UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

Threading natural capital into cotton

Doing business with nature

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CISL is particularly focused on setting a bold ambition for business and innovating to deliver greater value (Task seven). CISL's Natural Capital Leaders Platform has focused on commodity-specific Action Research Collaboratories (ARCs) to consider how value can be created while having a neutral or positive impact on the natural world.

Publication details

Disclaimer
The opinions expressed here are those of the authors and do not represent an official position of CISL or any of its individual business partners or clients.

Authors and acknowledgments
The principal investigators and authors of this report and the Technical report are: Dr Gemma Cranston, Dr Jonathan Green and Hannah Tranter of CISL.

This document is part of a series of 'Doing business with nature' publications; these identify challenges and opportunities for companies whose future growth depends on a healthy and sustained supply of nature's goods and its services, known as 'natural capital'. The rationale for investing in sustainable natural capital management is set out in Doing business with nature: Opportunities from natural capital and has been further developed through commodity-specific Action Research Collaboratories (ARCs) for Dairy in the UK and Ireland and for Cotton (described here). This work forms the basis of the Cotton Tool.

The authors would like to thank all members involved in this Action Research Collaboratory (ARC) for their input and Steve Strebl who led the evidence review which underpins this work.

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February 2016

Collaboratory Members

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Foreword

Andy Clarke
President and CEO,
Asda Stores Ltd.

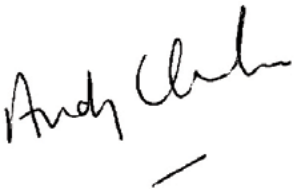
As one of Britain's major clothing retailers, we have a responsibility to develop environmental sustainability strategies that spearhead the industry.

While we have substantially improved our environmental performance within our operations, especially with regards to energy and waste, we are now turning our attention further afield and are aiming to go beyond our stores. This means working with all those impacted by and dependent on cotton's natural capital to secure a sustainable base of raw materials.

Today's supermarket world is both challenging and compromised; economic sustainability is a top priority for us. We cannot envisage being economically viable without considering the natural capital upon which our products depend: focusing on nature is vital to securing long term financial capital. We see business success going hand in glove with sustainability for the benefit of our customers and of our business. We pride ourselves in customer loyalty and we want our customers to be able to access not only low prices and good quality but also sustainable products.

At Asda, we source an incredible number and variety of products, including cotton. Mapping complex cotton supply chains and exploring where our cotton comes from enables us to appreciate the environmental impacts at the growing phase. Understanding and transparency are only the first steps to action; engaging in healthy and informed conversations with other stakeholders within our supply chains is the only way the cotton industry will collaboratively see action.

Companies such as Asda can lead such an industry to change but need to be equipped with the appropriate science and knowledge and can only generate momentum with the support and involvement of all other industry players. Our work with CISL on cotton has done just that and we hope that by being part of this journey, we will pave the way for action in the future.



Andy Clarke
President and CEO,
Asda Stores Ltd.

We cannot envisage being economically viable without considering the natural capital upon which our products depend: focusing on nature is vital to securing long term financial capital.

Executive summary

Cotton is a natural fibre worn throughout the world across socio-economic boundaries and is one of the world's most important crops. In 2014-15 it was grown across 2.5 per cent of the world's agricultural land (an area comparable to the size of Finland).

Seven businesses came together to spearhead this project with the ambition of ensuring that producers are able to meet future demand for high quality, ethically sourced and sustainably grown cotton.The Cotton Action Research Collaboratory (ARC) explored 15 different interventions and the evidence of positive natural capital impacts for each. This assessment can support business decisions to guarantee that the natural capital underpinning the industry is used and managed more sustainably. The ARC focused on water, biodiversity and soil particularly at the growing stage of the supply chain where natural capital challenges are most prevalent.

The cotton industry is dependent upon natural capital. Sustainable cotton production requires healthy soils and biodiversity as well as access to sufficient water to provide for the crop's needs. These influence the quantity and quality of cotton yields as well as the crop's ability to cope with stresses such as drought or pest infestation. If poorly managed, these factors can combine to threaten cotton supply chains, influence prices and impact farmer livelihoods.

The cotton industry is dependent upon natural capital

There are some excellent examples of progress in managing natural capital to create sustainable and resilient cotton supply chains; however, there is a need to strengthen and accelerate this progress. By revealing the evidence of positive natural capital impacts from different management practices businesses can go further in securing sustainable supplies of cotton.

Making informed decisions about safeguarding the natural resources that cotton production depends upon is vital to ensure the long-term security of cotton supply chains. This project has identified the natural capital challenges to cotton production and evaluated evidence on how 15 different interventions impact on natural capital. The study focused upon natural capital but acknowledges the broader sustainability issues, such as poverty, labour issues, and socio-economic resilience within which it sits. It is clear that there are opportunities to reduce negative natural capital impacts and thus reduce business vulnerabilities and risk.

This work is a first step towards assembling the appropriate evidence for best practice around sustaining natural capital. It will help businesses to have informed discussions with their supply chains and farmers so these are secured for the future.

Threading natural capital into cotton

One crop grown across six continents

In 2014-15 cotton was grown across an estimated **2.5 per cent of the world's agricultural land**

Three key challenges to secure dependencies

Water stress from over exploitation and changing weather patterns can decrease product quality and impact global commodity prices.

Biodiversity losses from sub-optimal pesticide application, conversion of natural habitat and mono-cropping can mean that cotton crops are less able to cope with climatic stresses and pest infestations, thereby affecting quality and quantity.

Frequent and high rates of agrochemical application, compaction due to farm traffic and **erosion** of fertile top soil can degrade soil fertility so that cotton production is no longer economically viable.

Seven leading companies considering natural capital

ASDA · BAYER · C&A · Cargill · KERING · Olam · VALUE RETAIL

Fifteen interventions addressing natural capital challenges

160 scientific studies reviewing their effectiveness

One big step to take forward

Begin more informed dialogue and supply chain opportunities by using more appropriate and consolidated evidence around best management practices for natural capital

Figure 1: The Cotton Action Research Collaboratory journey

Part 1
Introduction

1.1 Natural capital and cotton

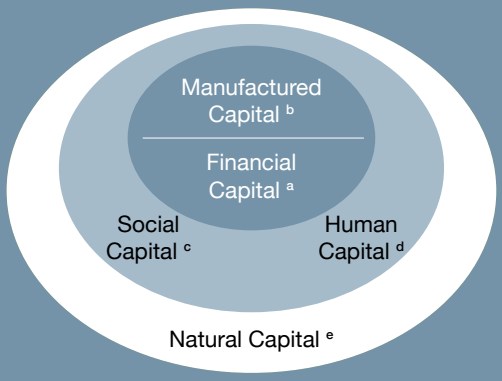
Natural capital[a] underpins human, social, manufactured and financial capital (Figure 2). This report highlights the dependence of cotton production on natural capital (nature's goods and services) that relate particularly to water, biodiversity and soil. Natural capital needs to be preserved, maintained and restored in order to safeguard cotton supply chains. This study aims to collate knowledge and present evidence on how current practices are achieving this so that businesses can make better decisions in their supply chains.

Cotton represents one third of the world's textile demand[1]; the growing and processing of cotton fibre supports an estimated 250 million jobs in 80 countries[2]. Despite erosion of cotton's share of the market to synthetic textiles, absolute demand for cotton continues to increase[3]. In addition, and illustrating concern over cotton farming practices, the share of cotton that is produced to meet enhanced social and environmental requirements has increased dramatically with a number of different schemes setting standards for sustainable cotton. For example, the Better Cotton Initiative certified cotton already constitutes almost ten per cent of the world's supply and is steadily increasing[4].

Substantial attention, however, has been paid to the negative impacts of cotton production. In particular, those related to unsustainable water use and labour conditions have been investigated[5]. Sustainability in cotton growing requires a farming system that improves or maintains natural resources, meets social expectations, yields a safe product and provides producers with good standard of living[6].

This Cotton ARC presents the case for natural capital and cotton; it analyses the scientific literature and evidence that is currently available with regards to impacts and dependencies on water, biodiversity and soil. It acknowledges that a number of other factors, including social and economic, need to be assessed. The information in this report does not constitute recommendations for specific farming practices and expert advice should be sought before any particular action is taken.

This report focuses particularly on the need for practices to concentrate on water consumption, soil fertilisation and land and diversity management whist minimising impacts associated with pest management. Such interventions can make commercial sense for businesses and can help reduce costs along the supply chain.



[a] money, stocks, bonds
[b] infrastructure, tools, roads
[c] families, communities, governance systems
[d] knowledge, skills, health
[e] water, biodiversity and soil, ecosystems, sea

Figure 2: *Forum for the Future's Five Capital Model of the Economy*[7].

[a]Capital is most often thought of as the wealth or assets of an individual, company or nation. 'Natural capital' is an economic characterisation of the limited stocks of physical and biological resources found on Earth. It refers to the limited capacity of ecosystems to provide services (i.e. the direct and indirect contributions of ecosystems to human well-being).

Part 1: Introduction *continued*

Global water, biodiversity and soil maps and statistics reveal high levels of degradation of these natural capital resources (Figure 3a-c). These maps highlight where natural capital risks lie geographically and can be considered alongside cotton production trends (Figure 3d).

However, shifting patterns such as climate change, along with a number of other factors, including availability of technologies, capacity building and development of better practices, can influence both natural capital stresses and cotton production trends.

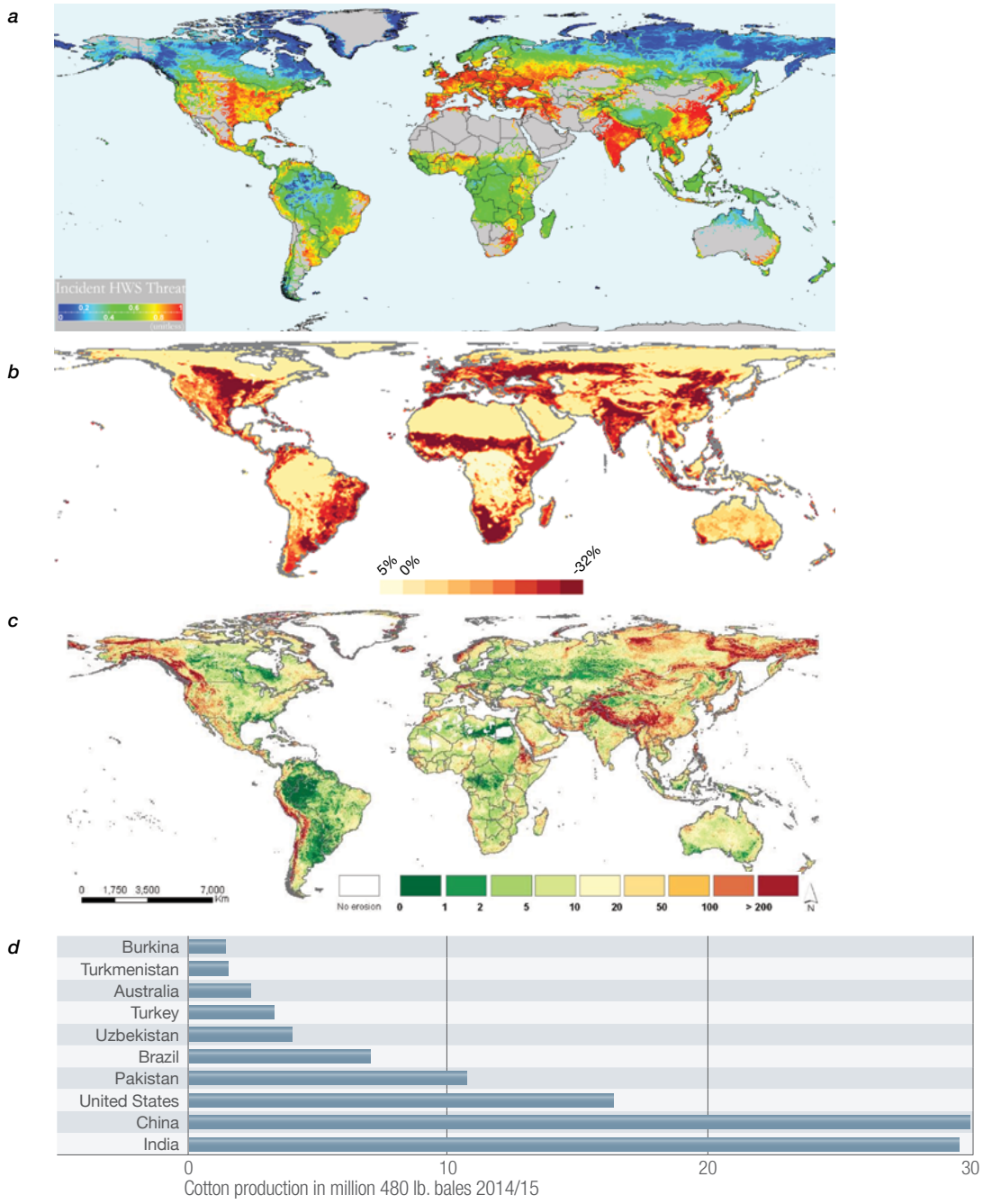


Figure 3: *The global distribution of (a) Water security: incident threat to human water security[8]; (b) Biodiversity: net change in local richness caused by land use and related pressure from (1500- 2000)[9] and (c) Soil degradation: predicted soil loss in ton/ha/year[10]. These can be compared alongside (d) the top cotton producing countries[11].*

1.2 Responses to the challenge

In response to cotton challenges, there are a considerable number of enterprises, programmes and initiatives that are directed at improving the reputation and environmental, social and financial sustainability of the cotton industry. These include: the Better Cotton Initiative (BCI)[12,13]; CottonConnect[14]; Cotton made in Africa (CmiA)[15]; e3TM (Bayer)[16]; Fairtrade®; Field to Market® in the USA[17,18]; myBMP of Australia[19]; Organic[20]; and The Textile Exchange[21]. These entities aim to improve sustainability by promoting techniques to maximise efficiency of natural resource use for cotton production, identifying better practices to minimise adverse impacts on natural resources and investing in plant breeding whist bilaterally safeguarding social and economical sustainability.

1.3 The gaps

The extent to which current initiatives address challenges around water, biodiversity and soil varies considerably. There are also large differences (both within and between countries) in farm management and efficiency, suggesting that considerable opportunities still exist to improve[e.g.18,22-24].

Improvements can be achieved by consistently implementing interventions that account for natural capital (specifically water, biodiversity and soil), and the benefits that flow from it; these benefits include sustained quality and quantity of yield, maintained ecosystem health, optimised cost of inputs and reduced risks by creating resilience to natural resource stresses. Although there are examples of farmers making significant progress in improving their management of natural capital, economically, socially and environmentally sustainable cotton production systems are yet to be fully mainstreamed within the industry and there is a need to accelerate the adoption of best practices.

Certain interventions can enhance long-term financial security throughout the cotton value chain by increasing productivity and optimising costs whilst also safeguarding wider societal benefits such as clean water and labour opportunities. The cotton supply chain must be strategic in prioritising its investments to align with these goals.

1.4 Business Response

To ensure the long-term security of cotton supply chains it is vital that informed decisions are made to safeguard the natural resources that cotton production depends upon.

Market drivers for increasing sustainability in the cotton value chain include the ethical concerns of shareholders, investor perspectives and impacts on other stakeholders as well as increasing pressures on businesses for responsible procurement. Businesses also have an interest in maintaining future quality and yield resilience, optimising on-farm input costs and securing supply in a volatile global commodity market.

Underpinning this is a dependence upon water, biodiversity and soil. For businesses to secure these natural capital elements in their supply chains they need to understand which agricultural practices and interventions they should be considering and ensure that they are appropriate for the context and scale at which they are applied.

The impacts and dependencies that cotton production has upon natural capital can be felt throughout the supply chain. Figure 4 shows different shows business perspectives across the cotton supply chain.

A stronger evidence base is required that can direct business to informed decisions on their cotton supply chains, particularly around the actions at the growing stage of the supply chain where the natural capital challenges are most prevalent.

Fairtrade International
(Madhya Pradesh India),
Photographer Suzanne Lee

Perspectives along the supply chain

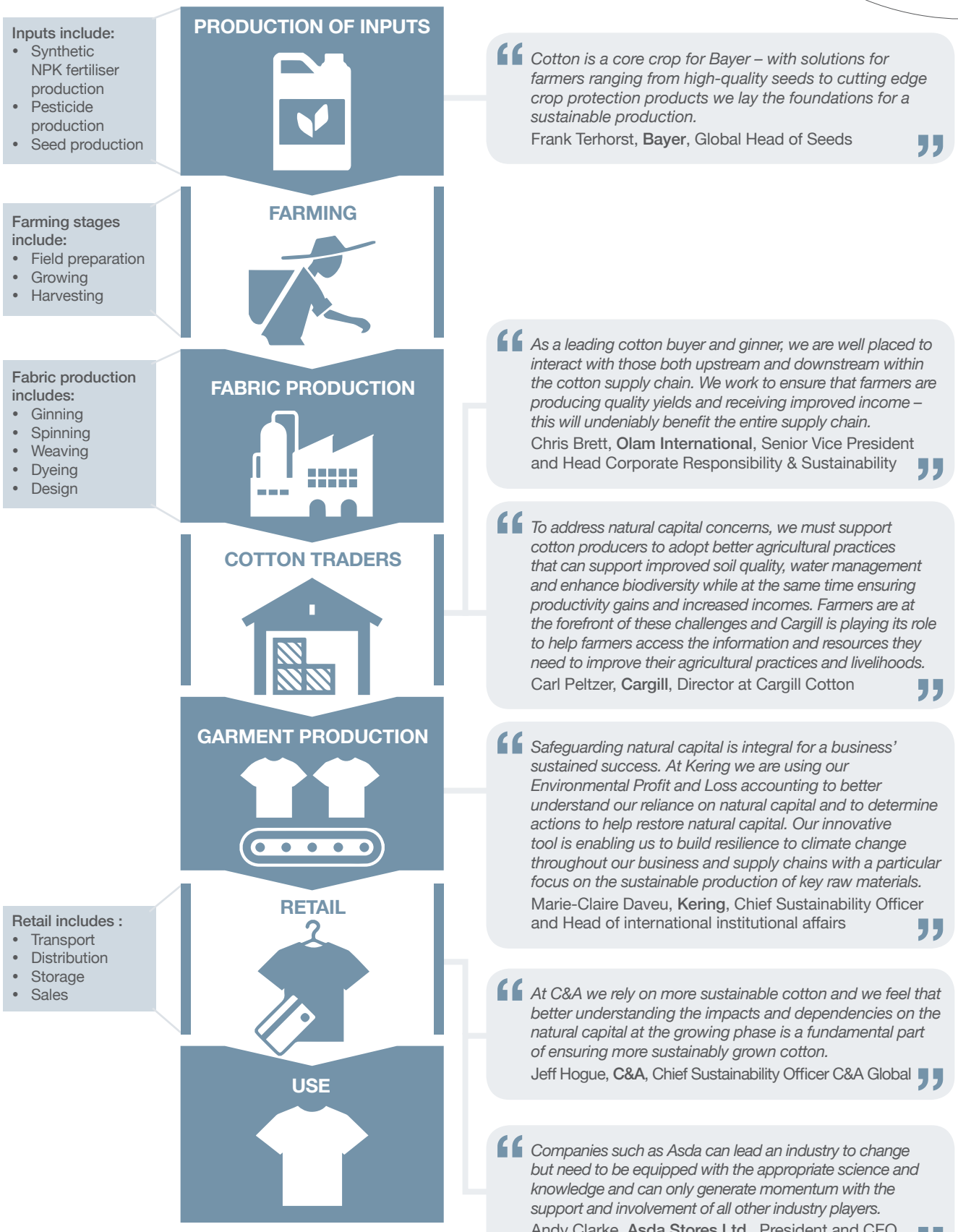


Figure 4: *The cotton supply chain and company perspectives on natural capital*

Part 2

Key issues for cotton and natural capital

Sustainability in cotton growing requires a farming system that improves or maintains natural capital

Cotton sustainability necessitates overcoming some key challenges that arise around water, biodiversity and soil.

The cotton plant has unique features that will allow its broad cultivation and its supply of food, feed, fibre and income well into the future. Cotton has a wide geographical and environmental range due to its stress tolerance; this influences quantity, quality and seed accessibility. For example, cotton is grown:

- from 45 degrees north, to the equator, to 36 degrees south;
- in regions with greater than two metres of rainfall to less than ten centimetres of rainfall;
- at temperatures ranging from zero to fifty degrees Celsius; and
- as fast as 120 days from planting to harvest, to multi-year perennial trees.

The relationship between cotton and water, biodiversity and soil is complex and these relationships have subsequent implications for business. When considering options for securing and sustaining cotton supplies water, biodiversity and soil management should not be carried out in isolation but be considered as a collective natural capital base[25]. Securing a single natural capital element in isolation will not guarantee resilient and sustainable systems; an integrated approach is essential.

Part 2: Key issues for cotton and natural capital *continued*

2.1 Water

Ensuring timely and high quality water for the production of more food and fibre is one of the agricultural sector's biggest challenges[23]

DEPENDENCIES

Cotton producers are dependent upon water resources for yield quantity and retention of cotton boll which is influenced by water stress during the growing season

IMPACTS

While rainfed cotton uses approximately 3,400 litres per kg of lint cotton[26], non-irrigated cotton farming relies on ground/surface water, consumption can vary from 6,000 litres per kg (China) to 22.500 litres per kg (India)[27,28]

BUSINESS IMPLICATIONS

Supply chains depend upon a healthy yield of cotton which can be impacted by water stress

Water stress can decrease product quality (cotton fibre length)[29]

Water scarcity can have impacts upon global commodity prices

***Box 1:** Quick facts on cotton and water*

Cotton is often grown in arid regions where water scarcity is a critical concern: 73 per cent of global cotton harvest is irrigated[30].

Water consumption in cotton's growing stage is significantly higher than the amount of water used in the subsequent production of textile products (e.g. dyeing, finishing and ginning) and is a hot spot for businesses with a concern around water security in their supply chains. Nevertheless, cotton is a relatively drought resistant crop requiring significant amounts of water only at particular growing stages. This is not always considered and as such there are often problems with over irrigation.

As cotton is **grown in hot and semi-arid climates**, the misuse of a scarce water supply is likely to lead to conflict with other users in the landscape[31]. Water use efficiency is important to farmers who must manage this limited resource, particularly when farms are irrigated and water prices are paid according to the volume used or when small-scale farms which depend on rain water face intensifying climate change impacts and variable rainfall patterns.

In both non-irrigated and irrigated systems, water conservation and management are critical for maximising yields and much more could be done around water harvesting and other mechanisms.

Water scarcity can have impacts upon global commodity prices. Indeed, droughts in India, China and Texas have already impacted cotton commodity prices by reducing yields and productivity. There are also debates about the allocation of water which has implications for the entire supply chain; stakeholders may increasingly have to justify their use of it across the supply chain and may be required to reduce the total amount that they use because of competition for limited water resources and legislation[32].

It is not only water quantity that is a concern; **water quality** is also impacted by cotton production, including through pollution of water sources from leaching and runoff of agrochemicals[33].

Where have water stresses already had an impact?

Climate change pressures and increasing frequency of droughts and floods directly impact cotton harvests in arid regions and therefore global trade; the subsequent price fluctuations have ripple effects across the world. For example, severe flooding in Pakistan in 2010 caused the loss of infrastructure, sweeping away of lands and crops and destruction of seed reserves. Such impacts had unprecedented effects on cotton prices on the New York Stock Exchange and in national markets. As a result of the floods the price of cotton increased by nearly 3.5 per cent within a week to 90.10 cents per round, the highest it had been trading since 1995[34].

2.2 Biodiversity

Pests are a problem. While cotton is grown on 2.5 per cent of global arable land, cotton's share (by monetary value) of global pesticide to tackle certain pests was 6.8 per cent in 2008[35]

DEPENDENCIES

Cotton producers can benefit from biodiversity as it can prevent soil erosion, enable nutrient recycling and act as biocontrol for pests

IMPACTS

Biodiversity can be negatively impacted by the misuse of certain pesticides, the conversion of natural habitat and mono-cropping

BUSINESS IMPLICATIONS

Reduced biological abundance and diversity means that crops are less able to cope with climatic stresses such as drought and pest infestations, such that quality and quantity of cotton can be threatened in supply chains

Box 2: Quick facts on cotton and biodiversity

Biodiversity is the variety of life found on earth and can be measured at the level of genes, species or even ecosystems.

Cotton producers can benefit from biodiversity[36], which is closely interwoven with water and soil. For instance soil organisms help cycle nutrients[37], thereby promoting growth of vegetation, which then contributes to filtering and regulating water flows.

Benefits from biodiversity include helping to avert soil erosion, acting as biocontrol for pests and assisting nutrient recycling. Soil microbes contribute to enhancing water retention in soil, nutrient availability for plants and biologically controlling plant diseases[38]. Such biodiversity benefits and services underpin cotton production and are fundamental to successful harvests.

Biodiversity can be negatively impacted due to the misuse of certain pesticides. Crop protection products and pesticides have been common in cotton growing (partly driven by the crop's long growing season, which makes it vulnerable to a large variety of diseases, weeds and pests[39]) but certain pesticides can also affect non-target organisms, including beneficial soil microorganisms and beneficial insects and spiders[5,40-42]. Non-synthetic and organic pesticides, which can be naturally occurring substances or locally made recipes, can also be toxic depending on local ecosystems. Although organic pesticides may not necessarily be safer, they can be much more easily decomposed by the environment. Understanding local ecological context as well as the pests involved is crucial to identify most appropriate organic or synthetic pesticides.

Biodiversity can also be degraded through the conversion of natural habitat and the pollution or depletion of water resources; runoff from cotton fields into water systems can negatively impact local biodiversity and water catchments[5,36].

Where has biodiversity already been impacted?

Cotton production is extremely important for Benin as it represents nearly 40 per cent of the country's GDP but there is concern about the impact of production on ecosystem health[43]. Large quantities of pesticides are still widely used by cotton producers in Benin and these can end up contaminating the rivers both within Benin's cotton-producing basin and outside it with high levels of endosulfan, heptachlor, DDT and metabolites.

Endosulfan is already banned in many countries and being phased out but its effects appear long-lasting.

A 2015 assessment of the general health of the Guinean tilapia and the African catfish reveals that the sampled fish from the polluted sites are in poorer health (as defined by biometric indices, plasma levels of sex steroids and the histopathology of the gonads and liver), compared with those from the reference site[44].

Part 2: Key issues for cotton and natural capital *continued*

2.3 Soil

Soil erosion causes eutrophication: poor soil management practices cause phosphorous and nitrogen within eroded sediments to enter water systems which can result in reduced oxygen levels in water and disruption to fragile aquatic ecosystems

DEPENDENCIES

Cotton production requires healthy soil systems. The differences in soil health explain some of the variation in cotton growth and yields

IMPACTS

Growing cotton can impact soil structure and fertility due to the high rates of pesticide application, compaction due to farm traffic and erosion of fertile top soil

BUSINESS IMPLICATIONS

In some areas agricultural practices degrade soil fertility so severely that cotton production will no longer be economically viable

Box 3: *Quick facts on cotton and soil*

Soil is critical in supporting both our natural ecosystems and our agricultural systems.

It takes **thousands of years for a fertile topsoil to be created** yet, without careful management, this soil can be eroded, compacted or depleted of its nutrients on timescales ranging from hours to years[45]. Indeed, as cotton is grown in areas where soil is often poor quality, the top soil is even more vulnerable to erosion from wind and water[5].

The **physical, biological and chemical properties of soil are crucial** to the production of cotton and explain much of the variation in cotton growth and yields[13,46-49]. It is in the soil that much of the interaction between hydrological, chemical and biological elements takes place.

A number of different practices impact soil fertility and compaction, including on farm traffic. Traffic can be particularly damaging when soils are wet and when there is a constant need for high rates of agrochemical application in the cotton growing phase[50, 51].

Soil damage has been reduced significantly in certain parts of the world, notably the USA. Since 1980, each acre of cotton farmed in the USA has 40 per cent less soil erosion (the majority of this reduction occurring prior to the year 2000 from improved farming practices including reduced tillage), whilst yields per planted acre almost doubled[18]. It is important to note that this erosion rate is likely to be above what is sustainable but increased fertiliser applications have masked this concern.

Where has soil already been impacted?

The situation in many parts of the world remains fragile and while the issue is global, impacts and dependencies resonate at a local level. For example, current agricultural practices in Mali, the second largest cotton producer in Africa[52] are severely degrading soil organic matter to thresholds below which cotton production using existing varieties and practices will not be economically viable in coming years[46].

Part 3

Interventions to safeguard natural capital

There are a variety of management interventions that are adopted to improve cotton yields, address environmental issues, adapt to local contexts and/or secure natural capital at the growing stage of the cotton supply chain

Fifteen key interventions that are commonly considered to be beneficial for natural capital were investigated.

These were determined by the Collaboratory's group of businesses and expert advisors and are summarised on pages 18-19. They fall into four categories:

1. WATER CONSUMPTION	 Drip irrigation	 Deficit irrigation	 Irrigation with brackish or saline water		
2. SOIL FERTILISATION	 Recycling cotton gin waste	 Fertilisation using plant waste	 Animal manure		
3. PEST MANAGEMENT	 Organic pesticide	 Pesticide use optimisation	 Habitat management for predators	 Promoting biocontrol through genetic modification	
4. LAND AND DIVERSITY MANAGEMENT	 Crop rotation	 Habitat diversity	 Keeping a tidy farm	 Removing volunteer cotton	 Limiting cotton expansion

Part 3: Interventions to safeguard natural capital *continued*

3.1 Technical report

A systematic review evaluated the scientific evidence underpinning interventions that businesses may wish to discuss with their supply chain. The impacts that these interventions have upon natural capital have not always been substantiated. This review of scientific evidence identified how effective these interventions are in delivering positive outcomes for water, biodiversity and soil. The findings have been compiled in an accessible technical report.

A total of 160 academically and peer reviewed published studies were critically reviewed to provide detailed evaluations of the evidence for specific cotton management interventions and their impacts on natural capital. The evidence highlighted whether those interventions had previously been successful in providing positive impacts on natural capital. The review exposed a geographical imbalance with limited scientific data available in certain regions.

Reviewing 'Pest Management' interventions yielded a number of studies on genetic modification and its impact on biocontrol services. The intervention 'Promoting Biocontrol using Genetic Modification' is therefore a compilation of the gm-focussed studies that were not captured by the other 'Pest Management' categories. This does not signify that there is a lack of studies or of evidence since the topic itself was not explicitly researched here.

The full Technical Report can be read here. It includes a description of each intervention, some quick facts and a brief synthesis of evidence; the studies are detailed individually by focusing upon water, biodiversity and soil impacts.

These interventions are fairly common. Many of the interventions, and their sub-elements, are referred to in widely endorsed programmes and standards that consider Integrated Pest Management (IPM)[53], Good Agricultural Practices (GAP)[54], core agro-ecological principles, fair prices, decent work, local resource inputs, and natural habitat conservation.

The systematic review of evidence revealed two messages:

1. There are several evidence based options for cotton farmers and the supply chain to better manage their natural capital impacts and reduce their vulnerability to its degradation
2. For many of the selected interventions there is poor understanding of how they impact natural capital within specific contexts

http://www.cisl.cam.ac.uk/publications/natural-resource-security-publications/threading-natural-capital-into-cotton

3.2 Categorising the evidence for decision-making

As well as concerns around natural capital, the businesses involved identified six additional categories to be considered when assessing possible interventions, these are highlighted in Table 1.

CATEGORISATION	REASON
Natural capital	Natural capital underpins raw material production which businesses depend upon to ensure the long-term security of cotton supply chains
Cost of implementation	Interventions have costs associated with them, which can impact profitability as well as human and social capital at varying temporal and geographic scales
Yield	Interventions can have positive and negative impacts upon the yield of cotton which vary depending on how and where they are implemented
Fibre quality	Interventions can impact the quality of cotton fibre which determines the price received by farmers and supply chain opportunities
Geographical spread	Not all interventions are applicable in all regions of the world; understanding where they have been successful is fundamental to contextualising impacts
Conditions	Interventions and their effectiveness differ for non-irrigated and irrigated systems
Size	Interventions are applicable to small scale farms and/or larger farms

Table 1: *Categorisation of interventions*

3.2.1 Natural capital

Natural capital was classified as the following:

	**Water:**	Including water quality and/or quantity
	**Biodiversity:**	Including diversity and/or abundance
	**Soil:**	Including structure and/or fertility

Table 2: *Natural capital classifications*

A business must decide its priorities regarding water, biodiversity and soil; this will be dependent upon the context and natural resource challenges of particular sourcing locations.

Some of the interventions tackle water, biodiversity and/or soil impacts in either a positive (positive impact derived from an abundance of scientific evidence) or a likely positive way (assumed positive impact based on common sense, experience from practice, research related to other crops or some scientific evidence).

It was expected that some interventions would have more positive impacts on natural capital but the systematic review suggested that there is not always enough scientific evidence to support these assumptions. For this reason, the analysis (pages 18-19) may appear incomplete; for details of how the conclusions were drawn see the Technical Report.

Part 3: Interventions to safeguard natural capital *continued*

3.2.2 Cost of implementation

The cost of implementing an intervention can be considered as a barrier if it is too high; however, if implemented correctly, can play a significant role in cost reduction.

The relative values of costs are summarised in Table 3. The indicative cost of implementation should not be considered in isolation as it will vary by geographical location, temporal effectiveness, input accessibility/ availability and labour implications.

$	**Low:** Affordable solution for the majority of farmers in developing, as well as developed, countries. Knowledge, risk management or other non-financial factors could be the only obstacles preventing implementation.
$$	**Medium:** The solution faces some capital requirements, imposing some constraints on implementation, which may be amplified in a developing country environment. However, the solution would produce a reasonable return on investment if implemented.
$$$	**High:** Capital intensive solution, which could be highly problematic for developing, as well as developed, countries to implement due to financial requirements. The solution may not be viable from a supply chain perspective.

Table 3: *Relative values of costs*

3.2.3 Yield

The interventions impact on cotton production yield in a number of ways, as highlighted in Table 4.

	**Increases:** Evidence shows that the intervention increases yields
	**Decreases:** Evidence that the intervention decreases yields
	**Is not affected:** Yield has not changed as a result of the intervention.
	**Limited Evidence:** There is limited or mixed evidence on the impacts of the intervention on yields and no conclusion can be drawn.

Table 4: *Impacts on yield*

3.2.4 Fibre quality

The quality of fibre determines the price received by farmers and can be impacted by different interventions. While spinner and ginner priorities may differ, a relative indicator for impact on fibre quality was assigned to each intervention (Table 5).

	**Increases:** Evidence shows the intervention generally improves the spinnability of cotton fibre
	**Decreases:** Evidence shows the intervention frequently lowers the spinnability of cotton fibre
	**Is not affected:** There is no evidence that the intervention consistently impacts the spinnability of cotton

Table 5: *Impact on fibre quality*

3.2.5 Geographical contribution to the evidence

The interventions require an understanding of the context in which they are applied; they are not applicable to all regions of the world.

The assessed evidence regarding the impacts and dependencies of cotton production on water, biodiversity and/or soil came from around the world but the majority of the studies focused on Asia (Figure 5).

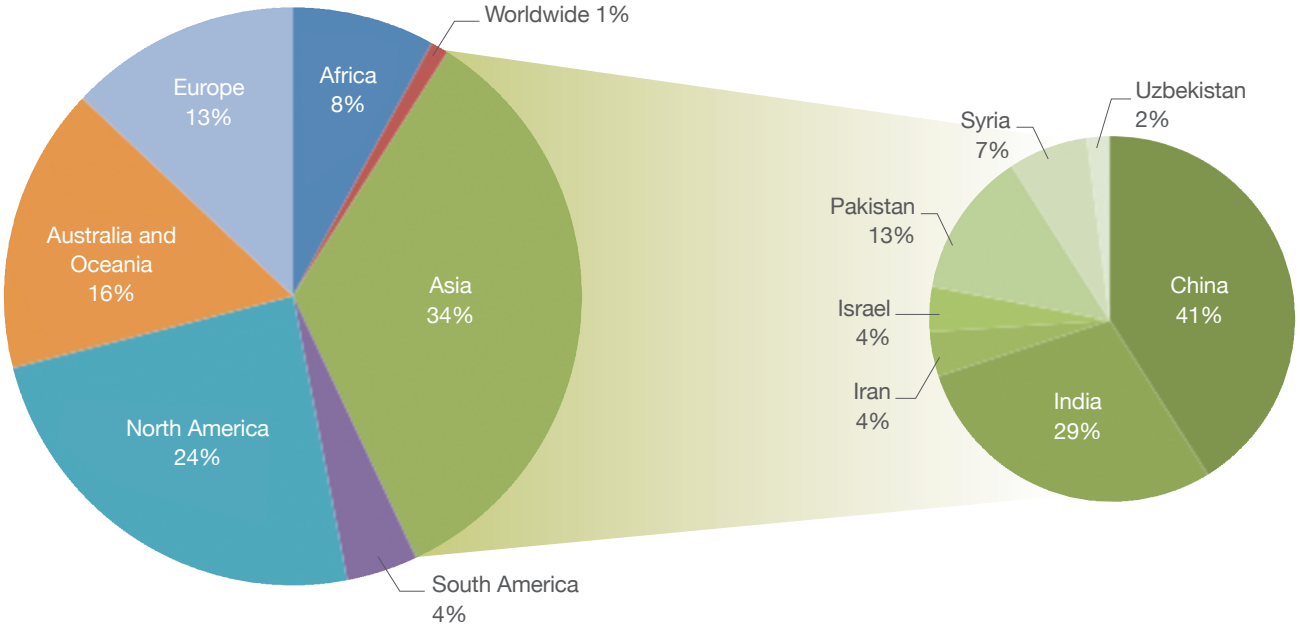


Figure 5: *The 160 critically assessed studies were from a number of regions but there is a significantly biased geographical spread due to the availability, accessibility and feasibility of scientific research.*

Summary of interventions and their categorisations

Details of these interventions and the evidence supporting them can be found in the Technical Report. The chapters refer to the sections within this more detailed report.

Chapter 1: Drip Irrigation

Evidence	Yield	Cost	Quality
Positive	Positive	Limited	Increases	$$$ High	Increases

Definition and purpose: Installing surface or sub-surface irrigation systems to provide water directly to plant roots and reduce evaporative water losses
Benefits: Maximises water use efficiency; minimises losses to evaporation; and reduces weed growth

Chapter 2: Deficit Irrigation

Evidence	Yield	Cost	Quality
None	Positive	Limited	Decreases	$ Low	Is not affected

Definition and purpose: Implementing irrigation schedules that maximise water use efficiency rather than yield per unit area as a means of reducing water consumption
Benefits: Maximises water use efficiency; relieves pressure on water supplies; and minimises negative impacts to yield or quality

Chapter 3: Irrigation with Brackish or Saline Water

Evidence	Yield	Cost	Quality
Negative	Positive	None	Decreases	$ Low	Decreases

Definition and purpose: Using water with high salt concentration to irrigate crops and to reduce freshwater consumption for cotton production in water scarce areas
Benefits: Reduces reliance on scarce freshwater supplies; and increases cotton production in water scarce areas while potentially damaging soil structure and causing soil aggregates to disperse (deflocculation)

Chapter 4: Recycling Cotton Gin Waste

Evidence	Yield	Cost	Quality
Positive	Positive	None	Increases	$ Low	Increases

Definition and purpose: Post-processing use of cotton gin waste (a by-product of separating cotton fibre from seeds) as, for example, compost as a means of creating value from a by-product and reduce reliance on other inputs to cotton production
Benefits: Improves soil physical, chemical and biological characteristics; reduces reliance on inorganic fertilisers; and improves water quality

Chapter 5: Fertilisation using Plant Waste

Evidence	Yield	Cost	Quality
Positive	None	Positive	Increases	$ Low	Increases

Definition and purpose: Using organic matter (plant waste or compost) to fertilise fields and composting these leftover plant residues to improve soil properties
Benefits: Benefits long term soil health; builds more resilient systems; increases yields; and reduces usage of synthetic fertilisers

Chapter 6: Animal Manure

Evidence	Yield	Cost	Quality
Positive	None	None	Increases	$ Low	Is not affected

Definition and purpose: Incorporating animal manure into cotton crop fertilisation nutrient management plans as a means of fertilising crops using an organic waste product
Benefits: Improves soil health; and reduces reliance on synthetic fertiliser

Chapter 7: Organic Pesticide

Evidence	Yield	Cost	Quality
None	Limited	Mixed	Limited evidence	$$ Medium	Is not affected

Definition and purpose: Using pesticides made from plants with insecticidal properties to control pests organically
Benefits: Reduces pest incidence; and reduces need for synthetic pesticides

Chapter 8: Pesticide Use Optimisation

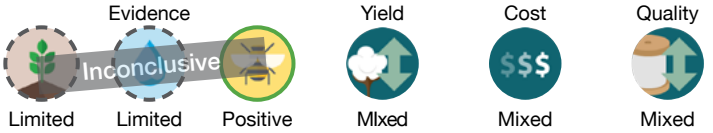
Evidence	Yield	Cost	Quality
Positive	Positive	Positive	Limited evidence	$ Low	Increases

Definition and purpose: Optimising the amount of pesticide used as a means of controlling pests and weeds while minimising unnecessary pollution or negative impacts on non-target organisms
Benefits: Reduces pesticide use; reduces risk of water pollution; and reduces likelihood of harming beneficial insects

Chapter 9: Habitat Management for Predators

Definition and purpose: Managing habitats around cotton fields to create favourable natural habitats for beneficial insects
Benefits: Reduces insecticide use; reduced water/soil pollution; and conservation of beneficial insects

Chapter 10: Promoting Biocontrol through Genetic Modification[a]



Definition and purpose: Controlling pests by using crop breeding and genetic modification to promote natural predators
Benefits: Eliminates or delays application of insecticides; promotes natural predation; and reduces water/soil pollution

Chapter 11: Crop Rotation

Definition and purpose: Growing a rotation of different crops in different years and during different seasons to improve long-term soil fertility and nutrition with time as well as to enhance biological control
Benefits: Eliminates or delays application of insecticides; promotes natural predation; and reduces water/soil pollution

Chapter 12: Habitat Diversity

Definition and purpose: Safeguarding habitat diversity on farmed lands and managing different types of vegetation within-crop and within-field to protect insects, including the beneficial insects that predate upon cotton pests and maintain soil fertility and structure
Benefits: Reduces incidence of pests; reduces insecticide use; protects other species; and maintains ecological productivity

Chapter 13: Keeping a Tidy Farm

Definition and purpose: Removing weeds and spontaneously appearing crops from cotton fields to reduce competition for nutrients and remove potential harbours of pests
Benefits: Increases crop yields; and reduces pest populations

Chapter 14: Removing Volunteer Cotton

Definition and purpose: Removing volunteer (spontaneously appearing) cotton from cotton fields to remove harbours for cotton pests, prevent wasting fertiliser and moisture on unwanted crops and avoid unfavourable gene flows
Benefits: Maintains yields and quality

Chapter 15: Limiting Cotton Expansion

Definition and purpose: Limiting cotton expansion to previously farmed land to avoid clearing new areas of natural habitat for cotton production
Benefits: Reduces controversies over land rights; prevents clearing; and decreases loss of native biodiversity

[a]Due to the nature of the search criteria that was used to draw evidence on promoting biocontrol through genetic modification, the results are inconclusive; a number of other searches and studies would have to be included in the review to yield any sort of categorical claims. More detail can be found in the Technical Report

Part 4

The tool

The cotton tool can help businesses determine the types of interventions that they should be discussing with their supply chains to secure the natural capital needed for a sustainable supply of cotton

The online tool enables users to explore the interventions that are material to their business (Figure 6). It converts the Technical Report, which provides a wealth of information, into an accessible tool that is easy to navigate and logical.

The tool will enable users to:

- Influence the supply chain on natural capital issues
- Engage more confidently in conversations with farmers, extension workers and partners on the ground
- Explore where interventions have proven to result in positive outcomes for cotton and natural capital
- Identify where gaps exist that need further research

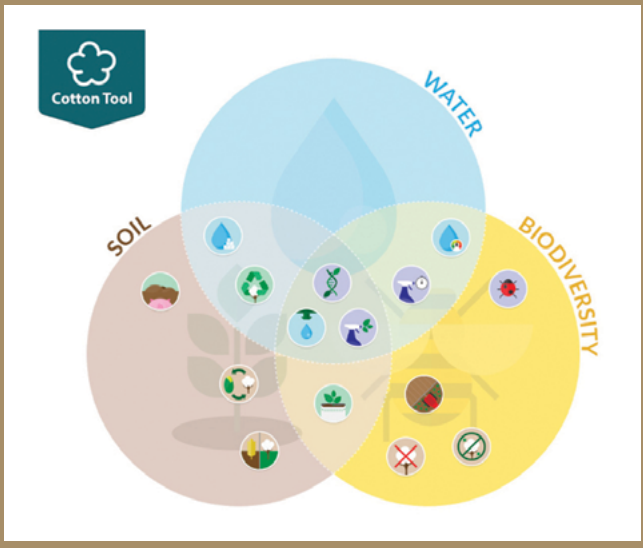


Figure 6: A screenshot of the tool at www.cottontool.com

The tool allows users to apply filters so they can explore interventions that are most relevant to their cotton production contexts (Figure 7). They can then investigate the interventions based on their assumed benefits for water, biodiversity and/or soil.

Figure 7: The tool enables users to explore interventions depending on different contexts.

Users can select the interventions that are of interest to their business which are summarised in the final part of the online tool. Factsheets for each intervention can also be downloaded.

Part 5

Additional considerations

There are a variety of additional considerations before making key decisions

5.1 Seek expert advice

It is not always straightforward to determine the right interventions that may be effective, and it is best to seek expert advice from people on the ground who know the crop and the landscape. Experts can also advise on issues such as social implications and the option of education. These have positive impacts upon natural capital challenges; for example, upskilling and incentives are likely to be important to manage water quality without understanding the local community it is difficult to implement training schemes[55].

Natural capital is but one of a number of issues that should be considered when looking to create sustainable and resilient supplies of cotton. This report focuses upon natural capital and analyses the scientific literature and evidence that is currently available as pertains to water, biodiversity and soil. It acknowledges that a number of other factors, including social and economic, need to be assessed and that expert advice should be sought before any action is taken.

5.2 Timing

Decisions (such as tillage, fertilisation, pest management and irrigation) taken in one year on one field have relevance for multiple years and multiple crops. Timing of interventions is therefore important. Agronomists and input developers now look at entire cropping systems not just a single crop.

5.3 Understanding context

Contextualising cotton production systems is fundamental when assessing natural capital. Some cotton is rain fed and can therefore be considered to be the most efficient in terms of water use but in other arid contexts a rain fed crop would not be successful. It is important to understand the conditions and alternatives under which cotton is being grown before identifying interventions.

Sometimes the most obvious choice is not the right one to implement and understanding the context is vital. For instance, where water resources are scarce (or variable), irrigation strategies for maximum yield may need to be switched in favour of reducing irrigation to maximise crop water use efficiency. Although such strategies may not see economic benefits to individual farmers in the short term, if applied across a landscape they may benefit local communities, the environment and, in the longer term, the farming community itself.

5.4 Addressing broader issues of balancing supply and demand

Subsidies can encourage the overproduction of cotton resulting in increases in global supply; this can reduce global cotton prices. These subsidies along with currency devaluation can also have significant impacts upon farmers where they can be driven more deeply into poverty; this is particularly so in West Africa [56,57]. This can have a double impact as the prices of inputs, which tend to be determined by that of energy, are rising. These farmers are at the end of a long and complex cotton supply chain.

Part 6

Barriers to implementation

6.1 Farm level barriers

Farmers are often keen to adopt measures that improve their environmental performance, especially when it can also enhance the profitability of their business [58]. However, uptake may be limited by the perceived security of the natural resource supply or by its cost and the farmers' confidence in future production and prices. Therefore, it is crucial to consider the natural capital implications of different interventions alongside the farmers' profits and demonstrate the positive outcomes for both.

Farmers take on the greatest burden of risk and uncertainty, so they need confidence in the evidence that a change in their farming practice is going to be successful and reduce their risks in both the short- and long-term. There is a need to upskill farmers on the benefits of natural capital interventions and how these production methods can be implemented and provide them with the appropriate incentives for doing so.

For consumers to make informed decisions about purchasing products that are more sustainable, it is necessary to account for the cost of negative externalities in the pricing of retailed goods.

6.2 Supply chain barriers

For consumers to make informed decisions about purchasing products that are more sustainable, it is necessary to account for the cost of negative externalities in the pricing of retailed goods.

Whilst most cotton is, in theory, traceable upon arrival at the gin, there is a significant complexity associated with tracing opaque supply chains to their source, particularly as cotton is a globally traded commodity. Addressing such a complexity would transfer the responsibility for sustainable cotton growing further down the supply chain to manufacturers and retailers and help business take appropriate action to secure natural capital. Many businesses are now demanding greater transparency in their supply chains and several programmes are designed to allow full traceability. Vertically integrated supply chains can increase transparency and also help businesses be prepared to react to shocks in the supply chain.

6.3 Research barriers

There is lack of scientific evidence around landscape level approaches and the scalability of interventions across different time scales and geographical and cultural boundaries. A stronger evidence base is needed which includes both quantitative and qualitative data. There are many gaps and biases around where research is carried out, how it is funded and how it is translated practically for business application.

Fairtrade International (Senegal)

Part 7

Key messages and call to action

Threading natural capital into cotton presents challenges and opportunities: it is time to take action

1. Consider natural capital
The industry needs to have a greater recognition and understanding of the water, biodiversity and soil that underpins the production of cotton and businesses need to take natural capital into account in their decision making.

2. Integrated management
Developing cotton production systems that are both sustainable and resilient requires a holistic and balanced approach; natural capital management needs to be an integral part of the puzzle, alongside social and human capital, in defining business practices for sustainable cotton production.

3. Continuous adaptation
It is of critical importance that companies assess their natural capital impacts on an ongoing basis; the complexity around cotton production systems demands a sophisticated solution that involves ongoing adaptive management as well as continuous measurement and evaluation of impacts.

4. Strengthening the evidence base
A solid and strengthened evidence base is necessary for businesses to make better informed decisions that work towards securing natural capital for their cotton supply chains.

Call to actions

This group of businesses, cotton initiatives and experts calls to those in the cotton supply chain to accelerate action on natural capital. Closer collaboration between businesses, cotton initiatives and cotton field experts is required to inform the next iteration on the debate.

There is a need to strengthen the progress that has already been made around creating sustainable and resilient cotton supply chains; to take this step forward:

(a) The industry as a whole needs to start considering natural capital within supply chains

(b) The cotton initiatives have a role to play in ensuring that research is translated into ‘on the ground’ action within the different production systems

(c) Researchers and experts should contribute through focused research to strengthen the evidence base and inform scalability

Through conscious, collective and evidence-based efforts to enhance natural resource dependencies, the industry will be able to deliver secure, sustainable supplies of cotton.

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