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Socioecological Transformation and the History of Indian Cotton, Gujarat, Western India

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Abstract

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Landscape management is often referred to as a holistic concept, which deals with large-scale processes and multidisciplinary manners in regards to natural resource use with ecological and livelihood considerations. Seen in this light, landscape transformation should be understood within the context of the human-nature relationship, viewing human activities and their institutions as an essential part of the system rather than as external agents. When it comes to the landscape planning and management related to cotton farming in Gujarat, there has been diversity of interest groups such as local communities, governments, corporations and non-governmental organisations. In the present study, I examine two case studies of cotton production pertaining to the Gujarat region in order to study the opportunities and challenges faced by local farmers in the process of developing agriculture. In the first case study on Cotton Improvement Program in the nineteenth century, I highlight the socioecological consequences of the colonial cotton project and how it relates to the social dynamics of networks and agricultural landscape management. The second case study examines current debates regarding the social, economic and environmental impacts of genetically modified (GM) cotton on India's social and natural landscape. This thesis emphasises that there are recursive motifs between the two case studies in terms of the local resistances, power relations and possible environmental effects, which can be explained through the state of 'global core' and 'periphery', and partly the framework of ecologically unequal exchange. The analysis of recurring patterns concludes that exploring the narratives of local experiences offers a number of significant details that show complex power dynamics manifested through constant struggles and resistances by 'peripheral agent'.

Keywords: Cotton cultivation, Agricultural landscape management, Ecologically unequal exchange, Cotton improvement program, GM cotton, Power dynamics

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Table of Contents

List of Illustrations 4
Figures 4
Tables 4

1. Introduction 5
1.1. The world behind cotton 6
1.2. Research objective and questions 7
1.3. Outline of the study 8

2. Theoretical Framework 10
2.1. Inspiration 10
2.2. Time, Space and Inequality: Ecologically Unequal Exchange 12
2.3. Methodological Limitations 13
2.4. Summary of research approach 15

3. Background 16
3.1. Selling to the world: the origins of cotton production and India 16
3.2. Make fashion follow the trade: the colonial British and English East India Company 17
3.3. The ecology of cotton cultivation 19
3.4. Entering a new phase: Genetically-modified cotton varieties 21

4. A Hub of Indian Cotton Industry: Gujarat, Western India 24
4.1. Geographical and Climatic Features 24
4.2. Indian Cotton Production in Historical Perspectives 26
4.2.1. The role of cotton textiles in Gujarat's political economy 26
4.2.2. Specialisation in cotton production system 28
4.2.3. The socioenvironmental aspect of cotton cultivation 29

5. Cotton Imperialism: state-directed cotton program in the 19th century 32
5.1. The State Imperative 32
5.2. Cotton Quality Management 34
5.3. Possible Environmental Effects 36
5.4. Discussion 38

6. GM cotton controversy: triumph of science or seed of death? 40
6.1. Dynamics of cotton seed provision 40
6.2. Adoption and Farmers participation in GM cotton 43
6.3. Environmental Impacts of GM cotton varieties 47
6.4. Discussion 50

7. Analysis and Discussion 52
7.1. Learning from Past to Present 52
7.2. Concluding reflections 55

References 56

Appendices 63
Appendix A. Cost of production in Rupees per hectare in Gujarat: Irrigated cotton 63
Appendix B. Growth of acreage under cotton in selected districts 63

List of Illustrations

Figures

Figure 1. Location Map of Gujarat, Western India……25

Figure 2. Illustration of the Production and Trading System of the Traditional Indian Cotton Industry as summarised in the text…….....29

Figure 3. Southern Districts of Gujarat State (India)……33

Figure 4. Unauthorised Bt Cotton Seed Package……...45

Figure 5. Indian Cotton Farmers' Protest Against Bt cotton…….46

Tables

Table 1. Age and Gender Wise Distribution of Farmers' Suicides in 2014 (Cause wise).……22

Table 2. World Cotton Manufacturing Output 1750-1938 (in per-cent) ……...27

Table 3. The Quantities of Raw Cotton Exported from India 1861-1870…….33

Table 4. Land Use in Gujarat 1880-1980…….…….37

Table 5. Railway Expansion in India, 1853-1910…….38

Table 6. The Conflicting Claims on Bt cotton…….…….43

Table 7. Cotton production and numbers of farmers adopting irrigation system in Gujarat (2006-07 to 2013-14)……..47

Table 8. Pesticide Use and Consumption in Gujarat and India…….48

1. Introduction

Cotton today is the most ordinary material for our dress and furnishings, a world-widely traded commodity as well as the means of living for millions of people who engage in cotton cultivation, manufacturing and merchandising sectors of differing sizes. Cotton also has various socio-ocultural meanings acquired through a vast of consumption all over the world for a long period of time. In general, cotton textile is considered as a ubiquitous commodity in terms of its practicality, applicability and flexibility in comparison to other textiles such as wool and silk (Berg 2005; Lemire 2011; Riello 2013). Perhaps, these attributes have led tremendous demands for cotton textiles throughout the world. Unlike today's easy availability of cotton textiles, the presence of cotton was very limited a thousand years ago. Raw cotton was cultivated and manufactured only in some specific parts of the world, especially Indian subcontinent and China. Enlarging the volume of trade and exchange of cotton, Indian cotton textile became a central part of the global exchange due to its renowned fine quality and beautiful textiles. Cotton significantly contributed to reshaping the consumption and material culture in the world, particularly in early modern European society, but also the initiation of industrial revolution as a crucial raw material. In the history of global commodities, cotton has played a pivotal role in structuring systems of trade but also the complex ways in which people, commodity, meanings and landscapes interacted across Asia, Africa and Europe.

Discussing the global trade of cotton textiles and production system, Riello (2013) articulates the transition of Indian cotton system from industrial to agrarian production as the West became a mainstream of cotton textile production and trade. In other words, the transition induced by European expansion, introduced a new paradigm in the use of raw materials produced outside the boundaries of the West. In this context, I argue that this transition may, to some extent, caused the unequal exchange of biophysical resources in the late industrialised or marginalised part of the world. As David Harvey (1996) has emphasised, when discussing recursive relationships in socio-ecological processes, I suggest that the critical challenges faced by Indian cotton farmers can be explained through a careful analysis on historical and contemporary events in terms of the dynamic networks, experiences and landscape. Considering the complex dimensions of global material exchange, a concept of ecologically unequal exchange will be used here, acknowledging how socio-ecological displacements have occurred in the world system (Hornborg 1998; Hornborg and Crumley 2007; Hornborg 2009; Hornborg and Martinez-Alier 2016). As has already exemplified by Hornborg (2006), cotton is an excellent example of the displacement and appropriation related to the ecologically unequal exchange. At the same time, the concept of unequal exchange risks overlooking the local dynamics of power and resistances. This is why I have chosen to give emphasis on this discussion here, something that is made possible by zooming in geographically.

In this thesis, a wide historical overview of Indian cotton, changing trade relationships, social dynamics and landscape changes will be presented focusing on Gujarat region, in western India. In order to understand the effects of global inequality and power relations in Indian cotton industry, two case studies will be examined: first, the colonial cotton experiment program in the 19th century, which aimed to improve the quality of Indian cotton by introducing foreign cotton varieties and new farming methods; and second, the commercialisation of genetically

modified (GM) cotton since 2002. Through the lens of ecologically unequal exchange and the assessment of human impacts on the environment in terms of its social, economic and political aspects, I will explore if there are any potential parallels between the cotton improvement program of colonial state and the government encourage shift to GM cotton cultivation that is presently ongoing. To what extent, I consider that historical case could give perspectives to GM cotton controversy today. Furthermore, this thesis is a critical analysis on the limitation of application of the concept of ecologically unequal exchange and discusses the Indian agricultural landscape management and its various influences on the local particularities and their surrounding environment in Gujarat, in western India.

1.1. The world behind cotton

Cotton is the most important natural fibre known to us today. It has been around for centuries and empires have been built on its merits. It fuelled the colonial expansions, industrial development and subsequently became one of the causes for socioecological struggles around the world, even though it became the chosen fibre for comfortable clothing. This great fibre was, and continues to be, valuable to us, and the name "white gold", does not seem to be an exaggeration.

For about nine hundred years, from 1000 to 1900 CE, cotton had played a crucial role in the world's manufacturing industry and trade. For the early history of cotton, between 1200 and 1800, Indian subcontinent was the centre of cotton textile manufacturing and trade in virtue of the qualities of cloth, various colours, designs and competitive price. Due to the success of cotton textiles in global markets and the development of long-distance trade networks, the cultivation of cotton as well as related processes and technologies gradually diffused from subcontinents to Asia, Africa finally to the entire world (Riello 2009: 2). The global spread of cotton also can be addressed in terms of raw material supply for textile manufactures in European countries in the third quarter of the eighteenth century. Particularly, on the basis of a rapidly growing cotton textile production, Britain was able to initiate the Industrial Revolution and expand its imperialistic influences to secure raw materials, new market opportunities and the bulk of trade (see Chapter 3). During this period, slavery, the marginalisation of indigenous people, colonial expansion, unequal trades and the assertion of imperial power over people and land were at its core in the course of cotton industrial development (Hardiman 2007; Clingingsmith and Williamson 2008; Dejung 2013).

As of today, cotton is the most widespread profitable non-food crop in the world, accounting for approximately 50% of the world's fibre supply (Stewart *et al*. 2010: 379). It is grown in more than 50 countries around the world and is consumed by many more nations. According to the World Wildlife Fund (WWF 2014) report, cotton textile production provides income for more than 250 million people worldwide and employs nearly 7% of all labours in developing countries. Global cotton production encompasses the worldwide flow (also called supply chains) of raw materials, all components, and finished products (Ecomtrading 2000). Cotton supply chains are capital intensive and value-adding processes (Rieple and Singh 2010). Value is added in capital intensive stages (designing, purchasing raw materials, cutting, ironing, labelling, distribution, etc.), that are concentrated mostly in the developed nations. The lowest value-adding tasks, albeit most fundamental to the industry, e.g., cultivation, manufacturing and labour-intensive tasks are outsourced to the developing nations. The low value end of cotton production has been given attention with a focus on worker's rights, safety issues and environmental concerns. Sweatshops, child labour, low wages and overconsumption are all of help to

provide cheap clothing to the world markets. At the same time, cotton cultivation and production have been criticised for severe environmental impacts resulted from the excessive use of agrochemicals, high water consumption, disposal of wastes and the conversion of natural habitat to agricultural landscape (Igbedioh 1991; Aktar *et al*. 2009; Das 2011; Gandhi and Jain 2016a; Saravanan 2016).

Certainly, cotton is indispensable part of our lives and has improved the quality of life in many ways. In the meantime, cotton, as a crucial global commodity, has been centre around conflicts, exploitations and degradations throughout history. Considering the historical and current paths of cotton and how they have woven continents together, cotton provides the key to understanding the modern world, the great inequalities that characterise it, the long history of globalisation and possible socioenvironmental consequences derived from its dynamic networks. In this regard, I believe it is worth investigating the development of cotton textile industry from a view of not only political economic norms but also socioecological significances at different levels.

1.2. Research objective and questions

As a study on the Indian agricultural commodities situated within the field of environmental history, cotton is crucial to understand the broad dynamics of social changes and landscape management as it is deeply associated with diverse dimensions of Indian society. From the colonial cotton project during the 19th century to the current GM cotton controversy, there have been continuous conflicts in terms of cotton cultivation practices and local interests. In regards to the challenges that cotton farmers face, I argue that existing social, economic and ecological inequalities in India derive from not only the global trade system but also the unequal exposure of environmental risks such as deforestation, soil erosion, water pollution and climate change. In order to demonstrate such inequalities in the Indian cotton textile industry, I have selected two case studies of cotton cultivation in Gujarat, in western India. One is Cotton Improvement Program 1830-1860; the other is Genetically Modified (GM) Cotton Cultivation starting from 2002. In the light of cotton supply chains and ecologically unequal exchange, this thesis analyses the Indian cotton industry from both a historical and a contemporary perspective, emphasising the possible environmental effects, power relations and the landscape changes in Gujarat. Thus, the key questions addressed in this thesis include:

- How can unequal distribution of social and environmental risks and benefits concerning the cotton cultivation be addressed in the case of Indian cotton industry and the two case studies?
- How has cotton, social dynamics and the environment interacted to shape the Gujarat landscape?
- How can we understand local dynamics and resistances and what are the long-term effects of these negotiations on the agricultural landscape?

The research questions emphasize the importance of understanding social and historical context of cotton production and related landscape management in India. Agricultural landscape is the centre of farming and land use practices and at the same time for creating meaningful attributes such as identity, heritage and community (Crumley and Marquardt 1987; Piorr 2003; Crumley 2007). In this regard, landscape supports identities, cultures, geographical distinctiveness and ecological diversity. Thus, my aim is to demonstrate not only how cotton production came to shape a global economy and sociocultural relations, but also how it shaped the agricultural landscape and management practices. Given that the landscape transformation has significant

influences on a human and her surrounding environment, I consider a historical overview can offer a better description of the dynamics of social, economic and ecological relations in Indian cotton textile industry.

1.3. Outline of the study

This thesis presents a wide historical and contemporary overview on Indian cotton textile industry in terms of the dynamic human impacts on the agricultural landscape. Considering that landscape transformations entail social, cultural, economic and environmental impacts, it should be understood as a complex assemblage of the interactions among various actors (Crumley 1994: 5). Furthermore, Matthews and Selman (2006) have pointed out that landscape is closely linked to one's society, economy and environment in a mutually reinforcing way to accomplish the socially preferred outcomes. In other words, agricultural landscapes are often created and transformed by humans for their livelihood, tradition, community and political-economic aims. When it comes to landscape planning and management related to cotton farming in Gujarat, there has been diversity of interest groups over time, such as indigenous people, local government, settlers and outsiders. In the present study, I examine two case studies of cotton production related to the Gujarat region in order to study the opportunities, challenges and social negotiations faced by local farmers in the process of developing agricultural landscape.

In order to demonstrate possible unequal exchanges in Indian cotton textile industry and its supply chain, I will use the state of 'core' and 'periphery' and the concept of ecologically unequal exchange as theoretical frameworks. In my thesis, the conceptualisation of the relationship between societies and their natural environment is crucial to identify the possible recursion of events and the profound changes in social and ecological systems (Fischer-Kowalski 1993; Hornborg 1998; Matthews and Selman 2006). In order to address the recursive patterns found in the history of Indian cotton textile industry, I will focus on how power relations have operated in the past and present and how such power structures have been challenged by local agents, and what the possible environmental risks and benefits may be. In regard to applying the concept of ecologically unequal exchange, the mapping out of a strategy for integrating social and ecological changes in a biophysical framework and its limitations will be presented in Chapter 2. In addition to that, I explain the concept of ecologically unequal exchange, and why this concept has been particularly chosen for the case study analysis as the theoretical approach.

The selection of each case study is based on its historical and ecological importance in relation to cotton cultivation and environment as well as social contestations. In this thesis, the selected case studies act as empirical building blocks to construct a bridge between historical and present narratives of cotton, local farmers' life and the landscape in Gujarat. In the first case study, presented in Chapter 5, I study the Cotton Improvement Program in the nineteenth century. I highlight the socioecological consequences of the colonial cotton project and how it relates to the agricultural landscape management and social dynamics. The second case study, presented in Chapter 6, examines current debates regarding the social, economic and environmental impact of genetically modified (GM) cotton in India's natural and social landscape. For each case, I provide background information about its specific historical context, socioeconomic characteristics, geographical and climate features and production and trade figures for cotton textiles. In regards to the case studies of cotton production in Gujarat region, I explore evidence of the historical and current environmental degradations, economic losses and social conflicts among

cotton cultivators, businesses and government. In summary, the analysis of each case study will be followed three main steps below:

- First, qualitative descriptions of Indian cotton industry and each case study will be built based on a deep literature review in order to provide sufficient background for the analysis and discussions.
- Second, a detailed study will be carried out; I will investigate each case study in terms of social, economic, political and cultural aspects as well as possible environmental effects. Based on the findings of the case study and literature review, I will focus particularly on revealing recursive themes between two case studies, such as power struggles, local resistances and unequal exchanges formed around the cotton cultivation.
- Lastly, I will discuss the final results within the notion of 'core' and 'periphery' and the framework of ecologically unequal exchange in order to understand the social and ecological dynamics of Indian agricultural landscape that have been shaped by interactions over past and present with diverse agents. In addition to that, I will explore if there are possible recursive patterns between the colonial cotton improvement program in the 19th century and the GM cotton cultivation that is presently ongoing. The research questions will be addressed based on the discussions in Chapter 7.

2. Theoretical Framework

2.1. Inspiration

The representation of inequalities in Indian textile industry and cotton cultivation can be discussed within the distributive, political, cultural and ecological dimensions of global environmental issues. As I show in the following chapters, there have been significant systemic and physical changes in Indian cotton textile industry and landscape, particularly at regional levels. In other words, local communities have been influenced by, and have in turn influenced global factors interacting to shape environment both in historical times and in the present. In this thesis, I explore structural characteristics of networks, conflicts and inequalities embedded in Indian cotton production and trade from the perspective of power dynamics and a concept of ecologically unequal exchange, partly from a social metabolism approach.

My major interests are identifying significant shifts in the Indian cotton textile industry throughout the history of cotton as a global commodity and examining possible inequalities and distinct repercussions of landscape transformation at regional level. There are several ways to explore this suggestion: one is to focus on the systemic changes in political economic structure such as the intensive global exploitation, outsourcing of raw materials and division of labour from the beginning of the colonial era to the global capitalism of today (see for instance Bunker 1984; Hornborg 1998; Muradian *et al*. 2012). Another possible approach is to calculate the actual material flows, particularly the biophysical indicators (e.g., energy, natural resources, embodied land and labour) occurred between the local and other parts of the world (Fischer-Kowalski 1998; Hornborg 2009; Warlenius 2016). I will explore these approaches more in detail in Chapter 2.2. But, first I would like to pause and explain other conceptualisations of landscape transformation and inequality in a broader sense.

As a means of inspiration, I draw on social metabolism. Social metabolism has been established as a key concept in ecological economics and its basic principle is the application of biological concept of metabolism to social systems focusing on the flow of material and energy between nature and society (Fischer-Kowalski 1998; Haberl *et al*. 2010; Muradian *et al*. 2012; Martinez-Alier and Muradian 2015). Social metabolism has two different exchange relations in terms of its strategies, mode of production and whether there is human intervention or not; metabolism and colonisation (Fischer-Kowalski and Haberl 1993, 1998).

The metabolism, in this case, indicates the society that maintains sustainable level of energy and material flows (Fischer-Kowalski and Haberl 1993). In other word, the scale and size of society do not exceed the carrying capacity of natural system, which in turn keeps its metabolic processes – extraction of raw material, transformation, distribution and disposal – within sustainable ranges. Hunter and gatherer society and early agrarian community can be an example. Colonisation, on the other hand, refers to the exploitation of resources and labour by enhancing human control over society or nature, which is qualitatively different from the metabolism discussed above. In a colonisation 'mode', a society deliberately transforms some parts of the environment and intervenes with natural processes so that it is exploited effectively for various social needs (Fischer-Kowalski and Haberl 1993: 3). In other words, 'deliberate intervention' is crucial in order to render the environment more useful for human society. Historically and

geographically, one may find various examples of the colonisation strategy. Slash-and-burn cultivation in rainforest region, soil fertilization by animal manure, irrigation systems, domestication of animals and plants, landscape transformation and all sorts of human interventions in natural system can be regarded as the colonisation. Considering that the colonial mode of intervention enables to hold density of population maintaining relatively higher productivity and energy-intensive flow, the colonisation strategy can be viewed as a precondition for establishing the centralised of power and state as well as infrastructures (Fischer-Kowalski and Haberl 1998). However, as I have addressed here there are also degrees of colonisation, meaning that some societies have been more extractive than others, particularly when colonisation takes places elsewhere, e.g., where the effect of landscape transformation and inequality is not seen or experienced directly in an exploitative economy. In this context, I argue that India and cotton are excellent examples to show such colonial mode of intervention as when Indian cotton markets became dominated by England and the relationship between the commodity landscape and social fabric became increasingly served.

The second inspiration is the terms of 'global core' and 'periphery'. According to world system theory[1], the global economies are divided into core-state, semi-periphery[2] and periphery depending on the complexity of economic system, a degree of industrialisation, strength of the machinery, division of labour, political stability and cultural integrity (Wallenstein 1976). The global core areas are typically characterised by high-tech, capital intensive and high-profit production (Eisenmenger and Giljum 2006). The global core nations tend to have high consumption rate per capita and invest in a high value-added industry. The peripheries, on the other hand, typically have a labour intensive and extractive industry with relatively low technology requirements (Eisenmenger and Giljum 2006). The primary industrial sectors – such as mining, agriculture, forestry and fisheries are the main parts of the domestic production and most of the produced goods are exported to the cores. In other words, the global cores import raw materials and energy from the peripheries, whereas peripheries import manufactured (or finished) goods from the cores in return. In the networks of global exchange, core areas are often benefited as a consequence of capital, political and military strength, which is more likely to obtain advantageous position in trade (Rice 2007: 1372-1373). This unequal trade relationship between the core and periphery is based on the exploitation that contributes to solidify the asymmetric flow of natural resources and capital stocks as well as the core-periphery structure (Eisenmenger and Giljum 2006). Viewed from the perspective that the global trade flows underlie non-equivalent relations, I consider the term of 'core' and 'periphery' are suitable to address how the British colonial system strategically de-industrialised Indian cotton markets and thus made the periphery during the 18th and 19th century addressed in Chapter 4.

It is however, important to note the limitations of the world-systems theory as its embeddedness in systems theory often reduces the embedded tensions within and between core and periphery. In the global system, as far as I understand, the core seems to be perpetually the agent while the periphery is the submissive non-agent. In other words, regional level of social movement (e.g., local resistances, conflicts and rebellions) against the global system are often veiled by core-periphery hierarchy (Chase-Dunn and Gills 2005). Therefore, in the case studies I try to

[1] The world-systems theory was established by Immanuel Wallerstein (1976) and developed into a theoretical framework that examines global social changes and the interaction between nations. Primarily, the world-system theory seeks to identify the unequal exchanges among countries, and to provide detailed analysis on socio-political dimensions of world economy (Eisenmenger and Giljum 2006).

[2] In world-systems theory, the semi-peripheral state describes the regions and countries positioned between the core and periphery (Eisenmenger and Giljum 2006). The organisational structure of these countries has both of core and peripheral features and they are geographically located in between them or between two or more core nations.

focus specifically on the agents and tensions. In addition, I present how local resistance and conflict came to the fore in the Indian cotton industry despite attempts of making peripheries, in part of resisting such attempts.

2.2. Time, Space and Inequality: Ecologically Unequal Exchange

The concept of ecologically unequal exchange aims to demonstrate complex socio-environmental systems focusing on unequal exchanges in natural resources, human labour and industrial wastes between nation. As I have discussed in the previous chapter, the mode of colonisation and the global core-periphery structure are major inspirations for this thesis. Considering that ecologically unequal exchange is also inspired partly by the social metabolism and world-systems theory (Wallenstein 1974; Hornborg and Martinez-Alier 2016; Oulu 2016), I propose ecologically unequal exchange can combine both inspirations as well as shed light on unequal distribution of socioecological benefits and disadvantages in the Indian cotton textile industry over time.

Ecologically unequal exchange emerged as a concept in ecological economics as an alternative economic theory of trades (Hornborg and Martinez-Alier 2016). Having its roots in post-Marxist thinking and social metabolism discussed above, the concept challenges conventional economic theories and offers a method and conceptual tool to unravel uncalculated cost to region's or nation's biophysical environments such as its ecosystem, natural resources, human health and labour time. Ecologically unequal exchange has its roots in the Marxist tradition, particularly in the economic development theory (Hornborg 2001), however it has been developed as a new and multidisciplinary study encompassing anthropology, history, sociology, international laws and environmental sciences (Bunker 1985; Hornborg 1998; Rice 2007; Jorgenson and Clark 2009; Hornborg and Martinez-Alier 2016).

From the point of view of ecologically unequal exchange, various environmental and ecological problems have their roots in the unequal exchange of material and energy, which is shaped by a highly stratified global socioeconomic system (Jorgenson and Rice 2005; Hornborg 2009; Jorgenson 2016). In other words, key in the concept of ecologically unequal exchange is the biophysical whose metrics are natural resources and labour time. Reinforce that ecologically unequal exchange is not extraction of resources and energy, per se that creates unequal exchange, but the socioeconomic consequences that result from between and within importers and exporters. Relating back to the discussion on world systems theory, 'core' nations can accumulate disproportionate profits at the expense of peripheral nations through trades and other structural relationships (Bunker 1984; Hornborg 1998, 2009; Jorgenson and Clark 2009; Jorgenson 2016). In the global economy system, the peripheries tend to export large amounts of raw material with comparatively low economic value (low price) and to import small quantities of finished goods with high economic value (high price) from the core nations (see a discussion in Fischer-Kowalski and Amann 2001). In other words, developing countries have to export large amounts of natural resources and energy in order to gain economic profits in the global trade unlike to those of developed cores. In this regard, Bunker (1985) has pointed out that the extractive developmental model in the peripheries could diminish the 'natural values' derived from their own biophysical environment as the resources do not regenerate themselves naturally. Thus, I consider that countries belong to the periphery zone who pursue a resource-extractive and export-oriented industry may have not only a little economic profit but also a high possibility to place a great deal of stress on the environment.

As I have mentioned in the previous chapter, another possible approach to examine the unequal exchange is calculating the actual material flows, particularly the biophysical metrics between nations (Fischer-Kowalski 1998; Hornborg 2009). In order to investigate the links between unequal trade and world environmental issues, quantitative measures of calculating material and energy flows (material flow accounting) are developed by many scholars in the field of social metabolism and ecologically unequal exchange (Bunker 1985; Hornborg 1998, 2006, 2009; Muradian and Martinez-Alier 2001). The biophysical analyses of unequal trade can be varied from unit to unit variation of component values and data quality. In the theory of Ecologically unequal exchange, the exchange of embodied labour (time) and land (space) are key factors to demonstrate uneven ecological impacts of nations, which has been called 'Time-Space Appropriation' (Hornborg 2001, 2006). By calculating and analysing the environmental space[3], labour time embodied in commodity and ecological food prints, Time-Space Appropriation aims to reveal labour exploitation and possible ecological transformations in the global exchange relation and global division of labour (Rice 2007). In regard to Time-Space Appropriation, Hornborg (2006) provides a method for quantifying the global exchange of natural space and labour time by comparing inputs of land and labour embodied in British production of textile with cotton cultivation in colonial periphery (North America) during the late 18th and early 19th century (Hornborg 2006: 8). In the article, Hornborg (2006) estimates that the sizable amount of British land and labour could be saved by displacing cotton production to North America. Hornborg (2006) calculated annual hectare yields and hours of human labour (in British imports of raw cotton and British textile production) in relation to exchange values in order to demonstrate unequal appropriation of materials, space and labour time in world system.

Knowing that Ecologically unequal exchange mainly focuses on calculating biophysical values and trade relations, this concept might have limitations in being able to address the dynamic interactions in local communities and consequences of landscape transformation. In regard to the theoretical and methodological limitations in ecologically unequal exchange approach, there are some difficulties of identifying a whole process of exchanges between society and nature in this framework (Fischer-Kowalski 1998; Dorninger and Hornborg 2015). In other words, calculations of asymmetric distributions of biophysical materials might be incapable of reflecting the complexity of individual and place based sociocultural realities as Ecologically unequal exchange is primarily concerned with material and energy balance problems and the socio-environmental inequalities in the global system. Considering the bulk of material and energy flows between nations is accompanied with dynamic social, political, economic and ecological impacts, I argue that ecologically unequal exchange is short in addressing the diverse interactions and consequences of the exchange. Therefore, as a complement it is important to address the impacts of power relations on local communities and landscape transformation, but also deeper investigations on social, cultural and historical background in greater detail which is what I intended here.

2.3. Methodological Limitations

To analyse Indian cotton textile industry's Ecologically unequal exchange, my initial plan was to do both qualitative and quantitative researches. However, I realised that conducing a quantitative analysis is beyond the scope of my thesis in terms of time and space. Therefore, I have focused on a qualitative literature review on social, political, economic and cultural aspects of

[3] According to Rice (2007), the environmental space refers to the stocks of natural resources, capacity of natural sink or waste assimilative capacity. The flows of material and energy can be related to the environmental space (Rice 2997: 1372-1373).

Indian cotton industry based on the two selected case studies. In so doing, I could grasp much detailed descriptions and dynamic power relations embedded in Indian cotton production as well as its supply chain. Notwithstanding the limitations noted above, it is worth describing the methodology as the concept of ecologically unequal exchange and Time-Space Appropriation still are my major inspirations to build this thesis. Therefore, here, I would like to mention the method that I planned to conduct, how to apply it to the case studies and its major constraints.

In order to examine the inequalities in social, economic and environmental aspects of Indian cotton textile industry, I planned to draw in particular on Hornborg's (2009) study of Ecologically Unequal Exchange as a conceptual inspiration. Hornborg's (2009) aim is to identify the asymmetric distribution of economic losses and gains and the biophysical units when productions and transactions are made between nations (Hornborg *et al*. 2016). More simply, this can be translated into appropriation and asymmetry in time and space. The values of labour time and raw materials are appropriated differently by nations, which cause major inequalities in the process of trading on energy and natural resources from less developed countries 'peripheries' by developed countries 'global cores'. As explained in the Chapter 2.2, these biophysical metrics (quantifiable data) are crucial to analyse the unequal appropriation of time and space between nature and society or nations. On the basis of Hornborg (2006)'s calculations, therefore, I intended to conduct quantitative investigation focusing on the changes in the use of agrochemicals, production and yield of cotton, human labour embodied in cotton cultivation, price of investment (e.g., irrigation and seed price) and land-use changes. In the ideal study, the methodological materials, particularly data on cotton price, yield and production over the period, would be collected from Ministry of Textiles, Government of India, Cotton Corporation of India and other previous studies. In regard to the forestry and land use changes over the time period in Gujarat region, various figures and tables are presented to offer a clear overview of landscape transformation. The major constraints that I found are mainly related with collecting data (particularly when only limited the empirical cases and uncompleted statistical information are available) and calculating the asymmetric exchange of labour, resources and environmental risks in the selected case studies. In regard to the application of Time-Space Appropriation, the major challenge was to quantify the biophysical metrics in terms of transfer of time and space, which involved in the Indian cotton textile industry.

Although Ecologically unequal exchange is a relatively new concept that can be integrated into many academic fields, particularly in sustainable development as discussed in Chapter 2, I have found out some limitations to fully reflect the structural inequalities and conflicts embedded in society and its history. Firstly, ecologically unequal exchange primarily concerns asymmetric distribution of labour time and natural resource between nations; therefore, it can only be useful tool to analyse social and ecological distresses hidden by monetary system. In other words, ecologically unequal exchange has limitations to address complex patterns of unequal power relations in the process of cotton production and supply chain. Thus, I put more emphasis on the state of 'core' and 'periphery' in order to identify the power dynamics existing in the Indian cotton textile industry. Therefore, combining both qualitative and quantitative approaches, I expected to identify potential inequalities (in terms of both biophysical metrics and power structure) not only for understanding the environmental impacts of cotton production system, but for critical reflections in social, political, cultural and historical aspects of local communities. In this way, I could develop more accurate account of unequal exchanges in Indian cotton textile industry.

2.4. Summary of research approach

In this thesis, I apply the framework of ecologically unequal exchange to shape my research questions and the historical analyses of Indian and Gujarat cotton production. Building on narrative that highlights the impacts of power dynamics on negotiations with land and markets are presented in the two selected case studies. Knowing that Indian cotton textile industry encompasses the broad dynamics of social changes and landscape management, the cotton industry and its supply chain are closely linked to social, economic, cultural and ecological aspects of Indian society. In this regard, I consider the concept of ecologically unequal exchange is able to identify present unequal exposures of social and environmental risks and benefits concerning the cotton cultivation in Gujarat over time. As I have discussed in Chapter 2, the conventional theory of ecologically unequal exchange and Time-Space Appropriation set importance on the physical and quantifiable transfer of nature (e.g., matter and energy) and risk missing the details of an ecological view that connect the biophysical transfers with social, political and cultural dynamics. Thus, I begin my theoretical journey by looking at how cotton as raw material, commodity and industrial product has contributed to the phenomenal economic growth and trade volume of the world, at the same time, how it has produced the regional and global inequalities in terms of social, economic, political and ecological aspects over the time frame from around the 1850s to the present.

Focusing on the material dimensions of the society-environment interactions (Fischer-Kowalski 1998; Hornborg 2006; Hornborg 2009), I study how cotton textiles came to figure a world of exchange and question the presumed benefits of global trade and its link to the development. In this regard, I emphasise that having a deeper understanding on the relationship between society and nature and its interconnectedness to the global economy system is crucial to address current debates on sustainable development. In this thesis, my aim is to explore how India has been inserted in the global commodity trade through the lens of cotton and what social and environmental consequences can be found in local communities and landscape, particularly in Gujarat, in western India. Thus, I conduct detailed analysis on the history of Gujarat's cotton textile industry in terms of social, economic, political and cultural aspects. In this regard, a consideration of the agricultural landscape management and the interpretation of selected case studies lead to an insightful discussion about the cotton production, its supply chain and power relations formed through the context of 'core' and 'periphery'. In the discussion of the research questions, the two selected case studies have been studied to reveal how they are recursively related to global socioecological processes and how local communities and agents have responded to the social, political and economic challenges they face. In doing so, I understand better what inclusive and sustainable agricultural landscape management means and its implication for India's cotton production today.

3. Background

Agriculture is a primary industry, producing most of food resources that we consume every day. Besides food grains, agricultural industry also produces raw materials for a wide range of industrial sectors. Agriculture is important for India as a country, approximately two-third of its population is engaged in agricultural sectors including merchandising, marketing and trading businesses (Sharma 2007). Among the various agricultural commodities, cotton is one of the most important industry, material and commodity in India. Throughout the history, cotton, both processed and manufactured in India, played a crucial role in configurating a world of consumption, exchange and trade satisfying the variety of world demands. In this context, I will give a historical overview of Indian cotton production, marketing and trade system as well as explain the significance of cotton in shaping European material culture and economy in the early eighteenth to the nineteenth century. As background to the reader, I will also present the physiology of cotton and the ecology of cotton cultivation to give the reader a better understanding of the links between cotton and environmental issues, as well as how these relate to the case studies of cotton quality management.

3.1. Selling to the world: the origins of cotton production and India

Before the beginning of the nineteenth century, the bulk of cotton goods in global trade had their origins in the Indian subcontinent. Cotton was widely cultivated throughout the India subcontinent between 1200 and 1800, and cotton was crucial to crop rotation and peasant strategies for survival and subsistence (Riello and Parthasarathi 2009: 5). With an abundance of raw material, India could develop unique skills and knowledge in cotton textile manufacturing from early on. On the basis of technological advantages, several regions with long coastlines and proper ports, particularly in Gujarat, Bengal and Coromandel became the centres of cotton trade through the Indian Ocean trade routes. Indian cotton textile industry also had a large subcontinental market share, where cotton was widely used for textiles both for appeals, decorative and household materials. Indian cotton goods were still in high demands throughout the Indian Ocean commerce world, and after 1500 throughout the world markets reaching out to the Europe, West Africa and the Americas (Riello and Parthasarathi 2009: 17).

While India was expanding her trading volume to the world markets, Europeans had remained in the periphery of cotton cultivation, manufacturing and consumption before the eighteenth century (Berkert 2014: 22). When the representatives of the English East India Company arrived in India in the seventeenth century, the weaving of cotton textile was a thriving industry (Leacock and Mandelbaum 1955). At that time, Indian textile producers provided a wide variety of cotton goods and even customised products suited to the tastes and preferences of customers thousands of miles away (Riello and Parthasarathi 2013: 6). Thus, even though western European countries had respectable local textile industries of wool, silk and linen, most of European buyers and consumers much favoured Indian manufactured cotton products sold by East India Companies (Ward 1994). In this context, the Indian printed cotton textiles overflowed in

European market places and brought significant changes in the European economy, politics and societal structure by being integrated into the European material culture (Berg 1994).

Most of luxury products, such as tea, spices, silk and textiles, were mostly consumed within the European upper class however they had a little influence on the industrial and technical progress during early modern Europe[4]. In the early eighteenth century, however European countries began to pave the way for enlarging their production capacity and developing division of labour, specialization and adaptability to the global cotton textile market (Beckert 2014: 54-55). Nevertheless, given that India was already producing fine printed cotton fabrics with a number of skilled cotton spinners and dyeing techniques through labour-intensive methods, British industry could not compete with the Indian one. For these reasons, most of English manufactures in textile sectors were having economic difficulties. Despite efforts to innovate calico-printing techniques and lower the price, imported textiles were still increasing in demands. Seeing the limitations and growing discontent among local manufacturers and protesters, the members of parliament passed a coercive legislation 'Calico Act' in order to protect domestic linen and woollen businesses (Lemire 2011). As a result of the series of Calico Act, new legislations were issued against imported cotton textiles, particularly from India subcontinent, such as imposition of prohibitive tariffs on imported cotton goods from India to Britain, and illegalisation of wearing garments made out of Indian calicoes.

Robinson (2010) has stressed that the Calico Acts, which was expected to protect domestic woollen and line industry, might benefit British cotton industries to develop without facing global competitions, particularly with Indian manufactured goods. The Calico Acts made it possible for British cotton manufacturing sectors to take a leap forward by stimulating investment in the industry, which played some parts in the British Industrial Revolution. Knowing that the European colonial expansion and Industrial Revolution was based on the unequal distribution of resources, roles and opportunities (Ward 1994; Fisher-Kowalski 1998; Hornborg 2006, 2009; Martinez-Alier 2007; Dejung 2013), I consider the unequal exchange of resources and unprecedented commitment of state to secure raw material and markets might have been derived as followed results. In the following section, the background of the emergence of East English India Company, their role and impacts on Indian cotton textile production and trades will be discussed. In addition to that I will examine the structural changes in Indian cotton textile industry and possible land use changes under the British colonial regime.

3.2. Make fashion follow the trade: the colonial British and English East India Company

Cotton textile production in the West developed from local linen industries to become a world scale mechanized and industrialized trade. On the basis of a rapidly growing cotton textile production, Britain was able to initiate the Industrial Revolution, which gradually spread throughout Europe and to Asia. Among the frontrunners of industrialization, the British Empire expanded its imperialistic influences and trade volume overseas to secure raw materials, new market opportunities and tax collection in the early nineteenth century (Beverly 2011: 18). India, one of the world's largest producer and exporter of cotton textiles, was heavily exploited under the British colonial regime and suffered environmental deprivation, labour exploitation and a net outflow of resources and capitals. In this context, the English East India Company

[4] A moment of technological stagnation in cotton textile manufacturing observed around the world during the sixteenth and seventeenth century (Riello and Parthasarathi 2013: 8).

(EIC), partly as a political device of British government, played a pivotal role in conducting of foreign and colonial affairs as well as in developing their mercantile interests. Thus, this chapter will focus on explaining the emergence of EIC and their impacts on Indian cotton textile production and trades. In addition, I will identify specific changes in Indian cotton textile industry under the British colonial regime from social, political and economic aspects which would help the reader understand the historical basis for chapter 4 and 5.

The East India Company started from small scale enterprises managed by groups of City of London merchants, which had been granted the monopolisation of English trade in the whole of Asia by the royal charter of 1600 (Ward 1994). At its outset the East India Company was more interested in the commercial opportunities offered by the spice islands of Southeast Asia rather than India (Makepeace 2010: 2). However, as cargoes of Indian cloth sparked unexpected growing interest amongst consumers in England, EIC imported a large volume of calicos, chintz and muslin cloth from Gujarat, the Coromandel Coast and Bengal which could be easily accessed by the sea (Nierstrasz 2015: 155). Cloth was first imported as a complement to spices and tea, but the cheap colourful cloth gained popularity and overtook the EIC's spice trade by volume and value in the middle of the seventeenth century (Riello 2009: 262-265). The EIC embraced the demands, particularly of calicos (printed cotton textile), by enlarging the number of its factories and scale of production, which caused intensive competitions with domestic woollen and linen textile producers (see Chapter 3.1).

Some may ask why cotton was considered more special than any other commodities during modern European period. In this regard, Nova (2016) has stated that:

> "After all, before 1760, Europeans had traded extensively in many commodities in the tropical and semitropical areas of the world, including sugar, rice, rubber, and indigo. Unlike these commodities, cotton, however, has two labour-intensive stages—one in the fields, the other in factories. Sugar and tobacco did not create large industrial proletariats in Europe. Cotton did. Tobacco did not result in the rise of vast new manufacturing enterprises. Cotton did. Indigo growing and processing did not create huge new markets for European manufacturers. Cotton did. Rice cultivation in the Americas did not lead to an explosion of both slavery and wage labour" (Nova 2016: 6).

As a result, cotton spanned the globe with social and environmental impacts unlike any other industry. Viewed from this perspective, I consider EIC might find a great potential of cotton, as a most profitable merchandise and as an industrial system, which inspired the innovation of textile-manufacturing in England.

Primarily, EIC took charge of providing Indian cotton goods to the English market. In the process EIC, gradually shifted its activities from procurement of raw material to economic colonisation as British cotton textile industry was becoming competitive and in needs of raw material (Riello 2013: 209-210). With the growing influence of British Imperialism, EIC imposed several reforms in the administration systems of India, including tax revenue system, land development, market structure and agricultural reform. As part of the agricultural reform, the cotton quality improvement program designed by EIC in Gujarat specifically has been selected as the first case study in this thesis and I also make some comparison to other regions. During the late eighteenth to early nineteenth century Indian cotton was in a continuing demand among English textile industry, however, American cotton still regarded as the best quality cotton. Initially, Indian cotton was used by industry when the American cotton was highly overpriced or difficult to obtain (Leacock and Mandelbaum 1955). The main reasons why Indian cotton

was 2nd choice with British manufacturers can be explained in two ways: First, it contained impurities such as leaves, seed and dirt and often badly stained when it arrived at the ports in England. Secondly, Indian cotton had a short length of fibre compared to American cotton. The length of fibre is an important characteristic that determines its suitability for machine spinning and quality of cloth. Because of the short fibres, a considerable amount of Indian cotton was unusable or wasted in the process of cleaning and spinning. Therefore, English manufacturers were not that eager for Indian cotton despite a much lower price than American cotton. British colonial officials and EIC schemed the 'Cotton Improvement Project' in order to satisfy British textile manufacturers' flavour, which in turn, lead to profits and further business growths (see Chapter 5).

In the process of the colonisation, the traditional Indian cotton manufacturing industry and local market had dismantled due to the influx of English cotton textiles and the manipulation of Indian tariff. In the meantime, extensive cotton cultivation was carried out by marginalised Indian local population (Harnetty 1970; Parthasarathi and Wendt 2009: 398-405). In other words, British colonial rule of distant territories aggravated unequal exchange of resources and labour locally, which led to the decay of local economy, environmental degradation and the loss of local identity (see similar discussion in Clark and Foster 2009). During the nineteenth century, the core of cotton textile manufacturing globally had completely shifted from Indian subcontinent toward industrialised Britain (Riello 2013: 88 and see Chapter 4.2). In this regard, I argue that cotton textile trade and the industrial mode of production came to shape a world of exchange, socio-cultural relation and landscape different from the world before the European expansion. The process of what should best be described as a 'deindustrialisation' of Indian cotton spinning and weaving and the emerging European industrialisation show how the fashion has followed the trade.

3.3. The ecology of cotton cultivation

This chapter explores the ecology of cotton cultivation from seed to disposal, including the origins of cotton, its types, characteristics, conditions for cultivation, farming system, the use of agrochemicals, and lastly possible landscape formations as a necessary background to the case studies presented in this thesis.

Cotton is a soft and fluffy, staple fibre that grows covered by a protective case called a boll. The fibre consists mainly of cellulose that can be spun into yarns or thread used in fabrics. The fibre can be made into a wide variety of fabrics ranging from lightweight laces to heavy sailcloth, suitable for wearing apparels, home furnishings, medical supplies and industrial goods. Besides being the source of fibre, the by-products of cotton processing and cottonseeds are used as a basic raw material for the production of oil and cottonseeds meal as planting, fertilizer and animal fodder. Acknowledging such a vast use of cotton in human society, it is important to examine the physiology of cotton for a better understanding of its growth, development and impacts on the environment.

Gossypium is a cotton genus, which belongs to the tribe *Gossypieae*, in the mellow family *Malvaceae*. The origin of the genus *Gossypium* goes back from 5-10 million years ago and the diversification in *Gossypium* can be found in terms of its morphology, adaptation and domestication (Steward *et al*. 2010a). A variety of cotton species in *Gossypium*, approximately 50 species, are mainly distributed in the tropical and subtropical regions, some of which originated in Eurasia and some in Americas (Wendel *et al*. 2009). The primitive *Gossypium* species have been domesticated in antiquity and developed by selective breeding programs and hybridisation

(Steward *et al*. 2010a: 14). According to Steward *et al*. (2010a), the selection and domestication of cotton species was influenced by not only geographical feature, climate adaptability, pest resistance but also the development of weaving. For example, the hand-ginning method required soft-seeded and short fibre varieties that lint fibres can be easily detached from the seeds. In regard to the domesticated *Gossypium* species, the genus of *Gossypium* is botanically divided into four different species: *Gossypium hirsutum* (known as Upland cotton), *Gossypium barbadense*, *Gossypium arboreum* and *Gossypium herbaceum*. At present, *G. hirsutum* and *G. barbadense* are the most common commercial cotton species due to their good quality in length, strength and fineness (Steward *et al*. 2010a: 14-17). In the following sections, I will examine more in detail the types of cotton and the general conditions for growing cotton from biophysical aspects.

Cotton is a kharif crop[5] which requires six to eight months to mature. In India the time of sowing and harvesting of cotton is dependent upon the climatic and soil conditions in different parts of the country. In the case of Gujarat, cotton is usually sown in June and harvested between October and March (Cotton Corporation of India). Cotton is a crop of tropical and subtropical regions and requires an even temperature between 20°C and 30°C with enough sunlight. It is important to have at least 200 frost-free days in a year as the growth of cotton is hindered by the temperature below 20°C (Sharma 2007). The desirable amount of water for growing cotton can be met by an annual rainfall of 55 to 100 cm. However, some dry areas with lesser rainfalls have successfully cultivated cotton yields by means of irrigation systems (Sharma 2007). Cotton cultivation requires substantial amount of moisture in the soil throughout its growth, especially at the formation of cotton fruits (Van Iersel and Oosterhuis 1996). This is also why cotton is so water intensive. The heavy rainfall at the time of boll-opening and harvesting, however, may increase vulnerability to pests and diseases (Sharma *et al*. 2008: 257). Thus, sufficient and timely water supply during the development of cotton-bolls is crucial to produce long staple fibres that can be woven into a fine quality cotton fabric.

Cotton fibres are mainly composed of cellulose (90% of cellulose, 6% of moisture and the remainder of impurities). The fibres enclose the seeds inside the boll of plant. On average, a cotton boll contains six to nine seeds and 17,000 lint fibres attached to each seed (Sansone 2002: 51). The broad types of cotton are generally recognised on the basis of the length, strength and structure of its fibre. Among the features of cotton, the length of staple is the most important value which defines the quality of cotton (Steward *et al*. 2010b: 36). In general, the length of fibre (also called staple) is categorised into long stable, medium staple and short staple (Sharma 2007). The long staple cotton has the longest fibre whose length varies from 24 mm to 65 mm. The long fibre is used for making fine and sophisticated cloth. The major growing areas are Egypt, Sudan, Peru and USA. The medium staple cotton is between 15 mm to 35 mm. Medium staple cotton mostly grown in India and China as major commercial crop, which comprises maximum production of global cotton. The short staple cotton is the lowest quality cotton with fibre less than 20mm long. It is used for manufacturing inferior cloth or industrial purposes.

As it is mentioned above, the sufficient water supply is one of the crucial factors for growing cotton successfully. In this regard, there have been continuous endeavours to enhance the accessibility of water through the artificial means such as irrigation systems, canals, tube-wells, tanks and ground water extraction, which all relevant to the landscape transformation at differ-

[5] Kharif crop (or monsoon crop) is a domesticated plant that is cultivated and harvested in South Asia during the monsoon season. Rice, maize, pigeon, pea, cotton, groundnut, sugarcane etc. are the examples of Kharif crop.

ent levels. Irrigation facilities could increase agricultural productivity, however extensive irrigation systems in risk bring about salinization, waterlogging, soil erosion, water pollution and loss of biodiversity (Frenken 1997; Hardiman 2007; Gidwani 2002; Sharma 2007). Furthermore, the indiscriminate use of agrochemicals in the cotton fields has been a serious threat to environmental, health and societal concerns (Igbedioh 1991; Parmar and Visvanathan 2003; Aktar *et al*. 2009; Gandhi and Jain 2016a; Saravanan 2016). As a 'scientific' solution to the problems of cotton cultivation, transgenic cotton varieties have been launched aiming to grow cotton with less water, fertilizers and chemicals, than the common commercial cotton varieties. With a growing importance of biotechnology in the cotton agricultural sector, a heated controversy has arisen on the effectiveness of genetically-modified cotton varieties and its impacts on cotton farmers, as also possible environmental consequences associated with the new agricultural production system. Therefore, I will outline and discuss controversial debates on the socioecological constraints and effectiveness of genetically-modified cotton in the following chapter.

3.4. Entering a new phase: Genetically-modified cotton varieties

Genetically Modified (GM) cotton varieties were officially permitted in India for commercial cultivation starting in 2002. Currently, about 90% of all Indian cotton plants are GM cotton (Saravanan 2016). Among the GM cotton varieties, *Bt cotton hybrids* (Mech 12, Mech 162 and Mech 184) are the most commonly cultivated species, which are genetically engineered to produce a natural bacterial insecticide called *Bacillus thuringiensis* (abbreviated to "Bt") (Gandhi and Jain 2016a: 17). The genetic code of *Bacillus thuringiensis* specifically helps cotton plants build up resistance to the cotton bollworm that damages the fruiting body of cotton. During the fruiting period of cotton, pest migration control is directly related to the quality of cotton-boll (Saravanan 2016). Thus, Bt cotton was designed to produce higher yield and control the pest incidence with less pesticide, which in turn, could enhance economic profits and by extension also have ecological benefits. Under this circumstance, local Indian farmers have rapidly adopted Bt cotton and planted it in their cotton fields.

Since the introduction of GM cotton in India, millions of farmers expected that they would have remarkable harvests and income and crops would be free of insects and parasites if they switched from farming with indigenous cotton seed to planting GM cotton seed. However, GM cotton seed has not performed as expected, according to Indian farmers (Narayanamoorthy and Kalamkar 2006). Bt cotton is about three times more expensive compared to non-GM cotton seeds and requires higher production costs (Gandhi and Jain 2016a, 2016b; Chapter 6; and also see Appendix A). In addition, another growing concern is the use of chemicals. GM cotton designed to resist bollworm has been attacked by other pests and weeds, causing an increase of spraying with insecticide and herbicide. In other words, even on Bt cotton, farmers may have to use the same amount of agricultural chemicals as non-Bt cotton. Some other possible environmental impacts of GM cotton are briefly bullet pointed below and will be discussed later in detail in Chapter 6.3.

- Potential for out-cross pollination
- Resistance of target insect
- Potential soil health degradation
- Possible landscape changes

Whilst the environmental concerns remain a serious concern, in addition the possible concurrence of farmer suicides and GM cotton, has spurred controversy. According to the National

Crime Record Bureau (NCRB) of the Ministry of Home Affairs[6], 6,602 farmer suicide cases have been reported in 2014 (see Table. 1). Among the various causes of farmers' suicides, "farming related issues" and "bankruptcy and indebtedness" are major reasons for male suicides, accounting for 47 per cent of total male farmers' suicide according to the table below. In the study of Bt cotton and farmer suicides in India, Gruère and Sengupta (2011) have estimated farmer suicide rate in India ranging between 1.4 and 1.8 per 100,000 total population over a 10-year period from 2005.

Table 1. Age and Gender Wise Distribution of Farmers' Suicides in 2014 (Cause wise)

Cause	Male	Female	Total
Poverty	140	9	149
Property Dispute	52	0	52
Marriage Related Issues	63	58	121
Family Problems	1038	97	1135
Farming Related Issues	1719	202	1921
Failure of Crop	851	101	952
Due to Natural Calamities	449	42	491
Due to Other Reasons	402	59	461
Inability to Sell	17	0	17
Illness	682	63	745
Drug Abuse/Alcoholic Addiction	250	0	250
Fall in Social Reputation	6	1	7
Bankruptcy or Indebtedness	1112	51	1163
Due to Crop Loan	916	49	965
Due to Farm Equipment's' Loan	21	1	22
Due to Non-Agricultural Loan	175	1	176
Causes of Not Known	208	23	231
Other Causes	759	69	828
Total	**6029**	**573**	**6602**

Source: National Crime Records Bureau (NCRB), Ministry of Home Affairs. Note: family problems are excluded from marriage related issues.

Most outspoken about farmers suicides has been Vandana Shiva, an environmental activist from India, that stressed a tragic link between GM cotton and farmer's suicides. In regard to this tragedy, Shiva and Jafri (2003) have heavily criticised GM cotton for its application as a system of corporate control over seed, a system of ecological impacts on soil and biodiversity, a system of health impacts on humans and animals, a system of socio-economic impacts on the livelihoods and survival of farmers. Particularly, Shiva (2004) argues that the commercialisation of GM cotton is causing not only political and economic marginalisation of the Indian farmers but also the monopolisation of cotton seeds. Other voices more positive towards Bt cotton have stressed that the adoption of Bt cotton has been increasing among small farmers due to its higher yield, better quality, less damage and staining from bollworm attack and less expenditure on insecticide (Mayee 2003; Gandhi and Jain 2016a, 2016b). In addition, a number of scholars have also argued that there are a range of reasons behind farmer suicides, such as seasonal monsoon failure, burdensome debts due to risky credit systems, governmental policy, seed monopolisation, personal issues and family problems (Shiva and Crompton 1998; Shiva *et al*. 1999; Shiva and Jafri 2003; Gruère *et al*. 2008; Das 2011; Gruère and Sengupta 2011; Gagdekar 2013; Schurman 2013; Thomas and Tavernier 2017). I consider current debates on

[6] National Crime Record Bureau (NCRB) publishes annual reports on Crime in India, Accidental Deaths and Suicides in India and Prison Statistics in India.

GM cotton in India should be studied from various angles as it is deeply intertwined in economic, political, cultural and environmental aspects of Indian society. Thus, I will discuss socioeconomic and ecological challenges and opportunities faced by Indian cotton farmers as well as power dynamics involved in the cultivation of Bt cotton in the Gujarat region in more detail in Chapter 6.

4. A Hub of Indian Cotton Industry: Gujarat, Western India

Gujarat has played a crucial part in the economic, political and ecological history of India in virtue of its rich natural resources and unique geographical characteristics. Whether one is describing its landscape, its climate or even its cultural history, a dynamism of socioecological interactions will appear as comprised by the vast variety of landscapes from the desert in the north west, abundant forest in the southeast area and fertile terrains in the central of Gujarat. As one of India's major cotton producer, Gujarat has enjoyed considerable advantages in terms of cotton cultivation and textile trade, granted by its favourable climate conditions for growing cotton, suitable location for international commerce as well as highly sophisticated finishing skills. In this context, this chapter will explore the landscape of Gujarat states and overview a history of Indian cotton textile industry in light of social, economic and environmental aspects focusing on Gujarat region. In this subchapter, I will address the role of cotton textile in Gujarat's political economy in 1300-1800, how Gujarat's cotton textile industry had shifted from global core to the periphery during the 18th and 19th century and how the Indian cotton production and marketing system was organised, who participated. Lastly, I examine several socio-ecological conflicts related to cotton cultivation, focusing on the water resource managements (e.g., irrigation facilities, small-dam systems, well and reservoir construction) in Gujarat in Chapter 4.2.3.

4.1. Geographical and Climatic Features

Gujarat is situated on the western coast of India, encompassing the entire Kathiawar Peninsula (Saurashtra) and the surrounding area on the mainland. The state is bounded in the west by the Arabian sea and in the northwest by Pakistan (see Figure 1). Considering geographical boundary within the Indian states, Gujarat shares its borders with Rajasthan in the north, Madhya Pradesh in the east and Maharashtra in the southeast, which is generally regarded as a cotton belt of India (Gandhi and Jain 2016a: 22). The state of Gujarat holds the northern extremity of the western seaboard of India where the coastline is about 1596km long (Basak 2013). The Rann of Kutch (Rann of Kachahh) is the most remarkable area in Gujarat where a variety of ecosystem, such as mangroves, desert vegetation and wildlife can be seen. Particularly, this area is well known as seasonal salt marshy region that the land fill with water during the wet season and then dry out over the rest of the year (Negi 1996: 155). The mainland extending from the Desert of the Kutch and the Aravalli hills to the river Damanganga is on the whole a flat plain of alluvial soil (Basak 2013). To sum up, Gujarat state can be divided into three areas, based on its geographical conditions:

- The Saurashtra Peninsular – rocky region interspersed with low lying mountains
- Rann of Kutch – marshland which consists of desert areas and rugged terrain.
- Mainland – fertile plain located between the Rann of Kutch and the Damanganga river

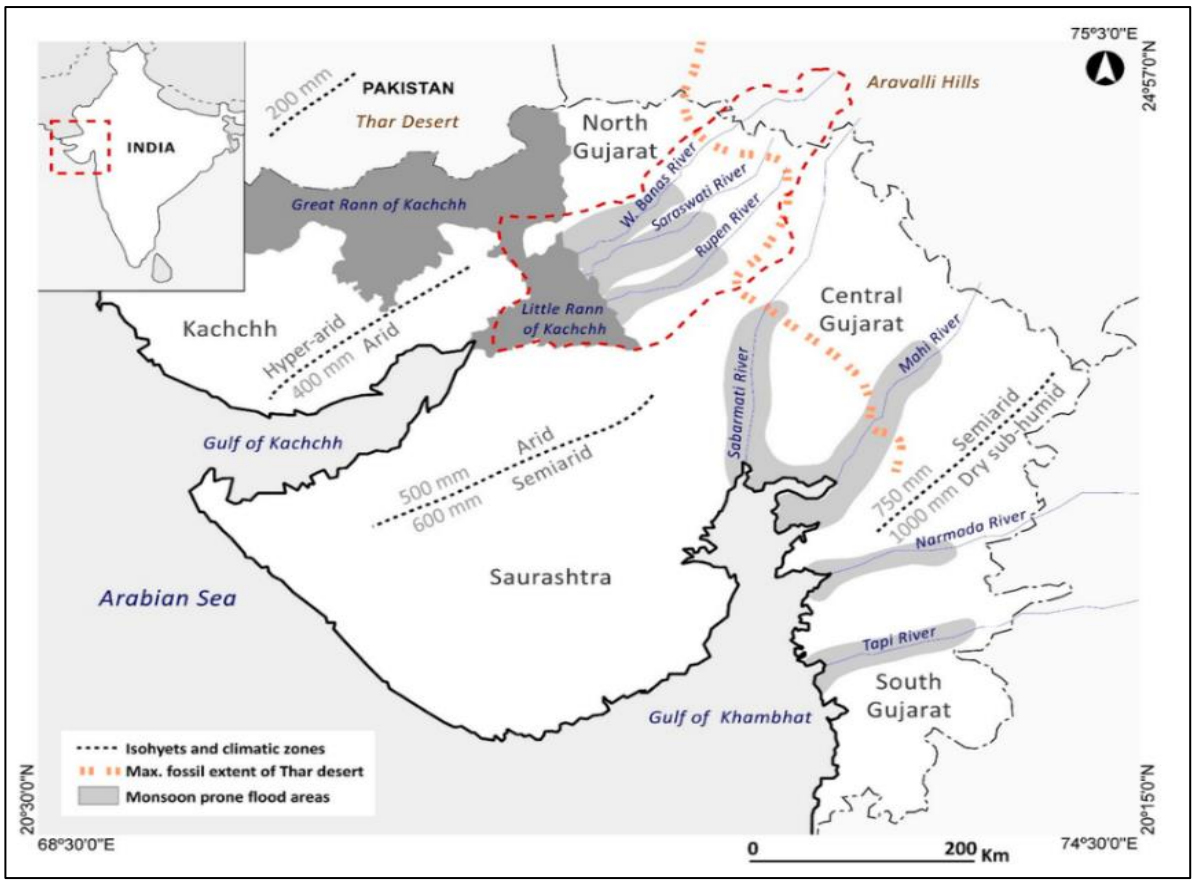

Figure 1. Location map of Gujarat, Western India

Reprinted from "Use of Satellite SAR for Understanding Long-Term Human Occupation Dynamics in the Monsoonal Semi-Arid Plains of North Gujarat, India" by F.C. Conesa, N. Devanthéry, A.L. Balbo, M. Madella and O. Monserrat, 2014, *Remote Sens* 6(11), p. 11422. Published by MDPI AG, Basel, Switzerland.
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The dominant climatological condition of India is defined as the monsoon tropics of sub-humid type (Kale 2014). In general, the monsoon season is divided into the active monsoon season which begins in the middle of June to the end of September and dry monsoon season which lasts the rest of the year (Sharma 2007: 36-38). The climate of Gujarat is a dry tropical monsoon type; humid in the southern districts and dry in the northern area (Bose 2013). For this reason, the rainfall at southwest areas is over 250 cm however, certain districts (particularly, north and westward Kutch areas) receive a very little rainfall due to the location of semi-desert area (see Figure 1). Therefore, such wide variation in rainfall across the districts has significant impact on crop productivity in Gujarat's agriculture, determining the success of seasonal farming. Most of Indian farmers rely on monsoon rainfall which is uncertain, irregular and unevenly distributed. For example, the seasonal drought (or monsoon gap) often imposes water stress on cotton plants and reduces crop productivity. Moreover, the effects of climate change on monsoon timing and variability (e.g., unexpected droughts, heavy floods or extreme temperatures) may increase the risks of agricultural failure (Shah 2005; Sharma 2007). Despite of such limitations, about 64% of cotton cultivation is still supplied with water by rain in most of Gujarat region (Gandhi and Jain 2016c: 132). Although the large-scale expansion of irrigation facilities has occurred since Independence from Britain, only one-third of the cultivated area is provided by proper irrigation while the rest of two-third area has to endure the vagaries of the

monsoons (Pradeep 2007: 3; Gandhi and Jain 2016b). Accordingly, crop failures or unsatisfying yields are often resulted from unequal distribution of rainfall throughout the country and seasonal irregularity of precipitation. Thus, the necessity of stable water supply for the cotton and other crops cultivation led to early development of water management systems, including irrigations, construction of water pipelines, wells and reservoirs in Gujarat (see Chapter 4.2.3 and 5).

4.2. Indian Cotton Production in Historical Perspectives

Archaeologists estimate that cotton has its origin in India, which is suggested by cotton cloth fragments found on the Indus river bank that has been dated back to about 3200 BC (Riello and Parthasarathi 2009: 2). This discovery proposes that the Indian subcontinent had a well-developed cotton textile industry already in ancient times. Gujarat, as one of the main cotton textile production regions, along with Coromandel Coast, Bengal, Punjab and Sindh, maintained a dominant position in the internal and external markets due to the remarkable designs of products as well as the broad networks of Gujarati merchants (Machado 2009: 161-163, 179). Nevertheless, Indian cotton textile industry had been gradually declined by being shifted from the core 'textile-manufacturing' to the 'resource-producing' periphery during the early 19th century. In this regard, I argue that it is important to address how this structural shift influenced the dynamic dimensions of local life. Therefore, below, I will review the historical context of cotton textile industry and discuss its economic, political, cultural and ecological entanglements in both local and global systems.

4.2.1. The role of cotton textiles in Gujarat's political economy

Throughout 1300-1800s, as discussed above, Gujarat state was well-known for producing high-quality cotton textiles with competitive market price. In particular Gujarat was renowned for its printed textiles and embroidery in the sixteenth and seventeenth centuries (Machado 2009: 161). In this regard, Gujarat cotton manufactures, by as early as the sixteenth century, had played a crucial role in the social, economic and political milieu of the interior and many parts of external markets (Parthasarathi 2009). In addition, Gujarat proved better able to manage Indian Ocean circuits of trade and distribution networks extending to Asia, Africa and Europe due to its geographical advantages. The combination of advanced manufacturing and artisanal skills with good access to global networks of supply chains, and the quality of the cotton textile, contributed to shaping the political, economic and cultural fabric of the world in early modern period. Indian textiles were often used for currency as a medium of exchange, including also ivory, slave and other commodities, which allowed Gujarati textiles to hold a prominent position in exchange relation (Machado 2009: 168). Furthermore, the complex and diverse motifs of Indian textiles stirred significant changes in the European economy, politics and societal structure by creating new desires and expectations in European consumption of material culture (Berg 2005; Broadberry and Gupta 2005).

As mentioned above, one of the greatest strengths of the Gujarat's textile industry was its ability to access and operate different networks of overseas trade and to produce a variety of cotton textiles, which was based on the early development of regional markets and strong commercial communities. Indeed, from the early sixteenth century to the middle of the eighteenth century, Indian cotton production rapidly increased in terms of raw cotton and textiles under the Mughal Empire (Ricard 1993). In response to the rising market demands, Agrarian Reforms by the Mughal Empire (by means of a new revenue system) gave farmers substantial incentives to

grow high value cash crops such as cotton and indigo (Ricard 1993: 190). In addition to agrarian reforms, the Mughal Empire further encouraged cotton textile manufacturing industry to diversify their product lines (piece goods, calicoes, muslins, bleached, unbleached and a variety of colours) in order to meet foreign market demands and to remain competitive. Gujarati merchants sought to take advantage of perceived politically favourable conditions, and they advanced more into the regional markets in the western Indian Ocean so as to secure more textiles to sell to the world (Machado 2009: 169).

Nevertheless, a demise of economic system was observed during the 18th and 19th century. According to Clingingsmith and Williamson (2008), the local handloom spinning industry underwent the most dramatic deindustrialisation among various industries. Cotton spinning was mainly performed by local women at home using the simple spinning machine, and it may have become impossible to compete with the imported cotton yarns from England in terms of the quality and quantity. The huge decline in the local spinning industry gave rise to the serial collapse of both weaving and finishing by the nineteenth century (Harnetty 1991: 472). As I have argued in Chapter 3.2, the deindustrialisation in Indian cotton industry began with Britain's challenge to India's dominance in global markets. The main reason for this shift was the early strategy of Europeans operating outside of continents as raw material-sourcing countries (Lemire 2011; Riello 2013). In 1750, India's share of world cotton textile production was almost a quarter, however India's manufacturing output sharply declined between 1830 and 1880. In 1938, India's share of cotton textile production was less than 3 percent (see Table 2). In the meantime, the developing core regions (particularly, England) had increased the world market share and trade volume through the industrialisation of products and processes.

In this context, I argue that Gujarat and India as a whole suffered much severe deindustrialisation than the rest of the periphery[7] considering the social, economic and political distresses. Gujarat (as well as other parts of India) transformed from a manufacturer of prestigious textiles to a supplier of raw material under the British colonisation.

Table 2. World Cotton Manufacturing Output 1750-1938 (in percent)

Year	India	Rest of the Periphery	Developing core
1750	24.5	15.7	27.0
1800	19.7	14.7	32.3
1830	17.6	13.3	39.5
1880	2.8	5.6	79.1
1913	1.4	2.5	92.5
1938	2.4	1.7	92.8

Source: Clingingsmith and Williamson (2008), Table 3, p.220. Note: India refers to the entire subcontinent.

In this section, I briefly explained the advantages of Gujarat cotton goods, the role of cotton textile in Gujarat's political economy and how cotton textile production in Gujarat had been shifted from global core to periphery during the eighteenth and nineteenth century. Even though Gujarat enjoyed commercial prosperity for centuries, the textile manufacturing industry began to decline during a period of British colonisation and the decay of the Mughal Empire. Knowing that the rural cotton textile industries were pivotal to supply cotton products to the world, it is worth examining how the supply chain structure was configured and what peculiarities may exist in the local cotton production system. Thus, the Indian cotton production system in terms

[7] According to Bairoch (1982), the trend of deindustrialisation had occurred across the non-European countries during the 18th and 19th century. However, as I set the geographical limitation to Gujarat, in western India, the decline in the global cotton manufacturing output in the rest of the periphery will not be discussed in this thesis.

of cultivation, manufacturing, merchandising and its distinctive features will be discussed in the following section.

4.2.2. Specialisation in cotton production system

Reflecting the long history of Indian cotton production and trade, it is clear that cotton was a crucial economic 'good', produced through a specialized system through which land and labour were exploited. The cultivation and marketing of cotton was deeply associated with the socio-ocultural aspects of Indian traditional society and the network of interactions between involved actors and agents in cotton textile industry. Starting of as one of the most prominent cotton manufacturing regions in the world, Gujarat gradually lost its competitiveness in cotton textile industry and land-labour relationships changed to adjust being a supplier of raw cotton (Riello and Parthasarathi 2009: 286-287). To understand the social implications of this shift, it is necessary to explain in more detail Gujarat's protoindustrial textile production system and find the uniqueness of this system compared to the European one. As it is hard to find details specifically from the Gujarat region, I will base the discussion below on a broader overview of India as a whole.

In general, the cotton textile production system involves four main stages: (1) cultivation, (2) cleaning and spinning, (3) weaving, and (4) merchandising and marketing. In Gujarat, as in most of India, the raw cotton was supplied by local farmers, and the process of cleaning and spinning was mainly done by women and children who were either family member of farmer or people lived in the same village. Professional village weavers produced quality textiles with cotton yarns brought from the *ryots* (a generic term for Indian local cotton cultivators) (Riello 2009: 63-65). The process of cultivation, spinning and weaving tended to be limited to the rural level (see Figure 2). The most unique feature of Indian cotton textile industry can be found in the merchandising and marketing of cotton products. According to Parikh (1975), the local weavers normally produced finished products that could be marketed directly through merchants. Nevertheless, the weavers preferred to make deals with village intermediaries (idem). The intermediary group negotiated between local weavers and merchants. The village intermediaries managed the local hierarchical stratification linked the caste system and helped weavers to retain a high degree of independence (Riello 2013: 59-65). Furthermore, intermediaries such as small-scale entrepreneurs carried on a moneylending business and managed the production and specific design requirements based on the market demands (Bhagavatula *et al*. 2010). In other word, the intermediary groups coordinated both social capital and human capital in the rural community in ways that enhance the productivity and efficiency of local-based cotton production and trade system.

Under the British colonial rule, the power of intermediary group was significantly weakened which caused major conflicts in the local cotton textile industry. As will be discussed in Chapter 5, local communities perceived the changes in market structure as a threat to their established mode of production rather than a new opportunity. The European cotton manufacturing system, on the other hand, was entirely dependent on the imported raw cotton and the weaving process was organised by guilds based in the urban areas. It was crucial for England to secure a stable supply of raw material and to develop urban production system, in which I consider why India and England had followed different paths of development in cotton textile industry.

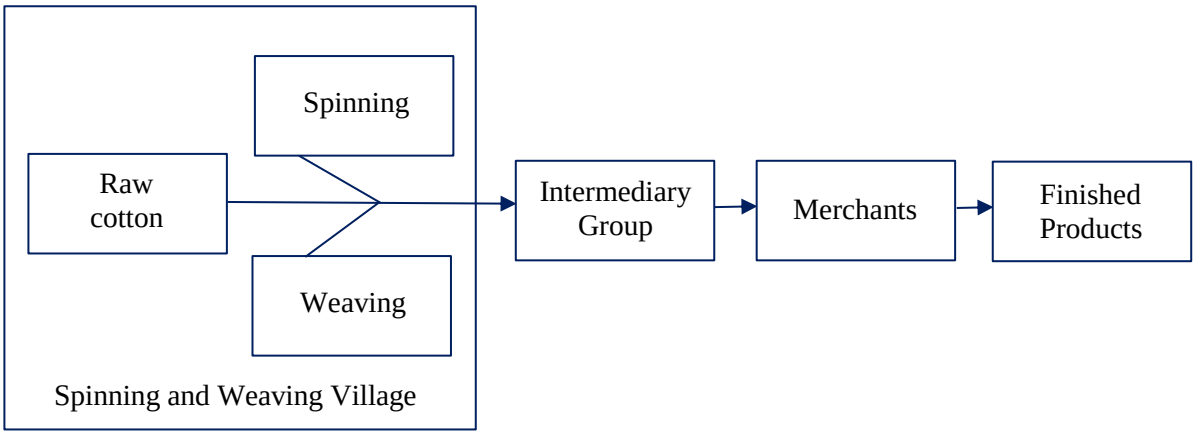

Figure 2. Illustration of the production and trading system of the traditional Indian Cotton Industry as summarised in the text

With British colonialism, the Indian cotton textile industry underwent substantial changes in its industrial structure; while the cotton manufacturing industry gradually declined as has already been discussed, the cotton production areas rapidly increased from the late eighteenth century (Parthasarathi 2009: 18-21). In other words, the industrial development retrogressed from commercial economy to agrarian mode of production. Through this structural reconfiguration, most of the influence of the specialised Indian cotton weavers and traders was diminished, as European manufacturing and marketing increased (Clingingsmith and Williamson 2008). This trend ultimately caused the collapse of traditional cotton-based rural economy and opened up for the rise of commercial cultivation of cotton plants in India, and I will discuss this process in more detail in Chapter 5.

Converting strategy into commodity flows from the manufactured goods to raw material inevitably involved the structural asymmetries in cotton trade, in terms of requiring more embodied land and labour in cultivating raw cotton. Given that the size and scale of cotton manufacturing had been dramatically increased in England due to the mechanisation of cotton production, it might explain why Indian cottons were ousted from the global core to the periphery – the de-industrialisation of Indian cotton textile industry.

4.2.3. The socioenvironmental aspect of cotton cultivation

Cotton farming had important socio-environmental impacts and here I will focus on irrigation systems and groundwater extraction in Gujarat. The irrigation systems were one of crucial factors in sustaining cotton agriculture. Irrigation agriculture involved, not only local knowledge of water resource management, but also dynamic power relations formed around village society and economy (Shah 2005; Hardiman 2007: 15-16). As my aim has in this thesis is to discuss power dynamics and possible landscape changes, I consider that navigating irrigation history would bring out some degree of complexities, contradictions, struggles as well as environmental problems embedded in Gujarat's landscape. This understanding is partly related to Chapter 5 in terms of the environmental and social impacts of colonial rule as well as the time period covered. Therefore, this section provides the reader with a detailed background necessary for the following discussions in Chapter 5.3. Other environmental aspects, such as deforestation, monoculture, application of chemicals, changes of vegetation and possible climate change will be discussed in detail in Chapter 5.3 and 6.3.

Agricultural conditions in Gujarat state are characterised by a variety of soils and climatic configurations as already discussed in Chapter 4.1. In the Gujarat region, overall temperatures and soil quality are suitable for cultivating cotton crops, supporting good productivity and a better quality of cotton than other Indian regions. Water and rainfall, as explained in Chapter 3.3, are crucial factors of cotton growth and development. In the case of Gujarat's planting season, farmers tend to plant cotton seeds mid-June to July after the onset of monsoon as they are largely dependent on rain-fed water (Global Agricultural Information Network 2016). Despite of a well-planned seeding strategy, the dependence on the monsoon season for planting often causes a massive agricultural failure. For instance, due to the monsoon gap and erratic rainfalls farmers produce low yields and short fibre that determines the low quality of cotton product (Gandhi and Jain 2016c: 165). In the absence of proper irrigation systems, therefore, most of India cotton cultivation took place in rainfall areas or alluvial plains[8] where the water supply and soil condition were adequate for growing cotton plants. Nevertheless, there has been a great need of building irrigation facilities in order to produce higher yield, better-quality cotton fibres, and to achieve effective water resource management.

Irrigation in India encompasses a broad network of major and minor canals from Indian rivers, groundwater well-based systems, tanks, and other rainwater harvesting systems for agriculture and other activities. Hardiman (2007) has written an extensive review on water management in the Gujarat region and much of what comes below will be based on his review. In Gujarat, well irrigation system was the most popular way of harvesting water because it was possible to obtain water at relatively shallow depths and wells could be dug at a low price (Hardiman 2002: 112). In this regard, in Gujarat, wells have provided water for drinking, irrigation and livestock to a large part (Hardiman 2007: 15-16). Historically, the construction of well irrigation was deeply associated with locally dominant peasant castes, which defined ruler (or elite) and subject (Hardiman 2002: 112). In a village, groups of peasants often built irrigation wells, reservoir and tanks when necessary. Such works became too expensive or hard to be maintained by individual peasants, they were able to receive a coordinated labour of a village as a whole, arranged by landlords or local elites (Hardiman 2002; Hardiman 2007). In this respect, the general efficiency and productivity could be much enhanced by the local hierarchy system. In addition, well irrigation works provided employment opportunities and subsistence resources for smallholders and labourers in rural areas (Prakash 2005; D'Souza 2006). The building of well irrigation systems in Gujarat came to the fore during the sixteenth and eighteenth centuries when large parts of local Gujarat population engaged in expanding all-Indian subcontinent and global trade (see Chapter 4.2.1 above). The wealthy merchants financed local village community to enlarge their agricultural plots to grow more cash crops (e.g., sugarcane, rice, cotton and fruits) to take the best advantages of the extending trade (Hardiman 2007: 334). Particularly, Central Gujarat became the centre of agriculture irrigated cotton, producing great quantities for export to domestic and international markets (ibid.). Farmers received water for cotton cultivation from the irrigation wells which were built in small-scale with traditional water harvesting technology and managed at an ecologically sustainable level in terms of water outtake and supply.

[8] Alluvial soil is a fine-grained fertile soil deposited by water flowing over floodplains or in river beds (English-Word Information). Alluvial soil is loamy and suitable for irrigated farming including hybrid cotton (Gandhi and Jain 2016: 131). In Gujarat region where the majority of famers rely on the monsoon, the alluvial plain is crucial in water containing by soaking up monsoon rains like a giant sponge.

During the early colonial periods, British colonial officials embarked on the new land-tax systems and large-scale canal irrigation works which were fundamentally different from what local communities had operated and accustomed to manage (Hardiman 2002, 2007; Prakash 2005; D'Souza 2006). The colonial canal constructions of the late nineteenth and early twentieth centuries were overwhelming the traditional irrigation management and local environment in terms of its scale and level of technology. In many other regions as well, colonial canal lines were often deliberately used to supplant other prevailing irrigation structures (D'Souza 2006). In other words, colonial irrigation strategies such as dams, canals and barrages, were unable to coexist with indigenous water structures, but were also deliberately aimed at destroying the latter in the name of 'modernising' and 'development' from the side of the colonial state (D'Souza 2006).

Another aspect of the decline in the traditional irrigation practices can be explained through the imposition of the revenue reform imposed by colonial administration (which will also be discussed further in Chapter 5). In this regard, Hardiman (2002) has stated:

> "In place of overlapping systems of access to natural resources, the state attempted to claim absolute ownership of all resources—whether of land water, minerals, or forests— for itself. Land was—supposedly—'rented' out to landholders, who had to pay a land-tax each year on pain of eviction. Water was subject to taxation at all levels, with water rates being an integral part of land-tax systems. There were well taxes, subsoil water taxes, canal charges and so on" (Hardiman 2002: 114).

Under the redefined property relationship, village networks began to breakdown following the introduction of new land revenue systems and market economy by the colonial officials. In other words, the irrigation systems maintained by traditional technique of irrigation and the local peasant castes substantially dissolved as individual peasants began to pursue economic interests as private owners (Hardiman 2007: 352). Colonial mode of intervention in the local market economy induced local peasants to bore wells deeper than the sustainable level, which exceeds the carrying capacity of natural system. In this regard, I argue that the commercialisation of water and peasant indebtedness were processes used deliberately to encourage farmers to plant more cash crops (particularly, cotton) by extending well irrigations and agriculture. Consequently, many coastal areas suffered from the salinization of shallow water wells, waterlogging, soil degradation and land erosion due to indiscriminate ground water extraction (Prakash 2005; D'Souza 2006; Hardiman 2007: 324). Furthermore, drinking water was fetched over far distances as traditional wells became drying up as a result of depletion of groundwater (Bhatia 1992). In my view, this process could be considered as an irreversible disruption of the "local hydrological cycle". Traditional water harvesting systems in India degraded and were gradually marginalised by a range of colonial strategies for rule and profit. The shift of power dynamics can also be found as a result of the changed relationship between the local peasant hierarchy and its people. The colonial endeavour to facilitate pursuit of high revenues and commodifying of land and natural resources caused not only the decay of indigenous irrigations systems, but also ecological degradations in local areas, which, in turn, led to the impoverishment of local communities and their environment.

5. Cotton Imperialism: state-directed cotton program in the 19th century

In the early nineteenth century, Stated-directed cotton experiment, here referred to as the colonial cotton program, was designed by the English East India Company in order to reduce heavy dependency on the raw cotton from the United States as well as produce longer fibres better qualified for weaving into fine clothes than Indian native cottons (see Chapter 3.2.). The shifts in agricultural landscape management in this case can be explained through recognising the interests, attitudes and actions of multiple actors. In this chapter, I will mainly focus on analysing the formation of agricultural landscape management promoted by *an external agent* (British colonial government) and the socioeconomic conflicts and unexpected environmental consequences derived from the colonial cotton program. Based on the case study analysis, I aim to examine changes in landscape management and cotton supply chains enforced to accomplish the economic, social and environmental objectives of the colonial state. In addition, local resistances, conflicts and power relation related to the colonial cotton program will be investigated.

5.1. The State Imperative

As examined in Chapter 4, by the middle of nineteenth century, Indian agriculture rapidly transformed into a commercial entity, as raw cotton trade volume was enlarged and it was subsumed into a European world economy and system (Harnetty 1971). Under the such circumstances, total cotton acreages in Gujarat (particularly, Broach, Surat and Khandesh districts) significantly increased as compared with other cotton growing states (Guha 1972 and also see Appendix B). This development was further accelerated by the outbreak of American Civil War (1861-1865) when cotton production dwindled in the United States. The low production in the states suddenly made colonial India the largest cotton exporter and India substituted for the decline of exports of raw cotton from the United State (see Table. 3). In this economic and political context, the English East India Company (EIC) designed a new agricultural program to reduce heavy dependency on the raw cotton material from the United States, and to satisfy textile demand from the rapidly growing English industry (Leacock and Mandelbaum 1955; Harnetty 1970). The initial motif of the state-directed cotton improvement program was to encourage Indian cotton farmers to plant more cotton, and to improve traditional methods of growing, picking and cleaning. Newly introduced cotton varieties from New Orleans were introduced, which in part required new techniques (Hazareesingh 2012). Colonial botanists believed that new exotic cotton could well adjust to a new habitat to produce larger yield and longer fibres. At minimum, new varieties were expected to perform well if they were hybridised with native cotton varieties, which were better qualified for weaving into fine clothes as has been explained in Chapter 2.3.

Table 3. The Quantities of Raw Cotton Exported from India 1861-1870

Year	Quantity (ib.)	Year	Quantity (ib.)
1861 /2	392,700,000	1866/ 7	425,568,892
1862/ 3	473,678,421	1867/ 8	614,056,049
1863/ 4	550,126,402	1868/ 9	697,630,796
1864/ 5	525,052,876	1869/ 70	554,834,522
1865/ 6	893,150,424	1870/ 1	577,600,764

Note. Relevant information adapted from "Cotton Exports and Indian Agriculture, 1861-1870" by Peter Harnetty, August 1971, The Economic History Review 24(3), p.414.

During the early1800's, the cotton improvement projects were already performed in several regions, mainly western and southern parts of India, ordered by EIC (Leacock and Mandelbaum 1955). There were many small-scale experiments in different parts of India going on, however, here I will focus on Bharuch area case as I already set a geographical limit to Gujarat state (see Figure. 3).

Figure 3. Southern Districts of Gujarat State (India)

The first extensive experiment in the cotton cultivation program was conducted at Bharuch situated in Gujarat, but also Khandesh and Dharwar in 1829 (Leacock and Mandelbaum 1955). Colonial botanists induced *ryots* to plant foreign cotton varieties – Brazilian, Egyptian, American Bourbon, Sea Island and New Orleans cottons in their croplands (Hazareesingh 2012: 3). Due to the growing suspicion of governmental intervention and uncertainty of the foreign cotton seeds, only few farmers were persuaded to take part in the experiment. Even those who involved in the experiment showed no will of cooperating, insisting that they could not take any risks of economic losses and possible agricultural failures (Dejung 2013: 142-143).

5.2. Cotton Quality Management

In 1838, EIC implemented a new plan. Unlike the previous experiment that encouraged ryots to plant foreign cotton without giving a clear motivation, the revised plan, designed by colonial officials and American planters, aimed for a progressive change in the traditional methods of cotton cultivating and marketing through a substantial funding from government (Leacock and Mandelbaum 1955; Harnetty 1970; Hazareesingh 2012). The experienced American botanists instructed ryots to plant new cotton varieties with methods of growing and cleaning that was adjusted to the specific varieties. In 1840, three American botanists were assigned to Bharuch region under the Bombay presidency (Leacock and Mandelbaum 1955). The primary tasks of the American botanists were to encourage ryots not to mix the foreign and native cotton when they are sowing and picking, and to offer a higher price for cotton of foreign varieties than native ones. Nevertheless, despite the financial encouragement and propaganda, only a few of ryots decided to plant exotic cotton varieties. Furthermore, many parts of India were simply not suitable for growing American cotton in terms of soil and climatic conditions (Leacock and Mandelbaum 1955: 341). The native cotton varieties have deep root systems that help tolerate long dry season, whereas American cotton varieties have relatively shallow roots that are highly vulnerable to water stresses and unfit for growing in black cotton soil of Deccan Plateau (ibid.). For these reasons, the program did result in any significant neither productivity gains nor quality improvement[9] (Leacock and Mandelbaum 1955; Shah 2005; Hazareesingh 2012).

On the 1st of October 1863, the Cotton Supply Association and colonial officials set the Bombay government headed by G. F. Forbes[10], in order to enforce new agricultural law and induce local cultivators to follow new farming methods by implementing a new land revenue system and a legislation called 'Cotton Frauds Act' (Harnetty 1970). In so doing, the new cotton department would introduce European legislations to effectively control the land revenue system and village-centred production practices. The new revenue system, formulated and exercised by the Bombay presidency in 1820s, mainly targeted the cotton-growing regions such as Gujarat with increasing tax charges directly from the individual peasants with an intention of higher production for the export markets (Leacock and Mandelbaum 1955; Harnetty 1970; Hazareesingh 2012). In colonial calculations, this additional tax charge would increase cotton production for the export market, which could bring higher returns to the ryots than local market (Hazareesingh 2012). Along with a new land revenue system, colonial bureaucrats issued 'Cotton Frauds Act', which restricting customary practice of adulterating cotton or blending the

[9] There were several successful cases reported by Bombay presidency in 1850s, however it only made meaningful yields for the first crop season, soon after ryots returned to their traditional cotton farming practices (Leacock and Mandelbaum 1955).
[10] After the outbreak of American Civil War, the British textile manufacturing industries were in a difficult situation as America could no longer provide enough high-quality cotton as much the pre-war scale. In response to the acute request from British government, G. F. Forbes, a first Cotton Commissioner of Bombay presidency, led the extensive cotton experiment campaign and policy decisions which would require changing traditional cotton cultivating choices and practices (Harnetty 1970).

seed and lint of the American and Indigenous cotton varieties during the picking of the cotton. Colonial administration also confiscated all mixed cotton that they could identify in their controls. Moreover, during the early experimental years between 1843 and 1845, there was an emphasis on intensive mono-cultivation without seasonal crop rotations (Hazareesingh 2012). By forcing cotton cultivators to plant 'every available land' with cotton, new legislations further increased vulnerability of food security and ecological systems in local communities.

Desiring a 'pure' American cotton lint, British colonial officials prevented local peasants from the mixing of two varieties and any adulterations, even persuaded them to sow foreign cotton seeds in their farmlands. The cotton improvement programme aimed to achieve three initiatives through cotton quality management: Increase in the amount of cotton for export encouraging the ryots to plant more cotton and improving their agricultural methods. A second aim was to, encourage Indian peasants to take great care in the picking and cleaning of cotton fruit and lastly, introduce a new cotton variety with longer fibre into the country, either to replace indigenous cotton or to be hybridized it with exotic cotton in order to increase its length of staple or fibre. Unlike to the foreign cotton varieties, the indigenous cotton varieties were well adapted, not only to the soil and local climate but also to the sociocultural practices of hand ginning, hand spinning, and local marketing. In regard to the hand ginning and spinning, it was a common practice to mix two cotton varieties among Indian cotton cultivators as it enabled production of cotton yarn both for traditional methods and spinning machine.

In spite of the increase in export volumes and prices of cotton, most of local cotton farmers and Indian artisans remained in the social and economic peripheries. In other words, local peasants were neither actively engaged in the colonial cotton project, nor economically benefited from it. Furthermore, ryots pointed out that the seed of American cotton plants was less valuable as food for their cattle in comparison with the indigenous cotton (Hazareesingh 2012). Planting foreign cotton thus still was optional for majority of local farmers as they accustomed to seasonal crop rotations which were oriented toward food production (Hazareesingh 2012: 7). The ryots found that cleaning of the American cotton (e.g., separating fibre from seeds) was more difficult. Foreign cotton fibre was much softer than Indian cotton, and prone to be injured in the traditional ginning process used. (Hazareesingh 2012). Because of the fragility of the new cotton varieties, Indian peasants had to use imported saw-gins. The imported saw-gins were owned by a small number of contracted merchants only, which often made them take the reluctant travel to another city if the gin owners were not local-based.

The colonial economy system modified the fundamental structure of the Indian cotton marketing (Dejung 2013). As already discussed in chapter 4.2, the traditional cotton trade was dominated by local, trustworthy intermediary groups who had established a long-term relationship with the ryots. However, the colonial cotton trade and marketing system required ryots to make business with merchants hired by colonial officials. The new trade system also coerced them to produce higher cotton yields for the global market rather than for the local demands creating greater dependencies of local farmers (in getting seeds, ginning, and in access to markets). At the same time, the local strategies for cropping pattern and livelihood diversification were discouraged and threatened. In other words, the colonial officials had a lack of involvement in the local market economy in ways not only never fully understood of the local system but also hardly managed to control it. The new land revenue system also imposed heavy financial bur-

dens on ryots, particularly as a result of following agricultural failures due to unexpected monsoon fails[11]. In opposition to the colonial rule and as a part of defending their control over the land and the mode of cultivation, most of ryots returned to their traditional way of cotton planting and marketing, even though they faced penalty fines and interrogations by colonial officials (Hazareesingh 2012).

5.3. Possible Environmental Effects

Before the cotton improvement experiments, most of Indian farmers grew cotton as a means of livelihood diversification. Cotton was part of a local system of risk-averse cropping aimed at food security and domestic uses (e.g., for clothing and textiles and feeding livestock). Compared to native cottons, the foreign cotton seeds and hybrids required much more water and more prone to pest insect attack (Leacock and Mandelbaum 1955: 341). From the labour perspective, they required larger farmlands and extra labour forces in picking, cleaning and ginning than native cotton varieties (Harnetty 1970). Not only socioeconomic hardships among local cotton cultivators, but also various forms of direct and indirect environmental degradation can be observed as consequences of the cotton improvement program. For example, the construction of railroads, shipbuilding, canal irrigation systems and increasing demands for timber led to massive deforestation in western parts of India, which, in turn, aggravated climate vulnerability, biodiversity loss and soil erosion. Knowing that landscape entails multiple interactions and processes (as discussed in Chapter 2.1), below I explore the environmental effects of the cotton improvement program and several following land use changes in Gujarat region during the nineteenth and early twenties century.

Vegetation is a crucial factor for determining both climate conditions and surrounding ecosystems. Particularly, forests play pivotal role in regulating the carbon cycle, water availability, soil conservation, fertility maintenance and climate changes, which all are closely linked to the agricultural production (Bawa *et al*. 2007). Historically, there are many cases showing how traditional agricultural patterns and forest management are mutually reinforcing and contributing to achieve an ecologically sustainable agricultural landscape (see similar discussions in Fairhead and Leach 1995 and Bawa *et al*. 2007). During the cotton experiment periods, there were massive deforestations in the processes of expanding arable lands for intensive agricultural production and for constructions such as shipbuilding, railroads, carriages and canal irrigations as discussed above (Macpherson 1955; Harnetty 1970; Hazareesingh 2012). Under these circumstances, local farmers were encouraged to plant more cotton (and even unfamiliar cotton varieties) as the demands for raw cotton were expanding at the global scale. Moreover, the focus on growing only a few cash crops resulted in monoculture plantations, which in turn significantly increased in vulnerability of food security and local ecosystem (Harnetty 1971). In Gujarat as in elsewhere, the most common way to develop farmlands was to utilise open grasslands, shrubs lands and forests (Guha 1983). As shown in Table 4 below, the total area of arable land had constantly increased while the area of forest, major wetland and unvegetated land had decreased significantly during this period. The expansion of farming on forest, major wetland and unvegetated that were previously available as commons must have put stress on

[11] According to Saha (2000) "during the 19th century, the first famine came during 1812-13 in Kachchh and North Gujarat. In 1813, there were destructive floods throughout Saurashtra. Monsoon failed in 1877 in Gujarat with Bihar, United Provinces (U.P.), North Western Provinces, Punjab, North Eastern Rajputana, Central Provinces, West Konkan" (Saha 2000: 19). Such unexpected climate changes (e.g., monsoon fails, drought and flood) as well as following environmental effects of cotton improvement program have been discussed in chapter 5.3.

livelihoods for non-landowning villagers. Noticeably, the massive and continuous deforestation had taken place between 1930 and 1940, linked with increasing the agricultural acreages, railway and irrigation systems as part of the colonial project. Although the time period covers the years after the cotton experiment program, I assume that the process of intensive agricultural development and deforestation had begun and was promoted by the gradual shift of Indian cotton textile industry from being a textile manufacturer, to being the supplier of raw materials in world system as discussed in Chapter 4.

Table 4. Land Use in Gujarat 1880-1940 (per hectare)

	Arable land	Forest	Major Wetlands	Unvegetated
1880	6834.7	791.9	1035.4	387.3
1890	7070.1	752.6	1022	379.6
1900	7030.8	718.9	995.4	375.6
1910	7615.8	674.3	982.4	394.1
1920	8302.7	621.4	954.5	383.3
1930	8645.6	572.4	948.4	379
1940	9112.5	517	922.9	364.3
1950	9328.3	424	917.7	356.3
1960	10321.2	364.7	893.8	339.3
1970	10314.7	330.9	892.4	342
1980	10073.3	295.6	884.2	370.6
Change %	**47.40**	**-62.80**	**-14.60**	**-4.30**

Relevant information is adapted from Haynes, Edward S. 1998. '*Natural and the Raj: Customary State Systems and Environmental Management in Pre-Integration Rajasthan and Gujarat*.' in Nature and the Orient: The Environmental History of South and Southeast Asia, ed. Richard H. Grove, Vinita Damodaran and Satpal Sangwan. 1998. New Delhi: Oxford University Press.

There is yet another following consequence of the cotton improvement project which needs to be addressed. Although Indian cotton output was greatly increased, there were problems in the supply chain or improvement in the quality of the cotton due to the absence of proper means of communication and transportation (Macpherson 1955: 184). For example, the enormous expense, loss of time, possible deteriorations from exposure (e.g., dust or rain) in the course of transportation were considered as biggest obstacles in the expansion of the cotton industry (idem.). In order to achieve effective and fast transportation of raw cotton, the I,500 miles of Indian railway constructed in 1861 were only to traverse the cotton growing regions[12] (Macpherson 1955: 183). By 1870s the end of the cotton experiment projects, there were extensive railway expansions financed by British capital for the benefit of British industry as shown in Table 5 (Macpherson 1955; Harnetty 1970; Guha 1983). In addition, the increasing value of teak and firewood, particularly as a result of growing demands from the railway companies led to intensifed deforestation in Gujarat region (Hazareesingh 2012 and see Table 4). Such activities, in parallel with the capitalist colonial ventures, shapted the trajectory of the cotton experiment to converge toward another colonial project of timber extraction following the extensive public work programs (Hazareesingh 2012: 17).

[12] Macpherson (1955) has stated that "[…] pressure was exerted in the case of the Bombay-Surat Ahmedabad (B.B.C.I.R.) line in the i850's. The Indian Government was at first willing to approve only the Surat-Ahmedabad section, but, after appeals from the Manchester Commercial Association and Chamber of Commerce, the chairman of the Oriental Bank and other bodies, it agreed to sanction the whole line from Bombay." (Macpherson 1955: 184). In this regard, I assume that the railway passed through cotton growing regions in Gujarat.

Table 5. Railway Expansion in India, 1853-1910

Year	Kilometrage	Outlay (Rs milion)	Net earnings (Rs milion)
1853	32	3.8	0.05
1860	1,349	266.6	3.0
1870	7,678	900.0	30.3
1880	14,745	1,285.7	63.9
1890	26,395	2,136.7	103.6
1900	39,834	3,296.1	164.5
1910	51,658	4,390.5	239.9

Reprinted from "Forestry in British and Post-British India: A Historical Analysis" by Ramachandre Guha. 1983, Economic and Political Weekly 18(44), p. 1883. * Note: original source can be found in "History of Indian Railways", Government of India, 1964, Delhi, p 214.

Consequently, the huge loss of forestation affected regional climate pattern exacerbarating local drought-prone environment and rainfall unpredictability (Hazareesingh 2012). Furthermore, the political and economic turmoil associated with colonial policies created a situation in which smallholder farmers became more vulnerable to famine and drought (Hardiman 2007: 340). It also reduced possibilities for alternative livelihoods in common and unused land (e.g., collecting, small scale hunting, lumbering, slash and burn cultivation), which pushed non-land holding people (mostly lower-caste peasants) to become more marginalised and may have to leave their land (Hardiman 2007: 368-373, 378). In this context, I argue that the state-directed cotton quality improvement program demonstrated the limitations of colonial knowledges to understand and control the diversity of cotton and its complex relationship with local communities and environmental conditions. The repercussions of the extensive colonial projects were therefore considerable.

5.4. Discussion

The colonial officials' elaborate scheme to manage the Indian cotton industry through legal regulations and introduce new cotton varieties was doomed to failure not only due the resistances of local peasants and merchants, but also due the lack of understanding of local norms. The most challenging factor of all was that the cotton experiment programs paid too little concern to the problems faced by Indian local farmers in terms of cultivating and marketing cotton. At the end of the cotton experiment program, the colonial botanists admitted that the foreign variety was not suitable for growing in India, acknowledging that native cotton varieties were more closely intertwined with every aspect of Indian society and environment (Leacock and Mandelbaum 1955; Hazareesingh 2012). Most of indigenous cotton cultivators had suffered from severe economic losses, high taxation and food shortages as an effect of the cotton program. Furthermore, regional ecological system risked losing its resilience through political and economic changes. For example, the massive irrigation constructions had increased deforestation, climatic vulnerability and biodiversity degradation at the local level as following repercussions (see Chapter 4.2.3 and 5.3). Consequently, the socioeconomic and institutional changes made local communities and households more vulnerable and less able to cope with scarcity. In this context, I argue that the cotton quality improvement program, which was lacking in basic social, economic and political consensus, inevitably stirred both difficulties and resistances among the Indian local communities. In addition, the cotton improvement programme though relatively short lasting as a project had long lasting effects as it set environment and society on a trajectory from which it could be hardly recovered.

The broader dynamics of colonial imperative to appropriate and exploit local knowledge and environments can be associated with colonial definition of 'improvement', which in effect meant transforming the Indian agricultural landscape into 'a raw material supply landscape'. As I have discussed in Chapter 4.2, the colonial strategies into commodity flows from the manufactured goods to raw material involved the structural asymmetries in cotton trade, in terms of requiring more embodied land and labour in cultivating raw cotton on the coast of local livelihoods and resilience. Furthermore, a wide range of the colonial projects and associated extensive public works programs aggravated environmental problems such as deforestation, soil erosion, water pollution, loss of biodiversity and climate changes.

However, regardless of all the efforts, the expected results in the state-directed program did not come about. The Indian cotton textile industry has been shaped by complex social and cultural relations of many actors and agents involving myriad of interaction, communication, coordination, distribution and persistence. In this regard, I argue that the colonial failure of creating productive agricultural landscape resided in the insufficient knowledge about social, economic and cultural background of rural community and its ecological conditions. In the same manner, established social and cultural patterns of local Indian life and the activities of the social classes embedded in agriculture were greatly overlooked by the colonial government. Such a lack of understanding of socio-political-ecological dynamics of agricultural landscape, the colonial experiment programme had little chance of success in cotton cultivation in India.

Applying the concept of ecologically unequal exchange to the case study of cotton experiment program, British colonial system exploited not only the local labour and social systems but also the local environments by enforcing excessive cotton farming practices and limiting local industrialisation. Ultimately, those exploitations can be estimated as costs that were paid by Gujarat communities to support the gains of the developing textile industry in Britain. As argued here, these local costs have long lasting effects on the landscape of the Gujarat region and also broke apart local systems of manufacturing and marketing cotton. In addition, the cotton development programme relegated of the Indian cotton production system to a mere source of raw material for the sake of the industrialisation of Britain as well as colonial interests that had both from an economic, social and ecological far reaching and long-lasting consequences.

6. GM cotton controversy: triumph of science or seed of death?

The 19th century introduction of new foreign cotton varieties through the Cotton Improvement Programme discussed in previous chapter provide an interesting parallel to ongoing debates on Genetically Modified (GM) cotton today. The recent years have seen a dramatic improvement in biotechnology, particularly in genetic engineering technology, stirring global debates on environmental and health risks, but also possible adverse impacts on farmers' livelihoods connected with GM cotton (as summarised in Chapter 3). The Cotton Improvement Programme introduced new seeds from Americas and there was a significant degree of genetic manipulation through hybrids. Today, genetic manipulation is facilitated by biotechnology that allows for genetic manipulation and hybrid experimentation on an even greater scale. Meanwhile the driving main actors in the Cotton Improvement Programme and the GM cotton cultivation have shifted, while in the former case the British colonial authorities were the main actor propelling change, now the Indian state authorities and GM companies are the main actors. In this regard, I consider that the changed relationship between main driving actors and local farmer is still one defined by 'core' and 'periphery' relationship in terms of economic and political power, albeit the relationship has changed character significantly, as will be discussed in this chapter. Cultivation of GM cotton has been introduced in India on a massive scale since it received the approval of the government in 2002. Government and civil society groups have made conflicting claims about its success, as briefly discussed in Chapter 3. In order to identify possible risks and benefits faced by local cotton farmers, I here examine the development and cultivation of GM cotton in Gujarat region from social, political, economic and ecological aspects following a similar structure as the previous chapter. Thus, here I review linked changes in the agricultural landscape changes and possible environmental impacts since the adoption of GM cotton. I also analyse the environmental risks and benefits faced by Gujarat cotton farmers by comparing the changes in the cotton yield and production, the use of agricultural chemicals (insecticides and fertilizer) looking at financial investment and social costs.

6.1. Dynamics of cotton seed provision

Following a long history of cotton varieties and cultivation, as reviewed in Chapter 3 and 4, hybrid cotton was firstly introduced in Gujarat in 1970 with the launch of Green Revolution[13] (Gandhi and Jain 2016b: 31). The hybrid varieties originated from the American cotton family (hirsutums) and made native cotton (arboreum and herbaceum) varieties obsolete (Shah 2008). With the expectation of its higher yield and commercial potential, hybrid cottons were extensively cultivated in Gujarat. However, cotton hybrids soon turned out to be prone to insect plague, which caused severe crop failures, reduction in yields and price fluctuations from 1993 to 1994 onwards (Gandhi and Jain 2016b: 31). Over 150 different species of pests attacked cotton at various stages of its growth leading deterioration in fibre quality. These unexpected

[13] The Green Revolution refers to a period when India made significant improvements in agricultural production by adopting modern methods and technology such as high yielding variety seeds (hybrid seeds), advanced farming machines, expansion of rural infrastructures (Shah 2008).

results led farmers to use excessive amounts of agricultural chemicals resulting in a higher cost of cultivation than anticipated. As a result, Indian cotton farming industry was faced with serious problems locally in terms of financial and ecological impacts on farmers and environments. Globally Indian cotton industry was also affected by low prices and decreased demand.

In the meantime, genetically engineered cotton varieties meant to be resistant to diseases and pests emerged in the world agricultural sectors in 1996. The story of India's seed provision began with the New National Agricultural Policy on Seed Development which was developed in 1998, for the purpose of promoting the growth of private seed companies (Egorova *et al*. 2015: 107-110). In the process of encouraging India's seed sector to be more market responsive and commercial, new rules of cotton cultivation were introduced in 1989. The new rules were launched under the Environmental Protection Act[14] (1986) and contributed to establish the Genetic Engineering Approval Committee (GEAC) – an inter-ministerial body of the Ministry of Environment and Forests. The committee played a pivotal role in the approval of GM crops and in conducting experimental large-scale field trials for granting the rights to the commercialisation of GM crops (Ahuja and Jotwani 2010; Egorova *et al*. 2015: 107-110). Due to the efforts of the government of India to promote seed sales and marketing, India achieved the increased seed importation and sales of commercial seeds as well as substantial investment by private (domestic and multinational) companies in the Indian seed sectors (Egorova *et al*. 2015: 107-108). In this context, India's seed industry emerged as a crucial international actor in the world seed industry from the end of the 1990s. At the same time, from the early 1990s, there had been increasing political concerns over the Trade Related Intellectual Properties (TRIPs) agreement and the application of intellectual property right in biological materials (e.g., genes, species and genetic modification) (Seshia 2002; Scoones 2006). The seed industry primarily focused on the sale, promotion and distribution of high-value hybrid crops such as cereals, vegetables and, important for this discussion, cotton. The hybrid cotton seeds discussed above was already widely cultivated on a massive scale and covered about 95% of total cotton acreage in India by 2014. In addition, a dramatic increase in cultivation has taken place since the GEAC approved the transgenic cotton seeds, particularly the Bt cotton varieties – Mech 12, Mech 162 and Mech 184. From April 2002, the Government of India and GEAC permitted the commercial cultivation of Bt cotton varieties in six states: Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu for a 3-year period (Qaim *et al*. 2006; Sangar *et al*. 2012; Gandhi and Jain 2016a; Saravanan 2016).

Since 2002, there has been a wide adoption of Bt cotton in India, and potential agro-economic benefits have been reported in many papers (some recent examples include: Choudhary and Gaur 2010; Egorova *et al*. 2015; Mal *et al*. 2015; Saravanan 2016; Veettil *et al*. 2017). India has more hectares of cotton than any other cotton growing nation, nevertheless total yields are comparatively low in global terms (USDA Foreign Agricultural Service 2016). Furthermore, indiscriminate use of pesticide in cotton fields associated with hybrid cotton has been reported to affect the health of farmers, soil, water and biodiversity on a large scale (Herring 2007; Kumar et at. 2008). In this regard, the advocates for Bt cotton claim that it has resulted in higher yields per hectare, better quality of cotton fibre, less use of chemicals and increased income as well as general environmental and health improvement in rural areas. Particularly, the significant decrease in the volume (quantity) of insecticides has led to considerable reduction in pesticide residues in soils and aquifers, which in turn would induce less chemical exposure to humans, animals and the ecosystem (Saravanan 2016; Brookes and Barfoot 2006). Furthermore,

[14] The Ministry of Environment and Forest, Government of India informed the regulations and procedures for the importation, manufacture, usage, research and distribution of Genetically Modified Organisms (GMOs) as well as products made by using GMOs on 5th of December, 1989 on the basis of the Environmental Protection Act 1986 (Ahuja and Jotwani 2010). A copy of the regulations can be found at http://envfor.nic.in.

increased in yields and much reduced costs of production have brought farmers' net income growths, despite higher prices for Bt cotton seeds (Kathage and Qaim 2012). In this regard, Bt cotton growers believe that transgenic technology will not only alleviate some of these constraints on production and externalities, but also improve quality of life of farmers by reducing cost and time inputs on insecticides, sprayers and labour charges from the perspective of sustainable livelihoods (Pray *et al*. 2002; Viswanathan and Lalita 2010; Veettil *et al*. 2017).

Nevertheless, there are increasing criticisms and fears that have been raised against Bt cotton. Criticism comes from the concerns for possible environmental impacts of transgenic cotton (see table 5). Another criticism is the cynical linkages between Bt cotton and local farmers' suicides that have also received media attention internationally (see discussion in Chapter 3.4.). In regard to the seed monopolisation and patent control, Thomas and Tavernier (2017) have argued that there is a definite link between economic and political factors associated with Bt cotton farming and local farmers' suicides. GM cotton advocates and some scholars have countered this connection with farmers suicides arguing that there is no direct linkage between Bt cotton cultivation and farmers' suicides. Rather, farmers' suicides are more likely derived from a failure economic system not being able to provide reliable credits for farmers. In addition, advocates for Bt cotton list the problem of access to irrigation equipment and water resource, seasonal droughts and any types of condition that would make it more difficult for farmers to grow their cotton as reasons for farmers suicides (Bennett *et al*. 2004, 2005; Ramasundaram *et al*. 2008; Gruère and Sengupta 2011; Veettil *et al*. 2017, along with other reasons listed in Chapter 3.4). However, many researchers still maintain that the marginalisation of Indian cotton farmer has been intensified by the GM cotton seed provision, which in turn weakens the farmers' rights and control over seed management practices. Furthermore, in terms of the seed characteristic, farmers have to buy new seed stocks every year as GM seed lose its vigour after one generation. Roy (2015) has argued that this what she calls 'termination technology', may result in an endless cycle of market dependency.

The tensions and dilemmas embedded in the cultivation of Bt cotton involve both state governments, academics, environmental activists, smallholder farmers, other local stakeholders and pastoral communities. Apart from the possible environmental impacts of Bt cotton, the voices against the transgenic cotton varieties argue that the purpose of transgenic-technology is to strengthen the application of intellectual property laws on seeds at a global level, which may cause the loss of the common heritage of farming households in terms of seed preservation and local knowledge of seed production, referring as a 'freedom struggle' (Shiva 2000; Herring 2007; Gupta 2013). In other words, farmers' potential contribution in terms of agricultural innovation and local practices of saving cotton seed varieties and related local activities regarding cotton cultivation and innovation can be diminished under the new seed provision. Furthermore, Shiva (2014) has heavily criticised the policies of government agencies and scientists as coercive, generally disregarding local democratic decision-making processes[15]. In general, researchers have also criticised the disinterest in and exclusion of more eco-friendly cotton alternatives from the side of the Indian authorities and seed companies (Egorova *et al*. 2015).

However, following the arguments of either sides in this debate is complex and I have therefore summarised the conflicting claims about GM cotton cultivation in Table 6 below in order to offer a clear presentation of the main arguments. The potential environmental impacts of GM cotton will be examined more in detail in Chapter 6.3.

[15] Shiva (2014) has warned that scientific research is neglecting the long-term consequences of GM cotton, particularly potential impacts on society and the environment.

Table 6. The Conflicting claims on Bt cotton

GM cotton advocates	GM cotton opponents
- Biotechnology as a new sunrise industry with enormous potentials - Enhancing agricultural production and productivity - Net income and trade gains - Achieving a better pest control - A better quality of cotton fibre - Sustainable benefits of Bt cotton in economic and social development in India - Modernisation of agriculture and advancing agricultural knowledge	- Contamination of wild relatives of cultivated species and organic cotton - Bt-toxin impact on soil microbial functioning -Restriction in choice and in farmers' control over seeds - Increasing input prices – seeds, chemicals, fertilizer and facilities (no significant reduction in chemical use) - Monopolisation of seeds by multinational agribusiness corporations - The unequal appropriation of benefits by the global seed and chemical industry - The emergence of pesticide resistance weeds and insects - The destruction of the biodiversity and local knowledge based on marginal and smallholder farmers

Sources: Shiva and Crompton 1998; Shah 2005; Scoones 2006: 10; Choudhary and Gaur 2010; Gruère and Sengupta 2011; Tarafdar *et al*. 2011; Gupta 2013; Shiva 2014; Mal *et al*. 2015; Roy 2015; Gandhi and Jain 2016a, 2016b; Saravanan 2016.

In this section, I have provided a brief history of the introduction of transgenic cotton variety in India and the controversial aspects in its success. Yet, I have not addressed the relationship between local farmers and GM cotton cultivation on a local scale. Thus, in the following section I focus on examining the socioeconomic and ecological challenges and opportunities faced by Indian cotton farmers as well as the changes in farmers' perception and attitude towards the GM cotton.

6.2. Adoption and Farmers participation in GM cotton

The debates on the social, economic and ecological appropriateness of GM cotton has emerged at a critical phase when over thousands of Indian farmers have already adopted and actively cultivate patented Bt cotton seeds. Since the commercialisation of the GM cotton in 2002, Bt cotton has been widely adopted among local famers, and now covers approximately 92 percent of total cotton area and over 95 percent of India's total cotton production (USDA Foreign Agricultural Service 2016). Among the cotton growing states in India, Gujarat shared 31.54 percent of total cotton production in the year 2014-15, and the area of Bt cotton in Gujarat is estimated to be 2.7 million hectares (Satashia *et al*. 2017). Generally, when making planting decisions, farmers consider several factors, such as seed price, production costs (fertilizers and insecticides), water availability, central or state governmental supports and monsoon season that affect the profitability of agriculture (USDA Foreign Agricultural Service 2016). Due to the potential advantages of Bt cotton when it comes to pest control and therefore, reduced cost of cultivation, in combination with potential higher yields, farmers have shown strong interests in Bt cotton farming. But despite of the rapid local diffusion and preference on Bt cotton among farmers, the switch from native or hybrid cotton to Bt cotton has not been considered as a uniform success.

Cotton cultivation requires a wide range of resource from nature as discussed in Chapter 3; but hybrid and Bt cotton varieties also require large volumes of fertilizer and pesticides as well as increased capital, labour and energy inputs to meet the cost of seed prices (Parmar and Visvanathan 2003; Bennett *et al*. 2004; Gandhi and Jain 2016a). In other words, proper and sufficient

agricultural inputs must be balanced against the economic gains received from higher yields and better quality of cotton fibre (either Bt cotton or non-Bt cotton). In terms of utilisation of land, water, capital and labour, the resource and capital-rich farmers are highly advantageous compared to subsistence and small-holder farmers (e.g., those who own less than 2 hectares of cotton) (USDA Foreign Agricultural Service 2016). In India, small-scale farmers account for the majority of farming households. Small scale farmers face the critical challenges from a lack of financial resources, insufficient agricultural infrastructures and market uncertainty (Schurman 2013; Shivamurthy *et al*. 2015). Consequently, when purchasing seeds, fertilizers, and other crop-related items, poor farmers often turn to private money lenders. These private moneylenders charge high loan rates, which in turn add further economic burdens on farmers (Gupta 2013). According to OECD Better Policies Report (2012), many of the local farmers remain excluded from the Bt cotton industry, due to inefficiencies in the formal finance institutions, the weak regulatory framework, high transaction costs, and risks associated with cotton agriculture. Furthermore, knowing that Bt cotton was originally designed to mitigate pest insect but not to specifically endure water stresses, Bt cotton might be more suitable for assured irrigated areas than rainfed areas (Gandhi and Jain 2016c: 172). As a result, unequal distribution of resources, income and power risks being intensified as transgenic cotton can only be bought by, or its advantages only fully adopted by resource-rich farmers. Meanwhile small-scale farmers are unable to compete for lack of capital, infrastructures and networks. The required capital investments and material inputs associated with Bt cotton can further marginalise smallholder farmers (Shiva and Jafri 2003; Shiva 2004; Egorova *et al*. 2015). The potential effect of this imbalance is that small-scale farmers will be completely outcompeted by the resource-rich farmers.

As I have already discussed in the chapter 3.4 and 6.1, the participation in GM cotton and non-GM cotton farming results in different interactions with technology, governments, farmers, corporations, non-governmental organisations (NGOs) and advocacy groups. In the specific context of socioeconomic relationship between Bt cotton and local farmers, it is important to investigate how global technology and knowledge have been appropriated, modified and exchanged at local level. Local adaptation of biotechnology can be presented in various forms. However, I consider farmers' active engagement in the multiplication and distribution of unauthorised hybrid Bt seeds can be seen as one way of appropriating and also resisting global seed technology. The unapproved hybrid Bt varieties[16] first appeared and was sold in the Gujarat region as early as 2001. Today Bt cotton still maintaining high market share in local seed markets (Lalita *et al*. 2009: 135-136 and see Figure 4). According to Shah (2008), a majority of Gujarati farmers are multiplying, self-pollinating, and crossing Bt seeds with local hybrid varieties in an independent way. In this regard, Anil Gupta has informally named the local farmers' seed experiment with Bt cotton "the greatest participatory plant breeding experiment in human history" (Herring 2006: 6). As noted earlier, the reason for the rapid adoption of illegal over legal transgenic cotton is primarily the higher price of official Bt cotton seeds and the potential risks of the authorised Bt cotton varieties (Herring 2007; Lalitha *et al*. 2009). Apart from such agro-economic considerations, Indian farmers have had a wish to continue traditions of seed saving, seed exchange and seed multiplication, and thereby through traditional networks they have created a decentralised cotton seed supply chain by hybridizing the

[16] The unauthorised of genetically modified technology gave a birth to Gujarat's own hybrid Bt cotton seed known as Dr D.B. Desai conducted by the executive director of Navbharat Seeds Company and local farmers. The Navbharat seeds company first produced N-151 seeds (hybrid Bt cotton varieties) by crossing an official Bt male line with the GujCot 8 (local hybrid seed) female line (Shah 2008: 437). Tracing the cross-pollination method is not important for this chapter. Instead, I will more focus on addressing how Indian farmers have interpreted and dealt with global biotechnology.

transgenic with a local variety (Herring 2007; Roy *et al*. 2007; Figure 4). Although there are growing concerns about biosafety and regulation issues related to the unauthorised Bt cotton hybrid seeds (see similar discussion in Ramaswami *et al*. 2011), the hybridisation of Bt cotton varieties by local agents can be understood as a user-innovative and rebellious local control of the centralised global technology and knowledge system.

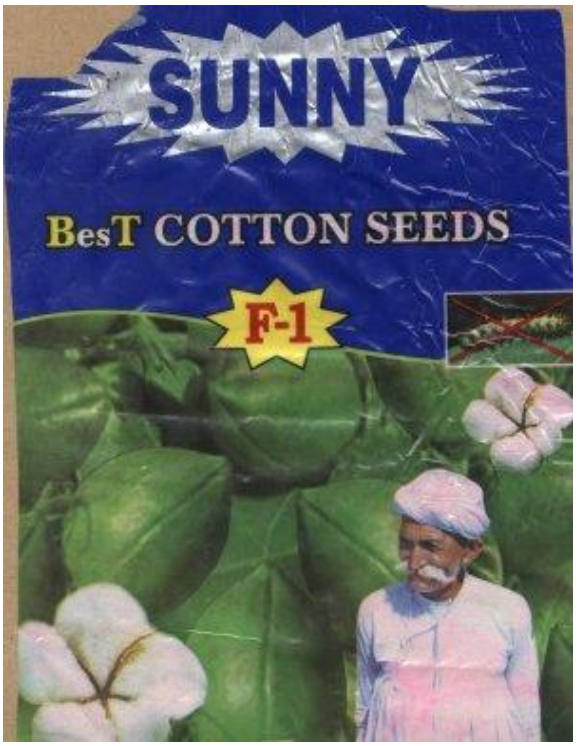

Figure 4. Unauthorised Bt cotton seed package.

Reprinted from *Chor Bt aur Bt chor*, In India Together, by P. Sainath, Retrieved April 24, 2018, from http://www.indiatogether.org/seeds-op-ed. This image was first published in India Together (www.indiatogether.org) and is republished here with permission.
* Note: locally produced 'Illegal' or 'Unauthorised' Bt cotton seed package with no manufacturer's name or address on it.

In addition to farmers appropriation of and innovation around hybrid Bt cotton planting, there are also a growing movement of farmers' resistance and protests against the genetically engineered cotton seeds and companies providing them. In general, the transgenic technology is regarded as one of most prominent industries based mainly in global 'core' nations[17] to refer to the core-periphery concept explained in Chapter 2 (e.g., Wallerstein 2004; but see also implicit references in Roy 2015). Since the arrival of global agribusiness in Indian seed market, the aggressive market dominance of multinational global seed companies has emerged as an overall threat to local knowledge of seed management, innovation, marketing, ownership as well as a threat to the heritage of related agricultural practices and agrobiodiversity (Herring 2005; Gupta 2013; Roy 2015). Such concerns have led to vigorous anti-GM movements among Indian farmers, partly with nationalistic and anti-imperialistic themes, and further fuelled by Vandana Shiva's organization, Research Foundation for Science, Technology, and Ecology (RFSTE), in additions to the organisation Gene Campaign, and other NGOs and civil society groups (Roy 2015; Figure 5). The GM-cotton protests are expressed through not only interna-

[17] The global seed corporations such as BASF, Bayer, Dow Agrosciences, DuPont, Monsanto, and Syngenta.

tional demonstration, but also sharing information on seed varieties, storing capacity, germination, crop yields and disease resistance to enhance local knowledge of traditional seed production. From the perspective of farmer's right to seeds and landscape, I stress that the farmers' resistances against Bt cotton should be understood, to some extent, as a restoration of farmers' choice of cotton seed, and agricultural strategies, but also as local struggles for the power to shape the Indian agricultural landscape (see Figure 5). This movement and local resistance can be related to the farmers' resistance discussed in Chapter 5 in the way that local communities and cotton farming resisted subordination and imposed policies by the colonial officials. In this regard, I argue that both past and current farmers' actions should be understood as active and dynamic forces that have resisted the inequality of power relations.

Figure 5. Indian cotton farmers' protest against Bt cotton

Reprinted from *How Monsanto wrote and broke laws to enter India*, In Seed Freedom, by Vandana Shive, Retrieved April 24, 2018, from https://seedfreedom.info/how-monsanto-wrote-and-broke-laws-to-enter-india/. Copyright ©SEEDFREEDOM 2014-2018. Reprinted with permission.

6.3. Environmental Impacts of GM cotton varieties

The potential impacts of GM cotton on the environment have been a centre of general interest, particularly in the context of the Convention on Biological Diversity (CBD) and the Global Environment Facility[18] (Carpenter 2011). Agricultural biodiversity in the CBD is defined at the genetic, species and ecosystem levels that constitute or contribute to agricultural production as well as its structures and processes (CBD 2002). In other words, agricultural biodiversity is the outcome of the dynamic interactions occurred among genetic resources, the environment and various human activities within agricultural landscapes. As I have discussed in the previous sections, GM cotton varieties have been developed and evolved in response to the diversity of interests and changing ecological conditions. In this regard, I consider possible environmental impacts of GM cotton should be addressed not only from a socioeconomic and cultural perspective but also from biological standpoints, in particular relating to pest and disease control, hydrological cycle management, pollination, soil quality and possible health impacts. Thus, below I examine the changes particularly in water resource management, agrochemical application (pesticides and fertilizer), carbon emissions, land use since the commercialisation of Bt cotton in Gujarat. In addition, potential biosafety concerns are also discussed.

Historically, irrigation system has been one of the most crucial factors for agricultural productivity as discussed in Chapter 4.2.3. In Gujarat, wells and tube wells are the major irrigation sources accounting for 82.5 % of the total net irrigation systems (Gandhi and Jain 2016c: 133). Water availability in Gujarat compared to overall national level is low due to geographic and climatic conditions (Saha 2000). Under these circumstances, extensive irrigation development may lead to falling water tables and an overall depletion of freshwater resources. At the same time, the changes in water tables along the irrigation channels can cause soil waterlogging and salinization which affects crop growth and yield in low-lying rainfed areas (Soth *et al*. 1999). Notwithstanding such concerns, the yield of both Bt and non-Bt irrigated cotton is higher than that of unirrigated cotton throughout the districts of the Gujarat state (Qaim *et al*. 2006; Lalitha *et al*. 2009; Gandhi and Jain 2016c: 145). In other words, higher yield of irrigated cotton shows a strong association between increasing number of farmers adopting irrigation systems and cotton production as shown in Table 7. In addition, Bt cotton varieties, particularly germplasm of Mech 12, Mech 162 and Mech 184, have over time shown to be unsuitable for drought situations (Gandhi and Jain 2016c: 172). Bt cotton cultivation may be ideal for assured irrigation conditions, which in turn, could further facilitate irrigation agricultural development which potentially further widens the gap between large (viable) and smallholder (vulnerable) farmers as discussed in Chapter 6.2.

Table 7. Cotton production and numbers of farmers adopting irrigation system in Gujarat (2006-07 to 2013-14)

Year	Cotton production [(a)] (million bales)	Number of farmers adopting Irrigation [(b)] (in '000)		
	Gujarat	North Gujarat	Middle Gujarat	South Gujarat
2006-07	10.5	2.43	1.05	1.69
2007-08	11	6.6	1.62	2.11

[18] Global Environment Facility (GEF) was established in 1991 to provide new funding and additional grants in order to achieve global environmental benefits in primarily four and later six key categories: biological diversity, climate change, global water management, land degradation, ozone layer depletion and persistent organic pollutants (IEG World Bank Group http://ieg.worldbankgroup.org/evaluations/gef).

2008-09	90	6.35	2.15	2.13
2009-10	98	13.89	3.32	1.81
2010-11	106	21.46	7.83	10.62
2011-12	120	25.9	15.58	7.29
2012-13	89.8	44.22	17.08	10.94
2013-14	112.8	47.65	13.39	8
Total	638.1	168.51	62.02	44.6

(a): Relevant information is adapted from "History of Cotton in Gujarat" by Solanki, B.G., 24th of November, 2015, Weekly Publication of Cotton Association of India: Cotton Statistics and News (no. 34), p. 6.
(b): Relevant information is adapted from Bahinipati, C.S., Viswanathan, P.K. 2017. '*Adoption and Diffusion of Micro-irrigation in Gujarat, Western India: Do Institutions and Policies Matter?*' in Global Change, Ecosystems and Sustainability, eds. P. Mukhopadhyay, N. Nawn and K. Das, 2017, New Delhi: SAGE.

In order to achieve a successful cotton production, apart from the irrigation systems, it is crucial to control various insect pest attacks during the formation of cotton fruits as discussed in Chapter 3.3. With the growing concerns about indiscriminate use of pesticides, Integrated Pest Management (IPM), Insecticide Resistance Management (IRM) and Transgenic Technology (use of genetic resistance to pest) have been developed to maintain pest insects at tolerable level with less chemical inputs (Kumar *et al*. 2008). Among the pest management strategies introduced above, transgenic technology has been regarded as the most effective strategy for protecting cotton from its main predator, the pink bollworm (Kumar *et al*. 2008; Saravanan 2016). The basic mechanism of Bt cotton technology is an inserted gene that produces 'Cry', an insecticide protein extracted from *Bacillus Thuringiensis*. The insecticide protein acts as a 'biological control agent' against agriculturally harmful pests but benign to non-targeted organisms (Sansone 2002; Kumar *et al*. 2008). Judging from the changes in pesticide use during 1989 to 2015 presented in Table 8 below, there were significant declines in the use of pesticides both in Gujarat and India between 1995-96 and 2005-06. Judging from these numbers and knowing that the commercialisation of Bt cotton began from 2002, Bt cotton varieties have been able to substantially reduce the amount of pesticides cotton while at the same time offering better control over bollworm pests (Pray *et al*. 2002).

Table 8. Pesticide use and consumption in Gujarat and India

Year	Gujarat	India
1989-1990	5,500	71,894
1990-1991	4,100	75,033
1995-1996	4,560	61,260
2005-2006	2,700	39,773
2007-2008	2,660	43,630.3
2008-2009	2,650	43,860
2009-2010	2,750	41822
2010-2011	2,600	55540
2011-2012	2,190	52979
2012-2013	1,210	45619
2013-2014	2,330	60282
2014-2015	1,840	57353

Source: Ministry of Statistics and Programme Implementation, Government of India (www.indiastat.com)
* Unit: M.T. (Tech. Grade)

As already discussed in Chapter 3, cotton is one of the most chemical-intensive and water-thirsty crops. Emissions from insecticide spraying and fertilizers are the major determinants in overall greenhouse gas emissions related to cotton production. Therefore, integrated agrochemical management is the key in reducing greenhouse gas emission (WWF 2013). In this regard, transgenic cotton varieties have made a considerable contribution to facilitating a reduction in greenhouse gas emissions through less-frequent insecticide spraying and an increasing efficiency in the material inputs (see more discussion in Brooks and Barfoot 2017).

Nevertheless, there are warning voices about potential biosafety impacts of Bt cotton and its application on farm-scale diversity as summarised in Chapter 6.1. Firstly, the issue of resistance development has given rise to the concerns over the continued excessive use of agrochemicals and decreasing productivity due to nullified effectiveness of Bt cotton (Kumar *et al*. 2008). In other words, despite reduced insecticide use on Bt-cotton, re-emerging pink bollworm and survival and multiplication of the minor pest may, gradually increase the use of insecticide on cotton fields. Secondly, the cross-pollination of non-Bt cotton varieties with Bt cotton results in non-Bt plants with seeds that contain Bt transgenes. From the perspective of seed preservation and marketing, this cross-pollination risks not only contaminating the conventional cotton gene flow, but also labelling conventional or organic cotton products (Bennett *et al*. 2005; Ahuja and Jotwani 2010; Rieple and Singh 2010). According to National Organic Program (NOP)[19], the application of any synthetic fertilizers and pesticides, and the use of any transgenic cotton varieties are not allowed in any type of organic agriculture. As one of the key factors related to the organic labelling standards is a concern for sustainable and ethical practices, it is important to comply with regulatory standards regarding organic labelling schemes. However, organic farmers often fail to pass ELISA GMO-test[20] due to unexpected cross-pollinations or difficult to find cottonseeds that are guaranteed GMO-free (Bennett *et al*. 2005; Eyhorn *et al*. 2005).

Another concern of Bt cotton is that the insecticidal Cry proteins (referred as Bt toxin) may have possible health impacts on livestock (see discussion in Ramdas 2010) and may also potentially change the soil microbial dynamics (Vadakattu and Watson 2004; Sharma and Bambawale 2008; Carpenter 2011; Tarafdar *et al*. 2011). Having considered the effect of Bt toxin released from Bt cotton plants on cotton soils and surrounding ecosystem functions, significant differences have been observed in the composition of soil biota as regards the crop residues of the Bt cotton and non-Bt cotton varieties (Vadakattu and Watson 2004; Tarafdar *et al*. 2011). The analysis has revealed that in Bt cotton fields, though varying depending on soil type, season and management practices, there was a sizable decline in total microbial population, enzyme activities and biomass which all are minor but crucial components of nutrient cycling in soil ecosystem (Vadakattu and Watson 2004; Tarafdar *et al*. 2011).

The most direct impact of agriculture on biodiversity is attributed to the conversion of natural ecosystems into arable land (Bawa *et al*. 2007; Carpenter 2011). Loss of agrobiodiversity and decreased resilience due to further expansion of farming land upon communal land and forests can be possible long-lasting effects of agricultural expansion resulting in overall landscape

[19] The National Organic Program (NOP) is a regulatory program based on the USDA Agricultural Marketing Service. NOP has responsible for developing national standards for organically-produced agricultural products. The organic standards assure both producers and consumers that products with the USDA organic labels meet consistent and uniform standards (https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program).

[20] Enzyme-linked Immunosorbent Assay (ELISA) is antibody-based GMO detection method for measuring GMO protein in unprocessed material such as seed, grain or leaves. This method has high sensibility to detect GM protein but may not suitable for processed products (http://www.gmotesting.com/Testing-Options).

degradation. Agricultural land use in Gujarat has kept increasing with the growth of input size and the wide adoption of Bt cotton varieties (USDA Foreign Agricultural Service 2016). Particularly, local participations in Bt cotton have increased rapidly, due to the expectance of higher yields and better economic outcomes (Pray *et al*. 2002; Viswanathan and Lalita 2010; Lalita *et al*. 2009; Veettil *et al*. 2017). In this regard, I consider the expected increased productivity and yields associated with Bt cotton has led to large expansion in crop acreage inducing farmers to plant more Bt cotton at the expenses of other farming activities. Expanding farmlands have also increasingly invaded natural and/or communal areas. Bt cotton is normally grown as a monoculture with irrigation systems, whereas indigenous cotton is usually cultivated through a combination of intercropping or mixed-cropping under rain-fed condition. The loss of mixed cropping systems may lead to considerable loss of agrobiodiversity but also of the traditional systems of experimenting with local cotton varieties as has already discussed above. The large-scale monocropping of drought sensitive crops at a cost of resilient varieties and land conversion (i.e., farming on marginal lands that were previously uncultivated), therefore, may cause irreversible and long-term damages to both smallholder farmers and the local agricultural landscape.

6.4. Discussion

In many circumstances, the changes in the ecology of production can improve the agricultural efficiency and productivity to a significant level. The introduction of GM cotton elucidates the role of different actors and agents involved in agricultural biotechnology and the dynamic interplay between public policy, science technology, agriculture, the environment and local farmers as discussed throughout this chapter. Yet in a sense, these changes may create potential risks for cotton cultivators considering that the effects of Bt cotton remains a controversy: with voices ranging from claiming great success in increasing yields and quality of cotton to a devastating failure in implementation for smallholder farmers (Fayet and Vermeulen 2012). Risks involved in cotton cultivation (e.g., local knowledge of agricultural biodiversity, land use changes, seed provision, participatory processes and political decisions) are substantial, thus there is great need of social, political and material resources to be mitigated (Shah 2006). In this specific context, I argue that local farmers' adoption and participation in Bt cotton cultivation put great emphasis on socioenvironmental relations that should be taken into account. Thus, as learnt from the previous example of the state directed cotton improvement programme discussed in Chapter 5, new cotton varieties and related policies to promote them may risk resulting in the extinction of local knowledge, experiences, ecological capacity for resilience, but also in stimulating inequalities in power relations both locally and between the local, the state and various global actors.

Traditional agricultural knowledge is key in sustaining both biodiversity and farmers' right to their land (Gupta 2013; Roy 2015). Today, many of local farmers are required to both preserve the environment where they live and contribute to meet the world demand for raw material (see discussion in CBD 2002). However, farmers often face challenges in managing all factors related to agricultural policies, incentives, markets and technological solutions. Concerning the opportunities, challenges and social negotiations faced by local farmers in the process of developing agricultural landscape, the traditional agricultural knowledge underlies the importance of scrutinising inequality of power, wealth and knowledge. The absence of proper irrigation systems in drought-prone areas, combined with costly agricultural inputs and ignorance of local socioeconomic structures, plays a role in the overall tragedy of marginalised farmers and in some of the suicide cases (Gruère *et al*. 2008; Gruère and Sengupta 2011). At

this stage, with quantitative and qualitative evidences, I argue that unequal distribution of resources and asymmetric power relationship may have contributed to distress among local farmers and ultimately to farmers' suicides, which, in turn, is an extreme case exemplifying how the survival of smallholder farmers can be threatened by the global seed corporations who pursue maximising profit through a system of economic dependency and exploitation.

Nevertheless, the local smallholder farmers who tend to have low availability and high vulnerability have generated authentic anti-imperialist and anti-corporate rebellions by resisting the monopolies of leading global firms based in core states. As discussed in this chapter, Gujarat cotton farmers have in effect naturalised Bt cotton varieties by hybridising Bt cotton with native cotton varieties or slotting them into habituated agricultural practices (Roy *et al*. 2007). Furthermore, some local farmers have begun to plant non-Bt cotton varieties again (both native and hybrid) and to participate in sustainable organic cotton cultivation mainly supported by NGOs (Fayet and Vermeulen 2012). Particularly, Fairtrade standards and Shop for Change focus on social and economic factors, Organic Standard emphasises on the environmental sustainability and Better Cotton Initiative aims for enhancing productivity and traceability of supply chain (Fayet and Vermeulen 2012). Although each of the different organisations has their own primary objectives, they share cognate goals for the long-term development concerning social, economic and environmental aspects of cotton production and its supply chain.

Seeing this from the perspective of Indian smallholder farmers, such sustainable practices can further improve their understanding of different initiatives, stakeholders, negotiations and environmental standards helping to overcome the risks they face. In this regard, I argue that neither cotton nor local farmers are subordinate to be supervised and managed by dominant powers. Rather, they were active and dynamic forces that constantly resisted the expectations of the 'core states' in the world system. As equally significant as the discussion of the cotton improvement programme in Chapter 5, therefore, the introduction of Bt cotton also can be paralleled with the challenge in terms of introducing a specific cotton species without much considerations of a broader socioecological fabric in which local people have woven through dynamic networks, experiences and landscape. Thus, I argue that the cotton improvement programme makes an important comparison to the ongoing GM cotton seed provisioning since both the short- and long-term, social, economic and environmental effects can be assessed for the former.

7. Analysis and Discussion

As outlined in the introductory chapter, the landscape influences and is influenced by complex processes encompassing the flow of energy, materials, species and dynamic human activities. From the middle of 18th century to the present day, and as discussed in this thesis, India's agrarian transition can be divided into three phases: the deindustrialisation of textile manufacturing industry caused by British industrialisation and colonial policy in India, the colonial cotton experiment and current Bt cotton controversy. In this chapter, I highlight recursive themes and landscape changes in Gujarat's cotton industry since the 19th century. The overarching questions shaping the structure of this chapter is the dynamics of socioecological transformation embedded in the cotton production and agricultural development in India.

7.1. Learning from Past to Present

The local resistances are one of the most crucial indicators in the analysis of power and interplay between state, state actors and local power. An obvious example is the introduction of new cotton species to the cotton farms in Gujarat by the English colonial government and then by the global seed company, that stands as a seemingly acute contrast to the traditional agricultural knowledge and practices continued by Indian cotton farmers. In the both historical and current cases studied in this thesis, Gujarati cotton farmers were/are largely independent when deciding which varieties of seed to purchase and plant. In the first case study, local farmers were reluctant to cultivate the American cotton seeds for several reasons: not only was the colonial implementation of the "cotton experiment" little concerned with local farmers' interests and needs, but also local farmers felt that the American cotton seeds were genuinely foreign to the local environment. In terms of the features of cotton variety, native cotton varieties proved far more resistant to the vagaries of the local climate and insect pest attacks than the American cottons. Thus, as discussed in Chapter 5 although a few farmers were persuaded to plant new cotton varieties expecting higher quality and better yield, they soon returned to planting the indigenous cotton seeds that were more suitable to the local environment and economy. In the second case study, presented in Chapter 6, Bt cotton has been largely and rapidly adopted by most Gujarati cotton farmers at the onset of its commercialisation phase. A number of successful cases of Bt cotton cultivation have been reported, yet there are devastating socioenvironmental consequences for smallholder farmers and local ecosystem as discussed in Chapter 6. Knowing that both case studies did not bring uniform successes, I argue the challenges in historical and the current Bt cotton "experiment" are both influenced by a lack of understanding of the complex relationships among social dynamics, cotton and the environment.

A second recursive theme can be the sharing of experience and knowledge with other farmers and rural businesses, those who belonging to the same cooperative community. As discussed in Chapter 4 and 5, the production and trading system of the traditional Indian cotton industry were primarily based on the village level. In other words, the entire process of seed provision and marketing of the production was an integral part of the local society and livelihoods. However, with the colonial intervention in the local cotton production system, much of knowledge

sharing network and processes were considerably restricted and over time almost disintegrated (Parthasarathi 2009: 17-22). In the present, Indian farmers can obtain wide information about the qualities of different seed varieties and farming practices from neighbour farmers as well as from governmental agents, private company agents, demonstrations and NGOs, which all are regarded as key sources of information (Roy *et al*. 2007; Roy 2015). While modern farmers may have more 'choices' and 'options' in terms of seed varieties than colonial Indian farmers had, much of cotton production and seed distribution are now controlled by agrochemical corporations (Müller 2011: 295). Thus, similar to the core-periphery relationship that defined the colonial cotton experiment, Bt-cotton controlled mainly from multinational seed companies signifies another core-periphery relationship were local farmers risk being disempowered. In this regard, I have here focused on the power struggles, conflicts and strategic actions concerning the issue of seed sovereignty in relation to Bt cotton.

For most of farmers, particularly small and marginal farmers, seed saving is a key strategy to develop their own farming and livelihood systems, as well as for the farmers' right to seed. The farmer's right to seed stands for free access to seeds and the ability to produce, use, store, share, exchange and sell them, which all are crucial issues for smallholder farmers (Shiva 2004). For the local farmers, I consider the rights to maintain, control and develop their seeds and traditional agricultural knowledge can tune a balance of power between the local and the state actors. In the case of the cotton experiment program, the British colonial officials controlled the local peasant communities through land revenue systems and agricultural policies leading to the exploitation of agricultural sectors of Gujarat. In the course of conducting the cotton quality programme, major tensions between the colonial government and local farmers were often expressed in forms of disobedience to colonial authority keeping their traditional way of agricultural systems. Today through the corporatisation of agriculture, the application of property right to GM seeds has spurred unprecedented and multifaceted conflicts regarding the right of the global seed corporations to control the means of cotton production and related practices (Müller 2011; Roy 2015). The current Bt cotton controversy highlights conflicts between local farmers and agribusiness corporations, and between holders of patents and providers of germplasm (Müller 2011). In the context of core and periphery, the values and interests of core are stated as innovative, active and forward thinking, whereas 'peripheries' are often described as people who lack in resources, power, and easy to persuade (Shiva 2004; Chase-Dunn and Gills 2005; Roy *et al*. 2007; Müller 2011; Roy 2015). However as shown in the two case studies presented here the relationship is not always that simple, especially when it comes to the rising local resistances and participations in empowering peasant communities.

Perceiving potential risks of economic and ecological damage on a broader scale, some farmers have shifted to plant native cotton varieties or have naturalized transgenic cottons by hybridising them with local varieties and fitting them into traditional strategies of managing risks and livelihoods (Roy *et al*. 2007; Shah 2008 and see Chapter 6.2). In addition, Chetna Organic, an Indian farmer support organisation, enables farmers to set up sustainable and multipliable open-source seed provision systems, using traditional knowledge (Fayet and Vermeulen 2012). With the establishment of seedbanks, smallholder farmers are becoming part of a thriving community, conserving India's indigenous seed heritage and protecting its seed sovereignty. This show again that farmers are not simply passive recipients of the state-led initiatives rather actively resisting inequalities in power, economic and relationship of exploitation. Although the meanings and practices of the cotton production have significantly changed with the course of time, traditional agricultural knowledge and marketing of cotton are still deeply associated with the sociocultural aspects of Indian society and the network of interactions in local cotton industry and its supply chains. Therefore, continuing recursive motifs represented through the local

struggles and resistances reflect the meanings attached to the seed, traditional agricultural knowledge and the landscape. The reflection implies the competitiveness of local agents confronting the social, economic and political inequalities and ecological challenges derived from the core-periphery structure in the world system.

However, there is another aspect of inequality in regard to core-periphery in the current global cotton market system: Indian farmers often find themselves in a situation where they are competing with cotton farmers receiving protective tariffs and large amount of farm subsidies (Roy *et al*. 2007). Particularly, U.S. cotton farmers are heavily subsidised, and have been criticised for using the cotton subsidies to lower world cotton prices and thereby increasing their share on the world market (Gillson *et al*. 2004). For many of cotton growing countries in the world, keeping an optimal cotton price is crucial for farmers to improve production efficiency, and to hinder rapid urbanisation by maintaining population in rural areas and encourage local economic development (Gillson *et al*. 2004; Roy *et al*. 2007). Indian cotton farmers are facing pressures from not only the stressful agricultural environment, but also from external movements in prices and yields linked to cotton supply on the world market. Considering that a small decline in global cotton price can make a considerable difference in the quality of farmers' life and livelihood, the cotton subsidy policy favouring the 'core state' farmers may further increase vulnerability of small and marginal farmers. In this regard, one may ask important questions about what the alternative opportunities are for marginal cotton farmers who are unable to compete in the global market, and what kind of leverage the smallholder cotton producers might have in the global cotton trade negotiations and agreements. In this thesis, I have discussed socioecological inequalities, conflicts and power dynamics focusing on the two case studies in Gujarat, however, continuing discussing the unbalanced cotton subsidy program between 'core' and 'periphery' nations will provide a fruitful insight on the structural inequalities emerged in a specific political economic context.

Throughout the history of cotton production in India, the experiences and voices of local agriculturalists have frequently been brushed aside in the pre-dominant metropolitan debates on the development of agricultural landscape– towards more a discourse of 'core' than of 'periphery'. In the past, American cotton varieties were introduced for quality improvement and today, Bt cotton is transforming the landscape and the way of local peasant life in many states of India. From past to present, Gujarat cotton farmers have suffered from adopting new cotton species and related environmental effects as discussed in the two case studies. Nevertheless, as shown and discussed here, local farmers were/are far from passive and took an active stance in the appropriation of knowledge and power. The farmers were actively resisting cotton improvement programmes and to some extent used new cotton varieties experimentally, constantly testing different cotton varieties to examine how well they would perform in local soil and climate conditions. What we learn from local resistances and the long-term effects of these negotiations on the agricultural landscape should help understand both the dynamics of power relations and the socioecological dimension of an equitable agricultural development. In my view as well as the views of power dynamics discussed in this thesis, the equitable agricultural development should be inclusive and integrated concerning not only the balance of power and the evolving relationship between 'centre' and 'local' states in the agricultural development, but also the enhancement of the physical and biological resilience on the landscape.

7.2. Concluding reflections

Human society has been developed in the way of influencing or being influenced by its natural and constructed environment. People form their habitats, livelihoods, workplaces and landscape settings in accordance with their desires, associated with social, economic, political and cultural aspects of one's community or society (Crumley and Marquardt, 1987). In other words, the modification of landscape should be understood within the context of people's history, knowledge, values and particular practices, as well as the process of integrating with diverse geographical and climatic conditions. Considering the complexity of landscape, therefore it is important to understand landscape through an accumulative history of the interactions between individual or/and groups ideas, actions and social practices – which are all fundamental shaping of the landscape.

My inspiration for building this narrative on cotton, agricultural landscape and power relation between local and state actors, started inspired by the concept of ecologically unequal exchange. However, as have delved deeper into the topic of the cotton improvement programme and Bt cotton controversy, I have also come to focus increasingly on power relations and core-periphery dynamics. I hope to have shown here that the links between the cotton improvement programme in the 19th century and GM cotton controversy presently ongoing. In this thesis, I have analysed two different historical and ongoing case studies in regard to the cotton production in Gujarat, in order to address the possible environmental risks and benefits of cotton cultivation, power relations and dynamic resistances exhibited by local communities. Interpretations of historical and current evidences can be presented in various forms depending on what the writer intends to convey and wants to accomplish, my aim with this thesis has been to reveal not only possible environmental effects and power struggles at different points in time, but also to demonstrate recursive themes among these conflicts from the perspective of 'core' and 'periphery' structure and partially of the ecologically unequal exchange. This potential connection between the cases of past and present implies that, recurrent conflicts for environmental equity and power appearing in the Indian cotton production have recurred throughout the 19th and 20th century history.

To me, the most valuable learning outcome of this study is that, social and ecological transformations should be understood within a wider frame encompassing the social, political, cultural and ecological aspects, rather than in the narrow frame of political or economic performance of an agricultural "experiment" (such as the American and Bt cotton). Also, having navigating the power dynamics and the evolution of local resistances reveals the limitations of 'global core' knowledge and technology system that will inevitable be appropriated, modified and exchanged by 'peripheral agents'. Still, despite local agency and innovation, the cotton industry and farmers in Gujarat have unfortunately suffered from exploitations and marginalisation, first by the English colonial government, then by the global agribusiness corporations within the 'core' and 'periphery' of the world system. Nevertheless, exploring narratives of local experiences offer a number of significant details that show complex power dynamics manifested through constant struggles and resistances by 'peripheral agent'. From this, the experience of the cotton improvement programme and the GM cotton controversy implies that the power of actual change begins with perceiving the inequalities existing in social and environmental landscape. Considering the increasing trend of concern in sustainability and the growing willingness/preparedness to defy structural inequalities among Indian cotton farmers, I expect that there is still hope for the local cotton farmers in shaping cotton cultivation systems on their own terms.

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Appendices

Appendix A. Cost of production in Rupees per hectare in Gujarat: Irrigated cotton

	Bt cotton	**Non-Bt cotton**
Seed	3079	1324
Human labour	10827	9587
Bullock labour	2468	2527
Tractor	1042	848
Farmyard manure	1488	1429
Fertilizer	3247	3292
Pesticides	2732	3168
Irrigation	3818	3872
Other operational costs	467	450
Total operational cost	29167	26497
Total marketing cost	576	496
Total cost	**29743**	**26993**

* Note. Relevant information adapted from "Economics of Bt cotton vis-à-vis Non-Bt Cotton Across the States" by V.P. Gandhi and D. Jain, In Introduction of Biotechnology in India's Agriculture: Impact, Performance and Economics (p. 44), 2016, Singapore: Springer Nature. Copyright 2016 by Springer Nature.

Appendix B. Growth of acreage under cotton in selected districts

	Gujarat (a)			**Karnataka (b)**
	Broach (Bighas)	**Surat** (Bighas)	**Khandesh** (Bighas)	**Dharwar** (Acres)
1834-35	198,015	42,321	91,433	
1835-36	274,609	49,217	119,494	
1836-37	242,036	39,877	94,757	
1837-38	287,667	62,845	121,194	
1838-39	322,640	62,590	89,436	
1839-40	307,591	51,897	92,273	
1840-41	289,182	48,028	76,014	
1841-42	259,499	71,343	123,793	
1842-43	268,760	57,439	108,956	184,264
1843-44	217,546	36,249	87,192	178,956
1844-45	273,480	65,933	119,799	185,186
1845-46	323,590	57,176	129,533	175,767
1846-47	215,715	35,597	n. a.	190,825
1847-48	394,992	43,723	173,827	199,405
1848-49	356,447	43,778	149,424	204,516
1849-50	306,320	30,126	134,637	241,250
1850-51	432,810	43,453	153,863	254,982
1851-52	337,952	77,400	239,430	264,323

* Note. Relevant information adapted from "Raw Cotton of Western India: Output, Transportation and Marketing, 1750–1850," by Amalendu Guha, 1972, The Indian Economic and Social History Review 9(1), p. 41.

** Note from Guha (1987: 41): "The series is not strictly comparable from year to year for various reasons. In the beginning, statistics were collected and given for Government lands only, to the exclusion of inam lands. Later, the coverage was extended also to inam lands, but exactly from which date-and whether consistently- cannot be determined exactly. For Broach, e.g., we have three different official figures for 1845-46 - 265,069 bighas (Shaw), 277,043 bighas (Crawford) and 323,590 (Jenkins). The last-mentioned one presumably included inam lands. Crawford assumes that figures at least up to 1845-46 relate to Govt. lands only. Shaw suggested that the average area of inam lands under cotton around 1850 in Broach could be about 80,000 bighas. In our series, figures for Broach up to 1843-44 apparently do not cover inam lands. By using Shaw's figures, the series for Broach may be deemed comparable up to 1845-46. According to the Imperial Gazetteer of India Vol. III (2nd edn., 1885) pp 101-11, of the total area in Broach about 21 percent was alienated (inam) land. In the case of Dharwar and Belgaum, the exclusion of inam lands is a source of confusion similarly in the initial years. It appears that inam lands were included only after 1854-55. Roughly speaking, about a fifth of all lands in this tract was held as inams. In the case of Belgaum, it should be, further noted that this district expanded in area after 1847-48, following the incorporation of a part of the Satara Jagir within it."

*** 1 acre = 4840 square yards. 1 standard bigha = 2477 square yards. However, bigha unit can be varied widely from area to area.