

Sustainability Framework for Farm Level Cotton Supply Chain Management

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ABSTRACT

In agricultural products, cotton is a cash crop for farmers. Cotton is environmentally a highly sensitive crop and is under risk from the effects of global warming and the intensive use of synthetic inputs. Due to global warming and climate change, the production of cotton is shrinking in the world's largest cotton producing countries such as China, India, USA and Pakistan. In the overall cotton supply chain management (CSCM) system, immediate sustainable measures are required for protecting the textile industry and the livelihoods of cotton industry stakeholders. Based on a thorough review of the literature, a cotton supply chain management cycle at both the farm level, and the industry overall, was developed in this study. A sustainable Cotton Supply Chain Management Framework (CSCMF) is developed in this study for farm level production by identifying the Critical Success Factors (CSF's) in the literature review, with subsequent interviews with six technical experts who were experienced in small, medium, and large farming enterprises, categorised under the headings of sustainability, supply chain management and cotton farming. The CSFs identified were classified in terms of cotton supply chain management under the three sustainability pillars of social, economic and environmental sustainability. This CSCM Framework will be useful to inform the future development of sustainability policies, and the assessment of farmers' behavior, regarding sustainable practices

Keywords:

Cotton Supply Chain Management (CSCM), Sustainable Cotton Supply Chain Management (SCSCM), Cotton Supply Chain Sustainability Framework (CSCSF).

1. Introduction

Cotton is a soft, fluffy staple fiber which is usually spun into yarn or thread and used to make a soft, breathable textile cloth. Cotton is a cash crop for a large number of farmers and farming enterprises and is an essential raw material for the survival and expansion of textile industry. More than 100 countries in the world have been producing cotton for more than 100 years, with almost 75% of total production coming from China, India, USA and Pakistan (Sameer Safaya, May, 2016). Worldwide cotton production in 2013-14 was 26.23 million tonnes, decreasing to 22.03 million tonnes in 2015-16 (Zulfiqar and Thapa, 2018). The major reasons for this tremendous decrease in overall cotton production, identified by researchers, are climate change and non-sustainable utilization of resources. Sustainability is the process of maintaining change in a balanced manner, in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. Usually, sustainability involves three paradigms of social, economic and environmental sustainability (Yang and Mei, 2017). Sustainability objectives seek to compel development in terms of economic growth, social progress, protection of the environment, and use of natural resources in a prudent way (Vasileiou and Morris, 2006). Sustainable development means to meet the needs of the present without compromising the ability of future generations to meet their needs.

The cotton supply chain management process includes the production of raw cotton (at the farm level), cotton ginning, spinning, weaving, dyeing, cutting, sewing to create products, retailing, and branding of cotton products (shirts, jeans etc.) (Zulfiqar and Thapa, 2018). Efficient and effective textile raw material delivery must enable sustainability in the production process and the overall supply chain management, from point of origin to point of consumption. Sustainable cotton supply chain is a competitive, efficient, and safe way of production, while ensuring the protecting of environmental, social, and economic conditions of communities (Platform, 2013). In the entire cotton supply chain cycle, farm level production has been responsible for producing 56% of emissions

which is more critical in terms of sustainability and its adverse effects on health, the social and natural environment. Emissions from ginning is 21%, whereas, remaining 23% is from others supply chain actors (weaving, dyeing, transportation etc.) (Visser et al., 2015).

This study was focused on cotton supply chain management farm level sustainability; the primary source of emissions (56% as stated). Farm level supply chain management has been largely ignored in previous work and is rarely used as a commercial term. The reason is that most farmers who own the farming business have inherited it from their elders and there has been little opportunity to develop and deploy formal supply chain qualified personnel from amongst these farmers. As elaborated in the Methodology Section, following an extensive literature review and discussions with technical experts, a full point of origin to point of consumption cotton supply chain management process was designed. Figures 1 and 2 illustrate partial farm level cotton supply chain management flow charts designed for that process. We also established a Cotton Supply Chain Management Sustainability Framework. We included in our Literature Review studies relevant to agriculture sustainability, cotton sustainability, agriculture supply chain management sustainability and cotton supply chain management sustainability and selected those according to our established criteria. Agriculture supply chain management sustainability critical success factors (CSF's) were identified and discussed with the participating experts to pick the appropriate CSFs for farm level cotton supply chain management sustainability, taking into consideration economic, social and environmental perspectives.

The findings from this study, and the supply chain framework developed, will contribute to the sustainable utilization of cotton growers' resources, and will be useful for sustainability evaluation and for informing governmental policy frameworks relevant to cotton farmers and cotton farming and subsequent processing.

2. Literature Review

2.1 Cotton Supply Chain Management

Supply chain management is the efficient and effective production and handling of goods and services from point of origin to point of sale and consumption in a coordinated approach and requires coordinated efforts by all stakeholders, and within the supply chain processes, to ensure efficiency in the overall supply chain (Kooistra et al., 2006) [10]. Intensive use of chemicals and maximum utilization of natural resources such as water, are required to ensure the sustainability of the entire supply chain management cycle. According to one study, the production of one pair of jeans requires 8,000 liters of water which is a big waste of natural resources (Sameer Safaya, May, 2016).

A significant product of our study was the design of a complete and detailed cotton supply chain management cycle which is depicted in Figure 1.

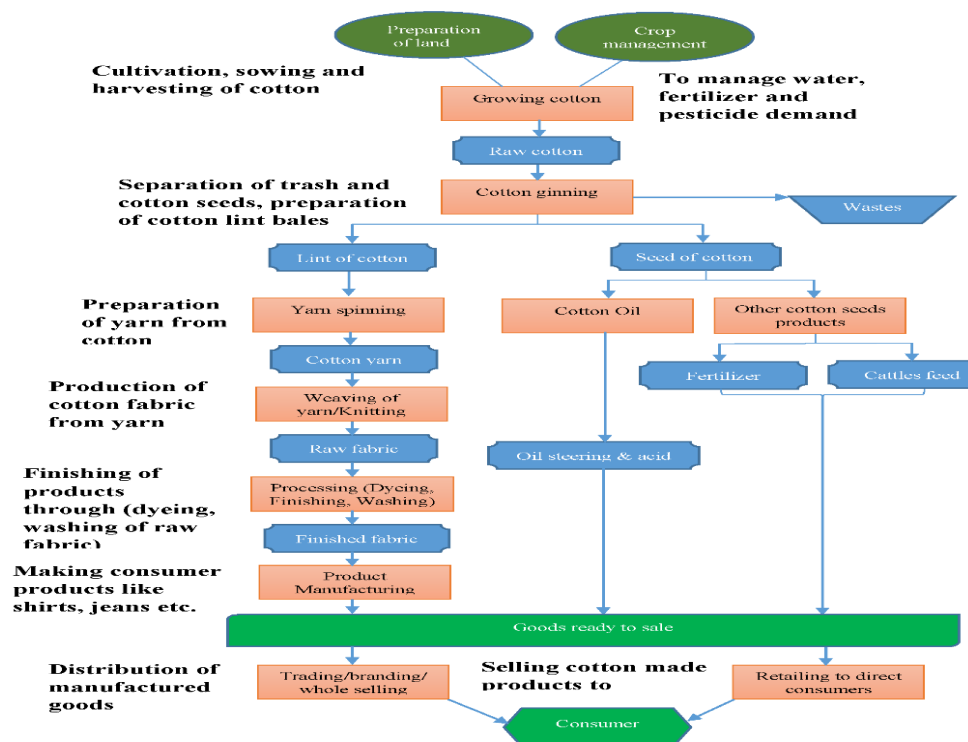


Figure 1: Cotton supply chain management flow chart

2.2 Sustainable Cotton Supply Chain Management

The term sustainability first appeared in a German dictionary in the 19th Century and the concept of sustainable development evolved more recently from a biosphere conference in Paris in 2015 (Grunewald and Bastian, 2015). Sustainable development is the commitment to meet present demand without compromising the ability of future generations (Roth, 2011). Economic, social and environmental sustainability are defined as the three important pillars of sustainability. Prior to the 20th century, cotton was cultivated organically but as the demand for higher yields grew, this resulted in the increased use of synthetic fertilizers, pesticides and genetic modifications (Pretty, 2005; Rieple and Singh, 2010). Agriculture pesticides have had a harmful impact on the cotton industry due to the use of older, out-of-patent, cheaper and less safe chemicals and equipment (Wilson and Tisdell, 2001), and the use of greater volumes of these pesticides has led to serious health problems for small cotton farmers and their families. In developing countries like Pakistan there is a doubling of these effects due to poor health facilities. Another matter of concern is that excessive use of pesticides results in a growing resistance in the target insects, together with collateral problem of killing farmer friendly pests, such as earthworms and birds. Herbicides also induce resistance in pest weeds and plant diseases. A temporary growth in yield of the cotton crop may be experienced from the use of pesticides and herbicides but that has been shown to be not sustainable, and yields tend to fall in the long run due to the destruction of soil fertility due to the eradication of earth worms and other beneficial organisms, with the consequential failure of crops (Blaise et al., 2004).

After some sixty years' of intensive use of chemicals, society now realize that chemicals have created detrimental environmental, social and economic impacts on their lives and livelihoods. Researchers are now seeking to change farming practices and move toward sustainable production processes (Herath, 1998). The farm is the initial and most important stage of the cotton supply chain and is the main focus of this study.

2.3 Farm level cotton SCM cycle

In the cotton supply chain flow chart shown as Figure 2, the first process is cotton production at the farm level. The farm level production processes are divided into 6 stages (land preparation, sowing, crop management, cotton picking, cotton storage, and post-harvest practices) which were identified and confirmed by our literature review together with discussions with technical experts.

Land preparation is the first stage of the farm level production supply chain cycle which is achieved by a variety of activities such as bedding and furrowing, laser levelling, deep ploughing, and the use of rotavators, scarifiers, plough and other ground preparation machinery. (Zulfiqar and Thapa, 2018). Sowing practices include seed grading, anti-fungal and other treatments of seeds, sowing; which may be by hand but is now ore likely to be using planter equipment and seed drills, and then germination tests. Crop management includes irrigation, thinning of plants (spacing), insect and weed pest control or eradication, soil nutrition testing etc. Picking of cotton is still often done by hand, manually, but also by machines. In Pakistan manual picking is still widespread and common. Picking requires special measures to be achieved successfully, such as only picking after the morning dew has dried away, picking bolls from the bottom to the top of the plant, and only picking only bolls that are at least 50% open. Post-harvest practices for cotton storage also require special quality assurance measures such as being protected from heat, storage in dry conditions, storing on plastic sheets, in small covered heaps. These are measures against both insects and diseases, such as mild and mould. Sales are usually made by farmers direct to a gin, or through middle men. The farming production cycles will then continue into preparation of the land for other crops.

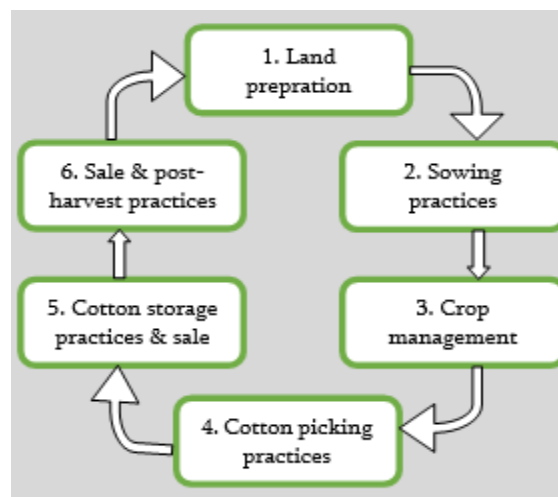


Figure 2: Farm level cotton production supply chain cycle

2.4 Sustainable cotton supply chain management critical success factors (CSF's)

Critical factors in farm level production supply chain cycle apply to each of the three pillars of sustainability; economic, social and environmental. The farming supply chain cycle from land preparation to post-harvest was extensively explored in the literature review and was investigated further in discussions with small and medium farmers, within each pillar as depicted in Table 1.

Available studies on cotton production mostly comprise information on the horticulture, agronomy, and agriculture engineering perspectives, and supply chain aspects have not gained substantial attention in terms of sustainability of production. Some research in the area of the sustainability of cotton production has been published by civil societies; NGOs, working in Pakistan, but, again, the main focus has been on cotton quality and its profitability, not on industry sustainability. Peer-reviewed work has been limited to the organic cotton production initiatives of small and medium farmers.

Table 1: Critical factors for cotton supply chain sustainability

No.	Critical factor	Sustainability pillars			Reference
		Economic	Social	Environment	
1	Environmental protection	-	-	✓	(Initiative, 2018; Platform, 2013; Zulfiqar & Thapa, 2018)
2	Water conservation	-	-	✓	(Initiative, 2018; Platform, 2013; Zulfiqar & Thapa, 2018)
3	Land and soil management	-	-	✓	(Platform, 2013; Zulfiqar and Thapa, 2018)
4	Care of nature (habitats)	-	-	✓	(Platform, 2013; Zulfiqar and Thapa, 2018)
5	Increase quality	✓	-	-	(Platform, 2013; Zulfiqar and Thapa, 2018)
6	Promotion of decent work	✓	✓	✓	(Platform, 2013; Zulfiqar and Thapa, 2018)
7	Energy	-	-	✓	(Platform, 2013)
8	Climate change	-	-	✓	(Yang et. al, 2017; Platform, 2013)
9	Use of chemical inputs	-	-	✓	(Initiative, 2018; Platform, 2013; Zulfiqar & Thapa, 2018)
10	Workers conditions	-	✓	-	(Yang et. al, 2017; Platform, 2013)
11	Training and development	-	✓	-	(Yang et. al, 2017; Platform, 2013)
12	Farmers and associated workers financial conditions	-	✓	-	(Yang et. al, 2017; Platform, 2013)
13	health facilities	-	✓	-	(Yang et. al, 2017; Platform, 2013)
14	Care of animal	-	✓	-	(Yang et. al, 2017; Platform, 2013)
15	Safety & quality	✓	-	-	(Yang et. al, 2017; Platform, 2013)
16	Financial stability	✓	-	-	(Yang et. al, 2017; Platform, 2013)
17	Supply chain efficiency	✓	-	-	(Yang et. al, 2017; Platform, 2013)
18	Risk management	✓	-	-	(Initiative, 2018; Platform, 2013)

3. Methodology

In this study we used a qualitative approach comprised of two steps. In the first step, we identified and reviewed 17 articles relevant to the topics of sustainable cotton supply chain management and on existing frameworks of sustainable cotton supply chain management processes. Cotton supply chain management processes were defined, and the Critical Success Factors (CSF's) for cotton production sustainability were identified from the literature. Using these papers as a foundation, the second step was the identification of any further CSF's for the development of a model of both the entire, and the farm level, cotton supply chain management cycles, which was achieved after further detailed discussion with technical experts (Figure 1 and 2). Six technical experts who were researchers in the field of sustainability, supply chain management and cotton farming, participated in this discussion. Two of the experts were proficient in each category.

Step 1 included searching the “Science Direct”, Emerald”, “Scopus”, “Web of Science”, and “Google Scholar” databases for appropriate articles. The keywords used in the literature search included “sustainable cotton supply chain management”, “cotton supply chain management”, “cotton supply chain sustainability factors”, “agriculture sustainability”, and “cotton sustainability framework”. All studies found were initially screened by reviewing the title of the study, and the studies apparently of interest were further screened for final inclusion or exclusion by reviewing the abstracts of the studies.

The results of this study will be useful for government in policy and frameworks development about small and medium level sustainable cotton growers. It will also be useful for researchers to assess cotton supply chain sustainability and to know cotton growers’ challenges and opportunities in terms of farm level supply chain management. The future demands about technology, education and training will also be able to be estimated through using this study.

4. Results

4.1 Cotton Supply Chain Management Sustainability Framework

A cotton supply chain sustainability model was developed by the Better Cotton Initiative (BCI) organization who introduced 6 principles for better cotton management namely, reduction in adverse environmental and health effects, efficient use of water, care for soil health, care for nature including habitats, enhancement in cotton quality and promotion of decent work (Zulfiqar and Thapa, 2018).

The model developed in our study is an extension of the BCI model, and addresses each of the economic, social and environmental pillars. Each pillar contains CSF's in regard to the sustainability paradigm, which were derived after discussion with the technical experts who participated in the study, as discussed above. As illustrated in Table 1, each pillar or paradigm includes certain CSF's (Figure 3). According to the technical experts, the environmental paradigm includes the CSF's pertaining to land and soil management, water conservation, ecosystem, energy, climate change and use of chemical inputs. Conditions of the workers in the industry, and their training and development facilities, farmers and associated workers’ financial conditions, workers’ safety relevant facilities, care of animals and other relevant matters are included in the social sustainability paradigm of the farm level sustainable cotton supply chain management model. The economic sustainability paradigm included; increase in quality, adoption of good practices, safety and quality and supply chain efficiency. Details of each factor is given below in Figure 3.

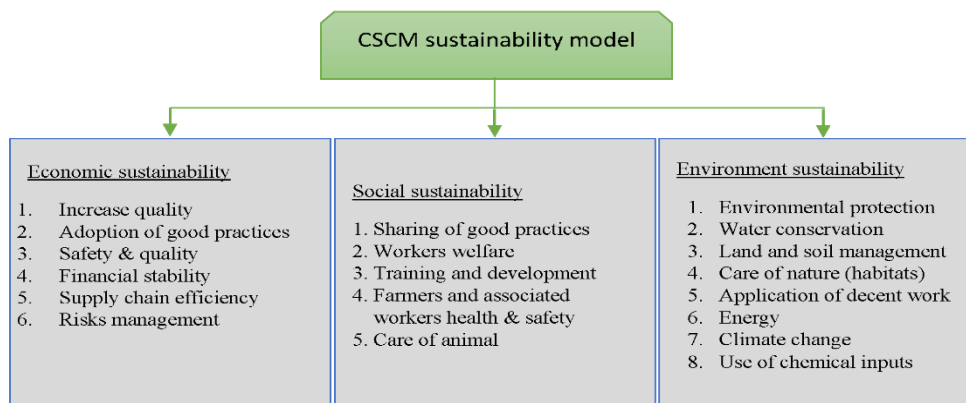


Figure 3: Cotton supply chain sustainability model

5. Conclusions

Cotton production sustainability is a serious challenge for developing countries such as India and Pakistan. Through different campaigns and serious United Nations (UN) programs, many countries, and industries, are collectively putting their efforts into the achievement of sustainability in every field of life. The agriculture sector is the most concerning and most directly affected industry, and requires serious attention to sustainability and sustainable practices. Cotton production is one of the most unsustainable agricultural industries due to the normal practices for heavy use of insecticides and pesticides, and the poor knowledge of small farmers of sustainable practices. To overcome these problems, social development programs by Non-government organizations (NGO's) have acknowledged the importance of sustainable cotton production and they are endeavoring to expand sustainable practices through foreign and domestic stakeholders like BCI. By developing a model of the social, economic and environmental sustainability paradigms, recognizing the Critical Success Factors essential in the farm level cotton supply chain, we are confident that this model can inform government policy and assist farm level stakeholders to achieve sustainable production practices. It must be acknowledged that the success of this model of sustainability depends on farmers' behavior and acceptance. Farmer awareness, level of education, attitude to risk, size of farms and other relevant matters must be explored and understood, and a government sustainability policy framework developed, to fulfil the growing demand of sustainable cotton production. Our model provides a basis for such policies and practices.

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