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The ICAC Recorder

International Cotton Advisory Committee

Sustainability of Agriculture, Textiles & Funding for Agricultural R&D

The ICAC Recorder

Editorial

Regular readers of the ICAC RECORDER are likely acquainted with the ongoing discussions around sustainability in cotton production systems. However, in this issue, we take a slight detour from the well-trodden path to explore the intersection of textiles and agricultural R&D funding. Despite this departure, the articles presented here share a common concern with sustainability, specifically the sustainability of agriculture, textiles, and agricultural R&D funding.

The concept of 'sustainability' has become a critical consideration in every aspect of our lives, guiding the direction of our plans for a safe and secure future for future generations. It is not an overstatement to say that the world is now fully engaged with the topic of sustainability. In essence, all paths ultimately lead to the goal of sustainability.

The current edition of the ICAC RECORDER highlights four articles that address the topic of sustainability. Included among them are two articles by Mr. Kanwar Usman concerning textiles, an article by Dr. Akhteruzzaman on carbon farming, and an article by Dr. Alexandro Plastina and Dr. Terry Townsend on 'World Spending on Agricultural Research and Development'.

Mr. Kanwar Usman was appointed by the ICAC to lead its new textiles division last year. During the past 18 months, he has focused on developing platforms to assist ICAC members with policies related to textiles, with a particular emphasis on improving sustainability throughout the textile value chain. In his article titled 'Organic Standards in Textiles Processing and Product Certification,' Mr. Usman proposes a roadmap to enhance policies and collaborations in existing sustainability initiatives, which can lead to a reduction in GHG emissions related to energy, logistics, and manufacturing of raw materials and chemicals. In his second article, as Chair of a session at the 80th ICAC plenary meeting, Mr. Usman summarizes lectures delivered by seven prominent speakers in the session titled 'Rethinking Fashion and Textiles for 2030.' Interestingly, all the speakers emphasized the role of textiles in contributing to national economies and highlighted the emerging challenges related to sustainability.

In his article titled 'Low Carbon Agriculture for a Better Environment,' Mr. Akhteruzzaman outlines fundamental strategies for achieving carbon efficiency in agriculture. He emphasizes that 'The transition to carbon-efficient practices in agriculture is critical for balancing economic, environmental, and social objectives, with the primary goal of mitigating climate change and promoting sustainable development.'

Dr. Alejandro Plastina and Dr. Terry Townsend address concerns regarding the decreasing allocation of funds for agricultural research and development (R&D) and its potential impact on sustainability in their article titled 'World Spending on Agricultural Research and Development'

A recent report published by the Breakthrough Institute, Berkeley, echoed similar sentiments. The report 'Growing Green The Environmental Benefits Of Public Agricultural Research & Development' https://thebreakthrough.imgix.net/Growing-Green_Report_v7.pdf states that "*…after years of steady growth, public agricultural R&D funding in the United States is waning. The United States no longer leads the world in public agricultural R&D funding. Falling R&D investment threatens to forfeit the advantages and benefits of agricultural advancements in the face of increasing global competition and new threats, such as climate change, geopolitical strife, and the COVID-19 pandemic*." The report also states that "*Increasing federal R&D funding can maintain, if not increase, the competitiveness of US farmers while representing one of the greatest opportunities to mitigate greenhouse gas emissions from agriculture, reduce land use, and keep food prices low around the world*". Indeed "*Growth in agricultural productivity has reduced food prices; cut the carbon footprint of milk, chicken, beef, and many other products; reduced land use; and led to more efficient use of many resources. This modern miracle of agricultural abundance owes much to over a century of public funding for agricultural research and development (R&D)*".

In conclusion, this edition of the ICAC RECORDER has shed light on the crucial role that sustainability plays in the cotton industry and beyond. From the importance of organic standards in textile processing to the need for low-carbon agriculture and the challenges facing agricultural R&D funding, the articles presented in this issue provide valuable insights into the efforts being made to achieve sustainable development. We hope that this discussion will inspire readers to engage further with the subject of sustainability and encourage them to take action towards building a more sustainable future.

– Keshav Kranthi

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The ICAC Recorder

Organic Standards in Textiles Processing and Product Certification

Kanwar Usman

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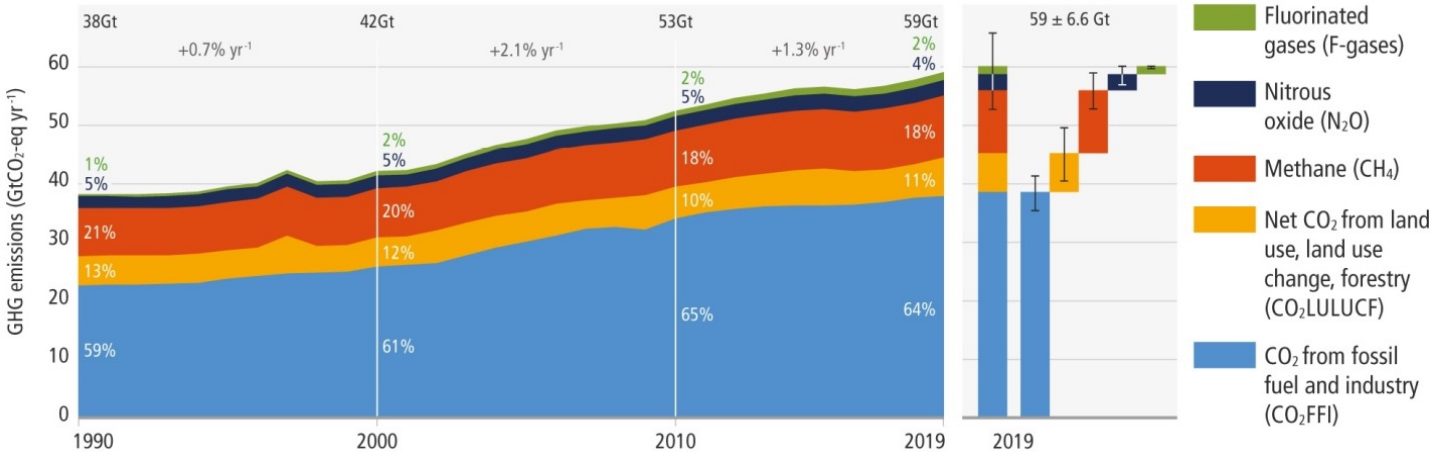
Kanwar Usman, a 1999 graduate of the National Textile University in Pakistan, has been appointed as the first-ever Head of Textiles at the International Cotton Advisory Committee (ICAC). With 23 years of experience in the textiles value chain, Usman has worked in various roles including production, teaching, retail brands, and in government for policy formulation and implementation. During his early years of practical experience, Usman worked with Nishat Mills where he was responsible for the installation of a spinning unit. He also worked as a lecturer at the National Textile University and completed his MBA program at the University of East London.

Usman worked for the Ministry of Commerce and Textile for 15 years and headed Research, Development and Advisory Cell and Textile Wing for 12 years. He played a pivotal role in formulating three textiles policies in Pakistan and designed and operated several support schemes to promote trade and improve competitiveness in the textiles value chain. In his current role at ICAC, Usman is responsible for providing advice to member countries on the development of their textiles value chain. He also provides a platform for sharing best practices, innovation, and sustainability measures for the textiles and allied industries.

Introduction

Global net anthropogenic greenhouse gas (GHG) emissions increased from 38 $GtCO_2$-eq in 1990 to 59±6.6 $GtCO_2$-eq in 2019, representing a 154% increase compared to 1990 (IPCC, 2022). CO_2 emissions from fossil fuel and industry (CO_2FFI) remained the highest, increasing from 23 $GtCO_2$-eq in 1990 to 38±3 $GtCO_2$-eq in 2019, a 167% increase. CO_2 emissions from land use, land-use change, and forestry (CO_2 LULUCF) increased by 133%, reaching 6.6±4.6 $GtCO_2$-eq in 2019 compared to 5 $GtCO_2$-eq in 1990. Between 1990 and 2019, methane (CH4) emissions increased from 8.6 $GtCO_2$-eq to 11±4 $GtCO_2$-eq, fluorinated gases (F-gases) from 0.43 $GtCO_2$-eq to 1.4±0.41 $GtCO_2$-eq, and nitrous oxide (N2O) from 2.05 $GtCO_2$-eq to 2.7±1.6 $GtCO_2$-eq.

Figure 1: Global Net Anthropogenic GHG Emissions 1990-2019 (Source: IPCC 2022)



In 2019, approximately 34% (20 $GtCO_2$-eq) of total net anthropogenic GHG emissions came from the energy supply sector, and 24% (14 $GtCO_2$-eq) from industry. When emissions from electricity and heat production are attributed to the sectors using the final energy, 90% of these indirect emissions are allocated to the industry, increasing its relative GHG emissions share from 24% to 34%. CO_2FFI accounts for the largest share of global net emissions.

Textiles

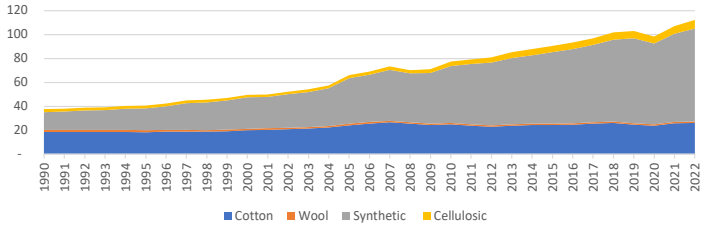
Textiles encompass a lengthy value chain, beginning with fibres that can be natural, synthetic, or artificial. Over time, global fibre consumption has experienced significant growth, with projections indicating continued expansion. As reported by the

International Cotton Advisory Committee (ICAC, 2021) in their annual World Textiles Demand publication, global fibre production rose to 107 million tonnes in 2021, a substantial increase from the 37 million tonnes produced in 1990.

Table 1: Global Net Anthropogenic GHG Emissions 1990-2019

	2019 Emissions $GtCO_2$-eq	1990 to 2019 Increase $GtCO_2$-eq	Emissions in 2019 - Relative to 1990 %
CO_2FFI	38±3	15	167
CO_2LULUCF	6.6±4.6	1.6	133
CH_4	11±4	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

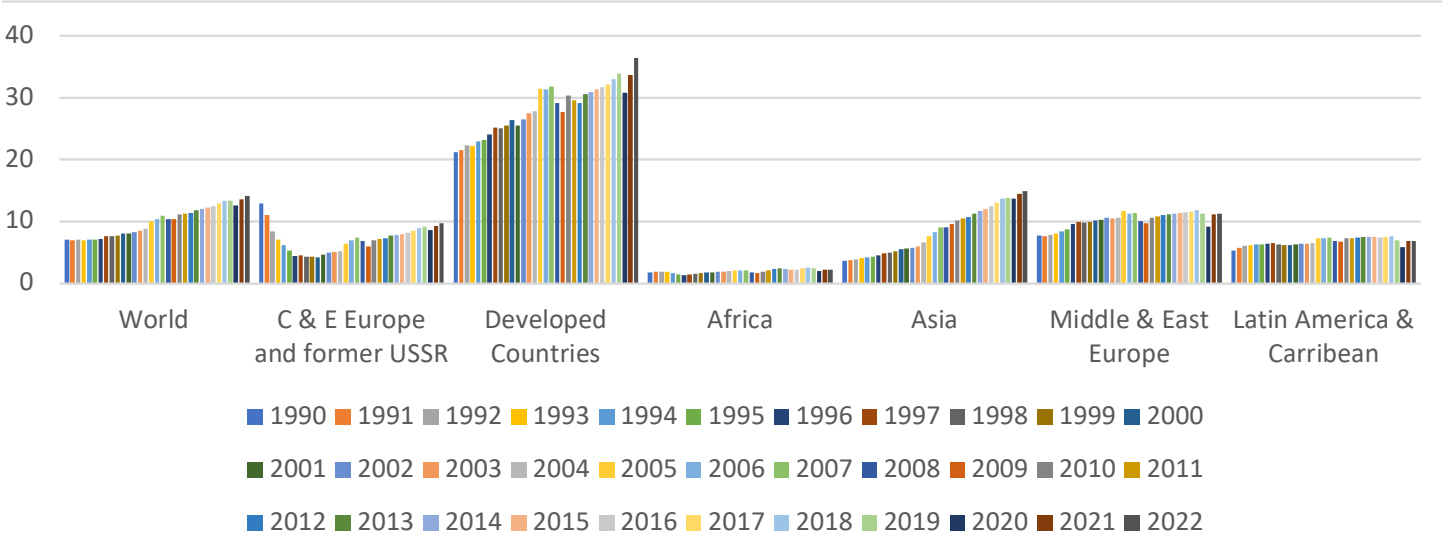
Figure 2: Fiber Consumption in Million Metric Tonnes 1990-2021



Source: World Textiles Demand, International Cotton Advisory Committee, 2022

The rise in textile consumption can be attributed not only to population growth but also to the increased per capita consumption. According to ICAC, per capita textile fibre consumption grew from 7.11 kg/capita in 1990 to 14.14 kg/capita in 2022. In developed countries, per capita consumption increased from 21.19 kg/capita in 1990 to 36.46 kg/capita in 2022. Asia experienced a remarkable surge in per capita consumption, rising from 3.73 kg/capita in 1990 to 14.91 kg/capita in 2022.

Figure 3: Textiles Fiber Consumption, Kg / Capita (Source: World Textiles Demand, International Cotton Advisory Committee, 2022)

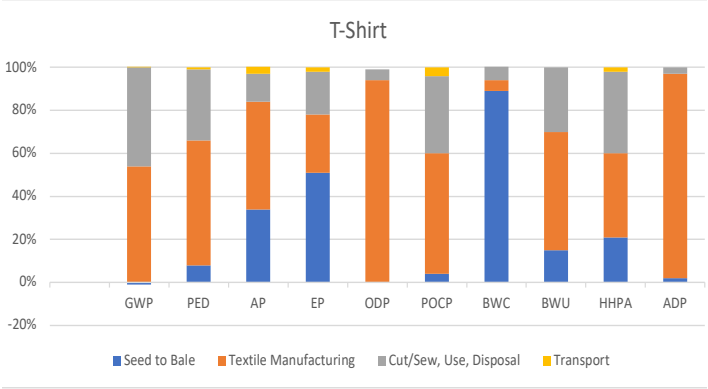


It is anticipated that per capita consumption in Asia will continue to grow as more individuals enter the middle and high middle-income brackets.

Life Cycle Assessment

Life Cycle Assessment (LCA) provides a comprehensive evaluation of the environmental impacts and resource usage of a product, from the raw materials utilized in its production to its disposal at the end of its life. A crucial element of LCA is the Life Cycle Inventory (LCI), which quantifies relevant energy, material input, and environmental release data associated with manufacturing and other processes. When examining the entire life cycle of cotton, the textile manufacturing and consumer use phases account for the majority of impacts across various categories (Cotton Inc., 2016). The assessment takes into consideration Global Warming Potential (GWP), Primary Energy Demand (PED), Acidification Potential (AP), Eutrophication Potential (EP), Ozone Depletion Potential (ODP), Photochemical Ozone Creation Potential (POCP), Blue Water Consumption (BWC), Blue Water Use (BWU), Human Health Particulate Air (HHPA), and Abiotic Resource Depletion Potential (ADP).

Figure 4: Relative Contribution to Each Impact Category of Knit T-shirt (Source: LCA, Cotton Incorporated)



In considering the entire cotton life cycle, the textile manufacturing and consumer use phases dominate most of the impact categories. This is primarily due to garment laundering, high electricity usage in fibre processing, and energy expenditures related to conditioning, processing, heating, and drying of water during preparation, dyeing, and finishing processes. While agricultural production's contribution to the total impact is lower than consumer use and textile manufacturing phases in most categories, water consumption, eutrophication, acidification, and field emissions associated with nitrogen fertilizer, irrigation, and ginning are identified as significant contributors to overall impact.

Hot-Spots In Textile Value Chain

Key hotspots in the textiles value chain are summarized in the "Sustainability and Circularity in the Textile Value Chain" report (UNEP, 2020) and the "Catalysing Science Based" report (UNEP, 2021), as follows:

Fibre Production:

- Extensive use of fossil fuels in synthetic fibre production, leading to impacts on climate, health, and ecosystems.
- Significant use of agrichemicals, land, and water for natural fibre production, particularly cotton, affecting biodiversity and ecosystems.
- Unsafe working conditions and fragile legal systems, resulting in health and social risks.

Textile Production:

- Heavy reliance on fossil fuels for heat and electricity generation in energy-intensive textile processes, causing impacts on climate, health, and ecosystems.
- Utilization of hazardous chemicals, which affect health and ecosystems, particularly through water pollution.
- Release of microfibres, impacting ecosystems and potentially human health.
- Unsafe working conditions and fragile legal systems, leading to health and social risks.

Use Phase:

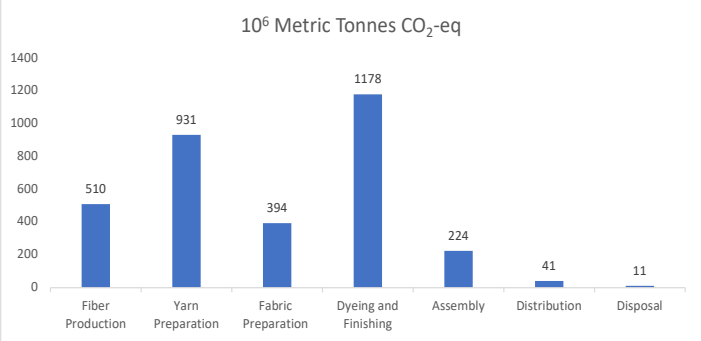
- High electricity consumption during textile care throughout their lifetime, with fossil fuels used for energy production, leading to impacts on climate, health, and ecosystems.
- Extensive water usage and release of microfibres during textile washing, contributing to water scarcity and impacts on ecosystem health.

End-of-Life:

- Low recovery rates of textiles at the end of their life, resulting in substantial material value loss and depletion of non-renewable resources.

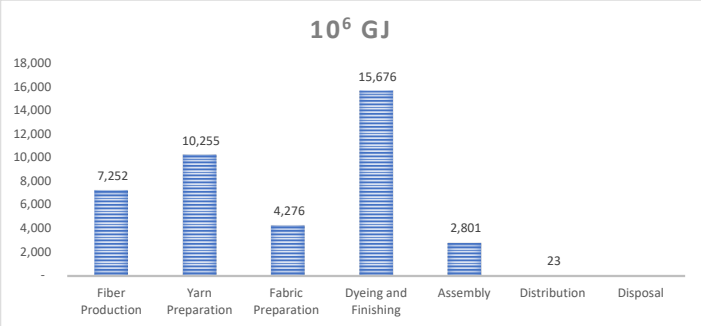
Furthermore, reports like "Carbon Emissions in the Garment Sector in Asia (ILO, 2021)" and "Measuring Fashion (Quantis, 2018)" have also evaluated the environmental impact of the global apparel sector.

Figure 5: Climate Change Impacts by Life Cycle Stage based on multiple fibers (Source: Measuring Fashion, Quantis 2018)



The study highlighted that these impacts stem from the apparel industry's dependence on hard coal and natural gas for electricity and heat generation. Dyeing processes demand high energy due to the wet processes employed, which involve heating large quantities of water. Fabric preparation (knitting and weaving) and yarn preparation (spinning) primarily require electricity and little to no additional heat, leading to a reduced impact on climate change. Hard coal and natural gas contribute to 60% to 70% of the climate change impacts during the dyeing and finishing stage.

Figure 6: Resources (Source: Measuring Fashion, Quantis 2018)



The dyeing and finishing, yarn preparation, and fibre production stages exhibit the most significant impacts on resource depletion. This is primarily due to the energy-intensive processes reliant on fossil fuel energy. Notably, the study estimates that if the business-as-usual scenario persists, GHG emissions could increase to 4.01 $GtCO_2$-eq.

In 2018, stakeholders from the garment sector collaborated to commit to climate action through the United Nations Framework Convention on Climate Change (UNFCCC) Fashion Industry Charter for Climate Action (UNFCC, 2021). Signatories of the charter pledged to reduce greenhouse gas (GHG) emissions by 30% by 2030, based on a 2015 baseline, and to achieve net-ze-

ro emissions by 2050. This commitment poses a significant challenge, as achieving this reduction would require over half a billion tonnes of carbon dioxide to be reduced across the sector per year by 2030. Meeting this challenge will require system-level changes in the production and consumption of textiles and garments, which will likely have significant impacts on how and where garments are produced, and the employment associated with this production (ILO, 2021).

Figure 7: Textiles Climate Change in 2030 in Business-as-Usual Scenario (Source: Measuring Fashion, Quantis 2018)

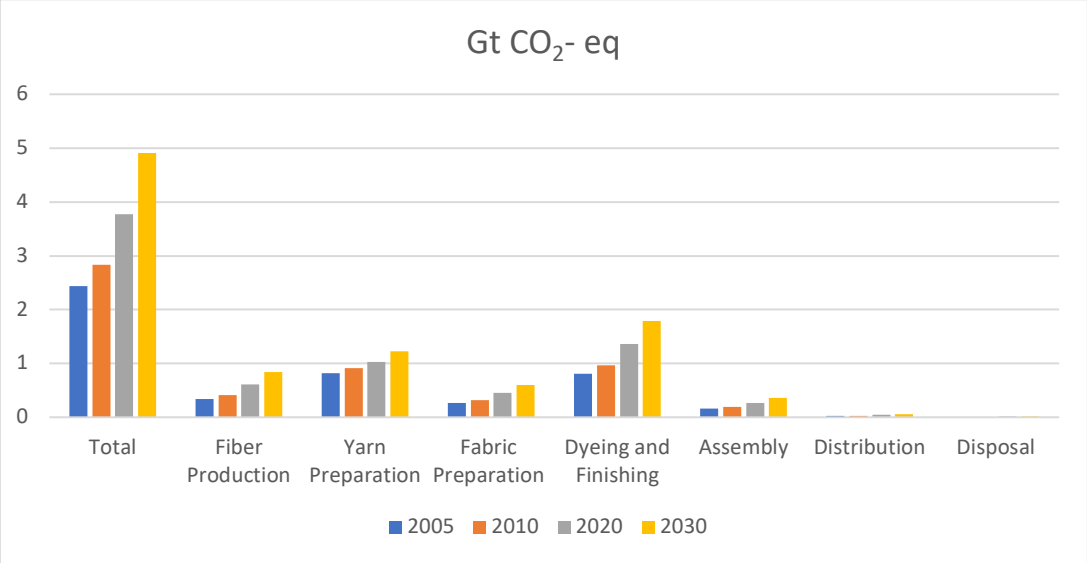
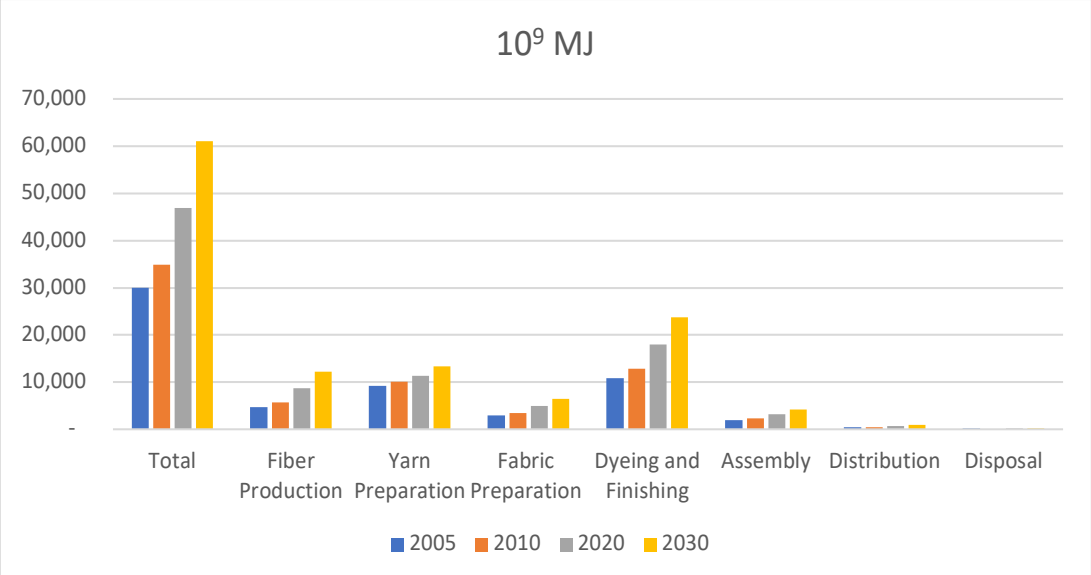


Figure 8: Textiles Resources in Business-as-Usual Scenario (Source: Measuring Fashion, Quantis 2018)



Taking into consideration the impact of fibres and textiles on the climate, key players around the world have become increasingly aware of their responsibility towards sustainability and the environment for over a decade. The sustainability of the value chain can be evaluated based on three dimensions: economic, environmental, and social impact. Environmental impact includes greenhouse gas emissions (also known as the cotton footprint or climate change impact), as well as other emissions to air, water, and land, depletion of resources, non-renewable energy use, land use, water use, and diminished ecosystem quality.

The use of organic textiles can contribute to controlling pollution and making products free from negative environmental impacts. Organic textiles can consist of natural, cellulosic, or synthetic fibres. Cotton and polyester are two major raw materials used in the textile value chain. Conventional cotton is one of the most chemically intensive crops, with serious consequences for the climate. On the other hand, organic cotton is grown with methods that focus on building ecosystem health. Farmers cannot use toxic persistent pesticides, synthetic fertilizers, or genetically modified organisms. Organic farmers also must use methods that build soil health and support on-farm biodiversity (Shade and Delate, 2021). The importance of organic cotton is evident from the fact that the Global Warming Potential (GWP) for organic cotton for 1,000 kg of fibre is 978 $KgCO_2$-eq, while for conventional cotton, it is 2,446 $KgCO_2$-eq (Angela, 2019). Therefore, using organic cotton can significantly reduce greenhouse gas emissions and contribute to a more sustainable textile industry (La Rosa and Grammaticos, 2019).

Polyester is the widely used fibre in textiles. Production of conventional polyester apparel starts with the extraction of crude oil. This non-renewable fossil fuel recourse consists of thousands of different organic compounds, including pure hydrocarbons, and molecules with functional groups containing, oxygen, nitrogen, and certain minerals (Speight, 2011). Crude oil is such a complex mix, it must be refined and

processed to obtain the building blocks of PET, namely ethylene glycol and purified terephthalic acid (PTA). This is achieved by heating, distillation and other processes that release harmful toxins (Greene, 2014) such as BTEX compounds (benzene, toluene, ethylbenzene, and xylene), particulate matter, nitrogen oxides (NOx), SO2 and CO. Ethylene glycol and PTA react by condensation to form ethylene terephthalate units, which are then linked via ester bonds (CO–O) to form the long chains of PET. In theory, ester bonds can be hydrolysed, which means PET can be de-polymerized, but the large aromatic ring gives PET notable stiffness and strength, especially when the polymer chains are arranged in an orderly manner as in the case of textile fibres, making PET highly resistant to biodegradation at its end-of-life phase (Mandal, 2019). The PET is then used to produce fibre and then spun into yarn and then fabric. Fabric is then processed and there are more than 15,000 chemicals that can be used during the fabric processing (Roos et al., 2019). The entire process may require significant amount of energy approximately 125 MJ/Kg polyester fibre which results in emission of 27.2 KgCO2-eq/kg of polyester woven fabric. In general, synthetic fibres show a higher impact on climate change than natural fibres (Beton, 2014).

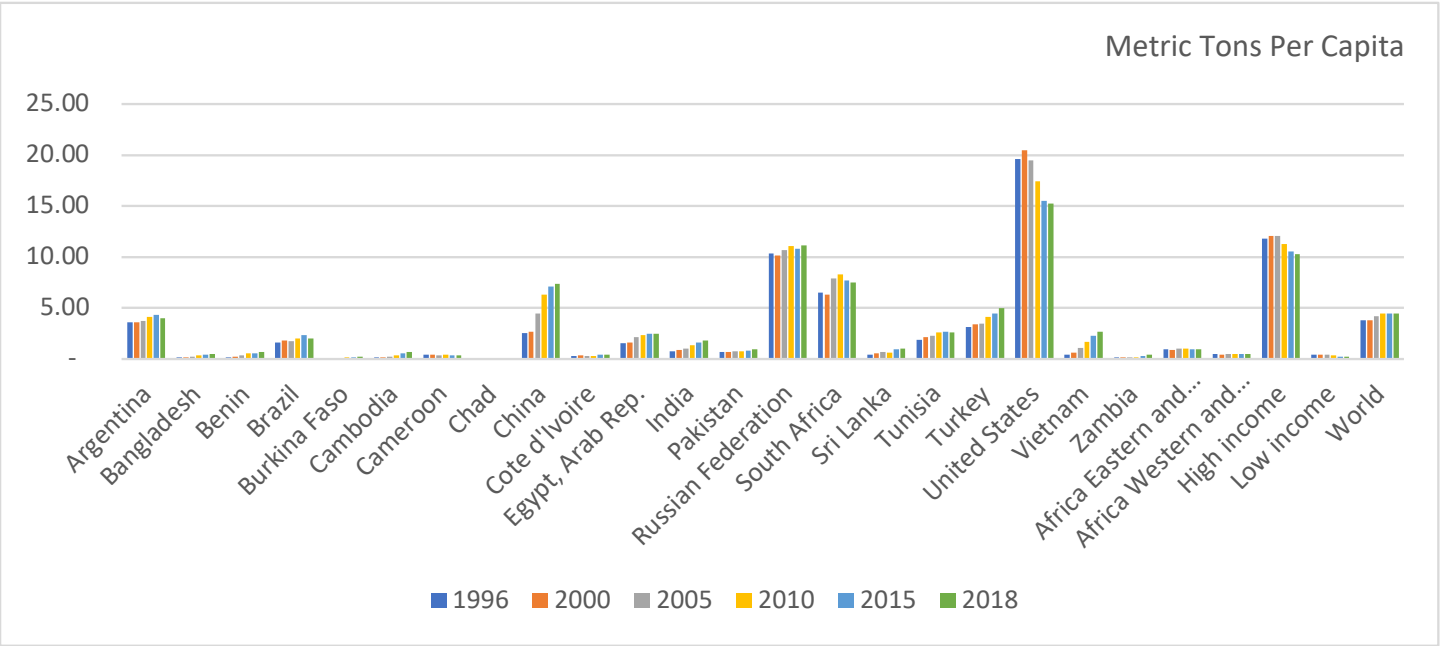
The term 'organic' extends beyond the fields and is not limited to cotton alone. According to the Global Organic Textile Standards (GOTS), when organic fibre is processed and certified through GOTS, it must follow strict regulations to protect the health of the planet and people from the farm to the consumer. GOTS requires fibres to be certified according to relevant International Federation of Organic Agriculture Movement (IFOAM, 2020) Family of Standards, which includes regulations from around the world, such as Regulation (EC) 834/2007, USDA National Organic Program (NOP), APEDA National Program for Organic Production (NPOP), and China Organic Standard GB/T19630.

Figure 9. Emissions (Source: World Bank Data)

Certification bodies must have a valid and recognized accreditation for the standard, such as ISO 17065 accreditation, NOP Accreditation, or IFOAM Accreditation. The GOTS Standard covers the processing, manufacturing, packaging, labelling, trading, and distribution of all textiles made from at least 70% certified organic natural fibres. To be labelled "made with organic," a fabric must be made of at least 70% organic fibre, while a fabric labelled "organic" must be made of at least 95% organic fibre. The remaining 5% or 30% of the fabric can consist of regenerated fibres from certified organic raw materials, sustainably managed forestry (FSC/PEFC), or recycled or certified recycled synthetic fibres (recycled polyester, polyamide, polypropylene, or polyurethane). The standard focuses on compulsory criteria only, except where an exception is expressly stated. Some of the criteria are compliance requirements for the entire facility where GOTS products are processed, including environmental management, wastewater treatment, minimum social criteria, auditing of processing, manufacturing, and trading stages, and ethical business behaviour.

While it is nearly impossible to produce textiles in an industrial manner without the use of chemical inputs, the approach taken by GOTS is to define criteria for low-impact and low-residual natural and synthetic chemical inputs. Therefore, in addition to basic requirements on toxicity and biodegradability, GOTS prohibits entire classes of chemicals, such as all heavy metals. This ensures that only chemicals with low environmental and health impact are used in the production process.

GOTS, however, does not directly address the carbon footprint of an organization or its production practices, but GOTS made it mandatory that companies shall assure compliance with the applicable national and local legal environmental requirements applicable to their processing/manufacturing stages including those referring to emissions to air, wastewater discharge as well as disposal of waste and sludge. It is required that Company shall have a written environmental policy and procedures in



place to allow monitoring and improving relevant environmental performances in their facilities. The environmental policy shall be shared with all employees. The available data and procedures for energy and water resource consumption per kg of textile output and target goals and procedures to reduce energy and water consumption per kg of textile output should be included, depending on the processing and manufacturing stages. Companies are also required to maintain complete records of chemical use, energy and water consumption, wastewater treatment, and sludge disposal. While GOTS does not specify wastewater standards beyond a maximum limit for COD, it does place significant emphasis on quality parameters and limit values for residues in GOTS goods, including additional fiber materials and accessories. This ensures that the products meet strict environmental standards and limit the negative impact of textiles on the environment and human health.

The GOTS sets requirements on social conditions that are equivalent to leading social sustainability standards. The labor practices are interpreted in accordance with the International Labor Organization (ILO) standards, which include prohibiting forced, bonded, or slave labor, ensuring workers have the right to join or form trade unions and to bargain collectively, maintaining safe and hygienic working conditions, prohibiting child labor, discrimination, and harassment. The GOTS also requires that companies have occupational health and safety, social compliance policies, and quality assurance systems in place.

The number of certified facilities in GOTS increased to 12,388 in 2021, compared to 10,338 in 2020. GOTS certification bodies also increased from 15 in 2020 to 18 in 2021. The world is recognizing organic textiles, with other organic certification organizations like the Organic Content Standard (OCS) also gaining traction. However, OCS is limited to certifying that a product contains 100% organically grown content (Textile Exchange, 2021).

Table 2: 2022 Environmental Performance Index (EPI) Ranking for 180 Countries (Source: World Bank Data, 2022)

Rank	Country	Score	RegionalRank
1	Denmark	77.9	1
2	United Kingdom	77.7	2
160	China	28.4	21
172	Turkey	26.3	19
176	Pakistan	24.6	6
177	Bangladesh	23.1	7
178	Vietnam	20.1	24
180	India	18.9	8

Most textiles are manufactured in developing and least developed countries, while a significant proportion is consumed in developed countries (UNEP, 2020). The Environmental Performance Index (EPI) offers a data-driven summary of the state of environmental sustainability worldwide (Wolf et al., 2022). The EPI ranks 180 countries on their environmental performance, using 40 performance indicators across 11 categories covering climate change, environmental health, and ecosystem vitality (Source: https://epi.yale.edu). Interestingly, the major hubs for cotton, polyester, and textile manufacturing are ranked at the bottom of the ranking, indicating poor environmental performance (Wolf et al., 2022).

Countries may view the situation differently, as about 60% of GHG emissions come from just 10 countries, while the 100 least-emitting contribute less than 3% (Source: World Bank Data).

There is much work to be done to improve sustainability in textile manufacturing countries, and organic textiles are an important way to achieve sustainability and implement the United Nations Sustainable Development Goals.

Roadmap

To promote sustainable and specifically organic textiles, a roadmap should be developed with stakeholders for:

- GHG emission reductions
- Energy/Processing (Manufacturing)/Chemicals
- Raw materials
- Logistics
- Policy formulation
- Collaboration in existing initiatives

It is crucial to engage stakeholders in textile-producing countries, including governments, to:

- Design an action plan with specific targets and timelines
- Map existing initiatives promoting sustainability, including organic textiles
- Identify measures to improve energy efficiency, renewable energy, effluent water treatment, and social compliance
- Design new schemes to incentivize textile manufacturers, set targets for manufacturers, and link government facilitation
- Explore practical ways for brands/retailers to collaborate and support manufacturers in achieving sustainability, since these activities involve costs and long-term buying commitments encourage faster implementation
- Create consumer awareness to share costs
- hare knowledge and success stories, especially for Small Medium Enterprises (SMEs)
- Consider out-of-the-box approaches, such as assigning carbon credits to consuming countries rather than producing countries, which may encourage brands/retailers to invest in manufacturing
- Establish a unified compliance audit system to reduce audit fatigue and costs, initially unifying common points of each compliance certificate
- Implement digital traceability techniques with open access policies
- Connect the supply chain from fibre to textile manufacturing

and ultimately to retailers/brands

- Address hazardous substances and improve transparency on product chemical content, production history, and use properties, devising effective communication strategies after consulting stakeholders
- Promote innovative raw materials, processes, machinery, and renewable energy
- Develop circular and climate-smart textile supply chains
- Coordinate efforts for agreed legislation across member countries, considering the entire value chain and using science-based targets and effective dissemination campaigns.

Figure 10. A spinning mill

ICAC Private Sector Advisory Council (PSAC)

Lastly, the ICAC's vision for textiles acknowledges the importance of textiles for cotton. The ICAC has recently revamped the Private Sector Advisory Panel into the Private Sector Advisory Council (PSAC) and shifted from individual members to national cotton and textile associations. The PSAC Executive Committee includes governments, cotton producers, merchants, the textile sector, and brands. The ICAC is also in the process of creating the International Textile Research Council to collaborate with the private sector, academia, and governments, intending to establish a uniform set of sustainability criteria, especially for organic cotton, accepted by member governments.

References:

La Rosa, Angela, D. and Grammaticos, S.A. 2019. Comparative Life Cycle Assessment of Cotton and Other Natural Fibers for Textiles Applications. Fibers 2019, 7(12), 101; https://doi.org/10.3390/fib7120101

Beton, A. 2014. Environmental Improvement Potential of Textiles 2014, European Commission, (p-78) https://publications.jrc.ec.europa.eu/repository/handle/JRC85895

Cotton Inc. 2016. Cotton Incorporated, LCA Update of Cotton Fiber and Fabric Life Cycle Inventory 2016, https://resource.cottoninc.com/LCA/2016-LCA-Full-Report-Update.pdf

Wolf, M. J., Emerson, J. W., Esty, D. C., de Sherbinin, A., Wendling, Z. A., et al. 2022. 2022 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

Global Organic Textiles Standards (GOTS), https://global-standard.org/downloads.

IFOAM. 2020. https://www.ifoam.bio/sites/default/files/2022-06/FamilyFrame_2020_June%202022.pdf

Greene, J.P. 2014. Chapter 3 - Life Cycle Information.

Textile Exchange. 2021. https://textileexchange.org/app/uploads/2021/02/OCS-403-V3.0-Quick-Guide-to-the-OCS.pdf

IPCC. 2022. Intergovernmental Panel on Climate Change (IPCC) 2022, Mitigation of Climate Change, IPCC_AR6_WGIII_FinalDraft_FullReport.pdf p 7/2913

ILO. 2021. International Labor Organization (ILO), Reducing the Footprint, How to Assess Carbon Emissions in the Garment Sector in Asia, 2021, https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_781938.pdf

Shade, J and Delate, K. 2021. Organic Cotton: one of the most important choices you can make for the environment, https://www.organic-center.org/sites/default/files/publication_files/organiccottonreport.pdf

ICAC. 2021 & 2022. Reports by Lorena Ruiz. International Cotton Advisory Committee, World Textiles Demand, https://icac.org/Publications?MenuId=41

Mandal, S and Dey, A. 2021. 1-PET Chemistry. In Recycling of Polyethylene Terephthalate Bottles; Thomas, S., Rane, A., Kanny, K., VK, A., Thomas, M.G., Eds.; William Andrew Publishing: Norwich, NY, USA, 2019; pp. 1–22. ISBN 978-0-12-811361-5

Quantis 2018. Measuring Fashion, Environmental Impact of the Global Apparel and Footwear Industries Study, https://quantis-intl.com/wp-content/uploads/2018/03/measuringfashion_globalimpactstudy_full-report_quantis_cwf_2018a.pdf

Roos, S., Jonsson, C., Posner, S., Arvidsson, R., Svanstrom, M. 2019. An inventory framework for inclusion of textile chemicals in life cycle assessment

Speight, J.G. 2011. Chapter 12–Petrochemicals. In: Speight JG (ed) Handbook of Industrial Hydrocarbon Processes. Gulf Professional Publishing, Boston, pp 429–466

UNEP. 2020. United Nations Environmental Programme (UNEP); Sustainability and Circularity in the Textile Value Chain: Global Stocktaking 2020, https://wedocs.unep.org/handle/20.500.11822/34184

UNEP. 2021. United Nations Environmental Program (UNEP); Catalyzing Science-based Policy Action on Sustainable Production and Consumption, 2021 https://www.unep.org/resources/publication/catalysing-science-based-policy-action-sustainable-consumption-and-production

UNFCC. 2021. United Nations Climate Change, Global Climate Action, Fashion Industry Charter for Climate Action, 2021 https://unfccc.int/climate-action/sectoral-engagement/global-climate-action-in-fashion/about-the-fashion-industry-charter-for-climate-action

World Bank Data. 2022. https://data.worldbank.org/

The ICAC Recorder

Rethinking Fashion and Textiles for 2030

Summary of the talks presented in the fourth Open Session of the 80th ICAC plenary

Kanwar Usman

International Cotton Advisory Committee,
1629 K Street, NW. Washington DC. USA.

Introduction

Seven distinguished speakers delivered talks on the theme: Rethinking Fashion and Textiles for 2030. Mr. Suresh Kotak from India spoke about the versatile benefits of cotton and its utilization in textiles, the food industry, rural economy, and the environment. Mr. Ilkhom Khaydarov from Uzbekistan discussed how his country transformed from cotton to the textiles value chain and presented the future strategy of doubling their textile exports. Ms. Natalia Isaeva from Russia highlighted the advantages of commercial laundry for managing textiles and its positive impact on sustainability. Dr. Tanveer Hussain from Pakistan explained the Sustainable Development Goals and the role of textiles in circularity. Dr. Olivier Zieschank from ITMF discussed the major challenges in sustainability, including creating cooperation among the entire supply chain and recycling. Dr. Lilac Osanjo from Kenya discussed the importance of capacity building from design to manufacturing and marketing for the growth of African fashion and textiles entrepreneurs. Ms. Belinda Edmonds from the African Cotton Foundation presented on the importance of policy for the development of textiles and apparel value chain in Africa.

In 2021, the global textile industry experienced a significant milestone, with textile exports surpassing $900 billion for the first time in history. This growth has highlighted the potential of textiles for member governments, leading the International Cotton Advisory Committee (ICAC) to introduce textiles as a full-time subject and hire its first-ever head of textiles.

To support the industry's continued growth, the ICAC has developed a textiles strategy that aims to connect the entire value chain, from fibers to high value-added products, and allied industries such as machinery, dyes, and chemical manufacturing. The strategy includes the development of a Business to Business (B2B) portal that will feature country profiles and facilitate business opportunities across the global textile industry.

Additionally, the ICAC has proposed the establishment of an International Textiles Research Council, subject to approval by the Steering Committee. This initiative would provide resources and support for research and development in the industry, further promoting its growth and development.

The ICAC's proactive approach to supporting the global textile industry's growth is promising, and these initiatives have the potential to make a significant impact on the industry in the years to come.

Versatile Cotton Fibre: A Composite Economy

Mr. Suresh Kotak

Chairman, Textile Advisory Group, India's Textile Ministry

Mr. Suresh Kotak has more than 65 years of experience in the cotton and textiles industry, especially commerce, economics, and education. He served on the ICAC's Private Sector Advisory Panel for many years as Government of India's nominated representative. Mr Kotak currently serves as Chairman of Textile Advisory Group (TAG) in India's Textile Ministry and has established the Suresh Kotak International ADR Centre at Indian Merchant's Chamber in Mumbai. He has served as the President of International Chamber of Commerce (India Chapter), Director of International Cotton Association, and President of Cotton Association of India.

The theme of "Rethinking Fashion and Textiles for 2030" is highly futuristic and aligned with the future of the industry. It's a positive step that the ICAC has introduced textiles as a full-time subject and taken a step towards promoting the growth and development of the industry. Cotton has a complete upstream and downstream value chain and numerous environmental advantages.

While there are criticisms of cotton due to the use of pesticides and fertilizers, the cotton sector has successfully addressed these issues. Additionally, cotton has one of the highest potentials for carbon sequestering and is often grown without irrigation in rainfed areas. Organic cotton technologies can make cotton even more environmentally friendly, and there has been past research on colored cotton, which could be highly beneficial for the sustainability of the textiles value chain if made commercially viable.

One of the unique advantages of cotton is its biodegradability and circularity. Two-thirds of the weight of seed-cotton is cotton seed, which can be utilized for a long list of products, such as edible oil, linters, animal feed, and materials for other industrial purposes. Many organizations, such as CIRCOT and Cotton Incorporated, have been working on the seed's application in industrial and food sectors.

The functional properties of cotton also enable it to blend well with other fibers, increasing its functional properties. Cotton has a significant economic impact on many countries and can play an essential role in the environment, social, and economic development of many regions and countries. Overall, cotton is a versatile fiber with a composite impact, and it's important for the world to understand its significance for sustainability and the development of the textiles industry.

Uzbekistan Textile Industry Strategy for 2030

Mr. IlKhom Khaydarov

Chairman, Uzbekistan Employers Association

Mr. Ilkhom Khaydarov started his career in cotton as a Deputy Director at the State Foreign Trade Company "Uzprommashimpeks" of the Ministry of Foreign Economic Relation of Uzbekistan in 1992. Then he worked as a Director for the Joint Uzbek-Swiss Marketing company UZDUN A.G. in Geneva, Switzerland and held several positions at Ministry of Foreign Economic Relation of Uzbekistan, Embassies of Uzbekistan for Benelux countries and Ukraine and Uzbekistan Association of Textile and Garment Industry "Uzbektextileprom". Mr Khaydarov now serves as Chairman at the Uzbekistan Employers Confederation.

Uzbekistan has a rich history in cotton and textiles dating back to the early 19th century, with the establishment of the first cotton ginning factory in 1922. Over the years, many textile factories and educational institutes were established, making Uzbekistan a strong player in the industry.

In 2017, Uzbekistan introduced the cluster approach, which made the textile industry more competitive. Since early 2022, the Uzbekistan textiles sector has emerged as a sustainable and reliable textile sourcing hub, achieving several milestones in the process. Uzbekistan has shifted from being one of the world's largest cotton exporters to an exporter of finished products. The country also received the GSP+ status from the European Union, lifted cotton restrictions, and increased textile exports to $3 billion.

Uzbekistan has introduced state-of-the-art technologies and high production techniques in spinning, dyeing, and finishing systems, making garments factories more cost-effective with modern quality control systems. The textiles industry is currently operating at 100% capacity, and textile exports have reached $3.2 billion. Uzbekistan has invested $3.5 billion in textiles, and 450,000 people are directly employed in the sector.

Uzbekistan has implemented traceability procedures from field to customers' shelves, particularly for organic cotton. Since this year, the Better Cotton Initiative has been introduced in nine clusters, incorporating circularity in pre- and post-textile operations. Uzbekistan has also initiated low water utilization programs in cotton farming, with already 200,000 hectares under this program.

Kyrgyzstan, Kazakhstan, Tajikistan, and Azerbaijan have requested support in cotton cultivation, with Azerbaijan also seeking assistance in developing its textiles industry. Uzbekistan is fast becoming a hub of textiles, with an export target of $5 billion for the next year. This target may be achievable due to energy competitiveness and efficient human resources. Uzbekistan's strategic location allows it to be within 14 days from Europe by road, within 4 days from Pakistan and from there into open sea, and 7 days to China.

The Uzbekistan government is providing duty-free access to CIS, UK & EU, direct support in transportation, certifications and exhibitions, and availability of organic cotton. Several Uzbekistan brands are prioritizing digitization, utilizing blockchain and barcode systems. Additionally, the government is planning to invest in green electricity.

The strategy for 2026 is to enter the global supply chain through guaranteed sustainability and transportation. Uzbekistan is also planning to utilize non-cotton fibers such as polyester and viscose. The strategy for 2030 is to work on water and soil management, organic and better cotton in agriculture to make cotton more sustainable. The textiles and fashion industries will focus on environment, social aspects, governance, transparency, and traceability to make the industry more sustainable.

How to Move From a Traditional to a Sustainable Model in Industrial Laundry

Ms. Natalia Isaeva

Executive Director, Cotton Way

Ms. Natalia Isaeva is Executive Director of Cotton Way, the leading Russian laundry company. Cotton Way was the first to offer a sustainable model of complex rental and laundry service in Russia. Natalia has been working in the field of corporate finance, bank lending and anti-crisis management for over 20 years. With her vast economic experience, she joined Cotton Way in 2019 to oversee sustainable business processes in the company. As the Executive Director, Natalia leads the team and plays a decision-making role in the company. Her key areas of responsibility include anti-crisis management, restructuring of troubled financial flows and debt obligations, and, most importantly, the ESG agenda and strategy.

Cotton way is a company that places extensive focus on sustainability and has been working on sustainable development for some time.

The company has nine processing facilities located in different regions and can process up to 400 tons per day. Cotton way provides bedlinen and terry products to a range of customers, including railways, public and private hospitals, hotels, and manufacturing enterprises.

Sustainability is at the core of Cotton way's business model, and the company has successfully executed sustainable practices that have resulted in substantial reductions in major costs and environmental indicators.

As a large-scale business, Cotton way has made significant investments that have had a positive impact on overall sustainability. For example, the company has reduced water consumption by half, achieved a ten-fold reduction in energy use, and an 88% reduction in CO2 emissions.

These sustainability measures have allowed Cotton way to provide a quality product and service while also achieving cost savings.

Overall, Cotton way's commitment to sustainability serves as an example of how businesses can prioritize sustainability without sacrificing quality or profitability.

Sustainable Development Goals and Textile Circular Economy

Dr. Tanveer Hussain

Professor of Textile Engineering, Rector, National Textile University, Faisalabad, Pakistan

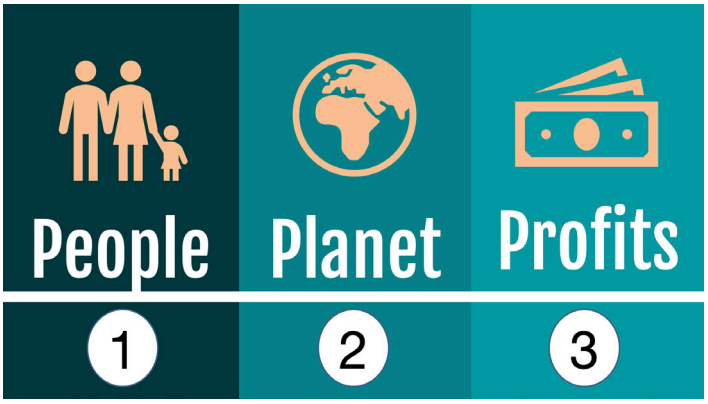
Dr. Tanveer Hussain is Professor of Textile Engineering and Rector at National Textile University, Faisalabad, Pakistan. He got his PhD in 2004 from Heriot-Watt University, United Kingdom. His current areas of research include Functional Textiles and Sustainable Textiles. He is Fellow of the Textile Institute, UK and has published more than 150 research papers in peer-reviewed journals. He has been awarded several research grants from the Higher Education Commission of Pakistan and has won various awards including Gold Medal in BSc. Textile Engineering, Bronze Medal from the Society of Dyers and Colorists, UK, and Best University Teacher Award from the Higher Education Commission, Pakistan. Previously, he has served at various positions at National Textile University including Head of Textile Processing Department, and Dean Faculty of Engineering & Technology.

As of 2022, the world population is 8 billion and is expected to increase to 8.5 billion by 2030. Textile and clothing exports in 2021 amounted to $871 billion, and it is projected to increase to $930 billion based on various macroeconomic factors.

The segment-wise breakdown of textile exports is as follows: silk (fiber, yarn, and fabric) was valued at $1.4 billion, wool at $10.9 billion, cotton at $60.4 billion, other vegetable fibers at $5.4 billion, manmade filaments at $51.2 billion, manmade staple at $35.5 billion, wadding and nonwoven at $31.6 billion, carpets at $17.7 billion, special woven at $12 billion, coated fabrics at $27.2 billion, knitted fabric at $40 billion, knitted apparel at $262.9 billion, woven apparel at $227 billion, and made-ups at $87 billion.

The world's fiber consumption is approximately 110 million tons per annum, with polyester having the major share of 57.7 million tons, accounting for 52% of the entire fiber production, while cotton is 23% of the total fiber production and consumption. By 2030, the world's fiber production is expected to increase to approximately 146 million tons, depending on recycling and circular economy efforts.

Approximately $400 billion worth of textiles and clothing are wasted worldwide, which is enough to meet the Sustainable



Development Goals of 59 of the world's poorest countries. This highlights the need for increased efforts towards sustainability and circular economy initiatives in the textile industry.

Globally, approximately 48 million tons of clothing are disposed of each year, equivalent to 45% of the world's fiber production. Shockingly, 73% of clothing waste is landfilled or incinerated annually, and the amount of waste may reach 65 million tons if no action is taken to reduce textile waste.

Textiles dyeing and processing consume 5.8 trillion liters of water each year, enough to supply 530 million people with water for nearly a year. Furthermore, the textiles and fashion industry emit 3.3 billion tons of CO2 annually, requiring the planting of 22 billion trees each year to offset the impact on climate change. Approximately 20% of the world's water pollution is caused by textiles wet processing, equivalent to the size of 3.7 billion Olympic swimming pools.

Given the above facts, sustainable development is crucial, defined as "meeting the needs of the present without compromising, but rather contributing to, the ability of future generations to meet their own needs." In textiles and apparel, sustainability is defined as "producing and consuming textiles and apparel in such a way that enough raw materials and other resources remain available for future generations without harming people and the planet." In essence, we must take care of people, planet, and profits to ensure a sustainable future for all.

There are 17 Sustainable Development Goals with 159 targets. The first SDG aims to end poverty in all forms and from everywhere, and the textiles and clothing industry can contribute to this by creating new jobs, increasing workers' minimum pay, providing workers with social security, introducing workers' share in businesses, and offering workers life insurance.

Globally, nearly 800 million people, or 1 in 9, suffer from hunger every day, according to the World Food Program. Therefore, increasing cotton area is not an option; instead, we must focus on increasing cotton yields and sparing lands for food crops to ensure food security.

The third SDG aims to ensure good health and well-being, and textiles can contribute by producing medical and healthcare textiles, personal protective equipment, and reducing the use of hazardous chemicals. About 200 million children are out of school globally, and by 2030, only 60% of young people will complete upper secondary education. Therefore, the textiles industry can contribute to quality education by providing free daycare centers, building free schools, and offering scholarships for workers' children.

To achieve gender equality, the textiles sector can increase the ratio of female workers and promote more women to senior management positions. To contribute towards clean water and sanitation, the textiles sector can focus on treating, reducing, and reusing effluents, as 3 in 10 people lack access to clean water, and 80% of industrial wastewater is discharged into rivers without treatment.

The 7th Sustainable Development Goal is to ensure affordable and clean energy, and the textiles sector can contribute to this goal by increasing the use of renewable energy sources and improving energy efficiency. As energy production is a major contributor to climate change, accounting for around 60% of global greenhouse gas emissions, it is crucial for the textile industry to transition to more sustainable energy sources.

To ensure decent work and economic growth, the textile industry must prioritize technological innovation and upgrades, pay workers equally for work of equal value, ban forced labor and child labor, and ensure that all workers have access to a safe working environment and full labor rights. The industry must also invest in research and development, support indigenous technology development, and improve workers' access to information and communication technology.

To contribute towards reducing inequalities, the textiles sector needs to address salary disparities among employees and strive to become an equal opportunity employer. Sustainable housing for workers and free transportation can be provided to promote sustainable cities and communities.

Responsible production and consumption is a critical Sustainable Development Goal, directly linked to the textiles industry.

The sector must focus on sustainable resource management, use of natural fibers and other natural resources, responsible chemical management, and waste reduction through prevention, reduction, recycling, and reuse. The textiles sector must

build knowledge and capacity to combat climate change and implement practices such as Zero Discharge of Hazardous Chemicals (ZDHC) to prevent harmful chemicals from polluting rivers and seas and reduce the use of materials that contribute to microplastic pollution to ensure sustainable life below water.

"The textiles sector must strengthen its means of implementation and revitalize the global partnership for sustainable development.

The circular economy in textiles is covered under the 12th Sustainable Development Goal, and target 12.5 aims to substantially reduce waste generation through prevention, reduction, recycling, and reuse by 2030.

There are various options for circularity, such as reusing textiles clothing after being used by someone else, repairing it to a functionality level similar to its original level, refurbishing it to a higher level of aesthetics and functionality, or recycling, upcycling, and downcycling material waste. This circularity of material waste needs to be accompanied by the recovery and reuse of water and energy.

However, there are key challenges in the collection and sorting of post-consumer waste. Better mechanisms for collecting post-consumption waste and automatic sorting of waste types will be developed in the coming years. Mechanical and chemical recycling are the two types of recycling methods, each with its challenges.

One challenge in mechanical recycling is preserving the fiber properties, especially the fiber length and strength. Meanwhile, preserving the degree of polymerization is the challenge in chemical recycling. Recycling cotton is particularly difficult since once it is recycled, it exhibits properties more like viscose rather than cotton."

It is possible to address sustainability challenges at different stages of the value chain, starting with the use of renewable, biodegradable, recycled, and organic materials at the raw materials stage.

Interventions can also be made at the production stage by reducing energy and water consumption, minimizing the use of chemicals, and managing waste and emissions.

At the packaging stage, the textile sector can use sustainable packaging materials that are renewable, biodegradable, and recyclable. The industry can also promote regional trade and use eco-friendly transportation to improve sustainability during distribution. At the usage stage, textiles that require less water and energy to wash and dry and do not need ironing can be promoted.

Finally, at the disposal stage, textiles that can be reused, recycled, or composted should be encouraged. By addressing sustainability at all stages of the value chain, the textile industry can make a significant contribution to achieving sustainable development goals.

Capacity Building for the Growth of African Fashion and Textiles Entrepreneurs

Dr. Lilac Osanjo

Department of Art and Design, University of Nairobi, Kenya

Dr. Lilac Adhiambo Osanjo is a lecturer at the University of Nairobi. She holds a PhD in Design and an MSc in Entrepreneurship. Osanjo is a member of the Executive Board of the Kenya Fashion Council. Her research interest is in quality training and professional growth of African fashion and textiles entrepreneurs. She provides training and capacity building for small and micro enterprises in product development for local and export markets.

The objective for African textiles is to address some of the global challenges through sustainable practices. In February of this year, Mr. Srini Srinivason, President of the World Design Organization, visited the University and encouraged us to align our design practices and education with the Sustainable Development Goals (SDGs). By 2030, our aim is to end poverty and hunger, increase access to education, address migration, combat climate change, and reduce inequality.

Handmade and high-end products have significant demand, and traditional products that have a story or cultural values are also potential revenue sources, in terms of style or raw materials. Additionally, most workers in traditional crafts and sectors such as weaving, tie and dye, screen printing, and embroidery are women.

To increase exports and address domestic challenges, we are looking to repackage the African narrative, redefine African fashion and textile products, re-examine business processes, increase return on investment, and undertake value addition by branding, developing new products, new packaging, and innovation. These activities are expected to create more jobs in textiles and fashion and increase income. Two case studies, namely, Kitui County Textile Center (KICOTEC) and Kenya Export Promotion and Branding Agency (KEPROBA) Small and Medium Enterprise program, incorporate some innovations that can be replicated.

KICOTEC is a rural company providing direct jobs to 600

people and many more indirectly. The company has provided jobs in rural areas and provided training to local tailors in industrial stitching. Moreover, it provided alternate jobs to people whose primary source was charcoal burning. During the COVID-19 pandemic, the company produced masks and other personal protection equipment using locally sourced raw materials, serving the entire country.

Renata adorning Maasai cultural jewellery posing with a Maasai warrior.
Source: Jowy, 2016

KEPROBA is a multi-agency project under which SMEs are shortlisted, evaluated, and supported according to their needs, such as technology, packaging, marketing, standardization, and compliance. KEPROBA SME program aims to increase exports, especially of Small and Medium Enterprises (SMEs) from Kenya, considering free trade agreements to reduce the trade deficit. Under the program, value addition is encouraged to stop or reduce the export of raw materials. Each market and product are carefully analyzed from a sustainability and design perspective, and the products are designed to have an African cultural touch."

South Africa is emerging as a fashion hub and source of inspiration, providing valuable support to the African textiles and fashion industry. The efforts of African designers who have created designs for world-renowned companies are commendable. Textiles and fashion are crucial for Africa, and programs aimed at supporting the entire value chain, from design to product manufacturing and marketing, are playing a significant role in establishing sustainable textiles in Africa. These programs offer valuable services to SMEs, including training and capacity building, and represent small but important steps towards building a sustainable textile industry in Africa.

Key Sustainability Challenges In Textile Manufacturing

Dr. Olivier Zieschank

Director, International Textile Manufacturers Federation, Switzerland

Dr. Olivier Zieschank was born in Lausanne, Switzerland, and studied Management at the university of Lausanne where he graduated in 2005. Until 2010 he worked in a Swiss based company specialized in negotiating and optimizing cell tower lease agreements. He became associate director while his role quickly expanded into every aspect of running a small company on a tight budget. In 2010, he returned to university and studied economics in Neuchatel, Switzerland. He wrote his PHD in economics at the university of Freiberg, Germany, in which he develops the process theory of organization. Mr. Zieschank was appointed Economist at the ITMF in August 2017. In October 2020 the ITMF Board promoted Dr. Zieschank to the position of Director as of January 2021.

There are several key sustainability challenges in textile manufacturing that need to be addressed. One of the biggest challenges is creating cooperation among the textile value chain to exploit opportunities for recycling. While it is possible for individual companies at the factory level to achieve sustainability using current technologies, implementing sustainability on a larger scale requires collaboration among people, companies, and governments.

Sustainability has enormous potential for value creation, but it is difficult to implement in practice. During the ITMF's annual conference held in Nairobi in 2018, an expert panel discussed the possibility of recycled cotton cannibalizing the market for virgin cotton. Four years later, while many types of recycled fibers have emerged in the market, the question remains. In a perfect world with advanced recycling technologies and fibers that don't deteriorate over time, the annual demand for virgin fibers would depend on the demand for newly produced fibers and their increased consumption over time. However, in reality, fibers do deteriorate, and the characteristics of recycled fibers are not equal to those of virgin fibers. Additionally, textile manufacturers may mix virgin fibers with recycled fibers in production, which would maintain demand for virgin fibers. The emergence of recycled fibers creates new forces that have been modifying the markets.

It is important to understand current recycling trends to

calculate the future demand for virgin fibers for cotton, polyester, and cellulosic fibers. According to data from Wood McKenzie, consumption of all fibers is expected to grow until 2030, but their share in total consumption could remain the same. For instance, polyester is expected to make up 60% of total consumption, cotton around 20%, and cellulosic fibers approximately 5%.

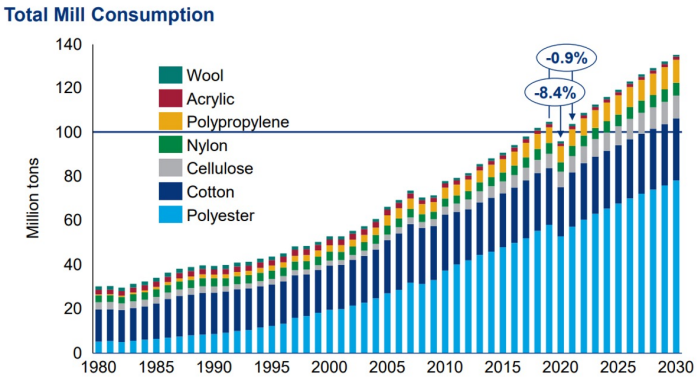


Figure source: From a presentation by Alexei Sinitsa, Ph.D., fibres consultant, Wood Mackenzie, at the ITMF Annual Conference 2022, Wood Mackenzie Chemicals Fibres Strategic Planning Outlook H1 20

Textile production is facing sustainability challenges, although degradable natural fibers like cotton are relatively sustainable, it still requires synthetic fertilizers, pesticides, and water for farming. Consumers also see cotton as a responsible choice. Hence, there is a need to improve sustainability throughout the entire value chain, starting from fiber production to end-of-life disposal. The principle of responsible production and consumption must be adopted. The strategies of ITMF's member companies focus on circular economy and using recycled fibers to reduce waste generation. In the current linear economy, we take materials from the earth, convert them into production, and eventually throw them away. A circular economy, on the other hand, aims to stop generating waste at each step of the value chain, preferably at the first stage. Sustainable guidelines such as 'reduce, reuse, and recycle' are being incorporated into textile manufacturing. To increase sustainability in cotton and cotton goods production, strategies such as increasing the share of renewable energy, overall energy efficiency, and adopting innovative technologies to reduce waste from production can be implemented.

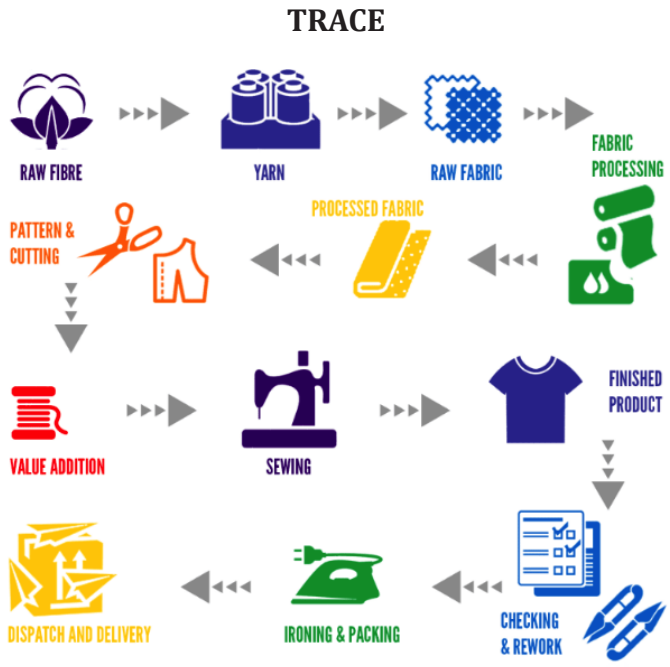
The main challenge for the textile industry is not in implementing individual solutions to improve sustainability at the company level, as these solutions can be applied independently with access to capital and technology. The real challenge lies in implementing sustainable solutions that require coordination along the value chain, such as textile and garment recycling. This requires material recycled at one point in the value chain to be shipped back to a given manufacturer to be reintroduced into the value chain. This manufacturing loop is associated with three key challenges: collection, traceability, and breakdown. Collecting textiles requires efficient ways to gather pre-consumer and post-consumer waste prior to shipping it back to the manufacturer or recycling plant to be processed into a new raw material. The creation of new logistic routes in the upstream value chain is one of the major difficulties associated with collection. To address this challenge, the European Commission has presented a new strategy as part of the European Green Deal and the Circular Economy Action Plan that prerequisites the separate collection of textile waste at the community level. The European Textile and Apparel Confederation is also currently working on recycling hubs, also known as rehab, to help European companies cope with the new guidelines.

The next challenge is traceability, which refers to the ability to track the composition of textile products at any step of the value chain. It is like the conventional concept of traceability but has a specific meaning in the context of textile recycling. Not only must the origin and mix of fibers be communicated down the value chain, but also the recycling requirements must be communicated up the value chain to facilitate the recycling loop. This is commonly referred to as design for circular economy, where the downstream industry considers the upstream recycling needs in product design. The breakdown challenge refers to the complexity of fragmented fabrics and yarns into smaller components by chemical or mechanical recycling. The precondition for sustainable recycling is a material that is as pure and consistent as possible.

Figure source: European Parlament, from a presentation by Eddie Ingle, Unifi, at the ITMF Annual Conference 2022

Natural mixtures can pose challenges or make recycling uneconomical or technologically unfeasible. The packaging industry has already understood this fact and adopted the mantra "design for recycling," which would equally benefit mechanical and chemical recycling methods as feedstock needs to meet certain specifications. The technology used for sorting and cleaning the input feedstock plays a major role in the success of textile recycling operations. The characteristics of fibers

are also modified by the mechanical recycling process, and their resulting fibers are often more difficult to process due to fiber types and quality. The industry is currently adapting to the challenges linked to the emergence of new fibers, and M/S Rieter is working on a solution to spin fibers with higher short fiber content. M/S Santis Textiles has developed mechanical recycling and advanced spinning technology to produce 100% pre-consumer recycled fibers. The Hong Kong Research Institute of Textile and Apparel Green Machine is capable of recycling blended products. A truly sustainable textile industry requires manufacturers to collaborate in addition to adopting individual strategies to reduce and reuse. However, working in a closed supplier-producer pair is not possible in this scenario.



The key to creating a sustainable textile industry is to bring together all stakeholders involved in the transformation of raw materials into consumer goods. This requires the creation of both physical and informational networks to facilitate the transportation of goods and recycled materials up and down the value chain, as well as the flow of information regarding fiber mix, origin, and recycling requirements. Vertical integration of information throughout the transformation process can improve collaboration and reduce costs.

However, the real challenge is understanding the consequences of using a single product at each step of the process. Only 1% of garments were recycled into garments by 2015, and this may still be the case. Recycling cotton textiles presents an opportunity for manufacturers to add value to products that have already reached the end of their life cycle, reducing the need for virgin cotton fibers, conserving water, and other resources, and reducing the impact of cotton production and consumption on the environment. By working towards recycling cotton technologies, we can create a sustainable textile industry that keeps useful fiber out of landfills or incinerators, extending its useful life.

The Textile Value Chain Africa's Opportunity

Ms. Belinda Edmonds

Managing Director, African Cotton Foundation

Belinda Edmonds has worked in almost all sectors of the African Textile and Apparel Industries over the past 30 years. Born and raised on a cotton farm, she entered the textile manufacturing sector in 1988, working in spinning, weaving, knitting and dyeing/printing facilities before transitioning to the apparel production sector in 1997. Since 2000, Belinda has used her experience to support and promote cotton, textile, and apparel exports from Africa. At its inception in 2018, Belinda joined the African Cotton Foundation as its Managing Director. Passionate about Africa, Belinda believes that promoting and assisting trade is a critical tool to uplift and protect its people, cultures, and its environment.

The African Cotton Foundation (ACF) was founded in 2018 with the aim of creating shared value along the entire textiles value chain and improving the lives of African cotton farmers. The vision of ACF is to establish a sustainable, modern, and thriving African cotton sector by increasing the productivity and incomes for at least 2 million African cotton farmers by 2025. To achieve this, their ecosystem partners are focusing on the strongest supply chains, income diversification policies, market linkages, financial services, and technical support. The African apparel and textile industry is supportive of these initiatives.

Figure 1. Textile Exports from Africa (US$ Millions)
Source: WTO & ITC

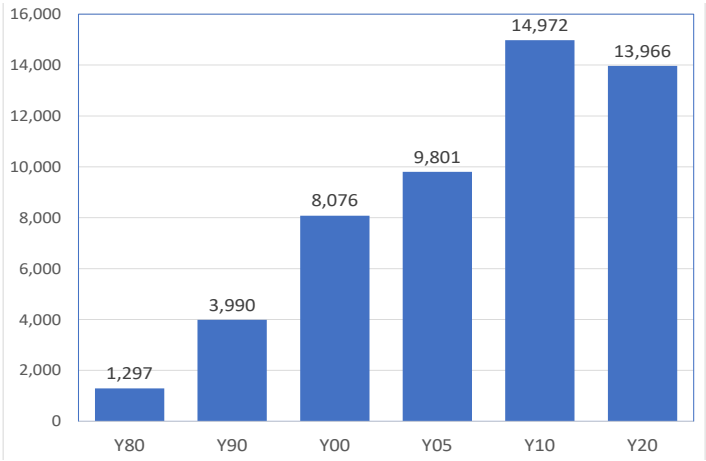


Figure 2. Textile Exports from North Africa (US$ Millions)
Source: WTO & ITC

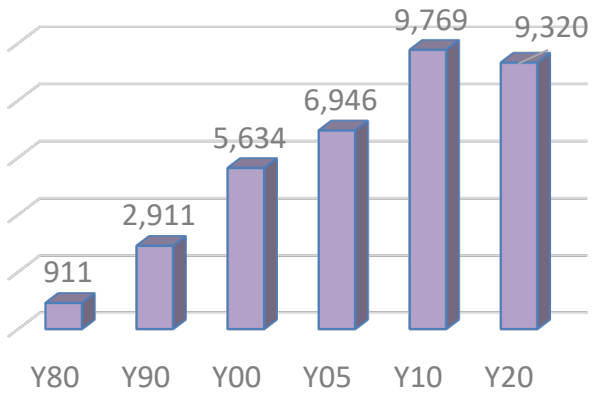


Figure 3. Textile Exports from West Africa (US$ Millions)
Source: WTO & ITC

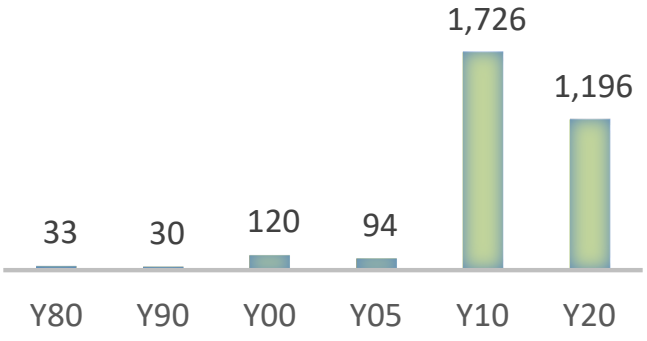


Figure 4. Textile Exports from East Africa (US$ Millions)
Source: WTO & ITC

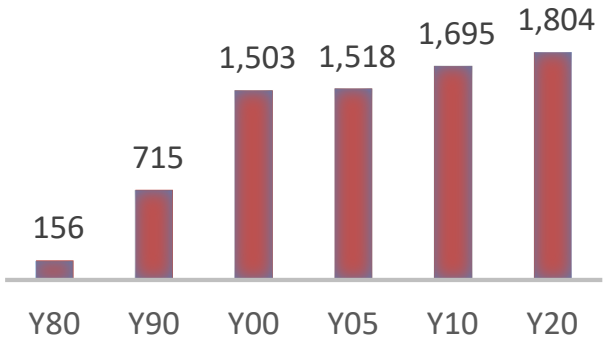
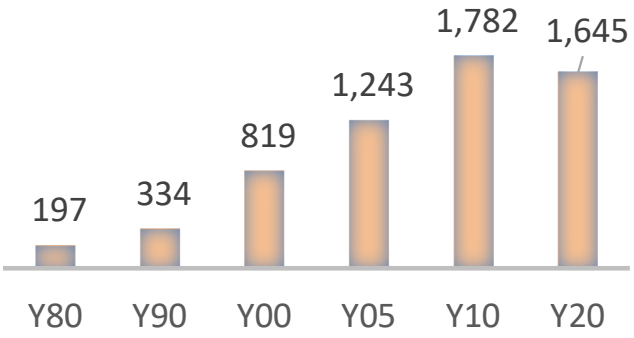


Figure 5. Textile Exports from Southern Africa (US$ Millions)
Source: WTO & ITC



According to the World Trade Organization (WTO), in 2019, the global textiles exports market was valued at $305 billion, and the global apparel exports market was valued at $493 billion.

Since the first industrial revolution, the cotton, textiles, and apparel sectors have been driving growth through industrialization and increased trade. Furthermore, the textiles value chain generates employment, especially for women with minimal training. Despite having preferential access to developed nations' markets, most African countries, especially Sub-Saharan countries, are not contributing to the international textiles trade.

Currently, most of the fiber is exported, and few African countries have successfully developed an export-focused apparel sector. Some African countries have integrated the textile value chain, creating jobs, but most of the added value remained offshore.

In summary, the African cotton, textiles, and apparel sectors are, for the most part, three separate industries that do not fully realize the potential of a robust value chain.

It is imperative to create a sustainable and thriving African cotton sector to improve the lives of African cotton farmers, empower cotton-growing communities, respect human rights, conserve the environment, and establish a modern industry that contributes to the international textiles trade.

The textiles and apparel sectors function differently from each other, with fixed assets being required in the former and movable assets in the latter.

While a high investment is necessary in textiles, the return on investment is low, whereas in apparel, the return on investment is high with a lower investment required. Additionally, textiles generate fewer jobs per dollar invested compared to apparel, which creates more jobs.

To develop the textiles and apparel value chain in Africa, government policies need to be put in place with the participation of the private sector in investment.

The private sector requires guaranteed protection of their investments, repatriation of forex, investment incentives, ease of doing business, and reliable access to energy at lower prices.

Other necessities include the development of industrial zones, access to land, duty-free imports of textile machinery, and alignment of labor laws with the International Labor Organization (ILO).

Foreign investors require protection from dumped imports and long-term duty-free trade concessions.

Establishing a sustainable textiles value chain in Africa would help achieve Sustainable Development Goals (SDGs) commitments, create jobs, promote industrialization, reduce poverty, and mitigate environmental impacts in the future."

The ICAC Recorder

World Spending on Agricultural Research and Development

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Dr. Alejandro Plastina is an Associate Professor/Extension Economics in the Department of Economics at Iowa State University (USA), specializing in agricultural production and technology, with an emphasis on farm business and financial management. His research focuses on the socioeconomic drivers of conservation practices, voluntary pest resistance management, carbon farming, and agricultural productivity. Dr. Plastina graduated with an MS in Statistics and a PhD in Agricultural Economics from the University of Nebraska-Lincoln (USA), and a BA in Economics from the University of La Plata (Argentina). Between 2007 and 2014, he served as Economist and Senior Economist at the International Cotton Advisory Committee

Dr. Terry Townsend retired as executive director of the International Cotton Advisory Committee (ICAC) at the end of 2013. He previously worked at USDA from 1983 to 1987 analyzing the U.S. cotton industry and editing a magazine devoted to a cross-section of agricultural issues. He served as statistician at ICAC from 1987 to 1999. He has a Ph.D. in Agricultural and Resource Economics from Oregon State University in the United States. He remains active in support of natural fibres through memberships in various committees, as an author of articles and papers for industry publications, and as a consultant. Dr. Townsend has a deep appreciation of the importance of fundamental analysis in understanding structural change in commodity markets.

Introduction

USDA reported in May 2022 that public spending on agricultural research and development (R&D) was the largest in China, followed by the European Union, the United States, India, and Brazil (Fuglie and Nelson, 2022). The report emphasized that public expenditures on agricultural R&D in the United States were about a third lower in real terms in 2019 than they had been at their peak in 2002 when spending, in 2019 dollars, was $7.64 billion.

In contrast to the decline in public expenditures in the United States since 2002, public expenditures on agricultural R&D (deflated by national GDP indexes), rose by a factor of approximately five in China in the two decades since 2000. Expenditures rose by about one-third in the EU, approximately double in India, and expenditures rose by about half in Brazil.

The USDA report carries and alarmist tone, suggesting that the reduction in public spending on agricultural R&D in the United States will lead to a reduction in competitiveness in agricultural production and lower social welfare in the long term. The purpose of this article is to provide a wider perspective on the recent evolution of public investments in agricultural R&D across major producing countries, highlighting their relative size to the value of local agricultural production, and the role of private R&D.

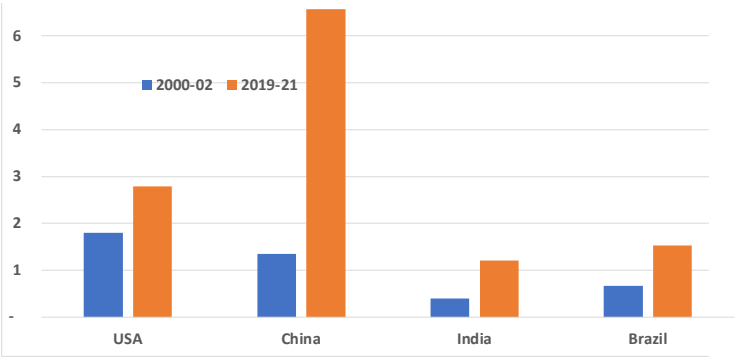
Public R&D vs. value of Ag production

Data from the OECD demonstrate the relative size of public sector expenditures on agricultural research and development (OECD, 2022). Annual average spending on Agricultural knowledge and innovation systems (OECD speak for R&D) rose in the USA, India and Brazil in nominal dollars between 2000-02 and 2019-21 by about $1 billion in each country. According to the OECD, investments in Agricultural knowledge and innovation systems include budgetary expenditure financing (1) R&D activities related to agriculture, and associated data dissemination, irrespective of the institution (private or public, ministry, university, research center or producer groups) where they take place, the nature of research (scientific, institutional, etc.), or its purpose; as well as (2) agricultural vocational schools and agricultural programs in high-level education, training and advice to farmers that is generic (e.g. accounting rules, pesticide application), not specific to individual situations, and data collection and information dissemination networks related to agricultural production and marketing.

Spending in the United States rose from $1.8 billion per year to $2.8 billion, from $400 million to $1.2 billion in India, and from $700 million to $1.5 billion in Brazil. In contrast, public sector expenditures on agricultural R&D in China leapt by a factor of approximately 5, growing from around $1.3 billion per year to $6.6 billion. Annual average public sector expenditures on

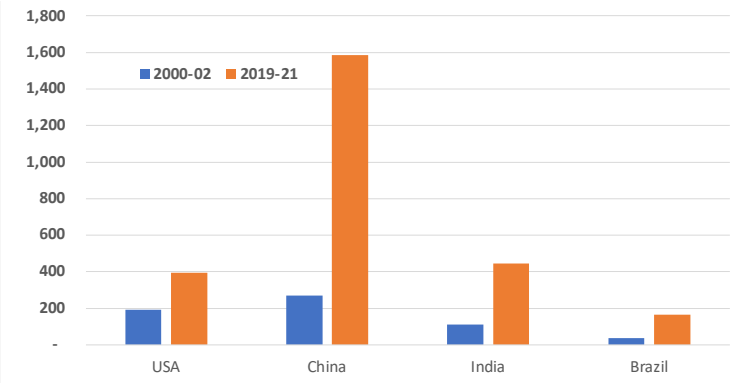
agricultural R&D in China were larger than in the USA, India and Brazil together by 2019-21.

Figure-1. Spending on agricultural knowledge and innovation systems, US$ Billion. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, https://doi.org/10.1787/7f4542bf-en.



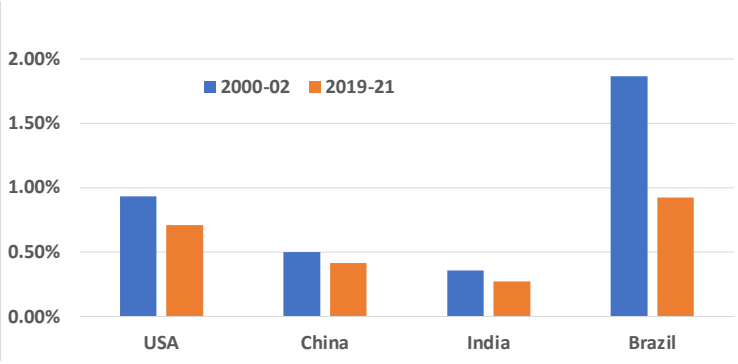
China also now has the largest agricultural system in the world by value of production. As of 2019-21, the value of production at the farm gate was about $1.6 trillion in China, compared with $400 billion in the USA and India and about $200 billion in Brazil. The structure of the farm economy in China is different from the structures in the other countries because China does not have an abundance of arable land. Except for in the far-West region known as Xinjiang, where cotton is produced, farmers in China operate relatively small farms producing high-valued products such as meat and vegetables. In contrast, the USA and Brazil have larger arable areas and much smaller populations and can afford to produce huge swaths of row-crops. India, with a population as large as China's but with more arable land can also afford to produce lower-valued products.

Figure-2. Value of agricultural production at the farm gate, US$ Billion. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, https://doi.org/10.1787/7f4542bf-en.



Therefore, as a share of the value of agricultural production at the farm gate, public sector expenditures on agricultural R&D were the largest in Brazil in 2019-21 at 0.9%, compared with 0.7% in the USA, 0.4% in China, and 0.3% in India. Public sector expenditures on agricultural R&D declined as a percentage of the value of agricultural production in all countries between 2000-02 and 2019-21, mainly because the value of production rose.

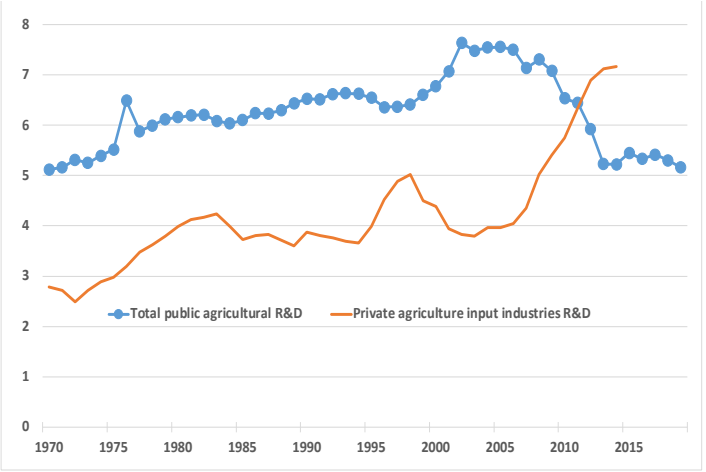
Figure-3. Spending on agricultural knowledge and innovation system as % of value of production. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, https://doi.org/10.1787/7f4542bf-en.



The role of private R&D

The USDA report acknowledges that lower public spending on agricultural R&D in the United States may be offset by private sector spending. The public sector funded about half of the agricultural R&D directly used by agriculture in the United States between 1970 and 2008. However, by 2013 the share funded publicly had fallen to between 40% and 45% because real (inflation-adjusted) public agricultural R&D fell by about 20%, while real private R&D spending by input firms increased by around 50%. Furthermore, if private sector expenditures on R&D for food manufacturing are excluded from the comparison (as shown in the following graph), the average share of private agriculture input industries R&D increased from 38% between 1970 and 2010 to 55% between 2011 and 2014.

Figure-4. Real agricultural R&D funding, 1970-2019. US$ Billion inflation-adjusted 2019. Source: USDA, Economic Research Service.



When private sector spending is considered, the United States is probably still the world leader in funding for agricultural R&D.

The USDA report does not disaggregate R&D expenditures by commodity, and budget information specific to cotton R&D is difficult to estimate. Expenditures on ginning research, for example, would be specific to cotton, but expenditures on pesticide or soil health research would be applicable to all crops. Nevertheless, there is no reason to think that public expenditures on R&D applicable to cotton has followed a path different than that for all expenditures on agricultural R&D.

Beginning in the 1800's, the U.S. government funded most agricultural research in the United States because firms in the private sector did not have the means to do so and because there are significant externalities generated by agricultural research resulting in significant public benefit. Over time, specialized firms in the farm machinery, agricultural chemical, crop seed, and other agricultural input industries grew large enough to make considerable investments in R&D. Between 1970 and 2013, private sector expenditures on agricultural R&D in the United States rose by a factor of three to about $6 billion, while public spending on agricultural R&D in the United States grew very little.

As a result, by 2013, private sector expenditures on agricultural R&D (not counting food manufacturing R&D spending) accounted for nearly 60% of total agricultural R&D expenditures. Data on private sector expenditures on agricultural R&D in the United States are not available for recent years, but the upward trend apparent between 2008 and 2013 has probably continued. By 2020, it is likely that private sector agricultural R&D spending was between two and three times that of the public sector in the United States, meaning that total agricultural R&D spending in the United States was between $15 billion and $20 billion.

In contrast, private sector expenditures on agricultural research and development in China are, almost by definition, zero, and private sector expenditures on agricultural R&D in the EU, India and Brazil are, at best, modest. Accordingly, total expenditures on R&D related to agriculture are still the largest in the world in the United States, albeit by a shrinking margin as public expenditures in China, the EU, India and Brazil rise.

There is a distinction between public and private agricultural R&D expenditures, but such expenditures tend to be complementary, rather than competitive. Therefore, the fall in public sector agricultural R&D spending and rise in private spending in the United States does not necessarily presage a decline in the rate of growth of agricultural productivity.

Improvements in genetics, chemicals, fertilizers, agricultural machinery, and farm management techniques have transformed United States agriculture since WWII. As agricultural productivity has increased, public sector research has tended to focus on environmental impacts, animal welfare, farm worker welfare, issues with farm structure (meaning the size of farms and how they are organized and managed), and other issues of broad public interest. Meanwhile, privately funded R&D has tended to focus on the development of marketable inputs and services eligible for patent protection.

Recent research suggests that over the last seven decades it has taken about twenty years for advances in basic agricultural science to be reflected in the adoption of useable technologies (Matt Clancy, 2021). Given that agricultural R&D expenditures by the private sector in the United States began to exceed public expenditures only about a decade ago, it may be another decade before the implications of reduced public sector spending become apparent.

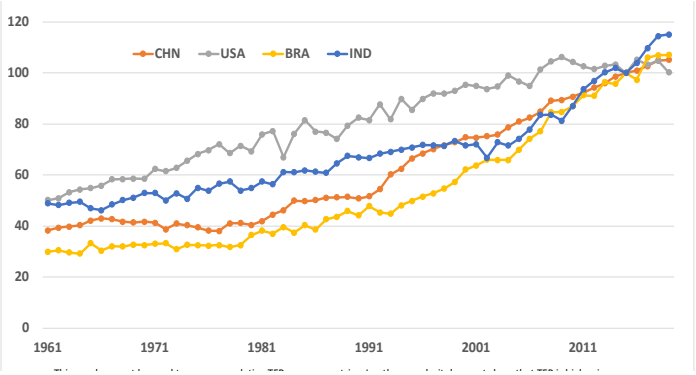
Total Factor Productivity

Total factor productivity, usually measured as the ratio of aggregate output to aggregate inputs, is a measure of productive efficiency. It measures how much output can be produced from a certain amount of inputs.

Data from USDA on total factor productivity (TFP) suggest that the decline in public sector spending on agricultural R&D in the United States may be affecting growth in productivity. An index of agricultural TFP, 2015 = 100, peaked in the United States at 106 in 2009. As of 2019, the index of TFP in the USA was 100, meaning that efficiency in the use of inputs in the United States actually declined by about 6% during the decade ending in 2019.

In contrast, indexes of TFP in China, India and Brazil increased between 2009 and 2019, meaning that the agricultural industries of those countries became more efficient in the use of inputs.

Figure-5. Total factor productivity indexes, 1961-2019 (for each country, 2015=100). Source: Fuglie, Keith O. (2015). "Accounting for Growth in Global Agriculture," Bio-based and Applied Economics 4(3): 221-54, and the website for the ERS-USDA data product, "International Agricultural Productivity."



Indexes of TFP cannot be compared from one country to another. Therefore, we cannot say that as of 2019, India was the most efficient agricultural producer among the countries shown. However, we can say that productivity grew faster in India than in China, the USA or Brazil during the past decade, rising from an index value of 81 in 2009 to 115 in 2019. The index of TFP, 2015 = 100, in Brazil grew from 85 in 2009 to 107 in 2019, and the index in China rose from 89 to 105 over the same years.

It is curious that productivity growth among the countries

shown was the greatest in India between 2009 and 2019. Spending on Agricultural Knowledge and Innovation Systems during 2000-02 and 2019-21 was lower in India than in China, the USA or Brazil, both in absolute dollars and as a percentage of the value of agricultural production. The index of TFP in India probably rose faster than in Brazil, China or the USA during the last decade because India was starting from a smaller base. Nevertheless, the growth in TFP in India between 2009 and 2019 is still a significant achievement.

The decline in the index of TFP in the United States between 2009 and 2019 might be a result of reduced public sector expenditures on agricultural R&D after 2002; this is what is implied in the USDA/ERS report. With public sector spending on agricultural R&D declining, enhancements to productivity in the agricultural sector of the U.S. economy are increasingly coming from private sector investments, and these may not be sufficient to maintain growth in agricultural input use efficiency in the United States.

However, the reduction in productivity could also be a reflection of the fact that a rising proportion of public sector spending on agricultural R&D in the United States is oriented toward welfare and environmental issues, rather than traditional productivity-enhancing topics like soil science and breeding. Therefore, the decline in agricultural input use efficiency in the United States after 2009 could reflect not just a decline in public sector R&D spending but also a shift in spending to topics that, while important, have little impact on traditional measures of productivity.

The reduction in the index of TFP in the USA could also be derived from factors having nothing to do with agricultural R&D spending. Reduced productivity in the USA could reflect reduced investments in agricultural infrastructure in response to better opportunities for the use of capital in other segments of the USA economy. It is possible that the agricultural sector of the USA economy attracted less investment during the past decade than more glamourous segments, such as cell phones, electric cars or space tourism, and productivity in the USA agricultural economy was destined to decline no matter how much was spent on R&D.

Regardless of what caused the decline in TFP in the United States after 2009, it is self-evident that more spending on agricultural R&D would result in more input use efficiency, other things equal. Therefore, while the reduction in public sector spending on agricultural R&D in the United States since 2002 may not in and of itself be a cause of a decline in agricultural productivity, it nevertheless is a subject that warrants more study.

Conclusions

Public sector spending on agricultural research and development has been declining in the United States since the early 2000's. However, private sector spending on agricultural R&D has been climbing, and total agricultural R&D spending (public plus private) is probably still larger in the United States than in other countries.

Public sector spending on agricultural R&D during 2019-2021 in China was roughly double the level of public sector spending in the United States and was four to six times more than spending in India or Brazil. As measured by indexes of Total Factor Productivity, agricultural productivity declined in the United States during the decade between 2009 and 2019 but rose in India, Brazil and China. Accordingly, the advantage enjoyed by the United States in agricultural productivity is less now than a decade ago.

It is not clear what caused the decline in Total Factor Productivity in the United States between 2009 and 2019. In all probability, the decline was caused by a multitude of factors, of which the reduction in public expenditures on agricultural R&D and the shift in public sector spending away from topics having a bearing on input use efficiency toward welfare and environmental issues, may be among those factors.

References

Fuglie, K and Nelson, K.P. 2022. Agricultural and Food Research and Development Expenditures in the United States (/data-products/agricultural-and-food-research-and-developmentexpenditures-in-the-united-states/), USDA, Economic Research Service, May 2022.

OECD. 2022. Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, https://doi.org/10.1787/7f4542bf-en.

Clancy, M. 2021. "How long does it take to go from science to technology?" by Matt Clancy, August 13, 2021 in New Things Under the Sun. https://mattsclancy.substack.com/p/how-long-does-it-take-to-go-from#details

Fuglie, Keith O. 2015. "Accounting for Growth in Global Agriculture," Bio-based and Applied Economics 4(3): 221-54, and the website for the ERS-USDA data product, "International Agricultural Productivity."

The ICAC Recorder

Low Carbon Agriculture For Better Environment

Dr. Md. Akhteruzzaman

Former-Executive Director of the Cotton Development Board, Bangladesh

Dr. Md. Akhteruzzaman, is the former Executive Director of the Cotton Development Board, Bangladesh. He is an experienced cotton expert in the field of research and extension. He obtained his M.Sc. degree on Agriculture from Bangladesh Agricultural University in 1992. He joined the Cotton Development Board in 1997 and served in various capacities such as Deputy Director, Project Director and Additional Director. Many of his research articles have been published in national and international journals. He has visited many countries such as China, India, Turkey, Australia, Russia and Egypt to exchange knowledge. He has received the Departmental Integrity Award; Innovator Award and he is a member of the Proud Research Team of the Revival of Legendary Dhakai Muslin Project. The project won the Public Administration Award in 2021.

Introduction

According to the World Resources Institute (WRI), the agriculture sector is responsible for nearly 12% of the world's greenhouse gas emissions. Carbon sequestration and reduction in greenhouse gas emissions can be achieved through a variety of agricultural practices. The term "low-carbon agriculture" encompasses actions to reduce the energy inputs and greenhouse gas emissions associated with agriculture.

The primary greenhouse gases linked with agriculture are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Although carbon dioxide is the most abundant greenhouse gas in the atmosphere, nitrous oxide and methane have longer atmospheric lifetimes and absorb more long-wave radiation. Therefore, even small quantities of methane and nitrous oxide can have significant effects on climate change. On the other hand, carbon dioxide is removed from the atmosphere and converted to organic carbon through photosynthesis. Conservation tillage, organic production, cover cropping, and crop rotations are practices that can significantly increase the amount of carbon stored in soils.

Low-carbon agriculture is characterized by low energy consumption, minimal greenhouse gas emissions, reduced pollution, and high efficiency. It involves cleaner production, waste utilization, and incorporates principles of sustainable, ecological, and circular agriculture. Carbon efficiency is an essential aspect of low-carbon agriculture, not only from a practical but also a conceptual perspective. The shift towards carbon efficiency in agriculture is crucial for balancing economic, environmental, and social objectives, with the primary aim of mitigating climate change and promoting sustainable development. The concept of low-carbon agriculture draws on various scientific fields and disciplines.

Greenhouse gas emissions from Agriculture

Agriculture is a significant contributor to greenhouse gas emissions. Poor management of nitrogen-based fertilizers can generate considerable amounts of nitrous oxide emissions, and irrigation systems used in crop production can also be significant drivers of GHG emissions.

Agriculture production contributes to climate change by emitting greenhouse gases, some of which can be avoided or reduced.

Nitrogen-based fertilizers: Poor management of nitrogen-based fertilisers can generate considerable amounts of nitrous oxide emissions, in addition to the GHG emissions associated with the production of fertilisers and pesticides.

Water: Irrigation systems used in crop production can be significant drivers of GHG emissions in certain areas where water must be pumped and moved across long distances or where the electricity grid operates on high-emitting power sources like coal.

Deforestation: Forests, wetlands and grasslands converted for crop production can eliminate natural vegetation that store carbon.

Agricultural activities serve as both sources and sinks for greenhouse gases. The primary sources of greenhouse gases in agriculture are the production of nitrogen-based fertilizers, the combustion of fossil fuels used by farm machinery, and waste management. Livestock enteric fermentation, which takes place in the digestive systems of ruminant animals, results in methane emissions. The concept of low-carbon agriculture combines cleaner production and utilization of waste, with a goal of balancing economic, environmental, and social goals while limiting climate change and promoting sustainable

development. The evolution of agricultural activities towards carbon efficiency is an important condition for achieving these goals.

The main sources of greenhouse gas emissions in agriculture are N_2O from soil, CH_4 from enteric fermentation, CO_2 from biomass incineration, and CH_4 from manure. The use of synthetic (N) fertilizers and incorporation of crop residues into soil result in nitrous oxide (N_2O) emissions, while the application of urea and lime to the soil leads to carbon dioxide (CO_2) emissions. While there is no universally accepted definition of a "low-carbon economy," it generally refers to a series of actions aimed at reducing greenhouse gas emissions while respecting the principles of sustainable development, promoting innovation, and enhancing competitiveness in the global market. Achieving a low-carbon economy requires the adoption of practical actions in all sectors and industries, including agriculture. The study of interdependencies and relationships between phenomena, concepts, and objects is essential to understand the conditions for low-carbon economic development, and this subject is studied in various fields, including agricultural, technical, and economic sciences.

Agriculture is a significant source of nitrous oxide (N_2O) and methane (CH_4) emissions, contributing to greenhouse gas emissions. However, agriculture also has the potential to limit carbon emissions by sequestering carbon in soils, resulting in a relatively small share of agriculture in net CO_2 emissions. Both plant and animal production are linked to agricultural emissions. Nitrous oxide (N_2O) is a greenhouse gas that is 300 times more effective than CO_2 in terms of heat absorption and is a fundamental emission from agriculture. Undesirable decomposition of nitrogen fertilizers in the soil (natural and mineral fertilizers) is a significant cause of N_2O emissions. Nitrous oxide emissions are affected by other factors as well, such as soil temperature, oxygenation, availability of hydrocarbons, pH, and soil humidity, and are associated with denitrification and, to a lesser extent, nitrification through microbiological processes. Nitric oxide is poorly soluble in water, does not elute with precipitation, and can accumulate in the atmosphere for approximately 150 years.

The emission of N_2O from agricultural soils occurs both directly and indirectly. Direct emissions of N_2O are mainly due to the use of nitrogen fertilizers and the emission of N_2O from organic nitrogen in animal waste, while indirect emissions are related to ammonia (NH_3) emissions and nitrogen leaching. Intensively supplying soil with nitrogen fertilizers is a significant source of N_2O formation. Emissions of these compounds can lead to adverse changes in agricultural soil, such as acidification and eutrophication of natural ecosystems. Additionally, nitrous oxide intensifies the greenhouse effect and contributes to the depletion of the ozone layer.

Greenhouse gas emissions from agricultural production are also impacted by the mechanization of agriculture. The emissions of air pollutants as a result of using agricultural machinery such as tractors, power tillers, harvesters, etc., need to be considered. Farm tractors, as well as other diesel-powered vehicles, emit gases that contain carbon monoxide (CO), hydrocarbons (HC), particulate matter (PM), and nitrogen oxides (NOx). Agricultural tractors contribute more than 6% of the total nitrogen oxide emissions from transportation.

Mitigating climate change through agriculture

There are various farming practices and technologies that can help to reduce greenhouse gas emissions and prevent climate change. These include enhancing carbon storage in soils, preserving existing soil carbon, and reducing emissions of carbon dioxide, methane, and nitrous oxide.

Key actions in low-carbon agriculture: The Better Farming Principles and Criteria require farmers to adopt good management practices that maintain soil integrity, restore degraded soils, and reduce greenhouse gas emissions.

Improving fertilizer management: Nitrogen fertilizer use efficiency can be improved by adjusting application timing, tillage practices, and other methods to limit nitrous oxide emissions. This can also decrease nitrogen leakage into the environment and contamination of surface and groundwater. Precision farming, which uses GPS tracking, is one strategy to improve fertilizer efficiency and reduce nitrous oxide emissions. Other strategies include the use of cover crops and animal and green manures, nitrogen-fixing crop rotations, composting, compost teas, and integrated pest management.

Implement efficient irrigation practices: To optimize water productivity and reduce emissions from irrigation, it is important to improve water use efficiency through various measures. This can be achieved by using mechanical improvements in irrigation systems, reducing operating hours, and implementing drip irrigation technologies or center-pivot irrigation systems. By reducing the amount of water and nitrogen applied to crops, these practices can help to lower greenhouse gas emissions of nitrous oxide and decrease water withdrawals.

The ten activities to reduce emission: In agriculture, there are ten activities that can be implemented to reduce emissions. The first is to reduce methane emissions in rice fields, followed by the reduction of chemical fertilizer use and improving its efficiency as the second action. The third is to reduce low-carbon emissions from livestock and poultry, while the fourth is

to reduce emissions from fisheries. The fifth activity is focused on promoting energy-saving green agricultural machinery. The sixth is to improve the carbon sink in farmland, while the seventh is to promote the comprehensive utilization of straw. The eighth action is to promote the use of renewable energy sources, the ninth is to support scientific and technological innovation, and the tenth is to disseminate scientific and technological innovations.

Conservation Tillage and Cover Crops: Conservation tillage encompasses various strategies and techniques for establishing crops in the residue of previous crops, which are deliberately left on the soil surface. Reducing tillage minimizes soil disturbance and helps mitigate the release of soil carbon into the atmosphere. Conservation tillage also enhances the carbon sequestration capacity of the soil. Besides, conservation tillage offers other benefits like improved water conservation, reduced soil erosion, reduced fuel consumption, reduced compaction, increased planting and harvesting flexibility, reduced labor requirements, and improved soil tilth. Cover crops are another approach used in conservation agriculture, as they can help prevent erosion, reduce nutrient loss, and provide additional organic matter to the soil.

Improved Cropping Systems: Recent reports suggest that organic agriculture can reduce greenhouse gas emissions by increasing soil organic matter levels through the use of composted animal manures and cover crops. Organic cropping systems eliminate the emissions from the production and transportation of synthetic fertilizers. The components of organic agriculture can be combined with other sustainable farming systems, such as conservation tillage, to further increase climate change mitigation potential. Generally, conservation farming practices that conserve moisture, improve yield potential, reduce erosion and fuel costs also increase soil carbon. Direct seeding, field windbreaks, rotational grazing, perennial forage crops, reduced summer fallow, and proper straw management are examples of practices that reduce carbon dioxide emissions and increase soil carbon. Using higher-yielding crops or varieties and maximizing yield potential can also increase soil carbon.

Land Use Changes: Land restoration and land use changes can encourage the conservation and improvement of soil, water, and air quality, and typically reduce greenhouse gas emissions. Implementing sustainable grazing practices such as sustainable stocking rates, rotational grazing, and seasonal use of rangelands can lead to greenhouse gas reductions. Converting marginal cropland to trees, shrubs, or grass can maximize carbon storage on land that is less suitable for crops.

Methane capture: Livestock waste treatment, especially in dairies, contributes significantly to large emissions of methane and nitrous oxide. Methane capture and combustion systems in agriculture include covered lagoons, complete mix and plug flow digesters. By using anaerobic digestion, animal waste can be converted to energy, capturing methane and preventing it from being released into the atmosphere. The captured methane can then be used to fuel a variety of on-farm applications or generate electricity. This process also reduces odors from livestock manure and labor costs associated with manure removal.

Other renewable energy options, such as wind and solar, provide significant opportunities for the agricultural sector to reduce greenhouse gas emissions.

Conclusion

The low-carbon economy responds to the challenges associated with climate change and aims to counteract disturbances in ecosystems, while also promoting agribusiness development in a more sustainable way. The transformation of agriculture towards low-carbon practices involves changing production and consumption processes, reducing emissions of pollutants and greenhouse gases, minimizing waste and ineffective use of natural resources, preserving biological diversity, and improving energy security. The transition to a low-carbon economy in agriculture requires smart growth based on knowledge and innovation. Innovative means of agricultural production with relatively low environmental impact, such as biofertilizers and biopesticides, precision agriculture (using GPS), and low-emission energy sources on farms (e.g., agricultural biogas energy plants), should be utilized. Additionally, crop rotation plants with a positive index of reproduction of soil organic matter and nitrogen compounds can help reduce emissions. Rational environmental management is also crucial for the development of a low-carbon economy, including the use of appropriate technical equipment.