

# Physical climate risk for global cotton production

## Global Analysis

Executive Summary



**COTTON  
2040**



**ACCLIMATISE**  
building climate resilience  
WillisTowersWatson

# CONTENTS

## FOREWORD

### 1 RATIONALE

- 1.1 | Why consider the impacts of climate change on the global cotton value chain?
- 1.2 | Why does the global cotton value chain need to consider climate impacts?

### 2 OBJECTIVES AND METHODOLOGY

- 2.1 | What is this study's unique value?

### 3 RESULTS

- 3.1 | Which cotton growing regions are projected to be exposed to the greatest physical climate risk?

### 4 IMPLICATIONS

- 4.1 | What does this mean for the cotton industry?

### 5 NEXT STEPS

- 5.1 | How should this report be used?

### 6 REFERENCES

# FOREWORD

Welcome to the **Physical Climate Risk Assessment for Global Cotton Production report**, which focuses on the climate risks to cotton growing and production around the world. This work was completed by Acclimatise in partnership with international sustainability non-profit Forum for the Future, as part of the [Cotton 2040 initiative](#), funded by Laudes Foundation. This global report is complemented by a detailed India report that explores the relationships between physical climate risks and socio-economic vulnerabilities, alongside a microsite with additional resources. Both reports are generated in response to the lack of comprehensive, readily available information about how the climate crisis is likely to impact cotton production, its supply chain, and the nature of the industry over the coming decades.

The Cotton 2040 initiative was originally established to bring together existing initiatives in the cotton sector to align around critical issues for - and accelerate the transition to - long term sustainability. In the context of climate breakdown, this goes beyond standards, certification or corporate commitments. Whether adequately prepared or not, the cotton system will be forced to change in the face of the dramatic changes that our warming climate will catalyse. With this report, our intention is to offer this data and analysis to spark a dialogue that will lead to joined up, informed and responsible action, and resilient responses that are deliberate, collaborative and systemic.

This Global report starkly demonstrates that under a worst-case climate scenario, all global cotton growing regions will be exposed to increased risk from at least one climate hazard by 2040. Half of global cotton growing regions will face drastic changes with high or very high risk exposure to at least one climate hazard. Some regions are set to be exposed to up to seven climate hazards, from heat stress to water availability and extreme weather events. This is likely to lead to complex and converging risks as these threats intersect. The six highest cotton producing countries – India, USA, China, Brazil, Pakistan and Turkey – are all exposed to increased climate risk, particularly from wildfire, drought and extreme rainfall, which threatens the entire cotton value chain. Climate risks are not only affecting cotton growing; extreme high temperatures affect worker wellbeing in the production cycle too.

Around half of cotton growing regions will be exposed to increased risk of meteorological drought by 2040. Water scarcity is set to be one of the most significant climate risks for the world's most productive cotton growing regions, adding extra pressure to a fibre already under scrutiny for its water footprint. Many cotton growing regions are set to experience insufficient rainfall, while others will experience extreme and more intense rainfall leading to flooding and crop failures. The highest climate risk overall is projected for two regions of the world; north western Africa, including northern Sudan and Egypt, and western and southern Asia. These pressures present enormous difficulties for farmers and other actors across the value chain. Coping with them will require a response that goes beyond incremental solutions to fundamental changes.

The cotton industry, like many others, is unprepared for the changes that the growing climate crisis is bringing. Already, the sector is hard-pressed to address deeply entrenched environmental, social and economic challenges<sup>1</sup> across its supply chains; these pre-existing vulnerabilities and inequalities will be exacerbated and accelerated by a warming climate.

**We need to radically rethink where, how and why cotton is produced and traded, and what the future holds for this economically and culturally important fibre.**

In other words, those actors and elements of the value chain that are already vulnerable will come under even greater pressure, and suffer increasing stress. Most industry-wide conversations and plans don't begin to address the scale of change that the climate crisis, if it continues on its current course (and even if ambitious steps are taken now) will force upon the industry, and the world.

Whilst Net Zero commitments made by countries and companies are establishing clear climate change mitigation pathways, at present the full sum of commitments is insufficient to keep the world within 1.5°C of warming above pre-industrial levels. This means that organisations across the cotton value chain need to simultaneously make bold commitments and take urgent action to decarbonise through their mitigation plans, whilst also developing robust adaptation plans to be prepared for the effects of the climate crisis. The reports highlight clearly that investing in climate justice and socio-economic resilience IS investing in climate resilience. Navigating planning for these multiple potential futures - the one we must aim for through mitigation efforts, and the ones we must nonetheless be prepared for through adaptation planning - is the critical challenge that the cotton sector is facing.

This is not just a theoretical exercise for the future. Change is not just on the horizon, it's happening now. In India, there is already a clear pattern of an increasing number of days over 40°C, and changes to the monsoon patterns resulting in extremes of floods and droughts. In Pakistan, Australia and in the United States' most important cotton growing state, Texas, cotton crop failures have already been attributed to climate change. The trend towards increasing unpredictability and volatility of weather events is already in play. We are on the pathway to a different world, and the changes will only accelerate.

A systemic threat requires systemic solutions. In considering the impacts of climate change, it is critical to emphasise that if we are to develop an adequate response, our focus needs to look well beyond understanding the changes in the weather. We need to find ways to build environmental and social resilience into supply chains, and also halt the downward spiral of the most vulnerable which will cost humanity and society so much more over time. Humanitarian crises have clearly demonstrated the economic argument for investing in resilience to avoid greater costs in responding to disasters.<sup>2</sup>

Both environmental and social impacts of climate change will affect the entire cotton value chain and cannot be tackled in isolation. The information in this report needs to be considered



not just for the changing environmental context for cotton production, but for how the impacts of climate will affect actors all along the supply chain. There are darker possibilities to factor in, such as the likelihood of societal disruption fuelled by resource scarcity or unequal distribution, leading to conflict or even war. All of this will have impacts not just on production, but transportation and distribution of goods, and beyond. The assumptions on which current supply chains are based cannot be presumed as a viable or predictable part of the future.

We urge people and organisations involved in the cotton industry to use this data and analysis to think radically about the future of cotton. No brand, retailer or trader will be able to avoid climate risk exposure in its supply chain. Organisations must responsibly decarbonise their operations and supply chain impacts globally as quickly as possible, and centre climate risk, and climate justice, in their sourcing strategies. But we particularly call for the report to be used as a collaborative resource to make decisions together about how the industry needs to work, from how cotton is produced, transported, and used; to strategies, business models, financing and more. We offer this report as a tool to inform thinking, and action, about mitigation as well as adaptation. The information it presents calls for nothing less than a collective reimagination and transformation of the cotton value chain to be sustainable, resilient and just.

**Charlene Collison and Hannah Pathak,**  
Forum for the Future

### 1.1 | Why consider the impacts of climate change on the global cotton value chain?

The world has warmed by approximately 1°C since the pre-industrial era (1880-1900)<sup>3</sup> and future changes to the global climate system will continue to intensify over the coming decades<sup>4</sup>. Despite the ambitious goal as set out by the Paris Agreement<sup>5</sup> to keep global warming “under 2°C by 2050”, to date, even the ambitious pledges and targets of countries around the world will only limit warming to between 2.2-3.4°C.<sup>6</sup> As it stands, current emissions reduction and climate change commitments and targets are being missed by the majority of countries, meaning that warming of more than 3°C is probable by the end of this century. However successful we are with decarbonisation, we are faced with decades of unavoidable climate change.<sup>7</sup> Preparing today for the changes that will occur tomorrow is essential if we are to limit the impacts of climate change on society.

### 1.2 | Why does the global cotton value chain need to consider climate impacts?

Cotton is the most widely produced natural fibre. A total of approximately 25 million metric tonnes of cotton is produced worldwide per year, with a market worth of about 1 \$12 bn.<sup>8</sup> Its fibre, which serves as the raw material for approximately 31% of the global textile market, has a yearly economic impact of at least \$600 bn.<sup>9</sup> Agriculture is the main contributor to the Gross Domestic Product (GDP) of most countries, especially developing countries, with cotton being a key agricultural crop.

**Cotton serves as the raw material for around 31% of the global textile market, with a yearly economic impact of at least \$600 bn.**

Climate change can cause direct damage to cotton crop either through gradual, incremental, changes, such as atmospheric warming or changes in total rainfall, or through sudden changes and extreme weather events such as flooding, hailstorms or heatwaves. Knock on impacts on the rest of the value chain can be felt across state-level, national-level and international-level cotton value chain and markets, and across the pre-garment, the retail and the consumption stages.

For example, in 2010 and again in 2011, extreme rainfall led to widespread flooding of Pakistan’s cotton fields, causing €35 bn worth of damage. Losses from cotton crops accounted for nearly 75% of all financial losses with one-fifth of the crop destroyed, severely impacting livelihoods of small-scale farmers, and workers across the cotton value chain (CVC). Cotton prices rose from a stable 10-year price of approximately US \$0.65-0.70 per pound of cotton in 2009 to spike as high as US \$2.48 on some shipments, with the flooding being a major contribution to this price increase. Climate change was stated as a major contributing factor to the flooding event by the Pakistan Government and the UN.<sup>10</sup>

This is but one example of how profound changes in the climate impact the CVC, the textile industry and more broadly the global cotton market, highlighting how essential it is to explore future changes and impacts.



## 2.1 | What is this study's unique value?

This study provides a high level analysis of physical climate risks across global cotton growing regions for the 2040s; a 20-year climatology spanning 2031-2050. This is done by using the latest, internationally recognised, climate projections from an ensemble of global circulation models<sup>11</sup> to capture an array of projected climate hazards. Reanalysis data is used to simulate present day conditions from which the study can then compare the same climate hazards in the 2040s.

What makes the study unique is that it not only considers a plethora of climate hazards rarely considered in the literature (including the change in the growing seasons, damaging wind speed above a certain threshold, relative humidity, wildfire and more) but that these hazards include thresholds which are specific to cotton, for example, the number of days in a given year when temperatures over 40°C pose a significant risk to yields.<sup>12</sup>

Numerous climate hazard indicators are amalgamated into a single climate risk score. This enables actors from across the cotton value chain to identify the cotton growing regions at greatest overall risk from climate change by the 2040s. The report - and the accompanying Climate Risk Explorer tool - allow users interested in a specific climate indicator, such as water stress or landslide risk, to dive into each individual climate hazard projected for the 2040s in more detail.

**This report is the first ever global analysis of climate risks to cotton production.**



The results are comprehensive and complex. Referring to the full results in the report and using the **Climate Risk Explorer tool** and supporting resources, is necessary to understand the distribution and composition of physical climate hazards across the world's cotton growing regions. As such, here, we only cover the high-level cross cutting risks.

### 3.1 | Which cotton growing regions are projected to be exposed to the greatest physical climate risk?

The cotton growing regions which are projected to be exposed to the greatest physical climate risk relative to other cotton growing regions are mainly located in two regions of the world; (a) a linear strip of cotton growing fields located along the banks of the Nile River in northern Sudan, and (b) cotton growing regions located in western and southern Asia, dotted in southeast Iraq, throughout central Iran, in southern Afghanistan and across southern Pakistan.

Heat stress, water stress and increased risk from flooding are projected to be the greatest drivers of risk across the cotton growing regions of northern Sudan. A high number of days when temperatures exceed threshold of 40°C, ultimately drives the projected shortening of the cotton growing season across this region. Increasing temperatures also give rise to wildfire risk. While this region is projected to experience intense extreme rainfall events, the total rainfall received throughout the growing season is projected to remain less than the minimum limit required for the cultivation of rain-fed cotton (approximately 500mm). Overall, a warmer and drier climate, punctuated by drought conditions and extreme rainfall events, will present issues regarding water security due to an increase in water shortages and flood risk conditions.

Water stress is the predominant issue facing cotton growing regions across the Middle East, western Asia and northern China in the 2040s. As with northern Sudan, As with northern Sudan, total rainfall across this regions during the growing season is projected to be less than the minimum threshold of 500mm required throughout the growing season to successfully grow rain-fed cotton. These dry regions are also projected to experience an increase in the intensity of extreme rainfall events, which, when combined with dry/drought conditions, present an enhanced level of risk. Depending on a number of factors, including rainfall intensity and soil structure and composition, dried-out soils can have a reduced capacity to absorb water,

leading to increased runoff and risk of flooding. Other key drivers of climate risk across western and southern Asia include high number of days when temperatures exceed the threshold of 40°C; wildfire risks for cotton growing regions in eastern Iraq; damaging wind speeds and storms for cotton growing regions in Iran.

Other cotton growing regions where climate risk is projected to be high in the 2040s are those in western Turkey, and the main drivers of risk for this region are damaging wind speeds and storms. Cotton growing regions across the Sahelian belt across central Niger, Chad and Sudan are also projected to experience high climate risk by the 2040s, driven mainly by high temperatures above the threshold of 40°C and wildfire risk. Furthermore, cotton growing regions in northern China are primarily driven by low rainfall and high wildfire risk.

### **In the 2040s, all cotton growing regions across the world will be subject to greater heat stress than under present day conditions.**

Across all cotton growing regions, the greatest projected change across all climate hazards relative to present day conditions, will be across the northern regions of the sub-Saharan countries, specifically across western cotton growing regions in Senegal and southern Mali. This change is mainly driven by significant change in temperature-related variables including number of days above temperature threshold of 40°C and risk of wildfire.

The report itself presents a full breakdown of the results for each of the climate indicators individually.

To access the full report, the Climate Risk Explorer tool and supporting resources, visit [www.acclimatise.uk.com/collaborations/cotton-2040/](http://www.acclimatise.uk.com/collaborations/cotton-2040/)

### 4.1 | What does this mean for the cotton industry?

In the 2040s, all cotton growing regions across the world will be subject to **greater heat stress** than under present day conditions. This is of special concern for cotton growing regions which are already growing cotton under temperatures which are close to the temperature threshold of 40°C. These countries are mainly located along the Tropic of Cancer and across sub-Saharan Africa, the Middle East and Southeast Asia, but especially in Egypt, Iraq and Pakistan. A warmer climate also raises issues regarding the workforce, including health and safety concerns and knock on impacts on labour productivity as cotton farmers out in the open sunshine will be at most risk.

Under warmer conditions, the **demand for water** by cotton crops increases. The analysis suggests that the majority of cotton growing regions are projected to experience an increase in rainfall during the growing season, with the exception of Pakistan, Venezuela and north eastern Australia, although this increase will be relatively low. However, the analysis also projected an increase in susceptibility for drought conditions across the majority of cotton growing regions globally. This is a significant issue. During drought conditions, water shortages will present a further barrier to the survival of cotton.

In the 2040s, all cotton growing regions across the world will be subject to greater heat stress than under present day conditions. Additional competition by users over a dwindling supply of water may also take place due to increasing populations, increasing urbanisation and increase in competition by other agricultural crops.

An increase in **extreme weather events** is also projected which can have significant and widespread impacts on cotton crops. Extreme rainfall is projected to intensify across the majority of cotton growing regions, increasing the risk of flooding and waterlogging cotton fields. While cotton can withstand short periods of waterlogged conditions, long periods can destroy the crop. In addition, extreme rainfall can directly damage the cotton crop during key stages of its development, especially during boll formation.

Damaging wind speeds are projected to increase across the Middle East and Turkey. These present a risk to the quality of the cotton crop as under the correct conditions, strong winds can pick up dust which can soil the cotton fibre.<sup>13</sup> Young cotton seedlings may also be damaged through being 'sand-blasted' during high winds. Poor infrastructure in rural or urban areas is also at risk from damaging wind speeds. All cotton growing regions are projected to experience an increase in wildfire risk, presenting a direct threat to cotton crop, infrastructure and the wider agricultural communities.



### 5.1 | How should this report be used?

The Global Analysis, and the detailed India Analysis, were both generated by Cotton 2040 in response to the lack of comprehensive, readily available information about how the climate crisis is likely to impact cotton production, its supply chain, and the nature of the industry over the coming decades.

The reports and supporting resources are aimed at apparel brands and retailers, cotton producers or those working with them, sustainable cotton standards and industry associations, the climate finance community, civil society organisations working on climate justice and adaptation, and other actors across the cotton value chain.

The information presented in this report is designed to help users identify the relative level of physical climate hazards projected in the 2040s across the world's cotton growing regions. Numerous climate hazard indicators are amalgamated into a single climate risk score to enable the report user to identify the cotton growing region at greatest overall risk from climate change. Secondly users can obtain information on the main hazards that are contributing to the climate risk score, i.e. temperature-related variables, water-related variables, and so forth.

In exploring these findings, individuals and organisations should consider the question:

**How can I, as a stakeholder in the cotton value chain, take action to help address climate risks and work towards increasing climate resilience in key cotton growing regions?**

Addressing this question forms the core objective of the Cotton 2040 Planning for Climate Adaptation workstream and its work through 2021-22 and beyond. The focus will be on supporting the sector to further engage with the findings of this technical evidence-based global report; deepen their understanding of the potential implications for individual organisations and the cotton industry; and – critically – create cross-sector dialogue to identify and act collectively on systemic solutions. We hope you will join us!

To access the full report, the Climate Risk Explorer tool and supporting resources, visit [www.acclimatise.uk.com/collaborations/cotton-2040/](http://www.acclimatise.uk.com/collaborations/cotton-2040/)

To learn more and explore how your organisation can help create a resilient cotton sector, please contact **Hannah Cunneen** at [h.cunneen@forumforthefuture.org](mailto:h.cunneen@forumforthefuture.org) or **Erin Owain** at [erin.owain@willistowerswatson.com](mailto:erin.owain@willistowerswatson.com).

To find out more about Cotton 2040 visit [www.forumforthefuture.org/cotton2040](http://www.forumforthefuture.org/cotton2040).



- <sup>1</sup>For a description of the challenges associated with the cotton industry, see the CottonUP Guide <https://cottonupguide.org/>
- <sup>2</sup>The World Bank. 2013. Available from: <https://openknowledge.worldbank.org/bitstream/handle/10986/13108/758470PUB0EPI0001300PUBDATE02028013.pdf;sequence=1>
- <sup>3</sup>NOAA, 2020: Climate Change: Global Temperature. Available from: <https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature#:~:text=Change%20over%20time&text=According%20to%20the%20NOAA%202019,more%20than%20twice%20as%20great>.
- <sup>4</sup>IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Available from: [https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA\\_FINAL.pdf](https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf)
- <sup>5</sup>The Paris Agreement is a **legally binding international treaty on climate change**. It was adopted by 196 Parties at COP 21 in Paris. Its goal is to **limit global warming to well below 2, preferably to 1.5 degrees Celsius**, compared to pre-industrial levels. For more information, visit: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>
- <sup>6</sup>UNFCCC. 2020. The Paris Agreement. Available from: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>
- <sup>7</sup>IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. Available from: <https://www.ipcc.ch/srocc/>
- <sup>8</sup>Khan, M.A., Wahid, A., Ahmad, M., Tahir, M.T., Ahmed, M., Ahmad, S. and Hasanuzzaman, M., 2020. World Cotton Production and Consumption: An Overview. In Cotton Production and Uses (pp. 1-7). Springer, Singapore. Available from: [https://link.springer.com/chapter/10.1007/978-981-15-1472-2\\_1](https://link.springer.com/chapter/10.1007/978-981-15-1472-2_1)
- <sup>9</sup>Khan, M.A., Wahid, A., Ahmad, M., Tahir, M.T., Ahmed, M., Ahmad, S. and Hasanuzzaman, M., 2020. World Cotton Production and Consumption: An Overview. In Cotton Production and Uses (pp. 1-7). Springer, Singapore. Available from: [https://link.springer.com/chapter/10.1007/978-981-15-1472-2\\_1](https://link.springer.com/chapter/10.1007/978-981-15-1472-2_1)
- <sup>10</sup>Thorpe, J., and Fennell, S., 2012. Oxfam Discussion Papers: Climate change risks and supply chain responsibility. Available from: [https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file\\_attachments/dp-climate-change-risks-supply-chain-responsibility-27062012-en\\_5.pdf](https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file_attachments/dp-climate-change-risks-supply-chain-responsibility-27062012-en_5.pdf)
- <sup>11</sup>A general circulation model (GCM) is a type of climate model which mathematically models the general circulation of a planetary atmosphere or ocean.
- <sup>12</sup>FAO, 2021. Cotton. Available from: <http://www.fao.org/land-water/databases-and-software/crop-information/cotton/en/>
- <sup>13</sup>FAO, 2021. Cotton. Available from: <http://www.fao.org/land-water/databases-and-software/crop-information/cotton/en/>

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This document is part of a set of resources published by Cotton 2040 aimed at helping actors across the cotton sector to understand the impacts of climate change on cotton production.

To access the full Global Analysis report, the Climate Risk Explorer tool, an India-specific analysis and supporting resources visit [www.acclimatise.uk.com/collaborations/cotton-2040/](http://www.acclimatise.uk.com/collaborations/cotton-2040/).

To explore how your organisation can help create a resilient cotton sector, please contact Hannah Cunneen at [h.cunneen@forumforthefuture.org](mailto:h.cunneen@forumforthefuture.org) or Erin Owain at [erin.owain@willistowerswatson.com](mailto:erin.owain@willistowerswatson.com).

## About Cotton 2040

Convened by Forum for the Future with support from Laudes Foundation, Cotton 2040 is a multi-stakeholder initiative to facilitate the shift to a sustainable global cotton industry which is resilient in a changing climate; which uses business models that support sustainable production and livelihoods; and where sustainably produced cotton is the norm. Find out more: <https://www.forumforthefuture.org/cotton-2040> or contact Hannah Cunneen at [h.cunneen@forumforthefuture.org](mailto:h.cunneen@forumforthefuture.org).

## About Forum for the Future

Forum for the Future is a leading international sustainability non-profit with offices in London, New York, Singapore and Mumbai. We specialise in addressing critical global challenges by catalysing change in key systems. For 25 years, we've been working in partnership with business, governments and civil society to accelerate the shift toward a sustainable future. Together we are reinventing the way the world works. Find out more at <https://www.forumforthefuture.org> or by following [Forum4theFuture](#) on Twitter.

## About Acclimatise

Since November 2020 Acclimatise is wholly owned by leading global advisory, broking and solutions company Willis Towers Watson. The Acclimatise team is now part of Willis Towers Watson's Climate and Resilience Hub (CRH). The CRH is a market leading centre of climate adaptation expertise, supported by the Willis Research Network, a network of more than 60 organizations in science, academia, think tanks and the private sector working to improve the understanding and quantification of risk, with the aim to improve the resilience of our clients and society as a whole. Learn more at: <https://www.willistowerswatson.com/en-GB/Insights/research-programs-and-collaborations/climate-and-resilience-hub>.

## About Willis Towers Watson

Willis Towers Watson (NASDAQ: WLTW) is a leading global advisory, broking and solutions company that helps clients around the world turn risk into a path for growth. With roots dating to 1828, Willis Towers Watson has 45,000 employees serving more than 140 countries and markets. We design and deliver solutions that manage risk, optimise benefits, cultivate talent, and expand the power of capital to protect and strengthen institutions and individuals. Our unique perspective allows us to see the critical intersections between talent, assets and ideas — the dynamic formula that drives business performance. Together, we unlock potential. Learn more at [willistowerswatson.com](http://willistowerswatson.com) or contact Erin Owain at [erin.owain@willistowerswatson.com](mailto:erin.owain@willistowerswatson.com).

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**Users who download the Report shall be deemed to be in acceptance of the above.**

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