Cotton: A Case Study in Misinformation

UPDATE

Updated With The Latest Data on Cotton

TRANSFORMERS FOUNDATION

This report was commissioned and authored by the Transformers Foundation. Our goal is to help suppliers share their expertise and opinion on industry threats and solutions, brands and retailers transform their jeans from a commodity into unique and valuable fashion, and consumers choose the most environmentally-sound denim products and avoid greenwashing. Our events connect industry professionals who want a deeper understanding of the denim industry, covering topics ranging from energy and water to social responsibility, technology and waste.

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Acknowledgements

Though this report represents the views of the Transformers Foundation only, the author would like to thank all the organizations and people who contributed their expertise and ideas.

Special recognition is extended to Marzia Lanfranchi and Elizabeth L. Cline for their foundational work in 2021, which paved the way for this update. We would also like to acknowledge the contributions of ICAC, the International Cotton Advisory Committee, that were critical to the successful completion of this report.

Our Revision Board was critical in reviewing the content of this paper:

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This report would not have been possible without the generous contributions of our founding members:

Alberto Candiani, Global Manager, Candiani Denim

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Executive summary

Fashion's narrative, particularly surrounding cotton, has been entangled in a web of half-truths and misconceptions. Transformers Foundation first sought to illuminate these issues in our 2021 report "Cotton: A Case Study in Misinformation", and now, recognizing the evolving dynamics and the imperative of accurate information, we are presenting an updated report with the latest data and context.

In this paper, readers will:

- Be provided with the best available data and context to replace misinformation. Specifically, this report presents 2020 data on pesticide use, water use and fertiliser use from ICAC's Cotton Data Book 2022 (whereas our 2021 report covered data from 2019 and did not cover fertilisers)
- Understand the complexity of resource use decision farmers have to make
- Rethink the way we source our cotton

The data gaps presented in this paper reveal a much deeper, structural challenge—the issue of partnerships. The future of cotton isn't only about what numbers state, but about understanding the individual farmers, the communities, and the unique challenges they face. It's about recognizing that each statistic has a human story, a local challenge, and a partnership opportunity behind it.

Redefining cotton sourcing requires reimagining these partnerships. It means looking beyond global averages, understanding the nuances of regional differences, and valuing the role of individual farmers. Because, if the industry wants to champion cotton farmers and foster transformations to mitigate varied impacts, it must move beyond traditional sourcing models that overshadow the essence of the cotton industry: the growers themselves.

By engaging in this report, we hope readers not only become equipped with factual clarity but are also urged to rethink cotton sourcing from its roots. This is not just a quest for data; it's a journey towards cultivating more responsible, equitable, and holistic partnerships within the fashion world.

INTRODUCTION:

Data, Context, and Partnerships

In 2021, we shed light on the fashion industry's misinformation problem, with half-truths and context-free data spread by various actors through our deep dive report, "Cotton: A Case Study in Misinformation". This misinformation undermines efforts to promote responsibility and transparency in the industry, and has serious consequences for public trust and democratic institutions.

IMPORTANT!

As one of the world's most widely traded agricultural commodities, cotton plays a critical role in the global economy and supports the livelihoods of millions of people around the world. While global averages are useful for providing a broad overview of the state of the cotton industry, we must not overlook the differences from region to region, farm to farm, and the important role that individual farmers play in producing this valuable commodity.

To this end, our 2021 report synthesized publicly available data from the International Cotton Advisory Committee (ICAC) and Food and Agriculture Organization of the United Nations (FAO), pulling information from 2019 that was relevant for the textile industry. We emphasized the importance of critical data consumption and responsible sharing, as well as the need to approach data and statistics with slight skepticism to ensure their proper use and interpretation. Understanding that different methodologies should not be compared, we highlighted the necessity of context for meaningful conversations about data, and emphasized how lack of context can be used to mislead. We stressed the significance of combating misinformation, being mindful of data limitations, and using the most reliable and up-to-date sources. Additionally, we emphasized the importance of using data to drive action and change across all sectors, without shifting problems or demonizing others. Lastly, we advocated for taking ownership of mistakes, correcting misinformation, and fostering an environment where errors can be openly addressed.

Since then, ICAC and FAO have released new data from 2020, and in our mission to provide the most current and sound data surrounding cotton, **Transformers Foundation is pleased to release an update to our 2021 report "Cotton: A Case Study in Misinformation."** This update amalgamates data from ICAC, Bayer Crop Science and the FAO, focusing on information relevant to the textile industry. This supplementary annex builds on our previous work, providing new data and analysis on cotton production, pesticide use, key trends in water usage within the industry, and also introduces information on fertilizers not covered in our last report.

Farmers are the foundation of the cotton sector, and their hard work and dedication are essential to producing high-quality cotton that meets the demands of the global market. As such, we must ensure that our analysis and reporting properly reward the contributions of individual farmers, farmer groups and communities rather than simply relying on global averages that may not reflect the unique circumstances of each farm and region. By taking a more nuanced and localized approach to data collection and analysis, we can better understand the challenges and opportunities facing farmers and work with them as the experts to support solutions that address their specific needs.

Although this paper offers insights into how a more nuanced and localised approach to data collection can ideally help upstream and downstream actors to be better partners to cotton farmers, it's worth emphasizing that it's difficult to become a better partner to cotton farmers if we do not know who those farmers are in the first place. **We ask readers to bear in mind that this challenge is not merely a data problem, but a partnership problem.** If the industry truly wants to support cotton farmers with the transformations needed to address the crop's highly varied impacts – which depend on the political and physical operating contexts within which a farmer operates – we must also reconsider sourcing models that render cotton farmers invisible and approach change from the bottom up. This requires addressing a highly inequitable distribution of financial risk and reward, such that downstream actors begin to have a vested interest in their growers' success, and requires brands to shift away from directive approaches to sustainability and shift into the role of supporter and enabler.

We still firmly believe that access to dependable data, transparent methodology, and context is crucial for making well-informed decisions and implementing effective strategies to tackle the intricate challenges within the cotton industry. By providing examples and analysis in this report, our aim is to encourage readers to conduct thorough data due diligence, understand that unfavorable numbers should not deter sourcing from specific regions, promote sound methodologies and impartial analysis, and foster a deeper comprehension of local realities to become better listening partners to farmers. Through this partnership we can foster changes that works with localized challenges and create localized solutions that reduce impacts. Through the presentation of accurate and trustworthy data, we aspire to counteract misinformation and cultivate a more nuanced and sophisticated discourse surrounding the challenges and opportunities in the global cotton industry.

The aim of the paper is to:

1. Gather and share publicly the best available data and context on cotton to use in place of misinformation.

2. Build on our previous work by providing updated and new data and analysis on cotton production, pesticide use, and fertilizers, and highlighting key trends and water usage in the industry.

3. Foster the cotton industry's consensus around the data contained in the report, so that it's trusted and usable for the industry and the wider public.

4. Help the fashion industry understand how complex cotton production practices and resource use decisions can be.

5. Urge readers to rethink the way we source our cotton.

Why should you trust us?

You might have wondered why you can trust us and the information we share. This is the right sort of question to be asking. We are writing on behalf of Transformers Foundation, a nonprofit that aims to support a responsible denim industry. Aren't we biasedtowards cotton?

Yes, we are, and here's what we did to balance that bias to ensure that this paper is built around credible data and context that isn't misleading:

- All data in the report come from a primary source (meaning we have verified the original study or first-person report from which it came) and the most recent available data from public and private sources. We draw on peer reviewed data whenever possible, meaning drawn from studies evaluated for quality by other experts in the same field, before being published.
- All claims have been fact-checked using an independent and experienced fact checker that is not employed by any industry association, including our own. Likewise, our writer is not employed by any cotton industry associations, including our own.

We've made every effort to research the best available and more relevant figures around cotton and make them available to you. We hope you'll find this isn't a paper written to make cotton look good, but to shine a light on responsible practices and information usage, starting with cotton. And here are a few final disclaimers before we get started:

- We've done our research and you should too! Check our sources against your own, and always exercise critical thinking and sound judgment.
- This is the best available data we have found yet. If you have better sources or can help us fill our data gaps, please contact us communications@transformersfoundation.org
- This is empirical research. Accordingly, the results should not be used to describe the fashion sector at large.

*This page was originally published in: Cotton: A Case Study in Misinformation in 2021

Please note that the data presented in this report is based on the latest available information and may not reflect the current situation in your specific location or context. While we have made every effort to ensure the accuracy and reliability of the data, we encourage all users to seek their own data and to verify the information presented here before making any decisions or taking action.

We encourage all users of this report to exercise due diligence and to seek additional information from experts as needed, in order to gain a more comprehensive understanding of the issues at hand.

SECTION 1:

Cotton and Water: The Reality

How Much Water Does it *Really* Take to Grow a Pair of Jeans?

The narrative surrounding cotton's water consumption is often misleading and lacks important context.

In our previous report, we delved into the complexities of cotton's water impacts and the challenges of analyzing it in a nuanced and accurate way. If you are looking at this for the first time, the main points you need to understand from our previous report are the concept of a *water footprint* and the different types of water that are included in these calculations, such as *green water* (rainwater), *blue water* (surface water and groundwater used for irrigation), and grey water (water needed to dilute industrial pollution), as well as the key differences between water use versus water consumption. If you want to know more read our last report from 2021 here.

One of the findings from our 2021 report was that there was an 805-fold difference in the amount of irrigation water (blue water) consumed in cotton between nations, from Brazil's 17 liters per kilogram of lint to Turkmenistan's 13,696 liters per kilogram.[1] With a global average of 1,931 liters blue water consumption per kilogram, you can understand why global averages do not reveal much and stress that one should never compare these numbers as like for like. This analysis of different water types (irrigated / blue water and rainfed / green water) led us to highlight the importance of considering the global water cycle, local water availability, water stress (when water demand outpaces supply or its quality limits use),[2] and water risks when analyzing cotton's water impacts versus only looking at water use, water consumption or the water footprint.

Doing due diligence when assessing the impact of cotton's water usage requires a broader understanding of factors like water sources, sustainable withdrawal rates, and potential interference with other uses. In water-stressed regions, external factors such as climate change, outdated technology, and weak regulations contribute to water scarcity. Simply doing away with cotton production likely would not resolve these challenges. Instead, promoting just, sustainable, and equitable water management in cotton and agriculture at large is crucial.

In this section, we aim to use the updated data we're sharing to provide a deeper understanding of the complex relationship between cotton and water through a new analysis of irrigated cotton in water stressed regions and the unpredictability of yields with rainfed cotton, as well as exemplify how sustainable water management is possible through activities and considerations that farmers and agricultural scientists already undertake.

Irrigation methods and footprint

In our 2021 report, the 2019 data showed the top ten cotton growing regions' irrigation water in litres per kilogram of lint and the percentage of what types of irrigation methods are used to help inform what water risks could be present, as well as give you insight into sustainable water withdrawal rates. This updated table provides data from 2020, given to us by ICAC and available from their 2022 Cotton Data Book. If you have other sources for this data, please get in touch with us.

The Methods & Footprint of Irrigated Water for Cotton

Fig. 01

Country	Region/Province/ State	Flood	Furrow	Sprinkler	Drip	Total Irrigation water applied mm/Ha	Total Irrigation water applied Billion Litres	Irrigation water Litres /Kg lint
Argentina	Chaco	0	0	0	0	0	0	0
	Santa-Fe	0	0	0	0	0	0	0
	Santiago del Estero	100	0	0	0	200	112	741
Australia	New South Wales	1	65	24	10	640	2,263	2,711
	Queensland	2	69	20	9	640	959	2,273
Bangladesh	Jessore	0	0	0	0	0	0	0
	Rangapur	0	100	0	0	70	1	69
Benin	Alibori	0	0	0	0	0	0	0
	Atakora	0	0	0	0	0	0	0
	Borgou	0	0	0	0	0	0	0
Brazil	Bahia	0	0	50	50	160	38	65
	Goias	0	0	0	0	0	0	0
	Mato-Grosso	0	0	100	0	160	72	36
Burkina Faso	Bobo-dioulasso	0	0	0	0	0	0	0
	Fada-n'gourma	0	0	0	0	0	0	0
	Ouagadougou	0	0	0	0	0	0	0
Cameroon	Garoua	0	0	0	0	0	0	0
	Maroua	0	0	0	0	0	0	0
Chad	Logone Occidental	0	0	0	0	0	0	0
	Logone-Oriental	0	0	0	0	0	0	0
	Mayo Kebbi	0	0	0	0	0	0	0
	Tandjile	0	0	0	0	0	0	0
China	Hebei	20	80	0	0	320	47	2,293
	Hubei	35	14	16	35	240	25	1,600
	Shandong	10	90	0	0	480	76	2,996
	Xinjiang	0	8	8	84	294	7,585	1,392
Colombia	Cordoba	0	99	1	0	800	45	6,154
		0	0	0	0	0	0	0
Cote-D-Ivoire	Savanes	0	0	0	0	0	0	0
Egypt	Beheira	70	30	0	0	616	7	6,405
	Dakahlia	80	20	0	0	626	121	11,575
	Faiyum	80	20	0	0	560	2	6,472
	Gharbia	80	20	0	0	611	3	5,742
	Kafr El-Shekh	75	25	0	0	592	212	12,885
	Sharkia	80	20	0	0	664	1	6,561
Ethiopia	Afar	0	96	4	0	320	54	3,432
	Amhara	0	94	6	0	270	7	364
	Benishangul	0	0	0	0	0	0	0
	Gambela	0	0	0	0	0	0	0
	South/SNNPR	0	100	0	0	225	16	1,948
	Tigray	0	0	0	0	0	0	0
Greece	Macedonia	0	10	68	22	400	291	3,747
	Thessaly	0	5	65	30	480	361	3,442
	Thraki	0	4	74	22	480	280	3,644
India	Andhra Pradesh	15	75	3	7	140	240	828
	Gujarat	10	85	0	5	270	4,440	3,491
	Haryana	80	14	0	6	480	2,839	12,690
	Karnataka	10	80	0	10	210	462	1,394
	Madhya Pradesh	34	55	0	11	180	484	2,004
	Maharashtra	25	65	0	10	100	119	98
	Odisha	0	0	0	0	0	0	0
	Punjab	90	4	0	6	480	1,181	10,735
	Rajasthan	88	7	0	5	450	3,198	7,582
	Tamilnadu	80	18	0	3	210	93	1,524
	Telangana	52	40	0	8	68	141	137
Indonesia	East Java	28	72	0	0	210	1	2,733
	East Nusa	48	52	0	0	280	3	4,271
	South Sulawesi	60	40	0	0	350	8	3,884
	Tenggara	80	20	0	0	210	2	3,182
	West Nusa	40	60	0	0	140	1	2,471
Iran	Ardebil	2	88	6	5	1,000	30	14,493
	East & Central	35	55	3	7	1,000	425	14,286
	Fars	40	58	0	2	1,200	226	12,000
	Golestan & Mazandran	63	5	2	20	400	71	5,846
Kazakhstan	Maktaaral	10	85	5	0	450	329	5,625
	Ordabasy	2	98	0	0	540	44	7,500
	Shardara	11	79	9	1	540	122	7,543
	Turkistan	12	82	6	0	540	43	9,030
Kenya	Baringo	0	0	0	0	0	0	0
	Busia	0	0	0	0	0	0	0
	Gaitu	20	80	0	0	120	1	1,333
	Lomu	0	0	0	0	0	0	0
Malawi	Lower shire valley	0	0	0	0	0	0	0
	Machinga	0	0	0	0	0	0	0
Mali	Kayes	0	0	0	0	0	0	0
	Koulikiro	0	0	0	0	0	0	0
	Segou	0	0	0	0	0	0	0
	Sikasso	0	0	0	0	0	0	0
Mexico	Baja California	0	100	0	0	375	48	2,313
	Chihuahua	0	95	0	5	420	471	2,275
	Coahuila	90	5	2	3	390	36	2,133
	Durango	85	5	4	6	560	9	3,298
	Sonora	0	95	0	5	532	14	3,521
	Tamaulipas	0	90	5	5	400	41	3,914
Mozambique	Cabo-delgado	0	0	0	0	0	0	0
	Nampula	0	0	0	0	0	0	0
	Niassa	0	0	0	0	0	0	0
Myanmar	Bago	0	100	0	0	225	2	3,261
	Magwe	0	100	0	0	150	15	2,113
	Mandalay	0	100	0	0	150	11	2,174
	Sagaing	0	100	0	0	150	5	1,935
Nigeria	Adamawa	100	0	0	0	70	0	43
	Gombe	100	0	0	0	80	1	118
	Katsina	0	0	0	0	0	0	0
	Zamfara	100	0	0	0	60	1	36
Pakistan	Punjab	0	100	0	0	640	8,186	9,317
	Sindh	0	100	0	0	720	4,277	8,391
South-Africa	KwaZulu-Natal	0	0	100	0	360	0	77
	Limpopo	0	0	100	0	450	16	2,131
	Mpumalanga	0	0	100	0	360	0	3,162
	North Cape	0	0	100	0	450	6	2,022
	North West	19	0	81	0	450	1	386
Spain	Andalucia	0	35	38	27	400	211	3,515
Sudan	Blue Nile	0	0	0	0	0	0	0
	Gezira	0	100	0	0	720	386	7,207
	Halfa	0	100	0	0	720	121	10,588
	Kordofan	0	0	0	0	0	0	0
	Rahad	0	100	0	0	720	16	425
	White Nile	0	100	0	0	1,080	48	19,286
Tanzania	Geita	0	0	0	0	0	0	0
	Mara	0	0	0	0	0	0	0
	Mwanza	0	0	0	0	0	0	0
	Shinyanga	0	0	0	0	0	0	0
	Simiyu	0	0	0	0	0	0	0
	Singida	0	0	0	0	0	0	0
	Tabora	0	0	0	0	0	0	0
Togo	Centrale	0	0	0	0	0	0	0
	Kara	0	0	0	0	0	0	0
	Maritime	0	0	0	0	0	0	0
	Plateaux Nord	0	0	0	0	0	0	0
	Plateaux Sud	0	0	0	0	0	0	0
	Savanes	0	0	0	0	0	0	0
Turkey	Cukurova	0	76	6	18	525	356	2,498
	Gap	0	60	28	12	450	1,120	2,286
	Turkey-Aegean	31	45	4	20	450	441	2,196
Turkmenistan	Lebap	0	100	0	0	450	664	7,941
	Mary-Velayats	0	100	0	0	450	722	7,444
Uganda	Apac	0	0	0	0	0	0	0
	Lira	0	0	0	0	0	0	0
USA	Alabama	0	11	89	0	167	30	198
	Arizona	0	95	5	0	1,401	725	9,975
	Arkansas	0	89	11	0	299	460	1,710
	California	0	92	8	0	975	440	5,398
	Georgia	0	0	100	0	183	309	643
	Kansas	0	0	100	0	213	24	584
	Louisiana	0	0	100	0	122	9	194
	Mississippi	0	61	39	0	144	85	438
	Missouri	0	91	9	0	188	153	866
	New Mexico	0	50	50	0	406	51	3,096
	North Carolina	0	0	100	0	122	5	32
	Oklahoma	0	43	57	0	366	137	906
	South Carolina	0	0	100	0	213	25	270
	Tennessee	0	0	100	0	122	9	73
	Texas	0	83	17	0	335	2,794	1,662
	Virginia	0	0	100	0	122	0	0
Uzbekistan	Andizhan	0	70	0	30	236	147	1,569
	Bukhara	0	68	0	32	340	326	2,818
	Dzhizak	0	69	0	31	204	131	1,474
	Ferghana	0	75	0	25	280	189	2,078
	Karakalpak	0	84	0	16	122	91	1,197
	Kashkadarya	0	81	0	19	227	265	2,007
	Khorezm	0	81	0	19	153	105	1,083
	Namangan	0	82	0	18	323	130	1,856
	Navoi	0	62	0	38	250	27	717
	Samarkhand	0	73	0	27	252	143	1,786
	Syrdarya	0	81	0	19	183	96	1,270
	Syrkhandar	0	81	0	19	324	170	1,978
	Tashkent	0	84	0	16	278	145	1,756
Zambia	Chipata	0	0	0	0	0	0	0
	Magoye	0	0	0	0	0	0	0
	Sinazongwe	0	0	0	0	0	0	0
Zimbabwe	Manicaland	0	0	0	0	0	0	0
	Mashonaland	0	0	0	0	0	0	0
	Mashonaland-East	0	0	0	0	0	0	0
	Mashonaland-West	0	0	0	0	0	0	0
	Masvingo	0	0	0	0	0	0	0
	Midlands	0	0	0	0	0	0	0
Global		**15.40**	**45.90**	**12.10**	**12.50**	**174.00**	**51,524.00**	**2,068.00**

Source: ICAC Cotton Data Book 2022

Like all plants, it's true that cotton requires water to grow. The amount of water applied to the crop in different regions can also vary greatly and is influenced by various factors including climate, rainfall and available groundwater, soil type and health, and the availability and efficiency of irrigation systems and productivity.[3] Generally, farmers choose to grow cotton when there is not enough water to grow other crops, such as corn or soy. Cotton and sorghum are the last two crops to grow in a dry area due to their inherent drought resistant properties, and if it were not for these crops, these drier growing regions would have a much harder time supporting their economy. So when looking at Figure 01, it is critical to understand that water stress is a complex issue affecting both humans and the environment, and irrigated cotton can be both a contributor to and victim of water stress.

In 2021, we aimed to emphasize the need for the fashion industry to do their data due diligence rather than taking numbers at face value and switching to other suppliers in regions that may look more favorable. This statement is also true when we do a deep dive into the data being presented in Figure 01.

Water stress: when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use.

For example, if we look at Iran, a small contributor to the world's overall cotton production, you can see how complex the situation can be, but also the opportunity to build and promote sustainable practices. Ardebil and East & Central Iran have the highest liters of water used per kilogram of lint sitting at 14,493 and 14,286 liters, yet Iran remains one of the most *water stressed* regions in the world. According to FAO, Iran's "Water Law and Methods of Nationalization of Water" states that "For any use of public water, as well as groundwater resources, a special authorization is required from the Ministry. In order to ensure the required water for the Country, the Ministry is obliged to control floods, desalinate the salty water, extract groundwater and establish a network of irrigation piping. Pollution of water resources is prohibited and for this purpose all necessary measures for water and sewage disposal should be taken. Any violation of the provisions of the Act shall be punished by fine."

Although Iran seems to have legislation in place for sustainable water management, one of the main concerns with extracting groundwater for irrigation is that it can lead to overuse of water resources, particularly in regions where water is scarce or subject to drought. Inefficient irrigation systems can also result in a significant amount of water being lost through evaporation or runoff, which can further exacerbate water scarcity and environmental degradation.[4]

While Iran has been working on modernizing its irrigation systems by implementing more efficient technologies like drip and sprinkler irrigation, the transition to these advanced methods is still ongoing and not widespread. Factors such as limited financial resources, lack of incentive (as water itself is free), and water governance issues may hamper the adoption of modern irrigation technologies in Iran. Furthermore, modernized irrigation systems do not guarantee better efficiency. Allan Williams, General Manager, R&D Investment at Cotton Research and Development Corporation, for Ecotextile News highlighted side by side trials undertaken in Australia between surface furrow, sprinkler and drip irrigation with no consistent winner on *water use efficiency*.

Water use efficiency: maximizing output from each unit of water used.

If a drip irrigation or sprinkler system were to break down during peak summer, it becomes very difficult to catch up. This poses a higher risk of stressing the crop, potentially leading to reduced yields. As a result, water use efficiency may decrease, heightening potential impacts in other categories. On top of this, switching to a pressurized system can lead to increased energy use. There are trials however, where over crop solar panels[5] provide shade for the crop, and could help in the future with these energy tradeoffs. All in all, you can see that the answer is far from black and white.

This new data and analysis re-illustrates the need for data due diligence to understand how complex resource use decisions can be before jumping to conclusions by taking numbers at face value. The *AWARE LCA* is a useful tool to begin the research and understand the contexts and risks associated with the region farmers are operating in. This method is the most accepted measure used in life cycle assessments and can be used to work with local researchers and farmers to find region-specific solutions and mitigate the risks found.

Their website states, “AWARE LCA is to be used as a water use midpoint indicator representing the relative Available WAter REmaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met.”[6]

Water risk assessment: typically involves evaluating the current and potential future risks associated with water availability, quality, and demand in a specific geographic area or region.

Furthermore, these new data give extra emphasis on the need for a *water risk assessment* [7] done by agriculture experts. This may involve analyzing factors such as climate patterns, water availability and use, looking at estimates of change in water availability from climate change (e.g.,changing rainfall, water tables, demand, etc.), local regulations and policies (ex. irrigation licences, population growth, and industry demand). The assessment may also include stakeholder engagement to gather input from local communities, businesses, and other groups affected by water management decisions.

IMPORTANT!

Based on the findings of the assessment, strategies can be developed to mitigate risks and promote sustainable water management practices, such as water conservation measures, improved irrigation techniques that make sense for local realities, and alternative sourcing of water. All assessments and strategy development should be led by agricultural experts, farmers, and their communities, to ensure the measures taken to promote sustainable water management are appropriate and will be adopted and owned by them in the future. If one cannot source cotton directly, programs like BCI or CmiA offer a beneficial starting point to support farmers. However, the ultimate aim is to establish genuine connections with the farmers themselves. Rather than merely ticking boxes via certifications and programs, the aspiration is to shift from a top-down, transactional approach to fostering true partnerships. The core of responsible cotton sourcing and production is rooted in these relationships, drawing fashion professionals closer to the source.

The core of responsible cotton sourcing and production lies in these relationships, putting fashion professionals closer to the source. All in all, it's crucial to keep farmers in the decision making position even when using technology and data solutions.

Another solution that is being explored when producing cotton in water stressed regions is storing rainwater for irrigation, as an average rainfall of 1,000 mm equates to 10 million liters collected on a hectare of land (or 4 million liters of rainwater collected in a year on an acre of land), pre-evaporation.[8] A great example can be seen in the villages of Narsinghpur district in Madhya Pradesh, India in which farmers have taken it upon themselves to manage excess rainwater and use it to recharge water sources. Villagers have since reported rising water levels, and the tube wells now have water in them which will help grow multiple crops in a year.[9] Cotton Incorporated also advocates for farm ponds, which play a crucial role in capturing large volumes of water during intense storm events. Serving as a reservoir or 'battery', they are a key strategy in addressing the challenges posed by increasingly extreme weather conditions.[10]

Rainwater Harvesting Techniques

Fig. 02

Rain Barrels	Dry System	Wet System	Farm Pond
The easiest and most affordable option in which water tanks are installed below the downspouts of the rooftop guttering system.[9]	Similar to the barrel system, but using dry processes where the gutter is redesigned so water is diverted to the barrel usually a few meters away from the property.[9]	Here the collection pipes and storage tank are stored underground. These pipes are connected to the downspouts of a building and will always have water in them.[9]	Here, rectangular holes collect and store rainwater with inlets for water flow, outlets for overflow, and bunds to prevent erosion. This stored water can be used for fields manually, via pumping, or both.[11]

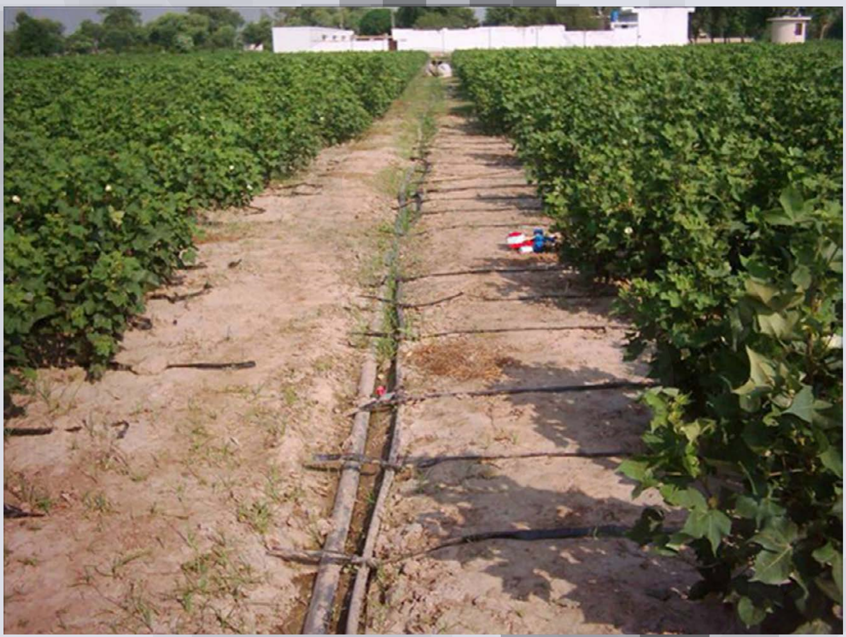


Fig. 03 Water Saving Technologies: UAF-USDA-ICARDA Initiatives for Farmers Drip Irrigation System on Cotton in Pakistan
Source: http://www.uaf.edu.pk/directorates/water_management/wmrc_dripirrigation.html

Extension system: an agricultural extension service offers technical advice on agriculture to farmers, and also supplies them with the necessary inputs and services to support their agricultural production. - FAO[12]

In addition to rainwater harvesting, *extension systems* worldwide already incorporate practices, such as drought-resistant crops, crop rotation, and sustainable livestock farming, as well as setting up seed banks to distribute drought-tolerant seeds. However, it's important to note that establishing a seed bank is a highly intricate undertaking that involves multiple steps such as producing and selecting varieties, maintaining cold storage facilities, registering seeds, and ensuring their distribution. Unfortunately, these extension and seed services have been underfunded and often cut under structural adjustment programmes. The advisors of this report are of the opinion that what is really needed for water use efficiency is properly funded, local seed research with extension, which can deliver updated varieties as needed to deal with changing climate and pest complexes.

Australia, Israel, and Spain have also utilized innovative technologies, such as desalination and wastewater recycling, to manage water resources sustainably.[13] This is particularly important when considering the impact on the water cycle and the need to clean and return contaminated water back to its source.

While these water conservation efforts are laudable, it is important to note that water availability remains a significant factor even with improved water management. By understanding the risks that farmers can encounter in water-stressed regions through a due diligence process and seeking experts, we can start to be better supporting partners to farmers and listen to what they need to succeed in the contexts in which they operate. Experimentation with multiple efficient approaches like drip irrigation systems, collecting and storing rainwater, desalinating salt water, and recycling waste water to recharge water sources will be needed to adapt to dwindling water resources.

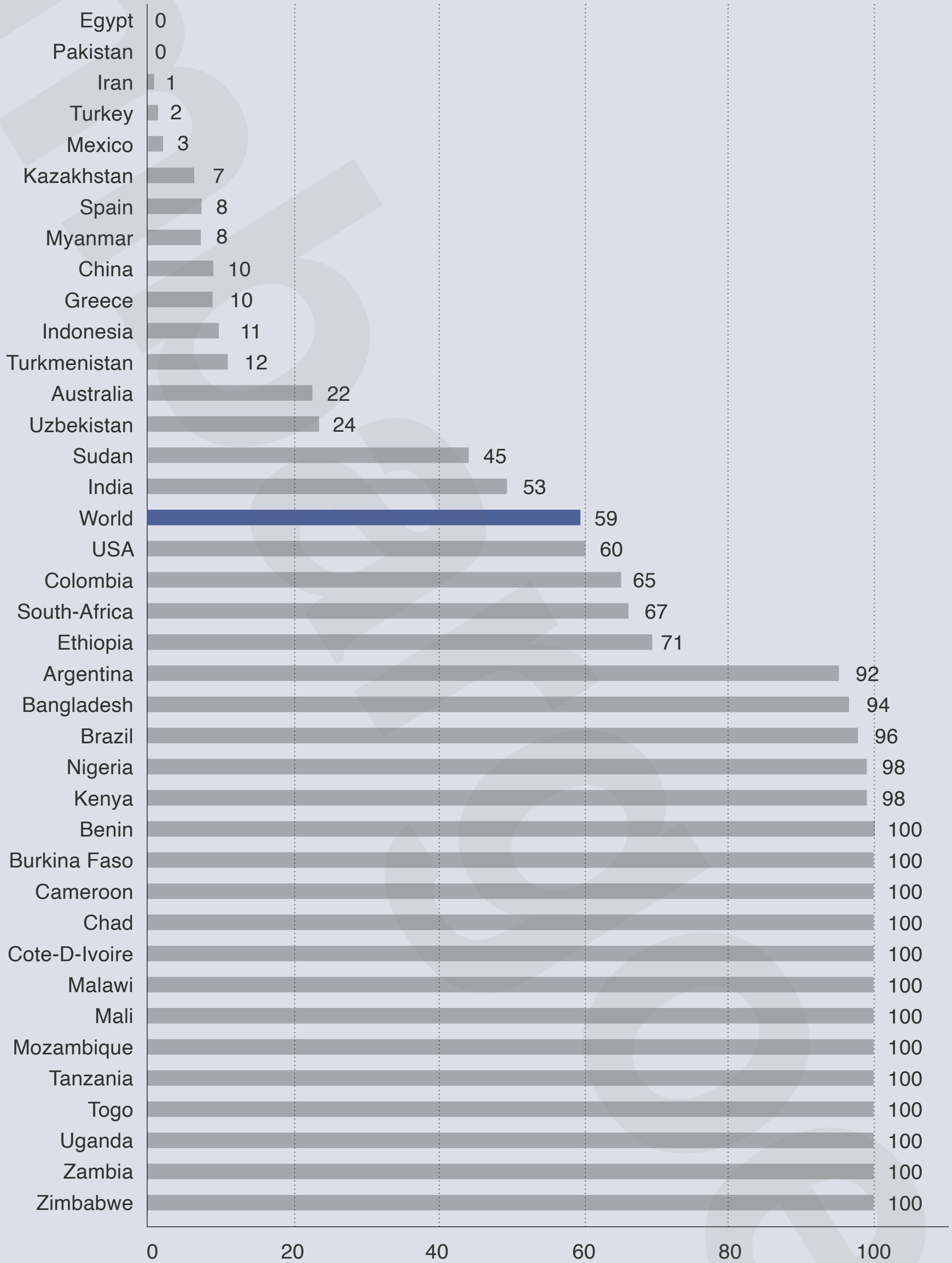
Whether it be through direct financial support or in-direct support through cotton programs and agriculture experts, it is crucial to be supporters and not dictators. It is also important to acknowledge that the political and physical contexts in which we operate will significantly impact our support efforts.

% of rainfed area

In our 2021 report, the 2019 data showed similar results with a global average of 50% of the world's cotton being rainfed compared to 2020 data sitting at 45%, likely due to shifting production regions and regional productivity. Even though these statistics have not changed significantly, we want to use this report to flag how these statistics intersect with vulnerability to climate change, which was not covered in our last report. This updated table provides data from 2020 given to us by ICAC and available from their 2022 Cotton Data Book.

% of Rainfed Area

Fig. 04



Source: ICAC Cotton Data Book 2022

This is the average percentage of rainfed area in each country. For region specific numbers and a detailed look, please look at ICACs 2022 Cotton Data Book.

In many countries, including Argentina, Bangladesh, Benin, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Ethiopia, Kenya, Mali, Mozambique, Sudan, Tanzania, Togo, Zambia, and Zimbabwe, a significant portion (often 100%) of cotton production relies on rainfed agriculture. This means that cotton farmers in these regions are highly vulnerable to the impacts of climate change and increasingly unpredictable rainfall patterns, which can lead to crop failure and loss of income.

In an analysis commissioned by Cotton 2040, it was found that all global cotton growing regions will be exposed to increased risk from at least one climate hazard by 2040[14] meaning it is crucial to consider the local situation and explore all possible options when it comes to managing water resources sustainably. This includes checking if water harvesting exists or is feasible in the area, identifying potential conflicts with other water users and uses, and assessing impacts on food security led by agriculture experts and farmers. While cotton irrigation can create additional water stress in some regions, it can create many benefits such as increased productivity, profitability, reduced *GHG emissions* per pound of cotton and more income security for the farmer.[15] Irrigation should not be viewed in a black and white perspective as it can be a key strategy for farmer's with a sustainable water supply to adapt to climate change.

GHG emissions: Any gas that has the property of absorbing infrared radiation emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapour are the most important greenhouse gases. - Britanica

In some regions, like Maharashtra in India, where more than 90% of cotton production is rainfed, farmers may face challenges in obtaining sufficient water for their crops during dry periods, and according to Cotton 2040, this is only going to get worse with 75% of the world's cotton-growing regions facing greater exposure to heat stress defined as temperatures above 40°C.[16]

Although cotton is considered drought tolerant, it is critical that the crop receives adequate water supply during specific growing stages, but is more flexible than most crops, as we explored in our previous report.[17] On average, cotton requires between 700 – 1300 mm of water during its growing period.[18] But as we know, the volume of water applied or used can range significantly across the globe from a low of 30 mm per hectare (300 cubic meters of water per hectare) per season throughout the growing season in Israel, to 1,230 mm per hectare (12,300 cubic meters per hectare) per season in Sudan[19] meaning that during dry seasons, over-extraction of groundwater and depletion of aquifers may occur in contexts that are particularly vulnerable to climate change. This can have negative impacts on local ecosystems and other water users and it is therefore crucial to carefully consider all available options and their potential impacts before implementing any water management strategies. To gain a better understanding of what potential risks are present, look to the Cotton 2040: Climate Risk Explorer Tool.

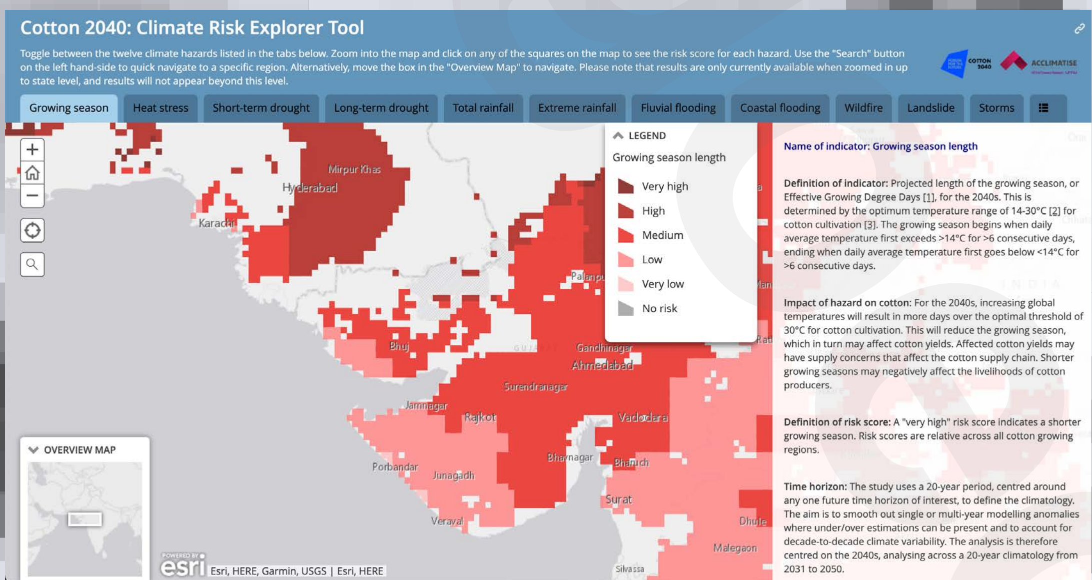


Fig. 05 Cotton 2040: Climate Risk Explorer Tool

Source: https://www.arcgis.com/apps/MapSeries/index.html?appid=472ec14d65d14b038cb5d5fecf9c4e5f

On the other hand, countries such as Australia and Greece, have a relatively small proportion of cotton production that is rainfed – less than 25% in some cases (this was also true in the data presented in our 2021 report). This may be due to a variety of factors, such as access to irrigation infrastructure, maximizing use of rainfall, government policies, and the driving factor, climate conditions.

You can see that in Spain, with a very limited amount of rainfall per year (139mm of water in Andalucia) their irrigation per hectare is 400mm compared to Ruhad, Sudan, which receives 522mm of rain yet still uses 720mm of irrigation water per hectare. This may be due to stricter regulations in the EU for water management, but in Spain, farmers have to pay to pump water versus in Sudan where water is free, leaving little incentive for Sudan to conserve any water at all.

Simon Ferrigno, an advisor to this paper and cotton expert, suggests, however, that much of cotton is over-irrigated and stresses the importance of remembering that cotton is a drought tolerant crop that may yield better under slight water stress. Jesse Daystar of Cotton Incorporated adds that many growers also use *deficit irrigation* [20] or don't have enough water to irrigate as much as they want.

Deficit irrigation: Irrigating below full crop-water requirements

This highlights the need to go beyond the numbers, re-emphasizes the need for context, and the importance of doing data due diligence to understand why water management strategies should be tailored to the specific needs and challenges of each region, rather than adopting a one-size-fits-all approach.

Key Takeaways:

This new data reinforces, strengthens and reframes the following three points as discussed in our previous report:

1. **There are many different water metrics and understanding what each metric represents is important.** Most common and helpful metrics include blue water consumption, blue water use, water risk, water scarcity, and the water footprint. It is important to carefully use the metrics and language to avoid misinformation and confusion around these very similar sounding words and measures.

2. **Partner with cotton programs that support education and research on best practice.** As a first step towards responsible water management, cotton programs, such as BCI or CmiA, serve as a starting point to support the farmers in your supply chain. Many cotton programs have data collection mechanisms that can provide insight into water usage, water systems and the impact of cotton cultivation on local water systems. The ultimate goal, however, is to create real ties with farmers through a traceable supply chain network. The essence of responsible cotton sourcing and production lies in these relationships, putting fashion professionals closer to the source.

3. **Support the implementation of responsible water management practices that consider climate change vulnerability.** After understanding the risks associated with water availability and use, it is important to explore local traditions that promote responsible water management practices to conserve water and reduce consumption, while keeping farmers in the decision making position. In addition, the patterns of rainfall, its frequency and intensity, and future projections should be evaluated by agriculture experts, along with available technology. Supporting farmers financially in implementing new technologies, improving water infrastructure, or adopting water-efficient processes and practices may be necessary, as finance and capital is a major limiting factor. It is crucial to ensure that water management practices do not negatively affect other water users.

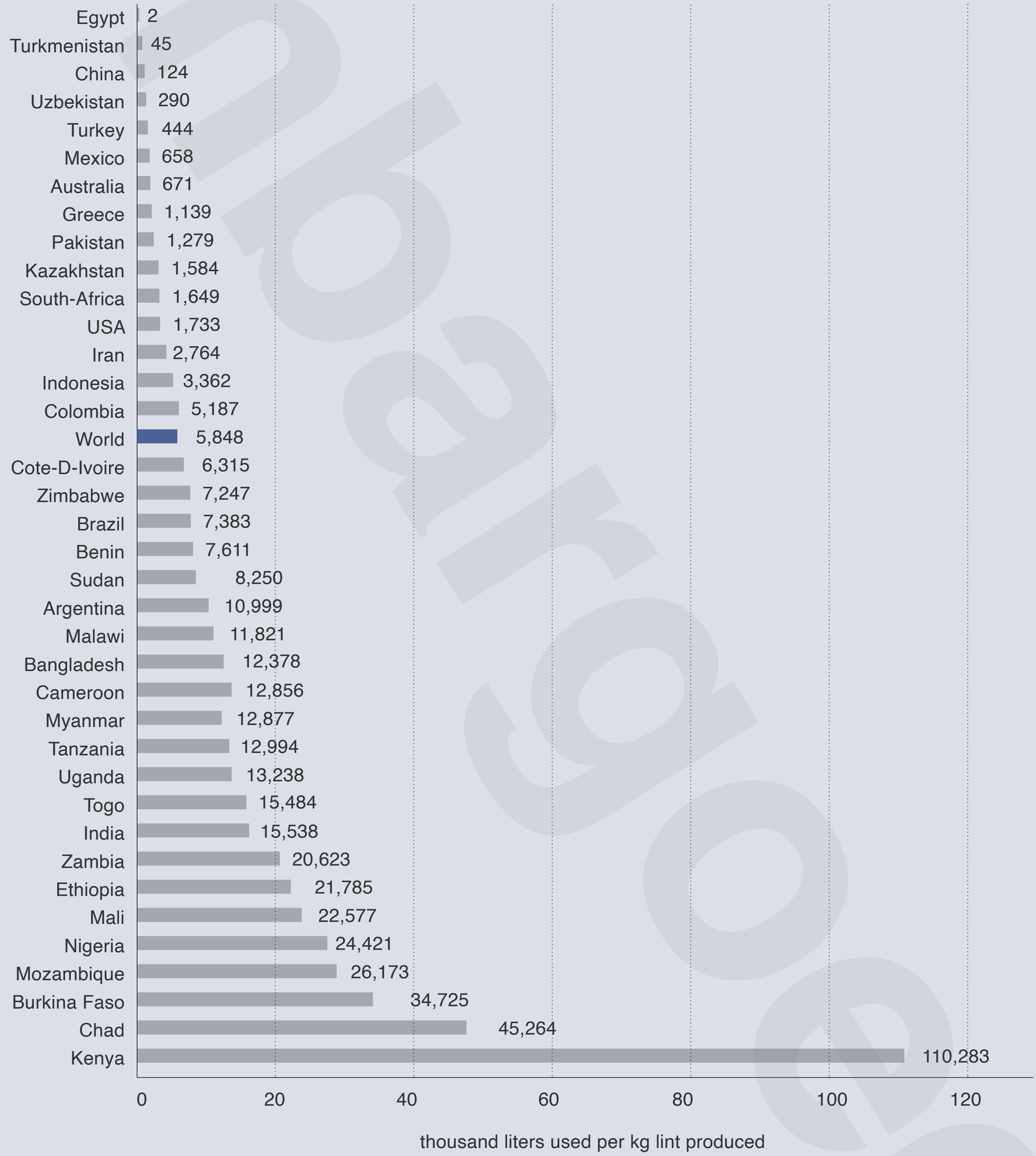
4. **Collaborate with stakeholders.** Responsible water management is a complex issue that requires collaboration and coordination among various stakeholders, including farmers, industry, government, and civil society organizations. By working together, stakeholders can develop more effective strategies for managing water responsibly and promote greater transparency and accountability in water use. As a brand, it is important to support farmers, directly or indirectly through cotton programs, in their transition while keeping them in the decision making position.

Cotton and water: additional data and figures

Here are key data and figures on cotton's water usage.

Green water used per kg lint produced

Fig. 06

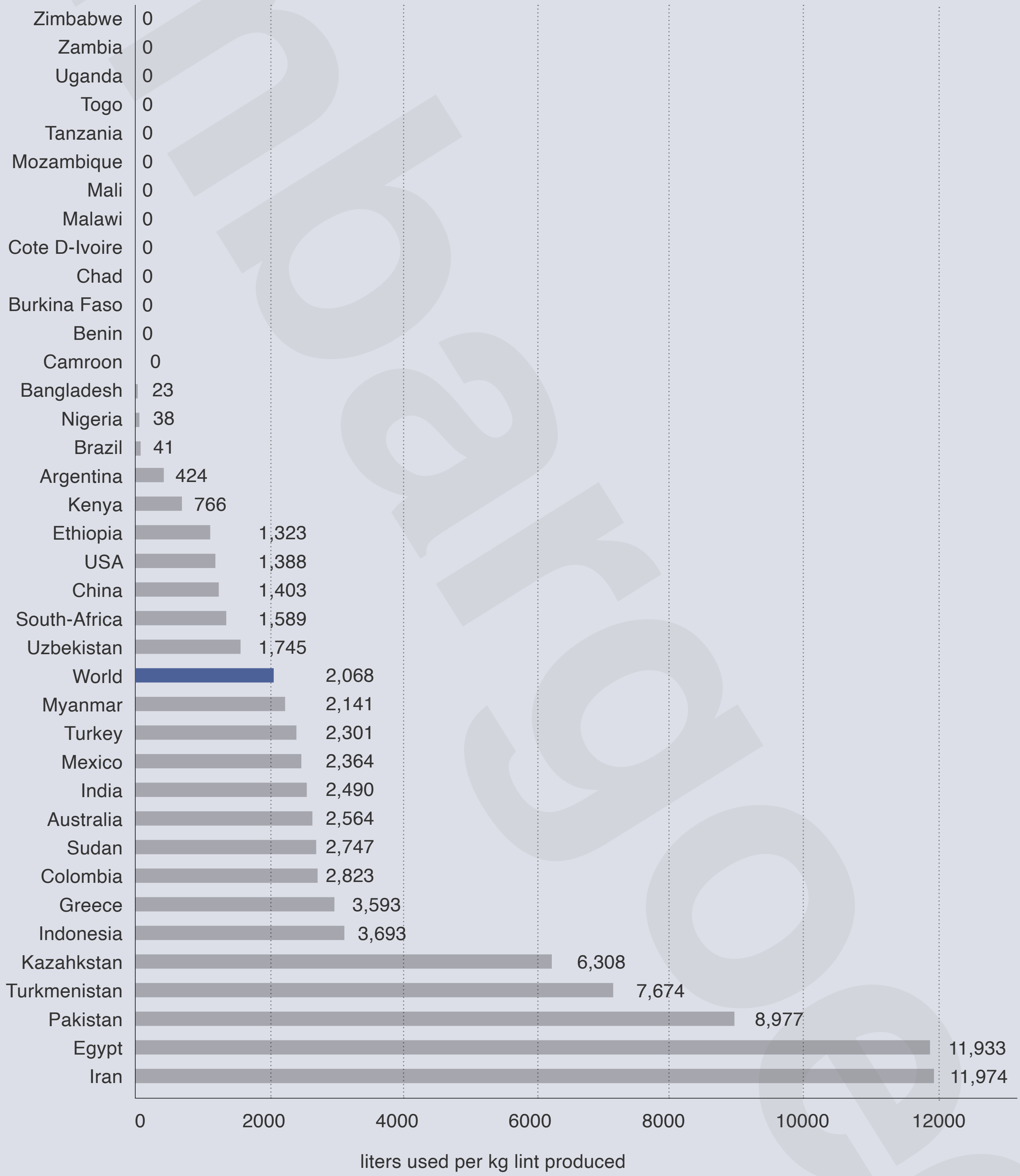


Source: ICAC Cotton Data Book 2022

Please note that this is the best available data to date, however, there are limitations. If you have sources for these data, please get in touch.

Blue water used per kg lint produced

Fig. 07



Source: ICAC Cotton Data Book 2022

Rainwater, ETc & irrigation

Fig. 08

Country	Region/Province/ State	% Rainfed	Annual Rainfall (mm)	Effective Rainfall (mm))	Crop Evapo Transpiration ETc	Effective Rainfall Billion L	Rain Water L/Kg Lint	# of Irrigations	Irrigation/HA (mm)
Argentina	Chaco	100	934	584	685	1,065	11,606	0	0.00
	Santa-Fe	100	1,088	812	683	413	19,340	0	0.00
	Santiago del Estero	75	675	638	675	1,430	9,455	2	200.00
Australia	New South Wales	13	257	171	580	693	830	8	640.00
	Queensland	30	149	70	916	150	150	8	640.00
Bangladesh	Jessore	100	1,698	1,524	584	253	12,462	0	0.00
	Rangapur	88	1,649	1,496	561	122	12,206	1	70.00
Benin	Alibori	100	341	331	648	994	6,908	0	0.00
	Atakora	100	481	455	538	465	9,906	0	0.00
	Borgou	100	402	382	533	488	7,510	0	0.00
Brazil	Bahia	92	2,858	1,704	553	5,108	8,685	2	160.00
	Goias	100	555	524	419	372	3105	0	0.00
	Mato-Grosso	96	1,416	1,277	515	14,299	7254	2	160.00
Burkina Faso	Bobo-dioulasso	100	1,706	1,447	487	3,449	39,649	0	0.00
	Fada-n'gourma	100	837	777	575	463	22,330	0	0.00
	Ouagadougou	100	1,149	1,087	627	2,073	32,074	0	0.00
Cameroon	Garoua	100	860	836	512	1,107	12,191	0	0.00
	Maroua	100	703	694	582	615	14,255	0	0.00
Chad	Logone Occidental	100	591	561	482	229	31,341	0	0.00
	Logone-Oriental	100	1,010	989	469	809	53,755	0	0.00
	Mayo Kebbi	100	809	798	489	186	38,010	0	0.00
	Tandjile	100	837	829	538	290	46,831	0	0.00
China	Hebei	14	154	306	475	22	1,089	4	320.00
	Hubei	12	221	439	608	13	806	3	240.00
	Shandong	12	254	503	578	36	1,406	6	480.00
	Xinjiang	0	10	19	861	188	35	7	294.00
Colombia	Cordoba	30	1,881	379	446	30	4,167	8	800.00
		100	1,449	499	390	52	6,051	0	0.00
Cote-D-Ivoire	Savanes	100	605	287	399	1,363	6,315	0	0.00
Egypt	Beheira	0	10	0	785	0	0	8	616.00
	Dakahlia	0	22	0	788	0	0	8	626.00
	Faiyum	0	10	0	994	0	0	8	560.00
	Gharbia	0	2	0	829	0	0	8	611.00
	Kafr El-Shekh	0	18	0	765	0	0	8	592.00
	Sharkia	0	22	71	548	0	700	8	664.00
Ethiopia	Afar	0	1,579	1,141	487	191	12,242	4	320.00
	Amhara	91	3,002	2,112	381	588	31,632	3	270.00
	Benishangul	100	1,743	1,544	401	96	23,865	0	0.00
	Gambela	100	2,933	2,358	344	133	38,457	0	0.00
	South/SNNPR	36	1,448	1,168	428	126	15,802	3	225.00
	Tigray	100	1,073	920	478	114	14,901	0	0.00
Greece	Macedonia	11	123	160	480	131	1,682	5	400.00
	Thessaly	10	359	86	526	72	688	6	480.00
	Thraki	8	187	146	480	92	1,205	6	480.00
India	Andhra Pradesh	69	628	550	526	3,047	10,494	2	140.00
	Gujarat	28	343	329	583	7,514	5,908	3	270.00
	Haryana	7	141	125	772	792	3,539	6	480.00
	Karnataka	67	712	472	402	3,147	9,493	3	210.00
	Madhya Pradesh	52	1,503	1,490	401	8,345	34,570	3	180.00
	Maharashtra	97	936	934	467	36,938	30,526	2	100.00
	Odisha	100	1,122	1,079	456	2,082	19,563	0	0.00
	Punjab	2	155	124	665	310	2,818	6	480.00
	Rajasthan	6	96	89	847	671	1,592	5	450.00
	Tamilnadu	70	615	232	476	343	5,606	3	210.00
	Telangana	89	1,026	1,014	489	19,160	18,577	1	68.00
Indonesia	East Java	18	1,116	370	519	1	5,873	3	210.00
	East Nusa	10	373	79	568	1	1,339	4	280.00
	South Sulawesi	19	614	220	525	6	3,018	5	350.00
	Tenggara	0	1,061	389	577	3	5,891	3	210.00
	West Nusa	10	570	176	568	1	3,443	2	140.00
Iran	Ardebil	0	469	219	503	7	3,168	10	1,000.00
	East & Central	0	525	326	559	139	4,657	10	1,000.00
	Fars	0	301	44	855	8	437	12	1,200.00
	Golestan & Mazan-dran	5	398	108	709	20	1,662	4	400.00
Kazakhstan	Maktaaral	15	115	61	748	53	901	5	450.00
	Ordabasy	0	428	198	813	16	2753	6	540.00
	Shardara	12	336	197	800	50	3,119	6	540.00
	Turkistan	0	428	198	814	16	3,314	6	540.00
Kenya	Baringo	100	1,953	1,354	478	29	89,046	0	0.00
	Busia	100	2,016	1,128	512	21	77,260	0	0.00
	Gaitu	92	2,488	1,574	492	90	218,611	2	120.00
	Lomu	100	1,193	441	492	4	13,788	0	0.00
Malawi	Lower shire valley	100	294	292	510	53	11,023	0	0.00
	Machinga	100	324	320	514	40	13,073	0	0.00
Mali	Kayes	100	969	925	630	466	19,305	0	0.00
	Koulikiro	100	146	132	906	171	3,075	0	0.00
	Segou	100	1,071	954	690	687	20,919	0	0.00
	Sikasso	100	1,879	1,233	490	5,770	28,601	0	0.00
Mexico	Baja California	6	338	15	572	2	98	5	375.00
	Chihuahua	8	75	120	730	146	705	6	420.00
	Coahuila	2	130	63	881	6	352	6	390.00
	Durango	0	77	119	632	2	698	7	560.00
	Sonora	2	138	278	724	7	1,875	7	532.00
	Tamaulipas	2	311	88	762	9	876	5	400.00
Mozambique	Cabo-delgado	100	334	330	420	128	26,274	0	0.00
	Nampula	100	360	345	429	231	42,357	0	0.00
	Niassa	100	448	440	421	108	14,388	0	0.00
Myanmar	Bago	0	2,992	1,384	412	10	20,059	3	225.00
	Magwe	8	1,050	603	410	67	9,227	2	150.00
	Mandalay	10	1,538	1,001	362	85	16,118	2	150.00
	Sagaing	15	1,538	1,001	396	39	15,188	2	150.00
Nigeria	Adamawa	98	740	693	492	238	21,183	1	70.00
	Gombe	95	572	557	516	123	16,488	1	80.00
	Katsina	100	948	946	642	405	25,501	0	0.00
	Zamfara	98	947	935	545	558	28,419	1	60.00
Pakistan	Punjab	0	149	76	833	966	1,099	8	640.00
	Sindh	0	95	136	1,000	810	1,589	9	720.00
South-Africa	KwaZulu-Natal	98	373	266	605	2	2,859	4	360.00
	Limpopo	58	181	146	643	13	1,641	5	450.00
	Mpumalanga	87	324	250	576	2	16,899	4	360.00
	North Cape	0	117	86	859	1	387	5	450.00
	North West	93	214	164	693	8	2,002	5	450.00
Spain	Andalucia	8	139	31	705	18	296	5	400.00
Sudan	Blue Nile	100	1,194	1,190	492	1,961	16,486	0	0.00
	Gezira	0	467	467	720	250	4,672	8	720.00
	Halfa	0	11	11	918	2	154	8	720.00
	Kordofan	81	138	130	664	4	2,398	0	0.00
	Rahad	90	522	522	671	114	3,113	8	720.00
	White Nile	0	15	15	917	1	273	12	1,080.00
Tanzania	Geita	100	1,627	1,007	525	159	59,940	0	0.00
	Mara	100	1,381	1,021	524	116	59,006	0	0.00
	Mwanza	100	650	633	500	118	29,840	0	0.00
	Shinyanga	100	1,336	865	427	140	22,281	0	0.00
	Simiyu	100	1,283	1,090	504	984	31,063	0	0.00
	Singida	100	617	600	532	112	44,118	0	0.00
	Tabora	100	790	572	353	69	851	0	0.00
Togo	Centrale	100	387	144	179	3	1,648	0	0.00
	Kara	100	1,926	1,408	425	238	17,299	0	0.00
	Maritime	100	1,065	775	478	62	11,065	0	0.00
	Plateaux Nord	100	2,167	1,650	425	176	21,085	0	0.00
	Plateaux Sud	100	1,506	1,129	427	140	17,933	0	0.00
	Savanes	100	1,084	866	425	162	12,307	0	0.00
Turkey	Cukurova	0	99	266	652	180	1,265	7	525.00
	Gap	5	429	55	533	145	296	6	450.00
	Turkey-Aegean	0	253	45	533	44	221	6	450.00
Turkmenistan	Lebap	10	126	1	955	2	25	5	450.00
	Mary-Velayats	12	18	3	886	6	62	5	450.00
Uganda	Apac	100	1,029	586	530	49	11,313	0	0.00
	Lira	100	1,161	699	529	80	14,774	0	0.00
USA	Alabama	89	389	189	547	307	2,043	5	167.00
	Arizona	0	682	390	643	202	2,773	12	1,401.00
	Arkansas	20	338	143	585	275	1,022	8	299.00
	California	1	63	7	780	3	36	12	975.00
	Georgia	64	297	175	586	820	1704	6	183.00
	Kansas	73	187	151	779	62	1,526	7	213.00
	Louisiana	82	307	182	619	77	1,606	4	122.00
	Mississippi	66	441	233	566	405	2,082	5	144.00
	Missouri	35	295	173	524	218	1,228	6	188.00
	New Mexico	18	444	298	655	46	2,766	9	406.00
	North Carolina	97	299	174	571	257	1,527	4	122.00
	Oklahoma	79	217	133	815	237	1,573	8	366.00
	South Carolina	86	315	183	601	153	1,652	7	213.00
	Tennessee	93	284	134	496	146	1,151	3	122.00
	Texas	63	204	147	843	3,319	1,974	8	335.00
	Virginia	100	246	128	487	38	1,033	2	122.00
Uzbekistan	Andizhan	21	76	13	616	10	109	4	236.00
	Bukhara	2	25	4	960	4	35	5	340.00
	Dzhizak	20	158	24	560	19	212	3	204.00
	Ferghana	18	52	7	677	5	61	5	280.00
	Karakalpak	14	20	4	786	4	50	2	122.00
	Kashkadarya	14	75	12	683	16	125	3	227.00
	Khorezm	17	20	4	788	4	38	3	153.00
	Namangan	37	72	13	640	8	117	5	323.00
	Navoi	67	30	2	728	1	18	4	250.00
	Samarkhand	25	403	305	518	229	2,862	4	252.00
	Syrdarya	27	119	12	625	9	114	3	183.00
	Syrkhandar	28	28	3	925	2	28	4	324.00
	Tashkent	28	155	21	603	15	182	5	278.00
Zambia	Chipata	100	355	354	533	177	29,533	0	0.00
	Magoye	100	239	238	528	84	17,225	0	0.00
	Sinazongwe	100	221	218	559	107	15,345	0	0.00
Zimbabwe	Manicaland	100	230	210	509	39	11,132	0	0.00
	Mashonaland	100	163	141	524	19	6,463	0	0.00
	Mashonaland-East	100	228	213	543	90	9,682	0	0.00
	Mashonaland-West	100	244	242	507	35	13,016	0	0.00
	Masvingo	100	133	120	577	24	4,855	0	0.00
	Midlands	100	157	150	560	187	6,024	0	0.00

Source: ICAC Cotton Data Book 2022

Where should you go for more information?

Credible sources, data and tools on water and cotton

A list of additional credible data and information online about cotton's water impacts. Keep in mind the data gaps and lack of local data in many regions. Please always apply your own critical thinking and do your own due diligence when using these sources.

WWF Water Risk Filter - Interactive maps and case studies of water risk globally.*

National reports - Within the WWF Water Risk Filter. Countries such as Australia, Benin, Burkina Faso, China, Egypt, Ethiopia, Greece, Mali, Pakistan, Tajikistan, the United States, Uzbekistan, have national reports full of detail and data.*

World Wildlife Fund - Tchibo water risk report, which includes cotton

Water Footprint Network tools - A suite of water footprint maps and water footprint calculators.*

World Resources Institute Aqueduct tools - Tools evaluating water risks globally.*

For more information about useful tools, we recommend looking at the WWF "Right Tool for the job" guidance.

National Level Data

The World Business Council for Sustainable Development's water tool

Field to Market national indicators report - A peer reviewed report on environmental impacts of U.S. commodity crop productions, including cotton.

Mississippi State University's cotton crop loss data - Crop loss data for U.S. cotton.

USDA's statistical service

Australian Cotton's Sustainability Report (2014, 2019)

CottonInfo's water management page - The Australian cotton industry's joint extension program, which provides cotton research.

*These are live tools and subject to change, we recommend checking the validity of sources of the data at the time.

*This page was originally published in: Cotton: A Case Study in Misinformation in 2021

SECTION 2:

Cotton and Pesticides: The Reality

How Much Harmful Pesticides is the Industry *Really* Using?

IPM is defined as an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.

In our previous report from 2021, we delved into the importance of understanding the diverse types of pesticides, their targeted organisms, and the reasons for their application. Synthetic pesticides are tools used in managing pests. *Integrated Pest Management (IPM)* is a system in which pesticides are used judiciously. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.[21] Farmers understand that insect populations are held in check naturally by predators (like lady beetles and spiders) and diseases (yes, insects get sick too), and often no intervention to control pests is needed. However, sometimes if the weather is right and food is abundant (like having a field of cotton to eat, for instance) a population of pests can explode, and pesticides must be used to preserve the cotton crop and to ensure all the cotton production inputs are not wasted. In those cases, IPM principles guide farmers in choosing the right product to be applied in the correct dose at the right time to protect the cotton yield while minimizing injury to non-target organisms.

IMPORTANT!

Pesticides vary in their potential hazards, with some posing significant risks to humans and the environment. Understanding pesticide classifications based on hazard levels defined by the World Health Organization (WHO), and published by FAO, and PAN UK, is crucial. Other organizations like the US EPA (US Environmental Protection Agency) and EXTOXNET (Extension Toxicology Network), also provide information and databases related to pesticides, which offer valuable resources and define hazard levels associated with various pesticides. We also noted that differing philosophies exist regarding the best approach to pesticide usage, from eliminating hazardous substances to managing risks through a "safe-use" approach. Lastly, we pointed out that global sales data on pesticides is not an accurate reflection of pounds of usage or impacts, and there is a major lack of publicly available data. If you do not have a thorough understanding of these concepts, read our last report from 2021 here.

What is the volume of pesticides used in cotton?

Our 2021 report highlighted that in 2019, cotton accounts for 4.71% of all global pesticides sales[22] and within the broader umbrella of pesticide usage, cotton accounts for 2.91% of global herbicide sales, 10.24% of insecticide sales, 1.03% of fungicides sales, and 15.74% of other pesticides, which includes growth regulators.[23] This analysis on different pesticide types and usage led us to highlight the severe data gaps and the urgent need for data that captures exactly which pesticides formulations are being used, where, and how, including the method of application, and their risk of exposure.

Pesticide use in cotton farming is a multifaceted issue that depends on several factors, including the specific pests that farmers are dealing with, climate conditions, soil type, local regulations, the price of cotton, control costs, and cultural practices. While cotton ranks forty-sixth on the list of crops that use pesticides,[24] the amount of pesticides used can vary widely depending on the region, farming practices, and crop type. However, it is essential to note that the data presented in official records may not accurately reflect the total amount of pesticides used in a given country, as some farmers may engage in side selling and marketing of pesticides (ie. farmers buy pesticides, often on credit, and will resell some for cash or use them on crops other than those for which they were intended)[25] that is not accounted for, although this is not unique to cotton growers, and some governments may not have robust systems in place for capturing accurate data on pesticide use, as we found in our previous report. This underscores the importance of going beyond the numbers to do your data due diligence.

According to ICAC, the new data from 2020 shows that cotton accounts for 4.8% of all global pesticides sales. Within the broader umbrella of pesticide usage, cotton accounts for 3.28% of global herbicide sales, 9.80% of insecticide sales, 1.4% of fungicides sales, and 14.18% of other pesticides, which is very similar to the numbers from 2019 and in contrast to much of the misinformation pieces we commonly hear.

% Share of cotton of the Global crop protection pesticide market

Fig. 09

% Share of cotton		
2018	**2019**	**2020**
4.83	4.71	4.8
2.74	2.91	3.28
10.78	10.24	9.8
1.15	1.03	1.4
16.93	15.74	14.18

Source: https://news.agropages.com/News/NewsDetail---41252.htm

Although the data presented in this section is interesting to monitor, risk and exposure remain the best method for understanding the impacts of pesticide use. Depending on their specific properties and the manner in which they're utilized, pesticides have the potential to cause varying degrees of harm to humans and the environment. It's worth noting that every pesticide comes with a label detailing safety precautions to safeguard the user and reduce exposure to others. Such measures are based on tests that determine "safe" usage levels.[26] Certain pesticides can be employed with minimal risk, but others carry a high degree of hazardousness and are challenging to use safely. If you do not have a thorough understanding of these concepts, read our last report from 2021 here.

Pesticides Used in Cotton (Tonnes)

Fig. 10

	Insecticides	Herbicides	Fungicides	Plant Growth Regulators	Total Pesti-cides 2020	Total Pesticides/ lbs cotton
Brazil	22,354	10,801	4,736	1,783	39,674	0.017
Usa	4,158	20,361	42	2,421	26,982	0.007
China	14,411	6,761	733	2,064	23,969	0.004
India	9,504	2,233	1,997	614	14,348	0.003
Pakistan	4,093	3,152	1	0	7,245	0.006
Turkiye	307	589	1	391	1,288	0.002
Uzbekistan	1,200	0	0	0	1,200	0.002
Greece	57	912	8	146	1,122	0.004
Cote D'ivoire	371	611	0	0	982	0.005
Australia	32	899	28	7	966	0.001
Mali	182	766	7	0	954	0.003
Mexico	40	568	15	100	722	0.003
Turkmenistan	663	0	0	0	663	0.002
Argentina	403	193	3	62	661	0.002
Zimbabwe	317	59	4	0	379	0.007
Egypt	257	2	0	0	260	0.004
Spain	12	138	0	13	164	0.002
Azerbaijan	150	0	0	0	150	0.002
Mozambique	49	91	0	0	140	0.006
South-Africa	23	105	0	2	130	0.01
Tajikistan	125	0	0	0	125	0.001
Peru	82	0	1	0	84	0.004
Kazakhstan	12	59	0	3	74	0.001
Israel	21	25	1	1	48	-
Colombia	9	24	5	2	41	0.003
Zambia	18	19	4	0	41	0.002
Malawi	34	0	0	0	34	0.002
Myanmar	14	0	0	0	14	0.000
Kyrgyzstan	11	0	0	0	11	0.001
Ghana	0	6	0	0	7	0.001
Vietnam	2	1	0	0	3	-
Cameroon	0	0	0	0	0	-
Kenya	0	0	0	0	0	-
Total	**58,911**	**48,376**	**7,585**	**7,609**	**122,481**	

Source: ICAC Cotton Data Book 2022
Source Data from Bayer Crop Science &
other industry sources, synthesized by ICAC

Understanding the intricacies of cotton production practices and resource utilization decisions can be a complex task, largely due to the significant differences in pesticide usage across various countries.

This critical data from Bayer presented by ICAC in Figure 10, provides insight into the types and overall quantities of pesticides utilized in cotton production around the world in 2020. This information is crucial for comprehending why specific pesticides are chosen and their respective purposes. It can also assist our partners in cotton cultivation to explore potential alternatives.

As you can see, the major cotton growing regions such as Brazil, USA, China and India, unsurprisingly make up the majority of pesticide volumes for cotton in 2020. Brazil has the highest volume of pesticides as an active ingredient at 39,674 tonnes or 0.02 pounds of pesticide per pound of cotton, the USA at 26,982 tonnes or 0.01 pounds of pesticide per pound of cotton, China at 23,969 tonnes or 0.004 pounds of pesticide per pound of cotton, and India at 14,348 tonnes or 0.003 pounds of pesticide per pound of cotton.

Although Brazil has the highest volume, the majority of this number is made up of insecticides at 22,354 tonnes. Brazil has also had to deal with the rampant boll weevil, which further contributes to their high insecticide use. The primary strategy for managing the boll weevil predominantly involves the application of conventional insecticides, chiefly organophosphorus compounds and pyrethroids.[27] These particular insecticide categories played a pivotal role in eliminating the boll weevil in the United States, and their usage remains prevalent in Brazil.[28]

However, ABRAPA, also known as the Brazilian Cotton Growers Association, states that biological and microbiological control is one of the most important tools for Integrated Pest Management (IPM) in cotton crops and has been growing around 15% a year in Brazil, due to the positive technical results, high economic viability, and environmental benefits involved.[29] This underscores the importance of doing your own due diligence to understand the context of local realities and going past the numbers to understand what is really happening.

If the goal is to reduce synthetic pesticide use, another great example illustrating the importance of understanding the types of pesticides used and for what, is Australia. Australia has an extensive history of pesticide application, but has been able to reduce synthetic pesticides dramatically over the past two decades. In the 1990's, chemical pesticides were the main methods of pest control and 15 insecticide applications per season was not uncommon.[30] This led to bollworm and spider mites developing widespread resistance and overuse was driving outbreaks of secondary pests.[31] Since then, integrated pest management practices and the introduction of *Bt cotton* have proved to be successful in managing insecticide resistance, and Australia has been able to reduce insecticide usage by 97% since 1992.[32] In this table, you can see Australia sitting at 966 tonnes respectively.

Bt cotton: "was developed to produce bacterial proteins that are toxic to herbivorous insects, ostensibly reducing the amount of pesticides needed" - Britannica

If the goal is to reduce the amount of land required to grow more crops, then cutting back on synthetic pesticides isn't always the prime or sustainable objective. A field susceptible to weeds or pests can see its entire seasonal yield decimated, wasting all invested resources and efforts. So when applied judiciously, pesticides can have ecological advantages, like safeguarding crop production and enhancing field yields, which in turn reduces the land required to grow more crops.[33]

While we encourage brands and retailers (and other stakeholders) to invest in understanding more about the contexts in which their cotton is produced, it is equally important to respect the expertise within cotton growing communities. For example, a cotton expert assessing the viability of a particular approach in a given context would ask technical questions such as:

- [ ] What are the specific pests that farmers are dealing with?
- [ ] What are the local climate conditions and soil types? What are the trends over time?
- [ ] What are the available resources for pest management, including both chemical and non-chemical approaches? How are pesticides used (e.g., calendar sprays)? Is pest resistance a problem?
- [ ] What is the cost of different pest management methods, and what is the economic feasibility for farmers? How much damage is manageable?
- [ ] What are the policies and regulations around pesticide use in the region? This is extremely important and will impact your support efforts.
- [ ] Are there any cultural or traditional practices that influence pest management in the region?
- [ ] What are the potential environmental and health impacts of pesticide use, and how are these being addressed? Look for any research on potential changes from climate change. Cotton 2040: Climate Risk Explorer is a great place to start.
- [ ] Are there any research and development efforts underway to develop new, more sustainable pest management methods for the region? How is seed research done and is there a focus on less need for pesticides?
- [ ] What is the amount of pesticide used per pound of cotton? Not the total, as the total tracks primarily with planted acres/total production.
- [ ] As a reader, what programs such as Better Cotton, CmiA, myBMP, or US Cotton Trust Protocol can you engage with to help provide support to producers and improve practices on the ground.

It is crucial to recognize that there is no one-size-fits-all solution to reducing pesticide use, and that each region and crop may require a unique approach. But, sustainable pest management practices are possible and are being implemented successfully in various regions and for different crops with the help of farmers' deep knowledge of their lands.

How much pesticide do cotton farmers use?

In our previous report, we compared the last three years of global pesticide sales to data from nearly two decades ago. Since our last report, AgNews has shared new data on 2020 global pesticide sales. Although these data show similar results to 2019 data, it underscores the severe data gaps and the need to look beyond these numbers and ask deeper questions to your farm partners to understand how brands and retailers can potentially support them financially to move to best practice for pest control. It is important to note the importance of paying fair prices, offering consistent contracts and remembering that finance does not only come in the form of grants or loans.

IMPORTANT!

Global crop protection pesticide market (2018-2020)

Fig. 09

	Global pesticide sales all crops US$ million			**Global pesticide sales on cotton** US$ million			**% Share of cotton**		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Global CP sales	60,304	59,827	62,036	2,910	2,820	2,975	4.83	4.71	4.8
Herbicide sales	26,563	26,175	27,407	727.5	761	899	2.74	2.91	3.28
Insecticide sales	15,121	15,146	15,681	1,629.60	1,551	1,537	10.78	10.24	9.8
Fungicide sales	16,473	16,356	16,804	189.15	169	235	1.15	1.03	1.4
Other pesticide sales	2,148	2,150	2,144	363.75	338	304	16.93	15.74	14.18

Changes in global pesticides sales over time. Sources: https://news.agropages.com/News/NewsDetail---41252.htm

The price of pesticides per kilogram of cotton lint can widely vary depending on several factors, but it is important to re-emphasize that sales is a less robust measure than risk and toxicity exposure, as prices vary from country to country. Factors such as pest complex, local conditions, weather, use of calendar spraying, IPM, local regulations, availability of pesticides, mix of products being sold, market demand, seller's discretion, the availability of generic brands, and currency exchange rates all impact the price of pesticides in a given region, along with types of seeds and different qualities and types of soils.

Choosing the right seed is a pivotal step in successful crop production, and goes beyond mere seed quality. This selection process considers the inherent traits of the seed that may offer resistance to insects and diseases. Some of these desirable traits may be present in genetically modified organisms (GMOs), but many can also be found in traditional, non-modified varieties. For instance, the physiological traits of a variety, like leaf pubescence (hairiness), can influence its susceptibility to pests such as fleahoppers.[34]

Equally important is crop rotation, which aids in disrupting the life cycles of diseases, weeds, and potentially insects, promoting healthier and more productive crops. Therefore, seed selection is not just about the immediate crop, but also its impact on future crop rotations.[35]

Moreover, the effectiveness of these seed traits should not be taken for granted. They must be researched and tested extensively to ensure they are a good fit for specific local conditions and will yield the expected results. Countries need to invest in seed research and breeding to identify these traits and develop improved seed varieties and production methods. This underscores the importance of genetic factors within seeds for yield, quality, and pest resistance, and why "seeds" in this context refers not just to the physical product, but also to the genetic potential that it carries.

"A general rule is that a healthy crop on good soil is less vulnerable than one on poor soils from poor seeds."

- Simon Ferrigno

Some countries may have stricter regulations on pesticide use, which can limit the types and amounts of pesticides available, possibly increasing their purchase price. Additionally, our conversations with cotton experts revealed the availability of pesticides can be influenced by factors such as import restrictions, production capacity, and local demand, which can affect their price.[36] These factors can create disparities in the price of pesticides per kilogram of cotton lint between different countries. However, the most valuable data to best understand the local context would be risk and exposure.

Cocktail effect investigates the combined impact of multiple toxins when mixed together.

As we learned, risk involves exposure and toxicity of chemicals and it is important to keep in mind that the utilization of high volumes of low-toxicity chemicals may not be as significant as low volumes of highly toxic substances. In our 2021 report, we dove deep into the risks associated with the different types of pesticides, which we encourage you to dive deeper into [here]. It is important to note, however, that research typically concentrates on studying the effects of a single active ingredient rather than exploring the *"cocktail effect"*. With infinite potential pesticide mixtures, comprehensive testing becomes extremely challenging. Therefore, the most sensible approach is to use the minimal necessary quantity and maximize pesticide use efficiency, thereby reducing the potential risks associated with diverse combinations.[37]

It may be in brand's and retailer's interest to financially support and encourage the disclosure of pesticide types and usage data, especially as new legislation regarding transparency in production is being implemented, which will legally require brands and retailers to provide this information. If one is unable to do so, cotton programs can act as a key interface between brands and growers, as many cotton programs have data collection mechanisms that can help provide insight and contact to the fields.

Data use and privacy considerations

While this paper appears to assume that farmers will readily share their data, it is paramount to address data use and privacy concerns explicitly. Farmers must willingly agree to share their data, confident in the knowledge of how their data will be used, stored, and protected. This data is also valuable and growers should be compensated for their time and data surrounding their production methods.

Farmers must be assured of the highest levels of data security and privacy. The data collection process should be transparent, with clear information on what data is being collected, why it is needed, how it will be used, and who will have access to it. Strict protocols should be in place to prevent unauthorized access and data breaches.

Furthermore, it’s not just about data collection; farmers should ideally gain added value from sharing their data. This could be in the form of higher compensation for their crops or access to knowledge sharing platforms. The data-sharing process should not be a one-way street; it should also contribute to the betterment of the farming community.

Not only does this strengthen trust within the supply chain, but it also ensures that farmers feel more secure and empowered when it comes to sharing their data, recognizing that their contribution is respected and valued.

Key Takeaways:

The data presented here serves to underscore and bolster the following three key points previously outlined in our report:

1. **Pesticide data is complex** and there is much misinformation surrounding cotton pesticide data.

2. **Cotton sustainability programs are a key interface between brands and growers.** These organizations can help promote more sustainable practices at the farm level while measuring the improved impacts.

3. **The need for due diligence.** Understanding the specific types of pesticides used, pests that farmers are dealing with, local climate conditions and soil types, and available resources for pest management are crucial in reducing pesticide use in different regions and crops, as well as trends in time.

4. **There is no one-size-fits-all solution to reducing pesticide use.** Each region and crop may require a unique approach. Responsible pest management practices are possible and have been successfully implemented in various regions and for different crops due to farmers' deep knowledge of their lands. As such, it is crucial to listen closely to farm partners to better understand local context and their needs for transitioning to potential solutions that reduce synthetic pesticide use.

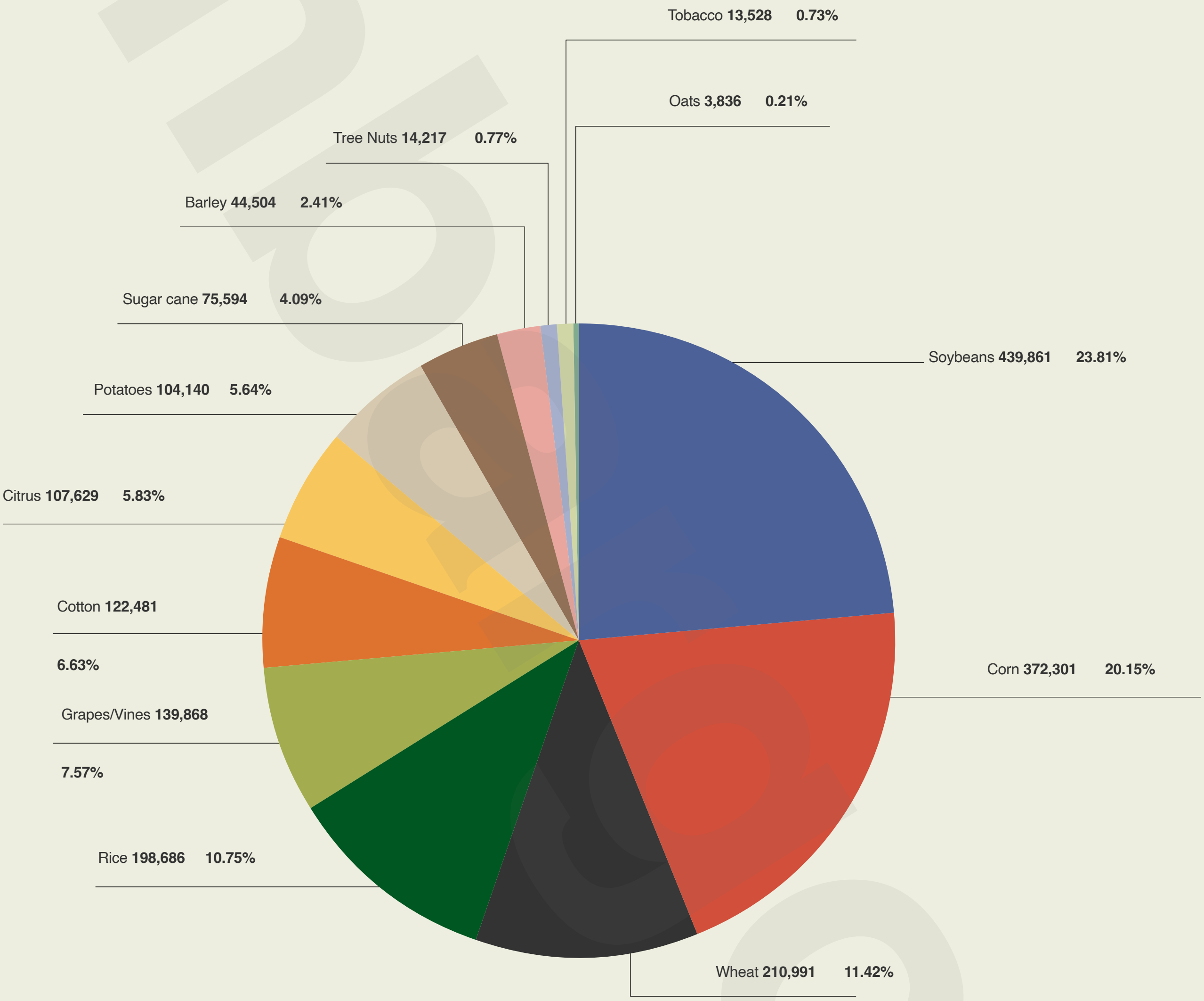
5. **There is a desperate need to fill data gaps.** Global sales and volume data on pesticides are not an accurate reflection of usage or impacts, and there is a major lack of publicly available data on the types and volumes of pesticides used. With new legislation regarding transparency in production, it will be legally required by brands and retailers to provide this data. However, data use and privacy mechanisms must be in place with explicit agreement from both parties on where, why, and how this data will be used.

Cotton and pesticide: additional data and figures

Here are key data and figures on cotton's pesticide usage.

Pesticide use in agriculture in Cotton Growing Regions (Kg/Ha)

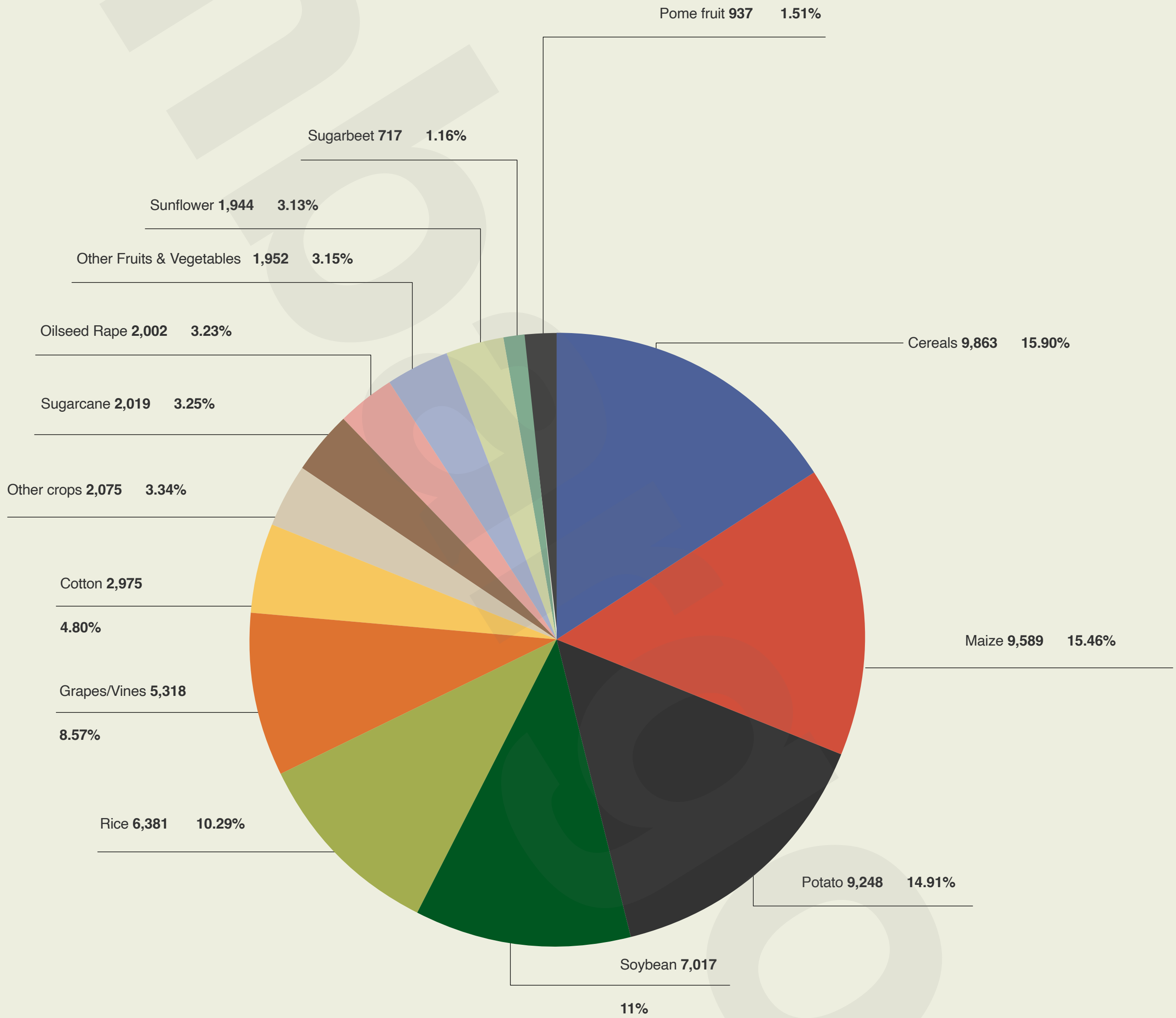
Fig. 11



Source: ICAC Cotton Data Book 2022

Crop-wise share of Crop Protection Products - 2020 (US$ Million)

Fig. 12



Source: ICAC Cotton Data Book 2022

Where should you go for more information?

Credible sources, data and tools

Please note that the data presented in this resource may not accurately reflect the total amount of pesticides used in a given country, as some farmers may engage in side marketing and selling of pesticides that is not accounted for in official records. There may also be a black market that includes obsolete pesticides from old stock piles, although FAO has funded a project on trying to reduce these. In addition, some governments may not have robust systems in place for capturing accurate data on pesticide use.[38] While we have made every effort to present the most reliable and up-to-date information available, users should be aware that the data may not be fully comprehensive or entirely accurate in all cases.

For U.S.-specific data on cotton production, we recommend consulting Cotton Incorporated. This not-for-profit organization serves as the research entity for US upland cotton and is funded by US cotton growers and importers.

Classifications and databases:

The WHO Recommended Classification of Pesticides by Hazard and guidelines to classification, 2019 edition

To understand the toxicity of widely used pesticides, we recommend reading the 2017 PAN UK report, "Is cotton conquering its chemical addiction?"

PesticideInfo by Pesticide Action Network

EU Pesticides database which allows users to search for information on active substances used in plant protection products, Maximum Residue Levels (MRLs) in food products, and emergency authorisations of plant protection products in the Member States.

U.S. Environmental Protection Agency Databases Related to Pesticide Risk Assessment

FAO compendium of pesticides information databases (active ingredients, use types, etc.)

Pesticides - Data Europa - the EU open data portal on pesticides

Sustainability standards indicators and guidances:

Measuring Sustainability in Cotton Farming Systems: Towards a Guidance Framework - pages 014 to 017

Delta Framework Sustainability Indicators

National-level data:

The USDA Quick Stats is one of the most useful live tools and can provide information on pesticide applications across the country. You can explore them by navigating: The *Survey>Environmental>Field Crops>Cotton>Applications* and *Survey>Environmental>Field Crops>Cotton>Pest Mgmt*

*This page was originally published in: Cotton: A Case Study in Misinformation in 2021

SECTION 3:

Cotton, Fertilizers, and Soil Health

Fertilizer: a substance added to soil to make plants grow more successfully.
- Oxford Dictionary

In this next section, we are thrilled to present completely new data and analysis of *fertilizer* use in cotton production, consolidated from data supplied by governments to FAO, as well as the price of fertilizers as a percentage of net returns, pulled from ICAC's Cotton Data Book 2022. By analyzing and leveraging these new data, we gain a deeper understanding of fertilizer use in cotton and how we can support our farm partners' endeavors to identify solutions that improve the environmental sustainability of cotton production.

Why are fertilizers necessary and what are the potential risks associated with their use?

IMPORTANT!

When crops are harvested, nutrients are removed from the land and to maintain crop yield and quality, it is necessary to replenish the soil with the essential nutrients. To maintain crop yield and quality, it is necessary to replenish the soil with the essential nutrients. This can be achieved through various methods, including the use of nitrogen-fixing crops, incorporation of organic matter such as manures and composts, and careful application of fertilizers. It is necessary to add minerals in the form of fertilizers to all agricultural fields to maintain soil fertility and optimize crop yields. However, over-application can lead to nutrient pollution, such as eutrophication, acidification, and greenhouse gas emissions.[39]

When looking at nutrients within a fertilizer, it is important to keep in mind that not all fertilizers contain all the nutrients that may be needed to produce a crop. Just like how a multivitamin might have high levels of certain vitamins, but not others, fertilizers may not contain all the micronutrients that are needed by the crop.

There are three main macronutrients needed for both plants and humans. As an analogous system, humans generally need three macronutrients, fat, carbohydrates and protein. The primary macronutrients that plants require for healthy growth and development include nitrogen, phosphorus, and potassium. Nitrogen is vital for plant growth, contributing to leaf and stem development and playing a key role in photosynthesis.[40] Phosphorus is crucial for energy transfer and storage in the plant,[41] promoting root development,[42] flowering, and seed production.[43] Lastly, potassium enhances overall plant health, supporting functions like water movement in plants,[44] protein production,[45] and disease resistance.[46]

Cotton production also requires several micronutrients (think vitamins and minerals for humans), including boron for example, which plays a crucial role in the growth and development of cotton plants. As one example, boron is essential for cell wall formation, pollen germination, and fruit development. Deficiencies in boron can result in reduced growth, fruit shedding, and reduced fiber quality.[47] As such, farmers monitor nutrient levels in their soils and apply fertilizers, manures, or compost when necessary to ensure optimal cotton growth and yield.

The four R's of fertilizer management

It's important to understand soil management through a holistic perspective and consider factors beyond just the quantity of fertilizer use, such as soil pH, salinity, organic matter, compaction, and other factors that may inhibit root growth and uptake of nutrients. The 4Rs (Right Rate, Right Source, Right Placement, and Right Timing) are essential principles in nutrient management, practiced by farmers and agricultural experts, to maximize efficiency and minimize environmental impacts, as laid out by the IFAS Extension of University of Florida.[48]

Right Rate	Determine the appropriate amount of fertilizer needed based on soil testing or a visual soil assessment, as well as crop nutrient requirements.
Right Source	Select the most suitable fertilizer type considering factors like cost, nutrient availability, and efficiency of use.
Right Placement	Place nutrients in the root zone to optimize uptake by the plant, considering techniques such as banding.
Right Timing	Apply fertilizer at the appropriate stages of crop growth to meet nutrient demand and avoid nutrient losses.

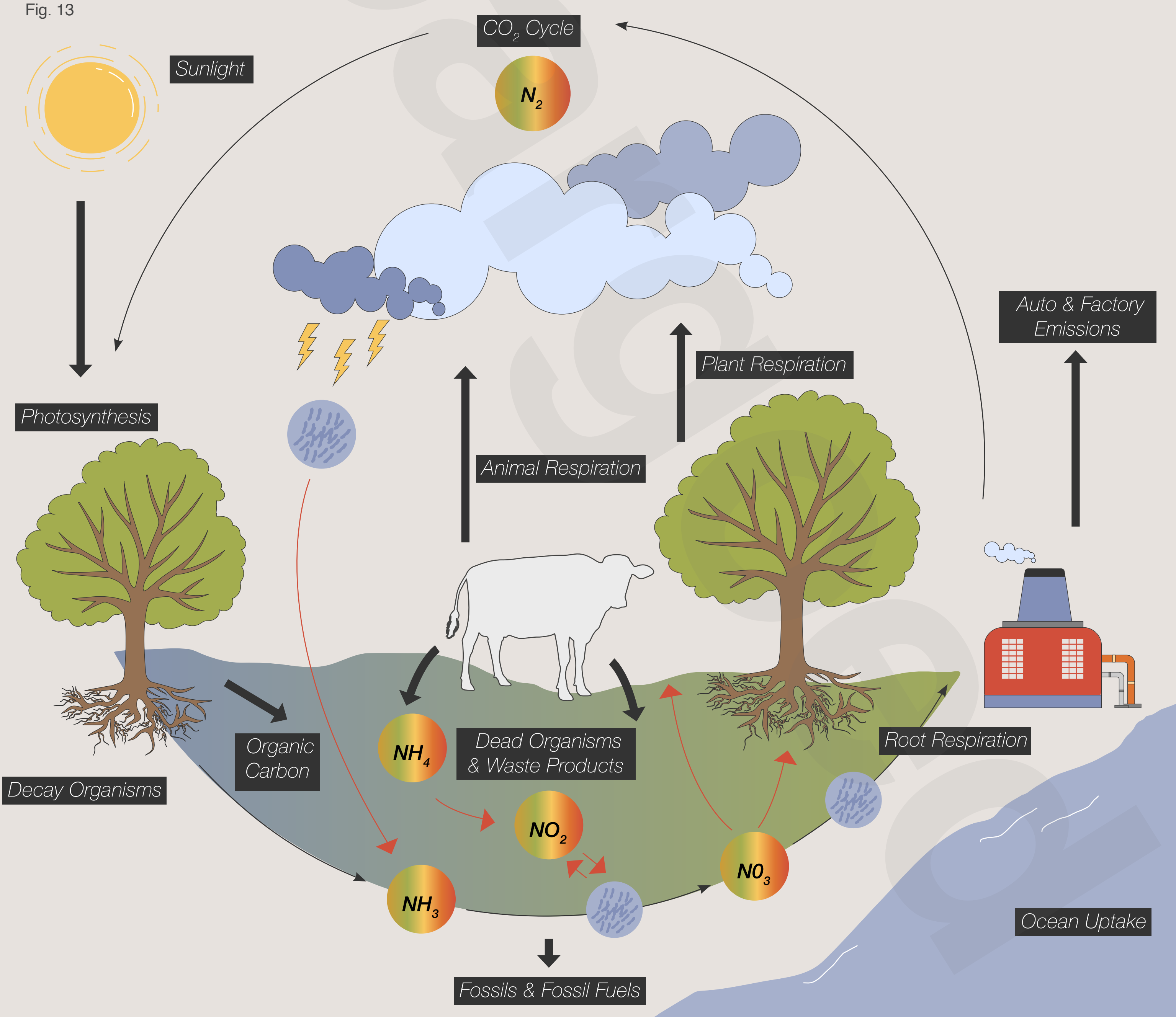
Through the 4Rs, the aim is to achieve optimal nutrient management, promoting profitable crop production while safeguarding the environment from nutrient pollution and reducing nitrous oxide emission.

The targeted use of fertilizers, rooted in sampling, measurement, science and the wisdom of farmers, is an essential part of sustainable agriculture and exemplifies the need to go beyond numbers to understand the local realities. Farmers, drawing on their deep understanding of their land, rely on tools like visual soil assessments, the 4R's, soil tests, and plant tissue sample tests to make well-informed, location-specific decisions, and to adopt responsible fertilizer practices that minimize nutrient losses and improve nutrient use efficiency. This can start with using composts, animal manures, crop rotations, and nitrogen fixing crops, in line with an Integrated Pest Management, agroecological or regenerative approach.

People often inquire about GHG emissions from soil and soil management, recognizing the significance of understanding the impact of their supply chains. It is important to acknowledge that GHG emissions from soil is a natural phenomenon and that GHG emissions are also emitted when using natural forms of fertilizers like manure.[49] It's worth noting that application of manure based on one nutrient may lead to over or under applying other nutrients. To get the appropriate amount of Nitrogen from manure, for example, one would have to overapply the other nutrients leading to runoff and pollution of waterways.[50] Therefore, stopping the use of synthetic fertilizers will not eliminate GHG emissions or environmental impacts. However, you can influence these levels through methods like carbon sequestration within the soil matter.

Enhancing soil's organic carbon can not only offset GHG emissions but also boost soil health, improve water retention, and increase biodiversity.[51] Strategies for sequestration could include maintaining ground cover, practicing conservation tillage,[52] and implementing diverse crop rotations in line with a regenerative agriculture approach.[53]

Fig. 13



Furthermore, having an understanding of the carbon and nitrogen cycle, and utilizing precision farming technologies can help optimize the use of fertilizers.[54] Precision agriculture embodies the idea of farm management rooted in detailed observation and response to variations within crop fields. It supplies farmers with spatial data, allowing for more refined, location-specific decisions. The ultimate aim of precision agriculture research is to develop a comprehensive farm management system that maximizes input returns and conserves resources.[55]

While it may seem like reducing fertilizer emissions would lead to reduced impacts in cotton production, our conversation with cotton experts revealed that this is generally not the case on a per pound of cotton basis. If a grower was to apply less fertilizer than required, the plants would produce less fiber on the same land, same water, and same field operations. The key is to get the right amount and follow the 4 Rs as best as possible.

IMPORTANT!

It is important to note that although brands and retailers are looking for cotton with a lower environmental impact, smallholder farmers often lack the resources to test their soil and meticulously manage nutrients, but remain pivotal players in the cultivation of cotton. This cotton not only stands as a vital crop but also serves as the very backbone of their livelihoods.

It's crucial to acknowledge in this context that when brands and retailers actively source their products from these smallholders, they are indirectly championing the Sustainable Development Goals (SDGs) of eradicating hunger and poverty (Goals 1 & 2). Even though smallholders might not possess the means to oversee input use with the precision found in more developed nations, they undeniably hold a significant place in the global cotton economy. Hence, it's imperative that their unique challenges and concerns are given equal weight and consideration.

In sum, the strategic use of fertilizers, rooted in an understanding of soil needs and guided by principles of optimal rate, source, placement, and timing by agricultural experts and farmers, is crucial for responsible cotton production. Integrating practices like carbon sequestration and precision farming technologies can boost soil health, biodiversity, and resource efficiency. Nevertheless, we underscore the significance of ensuring that the experts, notably the farmers, remain at the helm of decision-making. Brands, retailers and NGOs should avoid exerting dominance over the process, but rather assume a supportive role, allowing those with first-hand knowledge and experience to steer the course on what is needed.

Fertiliser use in cotton (Kg/Ha)

Fig. 14

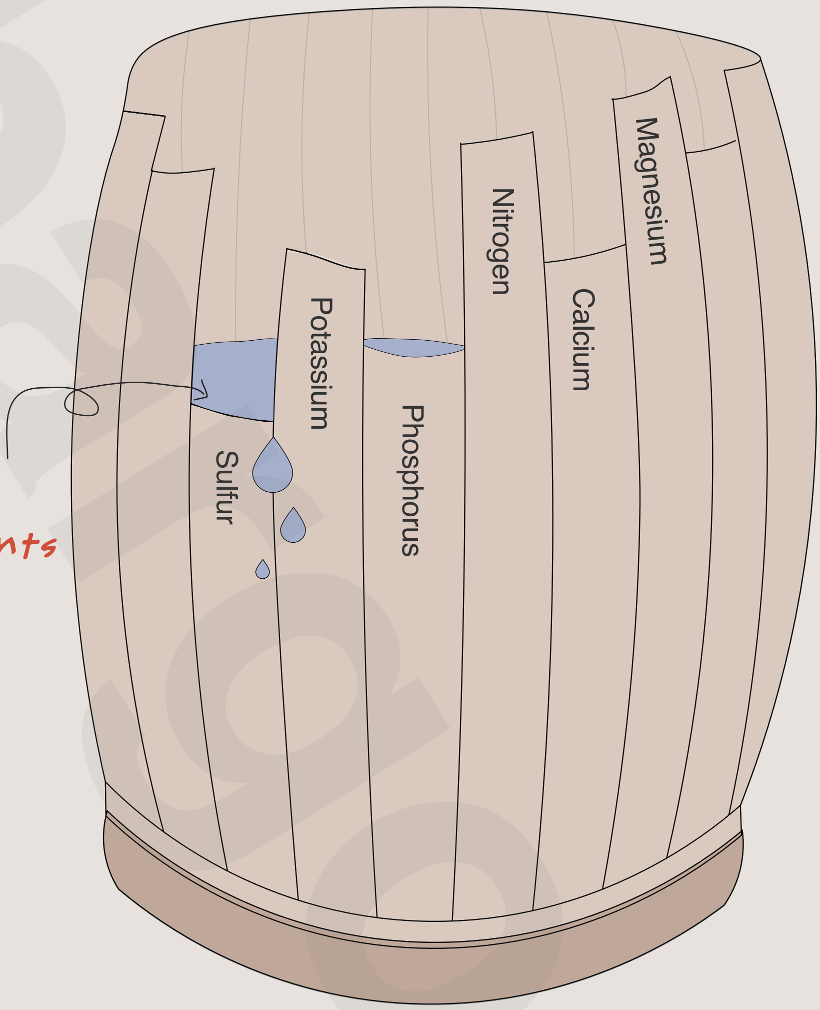
	FERTILISER USE ('000 Tonnes)				FERTILISERS APPLIED Kg/Hectare				FERTILISER USE EFFICIENCY g/Kg Lint produced			
	N	P2O5	K2O	N+P+K	N	P2O5	K2O	N+P+K	N	P2O5	K2O	N+P+K
Argentina	5	0	0	5	10	1	1	12	14	1	1	17
Australia	145	114	32	291	228	180	50	458	113	90	25	228
Bangladesh	4	2	1	8	90	45	30	165	116	58	39	213
Benin	33	23	23	79	51	36	36	123	106	75	75	256
Brazil	200	211	154	566	146	154	112	412	85	90	65	240
Burkina Faso	26	16	16	58	44	27	27	98	126	77	77	281
Cameroon	15	5	7	27	67	20	30	117	118	35	53	205
Chad	11	4	4	20	38	15	15	68	208	82	82	371
China	872	557	248	1678	288	184	82	554	152	97	43	293
Colombia	1	0	1	2	76	21	30	127	89	25	35	149
Côte d'Ivoire	25	14	14	54	53	30	30	113	117	66	66	249
Egypt	18	4	2	25	220	51	24	295	264	61	29	354
Ethiopia	2	1	0	3	24	10	5	39	32	13	7	52
Greece	17	6	5	28	64	22	18	104	57	20	16	93
India	1784	651	313	2749	148	54	26	228	342	125	60	527
Indonesia	0	0	0	0	18	11	4	33	29	18	7	54
Iran	16	2	1	19	162	25	8	194	197	30	10	237
Kazakhstan	1	1	0	2	7	8	1	16	10	13	2	25
Kenya	0	0	0	0	8	2	2	11	76	19	19	113
Malawi	1	0	0	1	6	2	2	10	24	8	8	40
Mali	32	19	19	71	44	27	27	98	102	63	63	227
Mexico	8	5	3	17	58	37	20	116	37	23	13	73
Mozambique	1	1	0	2	8	4	2	14	48	24	12	84
Myanmar	3	1	1	4	12	3	4	18	19	4	6	29
Nigeria	4	1	1	6	14	3	3	21	42	10	10	61
Pakistan	418	127	63	608	198	60	30	288	330	100	50	480
Senegal	1	1	1	2	37	46	28	110	79	97	59	235
South Africa	1	0	0	1	48	35	24	107	51	37	26	114
Spain	4	2	2	7	64	25	25	114	61	24	24	109
Sudan	23	8	1	32	127	44	8	178	174	60	11	244
Tanzania	4	2	0	6	6	3	0	9	27	14	0	41
Togo	8	6	5	19	41	30	27	98	373	273	246	893
Turkiye	72	29	10	110	150	60	20	230	82	33	11	126
Uganda	0	0	0	1	3	1	1	5	7	2	2	12
USA	341	119	163	623	82	29	39	150	89	31	43	163
Uzbekistan	170	83	43	297	180	88	46	314	260	127	67	454
Zambia	1	1	0	2	8	4	2	14	42	21	10	73
Zimbabwe	10	5	1	17	42	22	6	70	181	95	26	302
Global Avg.	4278	2024	1138	7439	136	64	36	236	176	83	47	306

Source: ICAC Cotton Data Book 2022v

Fertilizer use in cotton

If we take a closer look at the relationship between production, yield, and fertilizer use, we find that higher production and yield do not necessarily correspond to higher fertilizer application and use. Liebig's Law of The Minimum, a globally confirmed principle, states that the yield achievable is dictated by the nutrient that is most limiting.[56] This principle is commonly illustrated as a barrel, with each stave symbolizing distinct growth elements. If one stave is lacking or absent, the whole barrel loses its ability to hold the water.[57]

Fig. 15
Liebig's Law of The Minimum



In the realm of agriculture, nutrient management stands as a critical challenge for both the sustainability of our ecosystems and the livelihood of farmers worldwide. On one end of the spectrum, some growers have a propensity to over-apply fertilizers as they believe it ensures optimal crop yield and quality.[58] This not only results in wasted resources but can also lead to environmental issues such as leaching and runoff.[59] On the other end, barriers like financial constraints[60] restrict many farmers from accessing adequate nutrients leading to under-application. This in turn reduces yields and can negatively impact farmers' income. Both overapplication and under-application of nutrients underscore the importance of balanced nutrient management for the future of sustainable agriculture and the wellbeing of farming communities.

In the data presented in Figure 14, it's evident that cotton production and fertilizer use significantly differ across the globe, echoing the need to understand the unique agricultural context of each region. It is no surprise that China, one of the top cotton producers in the world, with a production of 5,730,000 Tonnes and yield of 1892 kg/Ha, has the highest amount of fertilizers used (N+P+K: 1,678,000 Tonnes). In contrast, Greece, having a small production of 305,000 Tonnes and yield of 1121 kg/Ha, has a relatively low amount of fertilizers applied (N+P+K: 28,000 Tonnes). If we break this down further, China uses 152 grams of Nitrogen per kilogram of cotton lint produced, while Greece uses 57 grams per kilogram of lint. This suggests that the relationship between the total volume of fertilizers used and production volume does not reveal much and we must go deeper into the data to understand how each nutrient impacts yield on a per production basis. With this, we can see that Greece may be more efficient with their Nitrogen application to achieve similar yielding fields to China. This may be due to various factors such as the fertility of the soil, farming practices, climatic conditions, and crop nutrient needs.

When examining USA and India, it becomes evident that higher fertilizer use doesn't necessarily equate to increased yield. India has the highest area of cotton production in this dataset at 12,055 thousand hectares, with a production of 5,220 thousand tonnes. Despite this high level of production, the yield is relatively low at 433 kg/ha. Looking at the fertilizer use, India uses a total of 2,749,000 Tonnes, however fertilizers are subsidized and leads to waste. On the other hand, the USA has a much smaller area of cotton production at 4,156 thousand hectares but manages a higher yield of 918 kg/ha, more than double that of India. The production level in the USA is also considerably higher, reaching 3,815 thousand tonnes. However, the USA applies significantly fewer N+P+K fertilizers (623,000 Tonnes). Despite a lower production area and lesser total use of fertilizer, the USA achieves a higher yield per hectare than India.

In cotton cultivation, seed breeding plays a pivotal role in determining yields, an anonymous cotton expert tells us. Countries that lead in cotton yields owe their success largely to advances in breeding that focus on optimizing yield, quality, and pest resistance.

In cotton cultivation, seed breeding plays a pivotal role in determining yields, an anonymous cotton expert tells us. Countries that achieve high cotton yields largely owe their success to advances in breeding, which may involve the use of new technologies like GM or traditional breeding techniques. The key is to focus on optimizing yield, quality, and pest resistance.

The challenges faced by some nations underscore the importance of well-managed and regulated seed breeding, research, and distribution. In some instances, when gene technologies are not adequately regulated or when the seed multiplication and delivery infrastructure is not efficient, it can lead to countries not realizing their full potential in producing high-yield cotton varieties.

This highlights that a higher use of fertilizer does not always lead to a greater yield per hectare. That being said, higher yielding fields and plants do require more nutrients to produce with all other variables held constant. It underscores the necessity for effective fertilizer management and the pivotal role of understanding a crop's nutrient needs through soil tests and assessments, along with frameworks such as the 4R's where possible. It further underlines the complexity of interpreting a crop's nutrient needs, emphasizing the imperative for adopting localized, context-specific approaches in agricultural management that look beyond mere numerical values. This stresses the importance of nuanced and detailed understanding over simplistic interpretation of figures.

These variations in fertilizer use depend on a multitude of factors, including soil type, yield, weather conditions and climate, crop type, and management practices. In some cases, fertilizers are applied according to a calendar or recommendations from local agricultural experts that are not according to the 4R's principles, rather than based on need determined by soil tests or plant tissue tests. This approach may not always take into account the specific nutrient needs of a particular crop or the soil conditions in a given field.

Soil fertility may also vary within a field, even a small one, meaning multiple soil samples should be taken and soil nutrient levels should be tested periodically to ensure that fertilizer is being applied in the right amounts and at the right time, as determined by the farmer and based on testing. Regular repeat sampling on an annual basis will allow the monitoring of soil organic matter and ultimately allow for a true understanding of the climate impact of the cotton you are sourcing.

It is important to emphasize the need for data due diligence, meaning that the data presented in this report should be considered indicative and a supplement to farmers' and experts' own soil test data to better understand the farm context and use local nutrient management recommendations for most accurately applying nutrients to fields.

> "Soil Health is the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans."
> - Soil Health Institute

Optimizing cotton production through soil health and testing

Soil health is vital for supporting a diverse array of soil organisms, including bacteria, fungi, insects, and earthworms. These organisms contribute significantly to nutrient cycling,[61] pest management,[62] and organic matter decomposition,[63] reducing the need for synthetic fertilizers in agricultural systems.[64] Embracing soil health systems can enhance microbial diversity, help the soil have access to and hold more water, uplift farmer livelihoods, boost agricultural productivity, and enhance climate resilience. This, in turn, can help optimize yields and reduce irrigation needs, leads to cleaner water for downstream communities, restoration of ecosystem health, preservation of rural landscapes, and mitigation of climate change for the benefit of future generations.[65]

After following the 4R's, the critical next step is soil testing or soil assessments, which will help to inform fertilizer recommendations that are tailored to the specific needs of a given crop and field. Soil testing can help determine the nutrient levels and pH of the soil, which can be used to calculate the amount and type of fertilizer needed to optimize crop growth and minimize the risk of over-applying nutrients.

In addition to soil testing, having an idea of what untouched soil looks like can be helpful in understanding the nutrient status of a field and identifying any potential nutrient deficiencies or imbalances. Going beyond the numbers in this report, historical records of agricultural practices going back decades or longer can be found in various sources, such as local agricultural extension or research offices, university records, and other archives, providing valuable information for understanding past practices and informing future sustainable approaches. The objective is to assess the availability of data and identify any changes or baseline information related to cotton production. Cotton cultivation has historically been associated with organized research and management practices, which persist today through dedicated research departments.

The Soil Health Institute has set out a soil health target setting approach that involves assessing soil health and carbon potential by monitoring soil health indicators under optimal conditions like minimal disturbance, continuous living roots, and soil surface protection.[66] In the concept of Soil Health Targets, the objectives must be interpretable, scalable, and locally relevant.[67]

Managing healthy soils is also critical for optimizing production in a responsible way. By implementing appropriate farming strategies, soil microorganisms play a crucial role in enriching and supplementing plants with essential compounds. However, inadequate farming conditions and intensified agricultural practices can lead to a significant decrease in both the quantity and activity of microorganisms, resulting in poor plant health and reduced crop yields.[68]

Monitoring soil electrical conductivity (EC) levels can also provide valuable insights for farmers in managing soil health. While EC is not directly used to inform irrigation decisions or manage the crop in-season, it serves as an indirect indicator of soil health and the presence of dissolved salts that can be detrimental to plant growth and hence, yield.[69]

Soil organic matter (SOM) and social organic carbon (SOC) are other critical components of cotton production. SOM is the amount of organic material in soil and plays a crucial role in soil fertility, water-holding capacity, and carbon sequestration.[70] Soil organic carbon (SOC) is vital as a food source to microbes and assists in moisture holding capacity, which goes hand in hand with SOM. Over time, changes in SOM can indicate whether carbon is being depleted or sequestered in the soil. Maintaining or increasing SOM levels can help improve soil health and reduce greenhouse gas emissions.[71] An increase in SOC shows plants are producing great photosynthetic effects and drawing CO2 from the atmosphere and measuring these changes overtime should be a long term commitment, as long as a decade to see change, which requires brands and retailers to become true partners with farms and farm workers either directly or in-directly through cotton programs.

IMPORTANT!

One can already see this work being done through the US Cotton Trust Protocol. The U.S. Cotton Trust Protocol is an organization that implements measures to track and promote responsible practices in cotton farming. It is not intended as a tool of improvement for individual farmers, but functions as a web-based platform to gather data on cotton production within the United States, serving primarily as a means for the country to document and validate its data collection. One key aspect they evaluate includes the soil conditioning index, an indicator of soil health. The measure of soil carbon employs a tool from the USDA NRCS, known as the Soil Conditioning Index (SCI). This index directly reflects practices that enhance soil organic content.[72]

Another example of a data-driven approach to impact data collection is Good Earth Cotton®. Good Earth Cotton® is Sundown Farm's branded regenerative cotton program and a founding member of the Transformers Foundation. This modern regenerative farming program's meticulous data collection, strict guidelines and third party verified methodologies ensure comprehensive coverage of all cropping data. This enables Good Earth Cotton to accurately determine the carbon score, illustrating the crop's ability to act as a carbon sink. Furthermore, a physical tracer is attached to the raw fibre by Good Earth Cotton, ensuring that its environmental credentials are preserved and traceable throughout its journey from fibre to finished garment and eventual recycling.

In conclusion, optimizing cotton production through soil testing and management is ideal for responsible cotton sourcing. By understanding the nutrient status of a field, identifying potential nutrient deficiencies or imbalances, electrical conductivity, and soil organic matter, cotton farmers can minimize the risk of over-applying or under-applying fertilizers/nutrients, reduce input costs (especially important in the ongoing economic crisis), and optimize yield. However, we must remember that the majority of the world's cotton farmers are smallholders who often lack access to such soil tests. With a due diligence approach and long-term commitment to measuring changes in soil health and supporting farmers' needs, cotton buyers can become true partners with farms and farmers, contributing to a more equitable and responsible future for cotton production.

Key Takeaways:

1

Fertilizers are necessary for cotton farming to maintain soil fertility and optimize crop yields. But, over-application can lead to eutrophication and other environmental problems, while under-application can reduce yields and decrease land use efficiency and grower profitability. Therefore, it is important to support farmers in adopting fertilizer management practices that minimize nutrient losses and improve nutrient use efficiency.

2

Fertilizer Use in cotton farming demonstrates considerable variation across different countries. While a higher production or yield doesn't always equate to an increase in fertilizer use, the best measure involves looking at nutrient use per unit of cotton produced. Several factors such as the type of soil, yield, weather conditions, type of crop, pests, genetics, and farming practices significantly influence use and production efficiency. Thorough data due diligence is crucial, and it is advisable to compare the data presented in this report with site specific soil test and assessment results. This helps in understanding the specific conditions of the farm, and thereby aiding the development of customized fertilizer strategies. These strategies should cater to the unique requirements of specific crops and fields, and be developed under the guidance and expertise of the farmer.

3

Managing soil health is critical to optimizing cotton production in a responsible way, and going beyond the numbers into soil testing and management can help minimize the risk of over or under applying nutrients, reduce input costs, and improve yield. A long-term commitment to soil health systems and measuring changes in soil health can lead to true partnerships with farms and farmers, ultimately resulting in a more sustainable future for cotton production.

Cotton and fertiliser: additional data and figures

Here are key data and figures on cotton's fertiliser usage.

Fertiliser cost % of net returns

Fig. 16

Country	Fertilizer Cost US$/Ha	Fertilizer Cost US$/Kg lint	Fertilizer Cost % of Cultivation Cost	Net Returns on Seed+Lint US$/Ha	Fertilizer Cost % of Net Returns
Argentina	34	0.05	2.6	701.5	4.85%
Australia	777	0.31	20.8	1497	51.90%
Bangladesh	412.9	0.53	24.6	396.5	104.14%
Benin	95.1	0.2	21.4	522.3	18.21%
Brazil	435.5	0.24	15.1	1422.1	30.62%
Burkina Faso	88.8	0.25	21.3	363.2	24.45%
Cameroon	91.2	0.15	17.3	692.7	13.17%
Chad	64.2	0.22	19.5	172.2	37.28%
China	714	0.38	28.6	2864.8	24.92%
Colombia	687.3	0.78	43.4	608.3	112.99%
Cote D'ivoire	111.2	0.23	20.5	437.4	25.42%
Egypt	411.1	0.49	21.3	1232.8	33.35%
Greece	225	0.2	9.3	402.6	55.89%
India	110.3	0.25	11.5	298.9	36.90%
Iran	90	0.11	6.9	1721	5.23%
Kazakhstan	105	0.16	8.7	429.6	24.44%
Kenya	112.8	1	23.5	37.7	299.20%
Malawi	25.2	0.1	5	99.4	25.35%
Mali	73.9	0.17	17.5	323.5	22.84%
Mexico	406	0.26	16.2	952.6	42.62%
Mozambiquie	2	0.01	0.8	89.5	2.23%
Nigeria	127.7	0.37	20.3	62.4	204.65%
Pakistan	192.8	0.27	25.3	1407.9	13.69%
Senegal	86.5	0.18	17.7	455.7	18.98%
South Africa	329.5	0.26	19.9	2403.7	13.71%
Spain	282	0.27	25.9	1762.3	16.00%
Sudan	317.3	0.51	36.4	530.1	59.86%
Tanzania	0	0	0	186.1	0.00%
Togo	91.9	0.31	21.3	171	53.74%
Turkiye	280	0.15	13.6	3378.1	8.29%
Uganda	0	0	0	972.7	0.00%
USA	180.4	0.17	11.6	1017.4	17.73%
Uzbekistan	374.3	0.54	26.1	405.1	92.40%
Zambia	118.5	0.62	29.8	-33.9	-349.56%
Zimbabwe	40	0.17	12.9	130.5	30.65%
Global Average	**231.70 US$/Ha**	**0.29 US$/Kg Lint**	**17.96%**	**850 US$/Ha**	**33.60%**

Source: ICAC Cotton Data Book 2022

Fertiliser use in cotton (Kg/Ha)

Fig. 14 (Extended)

	Area	Yield	Production	Share of production	FERTILISER USE				FERTILISERS APPLIED				FERTILISER USE EFFICIENCY			
	('000 Ha)	Kg/Ha	('000 Tonnes)		('000 Tonnes)				Kg/Hectare				g/Kg Lint produced			
					N	P2O5	K2O	N+P+K	N	P2O5	K2O	N+P+K	N	P2O5	K2O	N+P+K
Argentina	478	693	331	1.36%	5	0	0	5	10	1	1	12	14	1	1	17
Australia	635	2011	1277	5.25%	145	114	32	291	228	180	50	458	113	90	25	228
Bangladesh	46	776	36	0.15%	4	2	1	8	90	45	30	165	116	58	39	213
Benin	639	480	306	1.26%	33	23	23	79	51	36	36	123	106	75	75	256
Brazil	1373	1719	2360	9.69%	200	211	154	566	146	154	112	412	85	90	65	240
Burkina Faso	596	349	208	0.85%	26	16	16	58	44	27	27	98	126	77	77	281
Cameroon	231	570	132	0.54%	15	5	7	27	67	20	30	117	118	35	53	205
Chad	293	183	54	0.22%	11	4	4	20	38	15	15	68	208	82	82	371
China	3028	1892	5730	23.54%	872	557	248	1678	288	184	82	554	152	97	43	293
Colombia	18	855	16	0.06%	1	0	1	2	76	21	30	127	89	25	35	149
Côte d'Ivoire	475	454	216	0.89%	25	14	14	54	53	30	30	113	117	66	66	249
Egypt	84	833	70	0.29%	18	4	2	25	220	51	24	295	264	61	29	354
Ethiopia	83	745	62	0.25%	2	1	0	3	24	10	5	39	32	13	7	52
Greece	272	1121	305	1.25%	17	6	5	28	64	22	18	104	57	20	16	93
India	12055	433	5220	21.44%	1784	651	313	2749	148	54	26	228	342	125	60	527
Indonesia	4	621	3	0.01%	0	0	0	0	18	11	4	33	29	18	7	54
Iran	98	820	80	0.33%	16	2	1	19	162	25	8	194	197	30	10	237
Kazakhstan	126	638	80	0.33%	1	1	0	2	7	8	1	16	10	13	2	25
Kenya	42	101	4	0.02%	0	0	0	0	8	2	2	11	76	19	19	113
Malawi	86	250	22	0.09%	1	0	0	1	6	2	2	10	24	8	8	40
Mali	720	432	311	1.28%	32	19	19	71	44	27	27	98	102	63	63	227
Mexico	145	1592	231	0.95%	8	5	3	17	58	37	20	116	37	23	13	73
Mozambique	138	166	23	0.09%	1	1	0	2	8	4	2	14	48	24	12	84
Myanmar	241	634	153	0.63%	3	1	1	4	12	3	4	18	19	4	6	29
Nigeria	272	343	93	0.38%	4	1	1	6	14	3	3	21	42	10	10	61
Pakistan	2110	600	1266	5.20%	418	127	63	608	198	60	30	288	330	100	50	480
Senegal	19	469	9	0.04%	1	1	1	2	37	46	28	110	79	97	59	235
South Africa	14	937	13	0.05%	1	0	0	1	48	35	24	107	51	37	26	114
Spain	63	1046	66	0.27%	4	2	2	7	64	25	25	114	61	24	24	109
Sudan	180	730	131	0.54%	23	8	1	32	127	44	8	178	174	60	11	244
Tanzania	641	220	141	0.58%	4	2	0	6	6	3	0	9	27	14	0	41
Togo	193	110	21	0.09%	8	6	5	19	41	30	27	98	373	273	246	893
Turkiye	480	1827	833	3.42%	72	29	10	110	150	60	20	230	82	33	11	126
Uganda	104	428	45	0.18%	0	0	0	1	3	1	1	5	7	2	2	12
USA	4156	918	3815	15.67%	341	119	163	623	82	29	39	150	89	31	43	163
Uzbekistan	945	691	600	2.46%	170	83	43	297	180	88	46	314	260	127	67	454
Zambia	140	192	27	0.11%	1	1	0	2	8	4	2	14	42	21	10	73
Zimbabwe	247	232	57	0.24%	10	5	1	17	42	22	6	70	181	95	26	302
Global Avg.	31471	764	24346	100.00%	4278	2024	1138	7439	136	64	36	236	176	83	47	306

Source: ICAC Cotton Data Book 2022

General information about cotton:

Credible sources, data and tools

International Cotton Advisory Committee (ICAC) - ICAC is the world's intergovernmental body for cotton producing, consuming and trading countries. A reliable source for aggregated global data on cotton.

ICAC recorder

Cotton Inc. - Cotton Inc. is a nonprofit representing U.S. growers.

FAOSTAT - Data from the Food and Agricultural Organization of the United Nations (FAO) for over 245 countries and territories and covers all FAO regional groupings from 1961 to today. Access is free.

CottonInfo - The Australian cotton industry's joint extension program, providing research, the latest news, and other information.

*This page was originally published in: Cotton: A Case Study in Misinformation in 2021

Readers are also encouraged to seek cotton data from the following reputable scientific journals.

Reputable Scientific Journals

Fig. 17

Journal group	Website	Open access
Elsevier	https://www.sciencedirect.com	N. Some might be or occasional articles
Academia	https://www.academia.edu/Documents/in/Academic_Journals	Y
Wiley	www.wiley.com	N. Some might be or occasional articles
Sage	https://journals.sagepub.com	N. Some might be or occasional articles
JSTOR	https://www.jstor.org	N. Some might be or occasional articles
ResearchGate	https://www.researchgate.net	Y (registration required)
BMC	https://www.biomedcentral.com/journals	Some
Springer	https://link.springer.com	N. Some might be or occasional articles
PLOS	www.plos.org	Y
Ecology and Society	https://www.ecologyandsociety.org	Y
Taylor & Francis	taylorfrancis.com	N. Some might be or occasional articles
Annual Reviews	https://www.annualreviews.org	N. Has a system for converting some existing subscriptions to open access
Nature	www.nature.com	N. Some free articles
Copernicus	https://www.copernicus.org	Open access
MDIP	https://www.mdpi.com/about/journals	Open access Some open access
Oxford Academic	https://academic.oup.com/journals	N. Some might be or occasional articles
The Lancet	https://www.thelancet.com	Open access

Registered access sites will usually offer subscription or single article purchase options; this list is not exhaustive. Individual articles may also be available for free through ResearchGate or Academia.edu

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Conclusion and Calls to Action

Conclusions

The cotton industry encounters multiple obstacles to being more sustainable in terms of water usage, pesticide and fertilizer control, and social and environmental responsibility and it will take all stakeholders to move the industry towards better practices and rethink the way we source our cotton. Nevertheless, there are numerous chances to overcome these hurdles and foster a more equitable and responsible cotton industry by capturing the nuances in cotton production, as well as accurate data. Within our context, change takes the form of being led by producers and farmers, while brands play a crucial role as supporters and followers either directly or indirectly through cotton programs. Furthermore, brands and retailers can give farmers better security of contracts and relationships with buyers and intermediaries, support in research and access to knowledge and technology, promote fair labor practices, address social and environmental concerns with farm partners expertise, and engage with local communities to contribute to an equitable and responsible cotton industry.

Here are the five key takeaways from our report:

1. **The use of fertilizers, pesticides, and water in agriculture isn't inherently negative.** While their use has certain impacts, it also brings about notable advantages, influencing more than just the environment. Initiatives and challenges to blindly remove the use of certain compounds or fertilizers can be shortsighted and increase negative impacts in the long term. The key approach when using these resources is to ensure their efficient, safe, and responsible utilization, aiming to optimize farmer earnings while minimizing environmental and health hazards.

2. **The latest available information may not reflect the current situation in your specific location or context.** We suggest all users of this report to exercise data due diligence and to seek additional information from experts as needed, in order to gain a more comprehensive understanding of the issues at hand. The data presented in this report, as well as in others, is categorized by country. There are great regional differences within countries and even smaller geographical regions. Local context is key to understanding the specifics of cotton production.

3. **Use only the best and most recent data available**, but strive to go beyond the numbers to understand the local contexts. Remember that collecting this data isn't merely a data issue; it's a partnerships issue.

4. **Don't problem shift.** Use quality data, context and expert insights to inform and to drive action and change not just in your own operations but society-wide. Locate and use data from the primary source. Check footnotes, Be skeptical of global averages. Use the right data point. Never use obsolete data without context, transparent methodology and relevant disclaimers.

5. **We must listen to farmers and agricultural experts** on best practices and keep them in the decision making position, as they are the ones with deep knowledge of how to take care of their lands. All strategies should be led by farmers who should inform you on how you can support them. Change should be producer-led, brand-supported.

Data Due Diligence

Define your research question or problem statement	Identify the type of data you need to collect and the sources you need to consult.
Identify potential data sources	Consider where you might find the data you need. This could include published reports, government databases, academic journals, or industry associations.
Evaluate the quality of the data sources	Assess the credibility and reliability. Check for biases, conflicts of interest, and potential sources of error.
Assess the quality of the data itself	Once you have identified potential data sources, evaluate the quality of the data itself. Check for accuracy, completeness, and consistency.
Document your sources and findings	Always share the original source of your data.
Data Use and Privacy	Farmers should have control over how their data is collected, stored, and used. Clear consent mechanisms should be established to ensure that farmers explicitly agree to share their data and understand how it will be utilized, as well as ideally obtain value from sharing the data.
Update your research as needed	Data can change over time, so it’s important to update your research as new data becomes available or as circumstances change.

Data Gaps

Filling the remaining data gaps in the cotton industry is essential for developing effective and sustainable solutions for reducing water use, pesticide and fertilizer use, and improving overall environmental and social performance. This requires increased transparency and accountability throughout the supply chain, from farmers to brands and retailers. Governments, NGOs, and industry stakeholders can collaborate to develop more robust data collection and reporting systems that capture the full scope of environmental and social impacts of cotton production, including water use, pesticide and fertilizer use, greenhouse gas emissions, labor practices, and community well-being. By sharing this data openly and transparently, stakeholders can identify areas for improvement and develop more targeted interventions to address the most pressing environmental and social challenges in the cotton industry.

Calls To Action

1 Do your data due diligence

- [ ] **Brands and Suppliers** should conduct thorough due diligence versus taking numbers at face value to inform their cotton sourcing decisions and ensure cotton is ethically produced, which requires localised and context-specific data collection and analysis.

- [ ] **Policy Makers** should invest in accurate data collection and analysis methods to inform policy decisions, and ensure that data is regularly updated and publicly accessible.

- [ ] **NGOs** should use accurate and up-to-date data, while going beyond the numbers to speak to the experts on the ground, to inform advocacy efforts and support initiatives that promote sustainable cotton production.

- [ ] **Media** should follow our recommended due diligence measures above to ensure the data they are using in their arguments is credible and reliable while citing the original source, as well as updating articles as data changes over time.

Calls To Action

2 Advocate for transparency and disclosure of data

- [ ] **Brands and Suppliers** should work with farmers or cotton intermediaries to collect and disclose data on pesticide and fertilizer use, and make this information publicly available to showcase the accurate impacts of their production, especially as more legislation arises that will legally require brands and retailers to disclose this information. Data use and privacy consent mechanisms should be clearly established.

- [ ] **Policy Makers** could help enact and enforce due diligence and Product Environmental Footprint legislation, as well as help to fund and implement more robust systems for capturing accurate data that will ultimately help brands and retailers meet other legislative requirements, and farmers who release this data achieve higher compensation for their crops.

- [ ] **NGOs** should advocate for more transparency in the cotton supply chain, specifically traceability and disclosure of pesticide and fertilizer use, as well as help to fund these activities. NGOs should also advocate for the reduction of environmental and human impacts associated with the use of these materials. This can be achieved by optimizing resources, such as applying the appropriate quantities of pesticides, fertilizers, and water needed for optimal yields.

- [ ] **Media** should use their resources to help consolidate and advocate for the best available data and fill the data gaps.

Calls To Action

3 Rethink the way we source cotton

- [ ] **Brands and Suppliers** should prioritize responsible cotton sourcing and support farmers in adopting sustainable practices. This includes giving farmers better security of contracts, having a vested interest in their success, improved relationships with buyers and intermediaries, a shift in sourcing strategy such that brands and retailers know who their farmers are, and build in-house technical expertise to do so or work with agriculture experts. They should also invest in the development of new technologies to help farmers transition towards responsible cotton production. Most importantly, brands and suppliers should act as a supporter and follower of the real experts, the farmers.

- [ ] **Policy Makers** should invest in research and development of sustainable cotton production methods, including water conservation, integrated soil and pest management, and precision fertilization, as well as new technology like robotics, sensors, drones and data analytics. Additionally, policymakers should hold brands and retailers accountable for disclosing the investments they've made in their cotton supply chains.

- [ ] **NGOs** can advocate for responsible cotton sourcing and support farmer-led initiatives that promote sustainable and ethical farming practices.

- [ ] **Media** can highlight the importance of sustainable cotton sourcing, how complex cotton production practices and resource use decisions can be, and support the voices of small-scale farmers and community-led initiatives.

- [ ] A call to **all professionals in the fashion industry and its proxies**: visit the farm and create relationships over transactions.

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Appendix

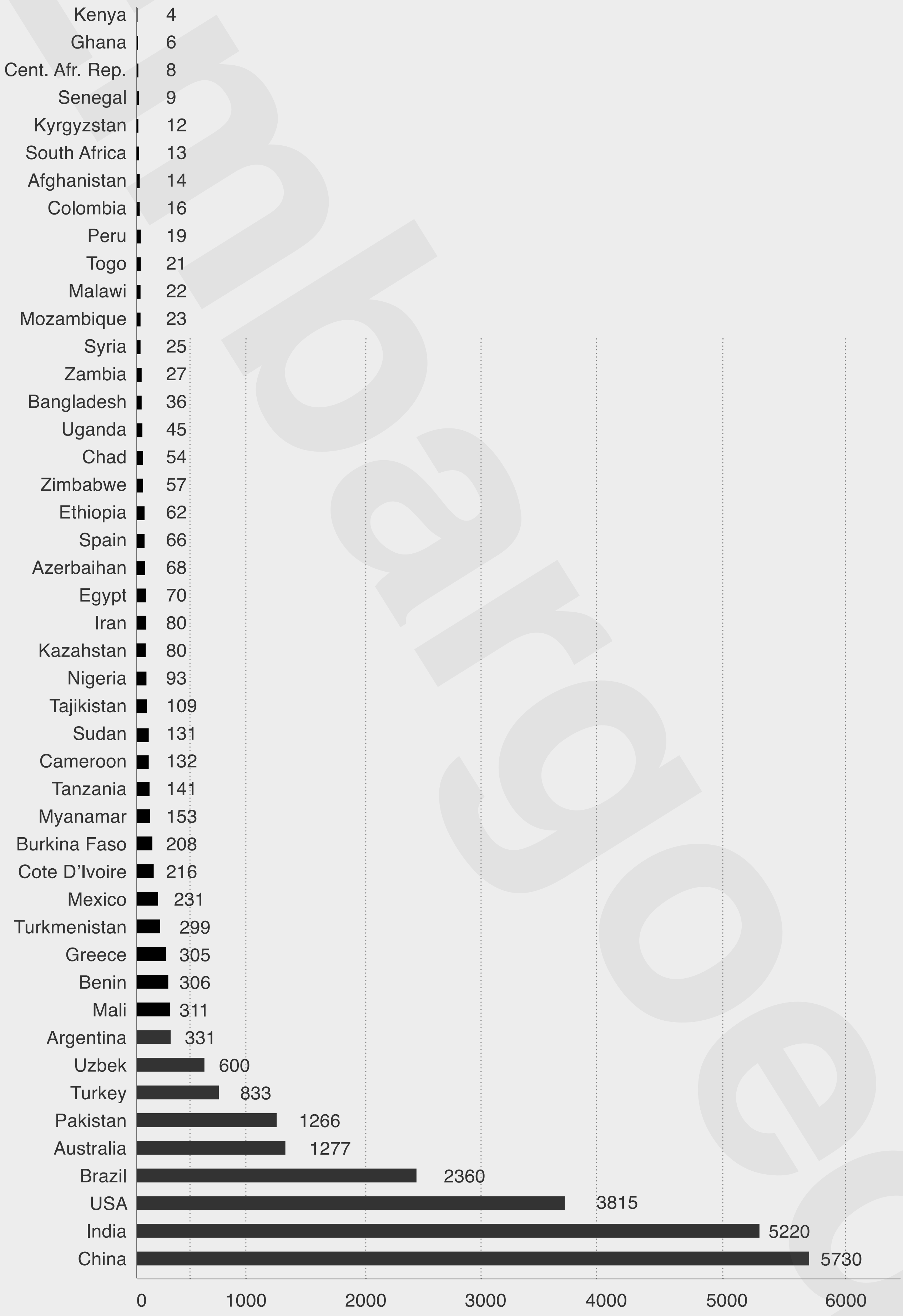
Additional Data

The International Cotton Advisory Committee kindly shared with us key data and statistics about cotton from their latest Cotton Data Book 2022, released in 2023. You can find the full 949-page book at this link or alternatively access the or access the free ICAC Recorder [here] for more information.

Additionally, we have gathered the latest government supplied data to FAO in 2022 that covers data from 2020.

Cotton Production ('000 Tonnes)

Fig. 18



Source: ICAC Cotton Data Book 2022.

Cotton Production ('000 Tonnes)

Fig. 19

Countries	'100 Tonnes	% of Global Production
Kenya	4	0.02
Ghana	6	0.02
Cent. Afr. Rep.	8	0.03
Senegal	9	0.04
Kyrgyzstan	12	0.05
South Africa	13	0.05
Afghanistan	14	0.06
Colombia	16	0.06
Peru	19	0.08
Togo	21	0.08
Malawi	22	0.09
Mozambique	23	0.09
Syria	25	0.1
Zambia	27	0.11
Bangladesh	36	0.14
Uganda	45	0.18
Chad	54	0.22
Zimbabwe	57	0.23
Ethiopia	62	0.25
Spain	66	0.26
Azerbaihan	68	0.27
Egypt	70	0.28
Iran	80	0.32
Kazahstan	80	0.32
Nigeria	93	0.37
Tajikistan	109	0.44
Sudan	131	0.52
Cameroon	132	0.53
Tanzania	141	0.56
Myanamar	153	0.61
Burkina Faso	208	0.83
Cote D'Ivoire	216	0.87
Mexico	231	0.93
Turkmenistan	299	1.2
Greece	305	1.22
Benin	306	1.23
Mali	311	1.25
Argentina	331	1.33
Uzbek	600	2.4
Turkey	833	3.34
Pakistan	1266	5.07
Australia	1277	5.12
Brazil	2360	9.46
USA	3815	15.29
India	5220	20.92
China	5730	22.96
Grand Total:	**24,958**	**100**

Updated With The Latest Data on Cotton

Source: ICAC Cotton Data Book 2022.

Number of farmers and farm unit area (Ha)

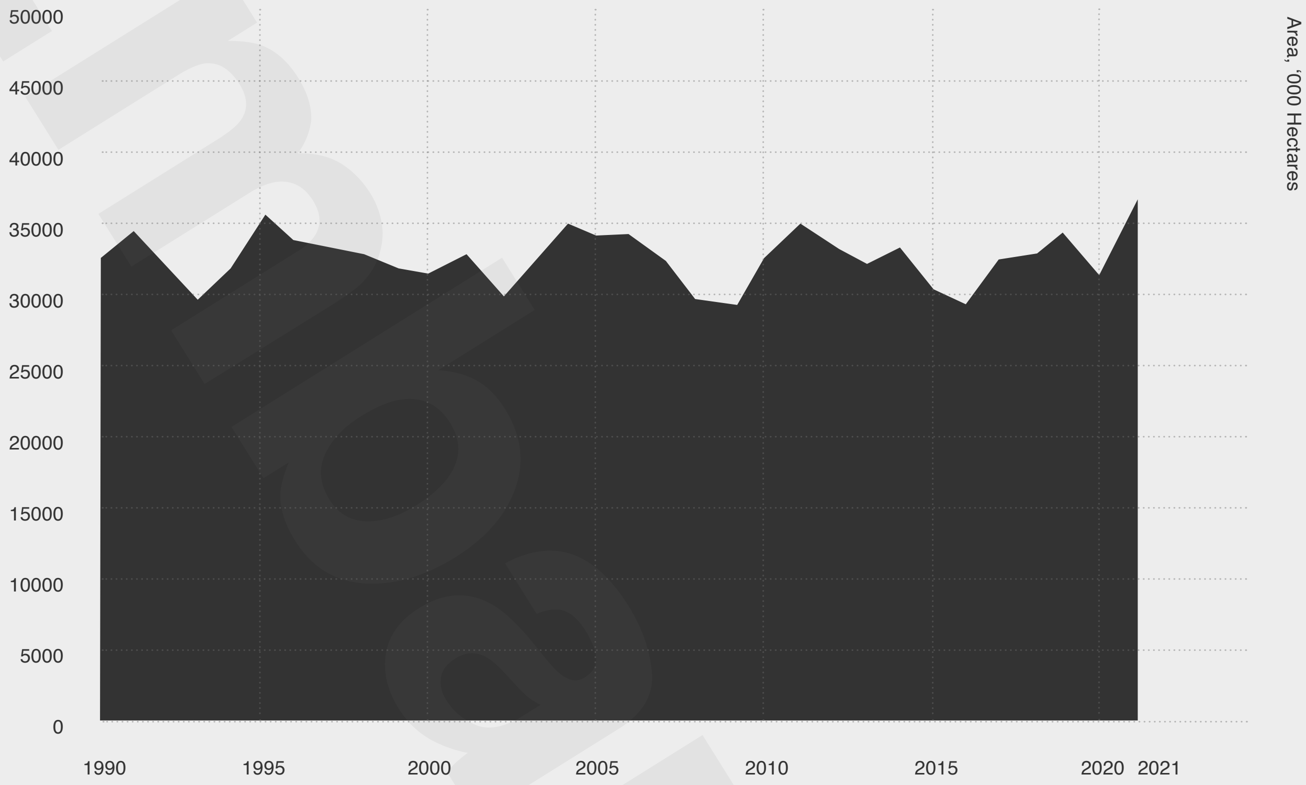
Fig. 20

	Area (Hectares)	Male Farmers	Female Farmers	Total Farmers	Avg. Land Holding (Ha)
Argentina	478,119	2,331	257	2,588	184.74
Australia	635,000	1360	366	1,726	367.90
Bangladesh	45,900	79,098	13,256	92,354	0.50
Benin	638,948	178,637	21,932	200,569	3.19
Brazil	1,372,891	2,651	612	3,263	420.75
Burkina Faso	595,866	208,194	7551	215,745	2.76
Cameroon	231,075	145,531	20,333	165,864	1.39
Chad	292.54	217.361	8,278	225,639	1.30
China	3,028,000	3,136,200	5,450,000	8,586,200	0.35
Colombia	18,450	496	113	609	30.30
Cote-D'lvoire	475.354	128.381	2475	130,856	3.63
Egypt	84,000	140,344	85,145	225,489	0.37
Ethiopia	83,157	48,627	750	49,377	1.68
Greece	271,928	22,743	21,030	43,773	6.21
India	12,055,000	6,157,385	4,104,922	10,262,307	1.17
Indonesia	4089	1800	1,200	3,000	1.36
Iran	98,000	34,231	0	34,231	2.86
Israel	4430	40	40	80	55.38
Kazakhstan	125,800	31,745	10,000	41,745	3.01
Kenya	42,000	18,745	9,293	28,038	1.50
Kyrgyzstan	14,100	700	69	769	18.34
Malawi	86,340	24,524	17,413	41,937	2.06
Mali	720.093	211,127	1,437	212,564	3.39
Mexico	145.418	6,676	788	7,464	19.48
Mozambique	137,660	92,280	30,076	122,356	1.13
Myanmar	241,481	190,424	47,606	238,030	1.01
Nigeria	271,920	51650	6,350	58	4.69
Pakistan	2,110,000	1,600,000	1,000	1,601,000	1.32
Paraguay	9,900	10,000	2,000	12,000	0.83
Senegal	18,572			18,577	1.00
South Africa	14,004	564	772	1336	10.48
Spain	63,489	2,763	1,461	4,224	15.03
Sudan	180,000	154,847	19,337	174,184	1.03
Tanzania	641,000	358,953	245,262	604,216	1.06
Togo	193,000	62,871	6,384	69,255	2.79
Turkey	480	70.201	21	70,201	6.84
Turkmenistan	545,000	120,662	0	120,662	4.52
Uganda	104.03	10,460	10,100	20,560	5.06
USA*	4,156,122	6,806	1,297	8,103	512.91
Uzbekistan	945,000	27.506	2,050	29,556	31.97
Vietnam	980	3,000	1,000	4,000	0.25
Zambia	139,869	81,542	22,043	103,585	1.35
Zimbabwe	246,808	216,074	141,014	357,088	0.69
Total	**32,045,334**	**13,859,530**	**10,336,011**	**24,193,120**	**1.32**

Source: ICAC Cotton Data Book 2022.

Cotton Area Trend (1990 - 2020)

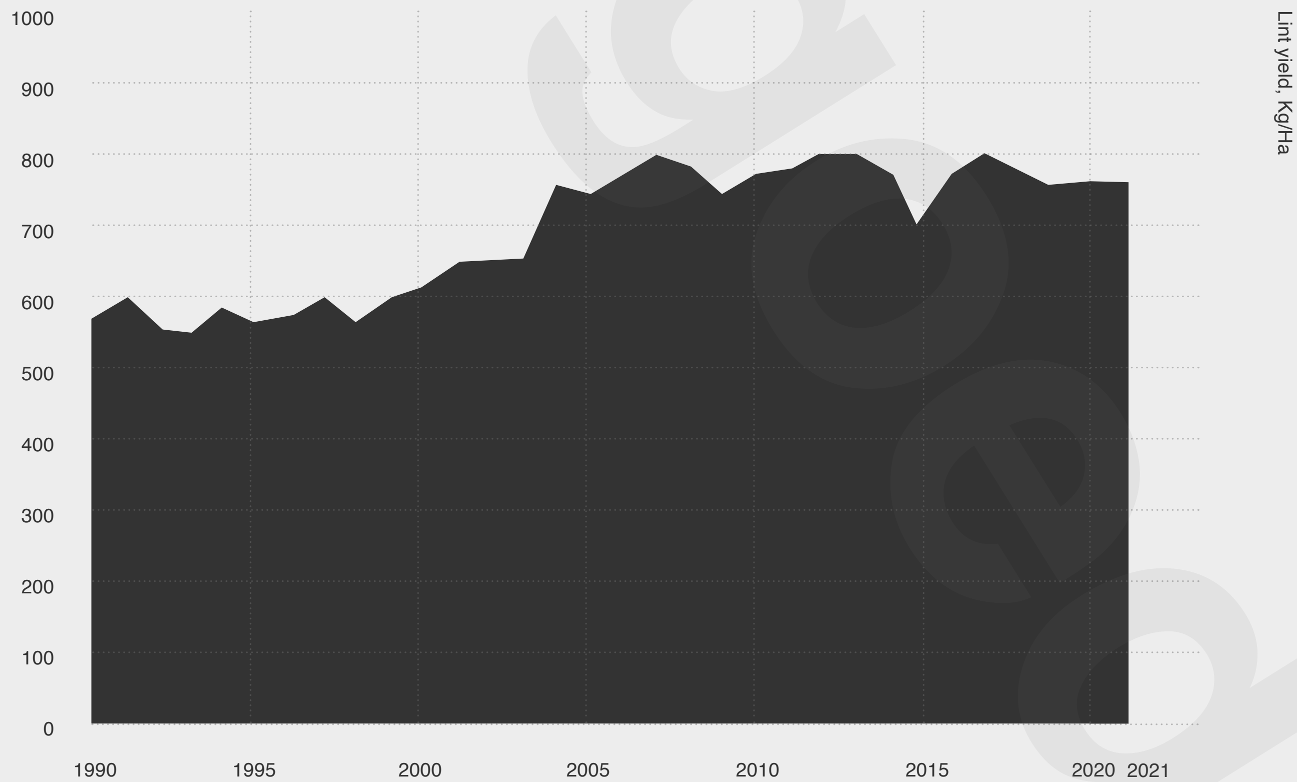
Fig. 21



Source: ICAC Cotton Data Book 2022.

Lint Yield Trend (1990 - 2020)

Fig. 22



Source: ICAC Cotton Data Book 2022.