creating the mineralization of organic matter and availability of macro and micronutrients essential for soil fertility. There are techniques such as *bokashi*/compost that increase the proliferation of these microorganisms in the soil, combined with a substrate from organic compounds, mainly from bran (rice husks or other cereals, corn husks, leaf litter, etc.). The bokashi production technique and its use is simple, but it requires some training by rural producers. It is a simple technique, low cost and effective over time.

For the (organic) correction of acidic soils, the addition of carbonates is indicated, which can be obtained through ground eggshells in small areas. Phosphorus can be added to the soil through wood ash and bone meal, organically and without the use of chemical compounds. This form of correction seems to be the most suitable for the sampled areas, since these methods make

phosphorus available slowly to vegetables. The application of chemical inputs, in turn, releases phosphorus quickly, and most of the inputs are leached and are lost without the plant absorbing the element. As well as the correction of soils by composting through bokashi, the correction of phosphorus, an essential macronutrient, can be done and made possible through training in new agricultural practices, where organic agriculture and permaculture can be assimilated by the owners and the community.

Recommendations for Changes in Perceptions

Freire (2000) justifies that a cultural revolution is at the source of change through individuals' awakening. A cultural revolution calls for a change from within subsistence farmers who become *conscientização*/aware of their own condition, and of their ability to do something about that condition. Because a cultural revolution implies the participation of individuals at all levels, for there to be action, the awakening must happen within all players involved in the process of injustice or, in Freire's words, oppression. Thus, not only the oppressed but also the oppressors need to go through the same process of first discovering they are oppressors (most often despite themselves) and second, realizing they can do something about their condition. It is not a pleasant awakening. However, like participants in this study, granite producers and consumers, local, federal, and international government entities, students, and activists have to undergo the same process.

In the past, the action of liberal politics in the Jequitinhonha Valley has resulted in violent processes of expropriation of traditional subjects and communities for the establishment of large development corporations (Sulzbacher et al., 2020). A cultural revolution, in Freire's (2000) words, is dialectical yet antagonistic to rebellion: "In order for this struggle to have meaning, the oppressed must not, in seeking to regain their humanity (which is a way to create

it), become in turn oppressors of the oppressors, but rather restorers of the humanity of both" (p. 44). Thus, a call for cultural change cannot be misunderstood as a call for insurgency or for physical fighting. Cultural change is rather aimed at understanding the problem collectively and remedying it in an equitable and balanced way.

For instance, cultural change from the perception of granite consumers comes from a transformed behavior in search of environmentally conscious goods or alternatives to granite derived products. Awareness is largely present in consumers' opinion on eco-friendly products (Delcea et al., 2019). More precisely, environmental awareness is among one of the main factors that influence consumers' decisions when buying a product (Delcea et al., 2019). Thus, if consumers become aware of the negative impact of granite extraction and processing activities on the environment and on those who depend on the environment, it has the potential of translating into tangible change. Those changes may lead to an improvement of peoples' lives and thus to a decrease of social injustice.

A series of papers have addressed several issues related to investigating the factors that may influence consumer decision over choosing green products (Delcea et al., 2019). There is a need to inform consumers so they can become aware of the problem in a trustworthy way. The integration of green trust and green perceived risk can increase the prediction of loyalty towards eco-friendly products (Pahlevi & Suhartanto, 2020). A recent study revealed that 63% of consumers believe it is important to take action to limit the damages caused to the environment, whereas 67% think that an eco-friendly attitude towards the environment is needed (Delcea et al., 2019).

We must realize that oppressed communities view the world in their own way. Their view of the world, manifested variously in their action, reflects their situation in the world. Freire

(2000) says that “educational and political action which is not critically aware of this situation runs the risk either of ‘banking’ or of preaching in the desert” (p. 96). The change thus, or the solution to the impacts of granite quarrying in the São Pedro River Valley, needs to be done through and for those who are affected by the problem. In essence, action can start with proposals for new policies for the recovery of the Caatinga through the sustainable development of family farming to ensure food security, combat rural exodus and promote social peace in rural areas (Guilhermino et al., 2019).

There is clearly a large spectrum for social and technical intervention needs in the Sertão. Besides climate risks, the characteristics of farms, farmers, and their production systems reinforce the low productivity in this region (Maia et al., 2018). Policies of rural extension have had a limited range, as the percentage of producers receiving technical guidance for the production or credit-orientation is still low (Maia et al., 2018). The Brazilian government has undertaken several projects to construct water cisterns for farmers in the Sertão and elsewhere (Burney et al., 2014). In critical drought times, local governments serve rural families experiencing lack of water in the region mainly by supplying the population with water through water-trucks (Galizoni et al., 2020). But in the context of this case study, only one out of ten households has received this type of assistance.

There is an urgency for implementing public policies for the recovery of the Caatinga Biome, and for that, family farmers are key parts of this reconstruction (Guilhermino et al., 2019). Local, state, and federal institutions should first identify the most vulnerable groups before implementing policies of climate resilience, followed by adaptation of resilience measures that already have proved to be economically effective and efficient in the region (Maia et al., 2018). There is a need for sustainable practices associated with ecological awareness through

environmental education (Souza & Honorio, 2020). The change calls for a new mentality, new projects, actions, research, and policies that can be translated and reflected in the transformative and participatory role of the individual (Souza & Honorio, 2020).

As part of the Caatinga biome, there is a need for local, federal, and international policies to engage in the safeguarding of the rural communities and the environment. Using the example of the São Pedro River Valley, government can start a dialogue aimed towards praxis as well as the joint action of the schools, society, and other government bodies (Souza & Honorio, 2020). Federal laws need to further increase their reach with respect to granite production and consumption in search of social and environmental justice, and ensure the population has access to the water necessary to live with dignity. The human right to water exists under international law (Alsaadi et al., 2020) but it needs to be reinforced locally and federally. Lastly, laws also must further protect farmers' lands from profiteering industries.

In the field, granite quarry operations should be regularly inspected and quarries close to settlements should not be allowed in order to prevent the negative effects of quarries. Thus, owners of quarrying companies and people using this area should be made aware of such problems (Sari & Özcan, 2018). Regular inspection should be carried out and all necessary precautions should be taken to promote the implementation of "the regulation on the natural rehabilitation of land degraded by mining activities" so that quarrying activities can be maintained without any damage (Sari & Özcan, 2018).

The Principal Investigator's Responsibility

It is necessary to participate with oppressed communities, describing their social justice goals and critiquing systemic structures that maintain social injustices in place (Frey & Hanan, 2020). In this sense, this study revealed an oppressed community to itself and to others, giving voice and awareness to those who were, and still are, fighting for their human rights and surviving through social and environmental injustices. However, raising awareness and exposing the problem is only the beginning. On-the-ground collaborative interventions with oppressed communities that seek to make socially unjust systems and practices more just also must be carried out (Frey & Hanan, 2020).

Figure 28

Webpage of Granite Ground Rehabilitation Foundation

At a personal level, my responsibility in this study grew towards the participants. I am indebted to subsistence farmers in the São Pedro River Valley. I cannot benefit from the data necessary for my research study and walk away from my participants. Walking away from this

study would defeat its purpose and everything that it stands for, including all the core values of the University of the Incarnate Word (UIW), especially with regard to social justice. Indeed, this study embodies human rights, and social and environmental justice values, reflecting UIW's mission and vision but also strongly aligning with the Dreeben School of Education program, emanating ethics for the profession, systems of belief, teams and groups, leadership, adult education, entrepreneurship, foreign language, and of course, the international element.

Figure 29

The Foundation's Projects

Thus, my responsibility as Principal Investigator is to continue working, following what I have learned at UIW and put it into practice (praxis). As Freire indicates, the first step consists in the initial awakening, followed by the realization that there is a need for action, and finally the culmination of action itself. GGREF, the NGO we have created, is how praxis materialized as a result of this case study. This NGO (see Figure 28) has been growing alongside this research. Even though this case study was not designed for the foundation, the findings here are crucial to

understanding the issues, help us be better listeners, remove ourselves from the picture, and better involve the community in projects and in the decision-making process. The work of GGREF is still incipient. All initiatives are implemented on a volunteer basis (see Figure 29) but I hope and believe it will continue to grow and help the community and spread awareness.

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Appendices

Appendix A

Guiding Prompts (English Translation)

1. General Prompts
    - In the last 30 years, what has changed regarding the way we plant crops to feed our family?
    - In the last 30 years, what has changed regarding the way we irrigate our crops?
    - In the last 30 years, what has changed regarding the way we harvest our crops?
    - In the last 30 years, what has changed regarding the way we raise livestock to feed our family?
    - In the last 30 years, what has changed regarding the way we use elements from the environment (leaves, fruits, roots and animals, among others) to feed our family?
    - In the last 30 years, have we noticed changes to the soil?
    - How would we describe hunting/fishing activities in the Valley today?
    - How do hunting/fishing activities today compare to 30 years ago?
    - In the last 30 years, have we noticed changes to the natural water springs?
    - In the last 30 years, have we noticed changes to water streams?
    - How do our lives as subsistence farmers compare to our parents' and grandparents' (those who planted 30 years ago)?
2. Specific Granite Related Prompts:
    - How would we describe granite quarrying activities in the Valley?
    - How close/far are our lands to granite quarries?
    - Are granite quarries currently using our lands?
    - How do quarries impact our lives as subsistence farmers?

- How do quarrying activities impact the soil?
- How do quarrying activities impact water springs and streams?

3. Brainstorming solutions prompts:
    - What have we done to manage the farming conditions we currently face?
    - What do we think would help increase our source of water and food?
    - How do we see the future of the next generations' farming activities?

Appendix B

Member Checking Script in English

Research Associate: Good morning to you all! Thank you so much, once again, for participating in our work. In October, I spoke to you, and about twenty people from around the region, about the problem of supporting our community. Everyone said: seven problems and three solutions. So, I would like to ask your help to say if I understood well each problem and each solution that you mentioned. First I will talk about the seven problems and then the three solutions. So, please tell me if that's right, and if there's anything missing. Ok? So let's see...

The seven problems: the community spoke about water, soil, nature and the Quarries.

First problem: in the past, we planted and harvested in abundance. But, today, the planting yields very little, or not, not even watering. In the past, you could plant even in the dry season, which you harvested. Today, we plant a lot and harvest little. Is that right? "In the old days, I made ditches in the earth, and watered the plantation. And today, what you plant, it's bad, bad to eat." "The harvests were great. Today, there are times like wetting, you see the difference." "The abundance of watermelon here... Here is the most talked about place, which produces more watermelon. And it's been about three years since no one harvests even corn."

Second problem: in the past, even when it didn't rain, there was water in the streams and today, there is no water even to drink. About the lack of water. Before, it was a lot of water. With each passing time, it only gets harder, because the water is harder. "In the old days, it was rarely seen a cistern…a spring drying up. Before, there was a lot of spring, there was swamp, and today the springs are all over. No more."

Third problem: in the past, the land did not need to be fertilized. But today the ground is very damaged. On the ground, I didn't need to fertilize the land to make a vegetable garden; there was a lot of leaves, a lot of roots to rot to fertilize the earth. Previously, the backyard was cooler. These days the earth is sandy, more tired, and the soil temperature is warmer. "When the forests were cut down, the fertilizer in the land ran out. This is all the residents' report, ok? That's right, do you agree?"

Fourth problem: in the past I found all kinds of plants, animals, but today nature is disappearing. In the past, I used to think of a gabiroba tree, it was orange, it was some fruit, everything you could find there. And in the past there was also fishing... Today fishing is prohibited, and you rarely find wild plants. "In the past, I found medicine from the bush. Still think?" "There is no

water even to drink; how are you going to have fish?" "Hunting was used as a food source for humans in the past." "The trees that conserved water don't have any more."

About the Quarries now: the community said that the Quarries destroyed nature, water and soil. I'll give you some examples: how far is the land from the masters to the nearest quarry. "Nature was devastated by the extraction of granite." "The Quarries came to reduce the rain for us because, when we deforest, the rain runs away from us." “Because of the Quarries, some mining tailings came down. The Quarries works with water and oil. They fired at the quarry there, then the spring fled.” “The rivers clogged up. The barriers went down and clogged everything. How are these barriers?" “As Pedreiras works close to the springs. That hit." “When it rains, the rain catches the tailings and goes down into the river. The dust of the earth, when it rains, goes down to the rivers.” "The land is no longer good because of the Quarries."

These were the problems. Now we are going to talk about the three solutions presented by the community. The community provided a solution to the problem of lack of water, the destruction of nature and the situation of the soil. The first solution was: build an artesian well for the community, so that the entire community can benefit from it. Mainly to have water to drink. Do you agree with this?

The second solution was to recover the springs and plant trees. The resident said: mainly planting trees, right? Mainly in the springs. Trying to rescue a little of what it was before. For example, stop deforestation a little, preserve springs more, make sure they don't dry up.

The third solution: resolved soil erosion, treat the soil and fertilize. You'll have to plow all the land and put fertilizer. Cover the erosions, bar the land so as not to descend. We need a technician. Is that right? Would you like to add anything else?

To finish our work I would like to take a sample here of the soil in your backyard. With this sample it will be possible to know if there is any granite tailings in the earth. Do you agree to give a sample of your backyard?

Thank you so much, once again, for participating in our work. Have a good day.

Appendix C

Soil Fertility Analysis (*translated from Portuguese*)

Soil fertility is the capacity of the soil to supply essential elements to plants. Good soil fertility implies supplying adequate amounts and proportions of nutrients for plant growth and productivity. Like every living thing, plants need water and different organic molecules for their survival. Therefore, the elements that make up water (H2O) and any organic molecule (C, O, H) obviously have their essentiality fully proven. These elements are absorbed by plants from the water absorbed by the roots and from the CO2 absorbed via photosynthesis. Along with these three elements, six more are absorbed and required in greater amounts than the others: nitrogen (N), phosphorus (P), sulfur (S), potassium (K), calcium (Ca) and magnesium (Mg), forming the called macronutrients. The micronutrients, which are required in amounts lower than the nine mentioned above, are: iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B) molybdenum (Mo) and chlorine (Cl).

Nutrients composed in the soil, called components of organic compounds, are fundamental for the good development of plants, constituting 90 to 96% of their plant tissues. They are: carbon (C), hydrogen (H) and oxygen (O). However, these elements are primarily produced by air and water. In other words, they are natural elements that end up neglected in studies on soil fertility. In the development of research on soil fertility, nutrients are categorized according to their concentration in plants:

Macronutrientes	Forma absorvida	Micronutriente	Forma absorvida
N	NO_3^- ou NH_4^+	Cu	Cu^{2+}
P	$H_2PO_4^-$ ou HPO_4^{2-}	Mn	Mn^{2+}
K	K^+	Zn	Zn^{2+}
Ca	Ca^{2+}	Fe	Fe^{2+}, Fe^{3+}, Fe-quelato
Mg	Mg^{2+}	B	H_3BO_3; $B(OH)_4^-$
		Mo	MoO_4^{2-}
S	SO_4^{2-}	Ni	Ni^{2+}
		Cl	Cl^-

- Primary macronutrients – nitrogen (N), phosphorus (P) and potassium (K); ⎫
- Secondary macronutrients – calcium (Ca), Magnesium (Mg) and sulfur (S); ⎫
- Micronutrients – boron (B), iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), molybdenum (Mo) and chlorine (Cl).

Chemical analyzes carried out on nine soil samples from the region of São Pedro River Valley, MG, identify the amount of primary macronutrients, Phosphorus (P) and Potassium (K), essential for soil fertility. The macronutrient Nitrogen (N) was not analyzed, compromising, in part, the soil evaluation.

Of the secondary macronutrients, calcium (Ca) and Magnesium (Mg) were analyzed, but the macronutrient Sulfur (S) was not evaluated. All micronutrients were not evaluated by the analyses. Macronutrients (N,P and K) play a fundamental role in plant development, namely:

- Nitrogen (N): responsible for the strong growth of plants, making them healthier and greener, therefore, it is great for the leaves and stems;
- Phosphorus (P): important for flowering, fruiting and rooting, that is, this element is essential for planting;
- Potassium (K): improves the quality and resistance of plants, making them stronger to resist trampling and damage from pests and diseases.

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,1	20	0,41	3,6	1,9	0,0	2,8	-	5,9	5,9	8,7	68	0	-	18	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Results of Soil Sample#1

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,2	3	0,44	4,1	1,4	0,0	2,6	-	5,9	5,9	8,5	70	0	-	16	-	-	-	-

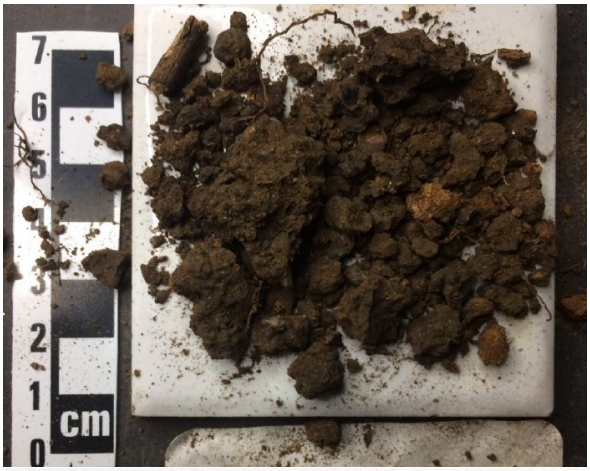
Results of Soil Sample#2

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	5,7	10	0,72	2,8	1,0	0,0	2,5	-	4,5	4,5	7,0	64	0	-	16	-	-	-	-

Results of Soil Sample#3

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,2	2	0,35	4,1	1,3	0,0	3,1	-	5,8	5,8	8,9	65	0	-	16	-	-	-	-

Results of Soil Sample#4



Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	5,6	5	0,36	2,7	1,1	0,0	2,8	-	4,2	4,2	7,0	60	0	-	19	-	-	-	-

Results of Soil Sample#5

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	5,3	2	0,36	2,0	1,0	0,1	3,7	-	3,4	3,5	7,2	47	3	-	18	-	-	-	-

Results of Soil Sample#6

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,3	3	0,36	4,0	1,5	0,0	2,8	-	5,9	5,9	8,7	68	0	-	18	-	-	-	-

Results of Soil Sample#7

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,2	2	0,36	4,2	1,3	0,0	2,8	-	5,9	5,9	8,7	68	0	-	18	-	-	-	-

Results of Soil Sample#8

Identificação	pH	* mg/dm³	* cmol$_c$/dm³ de solo									%			* g/dm³	* mg/dm³			
	(H_2O)	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	Na^+	S.B.	t	T	V	m	PST	M.O.	Cu^+	Mn^{++}	Zn^{++}	Fe^{++}
	6,0	14	0,46	3,1	1,3	0,0	2,6	-	4,9	4,9	7,5	65	0	-	16	-	-	-	-

Results of Soil Sample#9

PH parameters

The pH is defined as the hydrogenionic potential, which is a logarithmic scale that indicates with values from 0 to 14 whether the solution is acidic, neutral or basic. Thus, the pH serves to tell us whether a solution is acidic, neutral or basic. Of the nine samples analyzed, the pH ranged from 5.3 to 6.2, indicating that the soil has acidic chemical characteristics (PH<7). The ideal pH range for plants is around 6 to 7, as in this range the nutrients are more available. In the analyzed samples, it is observed that the Soil Sample#6 has a pH of 5.3, the Soil Sample#3 (PH 5.7), the Soil Sample#5 (PH 5.6) are below the ideal pH range. The other samples characterize soils within the ideal acidity range for agriculture: Soil Sample#9 (PH 6.0), Soil Sample#1 (PH 6.1), Soil Sample#2 (PH 6.2), Soil Sample#4 (PH 6.2), Soil Sample#7(PH 6.3) and Soil Sample#8 (PH 6.2).

For the (organic) correction of acidic soils (in the case of the Soil Sample#6 PH 5.3) sample, the addition of carbonates is indicated, which can be obtained through ground eggshells (in cases of small areas), for example, or by liming with dolomitic limestone (Magnesium

Carbonate) when the area is very extensive. In the areas of the Soil Sample#9, Soil Sample#1, Soil Sample#2, Soil Sample#4, Soil Sample#7and Soil Sample#8, the PH correction is not necessary. Also in relation to pH, the Soil Sample#6 area presents the lowest index and is the only sample that has $Al^{3}+$ detection, characteristic of very acidic soils. The excess $Al^{3}+$ ion in the water solutions in the soil prevents other nutrients from being made available to the plants. Probably, of the analyzed lands, the Soil Sample#6 area is the one with the lowest productivity due to the excess acidity of the soil, already making the $Al^{3}+$ ion available in the aqueous solutions.

Cation Exchange Complexes - Guiding Table

The tables below list the ideal parameters of elements that participate in the cation exchange in soils, classifying the soils according to the participation of these elements in their composition in relation to fertility. Not all elements listed in the table were analyzed, based on, therefore, only those elements whose values appear in the analysis bulletins.

Característica	Unidade[1]	Classificação				
		Muito baixo	Baixo	Médio[2]	Alta	Muito Alta
Carbono orgânico (C.O.)[2]	dag/kg	£ 0,40	0,41 - 1,16	1,17 - 2,32	2,33 - 4,06	> 4,06
Matéria orgânica (M.O.)[3]	dag/kg	£ 0,70	0,71 - 2,00	2,01 - 4,00	4,01 - 7,00	> 7,00
Cálcio trocável (Ca^{2+})[4]	$cmol_c/dm^3$	£ 0,40	0,41 -1,20	1,21 - 2,40	2,41 - 4,00	> 4,00
Magnésio trocável (Mg^{2+})[4]	$cmol_c/dm^3$	£ 0,15	0,16 - 0,45	0,46 - 0,90	0,91 - 1,50	> 1,50
Acidez trocável (Al^{3+})[4]	$cmol_c/dm^3$	£ 0,20	0,21 - 0,50	0,51 - 1,00	1,01 - 2,00 [11]	> 2,00 [11]

Soma de bases (SB)[5]	$cmol_c/dm^3$	£ 0,60	0,61 - 1,80	1,81 - 3,60	3,61 - 6,00	> 6,00
Ac. potencial (H + Al)[6]	$cmol_c/dm^3$	£ 1,00	1,01 - 2,50	2,51 - 5,00	5,01 - 9,00 [11]	> 9,00 [11]
CTC efetiva (t)[7]	$cmol_c/dm^3$	£ 0,80	0,81 - 2,30	2,31 - 4,60	4,61 - 8,00	> 8,00
CTC pH 7 (T)[8]	$cmol_c/dm^3$	£ 1,60	1,61 - 4,30	4,31 - 8,60	8,61 - 15,00	> 15,00
Saturação por Al^{3+} (m)[9]	%	£ 15,0	15,1 - 30,0	30,1 - 50,0	50,1 - 75,0 [11]	> 75,0 [11]
Saturação por bases (V)[10]	%	£ 20,0	20,1 - 40,0	40,1 - 60,0	60,1 - 80,0	> 80,0

Organic Matter

The nine analyzes were analyzed for the content of Organic Matter, providing data in the unit of g/dm³. It is unit, according to the observations of the analytical reports and the technical literature consulted, are equivalent to a percentage value multiplied by 10. Thus, for example, the value of 18 g/dm³ of the Soil Sample#1 is equivalent to 1.8 dag/Kg, where dag means the hundredth part of clayey soil that is contained in 1 kilogram of soil.

Thus, Soil Sample#1 (1.8 dag/Kg), Soil Sample#2 (1.6 dag/Kg), Soil Sample#3 (1.6 dag/Kg), Soil Sample#4 (1.6 dag/Kg), Soil Sample#5ue (1.9 dag/Kg), Soil Sample#6 (1.8 dag/Kg), Soil Sample#7(1.8 dag/Kg), Soil Sample#8 (1.8 dag/Kg) and Soil Sample#9 (1.6 dag/Kg) represent soils with low amounts of Organic matter. This low amount can reach very low as the dag unit takes into account the clay. The analyzed soils are generally clayey-sandy, that is, they are not 100% clayey, which makes these comparative indexes tend to be even smaller due to the good percentage of sand and silt present in the soil.

If there is only sand, the water is quickly drained to the water table. The selection, in the poorly selected case, indicates that in addition to fine sand we find sand grains of other sizes, this indicates that the source area is not far away. Although some descriptions refer to fine sand,

poorly selected, there is always an amount of clay, sometimes even greater than the fine sand fraction. This makes it difficult to quickly discharge rainwater from the soil to the water table, giving plants a greater possibility of consuming part of this rainwater.

It can be said that all analyzed samples are poor in organic matter. Without organic matter, there is less biological activity in soils and less availability of solubilized elements essential for plants. For the correction of these soils, in relation to Organic Matter, the composting of the soils must be provided with the introduction of effective microorganisms (bacteria, yeasts, actinomycetes, fungi, bacteria and others) that aim to establish the balance of the microbial flora, ie establishment of balance of soil life causing the mineralization of organic matter and availability of macro and micronutrients essential for soil fertility. There are techniques such as “bokashi” that increase the proliferation of these microorganisms in the soil, combined with a substrate from organic compounds, mainly from bran (rice husks or other cereals, corn husks, leaf litter, etc.).

The bokashi production technique and its use is simple, but it requires some training from rural producers, since it is a soil restoration with practically no organic life for a suitable substrate for the fertility of the plants. It is a simple technique, low cost and effective over time. It was observed in the samples, in the visual tactile analysis, that the soil presents itself in clumps, with total absence of canaliculi indicative of the presence of earthworms, for example. This indicates that the soil is very poor in terms of fertility. The soil needs to be more aerated, but loose and alive, producing food for the plants. The analytical results indicate that the region's soil is very poor in organic matter and has practically no microbial action required for desirable fertility.

Exchangeable Calcium

Calcium (Ca^{2+}) presents, in the nine samples, with high to very high values, with the Soil Sample#6 being the lowest index (2.0 $cmolc/dm^3$). This may be indicating a direct relationship with the regional granitic rock, which must be rich in plagioclases ((Na,Ca)Al(Si,Al)Si2O8), calcium-rich feldspars, where the weathering of these minerals eliminates Sodium (totally absent in the analyzed samples) and calcium transforming into kaolinite (observed in some samples in the visual analysis), with the formula Al2Si2O5(OH)4. Sodium is easily leached to lower portions of the soil and dissolved in the water table while calcium accumulates with other clay minerals, becoming available in aqueous solutions for plants as a secondary macronutrient, and its presence is positive for plant fertility.

Sodium (Na) when absent (or in small proportions) indicates that the soil is very drainable. On the contrary, its greater presence indicates poorly drainable soil, which may cause accumulation of salts in the soil (NaCl, mainly – halite, table salt). Sodium (Na) is not an essential element for plants, not compromising their development in case of absence. On the other hand, excess indicates undrained soil, which impairs plant development.

Calcium (Ca) in abundance can lead to carbonation of the soil, making it hard and mineralized. In turn, plants need Calcium (Ca), which is one of the essential elements. The excess causes cementation of the soil, forming a soil known as “calcrete”.

As these are soils with acidic pH characteristics, calcium does not present crystallization problems with the presence of CO2 (even because the soil is poorly aerated, as described above) in the form of calcium carbonate (which is soluble in an acidic medium). Therefore, it does not require correction.

Exchangeable Magnesium

The Magnesium indices (Mg^{2+}) in the nine samples analyzed are in the range of 1.0 to 1.9 cmolc/dm^3, being in a high to very high range of availability. In the same way as the Calcium, Magnesium is a secondary macronutrient and its availability is beneficial to plant fertility.

Sum of Bases (SB)

The sum of the bases reveals high to very high rates. The sum of exchangeable bases (SB) of a soil represents the sum of the exchangeable cation contents, except H^+ and Al^{3+} (SB = Ca^{2+} + Mg^{2+} + K^+). Base saturation is an excellent indicator of the general conditions of soil fertility, being used even as a complement in soil nomenclature. Thus, in this aspect, the soils are saturated in exchangeable cations, indicating good fertility with other agents such as moisture, pH conditions and organic matter available.

Phosphorus (P)

The table below is a guideline for Phosphorus (P) values in soils:

Característica	Classificação				
	Muito baixo	Baixo	Médio	Bom	Muito bom
	----------(mg/dm³)[1]----------				
Argila (%)	Fósforo disponível (P)[2]				
60 - 100	£ 2,7	2,8 - 5,4	5,5 - 8,0[3]	8,1 - 12,0	> 12,0
35 - 60	£ 4,0	4,1 - 8,0	8,1 - 12,0	12,1 - 18,0	> 18,0
15 - 35	£ 6,6	6,7 - 12,0	12,1 - 20,0	20,1 - 30,0	> 30,0
0 - 15	£ 10,0	10,1 - 20,0	20,1 - 30,0	30,1 - 45,0	> 45,0

Considering that the samples are essentially clayey-sandy, with a clay proportion greater than 60%, only the Soil Sample#1 (P = 20 mg/dm^3), Soil Sample#3 (P = 10 mg/dm^3) and Soil Sample#9 (P = 14 mg/dm^3) samples dm^3) are satisfactory in terms of Phosphorus content. The

other samples are in the low phosphorus concentration range and need to be rewarded in this element in their correction.

Phosphorus can be added to the soil through wood ash and bone meal, organically (without the use of chemical compounds). This form of correction seems to be the most suitable for the sampled places since these methods make phosphorus available slowly to vegetables. The application of chemical inputs, in turn, releases Phosphorus quickly, and most of the inputs are leached and are lost without the plant absorbing the element.

As well as the correction of soils by composting through "bokashi", the correction of Phosphorus, an essential macronutrient, can be done and made possible through training in new agricultural practices, where organic agriculture and permaculture can be assimilated by the owners and the community. to vegetables. The application of chemical inputs, in turn, releases Phosphorus quickly, and most of the inputs are leached and are lost without the plant absorbing the element.

Potassium The values presented in the analyses, in (K) cmolc/dm³ to be converted into (K) mg/dm³ must be multiplied by 390 (according to the soil measurement conversion tables). Potassium (K) is always abundant in granite regions. The main source is feldspar of the types sanidine, orthoclase and microcline, very common in granites. The samples reveal that Potassium was detected at values above 136.5 mg/dm³ (reaching 280.8 mg/dm³ in the Soil Sample#3 – it would be interesting to see the distance relationship of the Soil Sample#3 with granite quarries to assess the anomaly in this sample), that is, above 120 mg/dm³ which characterizes the soil as very good in Potassium, with no correction being necessary for this macronutrient essential for soil fertility, contrary to what was seen for Phosphorus. Unlike Sodium (a), Potassium (K) is an essential element for plant development. Its absence is detrimental to development. Potassium

(K), as well as Sodium (Na) and Calcium (Ca) are very mobile elements and easy to be leached with good drainage. The plant needs Potassium (K) and any excess Potassium (K) remains available in the soil for both the plants and for leaching.

The table below indicates the desirable values of Potassium, for soil fertility.

Característica	Classificação				
	Muito baixo	Baixo	Médio	Bom	Muito bom
	----------(mg/dm^3)[1]----------				
Potássio disponível (K)[2]					
	£ 15	16 - 40	41 - 70	71 - 120	> 120