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LARISSA OLIVEIRA DUARTE

Organic cotton network in Brazil addressing textile and clothing sector

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Revised Version

Dissertation presented at School of Arts, Science and Humanities from University of Sao Paulo to obtain the title of Masters of Science in Textile and Fashion from the Textile and Fashion Postgraduate Program.

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Dra. Júlia Baruque Ramos

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"You cannot solve the problem with the same kind of thinking that created the problem"
Albert Einstein.

"*It is better to live in a state of impermanence than in one of finality*"
Gaston Bachelard.

"*A primeira lei da ecologia é que tudo está ligado a todo o resto*".
Barry Commoner.

ABSTRACT

DUARTE, Larissa Oliveira. **Organic cotton network in Brazil addressing textile and clothing sector.** 2020 218 p. Dissertation (Master of Science) – School of Arts, Sciences and Humanities, University of São Paulo. São Paulo, 2021. Revised version.

Organic cotton is the main eco-material used by sustainable clothing brands. At the same time, cotton cultivation is of great economic importance in Brazil, as it can be cultivated in various climatic and soil conditions. The Brazilian textile and clothing sector covers the entire chain, from the production of raw materials, to the production of yarns and textiles, manufacture of clothing, distribution, marketing, retail and customers. However, even though the country is the fourth largest international producer of traditional cotton, organic farming still has a limited volume. Despite being a demanding fiber in the market, there is a gap in the understanding of its network, which may be hindering its potential development. The aim of this study was to identify the main actors and develop a description of the organic cotton network in Brazil. A literature review, interviews and technical visits in the states of Minas Gerais, Paraíba and São Paulo and analysis of annual cotton reports by national and international organizations were carried out. Interest in the production of organic cotton has been increasing every year, but producers still face difficulties in articulating with the market, both in the production and in the commercialization of organic cotton fiber. EMBRAPA Cotton, Laudes Foundation and VEJA represent the central positions in the analysis of organic cotton networks. This is followed by NGOs such as Diaconia, Arribaçã, Esplar and Textile Exchange, the companies OCC, NCC and Justa Trama and the public research institution EMPAER. The lack of a social organization or a company was noticed, to play the role of connection between producers and the textile industry in Brazil's organic cotton network. National and international NGOs open spaces for sharing value and exchanging information and play the role of financing agroecological projects in Brazil, supporting the structural consolidation of the network. Brands and retailers also have a crucial role to play, as they have the capacity to pull the sector towards greater sustainability, demanding and buying organic cotton.

Key-words: Organic cotton, network, NGO, textile, collaboration and innovation.

RESUMO

DUARTE, Larissa Oliveira. **A rede do algodão orgânico no Brasil voltada ao setor têxtil e confecção.** 2020 218 p. Dissertação (Mestrado em Ciências) – Escola de Artes, Ciências e Humanidades, Universidade de São Paulo. São Paulo, 2021. Versão Corrigida.

O algodão orgânico é o principal eco-material utilizado pelas marcas de vestuário sustentável. Ao mesmo tempo, a cultura do algodão tem grande importância econômica no Brasil, pois pode ser cultivada em diversas condições de clima e solos. O setor têxtil e de confecção brasileiro abrange toda a cadeia, desde a produção de matéria-prima, fabricação de fios e têxteis, confecção de roupas, distribuição, marketing, varejo até os clientes. Mas mesmo o país sendo o quarto maior produtor internacional do algodão tradicional, o cultivo orgânico, ainda tem volume limitado. Apesar de ser uma fibra exigente do mercado, há uma lacuna no entendimento de sua rede, o que pode estar atrapalhando seu desenvolvimento potencial. O objetivo deste estudo foi identificar os principais atores e desenvolver uma descrição da rede do algodão orgânico no Brasil. Foi realizada uma revisão da literatura, entrevista e visitas técnicas nos estados de Minas Gerais, Paraíba e São Paulo e análises de relatórios anuais do algodão, de organizações nacionais e internacionais. O interesse pela produção de algodão orgânico vem aumentando a cada ano, porém os produtores ainda enfrentam dificuldades de articulação com o mercado, tanto na produção quanto na comercialização da fibra do algodão orgânico. EMBRAPA Algodão, a Fundação Laudes e a VEJA representam as posições centrais na análise de redes de algodão orgânico. Seguem-se ONGs como a Diaconia, Arribaçã, Esplar e Textile Exchange, as empresas OCC, NCC e Justa Trama e a instituição pública de investigação EMPAER. Foi notada a falta de uma organização ou empresa social, desempenhando o papel de conexão entre os agricultores e a indústria têxtil na rede de algodão orgânico do Brasil. ONGs nacionais e internacionais abrem espaços de compartilhamento de valor e troca de informações e desempenham o papel de financiar projetos agroecológicos no Brasil, apoiando a consolidação estrutural da rede. Também as marcas e varejistas têm um papel crucial a desempenhar, pois têm a capacidade de puxar o setor para uma maior sustentabilidade, exigindo e comprando algodão orgânico.

Palavras-chave: Algodão orgânico, rede, ONG, têxtil, colaboração e inovação.

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LIST OF ABBREVIATIONS AND ACRONYMS

ABIT - Associação Brasileira da Indústria Têxtil e de Confecção (Brazilian Association of the Textile and Clothing Industry)
ABRAPA - Associação Brasileira dos Produtores de Algodão (Brazilian Assossiation of Cotton Producers)
ABR - Algodão Brasileiro Responsavel (Brazilian Cotton Responsible)
ACEPA - Associação de Certificacao Participativa Agroecológica (Association of Participatory Agroecological Certification)
ADEC - Associação de Desenvolvimento Educacional e Cultural de Taua (Association of Educational and Cultural Development of Tauá)
AL - Brazilian state Alagoas
AMIPA - Associação Mineira dos Produtores de Algodão (Minas Gerais state Association of Cotton Producers)
AMPA - Associacao Mato-grossense de Produtores de Algodão (Mato Grosso state Association of Cotton Producers)
ANEA Cotton - Associação Nacional dos Exportadores de Algodao (National Association of Cotton Exporters)
BCI - Better Cotton Initiative
DF - Distrito Federal
EMBRAPA - Empresa Brasileira de Pesquisa Agropecuaria (Brazilian Agricultural Research Corporation)
ESPLAR - Centro de Pesquisa e Assessoria (Research and Advisory Center)
EMPAER - Empresa Paraibana de Pesquisa e Extensão Rural (Paraiba Rural Research and Extension Company)
FAO - Food and Agriculture Organization
IBA - Instituto Brasileiro do Algodao (Brazilian Institute of Cotton)
IBD - Instituto Biodinamico (Biodynamic Institute)
ICAC - International Cotton Advisory Committee
IFOAM – International Federation of Organic Agriculture Movements
IBGE - Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics)
IMAmt - Instituto Mato-grossense do Algodao (Mato Grosso Cotton Institute)
INCRA - Instituto Nacional de Colonização e Reforma Agrária (National Institute of Colonization and Agrarian Reform)
GOTS - Global Organic Textile Standard
MAPA - Ministerio da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Food Supply)
MG - Brazilian State Minas Gerais (Brazilian state)
MT - Brazilian state Mato Grosso (Brazilian state)
OPAC - Organização Participativa da Garantia da Qualidade Orgânica (Participatory Organization for Organic Quality Assurance)
PB - Paraíba (Brazilian state)

PE - Pernambuco (Brazilian state)
PI - Piauí (Brazilian state)
PR - Paraná (Brazilian state)
RJ - Rio de Janeiro (Brazilian state)
RN - Rio Grande do Norte (Brazilian state)
RS - Brazilian state Rio Grande do Sul (Brazilian state)
SC - Brazilian state Santa Catarina (Brazilian state)
SE - Sergipe (Brazilian state)
SP - São Paulo (Brazilian state)
UAP - Unidade de Aprendizagem Participativa (Participatory Learning Unit)
USDA - United States Department of Agriculture
VEJA/VERT - Veja Fair Trade

SUMARY

1. INTRODUCTION

The textile and clothing industry is one of the most resource-consuming businesses worldwide, associated with extremely complex global networks and fast cycles of production and consumption (DESORE; NARULA, 2018). There are many challenges in this industry, such as the intense use of chemicals during cultivation and textile dyeing or surface treatments, worker exploitation, water and energy misuse, etc. (HUR; CASSIDY, 2019). Clothing companies are making a move toward embracing sustainable and ethical practices that recommends quality garments made from recycled and organic fabrics, improves the supply chain by adopting clean production, enhances the product life and adopts fair trade practices (MISHRA et al., 2020). Considering that, vegetable fibers, gained market relevance as they are biodegradable and renewable (OLIVEIRA-DUARTE et al., 2019). The cotton industry reaches everyone involved, from small farmers to high-end fashion stores in different locations around the world (MERCIAL, 2018).

Cotton (*Gossypium spp.*) is cultivated for over 7,000 years, mainly for production of its fiber (EGBUTA et al., 2017). Cotton cloth was used in ancient China, Egypt and Peru. Remains of cotton cloth dating from 5,800 BC were found in a cave near Tehuacan, Mexico. In India there are traces of woven fibers dating to 3,200 BC, as well as signs of remote cotton plantations. In 2,600 BC, India was already marketing cotton and it was through Indian merchants that cotton arrived in Egypt. Cotton spinning and weaving as an industry began in India and fabrics of good quality cotton cloth were being produced as early as in 1,500 BC. The Pima Indians were growing cotton when the first Spaniards came in America (KOZLOWSKI; MACKIEWICZ-TALARCZYK, 2020).

Today cotton is an important crop in the worldwide agricultural economy, and one of the most highly traded commodities and China, India, United States and Brazil are the largest cotton producers (BARROS et al., 2020). It is grown in more than 100 countries in the world on 30–35 million hectares (TAUSIF et al., 2018).

Global cotton industry includes more than 100 million farm families across 75 countries (FAO; ICAC, 2015). It is one of the most widespread crops in the world in terms of land area. It production systems vary globally, ranging from labor-intensive systems in Africa and Asia, to highly mechanized systems in Australia, Brazil and the United

States. Cotton network actors range from small and large farmers, intermediates, traders and ginners, to sophisticated mills, textile processors, brands, exporters, global manufactures and retailers, transnational NGOs and consumers (RIEPLE; SINGH, 2010; GLIN et al.,2012; FAYET; VERMEULEN, 2014; LAKHLA et al., 2008).

It begins with the farmer, who grows cotton and harvests the lint (fiber) from the bolls of the plant. The lint is separated from the seed using a cotton gin, a process called ginning, and it is sold to spinners, who produce yarn (ICAC, 2003). Textile manufacturers transform yarns into fabric, by knitting or weaving, and applying dyes and finishes (FAYET; VERMEULEN, 2014). In the final stage, end products (garments, home textiles etc.) are made from fabrics (DESORE; NARULA, 2018). Cotton has many positive characteristics such as versatility, comfort, color retention, absorbency, strength and durability (EGBUTA et al., 2017).

However, conventional cotton production requires intensive use of water and diverse inputs such as, synthetic chemical pesticides (fertilizers, growth regulators, hormones, defoliant, herbicides, etc.) and irrigation (ZULFIQAR, THAPA, 2016; ZULFIQAR et al., 2017).

As a more sustainable option, organic cotton is produced without the use of synthetically compounded chemicals and transgenic seeds and in the case of Brazil also without irrigation (MURUGESH et al., 2013). A system of production that seeks to maintain and replenish soil fertility and the ecological environment of the crop. Organic refers to the way agricultural products are grown and processed, including a system of production, distribution and sales that assures consumers the products maintain the organic integrity that begins on the farm and in this way have the organic certification (ICAC, 2003). Although organic cotton international production has gained importance and market signals the trend of the search for more sustainable products (LAKHAL et al., 2008), yet this natural fiber represents an inexpressive production, compared to conventional one (TEXTILE EXCHANGE, 2020a). Brazil has great agricultural potential, but both production and commercialization of organic cotton need to be improved. Supplying buyers demand for organic cotton can be a major impasse, as the offer is usually insufficient (EMBRAPA, 2019a). The strong demand for organic fiber, however, is not being accompanied by the increase in offer (BELTRÃO et al., 2009).

The viability of these producers, however, depends not only on technical solutions for the organic production of cotton, but also of its organization and insertion in production, processing, distribution and consumption networks that aim to strengthen economic and

social interactions that translate into long-term commitments, composing a strictly coordinated governance system (SOUZA, 2000b; BELTRÃO et al., 2009).

As is the case with a lot of organic cotton, demand outstrips supply. It is need to increase awareness among farmers about regenerative organic practices, not only so they can put these amazing climate friendly methods to work, but so that they can capture the higher premiums that regenerative organic products demand for themselves and their communities (TEXTILE EXCHANGE, 2020b).

The theme of colored, organic/agroecological cotton in Brazil, in the state of Paraiba, was developed by Lirborio (2017) and Azevedo (2018). While Cardoso (2017) and Ferraz (2018) presented the case of Ceará state. The authors described market challenges and opportunities, through geographical, business and agricultural conditions. And affirmed that, because of law application of oriented techniques and management, the shortage of young workforce, lack of commitment to rural environmental management, information and technological development, market knowledge and connection, farmers themselves can be the resistance to increase the production. In other hand, international brands and markets engage more with this material (GLOBAL FASHION AGENDA; MCKINSEY, 2020). In addition, literature shows that authors used to focus on specific issues and concentrate on individual case studies, missing the overall picture and the complex set of actors involved from farm to fashion (RIEPLE; SINGH, 2010; KOKSAL et al., 2017; ROTA et al., 2018). Further research is then needed to understand the network from the textile and clothing perspective (WAITE, 2014).

This research presents an exploratory aspect, identifying the main actors and developing a network description of the organic cotton in Brazil to understand actors' relationships. It was firstly conduced a systematic and exploratory literature review to relate relevant topics on cotton, organic cotton, sustainability in textile/clothing and agriculture. Exploratory visits to better understand the production operations were carried out. After that, it was identified the most important actors of organic cotton network in Brazil. Interviews and technical visits were conducted in the states of Minas Gerais, Paraíba and São Paulo. Cotton annual reports, from national and international organizations were analyzed.

In this way, this dissertation is organized in the following sections: (1) Introduction; (2) Objectives; (3) Justificative; (4) Literature Review; (5) Research Methods; (6) Results and Discussion; (7) Final Consideration and (8) Conclusion.

2. OBJECTIVES

2.1 General Objective

The main goal of this study is to identify and describe the main actors of the organic cotton network in Brazil, addressing aspects on actors' relationship

2.2 Specific Objectives

- Identify main actors in the organic cotton network from field to textile and clothing/fashion in Brazil.
- Describe principal actors' challenges and perspectives;
- Present the production and market panorama of organic cotton in the world and in Brazil;
- Analyze organic cotton network in Brazil considering the analysis elements of centrality and density;
- Analyze actors' network perspectives towards innovation.

3. JUSTIFICATIVE

For natural fibers, it is expected to evolve positively toward the end of the third decade of the 21st century, since the consumption must continue to be induced by increasingly organized global ecological movements (BARROS et al., 2020). In this way, it is enhancing the adoption of different types of environmentally-friendly materials, such as organic cotton, hemp, bamboo, flax, recycled fibers and new renewable materials research (FLETCHER, 2010; VULETICH, 2015; KHURANA; RICCHETTI, 2016).

At the same time, there is a rapidly growing body literature addressing the issue of sustainability in managing textile and clothing supply chains (KOZLOWSKI et al., 2015; KOKSAL et al., 2017; SIRILERTSUWAN et al., 2018). Reflecting a growing awareness of the significant environmental and social impacts practices on the communities in which it operates (YANG et al., 2017b; DESORE; NARULA, 2018). This is evident with large retailers who have a growing interest in improving their own overall footprint and who seek to provide customers with greater confidence and transparency in the integrity of their products (FAO; ICAC, 2015), emphasizing production standards and systems that claim to promote the objectives of sustainable farming (ZABANIOTOU; ANDREOU, 2010).

There has also been a surge in demand for organically produced goods in recent years, stimulated apparently by consumer demand and the promotion of organic products by some of the world's major retailers and manufacturers (FERRIGNO, 2010). Despite the organic cotton occupying a small niche of global cotton production, the number of producers converting to organic and the number of international projects is increasing, demanding further investigation in its network (TEXTILE EXCHANGE, 2020a). This segment tends to grow and have a strong impact on future market for natural and color fibers, based on consumer demand and the trend toward more sustainable field practices (BARROS et al., 2020).

In addition, Brazil has a large and important textile production among Western countries (ABIT, 2015), considered the top ten textile industry markets (AMARAL et al., 2018). The textile industry directly employs 1.5 million workers in its production chain with more than 8 million indirect jobs. Its revenues are U$ 51.58 billion a year for an average textile production of 1.3 million tons and 8.9 billion garment pieces. Worldwide, it is the second largest denim manufacturer, the third in the production of knitwear and the fifth largest industrial park, as well as a reference in beachwear, jeanswear and

homewear (DE OLIVEIRA NETO et al., 2019). Furthermore, the concern with the ethics and sustainability of the textile and clothing sector is gaining relevance in the country (BERLIM, 2012; TODESCHINI et al., 2017).

The relevance of organic cotton network research in Brazil is related with engaging smallholders in organized production systems, that adopt more sustainable practices such as rainfed crops, agroecological practices that considers the quality of soil and biodiversity and integrated fiber and food crop. In this way offering social and economic conditions to maintain the families in rural areas. According with Albuquerque et al., (2009) the introduction of cotton within the context of agroecological production in small rural properties, can be a viable alternative from the point of view of increasing the profitability of the production unit. Moreover, the management adopted for conventional cotton crop in large areas is practically established, however it is necessary to put into action more researches with organic cotton (GARCIA et al., 2015; BARROS et al, 2020).

In Brazil, the lack of panoramic understanding and network interaction generates diverse issues concerning organic cotton spinning and weaving to attend a national and international market. Organic agriculture still lacks the required support by business partners to be adopted, particularly in the textile industry (NICOLAY, 2019) and a demand that is usually higher than the offer (TEXTILE EXCHANGE, 2020a). There is clearly a gap regarding studies that intend to evaluate the integration of new technologies in the organic cotton production in Brazil (FERRAZ, 2018), including large associations typical of the textile and clothing/fashion industry, in order to understand how the complexity of this system and include small producers. So, this research is justified by the importance that the organic cotton production can represent internationally and the potential expansion of Brazilian production (EMBRAPA ALGODAO, 2019a).

This research can also motivate scholars and entrepreneurs to discuss sustainability in supply networks, delivering a holistic perspective. Prioritizing delivery of social and environmental benefits, through close integration between actors (BOCKEN et al., 2014). In this direction, Manzini and M´Rithaa (2016) emphasis a trend that includes a variety of initiatives, ranging from the rediscovery of traditional craftsmanship and local farming to the search for small-scale, high-tech, fabrication systems capable of supporting new forms of networked micro-factories (such as the ones proposed by fab labs and by the maker movement).

Finally, as a fashion designer working in the context of sustainability, I have supported small brands to find solutions for more sustainable textile materials and processes, including natural dyes and vegetable textile fibers, relating design and handcrafts. In addition, organic cotton is one of the first options when fashion designers are looking to use more sustainable materials. This aspect got my attention and also the difficulty to understand the organic cotton network in Brazil, which presents difficulties to access and buy fabrics and threads. In 2018, I started to plant organic cotton, experimenting different crop consortiums and syntrophic agriculture. Thereafter, trying to gin and spin this cotton, I realized how complex, opaque, and disconnected the textile and clothing industry was for small producers to access organic cotton supply and processing chain. Some few industries in Brazil are able to spin organic cotton and they demand a considerable amount of lint bales. For organic cotton smallholdings the machinery could be in an inexistent scale between industrial and handmade. On other hand, there is an increasing demand for organic cotton from Brazilian and foreign fashion brands. In this way, considering the scarce studies in this theme I have chosen to develop the present Master's dissertation.

4. LITERATURE REVIEW

As the awareness of sustainability in apparel production increases, considering the farming processes and raw material cultivation, to relate and connect the network is a need to promote integrative development. Sustainability needs to be defined as encompassing natural resource conservation as well as social justice and collective action (NAGENDRA, 2018). A wider range of perspectives are influencing the development of sustainability initiatives, including the approaches to information needs, collection, reporting, transparency and collaboration (GLIN et al., 2012; TODESCHINI et al., 2017).

A systematic literature review was developed first, then a broader perspective of considered to further explore a panoramic and in deep description of the context. This section is divided in five main items: (1) sustainable development (2) textile and clothing panorama; (3) cotton; (4) organic cotton; (5) Life Cycle Assessment (LCA); (6) cotton certifications and; (7) network theory.

4.1 Sustainable Development

This topic addresses sustainable development in the textile and clothing sector, agriculture and business. In recent years, social, environmental, economic and ethical governance and accountability mechanisms have become increasingly common within corporate life (CANIATO et al., 2012). This has been motivated by a number of factors including legitimacy issues, institutional pressures, and stakeholders' concerns (SPENCE; RINALDI, 2014).

The concept of sustainable development - which was born at United Nations Conference on the Human Environment (Stockholm Conference) in 1987 e is being widely discussed by academics and practitioners due to increased concern for the planet's sustainability over the last decades (CAIADO et al., 2017). In the current context, it is observed the need of organizations and institutions not only to improve their economic performance, but also to act with social responsibility to meet diverse actors' expectations (JAMALI; KARAM, 2018) and to address environmental and social impacts. This three-dimensional view of sustainability, known as the triple bottom line, was proposed by Elkington (1998) based on the proposal of the Brundtland Commission report, in a document entitled Our Common Future (WECD,1987), in which sustainability would be achieved through a balance between economic return, social equity and environmental preservation (GONÇALVES-DIAS et al., 2012; KRUGER et al., 2018). With the classic

definition of sustainable development, ‘meeting the needs of present without compromising the ability of future generations to meet their needs’.

In the past three decades, there has been an increased interest in the sustainability performance of companies. Business sustainability is defined as the ability to conduct business with a long-term goal of maintaining the well-being of the economy, environment and society (HASSINI et al., 2012; FORMENTINI; TATICCHI, 2016). Concepts of corporate citizenship, corporate social responsibility and environmental management (MATTEN; CRANE, 2005) have quickly gained popularity as stakeholders (customers, shareholders, employees, governments, etc.) are asking for more environmentally responsible business practice (CLARKSON,1995). They are commonly viewed as multidisciplinary since they are composed of four dimensions: society (people), environment (planet), economy (profit), and technology (DESPEISSE et al., 2012).

Eco-innovations, eco-efficiency and corporate social responsibility practices define much of the current industrial sustainability agenda. Sustainable business models (SBM) incorporate a triple bottom line approach (ELKINGTON, 1998) and consider a wide range of actors’ interests, including environment and society. They are important in driving and implementing corporate innovation for sustainability, can help embed sustainability into business purpose and processes, and serve as a key driver of competitive advantage.

The growing interest in “sustainable development” has led many companies to examine the ways in which they deal with environmental issues (BEVILACQUA et al., 2014). Sustainable development has become, one of the strategic focal points of business organizations (FRANÇA et al., 2017). Delivering environmental and social sustainability initiatives are related to employee welfare and living wages; community development; sustainable growing and harvesting of food and other crops, minimizing chemical fertilizers and pesticides, water consumption, and top soil erosion and; environmental resource and biodiversity protection and regeneration (BOCKEN et al., 2014).

There is a clear trend toward increased adoption of corporate social responsibility practices (CSR) in the fashion industry, including discussions about the ethics of communicating sustainable actions for business purposes and the risk of greenwashing (BALDASSARRE; CAMPO, 2016). CSR seems to manifest more often in supply chain management as leading fashion brands have to deal with increasingly complex networks of suppliers that are distributed around the globe. As a result, global clothing brands tend to adopt measures such as sustainability reporting, voluntary participation in multiple

stakeholder monitoring, auditing initiatives such as the Fair-Trade Association, development of codes of conduct and labor standards assurance programs, and adoption of supplier disclosure and transparency practices all along the supply chain (TODESCHINI et al., 2017).

Environmental, social and governance issues (ESG) are also considered by companies, to measure its practices. The concept refers to extra-financial material information, allowing investment judgements by enabling investors to better assess risks and opportunities (BASSEN; KOVACS, 2008). It concerns into investment practices, called socially responsible investing, partly because of increasing awareness of environmental risk (e.g. climate change) and social risk (MANESCU, 2011).

An organization can achieve sustainable development by enhancing operational efficiency and performing stakeholder (actor) management on a corporate strategy level (GEISSDOERFER et al., 2017). Also regarding products, processes and services innovation and looking outside their boundaries to other stakeholders with whom they can cooperate (BROMAN; ROBÈRT, 2017). According to Bocken et al. (2014), many innovative approaches may contribute to delivery sustainability through business models including systems that:

- Encourage minimizing of consumption, or imposes personal and institutional quotas on energy, goods, water, etc.;
- Are designed to maximize societal and environmental benefit, rather than prioritizing economic growth;
- Are closed-loop, which nothing is allowed to be wasted or discarded into the environment, which reuses, repairs, and remakes in preference to recycling;
- Emphasize delivery of functionality and experience, rather than product ownership;
- Are designed to provide fulfilling, rewarding work experiences for all that enhances human creativity/skills;
- Are built on collaboration and sharing, rather than aggressive competition.

These innovations are decreasingly accomplished solely due to their internal business and development activities, but they are increasingly looking outside their boundaries to other actors with whom they can collaborate (VISWANADHAM;

AMVEDI, 2013; BROMAN; ROBÈRT, 2017). In addition, the interaction between companies, society and environment modifies management and performance assumptions (GONÇALVES-DIAS et al., 2012). In this context, product development policies focused on sustainability require integration between economic, social and environmental issues that cover the entire production chain. The closed flow strategies need an efficient logistic organization, in which the linear flow business model is replaced by the circular cradle to cradle route (BRAUNGART et al., 2007).

Since the design of the product, each step contains a potential for environmental optimization: in the choice of raw materials, technologies and manufacturing processes, in the organization of logistics; in the context of the use, final product valorization and post use (MANZINI; VEZZOLI, 2002, GONÇALVES-DIAS et al., 2012). Establishing a coherent network of information flows amongst actors in the material flow chain, enabling a continual accumulation of knowledge that forms the basis for upcycling. In this way, the formation of an intelligent materials pooling community is a four-step process (BRAUNGART et al., 2007):

- **Creating community:** identification of willing industrial partners with a common interest in replacing hazardous chemicals with technical nutrients, targeting of toxic chemicals for replacement;
- **Utilizing market strength:** sharing lists of materials targeted for elimination, development of a positive purchasing and procurement list of preferred intelligent chemicals;
- **Defining material flows:** development of specifications and designs for preferred materials, creation of a common materials bank, design of a technical metabolism for preferred materials;
- **Ongoing support:** preferred business partner agreements amongst community members, sharing of information gained from research and material use, cobranding strategies.

4.1.1 Sustainability aspects in agriculture

Climate change, extreme poverty, scarce resources, cultural conflicts, political instability, human migration-based disruption, and globalization are some of the most controversial issues being discussed by academicians and practitioners nowadays

(IQBAL; AHMAD, 2020). Deforestation, soil erosion, biological degradation, and salinization have been affecting the terrestrial ecosystem because of incorrect business practices. These issues lead to a reduction in electricity production and flooding, degradation in the agricultural land, and a rapid loss of forest cover, causing these problems a great concern worldwide (MOYA-CLEMENTE et al., 2020).

Sustainable agriculture has three long-term concurrent goals: (1) quality of life (i.e. to satisfy personal, family, and community needs for health safety, food, and happiness); (2) environmental quality (i.e., to enhance soil nutrition, water, air, the ecosystem as a whole); (3) economics (i.e., to be profitable) (ROMEIRO, 1998).

A sustainable agricultural sector requires that farmers are able to secure income from production, while keeping ecological impacts to a minimum. As the global climate continues to warm, and water availability becomes increasingly uncertain, a sustainable agricultural system will not only be able to adapt to changes by incorporating farmer involvement and decision making, but also allow for less-water intensive crops, as well as a reduction in synthetic and costly inputs (FRANZ et al., 2009).

For most developing countries, the need to change the technological standard of agricultural modernization for ecological reasons concerns socio-economic aspects. In the case of Brazil two realities coexist: an industrial agriculture, with large machinery in large properties, with environmental problems similar to those of the developed countries. And smallholders' agriculture demanding investment and support to improve. A change in the pattern must be added to the need to articulate agrarian and agricultural policies in a new strategy of rural development, considering family agriculture (ROMEIRO, 1998).

4.1.1.1 Regenerative farmland

Rhodes (2017) explained that regenerative agriculture intents to improve the health of soil or to restore highly degraded soil, which symbiotically enhances the quality of water, vegetation and land-productivity, in a long-term, while offering a solution to carbon sequestration. Terra Genesis International (2020), defined as "a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services".

This type of agriculture fits into a larger umbrella, considering the recovery of ecosystems, which understands modern agriculture through a long-term holistic lens, redesigned rural production to work in sync with nature. This method aims to drastically

reduce the industry's carbon footprint, as deforestation and conventional agriculture are responsible for about a third of global greenhouse gas emissions (CERRI et al., 2009). Regenerative agriculture goes a step further by removing carbon from the atmosphere and storing it in the soil (RUMPEL et al., 2018), which can contribute to slowing down climate change. It is essential to consider the context of each location. Factors such as location and soil composition inform the customized plan for each area. It is also important to consider geography, climate, current crops, infiltration and water drainage (BELTRÃO et al., 2009).

Regenerative agriculture can be directly related to the sustainability in cropping production. Regenerative farming systems can provide organic crops, greater ecosystem services and profitability for farmers than an input intensive model production. Soils are crucial to managing climate change. They contain two to three times more carbon than the atmosphere. Plants circulate carbon dioxide from the air to soils, and consume about one-third of the CO_2 that humans produce (OLIVEIRA-DUARTE et al., 2019).

The term “regenerative” is increasingly considered regarding sustainable fiber choices. Regenerative agriculture is a holistic approach aiming at positively influencing carbon sequestration, biodiversity, climate resilience, water systems, micronutrients, and ecosystem services. Regenerative practices usually address a set of practices within the system. Hence, standard practices include cover cropping, multi-use systems, agroforestry, rotational farming, precision agriculture, integrated pest management (TEXTILE EXCHANGE, 2020a).

4.1.1.2 Organic Farming

Addressing sustainable production process, according to Le Guillou and Scharpé (2000), organic farming originated in England on the theories developed by Albert Howard in “An Agricultural Testament*”* (1940). ‘Biodynamic agriculture’, developed from the teachings of Rudolf Steiner in Germany in the 1920s, and ‘biological agriculture’, developed in Switzerland by Hans-Peter Rusch and Hans Müller, are types of organic farming. There are several principles that characterize certified organic farming: biodiversity, integration, sustainability, natural plant nutrition, and natural pest management (KUEPPER; GEGNER, 2004). The US National Organic Standards Board adopted the following definition of ‘organic’ agriculture as follow: Organic agriculture is an ecological production management system that promotes and enhances biodiversity,

biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. Organic farming has also been shown to make land easier to plough and retain water, helping crops to sustain periods of drought better (GOMIERO et al., 2011).

The consolidation of organic meanings and practices was extended internationally with the 1972 founding of the International Federation of Organic Agriculture Movements (IFOAM) by groups from Great Britain, France, Sweden, South Africa, and the United States. IFOAM established a singular organic definition based on farm management practices involving the use of natural methods of enhancing soil fertility and resisting disease, the rejection of synthetic chemical fertilizers, pesticides, and pharmaceuticals, and the protection of ecosystems. Acceptance of this organic definition has spread with IFOAMs recent expansion to include members from 100 countries (RAYNOLDS, 2004).

Organic agriculture uses only organic fertilizers and pesticides to ensure the sustainability of agro-ecological systems, however, since the productivity of organic agriculture is often much lower than that of conventional agriculture, it cannot meet the demands of ever-growing population for food, fiber and other grown products. The low yield combined with high cost of labor makes organic agriculture financially unattractive for the farmers who make labor and capital investments in anticipation of good financial return. Therefore, it is almost impossible to make organic agriculture financially better than conventional agriculture unless appropriate policy interventions enabling organic products to fetch premium price are made (ZULFIQAR; THAPA, 2016).

According to Brazilian legislation, organic product, whether raw or processed, is considered to be one that is obtained in an organic system of agricultural production or from a sustainable extractive process and not harmful to the local ecosystem (NOTAROBERTO et al., 2017). To be marketed, organic products must be certified by accredited bodies in the Ministry of Agriculture, and only those produced by family farmers who are part of social control organizations registered with the Ministry of Agriculture and Food Supply (MAPA), which exclusively on direct sales to consumers. With family farming, sustainable development happens when the inhabitants are the authors, the protagonists of agricultural production, of their wealth, the builders of their values. For this they need support for structuring knowledge, information for organization and healthy management of production, to finally integrate a network of fair production and trade (NOTAROBERTO et al., 2017).

Regulations are important because they standardize criteria for organic production and post-harvest handling/processing that will facilitate domestic and international trade. A three-year transitional period from conventional to organic cotton production is required for certification. Although decrease in productivity is only temporary during the transition period to organic agriculture as supported by the literature, it is still a discouraging element to farmers who would suffer yield loss for a few years. Environmental issues associated with chemical fertilizer consumption can in many cases be of secondary concern for the farmers. It is important to note that transition to organic agriculture require collective and collaborative action by the farmers due to the very nature and definition of organic agriculture (BAYDAR et al., 2015).

Organic farming is often promoted as a means of addressing the economic, environmental and health risks of conventional cotton production, and it is slowly gaining ground in the global cotton market (YANG et al., 2017a). Organic and fair-trade cotton are widely seen as opportunities for smallholder farmers to improve their livelihoods due to higher returns, lower input costs and fewer risks (GLIN et al., 2012). The majority of organic farmers perceives improved soil quality, improved health conditions, and positively assess their initial decision to convert to organic farming. Organic farming has also been shown to make land easier to plough and retain water, helping crops to sustain periods of drought better. Despite that, the major disadvantage of organic farming is the high manual labor input required (BACHMANN, 2011).

Organic and fair-trade commodities produced in developing countries offer a good case study for analyzing the performance of collaborative relationships within food and fibers chains in developing countries. Organic production and fair trade involve collaboration between the chains' agents in terms of transparency, sharing information on technical and managerial practices and, in particular for fair trade, contractual agreements related to defining prices (ROTA et al., 2018)

Organic farming is widely regarded as a more sustainable farming system than conventional agriculture because it produces food while conserving soil, water, energy and biodiversity (PIMENTEL et al., 2005), although 'sustainability' is a concept defined with multiple currencies (e.g. greenhouse gas emissions, synthetic inputs, land use and biodiversity).

4.1.1.3 Agroecological farming

In the search for sustainable agroecosystems, the agroecology adopts as basic principles the least possible dependence on external inputs and conservation natural resources. For this purpose, agroecological systems seek to maximize energy recycling and nutrients, as a way to minimize the loss of these resources during the production processes. Agroecology is a science developed since the 1970s, as a result of a search of theoretical support for the different currents of alternative agriculture that had been developing since the 1920s (DE ASSIS; ROMEIRO, 2002).

The agroecological performance of the agroecosystems, in terms of disease management and landscape preservation, is an important motivation for adopting agrobiodiversity rich production practices, without the use of agrochemicals. It is the scientific discipline that uses ecological theory to study, design, manage and evaluate sustainable agriculture systems that are productive and also resources conserving. Drawing on the natural social sciences, agroecology provides a framework for assessing four keys (productivity, resilience, sustainability and equity). Hence its importance is greatly realized by the dominant food policy and agricultural research bodies around the world (OLIVEIRA-DUARTE et al., 2019).

By reducing diversity and putting together plants of the same species and in large areas, it favors the reproduction and survival of certain herbivores, which, in the presence of few competitors and natural enemies, results in a large population, being considered as pests. The challenge, therefore, is to know not only the characteristics of agroecosystems, but also the most appropriate ways of diversifying them. In the transition to a sustainable standard will be essential the adoption of public policies that promote the expansion and strengthening of family agriculture (OLIVEIRA-DUARTE et al., 2019). In more sustainable agricultural systems, biodiversity becomes essential, as in addition to food, fiber, fuel and income production, it enhances soil nutrients, benefits local microclimate and control undesirable organisms (CARDOSO, 2017).

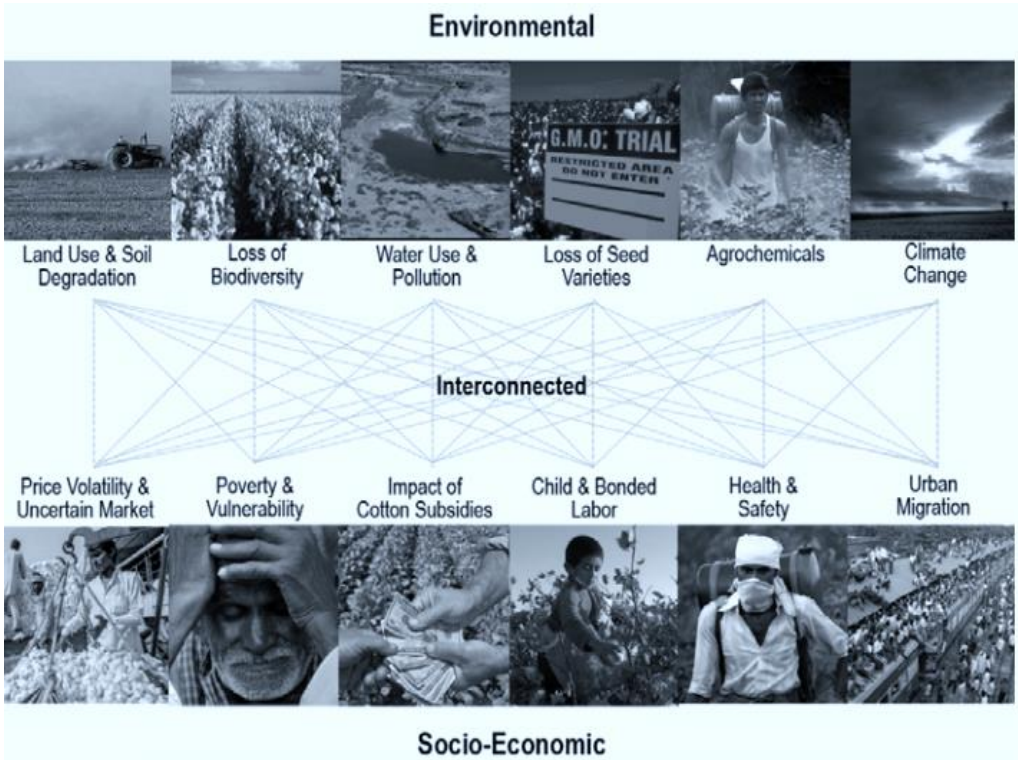
4.1.2 Sustainability transition in the textile and clothing

The global textile and clothing industry offers an excellent example for teaching and learning sustainability issues throughout the supply chain, from fiber production to retailing. At the fiber production stage, how natural fibers are grown is strongly related to the environmental impact of apparel consumption. Fair trade certified products are

often more expensive in order to support sustainable practices and to help improve the lives of the disadvantaged farmers and workers in developing countries. First, it seems that businesses involved with cotton, from farmers to retailers, must improve the way that educate and explain sustainability issues of cotton to today's consumers and students (HA-BROOKSHIRE; NORUM, 2011).

In the textile and clothing industry environmental impacts start at the initial stage of production itself (**Figure 1**) and can be grouped under categories such as raw material production, where chemicals toxic in nature is used in growing cotton (DESORE; NARULA, 2018). Next is the stage of textile manufacturing, dyeing and finishing where chemicals and solid wastes arising from yarn manufacturing of natural fibers are released in water (KHANDEGAR; SAROHA 2013; NGUYEN, et al. 2014).

Figure 1 - Interconnectivity between environmental and socio-economic impacts.



Source: TEXTILE EXCHANGE; KERING, 2017.

According to Toprak (2017), the problems related to environmental impacts in the textile and clothing sector begin with the use of chemicals used in the planting and cultivation of natural fibers, which need care to reach production. According to Muchinski and Sena (2015), the use of organic cotton instead of conventional cotton would be impactful, as conventional culture is the one that most pollutes and causes

irreversible damage to health, which can lead to the death of farmers worldwide. Organic culture dispenses with the use of any type of pesticide, also avoiding the illness of farmers, its use has increased considerably in the fashion world, several brands adopt this fiber as an alternative to sustainability (MERCIAL, 2018).

Sustainable textile processing may be an alternative in diverse areas of wet processing for instance: the use enzymes, eco-friendly dyeing, plasma treatment and supercritical fluid technology, digital ink-jet printing, use of ultrasonic waves in place of thermal energy, recycling of process inputs, electrochemical dyeing, foam finishing, innovations in dyeing and printing machines. Concerning textile dyeing and printing, sustainable developments are and have been extensive in terms of improvements in economy, quality and energy conservation as well as in addressing environmental concerns (TAUSIF et al., 2018). Therefore, common environmental practices for achieving sustainability include organic-fiber usage, material recycling or reuse, technology implementation (including clean technology and information technology), product certificates, green processes and product design, green manufacturing and logistics, and product traceability (CANIATO et al., 2012; MACCARTHY; JAYARATHNE, 2012).

Sustainable clothing has been described as ‘clothing which incorporates one or more aspects of social and environmental sustainability, such as Fair Trade manufacturing or fabric containing organically-grown raw material’. There is no one simple answer to improving the sustainability of clothing, but what this article has highlighted is that one of the key challenges is to improve the longevity of clothing. The suggested interventions require action from all parties in the clothing sector, including retailers, designers, policymakers and of course consumers (HARRIS et al., 2016).

As a driver of innovative and sustainable business models in fashion, collaboration refers to the adoption of a collaborative mindset by all stakeholders (actors) involved in a sustainable value network: suppliers, distributors, customers (who often are involved in co-creating initiatives), and even competitors. In fact, it does not seem uncommon to witness coopetition efforts among sustainable fashion startups. Collaboration allows the creation of a supporting ecosystem that drives resource and knowledge sharing, promotes the diffusion of sustainable practices, and ultimately allows business model experimentation. As a result, it is a critical driver for startups and small businesses and impacts the business model parameters related to value creation (key activities, key resources, and key partners), distribution (delivery channels and customer relationship),

and potential impacts on cost structure and revenue streams, as many collaboration initiatives involve revenue sharing (TODESCHINI et al., 2017).

The sustainable raw materials driver contemplates the development and adoption of different types of environmentally-friendly raw materials such as organic cotton, hemp, bamboo, lyocell and recycled fibers. As a driver of innovation and sustainability in business models, it mainly impacts the key activities, key resources, and customer relationship parameters by requiring technological development, reliable access to a source of materials, and communication of brand commitment to sustainable practices (MAGNUSON et al., 2017).

Fair-trade labeling, code of conduct initiatives, internal and social auditing, and looking beyond first-tier suppliers are attempts to improve sustainability within the social dimension (KHURANA; RICCHETTI, 2016). Corporate Social Responsibility programs are implemented in firms to improve the living standard of workers and their families as well as contribute to local communities and the economy (MACCARTHY, JAYARATHNE, 2012; SIRILERTSUWAN et al., 2018). Also, transparency in its different meanings is increasingly central in the sustainable fashion discourse and committing to transparency is an exercise in balancing risks with opportunities. The focus has shifted from sustainability of internal processes and products the brand sells to sustainability of all the process, inside the company and in the whole supply chain that creates the product (KHURANA; RICCHETTI, 2016). And education to ensure consumers are fully cognizant of the impacts of their purchasing and consumption decisions (BOCKEN; SHORT, 2016).

At the same time, the sustainable approach in the textile and clothing sector is emerging in Brazil, concerning international events, brands recognition in their processes of biodiversity support, handcrafts and traditional communities, innovation and creative hubs, the production and use of natural fibers and pigments facilitating the biodegradability and renewability of materials, new natural fibers research and industrial adoption, etc.

4.2 Textile and clothing chain

The textile and clothing industry is integrated by a complex supply chain, both in terms of fragmentation of production activities and geographical dispersion of the actors involved (FLETCHER, 2010; MACCHION et al., 2015). Any large apparel brand often

consists of thousands of suppliers, distributors and retailers (FLETCHER, 2010), including raw material, yarn and textile manufacturing, clothing construction, distribution, marketing, retail and use and disposal of the garment (CANIATO et al.,2012, DESORE; NARULA, 2018). Concerning a global supply chain that employs 58 million people worldwide (MOORHOUSE; MOORHOUSE, 2018), this complexity introduces myriad challenges associated with monitoring, reporting, and improving sustainability practices (KOZLOWSKI et al., 2015).

The textile and clothing chain consists of large industrial and productive sectors, namely: (i) chemical industry, which is responsible for manufactured fibers and supplies for dyeing and finishing; (ii) agricultural and livestock, supplier of natural fibers, both plant and animal; (iii) textile industry, which transforms the raw material into fabrics through the spinning, weaving and knitting processes; and (iv) the clothing industry, which transforms fabrics into clothing, which are offered to the consumer by different means of marketing (COSTA; ROCHA, 2009; SILVA, 2009).

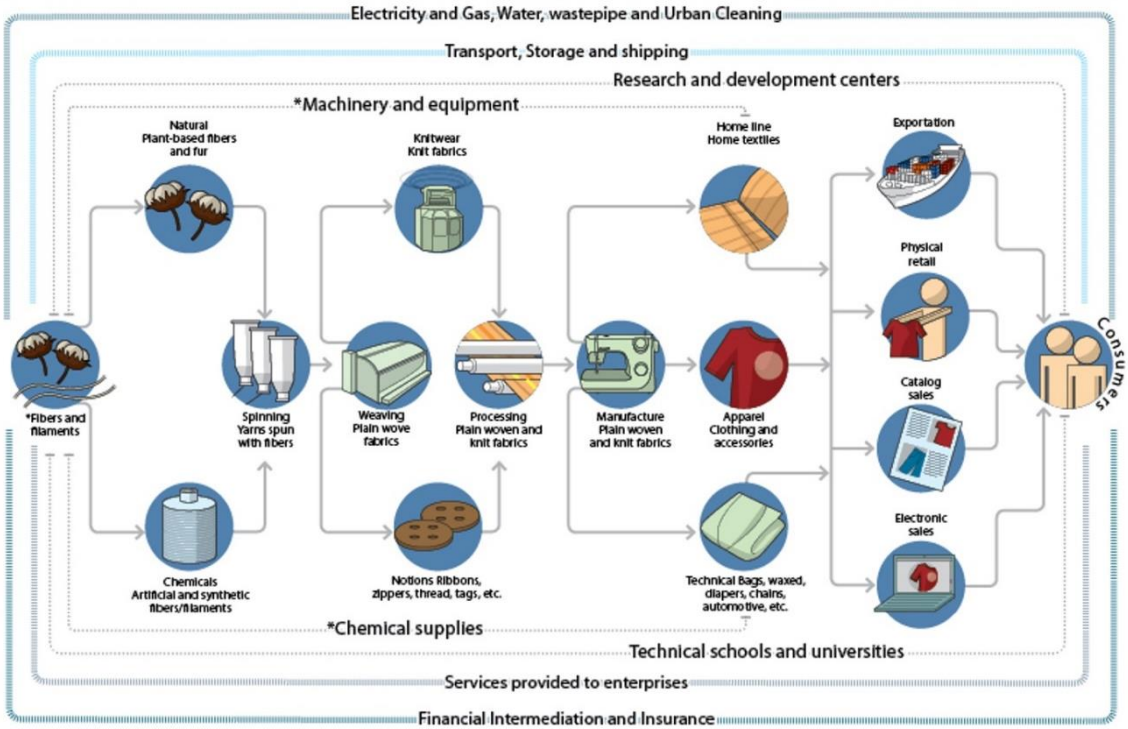
Currently, clothing companies must face challenges posed by demand unpredictability and must adapt to a new, competitive environment (GEREFFI; FERNANDEZ-STARK, 2016). But also increasingly time-based competition (FORZAAND VINELLI, 1996; JACOBS, 2006) and mounting consumer sensibility to social environmental issues (CANIATO et al., 2012), have driven fashion companies to reorganize their supply networks, searching for a new balance between local and global sourcing and production.

The manufacture of natural fibers is one of the bases of the production of garments, and Brazil is one of the largest cotton producers in the world. The consumption of cotton fiber is predominant in Brazil, about 84% of the total fiber consumption, or 1.042 million tons, followed by artificial and synthetic textiles fibers compounds (13%) and other natural fibers (3%) (IEMI, 2015).

The textile and clothing production (**Figure 2**) is present in all Brazilian States, with more than 27,500 productive units (IEMI, 2018) main small and medium-sized confections, located mainly in the South and Southeast regions of Brazil, especially in the State of Sao Paulo, which concentrates 27% of production units (IEMI, 2018). It is nearly 200-year-old industry. The sector is the second largest employer in the Brazilian manufacturing industry, behind the food industry. There are approximately 1.5 million direct jobs, of which 75% are women (AZOUBEL, 2018). Representing 17% of the total of workers engaged in the manufacturing industry, distributed in all segments of the

production chain, from the natural and synthetic fibers production, spinning, weaving, knitting, finishing and sewing (ABIT, 2015). An industry worth US$ 797 billion on global value according to estimates of the World Trade Organization (WTO, 2015).

Figure 2 - Structure of the textile and clothing production and distribution in Brazil.



Source: AMARAL et al., 2018.

After processing - ginning and cleaning the lint impurities, the product follows the flow of the production chain to the spinning stage. In this stage, the agricultural product goes through the first major industrial transformation where the bales of lint are transformed into coils of thread. All the necessary processing of this stage is done equally for both types of cotton, however, it is necessary to clean the machinery to receive the organic cotton lint so that there is no contamination, if it has previously processed conventional cotton (DA CUNHA; DE OLIVEIRA, 2019). It is in this context that Brazil has the fifth largest textile industry in the world, with a history that has lasted more than 200 years, in addition to being the fourth largest in clothing. The country, the only South American country to occupy a prominent place in the sector, accounts for 2.4% of the global production of textiles and 2.6% of the world production of clothing (GRUPO FEBRATEX, 2019).

Furthermore, the clothing textile industry has an important input of the cotton production and is an essential segment in the Brazilian economy, which is amongst the five most significant apparel producers in the world. The Brazilian clothing industry produced five million items, including clothing, accessories, bedding, table and bath linen, responsible for 17% of jobs with 1.5 million direct employees, and nearly 8 million indirect employees, being the second largest employer in the manufacturing industry (GARCIA et al., 2019).

4.2.1 Textile Fibers

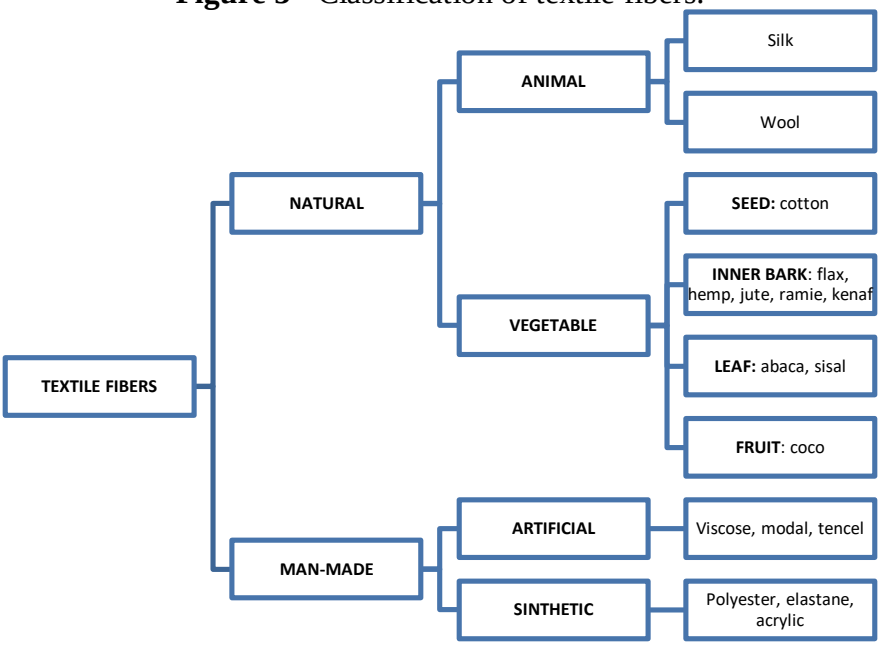
Textile fiber means any substance, natural or chemical, having a length much greater than its thickness and having suitable characteristics for spinning and weaving. About 6,000 years ago, linen was already used in Egypt, China was the cradle of silk and in ancient India, techniques associated with the use of cotton have been developed. Sisal cellulosic fiber, vicuna and llama wools were already used in textiles by pre-Columbian civilizations (CATANNI; BARUQUE-RAMOS, 2014). Until the end of the nineteenth century, the fibers used as raw material for making fabrics were exclusively those found in nature (PEZZOLO, 2012). The first chemical fibers were produced in 1885; with pulp extracted from wood, gave origin to the rayon, that by its aspect was known like artificial silk. Since then, numerous fibers have been developed in laboratories with the purpose of satisfying the needs of the industries of different productive sectors and, consequently, have become widely used in the fabrication of new fabrics (CATANNI; BARUQUE-RAMOS, 2014).

Many useful fibers have been obtained from various parts of plants including leaves, stems (bast fibers), fruits and seeds. Geometrical dimensions of these fibers, especially the fiber length depends mainly on fiber location within the plant. Fibers from fruits and seeds are few centimeters long, whereas fibers from stems and leaves are much longer (longer than one meter) (SFILIGOJ SMOLE et al., 2013). Plant fibers are obtained from various parts of plants, such as the seeds (cotton, kapok, milkweed), stems (flax, jute, hemp, ramie, kenaf, nettle, bamboo), and leaves (sisal, manila, abaca), fruit (coir) and other grass fibers. Fibers from these plants can be considered to be totally renewable and biodegradable. Plant fibers, which have a long history in human civilization, have

gained economic importance and are now cultivated on a large scale globally (SFILIGOJ SMOLE et al., 2013).

Fibers can be classified into natural and man-made fibers (GURUNATHAN et al., 2015). There are two types of natural fibers; protein fibers which are obtained from animal resources, such as silk, wool and hair, and cellulosic fibers which are obtained from plants, such as flax, jute, date palm and cotton (GURUNATHAN et al., 2015; HAKEEM et al., 2014). Cellulosic fibers can be classified based on the part of the plant from which they are extracted, for instance, fibers extracted from the stem are classified as bast fibers, whereas fibers extracted from the leaves are classified as leaf fibers (**Figure 3**). In addition to other parts of the plants, such as, seed, fruit, stalk, or grass could be classified into two other types (ELSEIFY et al., 2019). The increasing demand for more sustainable and renewable materials, has increased the interest in natural fibers. Natural fibers are not only environmentally-friendly, but they also have high specific properties, due to their light weight (STOKKE et al., 2013).

Figure 3 - Classification of textile fibers.



Source: Larissa Oliveira Duarte adapted from AMARAL et al., 2018.

4.2.2 Textile Processes

This section describes the steps and industrial machinery for textile production. Ginning is the first process of removing seed from cotton fibers (lint) and occur in a mill (**Figure 4**). The process involves their physical removal either with saw blades (saw-gin

machine) or roller blades (roller-gin machine) invented the cotton gin in 1793. This machine made it possible to remove the cotton seeds from the fibers more cheaply. With it, one person could do the work once done by 50 persons picking out seeds by hand. Even though chemicals are not used in the ginning stage and the process is the same for both organic and conventional cotton, a price premium can still be achieved at this stage, mainly the result of retailers' demand for traceability—fueled in turn by consumer pressure (TAUSIF et al., 2018; VAN DER SLUIJS, 2015).

Figure 4 - (a) Structure of an old mill and **(b)** modern machinery mill produced in Brazil.

(a) **(b)**

Source: RIBAS, 2015.

In order to gain full organic certification a mill has to store and process organic cotton separately from non-organic crops. One of the reasons why organic cotton commands a premium price at this stage is because there is a perception on the part of some buyers that the organic cotton fiber has a longer staple length and fewer impurities. These characteristics are held to result in a better quality yarn, and thus fabric. Explanations for this include the fact that the ginning mills tend to be located close to the organic farms, and hence the crop suffers less damage in transportation, and also because organic crops generally tend to be handled more carefully than conventional ones. However, evidence is equivocal on whether the fibers are in fact different (RIEPLE; SINGH, 2010). After that, according with Maluf and Kolbe (2003) following stages summarized the processes:

• **Spinning:** from natural fibers (animal and vegetable) and spinning of unnatural fibers (synthetic and artificial);

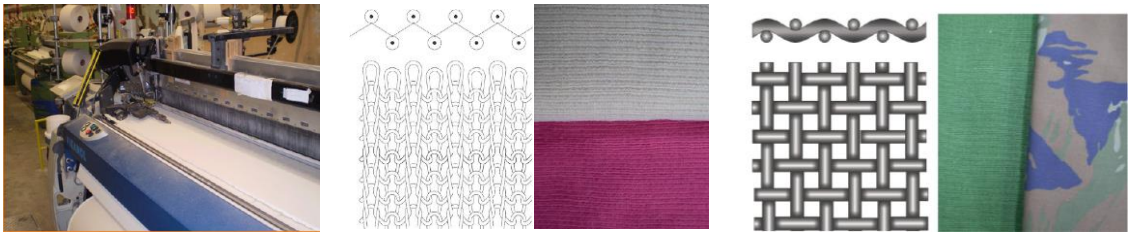
• **Weaving:** fabric elaboration stage with flat structure, characterized by the interlacing of yarns in linear structures (**Figures 5a** and **5c**);

• **Knitting:** the formation of knitted fabrics by means of loops (**Figure 5b**). It is subdivided into two categories being, filling knitting (tubular or rectilinear) and warp knitting (Kettenstuhl or Raschel);

• **Processing (finishing)**: preparation stage, involving for example, dyeing or mercerizing (in which the cotton is treated with an alkali, making it more receptive to dyes and also more lustrous), etc.;

• **Clothing manufacturing:** phase in which the development of garments and other items occurs.

Figure 5 - (a) weaving machinery, **(b)** textile strucure knitted mesh **(c)** and flat fabric.

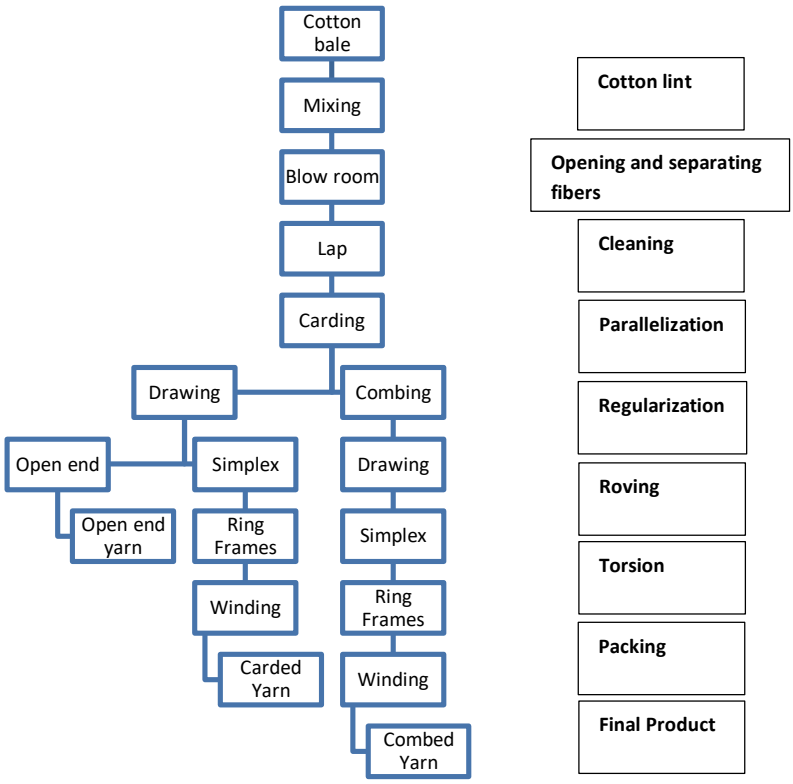


(a) **(b)** **(c)**

Source: DE LIMA, 2018

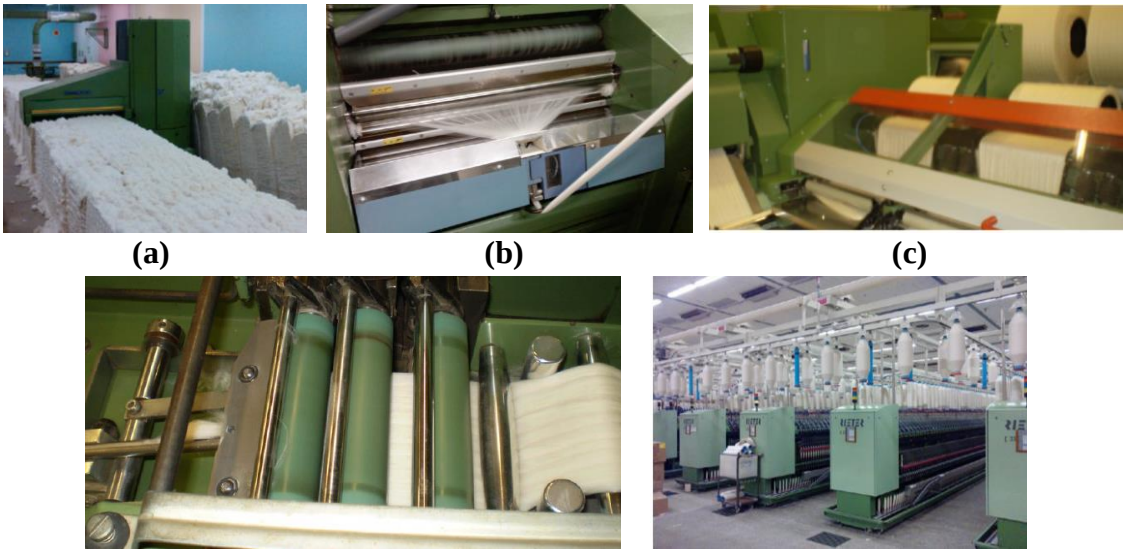
Transforming a cotton crop into a textile and then into a final item of clothing involves many stages of processing, using many skills and technologies. Carding and combing are two steps to prepare the raw fiber for spinning. In order to make a yarn, the raw material fibers need to be fluffed up and aligned (**Figures 6 and 7**). Combing creates a smoother yarn as the fiber are more aligned. Combing is a more expensive process aiming to separate short from long cotton fibers (RIEPLE; SINGH, 2010).

Figure 6 - Spinning process fow chart.



Source: Larissa Oliveira Duarte adapted from DE LIMA, 2018.

Figure 7 - (a) Cotton bale automatic opening and mixing; **(b)** carding; **(c)** combing; **(d)** drawing and **(e)** ring spinning.



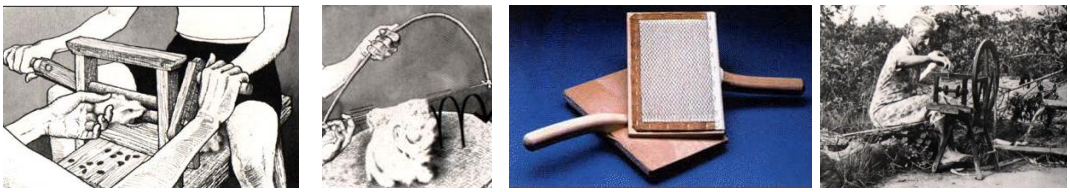
Source: DE LIMA, 2018.

Cotton yarns for textiles use can be spun by two processes: ring spinning or rotor spinning. Rotor spinning is also known as **Open-End (OE)** spinning because of the simplification of the yarn forming cycle. It offers lower price and better regularity compared to conventional yarn, but has less resistance. It is often employed for yarn production turned to denim fabric weaving. **Ring spinning** is traditionally known as conventional spinning, generally employed for long fibers spinning. The yarn produced by ring spinning presents greater strength and greater cost in relation to the Open-End (RIEPLE; SINGH, 2010).

Most of these are physical processes that are the same for both organic and non-organic cotton. However, as with ginning, there has to be a clear segregation of the operational area if a company is processing both types of cotton. Weaving and knitting are mechanical processes of transforming yarn into fabric. There is no difference in these processes employing organic or conventional cotton. The only detail that has to be taken into account while processing certified organic cotton is not to use oils that contain heavy metals or other potentially contaminating pollutants in these mechanical processes. Both organic and conventional cotton are stitched following same process, so there is little scope for value addition at this stage (RIEPLE; SINGH, 2010).

The handcraft cotton processing is first based in the manual lint cleaning, then separating the seed from the fibers in a manual cotton gin. The opening of fibers and carding is the final process of untangling the fibers. The spinning process for obtaining the yarn can be done with a drop spindle or with traditional spinning wheels (TECELAGEM MANUAL, 2020) (**Figure 8** and **Figure 9**).

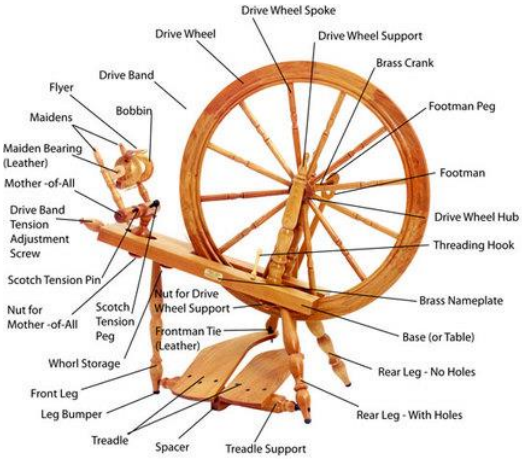
Figure 8 - Manual cotton processing: **(a)** ginning **(b)** and **(c)** carding and **(d)** spinning.



(a) **(b)** **(c)** **(d)**

Source: TECELAGEM MANUAL, 2020.

Figure 9 - Traditional spinning wheel: equipment parts details.



Source: RAISINGSHEEP, 2020.

4.3 Cotton (*Gossypium ssp.*)

The natural fibers of vegetable origin basically consist of cellulose, which is a natural polymer based on glucose, such as cotton fiber (**Figure 10**). For their construction, bundles of cellulose molecules aggregate in the form of microfibrils, and these construct fibrils constituting the cellulosic fibers. The main chemical components of plant fibers are polar substances, such as cellulose, lignin and hemicellulose. There are also small percentages of pectin, water-soluble substances and waxes (BENINI, 2011; CATANNI; BARUQUE-RAMOS, 2014).

Figure 10 - (a) Cotton plant and **(b)** cotton lint.

(a) **(b)**

Source: Larissa Oliveira Duarte, 2018.

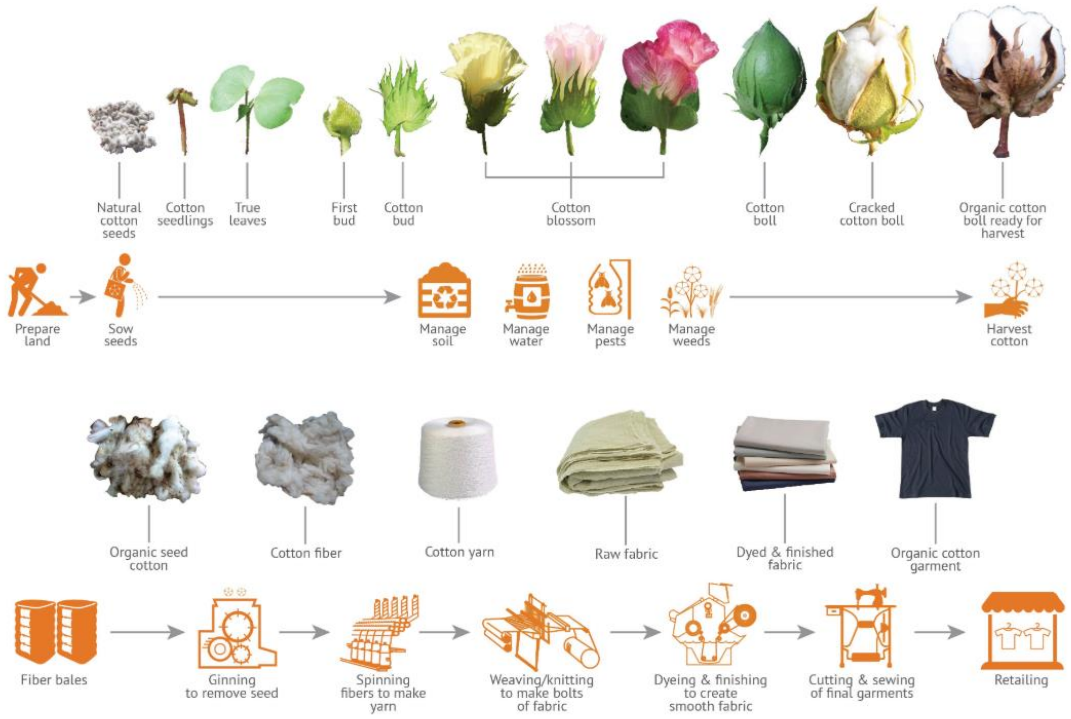
Cotton is grown around the world from the tropics to latitudes greater than 40°. The basic conditions required for the successful production of cotton include a long frost-free period, a temperature range of 18–32° C and 600–1200 mm of water over the growing

cycle, which typically lasts 125–175 days. Cotton production systems vary globally, ranging from labor-intensive systems in Africa and Asia to highly mechanized systems in Australia, Brazil and the United States (ICAC, 2003). India is the third-largest producer of cotton, producing about 12% of the world production, it has the largest area under cotton cultivation (9 million ha). Cotton farming and cotton textile industries are central to the economic growth of both developed and developing countries (FAO; ICAC, 2015). Cotton's strength, absorbency, and capacity to be washed and dyed also make it adaptable to a considerable variety of textile products (KHADI, et al., 2010). The microbial resistance of cotton is low, it burns readily and quickly, can be boiled and sterilized, and does not cause skin irritation or other allergies (SFILIGOJ SMOLE et al., 2013; OLIVEIRA-DUARTE et al., in press).

The defects found in the cotton fiber are due to several factors, among which are the characteristics of the cultivar used, the effect of climatic conditions during the crop cycle, the conduction of the crop, with emphasis on weed control practices, pests and diseases and the harvesting process. Mechanized cotton harvesting is an operation that can drastically affect the quality of the fiber, which is why the crop must be properly conducted for this practice, through the application of defoliants that reduce the contamination of the fiber with impurities (DA SILVA et al., 2010).

Its fibers grow attached to the seeds inside a capsule (**Figure 11**), or bud, which opens when ripe. It is a plant of tropical regions, so fear the cold. The vegetative period comprises from five to seven months, according to the amount of heat received. The cotton blossoms are short-lived, about 12 hours. The elements that compose it, cellulose, water and fat will constitute the cotton fiber. From the ovary of the flower appears the fruit in capsule format. When the capsule reaches its maturity, an average of 60 to 90 days after the emergence, it opens showing the cotton flakes that surround the seed. The harvest should be immediate. By weight, seed cotton is composed of roughly one-third cotton lint and two-thirds cottonseed. After that, the steps described in the previous textile process topic.

Figure 11 - (a) Field to fiber, cotton development; **(b)** Fiber to Fashion: The general process of transforming seed cotton from the farm into final garment.

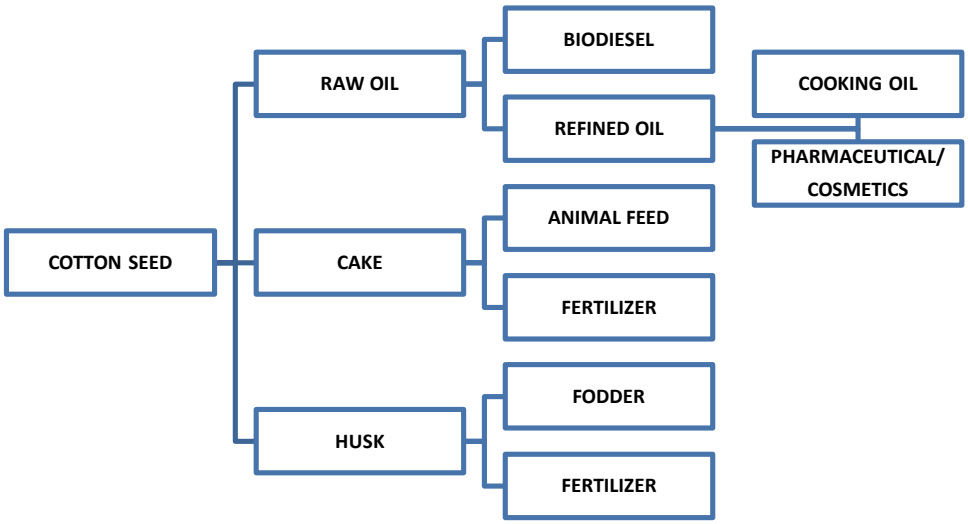


Source: ABOUT ORGANIC COTTON; TEXTILE EXCHANGE, 2019.

Cotton fiber has been used as the main natural source of the textile materials owing to its softness and breathability (GÜZEL; KARADAG, 2019). In addition, it presents good tensile strength and elongation; it shows moderate moisture regain (8.5%) under standard conditions of temperature (20ºC) and relative humidity (65% R.H.) (TAUSIF et al., 2018).

Besides the textile manufacturing from the cotton fiber, different by-products can be obtained from cotton seeds: linter, oil, cake and husks. Cotton linter is employed as almost pure cellulose source. The oil obtained from cottonseed can be used for human consumption (cooking, pharmaceutical and cosmetics) and recently, in the biodiesel production, while the filtration cake is widely used as feed for cattle, due to its high protein content (OLIVEIRA JUNIOR et al., 2009). Finally, husks are used as fodder and manure (**Figure 12**).

Figure 12 - Industrial uses of cotton seed.



Source: Larissa Oliveira Duarte adapted from ABRAPA, 2012.

4.3.1 Plant Description

This plant is about 1.20 m tall and can be grown annually. Cotton is one of the most important textile fibers, derived from vegetable seeds, composed largely of cellulose (88 to 96%), containing small portions of proteins, pectins, waxes, ash, organic acids and pigments (RIBEIRO, 1984). The production of cotton requires fertile soils, specifically in organic matter, phosphorus and potassium, and with balanced nutrient contents. Therefore, it requires specific management and production system, mainly rotation with leguminous and grass species. In general, cotton requires an average temperature above 20ºC, with an average daily average of around 25ºC.

The occurrence of moderately hot days implies a greater development of the crop, while the occurrence of cold days causes a delay in the growth of the plant (OLIVEIRA JUNIOR et al., 2009). For planting, approximately 25 kg of seeds are required (with linter). In the case of the use of delinted seeds, the quantities may be reduced by half. In soils with good fertility, the spacing should be 1.0 meters between rows and 0.20 meters between plants. The planting must be carried out in the rainy season, taking care to plan the sowing that allows a harvest in the dry period, so that there is no damage in terms of fiber quality (OLIVEIRA JUNIOR et al., 2009). The main cotton pest control strategies in Brazil are: cultivar handling, biological control by parasites, predators and pathogens, cultural control, climate control and chemical control. The chemical method has several

advantages over other weed control methods, such as: elimination of most weeds, weed control in rainy seasons (MERCIAL, 2018).

The cotton plant includes 52 species in the genus *Gossypium* (family Malvaceae) (**Chart 1**). Species of cotton grown for commercial purposes are G. *hirsutum*, G. *barbadense*, G. *arboreum* and G. *herbaceum*. G. *hirsutum* is the main cultivated specie and has medium length. G. *barbadense* is the most appreciated as presents long and extra-long fiber. G. *arboreum* and G. *herbaceum* have short fiber (LIRBORIO, 2017).

Chart 1 - Cotton varieties and geographical origin.

Gossypium	Origen
G. arboreum	Africa
G. herbaceum	Arabia
G. anomalum	Africa
G. truphillum	Africa
G. trifurcatum	Africa
G. bricchet tii	Africa
G. benadirense	Africa
G. papits – viridis	Cabo Verde
G. sturtianum	Australia
G. nandewarense	Australia
G. robinsonii	Australia
G. austral	Australia
G. constulatum	Australia
G. cunninghmii	Australia
G. nelsonni	Australia
G. pilosum	Australia
G. populifolium	Australia
G. puchelum	Australia
G. entryle	Australia
G. exiguum	Australia
G. londorriense	Australia
G. marchantii	Australia
G. nobile	Australia
G. rotundifolium	Australia
G. klotzschianum	Galapagos
G. riamondii	Peru
G. aridum	Mexico
G. amourianum	Mexico

G. davidsonii	Mexico
G. gossypioides	Mexico
G. karknessii	Mexico
G. laxum	Mexico
G. lobatum	Mexico
G. shuendimanii	Mexico
G. thurberi	Mexico
G. trilobum	Mexico
G. tumeri	Mexico
G. treysianum	Arabia
G. stocksii	Arabia
G. somalense	Arabia
G. longicalyx	Africa
G. tomcntosum	Hawaii
G. mustelinum	Brazil
G. darwinii	Galapagos
G. lancelolatum	Mexico

Source: Larissa Oliveira Duarte adapted from LIRBORIO, 2017.

Currently, there are five major types of cotton being grown commercially around the world (BERTONIERE, 2020):

(i) **American Upland** (*G. hirsutum*): the most commonly planted type of cotton in the world, making up about 90 per cent of the world's cotton crop. The plant may grow 1 to 7 feet (30.5 – 213 cm) tall, has creamy-white flowers, and produces white fibers up to 1¼ inches (3.2 cm) long. It can be made into many kinds of fabrics, and is used both for heavy canvas and for expensive shirts. It is grown as an annual;

(ii) **Egyptian** (*G. barbadense*): *Menoufi*, the most widely used variety, has exceptionally strong fibers about 1½ inches (3.8 cm) long. It has lemon-colored flowers and long, silky, light-tan fibers. It is made into clothing, balloon cloth, typewriter ribbons, and other fine fabrics;

(iii) **Sea-Island** (*G. barbadense*): It is now grown primarily in the West Indies. One of the most valuable and costly kinds of cotton, it has silky fibers that are about 1¾ inches (4.5 cm) long that can be made into very high-quality textiles. The plant has brilliant yellow flowers and white lint. It is expensive to raise, however, because it grows slowly and has a low yield and small bolls. Technically, Sea-Island is closely

related to Egyptian cotton, but growers consider it a separate kind of cotton because of its different fiber characteristics;

(iv) **Asiatic** (*G. arboreum*): grown mainly in China, India, and Pakistan. It has short, coarse, harsh fibers, and low yields. It is used for blankets, padding, filters, and coarse cloth.

(v) **American Pima**: a hybrid derived from Egyptian and American Upland cottons. It is the only variety of long-fiber cotton grown in commercially significant quantities in American continent (especially in United States and Peru).

'Mocó' cotton (*Gossypium hirsutum* r. marie galante Hutch), is grown in Northeastern Brazil, but its origin is unknown. The hypothesis is the mocó cotton lineage consists of several lineages rather than one, and that the 'marie galante' variety is one of them (MOREIRA, 1995). It presents great adaptability to semi-arid condition (PINTO DE MENEZES et al., 2010). It is also known as **'Seridó' cotton**. In this case, the name derives from the region of Rio Grande do Norte (state of Northeastern Brazil), which is the natural habitat of the mocó. This name can be used to identify the plant or even the long fiber that is obtained in this micro-region with the cultivation of mocó (MOREIRA et al., 1989; EMBRAPA COTTON, 1997; OLIVEIRA-DUARTE et al., in press).

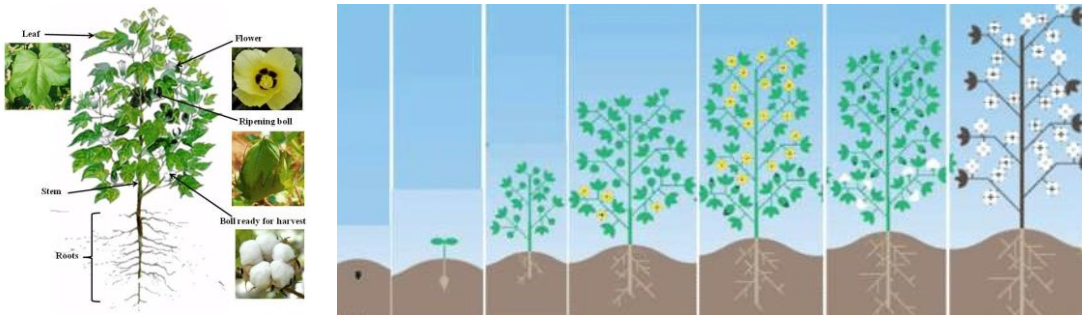
Cotton exhibits a certain degree of tolerance to salt and drought and it is therefore grown in arid and semi-arid regions. However, higher and consistent yield and fiber quality levels are generally obtained with irrigation or enough rainfall. There are several species of wild cotton in the world. They are found in Australia, Africa, Arizona, Central America, Lower California, Brazil, Mexico and other tropical countries and islands. Because of problems related to their refinement, however, they are not economically feasible to use (FAO; ICAC, 2015). Cotton is naturally a perennial plant that is now commercially cultivated as an annual plant in many parts of the world (EGBUTA et al., 2017).

The various kinds of cotton plants resemble each other in most ways, but they differ in such characteristics as color of flowers, character of fibers, and time of blooming (FAO; ICAC, 2015). In addition, each main type has varieties with different characteristics. Some varieties grow best on irrigated land. Some have lint 1¾ inches (4.5 cm) long, and others have lint only ½ inch (1.3 cm) long. Some varieties have stronger fibers than others and some are easier to harvest by machine than others (OLIVEIRA-DUARTE et al., in press).

As the plant grows, flowers are formed in a vertical as well as horizontal direction (**Figure 13**). A relationship can be established between the rate of boll formation in the vertical direction and horizontal direction. The relationship may vary depending upon varieties, but the rate of vertical boll formation is higher than horizontal. Square retention is the proportion of squares, usually expressed as percentage, retained by the cotton plant. Boll position on the plant influences boll retention. First position bolls have the highest chances of being retained than later position on the same branch. Shedding of fruits forms, particularly buds, could occur due to many complex factors including meteorological, physiological, entomological, and nutritional. The cotton plant is simply not able to retain all flower buds and convert them into bolls and retains only as many bolls it can afford to feed. By weight, seed cotton is composed of roughly one-third cotton lint and two-thirds cottonseed (ICAC, 2003; OLIVEIRA-DUARTE et al., in press).

Then it splits open, showing four or five *locks* (groups of 8 to 10 seeds with fibers attached). An average boll will contain nearly 500,000 fibers of cotton and each plant may bear up to 100 bolls. When fully matured, cotton bolls are picked and transported for processing, leaving the remaining plant as field trash. During the refining process or ginning of the harvested cotton, impurities are removed from the cotton fibers and are recovered as a processing by-product. From germination and emergence of shoots, to flower bud and peak flowering to boll development and bursting (GABER, 2016; OLIVEIRA-DUARTE et al., in press).

Figure 13 - (a) Cotton plant, the flower, boll, fiber and **(b)** Cotton plant development, from the seed to fiber.



(a) **(b)**

Source: GABER, 2016; OLIVEIRA-DUARTE et al., in press.

Requirements of the cotton crop: high temperature (ideally 30ºC); long vegetation period; ample sunshine; dry climate; min. 500 mm rainfall or irrigation; deep soils; heavy clay soils, ideally black soils; no waterlogging; strong root growth in first two weeks;

natural bud shedding (only approx. 1/3 of flowers develop bools) (WILLER; LERNOUD, 2019).

4.3.2 Fiber Characteristics and Properties

A large number of literatures is available about cotton characterization and properties (MURUGESH et al., 2013). Nearly 90% of the cotton fibers are cellulose (**Table 1**). Bast fibers (e.g. flax, jute, ramie and kenaf) are about three-quarters cellulose. Wood fibers contains 40–50% cellulose, whereas other plant species contain much less cellulose. The cellulose in cotton fibers is also of the highest molecular weight among all plant fibers and highest structural order (highly crystalline and oriented) (KHADI et al., 2010).

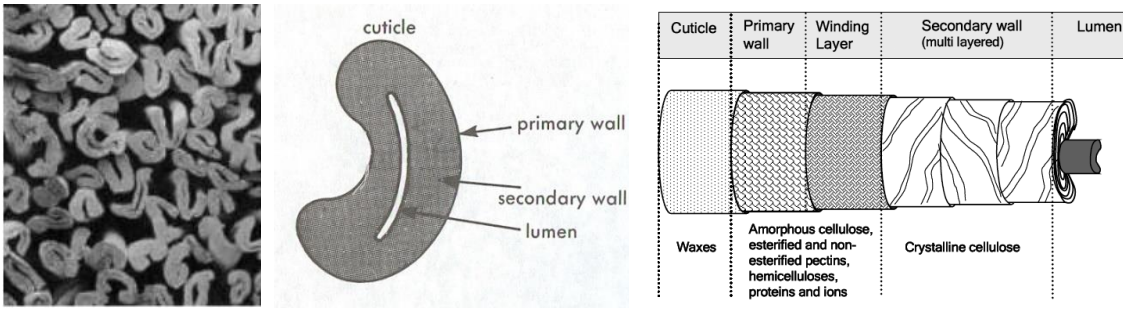
Table 1 - Composition of natural fibers.

Fiber	Cellulose (wt%)	Lignin (wt%)	Hemicellulose (wt%)	Pectin (wt%)	Wax (wt%)	Moisture content (wt%)
Cotton	82.7	-	5.7	-	0.6	-
Jute	61-71.5	12-13	13.6-20.4	0.4	0.5	12.6
Hemp	70.2-74.7	3.7-5.7	17.9-22.4	0.9	0.8	10
Kenaf	31-39	15-19	21.5	-	-	-
Flax	71	2.2	18.6-20.6	2.3	1.7	10
Ramie	68.6-76.2	0.6-0.7	13.1-16.7	1.9	0.3	8
Sisal	67-78	8-11	10-14.2	10	2.0	11
Kapok	64	13	23	23	-	-
Coir	36-43	41-45	10-20	3-4	-	8
Banana	63-67.6	5	19	-	-	8.7

Source: Larissa Oliveira Duarte adapted from MALKAPURAM et al., 2009.

The good length of cotton fiber helps in the easier spinning into a smoother and stronger yarn. Yarn quality parameters such as uniformity, strength, elongation and fineness are correlated to the length of cotton fibers. Spinning parameters depend of the length of cotton fibers, which results in a more comfortable, more durable fabric and garments. Cross-sectional view of cotton fiber is kidney-shaped (**Figure 14**). The cross-section tends to provide an indication of the relative dimensions of the lumen and fiber walls. The toughness and initial modulus of cotton are lower compared to hemp fibers, whereas its elongation at break (5-10%) and its elastic recovery are higher. The fibers are resistant to alkali but degraded by acids. The microbial resistance of cotton is low, it burns readily and quickly, can be boiled and sterilized, and does not cause skin irritation or other allergies (SFILIGOJ SMOLE et al., 2013).

Figure 14 - Cotton fiber: **(a)** cross-section of raw cotton; **(b)** macro structure; **(c)** schematic representation of mature cotton fiber showing its various layers.

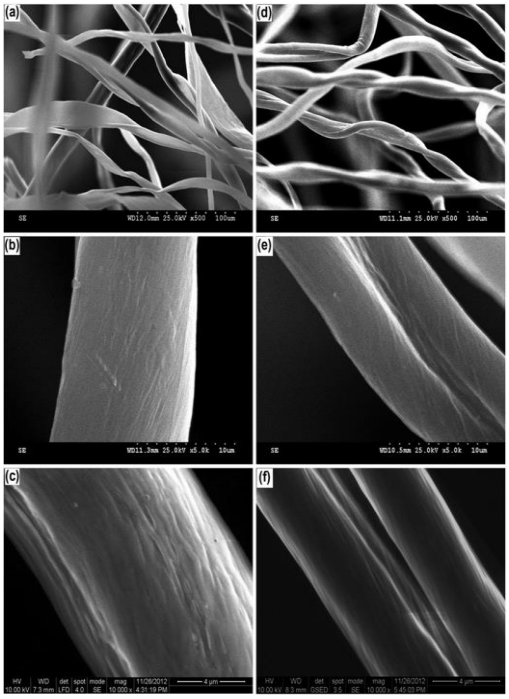


(a) **(b)** **(c)**

Sources: **(a)** and **(b)** BELOT, 2018; **(c)** ROCKY, 2012.

Murugesh et al. (2013) research characterized organic and conventional cotton fiber properties such as the surface morphology, surface chemical and elemental composition, internal chemical composition and architecture. The SEM (HITACHI Modal S – 3000H scanning electron microscope (Hitachi, Tokyo, Japan) image analysis reveals that both the cotton fibers are similar and have typical cotton morphological features, such as the ribbon shape rolled in a helical manner around the axis, and more-or-less bean-like cross-sections (**Figure 15**). The SEM image analysis reveals that both the cotton fibers are similar and have typical cotton morphological features, such as the ribbon shape rolled in a helical manner around the axis, and more-or-less bean-like cross-sections.

Figure 15 - SEM morphology of the conventional and organic raw **(a, b, d, e)** and scoured **(c, f)** cotton fibers.



Source: MURUGESH BABU et al., 2013.

The internal chemical composition and architecture of the cotton fibers were analyzed using FTIR (Fourier Transform Infrared Spectroscopy) spectrum and WAXS (Wide-angle X ray scattering) data. Further, it is observed that the conventional cotton fibers have slightly higher fraction of Iβ cellulose compared to that of the organic cotton fibers. The FTIR–ATR spectra analysis showed no major change in surface chemical composition between both fibers. The detectable waxy acids and alcohols present in the conventional cotton fibers were also observed in the organic cotton fibers, except tetratriacontanol which is observed only in the organic cotton fibers. The surface elemental composition of both the cotton fibers was analyzed using XRF (X-ray fluorescence) spectrum. When the presence of metals such as Fe, Ca, K, Al, Mg and P commonly found in cotton was analyzed, and the organic cotton fibers has higher percentage of metals than the conventional cotton fibers (except Ca). Based on MALDI–TOF (Matrix Assisted Laser Desorption/Ionization - Time of Flight) mass spectrum analysis, it is observed that surface chemical composition of the conventional and organic cotton fibers is similar (MURUGESH BABU et al., 2013).

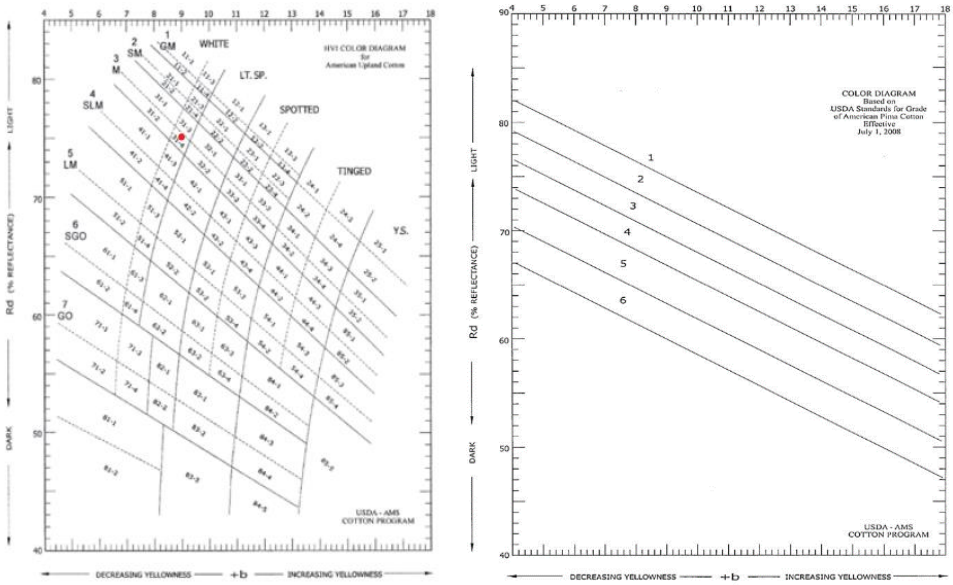
4.3.3 Fiber Quality

The quality of the cotton is evaluated according to the length of its fiber, following the fineness, color and purity. The classification of fiber quality is made according to resistance test, uniformity of length, and the relationship between fiber maturity. Cotton fiber quality is dependent upon progress in understanding and modifying the genetic and environmental influences on the cotton plant, particularly at the point of fiber development (OLIVEIRA-DUARTE et al., in press).

Fiber quality can be defined by the expression of fiber properties in transgenic cotton varieties, genetically enhancement and through better control of agronomic, water and nutritional variables. The fiber from these plants will likely be longer, finer and stronger, and may have new attributes such as color or increased extension. The mix of perennial crop and annual growth habits contriubute to the variability in cotton lint quality. The amount of sunlight, day and night temperatures during growth, variety and agronomic inputs are responsible for year-to-year variations in quality. Sunny climate, with two stations (rainy and dry), presents natural conditions to a great cultivation. Rain is harmful in the period of maturation, when the capsules open. The excess or lack of rain can hinder production (ICAC, 2003; OLIVEIRA-DUARTE et al., in press).

Fiber properties have been studied since the ealy 1900s, but electronic and physical sciences have been employed in measuring quality parameters only since the 1950s. High volume instruments (HVI) are machines for measuring quality chracterisctics in cotton, to reduce the time required to measure fiber properties (**Figure 16**) (ICAC, 2003). The color of cotton fibers can be affected by rainfall, freezes, insects and fungi, and by staining through contact with soil, grass, or the cotton plant's leaf. Color also can be affected by excessive moisture and temperature levels while cotton is being stored, both before and after ginning. As the color of cotton deteriorates due to environmental conditions, the probability for reduced processing efficiency is increased. Color deterioration also affects the ability of fibers to absorb and hold dyes and finishes. There are 25 official color grades for American Upland cotton, plus five categories of belowgrade color, as shown in the tabulation below (**Table 2**). USDA maintains physical standards for 15 of the color grades.

Figure 16 - (a) Official HVI color diagram grades for American upland cotton; **(b)** HVI color grades for American Pima cotton.



(a) **(b)**

Source: LIMA; BELOT**,** 2015, p. 290; COTTON INCORPORATED, 2019b.

The main HVI determinations include (USDA, 2001; OLIVEIRA-DUARTE et al., in press):

- **<u>Fiber Length</u>:** the average length of the longer one-half of the fibers (upper half mean length). It is reported in both 100ths and 32nds of an inch.
- **<u>Length Uniformity</u>**: the ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage.
- **<u>Fiber Strength</u>**: reported in terms of grams per tex. A tex unit is equal to the weight in grams of 1,000 meters of fiber. Therefore, the strength reported is the force in grams required to break a bundle of fibers one tex unit in size.
- **<u>Micronaire</u>**: a measure of fiber fineness and maturity (μg/in). An airflow instrument is used to measure the air permeability of a constant mass of cotton fibers compressed to a fixed volume.
- **<u>Color Grade</u>**: The color grade is determined by the degree of reflectance (Rd) and yellowness (+b) as established by the official standards and measured by the HVI. Reflectance indicates how bright or dull a sample is and yellowness indicates the degree of color pigmentation.

- **Trash**: a measure of the amount of non-lint materials in the cotton, such as leaf and bark from the cotton plant. The surface of the cotton sample is scanned by a video camera and the percentage of the surface area occupied by trash particles is calculated.

The complementary classer determinations include (USDA, 2001):

- **Leaf Grade**: a visual estimate of the amount of cotton plant leaf particles in the cotton. There are seven leaf grades, designated as leaf grade "1" through "7," and all are represented by physical standards. In addition, there is a "below grade" designation which is descriptive.
- **Preparation**: describe the degree of smoothness or roughness of the ginned cotton lint. Various methods of harvesting, handling, and ginning cotton produce differences in roughness or smoothness of preparation that sometimes are very apparent.
- **Extraneous Matter**: any substance in the cotton other than fiber or leaf. Examples of extraneous matter are bark, grass, spindle twist, seedcoat fragments, dust, and oil.

Table 2 - Color Grades of Upland Cotton.

	White	Light spotted	Spotted	Tinged	Yellow stained
GM (Good Middling)	11.1**	12	13	---	---
SM (Strict Middling)	21.2**	22	23*	24	25
M (Middling)	31.3**	32	33*	34*	35
SLM (Strict Low Middling)	41.4**	42	43*	44*	---
LM (Low Middling)	51.5**	52	53*	54*	---
SGO (Strict Good Ordinary)	61.6**	62	63*	---	---
GO (Good Ordinary)	71.7**	---	---	---	---
BG (Below Grade)	81	82	83	84	85

*Physical standards for color grade only; **Physical standards for color grade and leaf grade; All others are descriptive.

Source: OLIVEIRA-DUARTE et al., in press.

The measurement units, values and classifications for all the determinations expressed above is provided by USDA and replied by many other institutions related to cotton production and trade (USDA, 2001; COTTON INCORPORATED, 2019a; COTTON INCORPORATED, 2019b; OLIVEIRA-DUARTE et al., in press). HVI it was adopted in Brazilian labs following an international standard, in 2003, supporting

production and chain rastreability and fiber quality control (RODRIGUES, 2015). **Figure 17** ilustrates HVI use at the EMBRAPA cotton fibers and yarn lab.

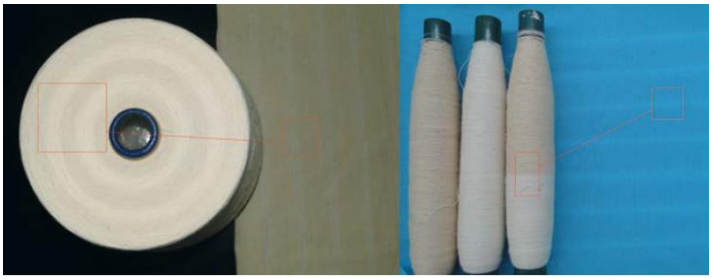
Figure 17 - (a) fiber lab analysis at EMBRAPA Cotton in Campina Grande – PB (Brazil) **(b)** BRS Rubi and BRS Jade cottons; and **(c)** HVI – High Volume Instrument.

(a) **(b)** **(c)**

Source: Larissa Oliveira Duarte, 2019.

The quality of fibers and their properties correlate with textile process and product development. The length characteristics for example, mean the longer the fiber is, it will enhance the machinery production. Resistant fibers will influence the textile softness. Also, the fiber color uniformity and cleaning will influence processes quality and costs (**Figure 18**) (LIMA; BELOT, 2015).

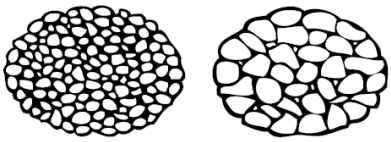
Figure 18 – Example of yarns and textiles with color variation.



Source: DE LIMA, 2018.

The micronaire index measures the maturity and density, it will indicate that the fibers with low value and high maturity will be more resistant and longer. The more the yarn is long and homogeneous, the high is the quality (**Figure 19**) (DE LIMA, 2018).

Figure 19 - Example of different micronaire characteristics.



Source: DE LIMA, 2018.

Cotton fibers may be classified into large groups, based on staple length (average length of the fibers making up a sample or bale of cotton) and appearance (**Table 3**) (FARM HUB; TEXTILE EXCHANGE, 2020):

- **Short staple:** includes the coarser cottons, ranging from about 10 to 25 mm in length, used to make carpets and blankets, coarse and inexpensive fabrics, and blends with other fibers.
- **Medium staple:** contains the standard medium-staple cotton, such as American Upland, with staple length from about 25 to 30 mm.
- **Long and Extra Long staple:** includes the fine fibers with staple length ranging from about 30 to 65 mm and includes types of the highest quality—such as Sea Island, Egyptian, and pima cottons. Least plentiful and more difficult to grow, long-staple cottons are used mainly for fine fabrics, yarns, and hosiery.

Table 3 - Fiber staple length description.

Stable Classification	Lenght (mm)	Length (inches)	Spinning Count
Short	Less than 25	15/16-1	Coarse Below 20
Medium	25-30	1.1/132-1.3/32	Medium Count 20s-34s
Long	30-37	1.3/32-1.3/8	Fine count 34s-60s
Extra long	Over 37	1.3/8-1.9/16	Superfine count 80s-140s

Source: FARM HUB; TEXTILE EXCHANGE, 2020.

Blaise (2004) demonstrated that cotton grown under organic conditions had significantly better fiber length and strength compared with cotton raised using modern methods of cultivation. Additionally, soil samples of the organic fields had significantly greater carbon content, water-stable aggregates and mean weight diameter than modern methods of cultivating fields. In another project to study the effect of organic and modern methods of cotton cultivation on soil nutrient status, organic carbon and nutrients were significantly built up, except for iron (Fe) and magnesium (Mg), in the organic cultivation system as compared to the modern method of cultivation (TAUSIF et al., 2018).

4.3.4 Cotton in The World

Cotton and flax are the oldest natural plant fibers cultivated by humanity. Even today it is the most used vegetal fiber, preferred for its quality related to softness, comfort and durability (BECKERT, 2015).

Egyptian cotton is considered one of the finest and highest quality cotton, it is characterized by long and extra-long fibers, soft and resistant. The best-known varieties are the yellow-colored from upper Egypt and the white Karnak from lower Egypt. Cultivated in irrigated crops and mostly harvested manually, which contributes to the high quality of the fiber. The Ming government (1368 to 1644 A.D.) gave to this textile fiber the same status as silk. In Europe, cotton played an important role in industrial development in European countries, especially in England (PEZZOLO, 2007). Fabrics from India, with their exotic motifs and beautiful colors, became much in demand, which motivated the growth of imports. In England, Lancashire became the center of the manufacture of cotton fabrics in the nineteenth century, the raw material was imported from the India, the West Indies and the United States. In a century the clothing industry in Europe that consumed 4% of cotton, started to consume 74% (BELTRÃO; CARVALHO, 2004; OLIVEIRA-DUARTE et al., in press).

In America, fiber was one of the most important Sources of pre-Columbian civilizations, such as the Mayans in Guatemala, and the people of Chimu, Nazca and Paracas in Peru. In Brazil, the cotton that grew in the wild was found by the Portuguese navigator Magellan in 1519. Cotton was already cultivated be natives (RODRIGUES, 2015). The cotton varieties of the East, introduced in the states of Maranhão and Pará at the beginning of the colonization, were brought by the Portuguese, after they had noticed the progress of their plantations in the Cape Verde Islands (BECKERT, 2015). During colonial period the production was only for Brazilian consumption and spinning and weaving were using rudimentary tools (RODRIGUES, 2015).

The Industrial Revolution (1780 - 1840), in its first phase, was based in the textile production, including technological innovation started mainly by cotton and wool textile producers (DO PRADO, 2019).

Nowadays, the livelihood of 17 million people in India depends on cotton farming. The Indian cotton textile industry contributes 38% of the country's export earnings. In some African countries like Burkina Faso, Mali, and Benin, cotton plays an even more dominant role in agricultural exports. World market cotton prices fluctuate to a great degree and have come down considerably over the last two decades. China produces over 20% of the world's cotton output with only 15% of the world's cotton land allocation. This high unit yield of cotton is mainly due to adoption of a series of intensive farming technologies for cotton production including seedling transplanting, plastic mulching, double cropping, plant training and super-high plant density techniques (TAUSIF et al.,

2018). **Table 4** indicates the volume of cotton produced for the main countries from 2016 to 2020.

Table 4 - Main countries in cotton (million metric tons): **(a)** production, **(b)** exports, **(c)** imports and **(d)** consumption.

World Cotton Production				
Million metric tons	**2016/17**	**2017/18**	**2018/19**	**2019/20**
India	5.9	6.3	5.6	6.4
China	5.0	6.0	6.0	5.9
United States	3.7	4.6	4.0	4.3
Brazil	1.5	2.0	2.8	2.9
Pakistan	1.7	1.8	1.7	1.3
Uzbekistan	0.8	0.8	0.7	0.8
Turkey	0.7	0.9	0.8	0.8
Australia	0.9	1.0	0.5	0.1
Greece	0.2	0.3	0.3	0.4
Benin	0.2	0.2	0.3	0.3
Mexico	0.2	03	0.4	0.3
World total	23.2	27.0	25.8	26.6

(a)

World Cotton Exports				
Million metric tons	**2016/17**	**2017/18**	**2018/19**	**2019/20**
United States	3.2	3.5	3.2	3.4
Brazil	0.6	0.9	1.3	1.9
India	1.0	1.1	0.8	0.7
Greece	0.2	0.2	0.3	0.3
Australia	0.8	0.9	0.8	0.3
Benin	0.2	0.2	0.3	0.3
Mali	0.2	0.3	0.3	0.3
Cote d´Ivoire	0.1	0.1	0.2	0.1
Burkina	0.3	0.3	0.2	0.2
Cameroon	0.1	0.1	0.1	0.1
Sudan	0.1	0.1	0.1	0.1
World total	8.3	9.0	9.0	8.9

(b)

World Cotton Imports				
Million metric tons	**2016/17**	**2017/18**	**2018/19**	**2019/20**
China	1.1	1.2	2.1	1.6
Bangladesh	1.5	1.7	1.5	1.5
Vietnam	1.2	1.5	1.5	1.4
Turkey	0.8	0.9	0.8	1.0
Pakistan	0.5	0.7	0.6	0.8
Indonesia	0.7	0.8	0.7	0.6
India	0.6	0.4	0.4	0.5
Malaysia	0.1	0.2	0.2	0.2
Thailand	0.3	0.3	0.2	0.2
South Korea	0.2	0.2	0.2	0.1
Mexico	0.2	0.2	0.2	0.1
Word total	8.2	9.0	9.2	9.1

(c)

World Cotton Consumption				
Million metric tons	**2016/17**	**2017/18**	**2018/19**	**2019/20**
China	8.4	8.9	8.6	7.2
India	5.3	5.3	5.2	4.4
Pakistan	2.2	2.4	2.3	2.0
Bangladesh	1.5	1.6	1.6	1.4
Turkey	1.4	1.6	1.5	1.4
Vietnam	1.2	1.4	1.5	1.3
Uzbekistan	0.4	0.5	0.6	0.7
Brazil	0.7	0.7	0.7	0.6
Indonesia	0.7	0.8	0.7	0.6
United States	0.7	0.7	0.6	0.5
Mexico	0.4	0.4	0.4	0.3
World total	25.3	26.7	26.2	22.2

(d)

Source: Larissa Oliveira Duarte adapted from Cotton Market Fundamentals and Price Outlook, 2020.

Commodity prices are primarily driven by supply and demand. Aspects such as fiber quality (staple length, strength, color, leaf grade, trash content, etc.) also play a part. Other price influencers and considerations include stocks and subsidies, logistics, transportation and warehousing, trader costs, currency conversions and insurance. Agricultural policies and strategies applied by some of the big producer countries (China, India and the USA) influence the market, as have environmental factors and competition from other commodities. The prices of competing crops influence farmers' decisions about what to grow. Higher prices for crops such as corn and soybean obviously make those crops more attractive to farmers - and, as a result, can displace cotton production

and drive up prices. Additionally, there is competition between fibers and, with polyester being so competitive in price, for example, the price of cotton is impacted (TEXTILE EXCHANE; KERING, 2017).

4.3.5 Bt Cotton, Better Cotton Initiative (BCI) and Responsible Brazilian Cotton (ABR)

For several thousand years, farmers have been altering the genetic makeup of the crops they grow (KHADI et al., 2010). “Bt cotton” is a genetically modified organism (GMO) pest resistant plant. Plant breeding has been revolutionized by molecular genetic approaches which permit the manipulation and insertion of genes. Seed companies have been promoting genetically engineered “Bt cotton”. It contains genes of the same micro-organism, *Bacillus thuringiensis*, that is used in bio-control against a number of insect pests (WILLER; LERNOUD, 2019). In India, many conventional farmers who tried Bt cotton complained about crop failure, due possibly to inappropriate varieties, unfavorable climatic conditions or adulterated seeds. Despite the benefits promised by its promoters, growing Bt cotton seems to be a high-risk strategy considering the ecosystem balance and health (WILLER; LERNOUD, 2019).

The BCI is an international not-for-profit organization stewarding the global standards for Better Cotton, emphasizing crop protection, improved water use efficiency and soil management, natural habitat conservation, fiber quality improvement, and promotion of decent work. The social awareness of a better work condition and workers right is an important aspect here, connected with the traceability of the cotton produced. Increased transparency from major retailers is critical, as the ability to identify the source of cotton and trace its journey through the supply chain remains a huge challenge (ZULFIQAR; THAPA, 2016).

The support provided to farmers by concerned NGOs include provision of extension services, training, on field demonstration, information on new technologies and certification. A certificate is issued only after farmers are found complying with the criteria stipulated by BCI. Such dedication of private companies to promote “better cotton” stems from their motivation to increase income by adding more value to their products by improving the quality of the cotton and by reducing the cost of production (ZULFIQAR; THAPA, 2016).

In Punjab province of Pakistan, an important reason given by farmers for not growing “better cotton” in was that they were not interested in “better cotton” as they were growing conventional cotton for so many years. Moreover, farmers perceived that any agricultural practices, including crops cultivated, based on their own knowledge were better than the practices developed and promoted by scientists. Since conventional cotton cultivation was their traditional practice, they did not even consider to take part in trainings on “better cotton” production. Another reason given by a very small percentage of farmers was that they thought that the yield of “better cotton” was lower than the yield of conventional cotton. They could not believe that the yield of “better cotton” was really higher than the yield of conventional cotton (ZULFIQAR; THAPA, 2016).

A different situation occurred in Brazil. ABRAPA has been BCI’s Implementing Partner since 2010. They became a Strategic Partner in 2014 after completing a benchmarking exercise which aligned ABRAPA’s own ABR (*Algodão Brasileiro Responsável*/Responsible Brazilian Cotton) program, with the Better Cotton Standard. In Brazil, cotton is sown from February to March and harvested from September to December. Thanks to various economic and technological interventions – such as targeted government support, the emergence of new cotton producing regions, and precision farming technologies – Brazil’s cotton production is thriving, and some analysts predict could rise further than expected (TEXTILE EXCHANGE, 2020c).

Brazil is the largest producer of certified cotton in the world. **Figure 20** indicates main production states (TEXTILE EXCHANGE, 2020c). Meanwhile, the area planted with cotton in Brazil in 2018/19 is expected to reach 1.4 million hectares, an increase of 19 percent from the previous season. Crop expansion is a result of high fiber prices and strong export demand. Brazilian domestic consumption is forecast at 3.5 million bales, which represents a marginal increase of 3 percent in the annual comparison (LEITE, 2019b).

Figure 20 – ABR- BCI cotton is developed in seven states in Brazil, in which the cotton producers' associations are committed with its promotion, standards and certification.

Source: ABRAPA, 2016.

Further information will be developed in **section 4.3.7.**

4.3.6 Natural Colored Cotton

Naturally colored cotton is dated around 5,000 years, native to a wide geographical dispersion including Egypt, Pakistan, China and Central America, North and South (SOUZA, 2000a). The growing demand for organic products generates interest in this crop because it does not require dyeing, saving resources and energy (BARROS et al., 2020; GARCIA et al., 2015).

More than 39 wild cotton species with colored fibers have already been identified. In most of these primitive species, cotton has colored fibers, mainly in brown. However, colored cottons in shades of green, yellow, blue and gray have already been described (OLIVEIRA-DUARTE et al., in press). Colored lint is shorter in length and the lint varieties have the same agronomic management requirements as white ones (**Chart 2**) (ICAC, 2003).

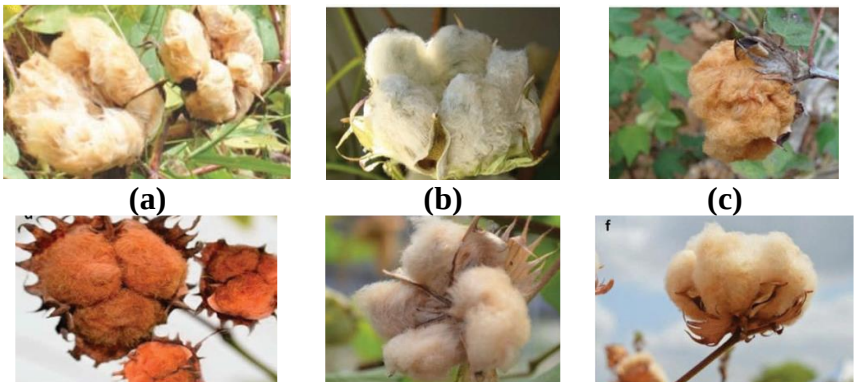
Chart 2 - Color inheritance of cotton fiber and geographical origin.

Gene symbol	Fiber color	*Gossypium* species	Region
Ld^{1k}	khaki	*arboreum* and *herbaceum*	Africa and Asia
Lc^{2b}	light brown	*arboreum* and *herbaceum*	Africa and Asia
Lc^{2k}	khaki	*arboreum* and *herbaceum*	Africa and Asia
Lc^{2M}	medium brown	*arboreum* and *herbaceum*	Africa and Asia
Lc^{2v}	slight brown	*arboreum* and *herbaceum*	Africa and Asia
Lc^{3B}	light brown	*arboreum* and *herbaceum*	Africa and Asia
Lc^{4k}	khaki	*arboreum*	Asia
D^{w}	off white	*raimondii*	America
Lg_1	green	*hirsutum*	America
Lc_2	brown	*hirsutum*	America
Lc	brown	*barbadense*, *darwinii* and *tormentosum*	America

Source: OLIVEIRA-DUARTE et al., in press.

In Brazil, colored cotton is originated from genetic improvement developed by the Brazilian Agricultural Research Corporation - EMBRAPA. Since the 80s, EMBRAPA Cotton has been working in order to select fiber cultivars with better characteristics (selection and improvement of cultivars more adapted to crop conditions). As an example the following cultivars have been launched commercially: BRS 200, BRS Rubi (“ruby”), BRS Verde (“green”) and BRS Topázio (“topaz”), which started to be developed in the early 1990s (**Figure 21**). This innovation aims to make cotton fiber long enough to be suitable for weaving (FARIAS, 2017). Colored fiber has a market value of 30% to 50% higher than white cotton fibers (DE CARVALHO et al., 2011).

Figure 21 - Fiber color of Brazilian cotton cultivars: **(a)** BRS 200 Marrom ("brown"); **(b)**, BRS Verde ("green"); **(c)** BRS Rubi ("ruby"); **(d)** BRS Safira ("sapphire"); **(e)** BRS Topázio ("topaz"); **(f)** BRS Jade ("jade").



(a) **(b)** **(c)**

(d) **(e)** **(f)**

Source: Adapted from BARROS et al., 2020.

The colorful cotton varieties began to be developed by EMBRAPA in crops of the Brazilian Northeast region, whose seeds present proper characteristics to be planted in dry regions (SOUZA, 2000a). The production of colored cotton on a commercial scale began only in the first half of the 2000s and the main state producing colored cotton is Paraíba. (MAIA et al., 2016; LIRBORIO, 2017). Clothes made with these materials do not cause skin problems related to dye allergic (**Figure 22**). The market of colored fibers, dedicated to organic/agroecological managements, permits a valuable opportunity for farmers in Brazilian semiarid region (BARROS et al., 2020).

Figure 22 - Organic Cotton clothing from the Brazilian fashion brand "Flavia Aranha", with colored cotton cultivated in Paraíba state - Brazil.

(a) **(b)**

Source: OLIVEIRA-DUARTE et al., in press.

4.3.7 Cotton in Brazil

4.3.6.1 Historical Aspects

By 1519, Portuguese navigators arriving in Brazil found wild cotton, which was already cultivated, spun and woven. The natives used it to make nets, some pieces that they used in the body, and in the elaboration of torches. Paulo Bomfim, refers to cotton weaving during the sixteenth century: "Alcântara Machado, in a research carried out in sixteenth century inventories, finds in the state of old Paulistas looms that were handled by natives who specialized in cotton weaving." In another section he states, "In 1585, the Municipality of Sao Paulo ordered that they were not allowed to produce cloths of cotton that were more than three and a half feet wide without a license from the municipality" (PEZZOLO, 2007).

The indigenous (natives) ever planted this fibrous since Brazil discovery period, weaving the threads to make clothes, whose process was described in early 16th century, by Jan de Lery (BARROS et al.,2020). Cultivars from *G. hirsutum var. marie galante* – perennial and long fibers – known as “Mocó” or Seridó cotton, were more predominant. Seridó, the best Brazilian fiber and one of the best in the world, is grown in the driest areas of the Northeastern region. The fibers of this variety have as characteristic the resistance and the softness, measuring from 36 to 38 mm (OLIVEIRA-DUARTE et al., in press). The “Rim de Boi” (*G. barbadense var. Brasiliens*e) was also widely cultivated in Northeast region, as a complementary activity for farmers. From then on, the annual cotton (*G. hirsutum var. latifolium*) was introduced in Brazil, and São Paulo State (Southeast region) emerged as a producer and exporter of cotton fibers (BARROS et al., 2020).

In seventeenth century, the cotton production was expanded and improved, from the inclusion of species from the East (RODRIGUES, 2015). In the eighteenth century, the cotton culture took a great impulse, mainly in the states of Pará, Maranhão, Ceará, Pernambuco and Bahia. The cotton cycle was between the decline of gold extraction and the beginning of the expansion of coffee cultivation in the country. As a result of cotton exports, Brazil began to industrialize, and several infrastructure works were made. With the British Industrial Revolution, there was a growing need for raw materials to feed the textile industry. This encouraged Brazilian farmers to opt for the cultivation of cotton. The largest cotton producer in the world was the United States, which also exported to

English industry. But with its independence there was a rupture of relations with England, which increased the demand for the product (LIRBORIO, 2017).

The demand for cotton was so great that practically all Brazilian production was exported to the English weavers (LEITE, 2019d). Because it had become the main Brazilian export product, cotton was planted and large scale. The labor that worked on the crops was totally slave and the cultivation was done in immense farms. The monoculture system prevailed at the time, that is, a single product was cultivated. After the Independence of Brazil, textile factories were built in the national territory, which were encouraged by tax benefits.

According with Pezzolo (2007) in the eighteenth-century cotton cultivation flourished in northwestern Brazil, fueling the cheetah print industry (a kind of colorful rapport textile), especially in the state of Minas Gerais. Spinning and weaving were common tasks and routine in many homes. The presence of the spinning wheel was common, and a wooden loom for the production of clothes for the family. The cotton was planted, harvested, ginned in a manual ginner, carded and spun. For dyeing, they mainly used barks and roots.

In the nineteenth century, England began to stimulate cotton cultivation in the Americas, as it needed the precious raw material for its textile industry. Brazil became an exporter of cotton, via Portugal, to England; the supply of foreign markets was the goal of the cotton crop (PEZZOLO, 2007). The opening ports, decreed by Dom Joao VI in 1808, facilitated the Brazilian commercial expansion. The fall of cotton production in the United States caused by the Civil War (1861-1865) encouraged Brazilian exports, benefited by high market prices (RODRIGUES, 2015). However, in 1880, when American cotton was already replete with the damage caused by discord between the southern and northern states, our export rates fell. The fall was offset by the considerable increase in our domestic trade (LIRBORIO, 2017).

In 1872, the *Cedro* and *Cachoeira* fabrics, from Minas Gerais, manufactured for the first time large-scale in the country. Basically, the Brazilian cotton textile, transformed from the rustic thread utilized for agricultural products exportation sacks and workers clothing in the XIX century, to a better quality clothing production in the states of São Paulo, Rio de Janeiro, Minas Gerais, Santa Catarina, Rio Grande do Sul and Pernambuco mainly after the second half of the XX century. Including the beginning of the first national textile industry fair, FENIT in 1958, specially to promote Brazilian cotton (DO PRADO, 2019).

In the twentieth century, the national textiles production was bigger than importation. The crises with coffee crops in 1929, created a favorable environment for cotton cultivation, motivating the crops in the Southwest region of Brazil (RODRIGUES, 2015). In the late 1980s, cotton crops were devastated by pests, causing farmers to start investing in other crops, especially soybeans. After a few years, the need to turn the crop, mainly to avoid the onset of pests, encouraged producers to invest in cotton. The crises moved production, specially from São Paulo and Paraná states, to Mato Grosso state in the central-west region of the country. Considering the ideal conditions of soil, climate and topography. The research had also an important development, considering the work of EMBRAPA (LIRBORIO, 2017). Brazilian cotton culture suffered a major blow in the 1980s, with the introduction of the boll weevil (*Anthomonus grandis* Boheman), which almost decimated cotton production in the country (LIRBORIO et al., 2016).

Without ignoring the economic problems, the occurrence of this small coleopteran in the cotton fields was one of the most harmful pests that have already occurred in Brazil (BERGER et al., 2019). Surprisingly, only four months after the insect was detected in São Paulo (Southeast region), its presence was also evidenced in Paraiba and Pernambuco (Northeast region). These difficulties resulted in a substantial fall in cotton belt yield, mainly due to the limited technological resources available to control the insect (BARROS et al., 2020). At the time, control and eradication measures were inefficient because Brazilian producers were not prepared to implement strong chemical control measures due to the high costs. In an effort to minimize the damages, EMBRAPA Cotton invested in development of early maturing cultivars, with compact fruiting, aiming to avoid the peaks of insect infestation (BARROS et al., 2020).

In 1997, it was created the first producer's association, in Mato Grosso state, named AMPA. In 1999, it was created the Brazilian Association of Cotton Producers named ABRAPA. In the same year, they were also created important states associations, in São Paulo, Minas Gerais, Goiás and Mato Grosso do Sul. And in 2000, in Bahia, Paraná and Maranhão. In 2001, the Brazilian cotton market was self-sufficient, supplying 100% of the textile industry demands, producing around 900 thousand tons per crop (RODRIGUES, 2015). Brazilian fiber production is now characterized by: high agroindustry scale; mechanization; analysis and fiber classification considering international standards; traceability system; environmental certification (BCI) (**Figure 23**).

Figure 23 - (a) Cotton crop in Brazil, **(b)** harvester machinery "Case" and **(c)** harvester machinery "John Deere".

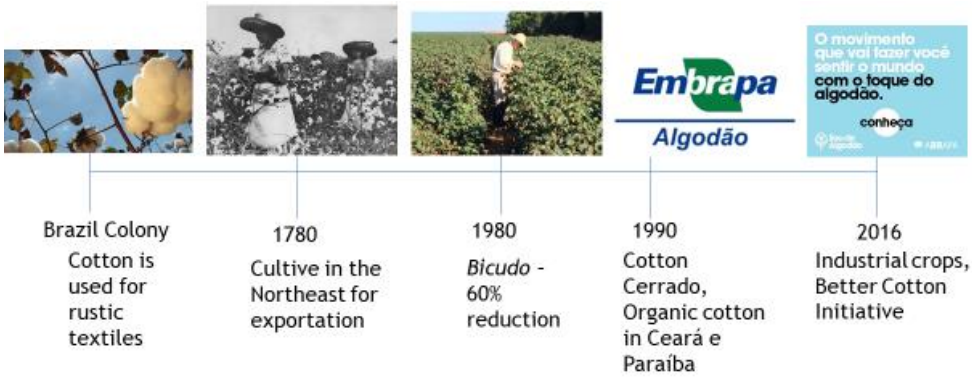
(a) **(b)** **(c)**

Source: BELOT, 2014

The second half of the 90s marked the migration of the cotton crop, from the traditional production areas in the semi-arid to the Brazilian Cerrado biome (EMBRAPA ALGODAO, 2019a). The cotton crop, due to its agronomic characteristics of adaptation to the region's climatic conditions, its historical-cultural value and, mainly, economic, established and gained prominence in family agriculture in the semi-arid region of Brazil. However, throughout history, cotton has gone through ascension, crises and declining production and productivity. In summary, one can attribute the reasons that led to the decline of cotton production: (i) non-conservative crop management (ii) government policies of low and price variations; (iii) occurrence of extreme droughts; and (v) advent and spread of the boll weevil (*Anthonomus grandis* Boheman) (BELTRÃO et al., 2009; SOUZA, 2000b).

Cotton is a plant well adapted to semi-arid regions, as it is drought tolerant, being one of the main crops explored in Brazil. The management of intercropped crops and organic fertilization are common practices of family farming based on agroecology. Cotton is one of the most important plants for the production of fibers, besides being a source of animal food and raw material for the production of oil from its seeds. To guarantee the evolution of the sector, the use of efficient technologies is essential, with a focus on improving productivity and cotton quality, favoring the sustainable development of the crop (DE AZEVEDO SANTOS et al., 2019). **Figure 24** summarized main events of cotton in Brazil.

Figure 24 - Cotton in Brazil timeline of important events.



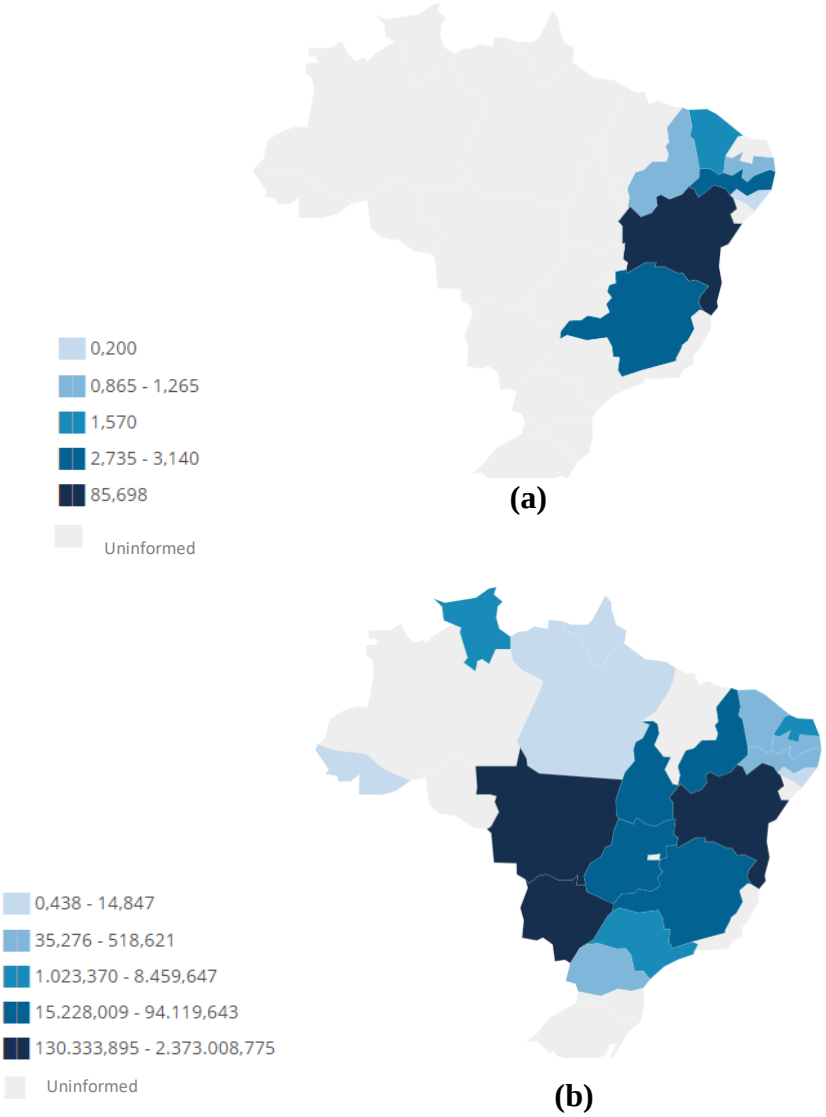
Source: Larissa Oliveira Duarte, 2019.

4.3.6.2 Production Aspects

Cotton contributes widely to Brazil's agricultural output and foreign exchange earnings. From 19th century until 90s, Brazil was a net exporter of fiber cotton and often a major source of world cotton supplies (BARROS et al., 2020).

According to the Brazilian Association of Cotton Producers (ABRAPA, 2012), Brazil has achieved and maintains the status in productivity in cotton crops under the rainfed system, which is called cultivation without irrigation. Mato Grosso is also the largest cotton producer in the country, accounting for about 70% of Brazilian cotton production. Although the country has great potential to increase its production area, factors such as logistics, infrastructure and improvements need to be improved. The national average is around 1.5 tons per hectare, while the United States, produces an average of 0.8 tons per hectare (LEITE, 2000c). **Figures 25** indicate the states and its production volume, presenting both cotton scale productions, **(a)** indicates the states and its production volume in Brazilian states in 2017 for *G. arboreum* and **(b)**, for *G. herbaceum* (OLIVEIRA-DUARTE et al., in press).

Figure 25 - Volume of Cotton Produced in Brazilian States in 2017: **(a)** G. arboretum (96,225 tons and 135 establishments); **(b)** G. herbaceum (3,664,808,060 tons and 3,081 establishments). At the left side of each map the tons' amount scale.



Source: IBGE, 2017.

The success of the corporate system implemented in the Cerrado biome is based largely on intensive use of modern agricultural inputs, mechanized operations, use of skilled labor, and access to large buyer markets in Brazil and abroad. This model involves higher production costs and need for scale, encouraging cotton production on large farms. Cotton farmers in Cerrado, generally, have good access to domestic and foreign markets, a result of the high quality of the fiber produced, the creation of sales coops, the strong performance of agricultural commodity trading companies, and the professionalism with which they meet deadlines and comply with legislation (ABRAPA, 2016).

The cotton fiber obtained in Brazil is currently marketed in more than 40 countries and can be considered one of the best in the world. Despite the great national production, Brazil is still an importer of cotton fiber. This is because most of the fiber produced in the country is medium in size, and the textile industry still lacks reasonable amounts of longer fibers. The longer fibers allow to manufacture lighter fabrics, which according to the analyst, are a trend. The new challenge of the Brazilian cotton sector is to produce enough fine or extra-long fibers, thinner and more resistant, that generate lighter fabrics that please consumers (ABRAPA, 2012).

With regard to the foreign market, Brazilian exports reached 1.95 million tons in the 2019/20 season and 98% of the Brazilian cotton exported went to Asia. There was a 49% increase in exports between August/2019 to July/2020 compared to the same period of the previous season. In the first month of the 2020/21 cotton season (August 2020), Brazil exported 109 thousand tons, a volume 141% higher than the same month of the previous season. Turkey, Indonesia, Vietnam, Pakistan and China were the biggest buyers in August/2020 (TEXTILE EXCHANGE, 2020c).

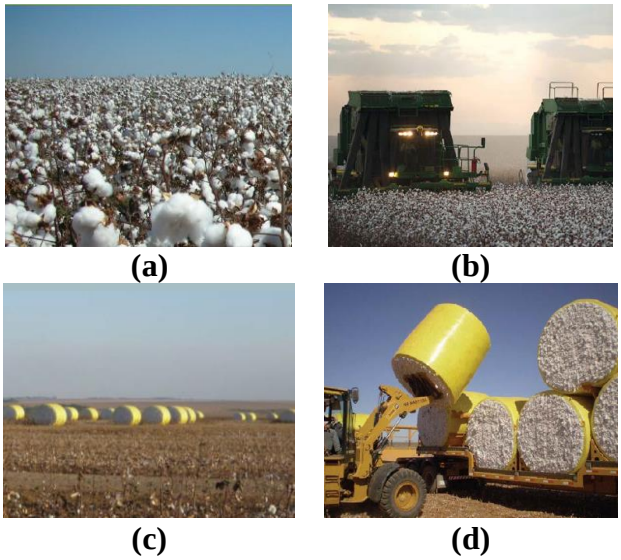
There is a growing demand for products and services generated without aggression to the environment and with respect to the dignity of the worker. In 2010, the ABRAPA implemented the Better Cotton Initiative (BCI) in Brazil. BCI is an international organization aimed at improving good production practices, fair working relationships and the transparency and traceability of cotton in the market. Following the same line, ABRAPA created the Brazilian Responsible Cotton (ABR) program in 2012 (AZOUBEL, 2018). 81% of Brazilian producers are ABR certified nationwide, and 71% also have the international BCI standard. Brands such as Adidas, Nike, Levi Strauss & Co, and C&A are some of BCI's most influential partners (AZOUBEL, 2018).

There are also alternative production systems practiced by family farmers, or even by small- and medium-scale growers, aimed at exploiting niche markets, among which are: production of colored cotton, organic cotton, and agro-ecological cotton. These systems are of major social importance and have received growing support from government policies and companies in the textile and clothing sectors that operate in niche markets in which these types of products are highly valued (ABRAPA, 2012).

4.3.8 Characterizing producers

In Brazil, conventional crop (**Figure 26**) is characterized as using machinery and agroindustry systems for scale production in extensive areas. Organic crop is characterized as small properties, family farming and manual activities such as planting and harvest (LIMA; SOUZA, 2006). Organic system is labor-intensive and can be more attractive for producers with smaller areas of cultivation, especially in a context of production with the predominance of family farming, where the hiring of temporary or permanent labor can be scarce (**Figure 27**) (FERRAZ, 2018).

Figure 26 - (a) Conventional cotton farming in Brazil for scale production at Cerrado biome and **(b)** mechanical harvesting **(c)** e **(d)** bales transport equipment's.



(a) **(b)**

(c) **(d)**

Source: BELOT; RIBAS, 2015.

Figure 47 - (a) Manual harvest agroecological cotton in the Tiracanga rural settlement, Caninde - Ceará, Brazil; **(b)** Manual harvest agroecological cotton, family Agriculture Assentamento Zé Marcolino - Prata, in Paraiba, Brazil.

(a) **(b)**

Source: LIMA, 2008; MARQUES, 2019.

According with INCRA (2019) in relation to the size of the area, the rural properties are classified in:

- **Minifundio**: is the rural property with an area less than 1 (one) fiscal module;
- **Small Property**: the property of area between 1 (one) and 4 (four) fiscal modules;
- **Average Property**: the rural property of area greater than four (4) and up to fifteen (15) fiscal modules;
- **Large Property**: the rural property of the upper area 15 (fifteen) fiscal modules.

Considering *fiscal module* as an unit of measure, in hectares (10,000 m^2), the value of which is set by INCRA for each municipality, taking into account: (a) the predominant type of exploitation in the municipality (permanent culture, temporary culture, livestock or forestry); (b) income earned on the predominant type of holding; (c) other holdings existing in the municipality which, although not predominant, are expressive according to the income or area used; (d) the concept of "family ownership". The size of the module varies according to the municipality where the property is located. The value of the fiscal module in Brazil ranges from 5 to 110 hectares depending on the municipality (EMBRAPA, 2019b).

To the Ministry of Agriculture, Livestock and Food Supply (2019a), smallholders and family agriculture in Brazil are characterized as using predominantly the family's own labor force in rural economic activities in an area of maximum 4 fiscal modules, having a minimum family income originating from rural economic activities in their establishment and / or enterprise; and driving the establishment with the family. Family farming is an important segment for the development of Brazil. There are approximately 4.4 million farm families, representing 84% of Brazilian rural establishments. For the economy it represents 38% of the gross value of agricultural production and the sector accounts for seven out of ten jobs in the field. It is responsible for the production of more than 50% of the food supplies of the Brazilian “cesta básica” (set consisting of food products consumed by a family for a month) (MINISTRY OF AGRICULTURE, LIVESTOCK AND FOOD SUPPLY; 2019b).

Taking in account the competences that need to be developed with smallholders in order to give them opportunities to access global markets they are summarized as follows (PARIKH et al., 2007; FAYET; VERMEULEN, 2014).

Enhancing smallholders' capabilities by:

- **Training:** Provision of farmer training enables farmers to improve their production capacity and productivity as well as their abilities to meet the quality standards demanded by international supply chains.
- **Information Systems:** Providing smallholders with access to information and communications can help them to make decisions and reach new or more beneficial markets. Market information is crucial for good decision-making.
- **Financial Services:** Access to finance has been identified as one of the major issues for small farmer inclusion. There is a growing need to facilitate and adapt financial products for small farmers, such as access to loans, advances for crop finance and crop insurance.
- **Social Entrepreneurship:** Social entrepreneurship aims to improve smallholders' inclusion by providing entrepreneurial opportunities within the supply chain. The relevance of entrepreneurs within farmer organizations who might be able to bridge the gap and coordinate small farmers and market actors is evidenced (HALL; MATOS, 2010; MAGNUS; STEENHUIJSEN, 2010).

It is important to highlight that in one hand, larger farmers have more bargaining power and better access to capital, information, finance and technology. On the other hand, smallholders' transaction costs are usually higher (GLIN et al., 2020). According to DataSebrae (2018), referring to the first quarter of 2018, the highest proportion of rural producers is between 45 and 55 years of age, representing 26.3% of the total. Those who are between 55 and 65 years old represents 20.5%. The younger rural business owners, who are up to 25 years of age represents only 6.7% of the total. It was identified 5,072,152 agricultural establishments in Brazil and15,036,978 people employed in agricultural establishments.

4.3.9 Limitations in Cotton Production

Cotton is a strategic crop that it is cultivated in many countries (CHAUDHRY, WAKELYN, 2006; ADANACIOGLU; AKIN OLGUN, 2010). It is the main natural fiber used in the textile industry (FLETCHER, 2010). However, cotton is a leading agricultural

non-food commodity associated with soil degradation, water pollution and pesticide poisoning due to high levels of agrochemical inputs (CHAUDHRY; WAKELYN, 2006; CANIATO et al., 2012).

Just as the world faces a crisis over the environment, regarding climate change, biodiversity lost and desertification (NAGENDRA, 2018), the excessive use and misuses of agrochemicals can significantly affect the natural biological system and damage soil and water resources (DE OLIVEIRA; OLIVEIRA-FILHO, 2014; YANG et al., 2017a). Furthermore, having an adverse impact on agricultural workers' health and living conditions (CHAUDHRY; WAKELYN, 2006; RIEPLE; SINGH, 2010; PAL, 2014; PAL; GANDER, 2018). In this way, the inefficient cotton production management practices can result in inefficient use of land and higher production costs (ZULFIQAR et al., 2017).

The cultivation of cotton is not so competitive compared with higher income biofuel crops such as corn and soybeans. Also, cotton cultivation requires a large number of resources like higher consumption of water leading to a high value of the water footprint ("blueprint") for this product. To be profitable, both economically and environmentally friendly, "blueprint" value of a product must be minimized. Possibilities of reducing water consumption in the cultivation and processing of cotton are studied. The impact of textiles on the environment, from the raw materials to final product delivered to the customer is very important. A better knowledge of the chemicals action used in the process, the impact on the environment and the possibilities for a biological degradation are necessary (DOCHIA; PUSTIANU, 2017).

Cotton production worldwide uses more than 20% of all insecticides employed in agriculture. In many areas, irrigated cotton cultivation has led to depletion of ground and surface water sources. Many conventional cotton farmers in developing countries are in a crisis due to decreasing soil fertility, increasing production costs, resistant pests, or low cotton prices. In this scenario, an increasing number of farmers turn to organic cultivation in order to restore soil fertility, reduce production costs, or to get a better price for their certified organic harvest (WILLER; LERNOUD, 2019).

The main common problems of agricultural management of cotton are the chemical impact of the pesticide on the environment and the mean health; the loss of the soil fertility due to synthetic nitrogen fertilizers without applying organic matters; the depletion of water resources by intensive irrigation by water consume up to 30,000 liters' freshwater per kilogram fiber; the spread of Genetically Modified cotton

(NEZNAKOMOVA, 2008). Additionally, despite the diverse contexts, most conventional cotton farmers faced similar challenges in these countries: long lasting monoculture cropping systems and over dosed application of chemical pesticides and fertilizer led to health problems, depleted soil fertility, and thus reduced yields. In many places, the low yields combined with volatile cotton world market prices resulted in negative gross margins and increased indebtedness of farmers (GLIN et al., 2012).

According with Beltrão et al., (2009) due to the massive use of pesticides, cotton cultivation has been identified as the main responsible for serious cases of environmental contamination, such as those in the Aral Sea (Uzbekistan), the Imperial Valley (California), the Canete Valley (Peru) and, especially in Brazil in the regions of Iguatu, (Ceará state) and Santa Helena (Goiás state) (LIMA, 1995b).

The excessive use of agrochemicals is one of the main environmental problems related to the cultivation of cotton in the world, reason to seek to modify cultivation patterns and alternative methods of pest control that propitiate the sustainability of the agricultural system (BELTRÃO et al., 2009; SOUZA, 2000b).

Further information will be presented in **section 4.4.3.**

4.4 Organic Cotton

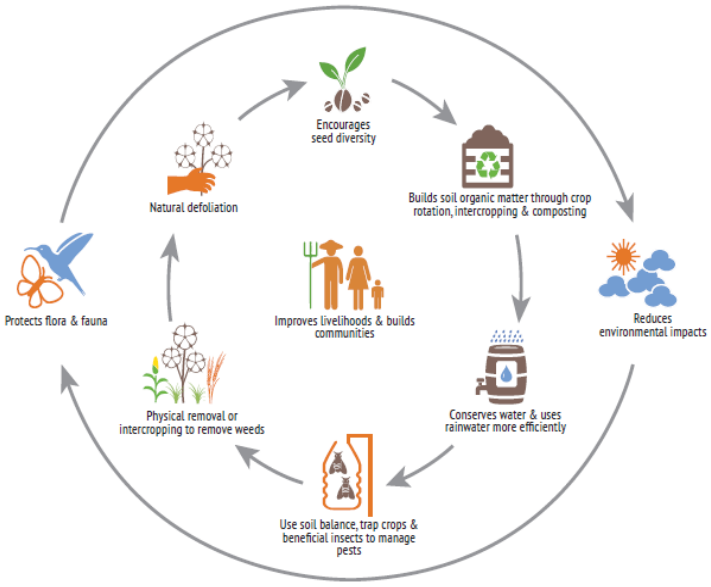
Organic cotton production started with initiatives of individual entrepreneurs, farmers, and NGOs as they were concerned about environmental problems, related with the overuse of pesticides, and social problems related to low prices and farmer dept. The European brands Hessnatur and Verner Frang were the pioneers in 80’s. Both found that a market for organic cotton did not exist and they had to work with individual farmers in Egypt and Peru to develop a source of supply. By the 1990s, other companies began offering organic cotton garments, including Patagonia (USA) and Remei (Switzerland) (ILLGE; PREUSS, 2012).

Organic cotton is grown without the use of any synthetically compounded chemicals (i.e., pesticides, plant growth regulators, defoliants, fertilizers, etc.). Also in organic agriculture the use of genetically modified organisms is not allowed (WILLER; LERNOUD, 2019).

The production of cotton using organic farming techniques (**Figure 28**) seeks to maintain soil fertility and to use materials and practices that enhance the ecological balance of natural systems and integrate the parts of the farming system into an ecological

whole (DE OLIVEIRA; OLIVEIRA-FILHO, 2014). Organic cotton is usually picked up by hand without using machinery or defoliants (RASHID et al., 2016).

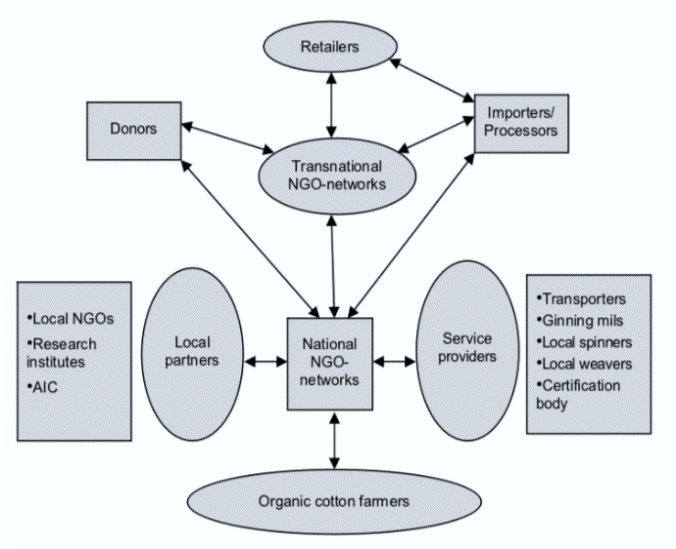
Figure 28 - Organic cotton main characteristics and benefits.



Source: TEXTILE EXCHANGE, 2016a.

Glin et al., (2012) analyzed the social dynamics that connect actors and practices within the organic cotton network, particularly flows of information and knowledge, trust building mechanisms, and power relations among actors from production level to global market level (**Figure 29**). Initiated by intergovernmental sustainable development cooperation, a transnational organic cotton network evolved into a hybrid structure, combining private economic actors and domestic and international NGOs.

Figure 29 - The transnational organic cotton network.



Source: GLIN et al., 2012.

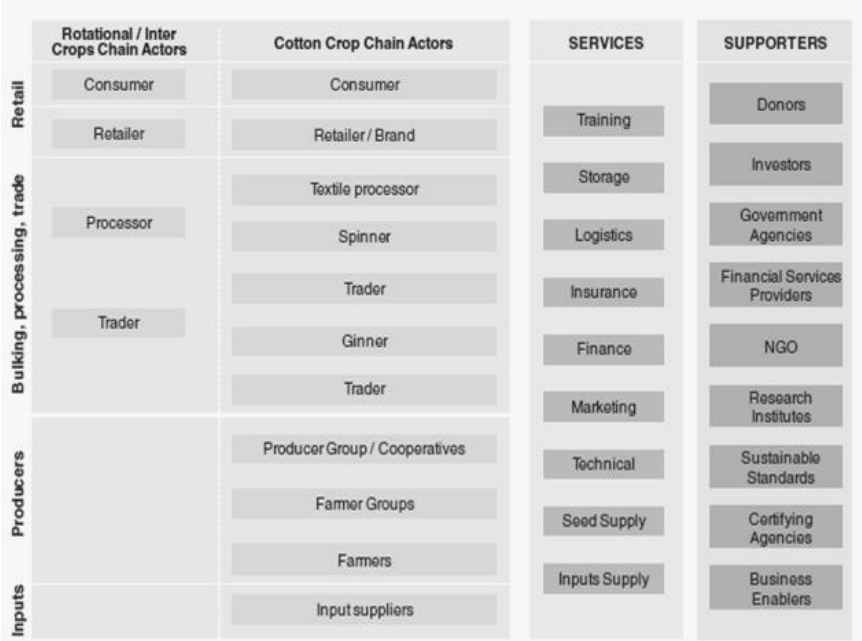
Influences come considerably from financial institutions, local banks, donors and governments and NGOs (LAKHAL et al., 2008). Intermediate actors, as transnational and local environmental NGO networks Solidaridad (Holland) and Helvetas (Swiss), are important instrumental in the construction, maintenance and transformation of the organic cotton network. They enable services such as training, storage facilities, logistics, insurance and financial services, marketing, technical support and the supply of seeds and inputs (FAYET, VERMEULEN, 2014).

International institutions, such as Textile Exchange (USA), plays an important role on financing capacity building in farmers' groups, acting as an agent in cotton marketing, promoting international events and publishing information (GLIN et al., 2012). Also Organic Cotton Accelerator (OCA, Holland) is a multi-stakeholder organization fully dedicated to organic cotton. As a global platform, they are committed to bringing integrity, supply security and measurable social and environmental impact to organic cotton (TEXTILE EXCHANGE, 2020c). OCA participated in the Organic Cotton Traceability Pilot; a joint effort between OCA, Fashion for Good and Laudes Foundation with support from C&A, Kering, PVH Corp., Zalando SE and Pratibha Syntex with Bext360 as the leading technical partner (TEXTILE EXCHANGE, 2020b).

Suppliers' cooperation in attending standards demands and stakeholder's better relations can be relevant topics to motivate a market grown. They might also demonstrate the need to integrate supply chain orientation with policies and developmental

approaches. Glin et al. (2012) indicate an ideal structure of organic cotton network actors (**Chart 3)**.

Chart 3 - Cotton network structure to guide a global view of actors.



Source: FERRIGNO et al., 2010.

In 2014, United Nations member states proposed a set of Sustainable Development Goals (SDGs), which will succeed the Millennium Development Goals (MDGs) as reference goals for the international development community for the period 2015–2030 (LE BLANC, 2015). Organic cotton makes a significant contribution to the SDGs, especially considering the flowing ones: SDGs #1: End Poverty, SDG #10: Reduced Inequalities, SDG #16: Peace, Justice and Strong Institutions, as central to its strategic plan. In this way, providing a market-driven solution to poverty, reducing inequality by raising farm incomes, and promoting inclusive societies through its reliance on cooperative working. Organic cotton motivates organic “communities” and its success from the fiber production until the clothing creation depends upon the goal #17: Partnership for the Goals, building committed, interdependent networks that co-create and distribute value. (TEXTILE EXCHANGE, 2016b). **Chart 4** summarizes a comparison considering advantages of organic related to conventional cotton.

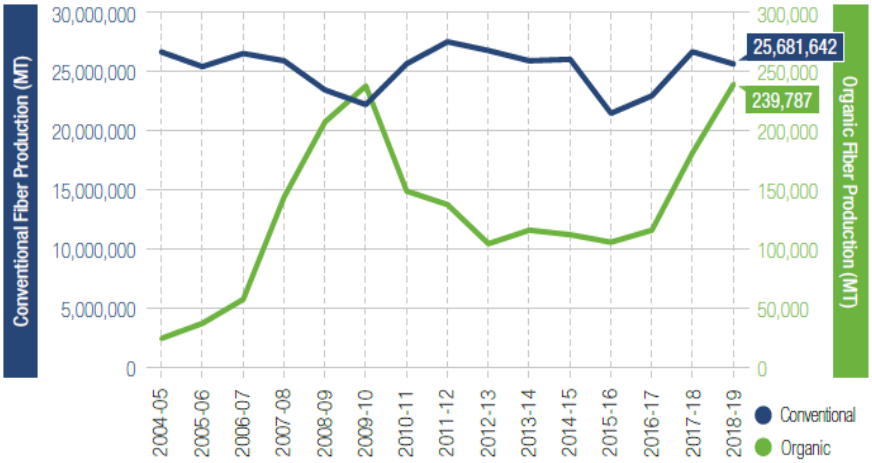
Chart 4 - Advantages of growing organic cotton compared with conventional farming.

	Conventional Cotton	Organic Cotton
Environment	• Pesticides kill beneficial insects • Pollution of soil and water • Resistance of pests	• Increased bio-diversity • Eco-balance between pests and beneficial insects • No pollution
Health	• Accidents with pesticides • Chronic diseases (infertility, weakness)	• No health risks from pesticides • Healthy organic food crops
Soil fertility	• Risk of declining soil fertility due to use of chemical fertilizers and poor crop rotation	• Soil fertility is maintained or improved by organic manures and crop rotation
Market	• Open market with no loyalty of the buyer to the farmer • Dependency on general market rates • Usually individual farmers	• Closer relationship with the market partner • Option to sell products as 'organic' at higher price • Farmers usually organized in groups
Economy	• High production costs • High financial risk • High yields only in good years	• Lower costs for inputs • Lower financial risk • Satisfying yields once soil fertility has improved

Source: OLIVEIRA-DUARTE et al., in press.

Organic agriculture offered a way out of indebtedness and reduced exposure to health hazards of farming families. The proposed alternative production and marketing method doing without expensive and harmful chemical inputs, offered competitive gross margins, thanks to premium sales prices and an overall increased livelihood resilience thanks to diversified cropping patterns and related income streams (GLIN et al., 2012). **Figure 30** compares the production of conventional and organic cotton over the year last decades.

Figure 30 - Comparison between conventional and organic cotton production trends.



Source: TEXTILE EXCHANGE, 2020a.

4.4.1 International Contextualization

Organic cotton cultivation is reported in the following countries: Africa: Benin, Burkina Faso, Egypt, Mali, Mozambique, Senegal, Tanzania, Togo, Uganda, Zambia, Zimbabwe. Asia: China, India, Kyrgyzstan, Pakistan. South America: Argentina, Brazil, Nicaragua, Paraguay, Peru. Middle East: Turkey, Israel. Europe: Greece. USA and Australia (WILLER; LERNOUD, 2019).

From about the year 2000, large conventional clothing retailers, such as Nike (USA), Marks & Spencer (UK), OTTO (Germany), H&M (Sweden) and Walmart (USA), discovered organic cotton clothing as a marketing instrument and began to include it in their product portfolios. On the demand side, these mainstream retailers aimed to tap into the price premium that environmentally aware customers are willing to pay for ‘green’ clothing. On the supply side, farmers had come to realize that they can receive up to 30 percent higher prices for organic cotton than for conventional cotton (ILLGE; PREUSS, 2012).

With its tiny market share, organic cotton currently represents a viable option and a lucrative niche for many small-scale farmers in developing countries, in particular due to attractive price premiums. However, these premiums may encourage more and larger producers to enter the market (BACHMANN, 2011). The aim is not to compare conventional and organic cotton value chains, but to provide the necessary reference to understanding the context of emergence and the dynamics within the organic cotton network (GLIN et al., 2012).

Market demand for textiles made from organic cotton mainly exists in Europe, the USA, Canada, Japan and Australia. The main reasons for consumers to buy textiles made out of organic cotton are: to reduce the risk of skin irritation and allergies; to protect the environment from toxic chemicals; to support sustainable agricultural production in the country where the cotton is grown; and to ensure that the farmers in developing countries receive a fair price (WILLER; LERNOUD, 2019).

Organic production began around the 1940s, arriving in Brazil around 1989 (LIMA, 1995a; OLIVEIRA-DUARTE et al., in press). The organic cotton culture is widely used in the northeast region of Brazil, mainly in the context of family farming, bringing benefits to farmers and being a source of income (MERCIAL, 2018).

4.4.2 Agroecological cotton in Brazil

Radhakrishnan (2017) states that cotton cultivation systems are diverse and the issues associated with cotton cultivation vary due to environmental, agroecological, climatic, socioeconomic and political situations. Since the seventeenth and eighteenth centuries cotton was grown in consortium with food crops. In Brazil, this type of management persisted until the early 1980s with *mocó or perennial cotton* (*Gossipyum hirsutum* Lr marie gallant Hutch), until the boll weevil infestation (*Anthonomus grandis* Boheman) mentioned previously. In 1990, an attempt was made in the state Ceará to produce cotton again on ecological bases disseminated by Esplar, an NGO established in this state. The cultivation of organic cotton, in general, is intercropped with corn, beans, sesame, watermelon, sweet potato, leucena (*Leucaena leucocephala*), sunflower, plants of the genus Vigna (family Fabaceae), according to the agroecological model. The areas of intercropping, in general, are usually about 1 hectare. (BELTRAO et al., 2009; LIMA; SOUZA, 2006; CARDOSO, 2017).

In this way, the damage levels of insects have been maintained at acceptable levels through the adoption of actions that include the introduction of diversity in the field through planting cotton with other species. Pest insects typically reach higher population densities in monoculture than in systems with diversity of cultures (BELTRÃO et al., 2009).

Alternatives are suggested worldwide to replace degrading practices of modern agriculture and environmental impacts on soil in order to achieve organic farming systems under agroecological practices (CUSSER et al., 2019). For example, intercropping may improve nitrogen availability, and thus improve the composition of the residue biomass

produced and complex associations combining various plant functional groups can be beneficial (BAUDRON et al., 2009). The diversity of planted crops increases the income possibilities of the small producer, in addition to favoring the great presence of natural enemies, mainly ladybugs and garbage bugs, large aphid predators (ARAUJO et al., 2011).

The biological control is also utilized, which is considered as the relationship established between two or more organisms in which an organism called a natural enemy, acts by preying, parasite or competing with another organism, called a pest, which has its growth prevented or reduced population. This concept can be applied to the cotton agro-ecosystem, maintaining the population densities of insect pests below the level of economic damage (BELTRÃO et al., 2009).

Cotton growers can promote bee abundance within their own farms by diversifying their landscapes, creating a mosaic of flowering patches and nesting resources that attract and support foraging bees. Given the benefit of bee pollination to cotton yields, there is powerful incentive for growers to improve agroecosystems management to dually support biodiversity conservation and enhance ecosystem service provision (CUSSER et al., 2019).

In addition, cultivating cotton without irrigation it is an important aspect. Water, a natural resource that is scarcity in many parts of the world, is a raw material for several kinds of industries, including agribusiness (EMBRAPA ALGODAO, 2019b). The better use of the water is responsible for reducing environmental impact and guides the business and political concern to create social responsibility and sustainability (GARCIA et al., 2019).

Agroecological cotton practices can make a significant contribution to increasing production in small rural properties (ALBUQUERQUE et al., 2009). According to Lima and Souza (2006), the selling price of agroecological cotton can be between 25% (cotton with seeds) and 100% (cotton lint) greater than the value paid by the conventional cotton (MAIA et al.,2016).

Both organic and agroecological agriculture concerns the no utilization of agrochemicals and transgenic seeds, however organic agriculture is connected to the market and the certifications (DE ASSIS; ROMEIRO, 2002). According to Fonseca (2000), for market objectives, a narrow definition of organic agriculture is used to protect both the farmer and the consumer. Organic standards stipulate the ban of some inputs and dictate a range of practices to be followed.

4.4.3 Motivations and constraints of organic cotton

As sustainability labelling is gaining momentum in the global clothing industry, opportunities for market expansion of organic cotton are related to the creation of farmer organizations (FAYET; VERMEULEN, 2016; OZTURK et al.,2016; PAL, GANDER, 2018). This allows small farmers to be more competitive, achieve economies of scale, reduce transaction costs, enhance their bargaining power, improve their market information, access technology, manage common pool of resources and reduce certification costs (RIEPLE; SINGH, 2010; OLIVEIRA-DUARTE et al., in press). Other motivations towards organic cotton include:

- **Farmers:** higher market prices for organic cotton, reduced costs for agricultural inputs, diverse income, reduces debt vulnerability for smallholders, reduced health risks and soil improvements (BACHMANN, 2011). As many traditional farmers in developing countries are not well educated and lack the channels to share their experiences, many of these costs remain unacknowledged (WILSON; TISDELL, 2001; LAKHAL et al., 2008). Farmers' work is recognized and valued and more health and fair returns from farmers to industries and brands, reaching consumers (OLIVEIRA JUNIOR et al., 2009).
- **Textile and clothing industry:** consumer demand for organic products, a recognition by firms of the benefits in terms of sales and profits from the increasing consumer awareness of organic methods, and the institutionalization and regulation of the industry with its attendant reputational benefits (ROTA et al., 2018).
- **Retail:** opportunities for exports, particularly to the European markets create further demand pressures on industry, for environmental improvements including more formal certification, expecting to cover more than niche markets (FOURE, MLAULI, 2007). The products reach the consumer's hands without losing their history (OLIVEIRA JUNIOR et al., 2009).
- **Clients:** costumers and the various media have played probably the most important role in raising ethical expectations of business and in achieving the public visibility of corporate social responsibility issues. They have more alternatives and more information about the products they are buying (OLIVEIRA

JUNIOR et al., 2009). Among recent changes in consumer habits and preferences, the trend of increased awareness about sustainability is one of the most important elements (TODESCHINI et al., 2017). Although there are a number of forces encouraging the move to organic production, other forces counteract these. Prices of organic cotton garments are still high to encourage the migration of the mass market to them. There is also, still, a lack of awareness of the consequences of the different production methods (RIEPLE; SINGH, 2010; OLIVEIRA-DUARTE et al., in press).

Challenges are linked with lack of information on cost of production and production methods, lack of work force and tax incentives, market assessment (linkages between cotton producers and international organic cotton buyers, including access to market information distribution channels), development of new markets and international certification issues (CARDOSO, 2017; FERRAZ, 2018). Also, convincing farmers to switching organic agriculture is the initial and the most important task in this endeavor as they unfamiliar with the concept (BAYDAR et al., 2015). **Chart 5** summarizes these main topics.

Chart 5 - Motivations and restrictions (challenges) for planting organic cotton and its consortia.

Motivations	Restrictions (challenges)
• Improving food security, family health, and the economic situation that organizes property income; • The women participation in organic cotton production in agroecological consortia in developing countries is more frequent due to the non-handling of dangerous chemicals. The access to training and financial income for women has a positive impact on their social autonomy; • Young people have the opportunity to participate effectively in the productive actions of the property. The production of organic cotton in agri-food consortia has a positive impact on their financial independence and activates the process of rural succession; • The diversified cultivation with the use of natural fertilizers and pesticides, let the environment clean and balanced, where groundwater and water reservoirs are free of chemical contaminants. The biodiversity of the property systems and subsystems is improved; • Enabling the organization of their participatory certification institutions, generating autonomy in the commercialization process.	• The need for a closer relationship between farmers and purchasing companies to accordance the organic market related to production processes in the field; • The improvement of the organic certification process to comply with laws and regulations related to organic products and processes; • Difficulty in accessing organic inputs such as bioinsecticides and seeds with organic certification; • Expansion of the market for machines and implements adapted to production systems combined with field activities and processing of organic products. The prices of machines and implements are most often incompatible with the reality of small cotton producers; • Access to a market with a fair price and compatible with the organic quality of the other products of the agri-food consortia. • Time constraints on production growth. Shifting from conventional to organic cotton farming takes a number of years. • Limited availability of market data, which has been interpreted as a lack of transparency in organic cotton production with resulting damage to the integrity of the organic cotton industry. • Insect and weed control. • Marketing problems, particularly price variability and unstable, underdeveloped markets and lack of organic cotton marketing information.

Source: OLIVEIRA-DUARTE et al., in press.

4.5 Life Cycle Assessment (LCA) – Conventional and organic cotton

The environmental impact and the ecological implications of the entire life cycle of a product are systematically classified and quantified from primary raw material production to processing and to final product disposal (VAN DAM, 2008). Life Cycle Assessment (LCA) of products and processes is a method developed in the early 1980s (LA ROSA; GRAMMATIKOS, 2019). It stands out as a tool that can give quantitative answers considering multiple environmental issues along the whole life cycle of

alternative products, technologies, and management procedures to designers, purchasers, and consumers (ROOS et al., 2015).

Different studies quantified the environmental impact associated to the production of virgin cotton from a global point of view, comparing with organic cotton. Results indicate global warming potential impact for conventional cotton is slightly higher (0.62–5.5 kg CO_2eq) than that reported for organic cotton (0.98–2.40 kg CO_2eq), most likely due to the differences in the use of human labor, tractor and other farm machinery in every cotton crop. The most relevant differences are observed for those categories where the use of fertilizers and pesticides are involved (ESTEVE-TURRILLAS; LA GUARDIA, 2017).

Cotton cultivation has been estimated to consume 11% of the world's pesticides while it is grown on only 2.4% of the world's arable land. The negative effects on the ecosystem of the abundant use of pesticides and fertilizers (eutrophication, nitrate contamination, increase in soil salinity) is in favor of organic cotton cultivation. Moreover, cotton requires large amounts of water both for cultivation and processing. Irrigation is used in areas where normal precipitation quantities do not match the requirements for the crop being cultivated (BEVILACQUA et al., 2014).

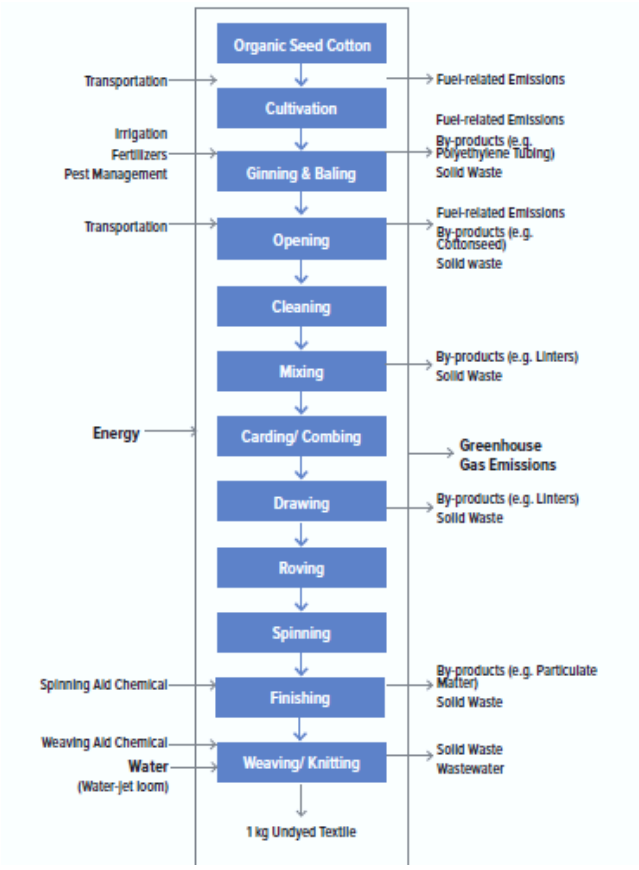
In developing countries, it is estimated that approximately 50% of all pesticides are applied in cotton cultivation (LA ROSA; GRAMMATIKOS, 2019). In addition, pesticide use and storage are often badly managed. Moreover, traditional cotton cultivation requires large amounts of water. Intensive irrigation is used in areas where normal precipitation quantities do not match the requirements for the cropping. 53% of cotton fields worldwide are irrigated, because irrigation generally allows higher yields per unit of area (LA ROSA; GRAMMATIKOS, 2019). Growing of crops results in the fixation in biomass of atmospheric CO_2 through photosynthesis and has therefore in principle a positive effect on the CO_2 balance. The degree of mechanization of soil preparation, sowing, weeding and harvesting adds to the impact, due to the fossil fuel consumption (VAN DAM, 2008).

The impact of transportation on the LCA was concluded to be very low due to bulk shipments. Cotton processing is largely mechanized, although in some parts of the world cotton is still harvested by hand. Specialized machinery has been developed for the harvesting of seed cotton, which either leaves the plants on the field or returns the trash after stripping. It is important for the fiber quality that the leaves are removed, so

application of chemicals for defoliation is common practice (BEVILACQUA et al., 2014).

Figure 31 explains the organic cotton process and steps from seed to weaving, detailing some aspects of a life cycle analysis that includes for example transport, energy and water use, waste, etc.

Figure 31 - System Diagram of Organic Cotton.



Source: TEXTILE EXCHANGE, 2016a.

It is obligatory for each member of the supply chain to handle the organic goods separately from the conventional production, to clean the machines, to label and document all intermediate and ready made goods in their way through the production stages- on cones, packages, roles, warp beams etc. To label and mark machines, to separate storage areas, to develop and carry out own training units how to handle the organic cotton and to avoid the contamination with conventional cotton; to establish own systems for internal control supporting the certification bodies (NEZNAKOMOVA, 2008).

Liu et al. (2020) present a detailed study comparing LCA between virgin cotton yarns and recycled yarns, employing BCI and organic cotton. Besides of presenting the intermediate values and the LCA inventory for all cotton production steps, they conclude that the LCA results reveal recycled cotton yarn is a viable alternative to relieve resource and environmental pressure. About 0.5 ha of agricultural land can be saved, 6600 kg CO_2 eq can be reduced, and 2783 m^3 irrigation water can be saved by using 1000 kg of the recycled cotton yarns.

4.6 Cotton Certifications

Certification provides consumers with objective information about the quality of a given product. Even though it is an additional source of costs, certification is a mechanism for reducing the cost of information, and consequently, the transaction costs, in markets with heterogeneous products (SOUZA, 2000b). In order to ensure the production model, origin and traceability, there are some types of standards and certifications, legally defined as external audit models. The most significant are: “Organic”, “Fair Trade” and “More Sustainable”. In addition, there are initiatives aiming at certifying recycled cotton (OLIVEIRA-DUARTE et al., in press). **Figure 32** summarizes cotton standards over the world.

Figure 32 - Cotton standards and cotton certifications.

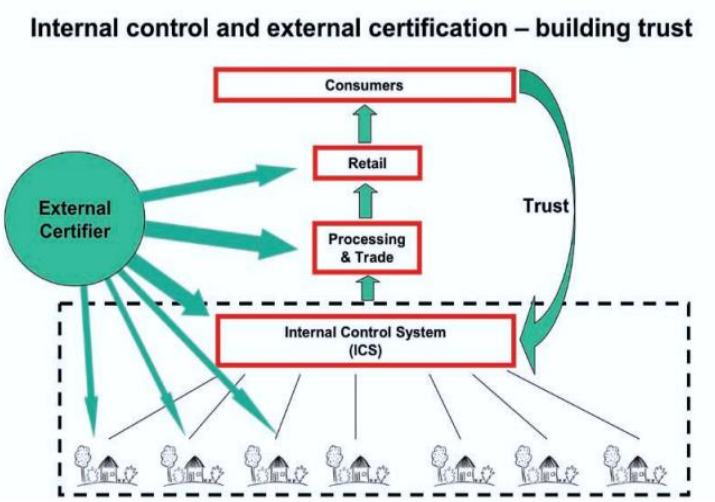
Source: TEXTILE EXCHANGE, 2020b.

In order to be certified as organic, cotton has to be grown without the prohibited chemicals for a period of three years (SOUZA, 2000b). In each country or region is subject to the laws governing organic production, such as Organic Regulation No 834/2007 in Europe, USDA National Organic Program in the United States, and the National Organic Production Program in India (OLIVEIRA-DUARTE et al., 2019).

The Brazilian Organic Law, Law No. 10,831/2003, was sanctioned in 2003, being regulated in 2007, through the publication of Decree No. 6,323/2007. (MARQUES, 2019). The regulation establishes different methods of obtaining organic certification including **certification by external audit** and certification through **Participative System of Guarantee (PSG)**, composing the Brazilian System of Evaluation of Organic Conformity (SISORG - MAPA) (MARQUES, 2019).

Certification by external auditing is carried out by independent organizations, which ensure compliance with organic production procedures - provided for international standards and legislation (**Figure 33**). External audit in Brazil are related to the institutions IBD and ECOCERT (OLIVEIRA-DUARTE et al., in press).

Figure 33 - Internal and external control in an organic cotton project.

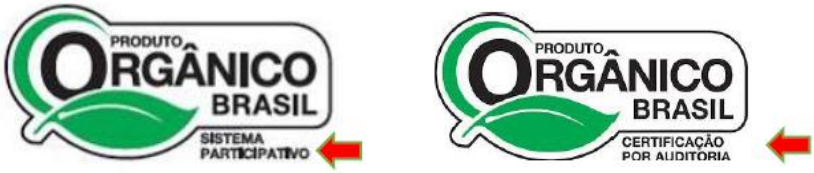


Source: WILLER; LERNOUD, 2019.

Certification by external auditing has high costs and it is often not feasible for smallholders. The PGS is a more inclusive system, as it considers the productive model of small farmers and their limitations, facilitating the obtaining of the national standard. The basic structure of the PGS is composed by (i) members of the system (producers and employees) and (ii) by the **OPAC (Participative Conformity Assessment Body)**

(OLIVEIRA-DUARTE et al., in press). The Ministry of Agriculture, Livestock and Food Supply (MAPA) grants the accreditation to OPAC, which may authorize the producers to use the Brazilian Organic Conformity Assessment System Standard. OPAC become responsible for launching and keeping up to date all the data of the production units it controls, informing the National Register of Organic Producers and the National Register of Productive Activities, in this way, making available the information to society (MARQUES, 2019) (**Figure 34**).

Figure 34 - Organic standard in Brazil and the detail of the difference from participative and external audited guarantee.



Source: MARQUES, 2019.

Participatory guarantee system was developed in Brazil and provides greater autonomy for family farmers, who monitor the entire production process, with the possibility of obtaining better prices in the sale of certified products (OLIVEIRA-DUARTE et al., in press).

As regards the certification of the whole textile chain, GOTS standard include a broader certification evaluating all stages of processing, from fiber to finished product (FERRAZ, 2018). GOTS (Global Organic Textile Standard) is a certification which helps verify that a given textile was made using organic materials, including that a mill, dyeing, farmer and other producer used organic practices to create its textiles (FERRAZ, 2018). It can be awarded by a number of different certification bodies that all operate using the same set of standards dealing with organic fibers, dyes, chemicals and bleaches, in addition to upholding the labor standards set forth by the International Labor Organization (TEXTILE EXCHANGE, 2020b).

In this process, the whole organic cotton spinning process is monitored by the same certifying agencies that monitored the lint's agricultural production. Large spinning companies require higher volumes to spin organic cotton, be it white or colored. This is one of the most problematic steps because in addition to the quantities being very small, there is also the process of cleaning the machines before and after use, which is why

companies are not interested in performing the service. The interruption in the operation of the machinery certainly causes a fall in the productivity of the companies and, therefore, raises the costs of the service (DA CUNHA; DE OLIVEIRA, 2019).

Throughout the entire organic cotton processing chain, it is important to avoid contamination and to separate organic from conventional cotton. As most spinning mills and processing entities process organic and conventional cotton on the same machinery, it is important to clearly separate the cottons and clean the equipment before processing an organic lot (WILLER; LERNOUD, 2019).

4.7 Network theory

Moving from the language of commodity *chains* to commodity *networks*, Raynolds (2004) helps portray the complex web of material and nonmaterial relationships connecting the social, environmental, political, and economic actors enmeshed in the life of a commodity, such as cotton. Understanding how individuals, firms, government authorities, and nongovernmental organizations (NGOs) are involved in economic and social transactions and how these different actors relate.

Networks can be conceptualized as a system of entities or nodes that are interconnected (BORGATTI et al., 2009). These nodes can be either individuals or “collective” participants, such as organizations (HOANG; ANTONCIC, 2003; KELLEY et al., 2009). Networks guarantee timely access to external knowledge, resources, and cost savings that would otherwise be inaccessible to an isolated company (BONATTO et al.,2017). They also allow testing the organization's internal competencies and learning capacity (BRANDAO et al., 2019).

Organizations relationships come in numerous forms, including alliances, partnerships, joint ventures, consortia, supply agreements, technology licensing, manufacturing collaborations, and marketing agreements (GULATI et al., 2000; BASOLE, 2009). Research on partnership considers that the role of network structure is critical to the performance of the project (MARTINEZ-TORRES, 2014). Since partners often turn to their social contacts to seek information or resources, such structures are a crucial means of accessing diverse sources of knowledge (ARRANZ; FERNANDEZ DE ARROYABE, 2013; ARRANZ et al., 2019).

Rich networks sharing elements link companies across products, services, and technologies (CLARYSSE et al., 2014). Iansiti and Levien (2004) argue that complex

network of firms and products have become an increasingly common feature of the business landscape in general. Network approaches focus on patterns of connectivity, for example, well-connected networks can improve access to information by increasing the number of transmission channels and by providing the actors with more accessible sources of knowledge. Strategies to attract isolated producers and entrepreneurs, for example, and reach customer have been devised, through online platforms for resources and needs; events for information sharing, and collaboration with large organizations such as universities, foundations, financial institutions, etc. (BAEK et al., 2015).

Network analysis seek to uncover various kinds of patterns of social ties in which actors are embedded. And they try to determine the conditions under which those patterns arise and to discover their consequences (FREEMAN, 2004). Concerning how relationship patterns, or structure, affect processes and outcomes (SAYLES et al., 2019).

In this way, a Social Network Analysis (SNA) will provide valuable information about the specific capabilities and reliability of actors since an actor can evaluate potential partners based on their network positions (BORGATTI; HALGIN, 2011; MONAGHAN et al., 2017). Structural analysis (involving the entire network) and relational analysis (involving peers) allow to understand the influence of certain actors on activities, resources, coordination, knowledge flow, performance and strategic behavior of other actors in the network (GRANOVETTER, 1985). SNA offers great potential for supply chain management research in investigating how patterns of networks translate into competitive advantage through the management of resource flows, diffusion of information, social control of opportunism and coordination (KURT; KURT, 2020).

Different forms and types of networks are increasingly utilized in different environmental contexts and for different purposes (HURMELINNA-LAUKKANEN et al., 2012). Social–ecological network analysis must study social-ecological entities and relationships. It considers how social units interact - the purview of studies about natural resource governance using classical social network analysis and simultaneously considers interactions between ecological units. These ecological units can represent specific plants or animals, entire habitats or ecosystems, or water resource areas. Environmental problems cannot be divorced from their social contexts. Integrating information about ecological health and social collaboration is essential. The results will help identify where to invest resources to improve environmental conditions as well as improve the social infrastructure to do so (SAYLES; BAGGIO, 2017).

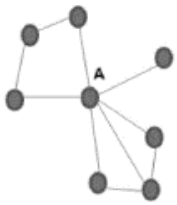
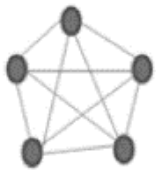
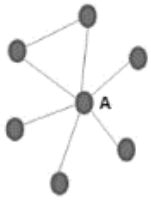
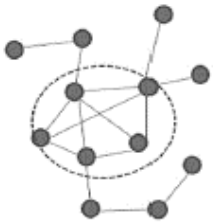
4.5.1 Network elements

SNA is (1) motivated by a structural intuition based on ties linking social actors; (2) it is grounded in systematic empirical data; (3) it draws heavily on graphic imagery, and (4) it relies on the use of mathematical and/or computational models (FREEMAN, 2004). It can be an invaluable tool for systematically assessing and then intervening at critical points within an informal network (CROSS et al., 2002). In a SNA the network perspective helps determine whether identified critical actors and their relationships: Three concepts are of vital importance in understanding (MEYER; ROWAN, 1977):

(1) “Nodes” or “actors” are entities, persons, organizations, or events.
(2) “Links” or “ties” are the relationships, of any kind, between the actors. Links may be money transfers, communications, publications sent to subscribers, friendships, exchange of resources like information, or overlapping memberships (TICHY et al.,1979). Actors can be directly or indirectly linked, joined by multiple relationships, or be separate.
(3) “Networks” are the patterns formed from the combination of all the actors and links within the system. Networks have characteristics. For example, networks may be “dense” (having many links) or “sparse” (having few links).

SNA concerns with the structural positions (such as central, isolate, bridging) of actors. If an actor has many links to others in the system, then it has different network characteristics than an actor with fewer links within the system. If an actor is connected to different members, it will have access to different no redundant sources of information, having the potential to facilitate exchanges between less central actors (TIMUR; GETZ, 2008). Kurt and Kurt (2020) detailed the SNA in the following figure (**Figure 35**).

Figure 35 - Visual representation of SNA measures.

Open networks (structural holes)	**Network Closure**	**Centrality**	**Core-Periphery**
			
Node A occupies a structural hole's position between otherwise disconnected groups, which represent an open network structure.	All nodes are densely connected to each other, representing a closed network structure.	Node A has the highest degree centrality with the highest number of direct ties.	Nodes within the dotted area are densely connected and outer nodes are scarcely connected, representing a core/periphery structure.

Source: Adapted from KURT; KURT, 2020.

Density refers to the number of connections between actors within the network. It is argued that highly dense networks result in efficient communication and enhanced diffusion of norms across networks (MEYER; ROWAN, 1977). The higher the density, the more complete the network is or the degree of its crosslinking is (UJWARY-GIL; POTOCZEK, 2020).

Another network characteristic is **centrality**. Networks may have one central actor with links from many actors directed to it, which indicates high network centrality, or a network may have several groups and no central actor that indicates low network centrality. Centrality measures are an indicator of how central an actor is within a social network. In other words, a central position within the network indicates the amount of power obtained through the structure, and capacity to access information and other members (WASSERMAN; FAUST, 1994; FREEMAN, 1979).

Centrality is one of the most popular measures used in network studies. It corresponds to being well connected within its local environment (SCOTT, 2000). It can be computed for in-degree centrality (which measures how many ties an actor receives) and out-degree centrality (measures how many ties are made with other actors) (TIMUR; GETZ, 2008).

A member with high centrality can act independently across the network and has an ability to act as an intermediary and help share knowledge efficiently to different parts of the network. Also have a high capacity to **broker relationships**, serving as the "movers-and shakers" in the network and can create bridges between disconnected members or parts of the network, resulting in much of the knowledge in the network to pass through them (SIMPSON; DE LOË, 2017).

According to Burt's structural hole theory (1992), structural holes are gaps in information flows between alters linked to the same actor but not linked to each other. It indicates that the actor on either side of the hole have access to different flows of information. Minimizing redundancy between partners is an important aspect of constructing an efficient, information-rich network (BURT,1992; AHUJA, 2000).

Strong and weak ties form a structure that can be mapped and analyzed to determine patterns. Strong ties indicate bonds between network members that support the sharing of information and advice, help build and maintain trust between members, allow members to influence other members' beliefs and values, and encourage two-way communication between members. Weak ties are formed by network members who bridge with disconnected or dissimilar groups either within or outside their network (SIMPSON; DE LOË, 2017).

4.5.2 Network towards innovation

If a company aims to evaluate which type of innovation strategy to carry out, one factor that should be taken into account is the way in which the firm interacts with other actors (GALASO et al., 2019). According with Obstefeld (2005) combination is the key to innovation, then social network activity may be an important predictor of people's involvement in innovation.

Whether these interactions are called **innovation networks** (e.g., VON HIPPEL, 2007), **innovation clusters** (e.g., PORTER, 2000), **regional innovation systems** (e.g., ASHEIM; COENEN, 2005) or **innovation ecosystems** (e.g., CARAYANNIS; CAMPBELL, 2009; ADNER, 2017) as the world has become more complex, organizations are obliged to develop new courses of action. All the above-mentioned modes of cooperation are built on the thinking that innovations are created best when capabilities and ideas possessed by different actors are combined.

Instead of individual and isolated organizations, welfare service innovations are typically invented, implemented and diffused in complex relationships between different organizations (JALONEN, 2013). In this way, the need for the coordination and cooperation of different knowledge bases is evident especially in the context of public welfare services where innovations are usually "based not on a product which can be seen, but on changes in relationships – e.g., between service providers and users, or between different parts of the organization or its partners" (HARTLEY, 2006; CANTNER, GRAF, 2006). Rogers (2003) explains the circulation of technologies in four principal topics – innovation properties (relative advantage), communication channels (knowledge of the innovation), time (rate of adoption) and social systems (influence of social structures such as power hierarchies) (SAGE et al., 2020).

Moreover, collaborative advantage comes from relational rent, a common benefit that accrues to collaborative partners through combination, exchange, codevelopment of resources, etc. (CAO; ZHANG, 2010). Collaboration skills and bridge-building is performed by actors such as mentors, innovation platforms, international NGOs or public services among others. Along the transition from innovation clusters to ecosystems, and the concurrent need to shift to relational models more suited to collaboration and shared value creation, the role of enablers comes in high demand (KORIA; SUBRA, 2017).

Collaboration has emerged as an important strategy in numerous settings where multiple actors share responsibility for, or an interest in, resolving common problems. Social networks, composed of inter-dependent members, promotes communication and encourages cooperation between members concerning issues that span administrative, physiographic, and political boundaries. The deliberation and negotiation of complex problems within social networks can result in the sharing of multiple knowledge, which supports collective learning and the development of knowledge and expertise, impacting innovation. Collaborative approaches are built around formal and informal forums. These approaches are important because the knowledge possessed by different interests often is required for developing solutions to complex problems (SIMPSON, DE LOE, 2017).

According Cao and Zhang (2010) collaboration addresses relevant aspects that includes *information sharing* referring to the extent to which a company shares a variety of relevant, accurate, information with its supply chain partners. *Resource sharing* referring to the process of leveraging capabilities and assets and investing in capabilities and assets with supply chain partners. *Incentive Alignment* referring to the process of sharing costs, risks, and benefits among partners. It includes determining costs, risks, and

benefits as well as formulating incentive schemes. *Decision synchronization* referring to the process by which partners orchestrate decisions in planning and operations that optimize the network benefits. *Goal congruence between partners* as the extent to which the own objectives are satisfied by accomplishing the group objectives. *Joint knowledge creation* referring to the extent to which partners develop a better understanding and response to the market by working together.

5. RESEARCH METHODS

5.1 Research general description

This study has an exploratory and qualitative approach, which aims to provide greater familiarity with the problem. This process allows a broad interpretation, learning a general pattern of understanding the codes that emerged in the technical visits and interviews. This phenomenon is related to the fact that the researcher filters the data through a personal lens located at a certain moment, viewing the phenomena in a holistic way (CRESWELL et al., 2007).

According with Caniato (2018) the intent of qualitative research is to understand a particular social situation, event, role, group, or interaction. It is appropriate to understand the context or environment that participant approach a problem. The researcher is linked not only with the cause and effect relations, but though the identification of complex fact interactions in a determinant situation (CRESWELL, 2014; PATTON, 2015).

In this way, it was required a structure to allow empirical data to be collected and to generate context-specific knowledge (YIN, 2015). To understand the organic cotton network in Brazil, the main producers; the main companies and institutions related to production at farming and textile and clothing sector; the important clothing brands utilizing organic cotton; and perspectives from the market were considered. The use of embedded units of analysis suggests that an equal emphasis should be placed on both the sub-units of the study (FLETCHER et al., 2018).

The complexity of the network and the high level of interpretation that is necessary create an advantage for using multiple sources, and complementary insights to the research. It was collected data from multiple sources covering the theme of organic cotton in Brazil, based in (**Figure 36)**:

(1) systematic literature review and exploratory literature review orientated to the topic of organic cotton in Brazil;

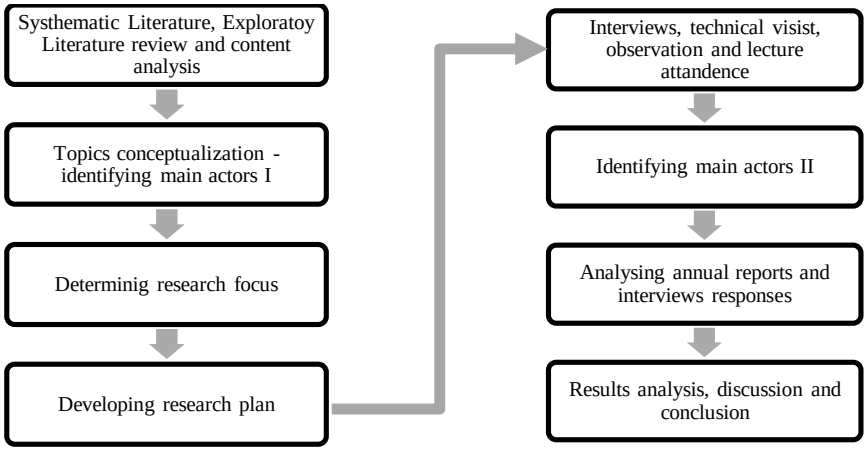
(2) semi-structured interviews;

(3) technical visits and observational analysis;

(4) lecture attendance; and

(5) report analysis detailed.

Figure 36 - Methodology study of the present study.



Source: Larissa Oliveira Duarte, 2019.

5.2 Data Collection

5.2.1 Systematic Literature Review and Exploratory Literature Review

Firstly, a systematic literature review was conducted utilizing the platforms Web of Science and Scopus, including the words:

- "organic cotton" (returning 152 articles in Web of Science and 398 in Scopus);
- "organic cotton" and "network*" (6 articles in Web of Science and 16 in Scopus);
- "organic cotton" and "Brazil" (2 articles in Web of Science and 4 in Scopus);
- "organic cotton and "textile" (31 articles in Web of Science and 142 in Scopus);
- "organic cotton and "clothing" (21 articles in Web of Science and 67 in Scopus).

Then the articles were selected firstly by title and summary. After this preliminary selection, the chosen ones were read in totality regarding the theme relevance. They are summarized in **Chart 6**.

Chart 6 - Systematic Literature review main authors and research subjects.

Authors	Year	Title	Highlights
Organic Cotton in Brazil			
Barros et al.	2020	A Review on Evolution of Cotton in Brazil: GM, White, and Colored Cultivars	In agricultural aspect, the management adopted for cotton crop in large areas is practically established, but it is necessary to put into action more researches with cotton-organic/agroecological management. This segment tends to grow and have a strong impact on future market for natural and color fibers, based on consumer demand and the trend toward more sustainable field practices. C&A Foundation has been working with ESPLAR and EMBRAPA to expand production of Mocó (*G. hirsutum* subsp. marie gallant) organic cotton supply (long fiber and resistant to drought). This initiative currently engages 300 farmers in Ceará State. Starting in 2018, the foundation will also support DIACONIA in engaging 750 smallholder farmers on organic cotton cultivation across the states of Alagoas, Ceará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe. This denotes that there is a lot of work to be done in this area.
De Oliveira and Oliveira-Filho	2014	Ecological agriculture and textile industry: the role of communication for organic cotton in Brazil	It is important that consumers and brands understand further the commercial value of organic cotton towards less environmental impacts.
Organic Cotton in the world			
Avadi et al.	2020	Life cycle assessment of organic and conventional non-Bt cotton products from Mali	A shift towards organic cotton would be desirable only if the yield gap can be overcome, or if a sufficiently important price premium could be obtained in international markets. Moreover, a shift towards Bt cotton would be justified only by a higher yield with comparable fiber quality, coupled with price levels that would compensate for increased seed costs.
Güzel and Karadag	2019	Sustainability of Organic Cotton Fabric Dyeing With a Natural Dye (Gallnut) and Analysis by Multitechnique Approach	Ecofriendly, nontoxic, antibacterial fabrics can be produced, which are especially important for use in hospitals and for baby and children's clothes. Since antimicrobial clothing and textile materials have recently attracted consumers' and manufacturers' interests all over the world, the results obtained are expected to make a contribution to the present knowledge in that respect.
La Rosa and Grammatikos	2019	Comparative Life Cycle Assessment of Cotton and Other Natural Fibers for Textile Applications	Organic cotton production seems to have managed to reduce consistently the environmental impact associated with the cotton market. Currently, in the textile industry, the optimum solution to reduce the high environmental impact associated with cotton fibers is to shift towards organic cotton cultivation, as the amount of water and energy consumption is lower than that for the traditional cultivation. Due to fact that the organic cultivation exhibits a reduced cropping yield, it

			might result into an inability to cover the market's need.
Rota et al.	2018	Assessing the level of collaboration in the Egyptian organic and fair-trade cotton chain	Information sharing (price information and logistics), decision synchronization (exception management and general management) incentive alignment (risk sharing and technical support).
Esteve-Turrillas and de la Guardia	2017	Environmental impact of Recover cotton in textile industry	The use of organic cotton requires a dyeing process, which is far to be considered as a sustainable practice and has deleterious effects on the environment preservation.
Fayet and Vermeulen	2014	Supporting Smallholders to Access Sustainable Supply Chains: Lessons from the Indian Cotton Supply Chain	Improvements in the livelihoods of small farmers increasing market access depends on what approaches are used. The future challenge is to create market links and enhancing supply chain efficiency while providing development support at community levels.
Glin et al.	2012	Governing the transnational organic cotton network from Benin	Global Value Chains (GVC) perspective focus on economic dimensions, incorporating sustainability and the importance of government and non-government support can integrate the organic cotton supply network.
Rieple and Singh	2010	A value chain analysis of the organic cotton industry: The case of UK retailers and Indian suppliers.	Transforming a cotton crop into a textile and then into a final item of clothing involves many stages of processing, using many skills and technologies. Examined the activities and the prices achieved at each stage of this chain, from the farming of the cotton crop to its eventual sale in clothes' retailers.
Lakhal et al.	2008	Comparing conventional and certified organic cotton supply chains: the case of Mali	Potential advantages to organic cotton farmers, including lower expenses for farm inputs, healthier soils, diverse Sources of income, and higher prices.
Organic Production in global networks			
Raynolds	2004	The Globalization of Organic Agro-Food Networks	Analyze organic production, distribution, and consumption patterns and the roles of social, political, and economic actors in consolidating international trade. Organic certification proves central to network governance, shaping product specifications, production parameters, and enterprise participation.

Source: Larissa Oliveira Duarte, 2019.

In addition, along all time of this research (from March 2018 to November 2020), the exploratory literature review continued to be conducted, also including GS database, considering the previous articles selected, targets searching, contextualizing the research topics and the discussion development. Publications were collected generally using the search strings "organic cotton", "Brazil", "network", "sustainability", "textile and clothing", "supply chain", "cotton network". With this approach and taking in account the few references found in literature, it was decided to search by topic and not by outstanding journals, in order to include all published information in this field, as suggested by Webster and Watson (2002) and Schiederig et al. (2012).

Our total data based references included 316 publications as evidenced by the References item. The extracted publication types include journals, conference proceedings, book(-chapters), additional journal articles and working publications (SCHIEDERIG et al., 2012). Thesis and dissertations published in Brazil since 2017, which are relevant to support information about the main organic cotton actors in Brazil, were also considered and summarized in **Chart 7**.

Chart 7 - Thesis and dissertations presenting topics related to the organic cotton in Brazil since 2017.

Authors	Year	Title	Highlights
Azevedo	2018	Trustability and commitment to interorganizational relationships for value formation: the case of the local productive arrangement of clothing and colorful cotton articles of Paraíba	Presented the structure of the Local Productive Arrangement of Clothes and Artifacts of Colored Cotton in the State of Paraíba and to analyze the interorganizational relationships for the formation of value of products from colored cotton. Including mainly i) producers, ii) artisans from Vila do Artesão, iii) CoopNatural iv) NCC v) Santa Luzia.
Ferraz	2018	Sustainability in the cotton supply chain: a case study of the relationship between a sports footwear company and organic cotton producers	Emphasizes organic cotton production in state of Ceara, focusing at the organizations ESPLAR, JUSTA TRAMA and the brand VERT, through business perspective.
Cardoso	2017	Agroecological cotton in the Brazilian semi-arid: production and market	Sustainable agriculture, support of partner institutions was fundamental for the development of agroecological alternatives for the cultivation of cotton and the coexistence in the Brazilian semiarid. Through agroecological perspective.
Lirborio	2017	The geographical circuit of colored cotton production at Paraiba estate-Brazil	The importance of EMBRAPA Cotton (Brazilian Agricultural Research Company specialized in Cotton), to motivated and support the production for family farming. Through colored cotton research and innovation development. Through geographical perspectives.

Source: Larissa Oliveira Duarte, 2020.

For the Network Theory, it was developed a supplementary literature review, based on key-words search from the Web of Science Core Collection, including the topics “Innovation*” and “network analysis” (Timespan: All years. Indexes: SCI-EXPANDED, ESCI, A&HCI, SSCI, CPCI-SSH, CPCI-S. Categories: Management and Business. Document type: article and reviews). Carefully considering title and abstracts content, it was firstly determined 398 articles potential literature databases. Then, regarding the

topics relevance in relating network and innovation it was selected 17 articles that could contribute with the literature, according expressed in **Chart 8.**

Chart 8 - Contributions of each work raised by systematic review.

Authors	Main contributions
Arranz et al., (2019)	A lower heterogeneity, greater cohesion and network centralization is more present in exploitation than in exploration projects. The cohesion and the overall distribution of ties in the network have a great impact on project results and on the performance perceived by partners.
Batallas,Yassine (2006)	Using all centrality and brokerage indexes presented (degree, closeness, betweenness, internal coordinator, external coordinator, gatekeeper and representative, liaison, and total brokerage) support the organization in order to identify high central teams called *Information Leaders Team.*
Belso-Martinez, Diez-Vial (2018)	By belonging to this "core" group of firms, reaching and maintaining strong positions, companies have access to complementary resources, ideas and knowledge while also having more status and power.
Brandao et al., (2019)	Appropriate relationships with external actors appear to be associated with higher innovation orientation within firms. Highly diversified network promotes greater visibility, wider access to sources of knowledge, enhancing the regional innovative potential and increasing destination competitiveness.
Buffa et al., (2019)	A new sense of community does arise from collaboration on shared goals. Finding strategies to cope with such individuals aims is crucial for the survival of the community. Then, working together on innovative projects proved a powerful tool to strengthen the community itself.
Cantner, Graf (2006)	Shared knowledge base is an important prerequisite for cooperation in R&D. A network of technological overlap can therefore be viewed as the potential for cooperation and knowledge exchange.
Chiu (2006)	Network competence and central network positions are positively related to innovation performance. Those companies with a higher level of network competence and central network positions perform significantly better in terms of innovation than companies low in network competence and centrality.
Cross et al., (2006)	Network analysis helps community leaders make informed and ultimately more successful interventions
Diez-Vial, Montoro-Sanchez (2014)	In a trusting and shared culture environment it could be that firms try to help each other by trying to transfer knowledge to those with slightly lower levels of human capital that might need it.
Franco, Wanke, (2017)	Companies set up networks to acquire the competencies they are unable to source internally. The concept of network power shows that the most influential actors within the network, i.e. actors with many ties, make many partnerships. Meaning that companies recognize their skills in terms of developing projects.
Galaso et al., (2019)	The degree of centrality facilitates innovation strategy. Having many direct links with other firms and organizations is relevant to buy innovation. However, indirect links that allow the firm to occupy a strategic position in the network are crucial to develop in-house innovation strategies.
Kurt, Kurt (2020)	SNA offers great potential for supply chain management research in investigating how patterns of networks translate into competitive advantage through the management of resource flows, diffusion of information, social control of opportunism and coordination.
Martinez-Torres (2014)	Many studies highlight the role of an emergent profile such as the community manager, responsible for monitoring the general behavior of the community and deciding about the most appropriate governance style. Tools based on SNA can help managers to monitor the participation of users within the community.
Monaghan et al., (2017)	Engaging specifically with four practical concerns associated with SNA – network boundary specification, data reliability, context of inquiry and network visualization – can support managers, consultants or researchers engaging with SNA.

Oriana et al., (2019)	The most frequently used indicators in livestock are: degree, betweenness and closeness so they could be proposed as structural variables in subsequent quantitative analyzes. Risk aversion, low training and low financial capacity of farmers contributes to technological adoption through interaction with nearby networks over peer influence.
Ramos-Vidal (2016)	Central actors are able to exert influence on the subset in which they are embedded, but intermediaries, brokers, and disseminators extend their connections between the core and the periphery, and between the groups that make up the network. The degree of centrality is an appropriate measure for learning about the predominant roles of some actors within cohesive subgroups, while intermediaries, brokers, and disseminators are particularly influential when the objective is to assess inter-group relationships.
Reed, Hickey (2016)	Knowledge and innovation was spread, in the formal cooperative structures, through predominantly vertical linkages where highly connected actors, generally leaders, acted as intermediaries between high-level partners (governments and markets) and the cooperative members. These key actors were reported as receiving significant power from their role, potentially resulting in a wide variation of knowledge and adoption of innovative practices across cooperative members, due to their ability to control the flow of knowledge.

Source: Larissa Oliveira Duarte.

5.2.2 Semi-structured interviews with the main actor of organic cotton network in Brazil

The empirical research was based on data collected from September 2019 to September 2020. The primary data sources are 60- to 90-minutes, semi-structured interviews, aiming to obtain detailed input from selected interviewers regarding critical actors of organic cotton network at Brazilian scale, including some international actors related to. Informed consent from the interviewers, were obtained before conducting the interviews. In this way, 21 interviews were conducted with the principal actors collaborating in Brazilian network (**Chart 9**). Semi structured interviews were conducted according the preliminary script (**Appendix 1)** and their answers are summarized in **Appendix 2**.

Chart 9 - Research Protocol: interviewers' details and further descriptions.

Fiber production and ginning				
Organization	**Category**	**Name/role**	**Interview Location**	**Date**
Coopercat	Producers organization	• José Tiburcio de Carvalho Filho (Coordinator)	Catuti (MG)	Oct. 25, 2019
Solidaridad	International NGO	• Jessica Liu (BCI cotton project coordinator) • Mariana da Silva Alves (BCI cotton project assistente)	São Paulo (MG)	Nov. 05, 2019
ACEPAC	Producers organization	• Amanda Procópio da Silva (Producers Association	Settlement Zé Marcolino - Cariri (PB)	Sep. 25, 2019

		president and cotton producer); • Ancelmo Coelho da Silva (Cotton Producer); • Soraia da Costa Araujo (Cotton Producers)		
Rede Borborema	Producers organization	• Alexandre Almeida da Silva (Association presidente and cotton producer); • José Cinésio da Silva (Cotton Producer); • Suzana Cordeiro de Aguiar (Association secretary and cotton producer)	Remígio (PB)	Sep. 27, 2019
EMBRAPA Cotton	Public research institution	• Marenilson Batista da Silva (Agronomy specialist); • Nair Helena Castro Arriel (Agronomy specialist); • Gilvan Alvez Ramos (Agronomy specialist); • Fábio Aquino de Albuquerque (Agronomy specialist)	Campina Grande (PB)	Oct. 4, 2019 Oc.t 01, 2019 Oct. 9, 2019
EMPAER	Public research institution	• Cristiano Campelo Cavalcante (Executive manager of operations)	João Pessoa (PB)	Oct. 03, 2019
Arribaçã	National NGO	• Amália da Silva Marques (Agronomy technician)	Campina Grande (PB)	Sep. 25, 2019
Diaconia - PE	National NGO	• Ricardo Menezes Blackburn (pedagogical political advisor)	Campina Grande (PB)	Sep. 25, 2019
Clothing and retail				
Organization	**Function**	**Name**	**Location**	**Date**
Coopnatural and Natural Fashion	Founder	Maísa Mota Gadelha	João Pessoa (PB)	Sep. 30, 2019
Organic Cotton Colours (OCC)	In-country manager	Diógenes Fernandes Pereira	Campina Grande (PB)	Sep. 30, 2019
Laudes Foundation	Sustainable materials manager	Luciana Batista Pereira	São Paulo (SP)	Oct. 9, 2019
Flavia Aranha	Founder	Flavia Aranha	São Paulo (SP)	Apr. 17, 2020
Brazil Eco Fashion Week	Co-founder and Creative Coordinator	Ana Paula Sudano Freitas	São Paulo (SP)	Sep. 21, 2020

Source: Larissa Oliveira Duarte, 2020**.**

5.2.3. Technical visits and observational analysis

The technical visits in the textile industry and retail complement the interviews information with observation and field analysis (**Chart 10**). The purpose of the visits is to have more information about the production processes, operations, machinery, logistics network and market.

Chart 10 - Technical visits for observational analysis.

Textile (spinning and weaving)				
Organization	**Category**	**Visit Description**	**Location**	**Date**
Associação de Mulheres Quilombolas de Catuti	Group of Cotton producers and artisans	Explained the processes of handcraft agroecological cotton ginning, spinning and weaving.	Malhada Grande (MG)	Oct. 4, 2018
Institute SENAI (Textile and Clothing Production)	Technology Institute	Explained all the sections of the textile industry, from spinning to designing and producing the clothes. They are spinning organic cotton for medium size clothing brands.	João Pessoa (PB)	Oct. 4, 2019
Unitêxtil	Weaving industry	Transforms the yarn into textile.	João Pessoa (PB)	Oct. 4, 2019.
Retail observational analysis				
Organization	**Function**	**Description**	**Location**	
João Pessoa city market	Retail	Observation and interaction with sales assistant considering organic cotton products.	João Pessoa (PB)	Oct. 3, 2019
Vila do Artesão	Retail	Observation and interaction with sales assistant considering organic cotton products.	João Pessoa (PB)	Sep. 24, 2019.

Source: Larissa Oliveira Duarte, 2020.

The observation firstly considered the technical aspects regarding organic cotton spinning and weaving. Also considered aspects related to organic cotton and organic certification understanding and communication in retail.

5.2.4 Lecture attendance at Brazil Eco Fashion Week

Textile Exchange lecture in the event Brazil Eco Fashion Week was attended (November, 2019).

Brazil Eco Fashion Week is an annual event whose first edition was in 2017. The event promotes sustainability practices in the Brazilian fashion industry and market,

presenting content, fashion shows, sales markets, exhibitions and entrepreneurial activities. The event is free of charge, open to the public and it is organized into four main thematic areas: (1) **content -** lectures, talks and workshops; (2) **innovation in products and materials**, (3) **entrepreneurship activities** and (4) **fashion shows**. The contents show relevant topics, such as organic crops, material certifications, conscious consumption, upcycling techniques, textile recycling, business models for circular fashion and collaborative fashion, transparency practices, diversity and fair trade.

Textile Exchange is the international NGO responsible to develop international reports on organic cotton in the world. The lecture attendance of Textile Exchange in Brazil Eco Fashion Week (2019) was especially important, as it was presented accurate data and perception focused in the organic cotton Brazilian production (**Chart 11**).

Chart 11 - Organic cotton lecture presented by Textile Exchange in Brazil Eco Fashion Week (2019).

Lecture at Brazil Eco Fashion Week November 18, 2019			
Organization	**Theme**	**Name**	**Location**
Textile Exchange (NGO)	"Sustainable Conference Vancouver 2019"	Silvio Moraes (Latin America Ambassador)	São Paulo

Source: Larissa Oliveira Duarte, 2020.

5.2.5 Annual Reports analysis

Several annual reports from relevant international institutions were analyzed in order to offer a market perspective into challenges and opportunities of organic cotton in Brazil, contemplating organic cotton from the fiber production to fashion perspectives.

The World Business Council for Sustainable Development explains that sustainability reports are "public reports by companies to provide internal and external stakeholders (actors) with a picture of the corporate position and activities on economic, environmental, and social dimensions" (KOZLOWSKI et al., 2015). The reports contain details on sustainable supply chain management, design practices, business innovation, consumer engagement, product sustainability and market perspectives.

Considering cotton, multiple indicators focus on the use of environmentally friendly material, examples of these indicators include "use organic cotton", "code of conduct for supplier" and "member of fair trade labor association" (KOZLOWSKI et al., 2015). Increasingly apparel brands are choosing to share details on their sustainability

initiatives in public available reports. Sustainability reporting may be done through a variety of mechanisms, such as corporate web sites, reporting integrated with annual financial reporting, or sustainability reports. For this study, the selected reports were listed in **Chart 12**.

Chart 12 - Summary of selected Annual Reports.

Organization/ Report Year	Description
Textile Exchange (2020)	Global non-profit working to drive industry transformation in preferred fibers, integrity and standards. A global non-profit organization that works closely with its members to drive the transformation of the fiber industry. Identifies best practices in relation to agriculture, materials, processing, traceability and product lifecycle in order to reduce the impact of industry in water, soil and air, and in the human population. The reports contain market and customers relevant information, also multiple aspects on the global supply.
Ellen MacArthur Foundation and Circular Fibers Initiative (2017)	Develops and promotes the idea of a circular economy. We work with, and inspire, business, academia, policymakers, and institutions to mobilise systems solutions at scale, globally. Our mission is to accelerate the transition to a circular economy. The Circular Fibers Initiative aims to catalyse change across the industry by creating an ambitious, fact-based vision for a new global textiles system, underpinned by circular economy principles, that has economic, environmental, and social benefits, and can operate successfully in the long term.
The Boston Consulting Group and Global Fashion Agenda (2018)	Global management consulting firm. The firm is one of the world's three largest strategy consulting firms by revenue, often considered by some to be the most prestigious firms in the management consulting industry. Global Fashion Agenda's work as a thought leader is further evident in the insightful reports it produces throughout the year. It is also leading the event leading business event on sustainability in fashion, the Copenhagen Fashion Summit.
Brazilian Association of Textile Industry - ABIT (2019)	The association is one of the most important entities among the economic sectors in the country. It represents the productive force of 27.5 thousand companies installed throughout the national territory.
Global Fashion Agenda and Mckinsey & Company (2020)	Global Management consulting firm. Help leaders in the commercial, public, and social sectors develop a deeper understanding of the evolution of the global economy.
Fashion Revolution Brasil (2019)	NGO working with diverse projetcs, related to education and accontability, aiming to support a more sustainable fashion industry. Related with the global moviment Fashion Revolution Foudation, based in London.

Source: Larissa Oliveira Duarte, 2020.

5.3 Data analysis and interpretation

Data analysis adopted prescribed analytical techniques to move from raw data to theoretical interpretations, iterating among data collection, analysis, and existing literature to generate insights (LANGLEY, 1999; EISENHARDT et al., 2016; GEHMAN

et al., 2018; SMITH; BESHAROV, 2019). Since this process was not linear, main steps were defined. It was developed a multi-actors case study that integrated the various sources of data.

In the first preliminary data analysis, it was presented a context of organic cotton in Brazil, with a timeline of significant events and previous projects involving organic cotton. The mains producers' states, Ceará and Paraíba, and the north of Minas Gerais state were considered.

Considering the elements and systematization obtained from the preliminary analysis, a second one was performed. It consisted in the identification of the main actors in the organic cotton network in Brazil and the dynamics they participate. **Dynamics in the present study means the interaction driving into a certain group of actors** (BATISTA DA SILVA, 2019). In this way, considering information from the literature, the interviews and annual reports, they were identified six main dynamics of organic cotton production in Brazil (**Chart 13**).

Chart 13 - Organic cotton dynamics in Brazil and its main actors.

Dynamic	Main participants
I	Veja, ESPLAR, ADEC.
II	"Program Cotton in Agroecological Consortia": Embrapa Cotton, Laudes Foundation, Diaconia, Arribaçã.
III	"Paraiba Cotton Project": EMPAER, Embrapa Cotton, Coopernatural, Norfil, Rede Santa Luzia.
IV	Natural Cotton Color, UNITEXTIL, SENAI, Flavia Aranha.
V	"Project +Cotton": FAO (Food and Agriculture Organization of the United Nations) and the Brazilian Ministry of Foreign Affairs' Brazilian Cooperation Agency (ABC/MRE)
VI	Justa Trama, ADEC, Univens.

Source: Larissa Oliveira Duarte, 2020.

The third analysis presented the challenges and perspectives of organic cotton network in Brazil, based in the data collect from the interviews, technical visits, lecture and reports evaluation (detailed in **Charts 9-12**).

The final analysis, consists of the organic cotton network evaluation, considering the aspects of density and centrality (descripted in **section 4.5.1**). Density and centrality network analysis was based in the Network Theory previously developed in the literature review. It was developed a list of actors and showcased the network using the platform GEPHI (gephi.org).

According to Freeman (2004), a social network analysis (SNA) is based on the study of the links between the participating actors. It is being used increasingly to help understand the structure and function of these networks and to measure how they influence the creation and sharing of knowledge. Traditional quantitative approaches to SNA are currently being augmented with qualitative data that are used in a complementary fashion. These approaches are being used to better understand how knowledge sharing within a network can help build shared values, promote social learning, build social capital, and lead to innovation (SIMPSON, DE LOË, 2017).

5.4 Designing the network

Initially, through the literature review, it as possible to start the identification of the organic cotton main actors in Brazil. Especially considering the publications of Lirborio (2017), Azevedo (2018), Ferraz (2018) and Cardoso (2018). However, considering the complexity of the process from the fiber to the market and still the inconsistence of the organic cotton production system, the information was varying, especially those related with some steps of the textile sector (spinning and weaving). The network was designed according with all data collected and analyzed in the present study.

It was utilized the platform GEPHI to design the organic cotton network in Brazil, considering the actors' information exchange. GEPHI is an open-source network analysis and visualization software package written in Java on the NetBeans platform (gephi.org). For the network design in GEPHI, it was utilized the *Fruchterman-Reingold* algorithm. It was taking in account the numbers of interactions between the actors and when it is lacking connections, this constitutes a gap or structural hole. In addition, the network was organized using the "degree of output" (the sending of data by the actor), the number of connections that leave from one node to another. According with the number of actors' connections, the circle representing each actor is bigger and greener.

GEPHI software was feed by data from two Excel (Microsoft) files. The first one contains the list of the network actors and each actor corresponds to a number. In this way, for the present study, the actors were identified without interruption by numbers from 1 to 82. The second, presents the relationships between one specific actor and others. In the case of the present study, 469 were identified (these relationships are indicated by a line).

6. RESULTS AND DISCUSSION

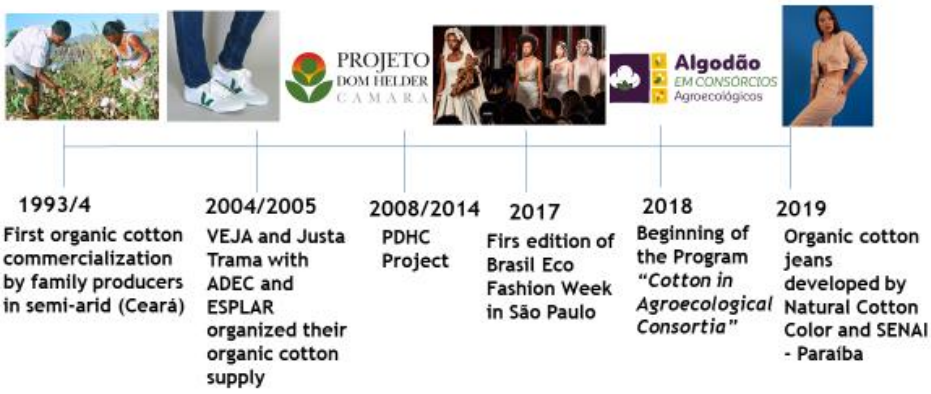
6.1 Organic cotton in Brazil

The research identified the main actors of the organic cotton network in Brazil. They started to be descripted in **Chart 9** and their detailing was expanded and improved in **section 6.2** (**Chart 14**). In this way, the meaning of all acronyms employed hereafter can be found there.

The production started in the 90s, motivated by the NGO ESPLAR, responsible for technical assistance actions for agroecological cultivation, training and exchanges of experiences between Brazilian Northeast semiarid producers (LIMA, 2008). However, investment, promotion, management to scale development and further logistics support are still lacking.

Organic cotton in Brazil is produced by smallholders, cultivating in agroecological model in the states of Ceará, Paraíba, Rio Grande do Norte, Pernambuco, Piauí, Sergipe and Alagoas. Paraíba and Ceará were the first states producing organic cotton and today they have a better structure and general production management. Producers are selling mainly to the fashion brands VEJA, Organic Cotton Color (OCC), Natural Cotton Color (NCC), Justa Trama and Coopnatural. Even with an incipient production chain in Brazil, the market for organic cotton products should continue to grow (DA CUNHA; DE OLIVEIRA, 2019). **Figure 37** summarizes main events concerning organic cotton in Brazil.

Figure 37 - Timeline of the development organic cotton in Brazil principal events.



Source: Larissa Oliveira Duarte adapted from ESPLAR, 2016.

The family farming system begins to attend a scaled demand - on average, producing 1,200kg of cotton per hectare, strengthening agricultural communities (LEITE, 2020). Textile Exchange (2019; 2020a) presented the following information in their annual report, considering the Brazilian organic cotton production in the last years (**Table 5)**.

Table 5 - Organic cotton production in Brazil (2017 to 2019) – total and under PGS (Participative Guarantee System)

Metrics	2017-2018	2018-2019
Planted area	619 ha (358 ha PSG)	2,072 ha (1,685 PGS)
Number of family farmers	930 (700 PSG)	1,903 (707 PGS)
Organic cotton production	22 tons (13 tons PSG)	97 tons (43 tons PGS)
Area planted in the process of organic transition	318 ha (30 ha PSG)	527 ha (195 ha PGS)

Source: Larissa Oliveira Duarte, based in TEXTILE EXCHANGE, 2019; 2020a.

Even thought, the organic production represents last than 1% of the total amount of cotton production in the country, there is a good grown expectation. Brazilian organic cotton production expanded almost 5 times in the last seasons, from 22 tons to 97 tons. And the fiber (mt) year on year grown increased 335%. (TEXTILE EXCHAGE, 2020a).

6.1.1 Project "Dom Helder Camara" – Initial Brazilian support to implement the organic cotton network

This section was developed from information and analysis considering the literature review and the interviews with the main actor of the organic cotton network in Brazil (**chart 9**), detailed in the Research Methods (**section 5**)

In the early 2000s, resources were directed from FIDA (International Fund of Agricultural Development) for projects aimed at reducing poverty and social inclusion of rural producers, including the Dom Helder Câmara Project (PDHC). Encouraged by programs developed in this conjuncture, many NGOs started to dedicate to support smallholders, also with EMBRAPA Cotton, ESPLAR, ADEF and the VEJA (FERRAZ, 2018).

According interview carried out with Ricardo Menezes Blackburn (Diaconia NGO – PE – Sep 25, 2019): "We had the mission with PDHC project to generate reference

for public policies. It was a government project, so we created this environment of contributions, several institutional contributions, to generate a model for the development of agroecological cotton in the semiarid region. We started in five states, with 30 people in each state. Rio Grande do Norte, Pernambuco, Paraíba and two groups in Ceará. Here in Paraíba we made a field for seed multiplication. And we thought of integrating with the national biodiesel program, which was something that was in fashion at the time. And we identified that a seed variety containing oil, BRS Aroeira. A variety that adapted well to the climate of the region. It was not simple to make biodiesel logistics viable, it was one of the problems that remained. There was no chain integration. Until today we use the same seed variety, it is of medium fiber, but it manages to make a comfortable yarn for knitting. With the changes in government the project with FIDA changed. And the actions did not continue, many people left. We worked with these producers until 2014".

With the end of the PDHC in 2014 and the drastic reduction of resources, there was a demobilization support groups and finally the major challenge was the producers' development and engagement independently from the project. To meet the growth in organic cotton demand, it was necessary to increase the cultivated area by entering of new families in the project. However, the introduction from other producers always requires additional staff to account for the training and follow-up tasks technical, which implies the availability of more features (LIMA, 2008).

6.1.2 Ceará and Paraíba Brazilian states: the main producers

This section was developed considering the literature review.

6.1.2.1 Ceará

Between 1990 and 1996, ESPLAR implemented the Research and Development project "Ecological management of cotton mocó (*Gossypium hirsutum* L. r. marie galante Hutch.) aiming at living with the boll weevil". This project included family of producers from different municipalities in the Ceará state and it was based in agroecological management. It was also supported by the Educational Development Association and Cultural from the municipality Tauá (ADEC) (BELTRÃO et al., 2009).

The cotton is intercropped with corn (*Zea mays*), string beans (*Vigna unguiculata*), sesame (*Sesamum indicum*) and pigeon pea (*Cajanus cajan*), and other

food. The stimulus to polyculture has the objective of increasing the productive alternatives and the economic flexibility of family systems, while reducing the risks of crop losses due to lack or excessive rainfall, pests or other adverse factors. According to the practice observed in ESPLAR projects, only 50% of these areas produce cotton; the other areas are destined for other cultures. Fiber harvesting is manual, using family and contracted labor. In the early 2000s, funds were allocated to projects aimed at reducing poverty and social inclusion of rural producers, including the Dom Helder Camara Project (PDHC) (MAIA et al.,2016).

The experience with agroecological cotton in Ceará became a reference for organizations of family agriculture in the semi-arid region of Ceará and Northeastern NGOs, research centers and fair-trade companies, who visit it to learn about work in progress and their results (LIMA, 2005).

6.1.2.2 Paraíba

The color fiber cotton is being produced on a commercial scale in the state of Paraíba, involving small producers with areas between 1.0 and 3.0 hectares. The chain of this cotton in Paraíba, which is already a state regional product, is in a marked process of organization, with 9 confections led by Natural Cotton Color, and guaranteed market for Europe and other regions of the world. Colored cotton to be considered organic, must follow the agriculture standards (BELTRAO; CARVALHO, 2004; SOUZA, 2000a).

The studies carried out attest to the importance of the aid and partnership of the NGO Arribaçã and EMBRAPA Cotton which aim to stimulate the resumption of cotton cultivation in the Paraiba region, facilitating this agricultural practice in family groups as a way to promote development of activities focused on agroecological actions (**Figure 38**).

Figure 38 - (a) Organic colored cotton cultivated with corn and beans at Paraiba, family farming and agroecology practices **(b)** colored cotton harvesting.

(a) **(b)**

Source: LIRBORIO, 2017.

Several aspects can be raised when it comes to the importance of such activity for the region, from the generation of jobs, to the way in which natural resources are used to obtain the product, which, because it has the support of NGOs and government agencies, has its marketing assured (DA SILVA et al.,2010).

The production chain for colored cotton in Paraíba as follows: planting; harvesting and processing (family farming); transformation (spinning, weaving, crafts and final product). In 2011, to motivate the production and commercialization it was created a "Management Committee of the Local Productive Cluster of Clothes and Artifacts of Colored Cotton in the State of Paraíba". Including micro-entrepreneurs, producers and their organizations, as well as support institutions, embroiderers and artisans distributed among municipalities in the Cariri and Agreste regions of Paraíba. Much of this production is destined for international markets, mainly Germany, Canada, Denmark, United Arab Emirates, United States, France and Japan (AZEVEDO, 2018).

Azevedo (2018) concluded that the perception of participants in the colored cotton cluster in Paraíba faces some governance and organization problems and the market is still recent. In addition, organic certification is important to add value to the product, because it attracts consumers who are concerned with sustainable way of production.

6.1.3 Smallholders producers of agroecological and BCI cotton in the North of Minas and South of Bahia

This section was developed considering the technical visits and interviews (September 2018 – October 2019) detailed in the **Section 5.2.3.**

Catuti is a small city located in the north of Minas Gerais state, with around 6,000 people. The region is well known for the cotton production as it is one of the main economic activities in the area, connected with the very structured traditional textile industry in the state. The city and villages around are all involved with cotton cropping cultivating Bt cotton by smallholders (**Figure 39**). COOPERCAT is the producers' organization offering technical support in the field and to access the market. They have the support of the NGO Solidaridad, that are also partners with ABAPA (Associação Baiana dos Produtores de Algodão); AMIPA (Associação Mineira dos Produtores de Algodão; Coopercat); Cooperativa dos Produtores Rurais da Catuti; Federal University of Lavras and IBA (Instituto Brasileiro do Algodão). The project with Solidaridad is from 2015 to 2021 and concerns to develop a model of sustainable cotton adapted to family

farming in the semiarid region, which, among other objectives, attracts companies in the textile sector, with strong insertion in national and international markets, so that family producers become their suppliers. Another important point is the possibility of systematizing the experience in a model that can be replicated in other regions of Brazil and in other countries, especially in Africa (SOLIDARIDAD, 2020).

Figure 39 - Coopercat cooperative of cotton producers: **(a)** and **(b)** ginning stages (Bt cotton) and **(c)** baling the cotton around 200kg to go to the industry named FITECA (MG).

(a) **(b)** **(c)**

Source: Larissa Oliveira Duarte, 2018.

In other hand, the "Comunitary Quilombola Woman Association in Malhada Grande" - Associação Comunitária das Mulheres Quilombolas da Comunidade de Malhada Grande - is cultivating agroecological cotton. They are residents of a quilombo, Brazilian countryside settlement founded by people of African origin (RIBEIRO DOS SANTOS et al., 2019). In 2017-2018 they had a support from Instituto Lojas Renner. From the incentive requested by the project, it was possible to better organize the work of the group of women, acquire necessary machinery and even expand an idea to nearby communities, involving, approximately 80 women (INSTITUTO LOJAS RENNER, 2018).

This woman association was cultivating agroecological cotton, and processing the lint in a handcraft traditional way: manually cleaning the lint, producing the yarn employing a spinning wheel and the final product was woven in traditional hand loom to produce cotton handbags (**Figure 40**).

Figure 40 - (a) Community Quilombola Woman Association in Malhada Grande handcraft cotton transformation: cleaning the lint; **(b)** manual spinning wheels: artisan spinning the cotton lint, **(c)** final products cotton yarns and cotton fabric manual woven.

(a) **(b)** **(c)** **(d)**

Source: Larissa Oliveira Duarte, 2018.

In 2018, the research object was the smallholders agroecological cotton producers in the north of Minas Gerais (Malhada Grande, a community about 40 km from Catuti municipality). In the visit to the local, it was observed the need of a well-established production system and a better organizational structure from the agroecological cotton producers. At the same time, it was observed how well organized and prepared they were the smallholders BCI cotton producers, in terms of infrastructure, technical support, logistics, production management and market accessibility. In 2019, when the research interviews were planned to happened, the agroecological cotton producers unfortunately lost their leader, thus the contact, the accesses to the community and the communication with the group got very difficult. As the leader was doing the broker role, in connecting the network actors. In this way it was not possible to interview the agroecological cotton group of producers and artisans there. It is relevant to point out the role of the cooperative leader here. Reed and Hickey (2016) affirm that knowledge and innovation spread, in the formal cooperative structures, through predominantly vertical linkages where highly connected actors, generally leaders, acted as intermediaries between high-level partners (governments, markets and others) and the cooperative members.

Therefore, there were realized interviews with the coordinator of the cooperative Coopercat from smallholders producing BCI cotton and in addition with the coordinator of the international NGO Solidaridad, supporting the producers. The goal was to understand their challenges and advantages related to organic cotton.

According the interview carried out with José Tibúrcio de Carvalho Filho (COOPERCAT - MG - Oct. 25, 2019) regarding the challenges and perspectives of BCI

cotton production for smallholders: “A great challenge is facing the market, the instability of prices, changes in world's demand, international competition. The cotton situation is a commodity. The challenge is to keep producers in a position to compete, and how to do that, introducing improvements such as certification and best practices. A positive aspect is the cooperative. So whoever buys our product wants to know the quality of our cotton and it is up to the producer to produce the best cotton, for the best price and profitability”.

Conforming the interview carried out with Jessica Liu (Solidaridad NGO - SP – Nov. 05, 2019): “The conventional producer manages to make, on average, 100 arrobas per hectare. Organic is doing 15. There is a huge productivity difference, obviously the price pays off. Because we sell ours for R $ 36 and they were selling for R $ 300. Ten to one, it pays off. The question is, retailers do not want to pay organic prices, with the pressure of fast fashion they cannot buy”.

Bt cotton cultivation is very organized and assisted. While the organic demands support, machinery integration with textile industry and market. It seems still a challenge to include the small family producers in the network, especially to integrate them with the market.

Thus, the Bt cotton is being promoted as a more sustainable cotton or “better cotton”. Considering the limitations of both conventional and organic agriculture, scientists and policymakers are arguing for the promotion of an alternative agriculture that can enhance environmental, social and financial sustainability of conventional agriculture (FAO, 2003). The findings of scientific studies have revealed that crop yield sand profits can be maintained by even reducing the amounts of inputs used (ABRAHAM et al., 2014). Nearly all cotton worldwide continues to be produced conventionally and that a large-scale transition to organic production is therefore unlikely to happen quickly (ILLGE; PREUSS, 2012).

6.2 Organic Cotton - Mapping the main actors and their dynamics

Identifying and mapping actors and its direct or indirect interactions and values, it is possible to visualize different social organizational scenarios, evolving clients, suppliers, infrastructure, material, production methods, logistics, and other various elements (MORELLI, 2006). The main actor of organic cotton network in Brazil are indicated in **Chart 14**. This mapping was developed based in the information collected in the literature review, interviews and technical visits, beginning with the actors

mentioned in **Charts 9, 10** and **13,** and being expanded and developed based in Oliveira-Duarte et al., (2020).

Chart 14 - Identifying and describing organic cotton main actors in the Brazilian network and their roles.

FARM		
Empresa Brasileira de Pesquisa Agropecuária – Algodão (EMBRAPA Cotton) https://www.embrapa.br/en/algodao	Brazilian government research agency. This unite in special concerns the crops cotton, castor, peanut, sesame and sisal. Develops research and innovations in the areas of genetic improvement, biological control, biotechnology, agricultural mechanization, quality of cotton fibers, plant health, among others. Provides knowledge and innovation, offering capacity building in producers' organizations; Acts as an agent in cotton marketing; Shares information; Edits books and papers; Co-promotes the new organic cotton project with Laudes Foundation; Co-edits technical and economic references on organic cotton; Field-level Intervention; Seed breeding; Field capacity building & training; Producers education & awareness raising.	PB
Rede Borborema https://www.facebook.com/Rede-Borborema-de-Agroecologia-101095914863290	Family producers' association. Organizes and arranges famers; Seed breeding; Field capacity building & training; Cotton cultivation/processing; Supports internal control system setting and participative organic certification.	PB
Associação Agroecológica de Certificação Participativa do Cariri (ACEPAC) https://www.facebook.com/certificacao.participativa.1	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	PB
Arribaçã https://pt-br.facebook.com/pg/arribaca/posts/?ref=page_internal	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	PB
Margarida Maria Alves (rural settlement)	Producers' families' association. Organizes and arranges famers; Seed breeding; Field capacity building & training; Cotton cultivation/processing; Supports internal control system setting and participative organic certification.	PB
Programa de Aplicação de Tecnologias Apropriadas (PATAC) http://patacparaiba.blogspot.com/2019/	Family Agriculture advisory entity in agroecological transition. Field-level Intervention.	PB
Agricultura familiar e agroecologia (AS-PTA) https://aspta.org.br/	Agroecology association. Field-level Intervention; Education & awareness raising.	RJ, PB, PR
Empresa Paraibana de Pesquisa e Extensão (EMPAER) http://www.empaer.mt.gov.br/	State research agency. Provides knowledge and innovation, offering capacity building in producers' organizations; Informing & Convening; Field-level Intervention	PB
Associação de Agricultores e Agricultoras Agroecológicos do Araripe (ECOARARIPE)	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton	PE

	cultivation/processing/ginning; Field capacity building & training.	
Associação Agroecológica do Pajeú (ASAP)	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	PE
Associação dos Produtores Agroecológicos do Semiárido Piauiense (APASPI) https://pt-br.facebook.com/apaspi	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	PI
Associação de Certificação Orgânica Participativa do Sertão do Apodi (ACOPASA) https://www.facebook.com/profile.php?id=100010949138794	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	RN
IMAFLORA https://www.imaflora.org/	NGO, offering technical support concerning certification. strengthen OPACS and market relationship maturity level.	SP
COOPERATERRA	Family producers' association. Organizes and arranges producers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	SE
Centro Dom José Brandão de Castro	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	SE
Instituto Palmas	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	SE
Colegiado Territorial do Alto Sertão Alagoano	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	AL
COOPABACS	Family producers' association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	AL
Sindicato de Trabalhadores rurais de Serra Talhada	Farmers groups working for workers' rights. Offer technical and local support.	PE
Secretaria da Agricultura Serra Talhada	Management of administration activities in general.	PE
Federação do Trabalhadores Rurais (FETAPE) https://www.fetape.org.br/#	State organization. Representing and organizing rural workers, with a view to sustainable and supportive rural development, contributing to the improvement of the quality of life and a fair society.	PE
Caatinga	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	PE

Chapada	Brazilian NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	PE
Sindicato de Trabalhadores rurais de Apodi (RN)	Syndicate. Farmers groups working for workers' rights. Offer technical and local support.	RN
Universidade Federal de Campina Grande (UFCG)	University. Offer technical and technological support; Access to resources and knowledge; Informing & Convening; Education & awareness raising.	PB
PROCASE http://portalsemear.org.br/fida/projeto-procase-paraiba/	Estate organization financing agricultural projects supported by Brazilian government and FIDA.	PB
Cooperativa Rural de Desenvolvimento Sustentável (COOPAPI) http://coopapi.blogspot.com/	Producers group commercializing different products. Offer management and local support.	RN
Secretaria da Agricultura Umarizal	Town secretary. Management of administration activities in general.	RN
Sindicatio de Trabalhadores Rurais e Agricultura Familiar de Janduis (SINTRAF)	Syndicate. Producers groups working for workers' rights. Offer technical and local support.	RN
Sindicato de Trabalhadores Rurais de Apodi (RN)	Syndicate. Producers groups working for workers' rights. Offer technical and local support.	RN
Associação de Agroecologia Oeste Verde (AAOEV)	Producers groups working with agroecological support. Offer technical and local support.	RN
Sindicato de Trabalhadores rurais Umarizal (RN)	Syndicate. Producers groups working for workers' rights. Offer technical and local support.	RN
Secretaria da Agricultura de Umarizal	Town secretary. Management of administration activities in general.	RN
Prefeitura São Raimundo Nonato	Administrative head of local community.	PI
Prefeitura Dom Inocêncio	Administrative head of local community.	PI
Universidade Federal Vale do São Francisco (UNIVASF) https://portais.univasf.edu.br/	University. Offer technical and technological support; Access to resources and knowledge; Informing & Convening; Education & awareness raising.	PI
IFPI São Raimundo Nonato http://www.ifpi.edu.br/saoraimundononato	Federal institute. Technical advisory. Offer technical and local support; Capacity building;	PI
Secretaria de Agricultura Familiar do estado do Piauí https://www.pi.gov.br/orgaos/secretaria-de-estado-da-agricultura-familiar-seaf/	State secretary. Management of administration activities in general	PI
Sindicato São João de Piauí	Syndicate. Producers groups working for workers' rights. Offer technical and local support.	PI
Programa de convivência no Semi-árido do estado do Piauí (PPCSA)	State government program to support families in the semi-arid, offering social and economic support.	PI
Cáritas Diocesana de São Raimundo Nonato http://caritas.org.br/	NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	PI
CELTA – Paulistana (Centro de Estudos Ligados a Técnicas Alternativas) https://pt-br.facebook.com/pages/category/Non-Governmental-Organization--NGO-/CELTA-266955856777798/	NGO. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	PI

Associação de Desenvolvimento Econômico e Cultural (ADEC)	Producers ‘association. Organizes and arranges famers; Seed breeding; Field capacity building & training; Cotton cultivation/processing; Field-level Intervention.	CE
Associação de Certificação Participativa Agroecológica (ACEPA)	Producers’ association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	CE
Associação Agroecológica de Certificação Participativa Inhamuns/Crateús (ACEPI)	Producers’ association. Organizes and arranges famers; Supplies posters; Supports internal control system setting and participative organic certification; Logistics and transports. Cotton cultivation/processing/ginning; Field capacity building & training.	CE
Universidade Federal do Ceará	University. Offer technical and technological support; Access to resources and knowledge; Informing & Convening; Education & awareness raising.	CE
Centro de Pesquisa e Assessoria (ESPLAR) https://esplar.com.br/	Technical advisory. Seed breeding; Field capacity building & training; Cotton cultivation/processing; Field-level Intervention; Education & awareness raising.	CE
Associação Escola Família Agrícola da Fronteira (AEFAF)	Group of smallholder and family farmers, working with more sustainable agriculture practices.	MT
COPABASE https://www.copabase.org/	Group of smallholder and family farmers, working with more sustainable agriculture practices.	MG
Diaconia http://bemvindo.diaconia.org.br/	Brazilian NGO. Provides knowledge and innovation; Offering capacity building in farmers’ organizations; Informing & Convening; Field-level Intervention; Supply Chain Intervention.	PE
Universidade Federal Sergipe http://www.ufs.br/	University. Offer technical and technological support; Access to resources and knowledge; Informing & Convening; Education & awareness raising.	SE
Universidade Federal Piauí https://www.ufpi.br/	University. Offer technical and technological support; Access to resources and knowledge; Informing & Convening; Education & awareness raising.	PI
Instituto Sociedade População e Natureza (ISPN) https://ispn.org.br/	Brazilian NGO. Works for social-environmental development, through the strengthening of sustainable livelihoods and strategies for adapting and mitigating climate change and supporting traditional communities.	
Ministério da Agricultura (MAPA) https://www.gov.br/agricultura/pt-br	Minister of Agriculture. Offer participatory certifications regulations and support; Standards/Chain of Custody.	DF
FAO (South-South Cooperation Project +Cotton) http://www.fao.org/in-action/program-brazil-fao/projects/cotton-sector/en/	The project works with technical innovations and sustainable production, through improvements in crop management, efficient use of resources, IPM, crop rotation, soil analysis, growth control, and efficient irrigation systems, among others.	DF
Associação Brasileira de Assistência Técnica e Extensão Rural (ASBRAER)	Brazilian Association of Technical Assistance and Rural Extension Companies. Technical advisory. Offer technical and local support; Capacity building; Field-level Intervention; Seed breeding; Field capacity building & training; Education & awareness raising.	DF
Associação Brasileira de Pordutores de Algodão (ABRAPA) https://www.abrapa.com.br/Paginas/default.aspx	Brazilian association of Cotton Producers. Works for profitability of the sector through the union and organization of its agents and seek strategic sustainability, acting politically, socially and economically with the public and private sectors	DF
Subsecretaria Nacional da Economia Solidária e Ministério do Trabalho National	National Sub secretary of Solidarity Economy of the Ministry of Labor. Management of administration activities in general.	MT

(SENAES-MT)		
	TEXTILE INDUSTRY	
Norfil http://pt.norfil.com.br/	Spinning Industry (transforming fiber into yarn).	PB; SP
Unitextil http://www.unitextil.com.br/	Weaving Industry (transforming yarn into textiles).	PB
Serviço Nacional de Aprendizagem Industrial de Tecnologia Têxtil e Confecção (SENAI – Textile and Clothing) http://institutostecnologia.senai.br/	Technology Institute. Spinning, Market making Market research & analytics; Informing & Convening.	PB
Bercamp Têxtil LTDA http://bercamp.com.br/	Spinning Industry (transforming fiber into yarn).	SP
Saltorelli do Brasil LTDA http://www.saltorelli.com.br/	Weaving Industry (transforming yarn into textiles).	SP
Menegotti http://www.menegotti.com.br/	Weaving Industry (transforming yarn into textiles).	SC
EuroRoma/ EuroFios http://euroroma.com.br/quem-somos	Spinning Industry (transforming fiber into yarn). It is the largest producer of ecological yarns and threads in Brazil.	SC
Cooperativa Unidas Venceremos (UNIVENS)	Seamstress cooperative. Artisans group manufactures clothes, silkscreen, embroidery and dyeing.	RS
	FASHION BRANDS	
VEJA/VERT https://www.veja-store.com/en_us/	French Shoes Company. Provide scale-up process and knowledge management in the organic cotton network; Has a large network and vast resources; Market education & awareness raising; Raises awareness of sustainability in textiles and clothing and among traders and general public in Brazil and internationally.	CE
Organic Cotton Colours (OCC) https://organiccottoncolours.com/en/	Clothes Company. Provide scale-up process and knowledge management; Large networks and vast resources; Market education & awareness raising.	PB
CoopNatural	Cooperative. Provide scale-up process and knowledge management; Large networks and vast resources; Market education & awareness raising; Supply Chain Intervention.	PB
Natural Fashion http://www.naturalfashion.com.br/site/	Clothes Company. Provide scale-up process and knowledge management; Large networks and vast resources; Market education & awareness raising; Supply Chain Intervention	PB
Natural Cotton Color (NCC) https://www.naturalcottoncolor.com.br/	Clothes Company. Provide scale-up process and knowledge management; Large networks and vast resources; Market education & awareness raising; Supply Chain Intervention.	PB
Ecosimple https://ecosimple.com.br/	Sustainable Textiles producer and retailer. Partner of NCC. Market education & awareness raising; Supply Chain Intervention.	SP
Santa Luzia https://www.redesantaluzia.com.br/	Home wear, decoration and textiles company. Provide scale-up process and knowledge management; Large networks and vast resources; Market education & awareness raising; Supply Chain Intervention	PB
Flavia Aranha https://www.flaviaaranha.com/	Clothing production and retail. Partner of NCC. Market education & awareness raising; Supply Chain Intervention.	SP
Central Veredas https://www.centralveredas.com.br/	Group of artisans. Cultivate organic cotton, thread spinning, weaving, natural dying and producing handcrafted products.	MG
Justa Trama https://www.justatrama.com.br/	Association working with artisans, seamstress, weavers, and clothing producers. Commercializing organic	RS

	cotton textile and clothing. Motivating fair trade. Market education & awareness raising; Supply Chain Intervention.	
Arte Natural Casulo	Handbag brand.	PB
MARKET		
Brazil Eco Fashion Week https://brasilecofashion.com.br/	First event relating sustainability and the textile sector in Brazil. Promoting brands; Offering lectures; Market education & awareness raising; Supply Chain Intervention.	SP
Instituto Lojas Renner https://www.institutolojasrenner.org.br/pt_br/pagina-inicial	Social organization. Supply Chain Intervention; Education & awareness raising.	SP
Sustainable Fashion Lab https://www.labmodasustentavel.org.br/	Innovation lab to integrate network actors. Supply Chain Intervention; Market research & analytics Multi-stakeholder platform.	SP
Laudes Foundation (former C&A Foundation) https://www.laudesfoundation.org/br?_ptr=1	International NGO. Financial support; Improving the business case for growing organic cotton; Promoting best practices throughout the organic cotton supply chain; Improving integrity and market transparency. Organizations; Organizes cotton marketing; Co-promotes a new organic cotton project; Supply Chain Intervention; Education & awareness raising.	SP
ECOCERT http://brazil.ecocert.com/index/	Standards/Chain of Custody.	SC
IBD https://www.ibd.com.br/customers/	Standards/Chain of Custody.	SP
Textile Exchange https://textileexchange.org/	International NGO. Field data & analytics Development; Supply Chain Intervention; Market research & analytics; Multi-stakeholder platform; Education & awareness raising.	RS
ABIT/APEX https://www.abit.org.br/ https://portal.apexbrasil.com.br/	Brazilian Association of the Textile and Clothing Industry / Brazilian Export and Investment Promotion Agency	SP

Source: Larissa Oliveira Duarte adapted and extended from OLIVEIRA-DUARTE et al., in press.

It can be noticed that the number of actors observed participating in the farm sector is higher than the others contributing in the textile industry, fashion brands and market. **Figure 41** overlooks and summarizes the process of organic cotton in Brazil, from the field to clothing, in a panorama of activities.

Figure 41 - (a) Cotton lint; **(b)** Cotton farming in Queimadas rural settlement – Rede Borborema location; **(c)** Cotton ginning in rural settlement Margarida Maria Alves; **(d)** EMBRAPA Cotton lab of fiber quality analysis in Campina Grande; **(e)** SENAI spinning the fiber in São Pessoa; **(f)** Unitextil weaving the textile in João Pessoa; **(g)** Natural Cotton Color textile **(h)** Natural Cotton Color tag in partnership with EMBRAPA Cotton; **(i)** and **(j)** Flavia Aranha clothing collection in São Paulo.

Source: Larissa Oliveira Duarte adapted from OLIVEIRA-DUARTE et al., in press.

The organic cotton dynamics in Brazil coexist and many actors participates in more than one. The following topics present the organic cotton main dynamics in Brazil as indicated in **Chart 13** in the Research Methods **section 5.3**.

6.2.1 Dynamic I - VEJA or VERT

One of the firsts dynamics include the French shoes brand named VEJA. Since its beginning, VEJA has been signing one-year contracts with farmers' associations and setting a market price per kilo of organic cotton. VEJA stated buying agroecological cotton from ADEC since 2004 (LIMA, 2008).

VEJA also pre-finances the harvest up to 50% and pays a premium per kilo of cotton produced that associations must use it to develop community projects. The agricultural approach farms are using based on mixed farming provides food independence and maintains nutrient balance in cultivated land (agroecological practices). These families are in rural communities and cultivate cotton together with other crops such as beans, corn, sesame, manioc, sunflower, and pumpkin in areas of maximum two hectares. In 2018, more than 23 tons of agroecological cotton was bought

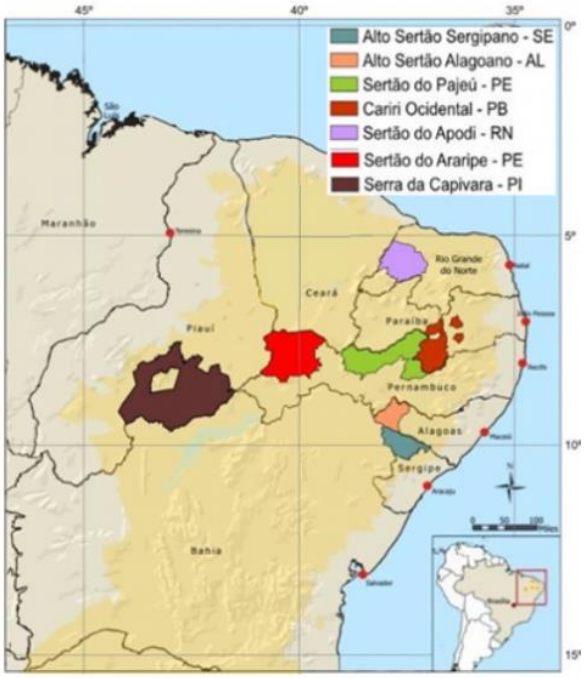
by VEJA directly from seven different associations in northeast Brazil. This cotton was cultivated by 259 families. VEJA buys the lint from farms groups such as Rede Borborema and ACEPAC, in Paraiba, and ADEC in Ceará. The cotton goes to spinning and weaving in Sao Paulo and the shoes production in the south of Brazil (TEXTILE EXCHANGE, 2020b).

Although there is an effort to expand the supply of organic cotton, volumes are still insufficient to meet the growing demand of the market. In this context, the low availability of organic cotton, added to the increase in demand, led VEJA to look for an alternative organic cotton supply. Thus, in 2017, the company began to buy organic cotton, already with GOTS certification from the Peruvian company Bergman & Rivera (TEXTILE EXCHANGE, 2020b).

6.2.2 Dynamic II - Program "*Cotton in Agroecological Consortia*"

The second dynamic is initiated in 2017 by Laudes Foundation (funding), EMBRAPA Cotton (technical support), Diaconia (technical support) and OCC and VEJA (business partners). The objective of the Program "*Cotton in Agroecological Consortia*", cultivated in consortium with food crops in the Semiarid Region is the expansion of organic cotton supply network. Also to present the advances obtained in the cultivation of lint in the region and the challenges to expand production, with a focus on meeting a growing worldwide demand for products with organic certification. Farmers also produce and sell organic sesame production (oil, tarrini). Cropping land in 2018 was 28 hectars (he), in 2019 developed to 600 he and in 2020 extended to 1,040 he. It generates income for more than 2,000 farming families that are planting cotton in consortium with other crops in 7 regions in 6 states in the Northeastern Semiarid (**Figure 42**).

Figure 42 - Map identifying Brazilian of semi-arid region and the areas participating in the project "*Cotton in Agroecological Consortia*".



Source: CAATINGA, 2020.

Each region is detailed bellow:

ALTO SERTÃO SERGIPANO – SE

Formed by seven municipalities (Canindé do São Francisco, Gararu, Monte Alegre de Sergipe, Nossa Senhora da Glória, Nossa Senhora de Lourdes, Poço Redondo and Porto da Folha), the region of Alto Sertão Sergipano covers an area of 4,900.69 km² and a population of 137,926 inhabitants (2007). It represents 22.37% of the Sergipe state's area and 7.11% of the population (ALGODAO AGROECOLOGICO, 2020).

ALTO SERTÃO ALAGOANO – AL

Alto Sertão Alagoano has historically been associated with traditional family farming. In this Region, Piranhas and Delmiro Gouveia stand out clearly with the presence of fruit growing alongside the more traditional crops of corn and beans (ALGODAO AGROECOLOGICO, 2020).

SERTÃO DO PAJEÚ – PE

The Sertão do Pajeú has an area of 8,689.7 km² and is formed by 17 municipalities where, there is a population of 314,603 inhabitants, 199,726 inhabitants in the urban area and 114,877 inhabitants in the rural area. The most populous municipalities are Serra Talhada, with 79,241 inhabitants, and Afogados da Ingazeira, with 35,091 inhabitants. The economy of Sertão do Pajeú is based on poultry, agriculture, small industry, commerce, services and tourism. In agriculture, in addition to corn and beans, the region cultivates sugar cane used by around 100 sugar mills that produce honey (ALGODAO AGROECOLOGICO, 2020).

SERTÃO DO APODI – RN

The Sertão do Apodi - RN is located in the Northeast region and comprises 17 municipalities: Apodi, Augusto Severo, Caraúbas, Felipe Guerra, Governor Dix-Sept Rosado, Itaú, Janduís, Messias Targino, Olho-d'Água do Borges, Paraú, Patu, Rafael Godeiro, Rodolfo Fernandes, Severiano Melo, Triunfo Potiguar, Umarizal and Upanema (ALGODAO AGROECOLOGICO, 2020).

CARIRI PARAIBANO – PB

Cariri Paraíba is located in the south of the state of Paraíba and is formed by 29 cities, among which, Sumé, Monteiro, Taperoá, Serra Branca and Cabaceiras with a population of over 160 thousand people. Its climate is typically semi-arid, characterized by low rainfall and an amount of sunlight exceeding 2,800 hours per year (ALGODAO AGROECOLOGICO, 2020).

SERTÃO DO ARARIPE – PE

Located in the Sertão of Pernambuco state, the Sertão do Araripe has an area of 11,969.5 km² and is formed by 10 municipalities where, there is a population of 165,062 inhabitants in the urban area and 142,580 inhabitants in the countryside. The main activity of the Sertão do Araripe economy is the exploitation of gypsum. The region concentrates 40% of the world's gypsum reserves. In addition, goat breeding and honey production (ALGODAO AGROECOLOGICO, 2020).

SERRA DA CAPIVARA

São Raimundo Nonato is a Brazilian municipality in the state of Piauí, 576 km from Teresina, the state capital. It has about 34,535 inhabitants and 2,606.8 km². Its economy is based on agriculture and livestock. Part of the Serra da Capivara National Park is located in São Raimundo Nonato, protected by UNESCO and covering 129,140 hectares and a perimeter of 214 kilometers, one of the largest in the Northeast Region (ALGODAO AGROECOLOGICO, 2020).

Another objective of the program *"Cotton in Agroecological Consortia"* is to guarantee the effective participation and recognition of women in both agricultural activities and political organization. In these three years of the project, more than 160 women have taken on leadership positions in their communities. This program has also worked with strengthening OPACs (Participatory Organizations for the Evaluation of Organic Quality) to obtain the certificate of organic compliance, to consolidate the producers network and autonomy.

Within this program many associations were licensed or are in the process to be OPAC's:

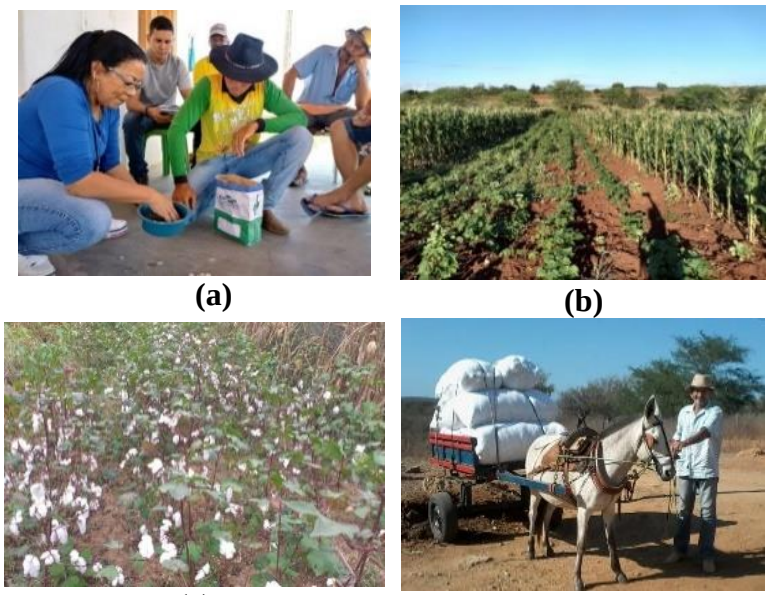
- Associação dos Produtores Agroecológicos do Semiárido Piauiense (APASPI/PI);
- Associação Agroecológica do Pajeú (ASAP/PE);
- Associação de Certificação Orgânica Participativa do Sertão do Apodi (ACOPASA/RN);
- Associação de Agricultores e Agricultoras Agroecológicos do Araripe (ECOARARIPE/PE);
- Associação Agroecológica de Certificação Participativa do Cariri Paraibano (ACEPAC/PB);
- Cooperaterra - Alto Sertão Sergipano;
- Coopabacs - Alto Sertão Alagoano.

According interview carried out with Marenilson Batista da Silva (EMBRAPA Cotton – PB – Oct. 4, 2019), there is an important role undertaken by Laudes Foundation, which relates to the participation in negotiation between representatives of OPACs and potential Brazilian and international buyers of organic cotton. Besides strengthening local farmers' collectives, the program also aims to create a regional network to promote collective action. With a focus on income generation, development of family-based social organizations, conservation of natural resources, and introduction of smallholders into

fair trade and the organic market, the initiative will benefit at least 1,000 families in the final of 2020. The main buyers of the organic cotton produced are the brands VEJA and Organic Cotton Color. There are 6 capacitation modules that work with the production system, related the themes of production, certification, gender and commercialization. Including soil management, planting orientation, harvest, post-harvest and processing.

The program is distributed in the following structural: (1) **strengthening of OPAC's;** (2) **female participation;** (3) **knowledge construction and dissemination;** and (4) **production and marketing** (ALGODAO AGROECOLOGICO, 2020) **(Figure 43)**.

Figure 43 - (a) EMBRAPA Cotton technical support activity at Alto Sertão Alagoano; **(b)** cotton crop in consortium with food species at Alto Sertão Sergipano; **(c)** cotton lint emerging before the harvesting at Sertão do Pajeu; **(d)** Transporting the cotton lint at Sertão do Apodi.



(a) **(b)** **(c)** **(d)**

Source: ALGODAO AGROECOLOGICO, 2020.

Through the access to knowledge and training, farmers learned practices that enabled them to combat degradation of soils, improve soil fertility and water-holding capacity, as well as to reduce pest and weed infestation on fields (ALTENBUCHNER et al., 2014).

6.2.3 Dynamic III - Paraíba Cotton project

According the interviews carried out with Maisa Mota Gadelha (Coopnatural – PB – Set. 30, 2019) and Cristiano Campelo Cavalcante (EMPAER – PB – Oct. 03, 2019), Paraíba Cotton Project is developed by Paraíba state government and supported by research companies such as EMBRAPA, producer associations such as Coopnatural, and spinning companies such as Norfil. The project has significantly increased the number of producers in recent years. The impact of these projects on production will become even more evident next year, with a record organic cotton harvest anticipated in 2019/20. They are planning to create the Institute "Casaca de Couro". Coopnatural started the actors' organizations and needed a company with a robust market approach. At the same time, the industry Norfil was interested in a partnership with someone capable of understanding the organic cotton realities, and familiar with the features of agriculture in the region. These two companies got together and partner with EMBRAPA and EMPAER that could offer technical support. The main aim is to support local communities, the environment, and the development of Caatinga Biome. It is the driest area of Brazil and we are willing to color cotton clothes with its dyeing plants cultivated by the native people of Caatinga. Norfil's objective is to develop a more affordable and commercial yarn, containing 5% organic fiber and 95% BCI cotton in its composition, a product developed for the knitting company Menegotti.

The partnership with large companies is essential for the development of this production chain, but explains that the sector of yarns and textiles needs to get closer, and cooperate for the development of agricultural production, with financing, etc. (DA CUNHA; DE OLIVEIRA, 2019).

6.2.4 Dynamic IV - Natural Cotton Color

The company Natural Cotton Color (NCC) commercializes textiles, produces and commercializes clothes and bags, attending Brazilian and international markets. The company is connected with family farmers from the Margarida Maria Alves rural settlement in (Juarez Távora) and works also with natural colored cotton (TEXTILE EXCHANGE, 2020). Today NCC spinning is made at SENAI and weaving with UNITEXTIL. NCC has been in the market for 23 years and for over 13 years has been working exclusively with 100% organic naturally colored cotton - certified by Ecocert.

“The cultivation of organic colored cotton is carried out under a guaranteed purchase contract so that it is economically viable for the farmer. We pay the best price in the country for a kilo of lint”, explains Francisca Vieira, CEO of the company (ETHICAL FASHION BRAZIL, 2020).

NCC sells the organic cotton textile to diverse clothing brands such as Flavia Aranha and is also engaged into exportation with the support of the Brazilian Association of the Textile Industry (ABIT) through the TEXBRASIL program, developed by Brazilian Export and Investment Promotion Agency (APEX-Brasil). They work to promote Brazilian products and services abroad and attract foreign investments. Other important partnerships include the event Brazil Eco Fashion Week.

The settlement Margarida Maria Alves (MMA) is located in Juarez Távora, in Agreste Paraibano, 100 km from João Pessoa. It was created in 1998. It has 37 families, of which 21 grow colored cotton in rainfed systems, without any type of fertilizer or synthetic insecticide. Cotton is benefited in the settlement itself through the developed by EMBRAPA Cotton for small cotton producers. The Margarida Maria Alves Settlement is the main producer of colored cotton in Paraíba, with 14 hectares of planted area (the second producer is the Queimadas settlement). Planting takes place in May and harvest in December. The settlement started with the planting of white cotton, between 1999 and 2000, starting to plant colored cotton in 2006 (AZEVEDO, 2018).

6.2.5 Dynamic V - Organic Colored Cotton: Generating income and citizenship in the Brazilian semiarid family farming/ Project +Cotton: Strengthening the Cotton Sector through South-South Cooperation

The fifth dynamic is organized by FAO (Food and Agriculture Organization of the United Nations) and the Brazilian Ministry of Foreign Affairs' Brazilian Cooperation Agency (ABC/MRE). It launched the publication “Algodão Orgânico Colorido: gerando renda e cidadania na agricultura familiar do semiárido brasileiro” (Organic Colored Cotton: generating income and citizenship in the Brazilian semiarid family farming). The work integrates a series of actions within the project *Más Algodón* (+Cotton: Strengthening the Cotton Sector through South-South Cooperation), a result of trilateral partnerships between the Brazilian government, FAO, and the governments of Argentina, Bolivia, Colombia, Ecuador, Paraguay, Peru and Haiti, with funds from the Brazilian Cotton Institute (IBA).

The +Cotton Project is an initiative between Brazil, FAO and seven partner countries, also involving government and research institutions, academia and associations, private sector, which have strengthened their capacities under a social, economic and environmental sustainability approach. The +Cotton initiative aims at consolidating production systems in cotton regions, adapting them to different types of producers as well as agroclimatic and technological contexts. It includes national governments and local governments; farmers; researchers and extension agents; rural youth; indigenous people; associations and cooperatives; universities, agricultural schools and research centers; Brazilian Association of Technical Assistance and Rural Extension Companies (ASBRAER); Brazilian Association of Cotton Producers (ABRAPA); Brazilian Agricultural Research Company (EMBRAPA); State Company of Technical Assistance and Rural Extension of Paraíba (EMPAER-PB); National Sub Secretary at Solidarity Economy of Labor Ministry (SENAES-MT) (FAO, 2020).

In addition, the project is based on 4 conceptual areas: (1) **sustainable technologies;** (2) **strategic alliances**; (3) **social innovation**; and (4) **inclusive markets**, while crosscutting issues include gender, rural youth, indigenous peoples, and climate change. The project works with technical innovations and sustainable production, through improvements in crop management, efficient use of resources, crop rotation, soil analysis, growth control, and efficient irrigation systems. The project main goals include investment in seeds, generation of knowledge, technical assistance, access to markets and support for public policies development (FAO, 2020).

The project promotes sustainable and inclusive production systems, with decentralized governance and adaptive management of local food systems, helping to reduce poverty and achieve social development and environmental sustainability by creating opportunities for new generations. Working together among different actors and with a multi-sectoral perspective can have a catalytic effect on the empowerment and scaling up of the agroecological scale of production systems of rural communities improving planet and people's health (TEXTILE EXCHANGE, 2019).

6.2.6 Dynamic VI - Justa Trama

Justa Trama is the brand of the agroecological cotton production chain. It is a ecological and sustainable production system and part of the solidarity economy network. Justa Trama is made up of workers organized in solidarity economy ventures. They are

cotton producers, spinners, weavers, dressmakers, artisans and seed collectors and processors. They are people who believe in fair and solidary trade and in production relations without exploitation. Its organic cotton certification is via “Associação de Certificação Instituto Biodinâmico” (IBD) (JUSTA TRAMA, 2020a).

The cooperative is spread across 5 regions of Brazil through the union of associations and other cooperatives, each one responsible for part of the production. In Tauá, in the state of Ceará, the Educational and Cultural Development Association (ADEC) grows agroecological and organic cotton. Still in production, there is the cooperative Escola Família Agrícola da Fronteira (AEFAF), from Ponta Porã, Mato Grosso do Sul. In Porto Velho, Rondônia, the Açaí Cooperative makes dolls, buttons and collages that accompany the clothing collections from the clothing scraps. Finally, in Porto Alegre, headquarters of Justa Trama, the Cooperativa de Costureiras Unidas Venceremos (UNIVENS) manufactures clothes, silkscreen, embroidery and dyeing, and the Inovarte group creates toys and toy animals with scraps (JUSTA TRAMA, 2020b).

According with Andrada and Sato (2014), Justa Trama gathers about 600 people, self-managed enterprises of all the geographic regions of the country. It was proposed by its workers, mostly low-income women, as a broad intercooperation network, based on agroecological cotton textile production chain, to generate more work and income. It covers a large part of the cotton production chain agroecological, from planting to final production. In the network arrangement, therefore, associates in self-management workers from rural and urban areas, from different sectors of the activities such as agriculture, industry and handicrafts that together manufacture the inputs that result in Justa Trama products: garments, bags, agroecological cotton toys and accessories.

6.3 Challenges and Perspectives in the organic cotton network in Brazil

This section is based in all information collected and analyzed in this study.

6.3.1 Farm: cotton-growers and ginning

Farming is the initial and the most crucial stage in the production of organic cotton fiber. The direct costs of a normal cotton crop at this stage come from fixed costs such as the purchasing of the farmland and equipment (and the opportunity costs of such investments). They also include variable costs such as labor, i.e. farm workers and those

staff needed to run a business (including the contracted costs of e.g. marketing the produce, or membership of a cooperative), raw materials such as seeds (LAKHAL et al., 2008).

Farming systems are conceptualized as a dimension within the agriculture system, together with farming outputs (not yet in the form of food, but rather as crops, livestock, etc.) and natural conditions (like soil, water and weather). This system is embedded in non-human nature, but at the same time within the realm of human activities and society. Therefore, it is considering it a socio-ecological system (NICOLAY, 2019).

According with farmers, main challenges in organic cotton in Brazil, include pest management, soil preparation, soil quality, appropriate cotton variety, water and crop management with initial weeding and crop harvesting. The need to develop a machinery suitable for smallholders was also a relevant issue pointed by producers and technicians. For the researchers at EMBRAPA Cotton, a major challenge is to establish relationships with industry and market partners, capable of completing the entire cotton production chain. Working closer with fashion brands and dialoguing with different sectors. In addition, the machinery for seeds preparation is a need.

Conforming to the interview carried out with Gilvan Alvez Ramos (EMBRAPA Cotton – PB – Oct 1th, 2019): “Both EMBRAPA and EMPAER technicians are not ready to resolve major issues alone. There must now be an interaction between the government and these interested micro entrepreneurs. It is understood as public power SEBRAE, SENAI, EMBRAPA and the State Government. The assistance in the field is essential to be accompanied by technicians”.

The main issue with organic cotton is making it possible to keep families working in the field and generating income in the semi-arid. According interview carried out with Amanda Procópio da Silva (ACEPAC – PB – Sep 25, 2019): “I'm a producer, my father is a producer and my other brothers also. We need to organized conditions to produce and sell, improve logistics, as the access to transports is difficult”.

Communication is the glue that holds partners together through balanced, two-way, multilevel contacts and message services (CAO; ZHANG, 2010). Still conforming to Amanda Procópio da Silva (ACEPAC – PB – Sep 25, 20190): “Communication between the groups of farmers is still a challenge, we speak via Whatsapp, but there are some who do not have access yet or there is no signal for connection. And the long distances between the production groups are a problem as we lack the transport”. In addition, according Diógenes Fernandes Pereira (OCC - PB – Sep. 30, 2019); “A great

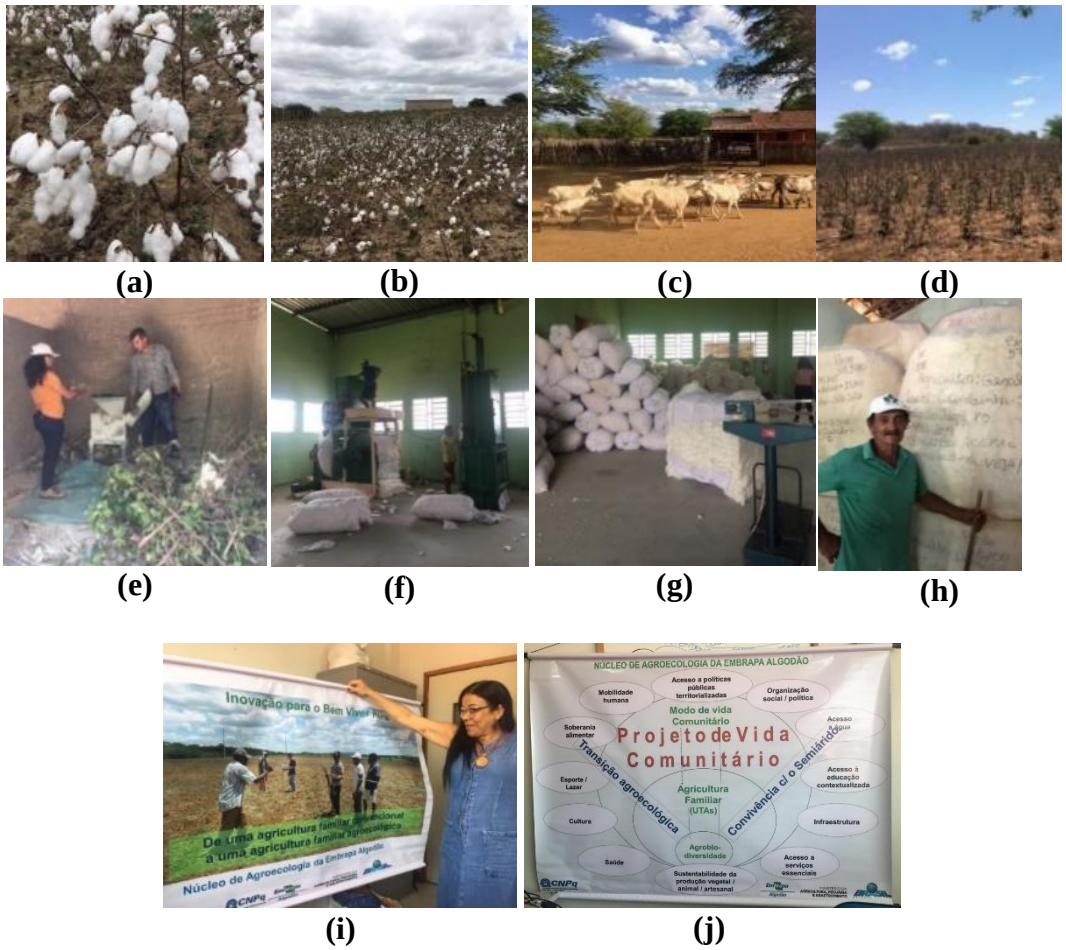
challenge is the communication itself in the different territories, it needs to be expanded every day for the work to continue and multiply more, including new families of farmers". A common objective for any community of practice program is to encourage information flow (CROSS et al., 2006).

In other hand, the manual harvesting has been a differential in cotton quality. Other positive perspective includes soil and water conservation, gender equality, generation integration and the diverse production besides cotton, such as sisal, sesame and cattle.

Considering the production, according the interview with Marenilson Batista da Silva (EMBRAPA Cotton – PB – Oct. 4, 2019): "We need to develop cultivation systems that protect the soil and conserve water". In addition, an important issue with cotton is making it possible to maintain families in the field, generating income. Considering the interview with Alexandre Almeisa da Silva (Rede Borborema – Sep. 25, 2019): "Here in Cariri, we work with three things, food for home, food for animals, and cultivation for income. And when cotton is organic, we can sell it at a better price, it is more valued". Furthermore, there is an affective and cultural link with cotton in the semi-arid region of Brazil. According Ricardo Menezes Blackburn (Diaconia – PB – Sep. 25, 2019): "Cotton is part of life of farmers in the semiarid, everyone will have a story to tell about cotton, it is part of life, it is an affective culture".

Figure 44 presents cotton in the field and the farm process after harvesting. The organic cotton in Brazil promotes integrated systems, in which producers have diverse activities, in this case, the animals feed with the rest of the cotton crop. Also, removing the plants of the cultivation area is part of sanitary practices to protect from boll weevil. Prodcuers can keep the seeds, can sell them or they serve for animal feed. Another important aspect is the process of "farmer researcher" implemented with farms by the EMBRAPA technical support, in which the smallholders learn how to observe, analyze, plan and control the crop development.

Figure 44 - (a) and **(b)** Cotton plant and lint, field and the shed at the back, in Queimadas community, town of Remigio, group Rede Borborema de Agroecologia; **(c)** Goat in the community of Zé Marcolino, group ACEPAC; (d) Cotton crop after the harvesting; **(e)** Transforming the cotton plant into small parts to feed the animals in the rural settlement Zé Marcolino. **(f)** and **(g)** Group Rede Borborama de Agroecologia cleaning, weighing and bailing cotton at the rural settlement Margarida Maria Alves; **(h)** cotton bags in the shed ready for sale; **(i)** and **(j)** Agroecology group at EMBRAPA Cotton.



Source: Larissa Oliveira Duarte, 2019.

According to the agronomy technical advisor Amalia da Silva Masques (Arribaçã – PB – Sep 25, 2019): “Research is essential and producers need to understand this. We live in a system where things need to be validated. The more research validating agroecological processes the better. Technical research institutions and farmers need to understand the importance of this. Because it is a cycle and everyone is building together interconnected”. The concept of preparing producers to research is important, in the field they are learning about measuring, observing, making filed notes, analyzing, organizing data, comparing best practices and production volume.

Lack of investment in technical advice to orientate more farmers is a challenge. Organic producers are engaged in a learning process through farmers' field school sessions, farmer-led informal experiments, and other forms of training in the field. This technology package comprises a guideline for a producer, from preparing the land until the cotton is sold, to achieve maximum yield including guidance from variety selection, soil preparation, planting time weeds elimination, watering, insect control, picking and storage of seed cotton (RASHID et al., 2016). Another challenge is to open the market and to have more buyers. As a good perspective, participatory certification is very positive, in addition to solving a problem of organic standard, it brought more women and young people to contribute to the process.

Sustainable raw materials manager at Laudes Foundation explains that the big challenge today for the production of organic cotton in Brazil is production volume. To scale the production, including techniques, investments, ensuring good price, chain management. According Luciana Batista Pereira (Laudes Foundation – SP - Oct. 9, 2019): "Even our strategy of going to the Cerrado biome in the Midwest, obviously is to expand the project to other areas, but it is also for people to be able to promote and raise awareness among medium and large producers. It inspires them to look and shift from BCI or conventional to organic. In this way, we want to have a business model that can be replicated for family farming with agroecological cotton production". Considering that, the steps are technically training people, work at the level of public policies, bring the topic up for discussion with the entire chain, as there is no point in looking at the production and not looking at the ecosystem as a whole. Additionally, according her: "Organic cotton has a greater demand than the offer, which is a dream for anyone. It is still a niche, now mainly for smaller brands, but even within big brands and large companies, for example, they have interest in having a line with only organic cotton production".

The Diaconia advisor Ricardo Menezes Blackburn (Diaconia – PB – Sep. 25, 2019) explains that a challenge is that the cotton chain in the textile industry starts with the yarn, few companies are willing to start with the lint. "With the OPACs today, we only go to the lint. We are in the process of negotiation and trying to transform the lint and start making thread, even for the fair trade companies that today we already sell the production. There is a much higher demand of organic cotton than the farmers have to offer". A good perspective is regarding the young people engagement and participation. Furthermore: "Today we see youth taking an interest. This is a very important factor for

sustainability, regardless of the project or not afterwards, the vitality and energy of the youth is very important in the process. We need to develop technologies even for young people, in order to consolidate their participation in agriculture, in the semi-arid region, labor-saving technology is needed".

According with the Textile Exchange ambassador in Latin America, Silvio Moraes (Textile Exchange Lecture at Brasil Eco Fashion Week – SP – Nov. 17, 2019), a significant challenge in organic cotton today concerns the low price for the farmer. "Everyone knows the social and environmental value of organic cotton and we need to reverse this paradigm". He agrees that the organic cotton in Brazil is very different from the cotton in the USA. "In USA organic cotton is produced in the same way that conventional is produced, with high mechanization and capital. It is organic when meeting the criteria of not using agrochemicals, but in terms of soil use, nutrition and conservation, it presents a negative effect. In Brazil, organic cotton has something else, as it is cultivated by small householders, producing also food in consortium in the fields. Called regenerative agriculture in some places, the agroecology has more intimacy with nature".

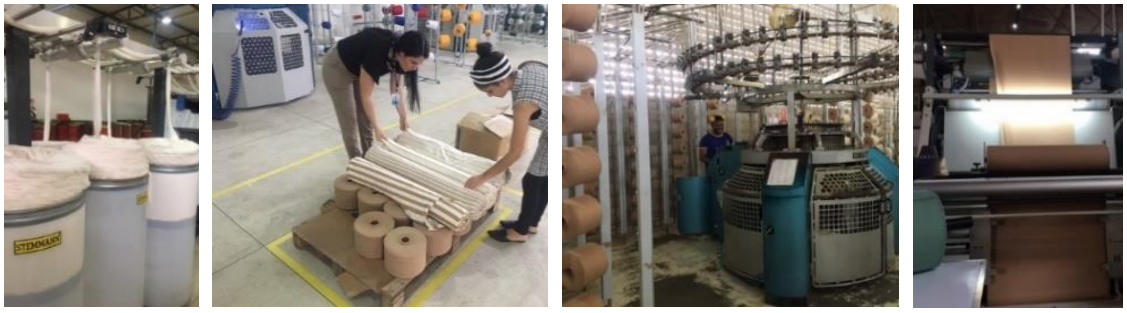
Brazilian organic cotton has a great potential. According with Nair Helena Castro Arriel (EMBRAPA Cotton – PB – Oct 1th, 2019): "The Brazilian cotton is known as a great quality fiber because it is produced in semiarid soil, with a great amount of light it gives an excellent quality fiber. We need to develop knowledge together with producers. If the technology is already being absorbed by the producer in the field, then we will have an immense impact".

6.3.2 Brazilian Textile Industry: mills and textile manufacturing

The Brazilian textile industry is in the process of adapting to these new values that guide the future of industrial production, and which demonstrates resistance in relation to organic cotton due to the incompatibility between production models and the logic of a market still very oriented the question of price, production scale and sales volume (DA CUNHA; DE OLIVEIRA, 2019). Spinning is today a great challenge to organic cotton in Brazil, as the fiber volume is instable still and no many companies are doing this process. The companies Norfil and Bercamp spinning and Unitextil and Saltorelli weaving. Euro Roma is starting the process together with NCC. SENAI in João Pessoa is also supporting brands with spinning, such as a partnership with NCC (**Figure 45**).

EMBRAPA Cotton is promoting the link between farmers and SENAI, for them to know both process from fiber to fashion and have the possibility to plan future collaboration.

Figure 45 - (a) and **(b)** Spinning process and colored organic cotton thread to NCC at the fab lab of SENAI Textile and Clothing in João Pessoa (Paraíba); **(c)** and **(d)** Unitextil weaving the colored organic cotton in João Pessoa (Paraíba).



(a) **(b)** **(c)** **(d)**

Source: Larissa Oliveira Duarte, 2019.

The technical advisor, Amalia da Silva Marques (Arribaçã – PB – Sep. 25, 2019) affirms that a challenge in organic cotton and the textile industry in Brazil concerns the spinning process that is very limited. “We can only follow up on the sale of cotton lint. Also we must improve logistics, adequate and sufficient space to store production and transport”. The advisor at Diaconia Ricardo Menezes Blackburn (Diaconia – PB – Sep. 25, 2019) agrees: “If you have cotton lint, few companies are willing to buy and take to spinning, etc. When it comes to the yarn, there is no market limit for organic yarn. But we still need to evolve in organization, management and machinery or we could outsource the service for example”.

Cotton producers also consider this challenge, “since we produce cotton and deliver the lint, we limited the market. If we could have the knowledge regarding how to spin, how to produce the fabric and benefit until the final product, actually delivering the product to the final part of it, our product could have more value” (Suzana Cordeiro de Aguiar – Rede Borborema – PB – Sep. 27, 2019).

The textile industry has not embraced the organic cotton yet; to stimulate production, arrange funding, facilitating logistics, sales and promotion. “The challenge of organic cotton for me is not itself the technique of cotton cropping, but the perspective of the industry, wanting to have new raw materials and systematizing different chains. It's more a mindset-changing challenge” (Flávia Aranha – SP – Apr. 17, 2020).

According to the Textile Exchange ambassador, Silvio Moraes (Textile Exchange Lecture at Brasil Eco Fashion Week – SP – Nov. 17, 2019), the main challenges would be to increase organic cotton production in the region and connect with the development of new business models, encouraging consumption. In this sense, advocacy actions could favor greater growth and use of organic cotton, and increase cooperation in the sector. “Brands and retailers might effort to finance this process, we also have the participation of NGOs, the public sector, SENAI, EMBRAPA. Right now the demand is undeniably increasing and production cannot keep up”.

“Bridges need to be created between the producer and fashion. We see weaving and knitting industries trying, but we really need to embrace this in a broader and integrated way” (Ana Sudano, Brasil Eco Fashion Week founder – SP – Sep. 21, 2020). According to DE DIVITIIS (2020), regarding information detailed for Fernando Pimentel, ABIT president, in the productive framework of the textile and clothing sector there is a great dispersion of companies, with a great prevalence of companies with 5 to 9 employees. In addition, 91 percent of clothing companies are micro and small businesses, while in the textile segment the percentage drops to 82 percent.

6.3.3 Brazilian Clothing brands and retail related to organic cotton

According to the clothing brand founder Flavia Aranha (Flavia Aranha brand – SP – Apr. 17, 2020), who have been using organic cotton since 2009: “People want to use these organic cotton products, because they want it for their bodies and for the world. I see that there are more and more customers who are proposing to consume this product, because they want to put their money in more positive production systems”. Concerning the market expansion, she adds: “The market is open for this product, we start with organic food, then cosmetics and clothes, I think we are in third place. So usually those who consume our clothes, already eat organic, use less synthetic cosmetics on their face, and the third one I feel is the opening for organic clothes, in the client's life. Organic cotton is still a niche product, but I think we are moving towards a scenario where we will be able to combine design and agroecological raw material in order to generate access to other groups of consumers that want to consume”. In this case, the logic might be consuming less and better, looking for quality and durability in products. “Customers are not buying ten clothes in a fast fashion and preferring to buy two T-shirts at Flavia Aranha, for example, we have seen this for some years now. I'm not saying that everyone

has to use organic cotton, I think we need to create a diversity of fibers, we have so many options in Brazil".

The brand has a long time partnership with two centers producing artisanal organic cotton in Pirinópolis (GO) and Vale do Urucuia (MG), they have no standards, however the brand founder has a close relationship with the local families and artisans. Still according her: "Thinking about the land, if we talk about family farmers and agroecology, we are talking about land without agrochemicals, about decentralizing the power of the land. They are small parcels of land, related to rural families who are taking care of this land. Besides that, farmers never plant just one crop, they plant several other crops, bringing autonomy and food security to these families. They can first produce their own organic food without external inputs, and then they can sell cotton. When we choose to use organic cotton from Brazil, we are fostering this political relationships, small and local productions, soil regeneration, possibility of agriculture with various species". Today they buy knitwear from Natural Cotton Color and Justa Trama (**Figure 46**). The organic cotton perspectives, include more engaged clients looking to sustainable brands, after the pandemic, and an improvement the online sales.

Figure 46 - (a) and **(b)** brand store window and inside, organic and colored cotton apparel.

(a) **(b)**

Source: Larissa Oliveira Duarte, 2019.

Brazil Eco Fashion Week BEFW co-founder, Ana Sudano (Brasil Eco Fashion Week founder – SP – Sep. 21, 2020) explains that many brands give of buying organic cotton today due to the difficulty of access to this raw materials, then many people migrate to recycled pet. "The organic cotton challenge today is a matter of access; people don't know who to buy from. I see that there is still this place of research and development, and then the industry embracing this development, supporting fabrics and the brands can buy.

Two major difficulties, the study and development of a chain and the market access. A great challenge concerns the general lack of understanding about organic cotton in the market, with the brands, of those who participate and attended the event, students, etc. Whoever has this organic mindset is because they associated with organic food".

In addition, she affirms: "It is a demand that is at the beginning and when people try it they adhere to it. As you start to broaden the customer's perception of the material, which is biodegradable, from a renewable source, suddenly that becomes a priority".

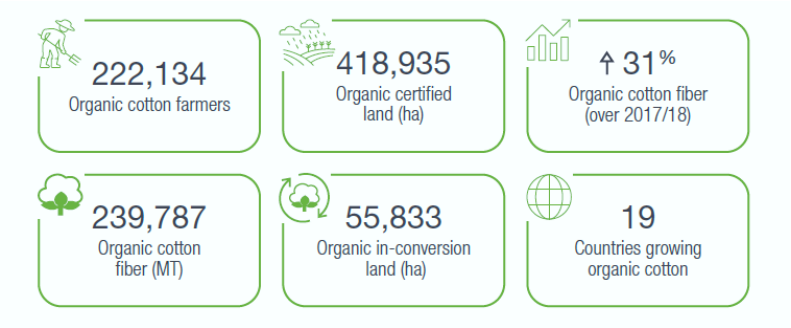
It is necessary to have more offer of organic cotton, also brands must understand the value of the material, commit with paying the correct price and there must be all the traceability that the business demands. Luciana Batista Pereira (Laudes Foundation – SP - Oct. 9, 2019) affirms that the use of organic cotton is expanding while the production system gets more organized and customers starts understending the process and the difference between conventional cotton: "We realize that the theme of organic cotton production, of sustainable raw materials in general, has been growing a lot within the business, the brands, and younger consumers have been questioning, so there is a movement - "Where does the raw material come from".

6.3.4 Organic Cotton market potential

In this section it was considered information analyzed from the technical visits and also the analyzed annual reports.

Organic cotton production rose 31% in the 2018/2019 harvest. Organizations certified for organic textiles also increased significantly between 2018 and 2019: 48% more with the Organic Content Standard (OCS) and 35% more for the Global Organic Textile Standard (GOTS). And 55,833 hectares of soil were being converted for organic cotton plantation, mainly in India and Pakistan, followed by Turkey, Greece and Tajikistan (TEXTILE EXCHANGE, 2020a). **Figure 47** summarizes organic cotton production over the world.

Figure 47 - Organic Cotton production snapshot – 2018/2019.



Source: TEXTILE EXCHANGE (2020a)

In addition, according with **Table 6,** 97% of organic cotton is produced in seven countries: India (51%), China (17%), Kyrgyzstan (10%), Turkey (10%), Tajikistan (5%), Tanzania (2 %) and USA (2%). Brazil ranks the 16th position (0,04%) (TEXTILE EXCHANGE, 2020a).

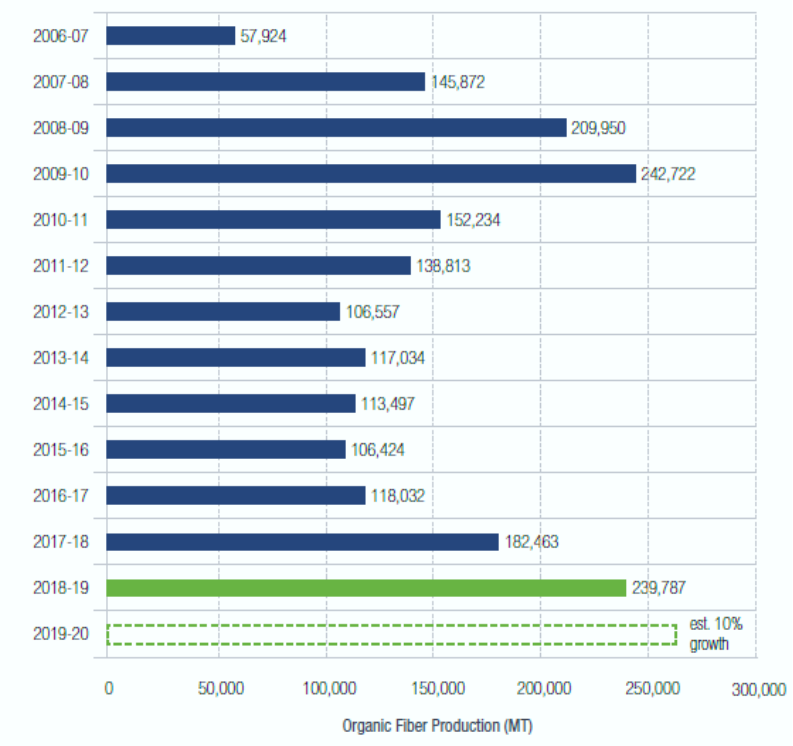
Table 6 - Organic cotton international production, volume by country, development and world participation.

	Organic Cotton Fiber (MT)	Fiber Year-on-Year	Share of global organic cotton production
Global	**239,787**	**31%**	**100%**
India	122,668	43%	51.15%
China	41,247	7%	17.20%
Kyrgyzstan	23,637	6%	9.86%
Turkey	22,839	77%	9.52%
Tajikistan	12,178	35%	5.08%
Tanzania	5,281	8%	2.20%
USA	5,175	2%	2.16%
Uganda	2,581	238%	1.08%
Greece	1,168	12%	0.49%
Benin	998	40%	0.42%
Peru	558	11%	0.23%
Burkina Faso	453	-16%	0.19%
Pakistan	398	(new)	0.17%
Egypt	287	-34%	0.12%
Ethiopia	130	115%	0.05%
Brazil	97	335%	0.04%
Mali	84	9%	0.03%
Argentina	11	575%	0.005%
Thailand	6	-9%	0.003%

Source: TEXTILE EXCHANGE, 2020a.

The world production had a great expansion in 2018/2019, with perspective to develop further in 2020 (**Figure 48**).

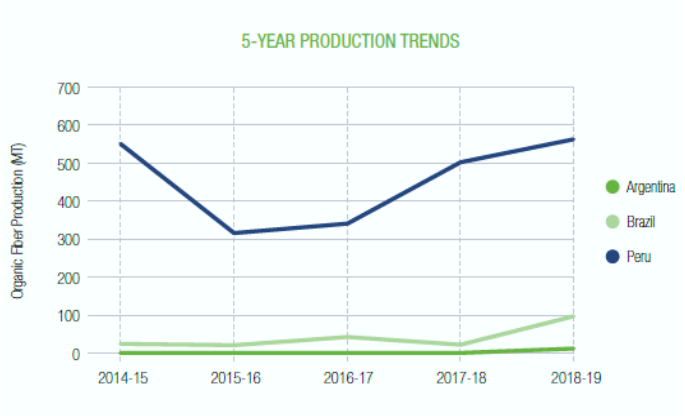
Figure 48 - Organic cotton global production from 2006 to 2019 and 2020 trend.



Source: TEXTILE EXCHANGE, 2020a.

In Latin America, the production of organic cotton takes place mainly in Peru, Brazil and Argentina, being mostly carried out by family farmers and Peru is the largest producer (**Figure 49b)** (OLIVEIRA-DUARTE et al., in press). The Brazilian production is increasing since 2018 (**Figure 49a**).

Figure 49 - (a) 5-year production trends in the main producers' countries of Latin America; **(b)** Regional overview 2018/19 organic cotton production in Latin America.



(a)

(b)

Source: TEXTILE EXCHANGE, 2020b.

The report of The Boston Consulting Group and Global Fashion Agenda (2018, p. 40) exemplify international brands engaging with organic cotton:

> Skunkfunk, a Spanish ethical fashion brand, moved from only 8% of organic cotton in 2010 to 92% in 2018, and aims to reach 100% by 2020, while Nudie Jeans has rolled out organic cotton in its entire denim collection. Pushing the ambition further, dozens of prominent brands and retail companies, such as Burberry, Adidas, Timberland, ASOS, and Levi's, committed in 2017 to using 100% sustainable cotton by 2025.Similarly, C&A developed a C2C certified T-shirt that is fully compostable, made of 100% organic cotton, using only 100% nontoxic chemicals, and produced within high social and environmental standards. The T-shirt is sold at a competitive price from €7, indicating a positive contribution margin (THE BOSTON CONSULTING GROUP AND GLOBAL FASHION AGENDA 2018, p. 40).

According with the report created by Global Fashion Agenda; McKinsey & Company (2020, p. 24), organic cotton overall market share represents only 2% of all cotton production. This takes into account reduced production and certification costs due to economies of scale and significant leading player commitments to fund the transition phase. It points out that:

> Consumers must play their part in driving industry efforts through their purchasing decisions. When provided with information, consumers may prefer products with lower emissions footprints, such as those made with low-carbon materials. Consumers can also embrace circular business models to extend the life of fashion products and reduce production-related emissions

> (GLOBAL FASHION AGENDA; MCKINSEY & COMPANY, 2020, p. 24).

They also point the important role of investor. “Investors must encourage decarburization efforts and transparency on full value chain emissions and promote the use of standardized sustainability assessments” (GLOBAL FASHION AGENDA; MCKINSEY & COMPANY 2020, p. 24).

According with the Textile Exchange (2020a, p. 40), in 2020, the rains remain irregular, leading farmers and technicians in the sector to consider changing the recommended period for sowing. Concerning especially the Brazilian production, they affirm that:

> Agroecological systems implemented in Brazil's semi-arid zone have transformed some regions - regenerating soil and recovering natural vegetation and water courses. The positive impact of organic soil and water management practices are notable, but not yet properly measured. Projects like the ones of Laudes Foundation in northeastern Brazil are intended to measure these impacts more objectively, so we should have better data about it in the near future. The semi-arid region where organic cotton grows in Brazil began to receive more regular rain in 2020. This happened at the same time as the planted area of organic cotton reached a record high, meaning a record harvest is anticipated in the 2020/21 crop year (TEXTILE EXCHANGE, 2020a, p. 40).

In addition:

> Moreover, several factors have improved Brazil's production of organic cotton this year, including accessibility of participatory certification system; the support from NGOs for technical assistance to farmers; the knowledge acquired by farmers over time that allows them to cope with the challenges posed by organic practices; planting in consortia that allows the diversification of production and food security; commercialization guaranteed by contracts, allowing the generation of family income, and partnerships with companies and institutions. Brazil have an impressive growth potential (TEXTILE EXCHANGE, 2020a, p. 40).

The expansion of production organization, was especially due to the funding of Laudes Foundation, the support of EMBRAPA Cotton and Diaconia, the buyers VEJA, OCC and NCC. Some challenges concerning the professionalization of the organic cotton in Brazil, to expand the market activities, consist of improving international sales, maybe integrated with international standards and touristic products, Brazilian design and handcrafts. The creative industry in Brazil has a great potential especially when connected with natural materials and local production. In the handcraft city market at Campina Grande, the shops attendants do not know exactly if the cotton is organic or not, as the products their do not have the standard (**Figure 50**). Mainly the communication link

colored cotton, the state of Paraiba and the handcrafts, not necessary the organic or agroecological aspect.

If a company aims to evaluate which type of innovation strategy to carry out, one factor that should be taken into account is the way in which the firm interacts with other actors in the cluster (GALASO et al., 2019). This is exemplified when clothing brands develop partnership with EMBRAPA Cotton, that offers the technical support and innovation to farmers, aiming to connected and be prepared for industrial and market demands. The name "EMBRAPA" being well recognized as a research institution, is showed in some product tags. Some brands were using the stamp of EMBRAPA as a matter of communicating the partnership with this organization, maybe to emphasis a quality of processes.

Figure 50 - (a) Handcrafts market Vila do Artesão handcraft**; (b)** Colored cotton at Rede Santa Luzia; **(c) and (d)** Store in the Joao Pessoa Airport selling local products; Bags of the brand Casulo using organic cotton**; (f), (g) and (h)** different product tags showcasing the IBD standard, USDA Organic and the EMBRAPA stamp in the products of Casulo and NCC.

(a) **(b)** **(c)** **(d)**

(e) **(f)** **(g)** **(g)**

Source: Larissa Oliveira Duarte, 2019.

The activities report of ABIT (2019, p. 42) presented the general perspectives for exports, but not emphasizing many details on brands, materials, exports volume, or the organic cotton activities. "In 2019, TEXBRASIL (Brazilian Textile and Fashion Industry Internationalization Program) finished its tenth agreement signed between the Brazilian Export and Investment Promotion Agency (APEX)". It also mentioned developments into aspects such as: "intelligent insertion into the global value network; market access for

Brazilian exports; alignment with Global Fashion Agenda and the SDGs; marketing & increase visibility of the textile and clothing sector in Brazil". However, without indication of organic cotton interest. The activities are briefly commented without in deep description on projects results and analysis or projects perspectives details.

Large garment brands have decided to blend a certain percentage (usually 5–10%) of organic yarn into their entire range of articles rather than selling purely organic clothes (**Figure 51**). This could increase the demand for organic cotton fiber considerably. Companies can communicate to their customers that they support organic cotton farming, which helps them to improve their corporate image (WILLER; LERNOUD, 2019).

Figure 51 - 2025 Sustainable Cotton Challenge signatories' brands, retailers and holding companies committed with reporting their cotton chain and expanding the organic cotton use.

Source: TEXTILE EXCHANGE, 2020b.

In the future, a number of changes to the cotton production industry are likely to affect the shape and scope of the value chain. It is predicted that the demand for organic cotton will grow substantially in the coming years (FERRIGNO et al., 2010). This demand is likely to be increasingly met by producers in developing countries, who are now benefitting from better support services, know-how, and the economic and regulatory infrastructure necessary to allow them to shift to organic production (RIEPLE; SINGH, 2010).

The potential organic cotton consumer profile includes environmental shopping attitudes and behavior, prior knowledge and demographics. Eco-literacy includes knowledge about organic cotton and the amount of chemicals required to process apparel garments. Even though organic cotton products are generally more expensive than equivalent products made from conventional cotton. This suggests that the niche market for organic cotton could be enlarged or that additional niche markets could be developed at lower price levels (RIEPLE; SINGH, 2010) (**Chart 15**). Examples of Textile Exchange members' progress towards organic cotton:

Chart 15 **-** International clothing brands and their commitment with purchasing organic cotton**.**

Already 100 percent organic cotton	**Committed to 100 percent organic cotton**
Boll & Branch Coyuchi Indigenous Designs KALANI Norrøna Nudie Jeans Wear Pact, LLC Patagonia PrAna Stanley and Stella Veja	ARMEDANGELS EILEEN FISHER: 100 percent cotton to be organic by 2020 Kering: 100 percent cotton to be organic by 2025

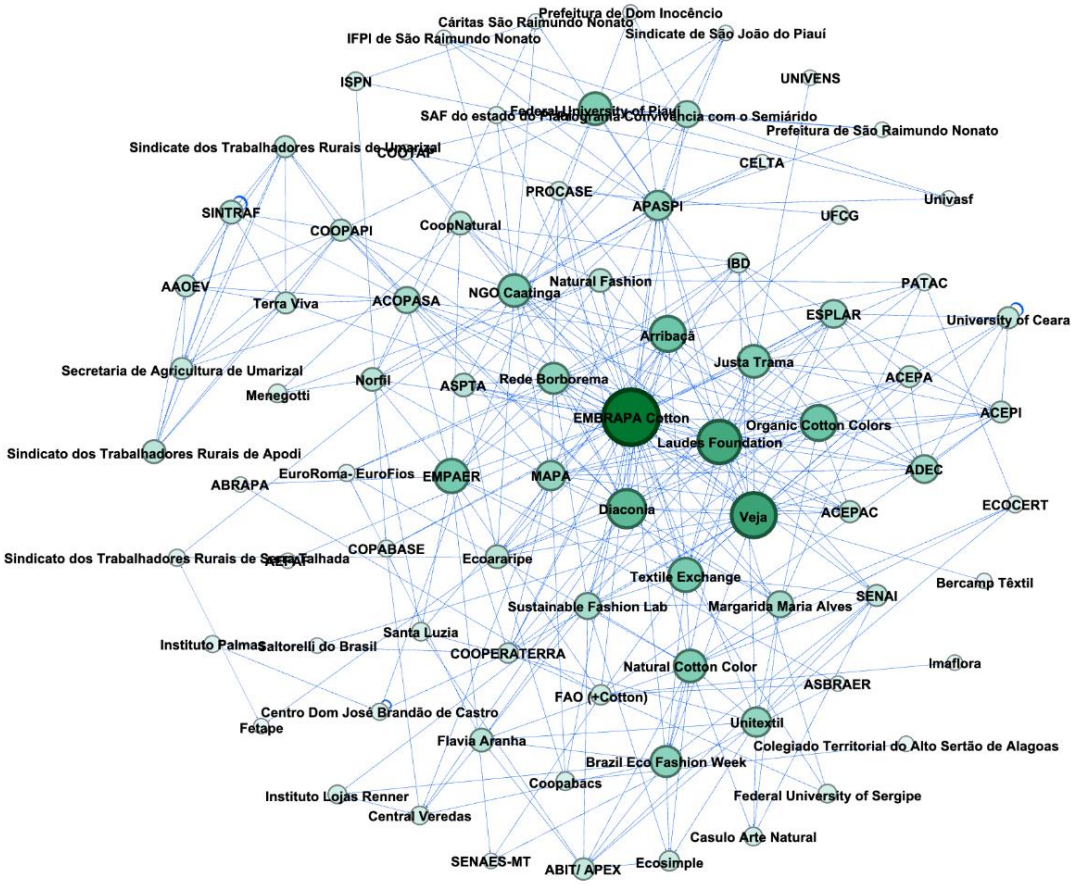
Source: Larissa Oliveira Duarte adapted from TEXTILE EXCHANGE, 2020a.

6.4 Brazilian Organic Cotton network analysis

It was utilized the platform GEPHI to design the organic cotton network in Brazil, considering the actors' information exchange. GEPHI is an open-source network analysis and visualization software package written in Java on the NetBeans platform (gephi.org). For the network design in GEPHI, it was utilized the *Fruchterman-Reingold* algorithm. For **density** analysis, it was taking in account the numbers of interactions between the actors and when it is lacking connections, this constitutes a structural hole. Also, **centrality** in terms of degree is the number of relations a given node maintains. Degree can further be differentiated in terms of in-degree and out-degree, that is, incoming or outgoing relations (LEYDESDORFF, 2007). For this study, the network was organized using the "degree of output" (the sending of data by the actor), the number of direct connections that leave from one node to another. According with the number of actors' relations, the circle representing each actor is bigger and greener.

GEPHI software was feed by data from two Excel (Microsoft) files. The first one contains the list of the network actors and each actor corresponds to a number. In this way, for the present study, the actors were identified without interruption by numbers from 1 to 82. The second, presents the relationships between one specific actor and others. In the case of the present study, 469 were identified (these relationships are indicated by a line). The follow figure demonstrates the case of organic cotton in Brazil (**Figure 52**), the actors participating and how they interact, **presenting the information flow**. The network was designed according with all data collected and analyzed in the present study. In this case, the circle size and intensity of green color are related with the amount of actors' connections.

Figure 52 - Organic cotton network in Brazil designed according to its actors' interaction employing GEPHI software.

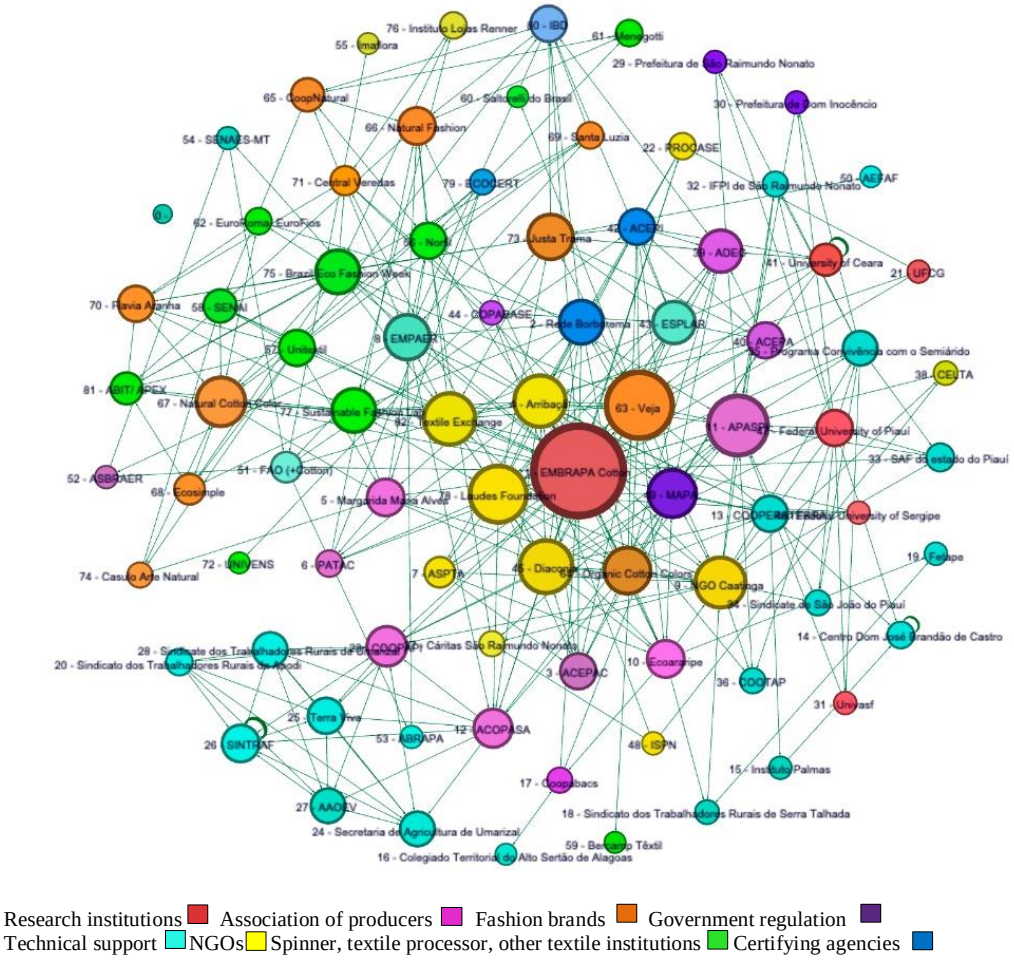


Source: Larissa Oliveira Duarte, 2020.

Additionally, based in the actors' categories presented by RAJALAHTI (2012), EKBOIR; RAJALAHTI (2012) and FERRIGNO et al. (2010), **Figure 53** emphases

actors' different categories, considering different colors. It includes research institutions, association of producers, fashion brands, government regulation, technical support, NGOs, spinner, textile processor and other textile institutions and certifying agencies.

Figure 53 - Organic cotton network in Brazil designed according to actors' categories, employing GEPHI software.



Source: Larissa Oliveira Duarte, 2020.

These types of visualization are important, allowing each actor to understand the work to be done to be considered a relevant actor. In this way, increasing the quantification of the value contributed to the system development (TEDESCO; SERRANO, 2019).

Further analysis and discussion of the organic cotton network in Brazil, considered the aspects (1) density and centrality; and (2) innovation aspects.

6.4.1. Network density and centrality analysis

Social networks are composed of inter-dependent members, promote communication and encourage cooperation between members. In this way, the deliberation and negotiation of complex problems within social networks can result in the sharing of multiple knowledge. Which supports collective learning and expertise between members of diverse groups, through sharing of expert science, local knowledge, and community values and beliefs (SIMPSON, DE LOË, 2017).

Based in the **Figure 52**, it is possible to notice that EMBRAPA Cotton, Laudes Foundation and VEJA have more connections with actors and represent the central positions in the network. These three institutions present considerable participation in the network as they are connecting with the majority of actors. They are followed by NGOs such as Diaconia, Arribaçã, Esplar and Textile Exchange. National and international NGOs participate mediating actors' relations, they also have relevant participation concerning the standards obtaining and market access. The companies OCC and NCC; the cooperative Justa Trama and the public research institution EMPAER have then more participation.

According to Chiu (2006), organizations with a higher level of network competence and central positions perform significantly better in terms of innovation than organizations low in network centrality. Also, high values of centrality indicate that linkage activity is centered in leading actors (AHUJA, 2000). Thus, even though most actors are linked to the network, some are more active than others. This could be associated with the fact that in complex networks when participants are spread out geographically, it could make frequent meetings of all participants more difficult. The structural solution to this problem is to centralize network governance activities around broker organizations (PROVAN; KENIS, 2008).

EMBRAPA Cotton participation emphasizes the relevance of cooperation with research institutions (FRANCO; WANKE, 2017). Spreading an intervention to the rest of the network it essential to have the support of other actors (RAMOS-VIDAL, 2016). In this case, the producers have access to training and technical support of research institutions and then they multiply the information to others producers.

Furthermore, EMBRAPA plays a brokering role in linking local producers to the global organic cotton market in Europe and vice versa. A member with high centrality can act independently across the network and help share knowledge efficiently to

different parts of the network. Also have a high capacity to broker relationships, creating bridges between disconnected members or parts of the network, resulting in much of the knowledge in the network pass through them (SIMPSON; DE LOË, 2017).

VEJA, OCC and NCC brands also act as brokers in the network, working from fiber to fashion, connecting producers to the next steps of the industrial transformation. To Batallas and Yassine (2006) central and broker actors in social networks have a larger number of colleagues that communicate with, thus becoming an influential member in the community. However, for new brands that want to enter the network it could be challenging.

The problem is that highly centered networks can have a negative effect on the sustainability and resilience of the system. The dependence on few central actors, with populated connections towards the outside, refers to a compact collaborative dynamic between peripheral organizations. And it can be considered as a system tending towards instability (HOFFECKER, 2019).

Considerations about network density indicate that the organic cotton scenario in Brazil is sparse and presents structural holes. Fragmentation of the network acts as a barrier to achieve a balance of diversity and redundancy of actors relations (BAEK et al., 2015). In other hand, deeply embedded networks can foster fine-grained information transfer and joint problem solving (UZZI, 1997), two essential components of successful resource sharing (AHUJA, 2000).

According with Hoffecker (2019) established but disconnected networks are crowded with many actors and initiatives that are not operating synergistically to produce innovation. There is lack of coordination, insufficient information-sharing, duplication of efforts, low levels of trust, ineffective capacity for effective collective action.

More connected networks, composed of partners with many interlocking and redundant ties, facilitates the development of trust and cooperation (GRANOVETTER, 1985; COLEMAN, 1988). Dense ties between partners are also likely to help in curbing opportunism (COLEMAN, 1988; ROWLEY et al., 2000). In closed networks, in which partners are connected to each other, information about one actor's opportunistic acts diffuses rapidly to other related actors, and sanctions for deviant behavior are more easily imposed (WALKER et al., 1997).

Such a network may be useful from the actors’ perspective when its partners are faced with a common external threat, for instance, adverse political or legislative actions, or in the context of standard setting in industries (OLIVER, 1990; AHUJA, 2000).

Extensive relations between partners can foster the development of shared norms of behavior and explicit interorganizational knowledge-sharing routines (UZZI, 1997).

In addition, based in **Figure 53,** it is possible to notice that the network could present more actors and connections relating to the textile and clothing sector. Important Brazilian actors, such as the Brazilian Association at Cotton Producers (ABRAPA) and the Brazilian Association of Textile Industry (ABIT), could present more participation. That could be related to the lack of the textile and clothing engagement.

The organic cotton network in Brazil lacks broker players, to connect producers and the textile and clothing sector. Central actors are able to exert influence on the subset in which they are embedded; however, intermediaries, and disseminators extend their connections between the core and the periphery, and between the groups that make up the network (RAMOS-VIDAL, 2016). Thus, it lacks an organization or social enterprise, linking farmers to the ginner, ginner to the spinner, spinner to the fabric mill, also connecting with the brands, to prospect market.

Some key issues were identified in that network development, mainly structural holes, **missing actors and relations**:

I. Actor linking all organic cotton dynamics previously mentioned;
II. An organic textile platform, acting as an agent for cotton marketing. Elaborating communication support, financing attendance at international events, etc.;
III. Intermediary actors related to innovation, perhaps an opportunity for startups, working with traceability, logistics, marketing and compliance;
IV. Textile industry and clothing brands participating closer and interacting with organic cotton producers;
V. Medium size producers with more potential to invest in the necessary research and machinery to expand production.

In this direction, international conferences and events provided important occasions for establishing linkages between organic cotton promoters and businesses, strengthening market relations (GLIN et al., 2012), such as the event Brazil Eco Fashion Week and the conferences and reports of Textile Exchange.

The “Program Cotton in Agroecological Consortia” presented relevant to connect actors and promote collaboration, bringing together complementary skills from different

actors. The Program is especially significant because engage and coordinate multi-actors. The advantages of network coordination are considerable, including enhanced learning, more efficient use of resources, increased capacity to plan and address complex problems, greater competitiveness, and better services for clients (PROVAN; KENIS, 2008). The program brings actor relationships closer, thus, common partners can serve as referral agents and relay expectations and responsibilities as part of the process of bringing together unconnected actors (GULATI, 1995; UZZI, 1997).

The resource sharing benefits of collaboration a rise from firms combining their skills, sharing their knowledge, and conducting joint projects to obtain scale economies, all of which presume the existence of trust between the partners (AHUJA, 2000). Collaboration promotes the diffusion of sustainable practices, and ultimately allows business model experimentation (TODESCHINI et al., 2017). Collaboration is about organizations working together and goes beyond normal B2B relationships (ROTA et al., 2013).

The benefits of a strongly collaborative network help to facilitate and enhance a sustainability agenda, for retailers, manufacturers and policy makers, as well as for the governance (MACCARTHY; JAYARATHNE, 2012). For the organic cotton network in Brazil it could for example, relate to facilitating the standard certification after the field stage, such as GOTS, giving more value to products for exportation.

6.4.2 Organic cotton innovation and opportunities

Innovation depends on an intricate set of interactions between technological and market elements. Requiring the combination of human and organizational factors integrated with technical and market dimensions (STEFANOVITZ; NAGANO, 2014). In this way, the new products would allow the exploration of new market segments, in terms of technical specificities, technology, raw materials or intended uses (BUFFA et al., 2019).

The first factor of adding value to the product in the case of organic cotton is the production of genetically improved seed, which is proper for semi-arid regions and suitable for the textile industry (FERRAZ, 2018). This means creating an innovative product with a difference: the environmentally friendly product and practices in the field of productive traceability and transparency. Another factor of added value is the organic certification, currently being carried out by the ECOCERT, IBD certifier and participative

certifications that attempt to lower the certification process among family farmers (FERRAZ, 2018).

For Natural Cotton Color (NCC) fashion brand, they innovate bringing added value to the finished product, based on the pillars of: ecologically correct, socially fair, culturally preserved and economically viable. Also working with rural settlements and encouraging family farming, as well as woman participation (TEXTILE EXCHANGE, 2020).

In terms of product innovation, NCC launched a new organic colored cotton Denim, developed in partnership with the SENAI Textile Technology Center. The colored cotton gains market relevance as it does not require additional dyes, saving water and any additional toxic component. Francisca Vieira, CEO of the brand, presented the news international faire Premiére Vision Paris, in Paris. The Denim is pending patent (ETHICAL FASHION BRAZIL, 2020).

Other innovative products are the threads made of organic colored cotton with silk (**Figure 54 a**). Silk is produced in southeastern Brazil also in a productive arrangement by local family members. A fabric sample (jacquard) with one of the threads was presented at the Smart Creation innovation hall, also at Premiére Vision (ETHICAL FASHION BRAZIL, 2020). Another partnership with the company EuroRoma created the EcoYarn, made with organic colored cotton (**Figure 54 b**). The idea is that the EuroRoma Ecoyarn becomes a product line, based on naturally colored cotton, with more options of yarns and other colors of naturally colored cotton (ECOFRIENDLY COTTON, 2020).

Figure 54 - (a) Textile silk and organic colored cotton from NCC; **(b)** Organic colored cotton thread developed by NCC and Euro Roma.

(a) **(b)**

Source: ETHICAL FASHION BRAZIL, 2020

The new products allow the exploration of new market segments, in terms of technical specificities, technology, raw materials or intended uses (BUFFA et al., 2019).

Additionally, the social advantages of organic farming relate to social learning that validates the producers' knowledge and views about technological development and social innovation. Domanski et al. (2020) describe social innovation as a new combination or configuration of social practices in certain areas by certain actors with the goal of better answering social needs.

Because of the specific approach and the expertise, it requires, organic farming gives rise to a reconfiguring of existing social networks. Different from the conventional cotton system, which focuses mainly on the cotton plant, growing organic cotton needs to take place within a farm system that aims to optimize the larger agro-ecosystem (GLIN et al., 2012). This calls for a change in producers' attitudes and behavior, as well as new knowledge and skills, such as the use of water and soil management and conservation practices in areas intended for planting. And implementation of diversified production areas, with the presence of natural protection barriers facilitating pest control, protection from pesticide contamination; use of natural pesticides and the application of biofertilizers (GLIN et al., 2012).

Distributed systems are the result of complex, innovative processes in which technological components cannot be separated from social ones. The more a system is scattered and networked, the larger and more connected is its interface with society and the more the social side of innovation has to be considered. No distributed and resilient systems can be implemented without social innovation (MANZINI; M'RITHAA, 2016). Pel et al., (2020) described social innovation important pillars:

(1) Local Embedding: Often existing in the form of "labs", "Hubs", "Towns" and community based initiatives. Many socially innovative collectives operate through intensive collaborations with local authorities, NGOs, community organizations, businesses, and educational institutions. The importance of these local roots manifests through the empowerment processes of (a) legitimacy (addressing local needs); (b) critical mass (for which vicinity is also important); (c) the provision of accommodation and material resources, and (d) institutional anchorage.

(2) Local and international connectivity: Forming part of various international networks, platforms, or movements. The importance of this transnational connectivity manifests through empowerment processes such as the construction of translocal political voice; the development of translocal collective identity (as materialized in brands and logos), and knowledge exchange. The international connections are also often important assets towards the acquisition of funds.

(3) Discursive resonance: Beyond the many individuals, local initiatives and transnational networks who seek to develop persuasive discourses and narratives of change. This discursive is a collective process that involves the whole communicative sphere through which socially innovative concepts gain political and scientific authority. Including the communication infrastructures through which the initiatives concepts are spread.

Furthermore, innovations are of capital importance for meeting current and future challenges in food, farming and the natural environment (NICOLAY, 2019). One of the ways through which companies seek innovation development is by establishing network (VITORELI, GOBBO JUNIOR, 2013; BELSO-MARTINEZ, DIEZ-VIAL, 2018). As companies do not themselves possess all of the information and knowledge needed for innovation (FRANCO, WANKE, 2017), they see partnerships as a means to address such gaps. Therefore, they seek out complementary capabilities to assist in the development of new products or processes (POWELL et al., 1996; TOPFER et al., 2017).

With gaining technological capabilities, firms start engaging in knowledge sharing and training. In addition to traditional role of regulation, the government may act as a public entrepreneur. Enlisting the support of local authorities, broad consultation and dialogue among actors, and establishing a vision for future are important pillars of the process (GHAZINOORY et al., 2020).

The adoption of innovations is rarely spontaneous but often the consequence of an external priming agent. External help, in financial and non-financial forms, is required for the farmer to face transition costs (FERRIGNO et al., 2005; BAUDRON et al., 2009). Agricultural system innovation involves bringing new ideas, practices, or processes into diverse smallholder farming systems (REED; HICKE, 2016). Therefore, **Chart 16** summarizes the main innovations in the organic cotton network suggested in the technical visits and interviews with EMBRAPA Cotton specialists.

Chart 16 - Identifying organic cotton innovation and their proponents.

	Innovation aspects	Proponent
Environmental	Agroecological cotton production system in agro-food consortium. Fertilization of production systems using biofertilizers recommended for organic systems according to the rules of the Brazilian organic law.	EMBRAPA Cotton, farmers, Arribaçã, Diaconia, ACEPAC and Laudes Foundation.
Communication	The use of the Whatsapp group of organic cotton producers to transmit technical knowledge between advisors-farmers and farmers-farmers.	EMBRAPA Cotton, Arribaçã, Diaconia, ACEPAC, Laudes Foundation and farmers.
Legal	Participatory organic certification of production systems in rural properties that work with agroecological cotton in agro-food consortium.	EMBRAPA Cotton, Arribaçã, Diaconia, Acepac, Rede Borborema, farmers, MAPA.
Management/ Coordination	Commercialization of additional products with the organic certification, such as sesame and beans. Better communication with the network actors. Development of agroecological reports and agenda.	Farmers, Acepac, Arribaçã.
Research	Application of the knowledge construction methodology called the Participatory Learning in the Research Units (UAP). Engaging and preparing farmers in research. Strengthen action research (production, vision, negotiation).	EMBRAPA Cotton, farmers, Arribaçã, Diaconia, Acepac and Laudes Foundation.
Technology	Mini cotton ginning machine that benefits cotton fiber, ensuring that the seed remains on the property for planting and use in animal feed. Beginning of the development of small machinery for family holders and adapted to semi-arid conditions (Small harvesting machine). The development of an APP for monitoring insects.	EMBRAPA Cotton, farmers, Acepac and Veja.
Production/ Sales	Diversifying products and commercializing fiber, food, etc. Transformation of cotton crop waste into a sub product for animal feed or pharma products. Expansion of market access.	Embrapa Cotton, Patac, Arribaçã, farmers and Acepac.
Training	Implantation of practices for soil and water conservation in cropping areas and rainfed methods. Capacitation of associations to access market. EMBRAPA video classes and distance learning. Motivation and engagement of young farmers and woman into organic cotton production, especially in management functions.	EMBRAPA Cotton, Patac, Arribaçã, farmers, Rede Borborema, Laudes Foundation, Acepac, etc
Business Services	Business model with order and pre-sale. Encouraging sustainable consumer behavior. Opportunity to certify the area.	EMBRAPA Cotton, farmers, Acepac, Rede Borborema, Arribaçã, Laudes Foundation.
Product	EcoYarn, made with organic colored cotton. Fabric made with silk and organic colored cotton. Jeans made with organic colored cotton.	Natural Cotton Color, SENAI, Euroma, etc.
Social	Fair trade, local embedding, translocal and international connectivity, discursive resonance, community engagement, young farmers and woman participation.	Laudes Foundation, Justa Trama, Rede Borborema, etc.

Source: Larissa Oliveira Duarte, 2020.

7. FINAL CONSIDERATIONS

Cotton is one of the most important crops in terms of its value. In one hand, conventional cotton, in long-terms, depletes the environment and leaves behind toxins. In other, organic cotton maintains clean soils, air and water resources, positively impacting a healthy environment for workers and wildlife. Organic cotton is considered to be more sustainable, especially when cultivated in agroecological and rainfed systems, with grown balanced ecosystem, producing organic food and fiber, considering soil nutrition and independent on many external incomes. It improves the fertility of the soil (softer soil, greater absorption of water, better water holding capacity, healthy crops); reduces the production costs and thus the financial risk; offers a better price for cotton; avoids negative effects of conventional farming such as declining yields, resistance of pests and diseases, health hazards of chemicals; and finally improves the profitability of the farm in the long term (WILLER; LERNOUD, 2019).

It was observed that conventional cotton and organic cotton address different markets. The first one with volume production and the second one, attending a niche with premium prices with great potential to expand.

In this way, organic cotton in Brazil includes several relevant aspects to get international market attention including: mixed livestock systems; smallholders support and guidance; biodiversity conservation; use of cotton crop residues and by product in livestock and fair trade. It is also related with agroecology and family farming, generating income to maintain families in the rural area. However, the organic cotton network in Brazil is fragmented, considering the production from field to fashion. It demands more integration to attend the market that grows every year.

At the same time, textile and clothing sector is complex, with many suppliers located in different countries. It lacks transparency, especially when involving small producers. From the textile and clothing perspective it is missing co-ordination between standard organizations by providing the sector with clear indications of market demand and understanding where the bottlenecks are. Increasing market uptake is therefore a precondition for the long-term viability of organic cotton programs (FERRIGNO, 2016).

Initiatives such as the “Program Cotton in Agroecological Consortia” are of great importance, as they address the gap between small family farmers’ producers, the textile industry and clothing market. The program connects actors from field to fashion and

promote collaboration, bringing together complementary skills from different actors. The resource sharing benefits of collaboration can impact the production and develop network models to obtain scale economies, to open new markets, and even attend the Brazilian local market.

If organic cotton production were combined with policies to increase local processing and ginning through the existing cotton chain, higher revenue could be generated. While at the same time reducing pressure on the environment and local resources. Therefore, the organization of the sector is a critical factor, which strongly influences every partnership strategy and ensures the mainstream-sustainability (FAYET; VERMEULEN, 2014).

Apparel brands and retailers still have a limited overview of their own supply chain. They are focusing their efforts on more sustainable material, however sustainability impacts can be considered in the entirely production systems. Increasing emphasis on collaborative efforts between brands and suppliers. Collaboration is important also in the consumer relation, given the similar lack of direct brand orientation concerning materials origin and production aspects (KOZLOWSKI et al., 2015). The fair trade and environmental approach are two characteristics addressing client's attention, so informing and engaging to clients is essential.

In this context, it is worth highlighting the role of different actors such as international and national NGOs, technical and technological support agencies, the consolidation of family farmers' groups and their link relation with the textile and clothing sector. Brands and retailers have a crucial role to play, as they have the capacity to pull the sector towards greater sustainability by demanding and sourcing more organic cotton. International buyers are playing an important role managing their supply. Also improving participation from national major institutions for market and commercial support is an important aspect. And the development of platforms to support the network interaction and communication, national events and multi-actors' meetings.

A better distribution in the network roles, maintains a higher numbers of actors in leadership positions, distributing the activities, responsibilities, knowledge, resources, etc. It allows shared leadership, interdependence, autonomy and strengthens fault tolerance in the network, in case that any investment or activity cease to exist. Giving greater representation to the diversity of views (HOFFECKER; 2019).

The following aspects could emphasize the opportunity for the organic cotton development in Brazil: to take in account the distributed production implementation by

mixing different logics of design and fabrication that range from those of traditional industry and; to create networks of small–medium enterprises, to support a craftsmanship revival and the application of high-tech miniaturized production systems (MANZINI; M'RITHAA, 2016).

Future studies could evaluate economic and commercial aspects in the studied network and analyze a larger sample of apparel brands using organic cotton in Brazil. Providing a better understanding of the framework's various elements, mapping organic cotton customers' and analyzing their perceptions in a survey. Further research could also investigate aspects relating to the governance structure in the organic cotton network in Brazil. Also to look deeply in the relation of the organic cotton network actors, including their goals, influence and type of information and resource exchange. In a couple of years, by the end of the Program "Cotton in Agroecological Consortia", it could be interesting to analyze the project results, comparing with the network evaluation presented in this research. Lastly, to verify the commitment of communities and their future vision related to the organic cotton production and how the agricultures can achieve more autonomy.

8. CONCLUSION

This research presented the organic cotton network in Brazil, identified the mains actors and discussed the existing links among them.

Organic agriculture especially together with agroecological practices, has a major role to play in assisting with resource management, such as reducing water demand, diminishing soil erosion, maintaining and enhancing biodiversity. When considering the agroecological aspects it brings clear social benefits, such as the integration of women in agricultural communities, as well as offering new employment opportunities that impacts the resilience of rural communities.

The interest in organic cotton production has been increasing every year, yet the production still faces difficulties regarding articulation with the textile and clothing sector and the market. Considering this perspective, actions are fragmented, what could provoke confusion to suppliers, brands and customers. Multi-actors' initiatives and programs, acting beyond commercial interests, could offer guidance and promote cohesion to the network. It is noticed that EMBRAPA Cotton, Laudes Foundation and VEJA represent the central positions in organic cotton network analysis. They are followed by NGOs such as Esplar, Diaconia, Arribaçã and Textile Exchange, the companies OCC, NCC and Justa Trama and the public research institution EMPAER.

Research institutions are fundamental in the development of new production systems arrangements. National and international NGOs networks opened up spaces for value sharing and information exchange and play the role of financing agroecological projects, supporting the network structural consolidation. Also brands and retailers have a crucial role to play, as they have the capacity to pull the sector towards greater sustainability by demanding, sourcing more sustainable cotton and informing costumers about the impact of organic cotton.

The low density of the organic cotton network in Brazil, regarding the connection to fashion brands, could emphasize that is missing intermediaries' actors related to textile and clothing sector. Small and medium organizations in this context, such as smallholders' associations and small and medium clothing brands are very important to diversify and expand the network. Results suggests that it is missing organizations or social enterprises in the Brazilian organic cotton network, playing broker roles. In this way, to connect farmers and the textile and clothing sector; linking producers to ginner

stage, ginner to the spinner, spinner to the fabric mill, thus, connecting to brands and prospecting markets.

In addition, more actors playing leadership roles to better engage the network. Such as medium size producers, with more potential to invest in research and machinery are necessary to expand production and improve logistics. More distributed networks can motivate a higher number of actors towards long term commitment.

This research was especially important to point out the need of collective arrangements to motivate new production systems in the textile and clothing sector. Collaboration is particularly relevant because it represents a chance to improve organic cotton competitiveness and producers' well-being. Also it is one of the principles of organic and fair trade funding, which translate into certification rules of transparency for joint management procedures. Innovation towards distributed systems in globalized production and consumption is challenging, therefore demanding collaboration to develop new products, services, technologies and social development.

Finally, with the industry united around a common agenda, it could drive the needed systemic change and work jointly on innovation.

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APPENDIX 1

Guide utilized for the interviews.

Farm - Producers organization

- A brief description of the organization you integrate.
- What are your current activities?
- When do you start planting organic cotton?
- Do you cultivate other species?
- What is the production volume?
- Where is made the ginning and weaving processes?
- Which company buys the cotton?
- How many are the associated families?
- What are the communication tools you use?
- Do you have a certification standard?
- What are the main challenges and perspectives for organic cotton in Brazil in production and market?

Farm - Public research institution

- What is your position and activities with organic cotton?
- Describe organic cotton production in Brazil.
- Which are the main producing states and how many families are involved?
- How you support the organic cotton production?
- Who are the participants in the organic cotton network?
- Is organic cotton considered more sustainable? Why?
- Why organic cotton is more expensive than the conventional cotton?
- What are the main challenges to expand the organic cotton market, in order to meet national and international demands and the main opportunities/perspectives for organic cotton in Brazil?

Farm - NGO

- A brief description of the organization you work for.
- What is your position and activities with organic cotton?
- Who are the main participants in the organic cotton network you are part of?
- How do you support producers?
- What are the communication tools you use?
- What is the importance of certification?
- What are the main challenges to expand the organic cotton market, in order to meet national and international demands and the main opportunities/perspectives for organic cotton in Brazil?

Clothing and Retail - Clothing Brand

- A brief description of the company.
- Which textile materials do you work with?
- Why do you opt for organic cotton?
- Since when do you use organic cotton?
- Who spins and weaves your cotton?
- Have you bought organic cotton from other countries?
- Are you familiar with farmers' processes and operations?
- Do clients know about your processes and materials?
- Where and who performs the spinning and weaving?
- What are the benefits of using it?
- Do you have feedback from your customers about organic cotton?
- From your experience with the organic cotton network in Brazil, which do you consider to be the greatest challenges and potentials?

Clothing and Retail - Foundation

- A brief description of the company.
- What are your activities?

- What are the Foundation projects with organic cotton in Brazil? Could you give a panorama of them and how they work?
- In Brazil does C&A uses the organic cotton in the production of garments?
- How do you engage with clients regarding that?
- From your experience with the organic cotton network in Brazil, which do you consider to be the greatest challenges and potentials?

Clothing and Retail - Brazil Eco Fashion Week

- A brief description of the company and your activities.
- What is the participation and relevance of organic cotton in the event?
- What are the challenges today of using organic cotton?
- Is there a demand from customers and brands for organic cotton?
- How do you see the market outlook for organic cotton?
- How do customers, brands and the market as a whole perceive the benefit of organic cotton?
- From your experience with the organic cotton network in Brazil, which do you consider to be the greatest challenges and potentials?

APPENDIX 2

Chart 2 - Main actors of the organic cotton network in Brazil: Summary of interviews realized from September 2019 to August 2020.

Interviewer Focus of activity	Main findings	Representative quote
Researcher at EMBRAPA Cotton – Genetic Resources and Breeding sector - Coordinates the agroecological cotton project "Improvement of Agroecological Cotton Systems in Agro-Food Consortia".	• Organic cotton in Brazil, needs adjustments concerning the cultivation system such as more research and investment. Knowing the most efficient cultivar for each local, quality seeds, soil, water, and insects' management. • Challenges include how to deal with the rain instability and the development of machinery for small producers. More investors and partners.	• If the technology is already being absorbed by the farmer, then we will have an immense impact. With the project "Cotton in Agroecological Consortia" we transformed farmers training modules into learning and participatory research units.
Researcher at EMBRAPA Cotton – Production system sector - Coordinates the agroecological cotton project "Improvement of Agroecological Cotton Systems in Agro-Food Consortia".	• It is being developed 4 case studies - for example, how cotton behaved in Paraiba soil and how droughts occurred in the territories and we are also doing soil and fiber analysis. • We believe that manual harvesting has been a differential in cotton quality. • The positive aspects of the project include diverse production besides cotton, such as sisal, sesame, cattle, soil and water conservation, gender equality, different generations integration. • We need to develop cultivation systems that protect the soil and conserve water. Improvement is need in machinery for seeds preparation.	• We think that the knowledge they have still needs to be adjusted to the local reality. Adjusting means experimenting, searching. Therefore, together with the farmers, some areas of experimentation were defined. • There is the conventional system - which has already had many advances, on the other hand there is the organic system, that needs an effective and greater attention from EMBRAPA, mainly because the areas of production of organic cotton most are in the semiarid region. Having a product capable of generating income in the semiarid region is fundamental. • A challenge is to establish relationships with other partners, capable of completing the entire cotton production chain. Work more together with fashion, getting closer, we have to dialogue with the different sectors. • If we continue this process of researching and improving systems, I believe that we will soon have a very significant increase production. Buyers have to understand and get closer to the productive base of the field. If you always work with monoculture, the tendency is that there is a depletion of soil in a certain element or that pests begin to appear. That is why thinking about the production system is essential to give sustainability to the production of organic cotton.
Researcher at EMBRAPA Cotton Agribusiness Analyst	• Abrapa represents entrepreneurs, all of them great. If you go to Cerrado Baiano Mato-grossense, Goiano and here in Piauí and Maranhão, you will notice that the companies that plant cotton and sell it will realize that this year, more than half of the cotton produced was exported to China, Singapore, Bangladesh. • The EMBRAPA brand helps micro entrepreneurs to sell and commercialize. There must now be an interaction between the government and these interested micro entrepreneurs, including SEBRAE, SENAI (S system as a whole), EMBRAPA and the State Government. The issue of assistance in the field is essential to be accompanied by technicians. The problem is that both EMBRAPA and	• One of the initial questions for this business community, who wants to work with organic cotton, will be to help governments and research institutions in the definition of their own technologies in Brazil to transform this culture into a sustainable business. • In order to have a change in the market, entrepreneurs and larger enterprises have to act, in order to improve research, speed up results and retain production in the field, while marketing these products. • Due to climatology and soil, the region is ideal for the production of organic cotton. But it would have to be a state action directed at engaged entrepreneurs. It is difficult to do, but if it is not done it will not develop.

	EMPAER technicians are not ready to resolve major issues.	
Researcher at EMBRAPA Cotton. Technical support in the project "Improvement of Agroecological Cotton Systems in Agro-Food Consortia".	• Challenges of organic cotton production include the organization, communication and professionalization of producers. Also the engagement of the groups, research and development of smallholder's equipment, to support them considering their health and wellbeing. • The opportunities include the demand of organic cotton, which is a different demand from buyers from India, as the country has social and farms rights issues. Cotton needs a soil with nutrients. Furthermore, organic cotton lint has a cleaner lint.	• The organic cotton in Brazil is developing, in the past producers had commercial problems, they don´t have now, as they are more organized. However, they need the technical orientation and support in the precise timing.
Executive Management of Planning and Operations at EMPAER - systematization and methodology that applies in the part of technical assistance to farmers: in search of markets, certification, technical advice all focused on organic agriculture or agroecological transition.	• EMPAER is the technical assistance part, regardless of whether it is for Norfil or Santa Luzia our role is to apply the assistance methodology. To guide farmers on how to produce, agroecological, organic, part of natural pesticides and the demand that arises from the company.	• The project Cotton Paraiba, started in 2016. There were 60 farmers, we assisted 8 municipalities with 54 hectares and production of around 11 tons, despite all the difficulties caused by the drought. This certification is done by IBD. In this project we have 200 registered producers.
In-country manager Organic Cotton Colores - articulation and mobilization of families of producers.	• OCC is a company that has been in the market for over 25 years, bringing a quality product to families, produced in a 100% organic way. • Today we have our own seal - OCC Guarante and we have been working and seeking, increasingly, to strengthen groups through participatory certification. • An average of 200 families producing for OCC.	• Our interest goes beyond a certification which is to train families, to motivate families to produce cotton again in consortium with the other crops they already work in, thinking about giving a quality of life to these families and long term partnerships. • The challenge is the communication itself in the territories, which needs to flow more and more in a shared way, I am not saying that it does not have, but it needs to be expanded every day. Communication is fundamental for the work to continue and multiply with the families that are in these territories. • Mocó is the most interesting, because it has a longer fiber, we need long fiber and get a better price. • What we have seen is that access to this product has still been very small in Brazil, even in the Northeast it is rare to find a piece of organic product in a store. • The organic market - not only for cotton - but this market itself is growing every day, the demand has been increasing.
Sustainable raw materials manager at Laudes Foundation	• Today our main focus is to promote organic cotton production in Brazil. We have a partnership, a project with ESPLAR and WTT, in the state of Ceará, to promote labor-saving technologies for family farming. We have a project with Solidaridad in Minas and Bahia, to encourage the production of BCI cotton, because today there is no BCI cotton for small producers. And our main project today, is with Diaconia and EMBRAPA, which aims to strengthen the production of agroecological cotton community. • The project "Cotton in Agroecological Consortia" takes place in six states and	• We are supporting around 1,200 to 1,400 family farmers and producers and an estimated production of around seventy tons. • The main achievement of the project is the confidence and motivation of farmers to plant cotton, arrange the sales and understand the market. • Organic has a greater demand than the offer, which is a dream for anyone. It is still very niche, there is a demand, mainly for smaller brands, but cool, but even within big brands, from large companies. I see an interest, for example, in having special collections with only organic cotton production. • The big challenge today for the production of organic cotton in Brazil is the gain of scale. Even our strategy of going to the Cerrado biome in the Midwest, obviously is to expand the project to other territories, but it is also for people to be able to promote and raise awareness among medium

	seven territories, in southern Piauí in Serra da Capivara, in the hinterland of Cariri in Paraíba, in the backlands of Apodi in Rio Grande do Norte, in the backlands of Pajeú and in the backlands of Araripe in Pernambuco, in the high backlands of Alagoas and in Sergipe also in the high backlands. • Also with SPTA, a new partnership this year, in the region of Paraíba, at the Borborema. • A project in the Cerrado biome, so we have a partnership with ISTM, which is an organization located in Brasilia and that will promote projects in the northwest of Minas Gerais in the Vale do Urucuia region, and we also have in Mato Grosso with indigenous and quilombola women producing organic cotton. • First challenge is scale of organic production. Second, qualified technical labor. Third, the legislation that deals with the organic certification of the management of OPACS is very bureaucratic and we have a project to discuss with the government and see how we can reduce this legislation. • And finally, how to link the institute and the business is a challenge.	and large producers. It inspires them to look and shift from BCI or conventional to organic. • We want to have a business model that can be replicated for family farming with agroecological cotton production. • A challenge is to technically prepare producers, another one is to work at the level of public policies, to bring the topic up for discussion in the chain, because there is no point in looking at production and not looking at the eco system as a whole. • The big challenge for organic cotton production in Brazil today is volume, it is a large scale. How to scale this production, ensuring good price, needs management techniques? • Another reality is that there is an aging generation and a youth that does not have much experience in the field. So even the investment in technologies is something that we are now seeing, technologies for family farming as an opportunity to retain young people in the field. A cell phone application to monitor insets, for example. We must take technology to the field to attract young labor.
President of Coopenatural and Natural Fashion	• The first organic cotton producers in Brazil where in Ceará with Pedro Jorge (ESPLAR). And then it was us. And Pedro Jorge has always given me a lot of support and strength. It was in 2005/2006 that we came out with certified organic cotton. • Now we are organizing a group of twenty-three members. They have small businesses in the clothing industry. Our buyer is Norfil. The buyers of fabrics that we have are small entrepreneurs who are starting, producing sustainable textiles. We don't plant the “aroeira” cotton crop. We planted it until 2018. We planted a new seed this year, BRS 286. Moco cotton is the competitor of pima and is the competitor of the Egyptian.	• There will be worldwide pressure for the production of organic cotton. • The organic cotton market is increasing. This year here in Paraíba we have more than two hundred farmers.
Textile Exchange Ambassador Latin America	• Textile Exchange started in 2002, focusing on organic fibers, it was called Organic Exchange. And in 2010 it expanded to work with different sustainable materials and changed its name. It was founded by an old cotton farming, which comes from a family of cotton farmers. Around the 2000s, her husband died, due to the impacts of	• Only 7 countries account for 98% of organic cotton production. The great champion is India, then China, Kyrgyzstan. Then Turkey, which is very traditional, USA, Tanzania. And Brazil represents a very small percentage, with a potential for brutal growth. Almost 19 countries produce organic cotton in the world. Brazil have an impressive growth potential. • When we talk about Latin America, the producer is Peru. They have a feature that facilitates a lot, which is the fact that they do not have the pests that we have in Brazil, and in Peru the transgenic

	chemicals on agriculture. She and her children started to produce organics together with a cooperative of producers in Texas. And she realized that it could be a way to impact and transform the textile industry. • TE does not certify, it creates the standards for certification to verify products for exportation. • The international production of organic cotton was 180 thousand metric tons; it is a very small production. The demand on the planet is much greater than that. There are 350 thousand certified hectares, a considerable area, only representing perhaps 1% of all cotton that is produced in the world. A positive number is the 44 thousand hectares that are in transition to organic. It means that the process is in continuous development.	is prohibited. What makes an environment more favorable to the development of organic. Brazil had a very important production in 2010 and 2011, in the northeastern semi-arid region, and from then on, drought climate problems began. And other problems of development and support for farmers. • Our organic cotton in Brazil is different from the cotton we have in the USA. Which is produced in the same way that conventional is produced. High mechanization and capital. It is organic, because it meets the criteria of not using agrochemicals, but in terms of soil use and conservation, it leaves something to be desired. Our organic has something else. This small farmer produces food in the fields and along with the food in consortium he has cotton. Called regenerative agriculture in some places, as it has more intimacy with nature. Different from conventional agriculture. The brands participating in this event are major brands, which have lines of ecological or more sustainable products. • The price for the farmer today is very low. And everyone knows the value of organic cotton. We need to reverse this paradigm. This is one of the challenges we face. Today this producer from the Northeast, which produces organic colored cotton, has a good remuneration for this product. • The main challenges would be to increase production in the region. In the development of new business models. In encouraging consumption. Advocacy actions that could favor greater growth and use of organic cotton, and increased cooperation in the sector. And in this effort to finance brands and retailers, we also have the participation of NGOs, the public sector, SENAI, EMBRAPA. Demand is undeniably increasing and production cannot keep up.
Pedagogical political advisor at DIACONIA	• Agroecological cotton in the Northeast has a history since 1995. So he is over twenty years old and started in Ceará with Pedro Jorge. With a research group, trying to identify an alternative way of producing cotton. • Cotton in the semiarid is a culture that represents a lot to the farmer, a culture that adapts well and integrates with animal production, which is the main activity of families in the semiarid region. • In 2003, the Brazilian Organic Law was created by the Ministry of Agriculture. In 2011 it was regulated, all the normative instructions. And it started with a very positive effect. Until then, we certified with external audit, such as IBD and ECOCERT.	• The participation of women in OPACs is fundamental for their sustainability. OPACs that had women involved in management were far ahead in development and organization. And where there were no women, business fell apart faster. • Challenges concern the need for labor-saving technologies. We have an important participatory research with EMBRAPA Cotton that aims to develop these technologies for family farming. In conventional agriculture there are giant machines. And everywhere we go, we hear families saying that the process is limited by labor. Families are smaller, the rural population is older, many young people have left the countryside. • Today we see youth taking an interest. This is a very important factor for sustainability, the vitality and energy of the youth is very important in the process. But we must develop technologies for young people, in order to consolidate their participation in agriculture, in the semi-arid region, labor-saving technology is needed. It is a factor that we will develop. Equipment adapted for small householders. • Another challenge is that the cotton chain in the textile industry starts with the yarn, few companies are willing to start with the lint. And with OPACs today, we only go to the lint. Today they have a much higher demand than the offer. And we are arranging a way so we can start making thread also. • If you have cotton, few companies are willing to buy, take to spinning, etc. When it comes to the yarn, there is no market limit for organic yarn. But we still need to evolve in organization and management for this, and machinery or we can outsource the service for example.

Founder of the brand Flavia Aranha	• We basically use natural fibers and some artificial ones with cellulosic base. Cotton, linen, silk is the most used. And wool occasionally, because of the climate and our Brazilian production. We use also modal and tencel. I've used some Lenze viscose. Carua, sisal and banana, for artisanal production. We work with varied vegetable fibers and it is a field of interest, we are now researching mallow, always researching new fibers and how we bring them to the industrial chain, in addition to accessories. • Cotton and linen are the most used materials. We work with knitted cotton, flat fabric and thread. We use organic cotton since 2009. • I started to buy from Natural Cotton Color. I met Francisca and I understood that she was able to have knowledge about the chain and the certificate, which for us was important. Then we started buying from Justa Trama, and we stayed on it. Ecotex is a Brazilian standard, it is used for export, but now Francisca is committed to obtaining GOTS certification, which is international and has a higher export value. • The need for us to bring the workshop, and lectures, comes very much from this great objective, which is to touch people and bring awareness to the client.	• Thinking about the land, if we talk about family farmers and agroecology, we are talking about land without chemicals, about decentralizing the power of the land. • Organic culture works best when we talk about family farming, because they are small lands who are taking care of this land. Also they plant several other crops, and then you bring autonomy and food security to these families. • They can first produce their own food without poison, and then they can sell cotton. • When I choose to use this cotton, I am fostering this political relationship that I believe in. Soil regeneration, possibility of integrated agriculture, various species and consumption without agrochemicals. • From what I see, people want to use these products, because they want it for their bodies and for the world. I see that there are more and more customers who want to consume this product, because they want to put their money in more positive production systems. • The market is open for this product, we start with food, then cosmetics and clothes, I think clothes are in third place. So usually those who consume our clothes, already eat organic, use less synthetic cosmetics on their face, and the third one I feel is the opening for organic clothes, in the client's life. • Organic cotton is still for a niche public. So I think we are moving towards a scenario where we will be able to combine design and agroecological raw material in order to generate access to another groups of consumers that we want to consume. • So we are back in this logic of consuming less and better. We come back to this, customers who are stopping to buy ten clothes in a fast fashion to buy two T-shirts at Flavia Aranha, we have seen this for some years. • I'm not saying that everyone has to use organic cotton, I think we need to create a diversity of fibers, we have so many options. • The challenge of organic cotton for me is not the technique of cotton itself. I think it is the perspective of the industry, of wanting to have few raw materials and systematizing new chains. I think it's a mindset-changing challenge.
Creative coordinator at Brazil Eco Fashion Week.	• Many brands come to me for consultancy not only on product, textile development and internal processes for sustainability, also concerning choosing materials. For the event this year we received 180 brands applying for the show, and 140 brands for the market. I am a person who finds out the practices of all these brands (website, Instagram, LinkedIn). • The event offers space for training entrepreneurs and possible sustainable practices. We offer the business and sales space, so the sale is essential and contact with the customer to explain the materials and processes, considering how important the information is to understand the value of the clothes. • We have the pillars of generating business, educating with lectures, conversation circles and courses, networking and the runway.	• We embrace the cause of organic and family farming, as a pillar. We explain to the brands that want to participate that it is not just because it is a natural fiber, such as conventional cotton, that it is ok, the question goes deeper. • It is not a prerequisite because we understand that access to organic cotton is complex. Many brands give up due to the difficulty of access to raw materials, many people migrate to recycled pet. • The lack of understanding about organic cotton is a general thing of the market, of the brands, of those who participate and attended the event, of the students, etc. Whoever has this organic mindset is because they associated the food. • The challenge today is a matter of access; people don't know from who to buy organic cotton textile. • I see that there is still this place of research and development, and then the industry should embrace this development so that in fact brands can buy organic cotton. Two major difficulties, the study and development and the market access. Bridges need to be created between the producer and fashion. And then we see big weaving and knitting industries trying, but we really need to embrace this cultivation. • There is a demand for organic cotton, but it is a specific audience. It is a matter of understanding

	• I have a lot of feedback from brands that were born from this place of inspiration. And the runway we understand is an old fashion and powerful media. Today the market questions the role of the runway, but for us, giving the possibility for small and innovative fashion brands to present in the runway, without depending on large investments is very important. • The internationalization of brands is another activity that we are raising. We brought international buyers and consultants for brands to have an international vision. • We have become a hub, of several actions that relate fashion brands and sustainable practices.	the product. I've seen clients looking for natural dyed organic cotton because of dermatologist's indication and skin problems. • It is a demand that is at the beginning and when people try it they adhere to it. As you start to broaden the customer's perception of the material, that is biodegradable, from a renewable source, suddenly that becomes a priority. • Many brands that started with cotton today do not buy organic cotton because they do not have access and it is easier to buy BCI. Not because of the price but because of the lack of supplier management. • The market is there ready. The issue is more the coexistence with conventional cotton. And the industry getting organized. • When we talk about the benefit of organic cotton, we have the feeling of comfort on the skin, of encouraging family cultivation, but we are still focused on aesthetics. And how cool that it is organic too, is a plus, but not that as a primary factor, impacting the purchase decision. Cotton planted without irrigation, naturally colored, without dyeing ... this is still not the factor to motivate buying clothes. Perhaps for intimate pieces this type of material is prioritized.
Farmer	• My family is four people and we all work with cotton. Before that, we planted corn and beans. Now we plant cotton and harvest in winter. My father plant with irrigation, corn and beans, pumpkin, watermelon. We have now learned to make new consortia with other species. • There are women who work in agriculture and others do not work, because they have no other source of income. So it would be good to teach them about handcrafts. They know how to sew, but they don't have a good machine. There are some who know how to do crochet.	• One of the benefits of planting agroecological cotton is not using agrochemicals, as there are several people who are allergic to the products. In addition to the inputs cost being less and the labor being good, you receive well, the work that has in the end a reward, because it pays well. • In the beginning it is difficult, it is laborious, as many farmers are used to using agrochemicals. But it is worthwhile to stop using them, both for our health, the soil health and the health of others. • The financial benefits will be much better. • Some issues concern the locomotion of going out on the farm, to benefit the cotton, because we have to pay for transportation. • When we have the training, were are committed to come. With the training, we learn, we know other people and we learn a lot with other groups of farmers.
Agricultural technician and field assistant for Veja. Secretary of Rede Borborema.	• I monitor farmers in production, planting, dates and period that was planted, expectation of harvest, estimate and weighing of cotton. I also monitor the processing and I also assist farmers in the issue of documentation for certification. • This year 2019 we have already certified 63 farmers. • We plant in consortium, with potatoes, beans, plucked beans, sesame or coriander cotton and normally the areas are from 1 to 4 hectares. • Here in the Queimadas rural settlement everyone has been producing agroecological since 2004 and 2005. When we speak organic, it is having the certification in hands. But it was already agroecological. • We produce an average of 500 kilos, in raw material per hectare, which gives about 200 kilos in lint. But it varies a lot. There are farmers here that the land is very good, very fertile,	• Our region now uses the herbaceous, the aroeira cultivar, we plant, harvest and make the empty area, to protect from insects. The mocó plantation, it is usually for more than one harvest. • The first thing the consumer wanted to know, is if the cotton was from Paraíba, the Northeast, semi-arid, families producing and that we don't use irrigation. • The main issue with cotton is making it possible to keep families in the field, producing and generate income. Keeping families together. I'm already a producer, my father is a producer and my other brothers in this story. • Before cotton, some people were not so interested in studying. But now it encouraged a lot of schooling, most of the young people here have a technical course, a lot of workshops, training, partnerships with Arribaçã. • Also there is Embrapa, who are always circulating here in the settlement. • Before, we had organic cotton with external certification by audit, but the problem is that half the money was to pay for the certification. Nowadays with participatory certification since 2016, the income is almost all for the farmer. So he gets a better life, like buying a TV, more comfort, buying equipment, materials, etc. • It is a challenge, to pay attention to the rainy season. We are in a region where the rainy season

	so they make 700 and 800 kilos of raw material per hectare. It depends a lot if the farmer is using tanned manure. But in itself, an average of 500 kilos of raw material per hectare. • Generally, 60% is dirt, seed and 40% is lint. Most farmers are very careful when cleaning the cotton, the better the quality of the lint. • We would like to transform the cotton in a final product. A product that identified the Queimadas rural settlement in Remígio, family farmers and agroecology. Everything has a flagship. The flagship of the chain today is organic lint, but in the future I would like to have a different product that you look and know.	is very short and if we miss the planting period, it affects all production. And the question of land use, you have to put the tanned manure, let it rest, get manure. • Where I fertilized with tanned manure I will have about 350 kilos of cotton lint. And where I didn't fertilize, around 150 to 200 kilos. • You have to take care of the soil nutrition, attempt to the rainy season and fertilizing the soil. Whoever fertilizes makes a better harvest. • Since 2011 we have been facing a lack of rain. This is a challenge that we do not control. You have to be aware and prepared to not lose the initial rains. • Rain instability causes production instability. In the past we knew that it rained that month, it was right to plant and know that we were going to harvest, now there is no right period. • With participatory certification, it has improved a lot, because in addition to certifying cotton, we certify the other products too. We want to maintain the quality of our participatory certification, the organization of groups, our head office and the ginning machinery running here. • Everything that is produced as organic must have traceability. Bales number, farmer's name, city, usually the farmer has a code. Then put the code and fill out a spreadsheet. And there are also invoices, which are important for traceability.
Farmer - Zé Marcolino rural settlement, Cariri region - Paraíba.	• I started planting cotton again in 2007, with Dom Helder Project, with technical support from EMBRAPA. It is a culture of the heart. We have the animals, we sell the lint and feed the seeds to goats, cattle and sell the seeds too. • The planting varies, if it rains and the land is wet so we can plant. In four and five months we harvest. We do spacing research, to yield and produce more.	• As it is, in two or three years we will have a lot of organic cotton here in Cariri. We plant everything in consortium: cotton, potatoes, corn, beans, sesame, watermelon, broad bean, jerimum, any food, for our use. • Now each association has its own seed bank, we are well organized about this. Since the aroeira arrived, we have been planting and spreading. The trend here is to increase farmers to plant. • Many producers live far away, for training with the technicians some people come from each community and then they will pass it on to others later. • We could improve communication with farmers, have access to the tractor at the right time and a car to transport the lint.
Cotton farmers association and participatory certifying group - president ACEPAC	• Here in Cariri, we work with three things, food for home, food for animals, and a culture of income. And when cotton is organic we can sell it at a better price, it is more valued.	• Cotton is a historical culture here for us, that many families made a living with cotton. My parents were raised by harvesting and planting cotton. And it is an income for the end of the year, there is a farmer who says it is the thirteenth. And the stalk, is to feed the goats. It is already a huge help. Economic is very positive. • Because of the distances between the production groups. Communication between the groups is still a challenge, we speak via Whats app, but there are some who do not have access yet. There is no signal here, so you have to send a message.
Cotton farmers association and participatory certifying group – president Rede Borborema	• In terms of vegetable products, everything produced on the property can be sold as organic. Since the beginning, it was formed to sell cotton, but we have already managed to sell corn, beans, cilantro, lettuce. • In the Queimadas rural settlement, they are 34 hectares, and the expectation is over 16 thousand kilos in raw and 6400 in lint, only the Remígio group. • Today Vert is our buyer. It is a French company but the office is in Fortaleza.	• One of the very good things is that, before planting, the farmer already knows the price and who to sell to. A very important point. And another point we have our certification. We own our certification and our registration with the Ministry as an organic farmer. • We produce cotton and deliver the lint, it would be good if we could benefit until the final product, knowing how to spin, how to produce the fabric, and deliver the product to the final part of it. In this way, have knowledge of the value of that product transformed.

Technical advisor and monitoring with farmers in the territory of Cariri with cotton cultivation in agroecological consortia. Representative of the organic committee of the state of Paraíba.	• I am developing activities in seven territories and here in Paraíba in Cariri. In the municipalities of Livramento, Monteiro, São João do Tigre, Amparo and Prata communities. And monitoring of the Borborema Network in the Queimadas and Hoziel Pereira in Remígio, Areia, Casserengue and Sumé. • The farmer has the function of multiplying what they learn here and this multiplication happens, because afterwards when I go to visit each place in the field, I notice in the speech and practices of the farmers. There are farmers who never came to the UAP, but the teaching is there in the field, so we know that the processes are being passed on.	• It is a problem to miss the right planting period and remembering that we are in a region that farmers are planting in rainfed, there is nothing irrigated. So it has to be accurate in the planting period. • Before there was no agrochemicals, they were created in the Green Revolution with a proposal to increase production and accelerate the economy. And what was previously worked with past generations has been forgotten. And now we are starting again. • Cotton is part of the life of farmers in the semiarid, everyone will have a story to tell about cotton, it is part of life, it is an affective culture. • My technical view is that audit certification is not sustainable for family farming. • We will have two certifiers for participatory certification in Paraíba, so it is a very important advance. • Another advance is that we have research institutions, developing research in this area and we need more. For farmers is important the research learning, that they understand how it works, what is an agroecological production system, which is allowed or not. • We have many technical advisory institutions, which only work with advice on organic, agroecological production, this is also an improvement. • Research is essential and farmers need to understand that too. We live in a system where things need to be validated. The more research validating these processes the better. Technical, research institutions and farmers need to understand the importance of this. Because it is a cycle and everyone is building together interconnected. • Technical advice is also a challenge, we do not have the financial means to support more farmers, so there is a lack of investment in this. • A challenge is to open new markets, to have more buyers. I always tell farmers, don't get with just one company. This is not good for anyone. It is important to expand the selling for other companies. • Another challenge is the spinning process and we are very limited, as we can only follow up on the sale of cotton lint. Also logistics, adequate and sufficient space to store production and transport. • Participatory certification, solved a problem, brought women and young people to contribute to the process. Farmers are now involved in everything in public policies, research, technical advice, logistics. So if we are not able to keep it working it gets complicated, because farmers cannot be alone. We are the collective.
Farmer	• In the 1970s, I worked on a farm and planted more than 100 hectares of cotton. Nobody heard about a weevil. When it was in 1981 the weevil arrived. When the weevil arrived at this property, it ended with cotton planting. Then the people invented the agrochemical to kill the insect. But it is a big lie. The more you use the agrochemical, the more the weevil multiplies. In the culture of cotton there are many insects that protect cotton. Like ladybug and others. They feed on the weevil's egg and don't let the weevil develop. When the farmer first sprayed the field,	• In 2005 I started planting in a consortium. I plant in any corner and weeds don't attack. Then we joined EMBRAPA, Arribaçã, EMATER, SPTA, and released a field and the weevil did not attack. Some beak arrived, we burned and it did not to develop. Until today we are working and there are no bugs around here. • EMBRAPA did the experiment here with 32 varieties and the aroeira was the one that gave the best results. Each region has a variety that adapts best and here was the aroeira. • A major challenge is to increase production. Today we plant and know what to do with cotton. Where it went and who is using it. • Sesame is costing R$5 a kilo. And it can transform into various products, oil and others. Knowing what can be done with processing is a challenge.

	the weevil did not die, but those other little insects all died. It means that the weevil was left alone in the field.	
Solidaridad project coordinators	• With assistance, we have s a monthly visit to the property, and support management, field days, workshops, training with specific topics. • With BCI is peer to peer learning. If we make a demonstration unit for a producer, which is very similar to the neighbor, if they look at the property from a producer, he will believe more than we speak. So it is the producers themselves who experience it.	• The conventional producer manages to make, on average, 100 arrobas per hectare. Organic is doing 15. There is a huge productivity difference, obviously the price pays off. Because we sell ours for R $ 36 and they were selling for R $ 300. Ten to one, it pays off. The question is, retailers do not want to pay organic prices, with the pressure of fast fashion they cannot buy. • C&A talks a lot about organic, in India it has a lot of offer, but here in Brazil you can't buy it. Producers of C&A organic cotton projects export this cotton; it is not for the domestic market. Flavia Aranha for example, buys directly from producers, but it is a niche.
Coopercat coordinator	• A great challenge is facing the market, the instability of prices, changes in world's demand, international competition. The cotton situation is a commodity. The challenge is to keep producers in a position to compete, and how to do that, introducing improvements such as certification and best practices. • A positive aspect is the cooperative. So whoever buys our product wants to know the quality of our cotton and it is up to the producer to produce the best cotton, for the best price and profitability. • Every industry tracks the product and our bales have the ABRAPA bar code.	• Monoculture is not a good business. Producer must have diversification and to plant to sell and knows the market. • The biggest bottleneck for producing cotton today is the harvest, which can cost 43% of production. Most farmers sell at Esalq's price. You need to reduce the cost of harvesting. A small tractor for small producers will be able to serve several farmers. Manual harvesting costs from R $ 8 to R $ 10 per arroba, in mechanical harvesting the cost is per hectare.

Source: Larissa Oliveira Duarte, 2020.

APPENDIX 3

Chart 1 – Summary of the data analysed in the Annual Reports.

Organization	Title/ Year	Main findings on organic cotton
Ellen MacArthur Foundation and Circular Fibers Initiative	A New Textiles Economy: Redesigning Fashion's Future, 2017	• Certifie organic cotton, which bans inputs of synthetic fertilisers and pesticides, represents less than 1% of the global cotton market while Better, Cotton Initiative (BCI) cotton, which reduces these inputs, accounts for roughly 12%. • Examples are emerging of clothes being designed that are completely biodegradable. For example, C&A has developed a Cradle to Cradle Certified T-shirt made purely from organic cotton, including the stitching, that is treated with safe materials and chemicals, as well as non-toxic dyes – allowing the T-shirt to be fully composted if it can no longer be worn or recycled.
The Boston Consulting Group, inc and Global Fashion Agenda	Pulse of the Fashion Industry, 2018	• Using organic cotton instead of conventional, could reduce energy costs by more than half and cut the contribution to global warming by 46%. It could also lower the acidification of land and water by two-thirds, soil erosion by a quarter, and blue water consumption almost entirely. • Skunkfunk, a Spanish ethical fashion brand, moved from only 8% of organic cotton in 2010 to 92% in 2018, and aims to reach 100% by 2020, while Nudie Jeans has rolled out organic cotton in its entire denim collection. Pushing the ambition further, dozens of prominent brands and retail companies, such as Burberry, Adidas, Timberland, ASOS, and Levi's, committed in 2017 to using 100% sustainable cotton by 2025.Similarly, C&A developed a C2C certified T-shirt that is fully compostable, made of 100% organic cotton, using only 100% nontoxic chemicals, and produced within high social and environmental standards. The T-shirt is sold at a competitive price from €7, indicating a positive contribution margin.
ABIT	Activities Report 2019	• Evolution of the value chain: Maximizing aggregation of value • Global Integration: Intelligent insertion into the global value network. Market access: Access for Brazilian exports • Sustainability: Alignment with Global Fashion Agenda and the SDGs • Marketing & Promotion: Increase visibility of the textile and clothing sector in Brazil • Doing Business: Improving Competitiveness and the business environment • Cluster: Create mini-ecosystems (centers of excellence) • Raw material: Explore the advantages of Brazilian biodiversity and promote the expansion of the supply of artificial and synthetic fibers • Credit: Guarantee of competitive financing for new investments and innovations • Training: Improve HR skills, productivity and business process reengineering • In 2019, Texbrasil (Brazilian Textile and Fashion Industry Internationalization Program) finished its tenth agreement signed between the Brazilian Export and Investment Promotion Agency • (Apex-Brasil) and the Brazilian Association of Textile and Clothing Industry (Abit), with the objective of promoting the positioning and internationalization of the Brazilian fashion industry.
Global Fashion Agenda and Mckinsey & Company	Fashion on Climate: how the fashion industry can urgently act to reduce its green house gas emition, 2020	• Organic cotton is around 50% less emissions intensive than conventional cotton, due to the limited use of pesticides and fertilizers and more advanced farming practices. In the case of organic cotton, the yields in the transition phase toward organic certification are lower compared to conventional cotton. This has a direct impact on farmers' revenues. If brands and suppliers cannot compensate for that loss, organic cotton production is unlikely to increase significantly over the next decade. • Organic cotton overall market share of ~2%: this takes into account reduced production and certification costs due to economies of scale and significant leading player commitments to fund the transition phase. Increased operating costs due to higher price of organic cotton compared to regular cotton. • Investors must encourage decarburization efforts. Due to the positive link between environmental, social and governance (ESG) performance and financial performance, ESG factors are playing an increasingly prominent role in decisions around mergers, acquisitions, and divestitures. Investors therefore have an inherent

		interest in driving their portfolio companies towards accelerated abatement, adoption of science-based targets and accountability on decarburization efforts. Investors should encourage transparency on full value chain emissions and promote the use of standardized sustainability assessments. • Investors can allocate capital towards innovative players looking to develop solutions towards key decarburization challenges such as closed loop recycling (CLR), towards sustainable material development and also demand prediction models that can reduce overproduction. • Consumers must play their part in driving industry decarburization efforts through their purchasing decisions. When provided with information, consumers may prefer products with lower emissions footprints, such as those made with low-carbon materials. Consumers can also embrace circular business models to extend the life of fashion products and reduce production-related emissions. • During the use-phase, consumers can take better care of products by reducing washing and drying. This improvement in behaviour can deliver as much as an 11% abatement in emissions under the accelerated abatement scenario. Consumers also have a role to play in recycling products, which can reduce incineration and landfill, and promote CLR across global markets.
Fashion Revolution	Tranparency index in fashion Brazil 2019	• Renner in partnership with Instituto Lojas Renner and UN Women, supports initiatives by productive groups focused on gender equality and income generation in the textile industry's value chain, such as: “Empowering Refugees ”, which offers professional training to refugee women; “Fashion Entrepreneurs”, which promotes technical and management training for low-income women; and “Women in the Cotton Chain Organic ”, for professional qualification of quilombola women producing rural communities in Minas Gerais to improve production processes in the cultivation of organic cotton, with participatory certification.
Textile Exchange A	Organic Cotton - Market Report 2020 (Covering production trends and initiative updates from the 2018/19 harvest year).	• The organizations, programs, and companies that used to assist farmers in-person have established a routine of virtual visits and of answering questions from farmers through this medium - and it is working incredibly well, as most families are used to using social media regularly. • In Brazil, organic cotton is sown in the semi-arid region, which suffered a historic drought for more than seven years. In 2019, torrential rains occurred at unexpected times, which harmed the cotton harvest. In 2020, the rains remain irregular, leading farmers and technicians in the sector to consider changing the recommended period for sowing. Agroecological systems implemented in Brazil's semi-arid zone have transformed some regions - regenerating soil and recovering natural vegetation and water courses. The positive impact of organic soil and water management practices are notable, but not yet properly measured. • Projects like the ones of Fundação Laudes (Laudes Foundation) in northeastern Brazil are intended to measure these impacts more objectively, so we should have better data about it in the near future. • The semi-arid region where organic cotton grows in Brazil began to receive more regular rain in 2020. This happened at the same time as the planted area of organic cotton reached a record high, meaning a record harvest is anticipated in the 2020/21 crop year.
Textile Exchange B	2025 Sustainable Cotton Challenge Second Annual Report 2020	• The Laudes Foundation, in partnership with the Brazilian NGO ESPLAR and World-Transforming Technologies (WTT) launched the program “Meaningful Innovation for Family Farming - Sustainable Cotton Challenge” at the end of 2018. The goal is to support simple innovations that can help smallholder organic cotton farmers to increase their overall productivity and living standards. • Several factors have improved Brazil's production of organic cotton this year, including accessibility of participatory certification system (PGS);1 support from NGOs for technical assistance to farmers; the knowledge acquired by farmers over time that allows them to cope with the challenges posed by organic practices; planting in consortia that allows the diversification of production and food security; commercialization guaranteed by contracts, allowing the generation of family income, and partnerships with companies and institutions. • With the support of the Laudes Foundation, an organic cotton expansion project has reached six Brazilian states. Companies like Veja have purchased cotton from associations and cooperatives involved in this project. • Other companies, such as Natural Cotton Color, Justa Trama, and Organic Cotton Colors, continued to encourage the cultivation of organic cotton in the country.

		• The Paraíba Cotton project, developed by the state government and supported by research companies such as EMBRAPA, producer associations such as Coopnatural, and spinning companies such as Norfil. The project has significantly increased the number of producers in recent years. The impact of these projects on production will become even more evident next year, with a record organic cotton harvest anticipated in 2019/20. • There remain barriers that restrict additional growth in organic cotton production, such as irregular rainy seasons, lack of public policies that support agroecological production and commercialization of products, insufficient technical assistance for farmers, and new markets for their production.
Textile Exchange C	Preferred Fiber & Materials Market Report 2020	• Worldwide production increased from 107,243 mt in 2012/13 to 239,797 mt in 2018/19. Organic cotton equaled a market share of 0.93 percent of all cotton produced in 2018/19.

Source: Larissa Oliveira Duarte, 2020.

APPENDIX 4

Chart 1 – Organic cotton actors and its ID label representing the network nodes.

LABEL	ID
EMBRAPA Cotton	1
Rede Borborema	2
ACEPAC	3
Arribaçã	4
Margarida Maria Alves	5
PATAC	6
ASPTA	7
EMPAER	8
NGO Caatinga	9
Ecoararipe	10
APASPI	11
ACOPASA	12
COOPERATERRA	13
Centro Dom José Brandão de Castro	14
Instituto Palmas	15
Colegiado Territorial do Alto Sertão de Alagoas	16
Coopabacs	17
Sindicato dos Trabalhadores Rurais de Serra Talhada	18
Fetape	19
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Source: Larissa Oliveira Duarte, 2020.

Chart 2 – Organic cotton network edges, utilized in the software GEPHI to design the organic cotton network in Brazil.

SOURCE	TARGET	TYPE
1	2	DIRECTED
1	3	DIRECTED
1	4	DIRECTED
1	5	DIRECTED
1	6	DIRECTED
1	7	DIRECTED
1	9	DIRECTED
1	10	DIRECTED
1	11	DIRECTED
1	12	DIRECTED
1	13	DIRECTED
1	22	DIRECTED
1	23	DIRECTED
1	25	DIRECTED
1	33	DIRECTED
1	35	DIRECTED
1	36	DIRECTED
1	45	DIRECTED
1	51	DIRECTED
1	56	DIRECTED
1	57	DIRECTED
1	63	DIRECTED
1	64	DIRECTED
1	66	DIRECTED
1	77	DIRECTED
1	82	DIRECTED
1	80	DIRECTED
2	1	DIRECTED
2	4	DIRECTED
2	7	DIRECTED
2	5	DIRECTED
2	45	DIRECTED
2	49	DIRECTED
2	62	DIRECTED
2	77	DIRECTED
2	63	DIRECTED
2	64	DIRECTED
2	80	DIRECTED
3	1	DIRECTED
3	4	DIRECTED

3	45	DIRECTED
3	63	DIRECTED
3	64	DIRECTED
4	62	DIRECTED
4	77	DIRECTED
4	1	DIRECTED
4	2	DIRECTED
4	3	DIRECTED
4	6	DIRECTED
4	9	DIRECTED
4	10	DIRECTED
4	11	DIRECTED
4	12	DIRECTED
4	13	DIRECTED
4	45	DIRECTED
4	49	DIRECTED
4	63	DIRECTED
5	64	DIRECTED
5	77	DIRECTED
5	1	DIRECTED
5	2	DIRECTED
5	6	DIRECTED
5	45	DIRECTED
5	56	DIRECTED
5	57	DIRECTED
6	66	DIRECTED
6	79	DIRECTED
7	1	DIRECTED
7	2	DIRECTED
7	3	DIRECTED
7	9	DIRECTED
7	10	DIRECTED
7	11	DIRECTED
8	12	DIRECTED
8	13	DIRECTED
8	1	DIRECTED
8	2	DIRECTED
8	51	DIRECTED
8	52	DIRECTED
8	53	DIRECTED
8	54	DIRECTED
8	56	DIRECTED
8	65	DIRECTED
8	66	DIRECTED
8	69	DIRECTED

8	82	DIRECTED
9	11	DIRECTED
9	23	DIRECTED
9	32	DIRECTED
9	33	DIRECTED
9	34	DIRECTED
9	35	DIRECTED
9	36	DIRECTED
9	37	DIRECTED
9	38	DIRECTED
9	1	DIRECTED
9	45	DIRECTED
9	49	DIRECTED
10	9	DIRECTED
10	17	DIRECTED
10	19	DIRECTED
10	18	DIRECTED
10	49	DIRECTED
10	1	DIRECTED
11	9	DIRECTED
11	1	DIRECTED
11	32	DIRECTED
11	33	DIRECTED
11	34	DIRECTED
11	35	DIRECTED
11	36	DIRECTED
11	37	DIRECTED
11	49	DIRECTED
11	38	DIRECTED
12	23	DIRECTED
12	24	DIRECTED
12	25	DIRECTED
12	26	DIRECTED
12	27	DIRECTED
12	28	DIRECTED
12	49	DIRECTED
12	1	DIRECTED
13	14	DIRECTED
13	15	DIRECTED
13	49	DIRECTED
13	1	DIRECTED
14	13	DIRECTED
14	14	DIRECTED
15	13	DIRECTED
15	14	DIRECTED

16	17	DIRECTED
17	1	DIRECTED
17	16	DIRECTED
17	49	DIRECTED
18	19	DIRECTED
18	9	DIRECTED
19	18	DIRECTED
20	23	DIRECTED
20	24	DIRECTED
20	25	DIRECTED
20	26	DIRECTED
20	27	DIRECTED
20	28	DIRECTED
21	22	DIRECTED
21	1	DIRECTED
21	4	DIRECTED
22	2	DIRECTED
22	4	DIRECTED
22	1	DIRECTED
23	24	DIRECTED
23	25	DIRECTED
23	26	DIRECTED
23	27	DIRECTED
23	28	DIRECTED
24	23	DIRECTED
24	25	DIRECTED
24	26	DIRECTED
24	27	DIRECTED
24	28	DIRECTED
25	23	DIRECTED
25	24	DIRECTED
25	26	DIRECTED
25	27	DIRECTED
25	28	DIRECTED
26	23	DIRECTED
26	24	DIRECTED
26	25	DIRECTED
26	26	DIRECTED
26	27	DIRECTED
26	28	DIRECTED
27	23	DIRECTED
27	24	DIRECTED
27	25	DIRECTED
27	26	DIRECTED
27	28	DIRECTED

28	23	DIRECTED
28	24	DIRECTED
28	25	DIRECTED
28	26	DIRECTED
28	27	DIRECTED
29	11	DIRECTED
30	11	DIRECTED
31	11	DIRECTED
32	11	DIRECTED
33	11	DIRECTED
33	47	DIRECTED
34	11	DIRECTED
35	11	DIRECTED
35	1	DIRECTED
35	29	DIRECTED
35	30	DIRECTED
35	31	DIRECTED
35	32	DIRECTED
35	33	DIRECTED
35	34	DIRECTED
36	11	DIRECTED
37	11	DIRECTED
38	11	DIRECTED
39	80	DIRECTED
39	1	DIRECTED
39	43	DIRECTED
39	63	DIRECTED
39	73	DIRECTED
39	78	DIRECTED
39	40	DIRECTED
39	49	DIRECTED
39	41	DIRECTED
40	82	DIRECTED
40	42	DIRECTED
40	39	DIRECTED
40	49	DIRECTED
40	43	DIRECTED
41	41	DIRECTED
41	63	DIRECTED
41	39	DIRECTED
41	40	DIRECTED
41	42	DIRECTED
42	41	DIRECTED
42	63	DIRECTED
42	39	DIRECTED

42	49	DIRECTED
42	43	DIRECTED
43	42	DIRECTED
43	80	DIRECTED
43	1	DIRECTED
43	39	DIRECTED
43	63	DIRECTED
43	73	DIRECTED
43	78	DIRECTED
43	40	DIRECTED
43	41	DIRECTED
44	43	DIRECTED
44	1	DIRECTED
45	71	DIRECTED
45	78	DIRECTED
45	1	DIRECTED
45	3	DIRECTED
45	4	DIRECTED
45	9	DIRECTED
45	10	DIRECTED
45	11	DIRECTED
45	12	DIRECTED
45	13	DIRECTED
45	22	DIRECTED
45	23	DIRECTED
45	43	DIRECTED
45	49	DIRECTED
45	63	DIRECTED
45	64	DIRECTED
46	78	DIRECTED
46	82	DIRECTED
46	13	DIRECTED
47	14	DIRECTED
47	9	DIRECTED
47	11	DIRECTED
47	23	DIRECTED
47	34	DIRECTED
47	29	DIRECTED
47	30	DIRECTED
47	31	DIRECTED
47	32	DIRECTED
47	33	DIRECTED
47	35	DIRECTED
47	36	DIRECTED
48	37	DIRECTED

48	38	DIRECTED
48	44	DIRECTED
49	71	DIRECTED
49	78	DIRECTED
49	2	DIRECTED
49	3	DIRECTED
49	4	DIRECTED
49	9	DIRECTED
49	10	DIRECTED
49	11	DIRECTED
49	12	DIRECTED
49	40	DIRECTED
50	73	DIRECTED
51	42	DIRECTED
51	55	DIRECTED
51	52	DIRECTED
51	53	DIRECTED
52	54	DIRECTED
53	8	DIRECTED
54	51	DIRECTED
55	51	DIRECTED
56	11	DIRECTED
56	37	DIRECTED
56	61	DIRECTED
56	8	DIRECTED
56	65	DIRECTED
56	66	DIRECTED
57	69	DIRECTED
57	80	DIRECTED
57	1	DIRECTED
57	5	DIRECTED
57	67	DIRECTED
57	68	DIRECTED
57	58	DIRECTED
57	70	DIRECTED
57	74	DIRECTED
57	79	DIRECTED
58	81	DIRECTED
58	82	DIRECTED
58	1	DIRECTED
58	67	DIRECTED
58	75	DIRECTED
59	63	DIRECTED
60	63	DIRECTED
61	56	DIRECTED

61	65	DIRECTED
61	66	DIRECTED
62	67	DIRECTED
62	70	DIRECTED
63	1	DIRECTED
63	2	DIRECTED
63	3	DIRECTED
63	4	DIRECTED
63	9	DIRECTED
63	10	DIRECTED
63	11	DIRECTED
63	13	DIRECTED
63	39	DIRECTED
63	40	DIRECTED
63	42	DIRECTED
63	43	DIRECTED
63	45	DIRECTED
63	59	DIRECTED
63	60	DIRECTED
63	73	DIRECTED
63	75	DIRECTED
63	78	DIRECTED
63	77	DIRECTED
63	82	DIRECTED
64	1	DIRECTED
64	3	DIRECTED
64	4	DIRECTED
64	9	DIRECTED
64	10	DIRECTED
64	11	DIRECTED
64	12	DIRECTED
64	13	DIRECTED
64	39	DIRECTED
64	40	DIRECTED
64	42	DIRECTED
64	45	DIRECTED
64	78	DIRECTED
64	82	DIRECTED
65	8	DIRECTED
65	56	DIRECTED
65	58	DIRECTED
65	61	DIRECTED
65	66	DIRECTED
65	80	DIRECTED
66	8	DIRECTED

66	56	DIRECTED
66	58	DIRECTED
66	61	DIRECTED
66	65	DIRECTED
66	80	DIRECTED
67	1	DIRECTED
67	5	DIRECTED
67	58	DIRECTED
67	62	DIRECTED
67	68	DIRECTED
67	70	DIRECTED
67	74	DIRECTED
67	75	DIRECTED
67	77	DIRECTED
67	79	DIRECTED
67	81	DIRECTED
67	82	DIRECTED
68	67	DIRECTED
68	75	DIRECTED
68	77	DIRECTED
68	81	DIRECTED
69	8	DIRECTED
69	56	DIRECTED
69	80	DIRECTED
70	67	DIRECTED
70	75	DIRECTED
70	77	DIRECTED
70	71	DIRECTED
70	73	DIRECTED
70	62	DIRECTED
71	70	DIRECTED
71	76	DIRECTED
71	44	DIRECTED
72	73	DIRECTED
73	72	DIRECTED
73	50	DIRECTED
73	39	DIRECTED
73	40	DIRECTED
73	41	DIRECTED
73	42	DIRECTED
73	43	DIRECTED
73	63	DIRECTED
73	75	DIRECTED
73	78	DIRECTED
73	82	DIRECTED

73	80	DIRECTED
74	5	DIRECTED
74	58	DIRECTED
74	67	DIRECTED
75	67	DIRECTED
75	76	DIRECTED
75	81	DIRECTED
75	82	DIRECTED
75	1	DIRECTED
75	58	DIRECTED
75	70	DIRECTED
75	71	DIRECTED
75	63	DIRECTED
75	68	DIRECTED
75	73	DIRECTED
76	75	DIRECTED
76	71	DIRECTED
76	77	DIRECTED
77	76	DIRECTED
77	81	DIRECTED
77	82	DIRECTED
77	78	DIRECTED
77	70	DIRECTED
77	68	DIRECTED
77	67	DIRECTED
77	63	DIRECTED
78	1	DIRECTED
78	3	DIRECTED
78	4	DIRECTED
78	6	DIRECTED
78	7	DIRECTED
78	9	DIRECTED
78	10	DIRECTED
78	11	DIRECTED
78	12	DIRECTED
78	39	DIRECTED
78	40	DIRECTED
78	42	DIRECTED
78	43	DIRECTED
78	45	DIRECTED
78	63	DIRECTED
78	64	DIRECTED
78	73	DIRECTED
78	77	DIRECTED
78	82	DIRECTED

79	5	DIRECTED
79	67	DIRECTED
80	65	DIRECTED
80	66	DIRECTED
80	39	DIRECTED
80	8	DIRECTED
81	57	DIRECTED
81	67	DIRECTED
81	68	DIRECTED
81	69	DIRECTED
81	70	DIRECTED
82	1	DIRECTED
82	4	DIRECTED
82	8	DIRECTED
82	43	DIRECTED
82	45	DIRECTED
82	51	DIRECTED
82	63	DIRECTED
82	64	DIRECTED
82	66	DIRECTED
82	67	DIRECTED
82	75	DIRECTED
82	77	DIRECTED
82	78	DIRECTED

Source: Larissa Oliveira Duarte, 2020.