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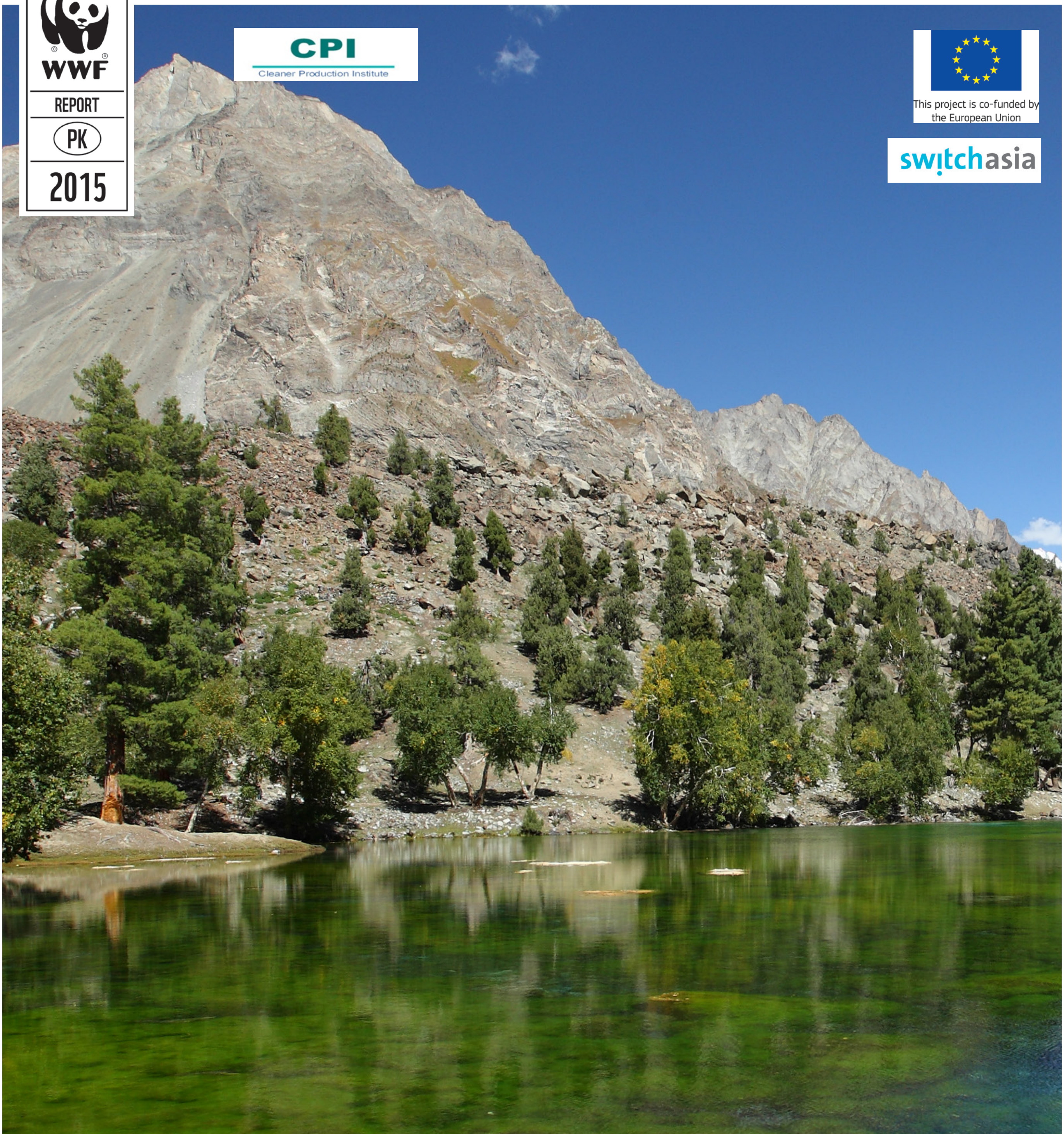

Water Footprint of Key Industrial Sectors in Punjab, Pakistan

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water stewardship Pakistan

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Water Footprint of Key Industrial Sectors of Punjab, Pakistan

Foreward

Hammad Naqi Khan

Director General
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Pakistan is highly dependent on its water resources for agricultural and industrial productions. Although research in climate change in Pakistan is still in its infancy, evidence suggests that future changes in available water resources will adversely affect the economy. Current water management practices are not robust enough to cope with the impacts of climate change on water supply reliability, energy and health.

Water has become the most stressed resource in today's world, extending the stress to all its users and dependents. Many industrial sectors in Pakistan heavily depend on water as a raw material and a significant input for processing. Water stress in Pakistan creates reputational, regulatory, physical and financial risks for these sectors. At such a point, water footprint evaluation comes in hand as a great assessment tool for measuring the amount of freshwater that is being used to produce a commodity. This study has been conducted with an intention for opening vistas for research and practice in Pakistan which look towards a tool that can lead towards a better policy debate and planning for the future water resource management in the country.

This study has been carried out by WWF-Pakistan, in collaboration with Cleaner Production Institute (CPI) and WWF-UK, launched under a project funded by the European Union, titled City-wide Partnership for Sustainable Water Use and Water Stewardship in SMEs in Lahore, Pakistan. This project aims to contribute towards improving environmental sustainability and livelihood, and support sustainable economic growth and development in Pakistan.

This assessment aims to evaluate the water footprints of cotton textiles, leather tanning, sugar processing and pulp and paper manufacturing industrial sectors of Punjab, Pakistan. The initial briefing is intended to support the reader in interpreting and evaluating the detailed water footprint accounts of key industrial sectors in Punjab, Pakistan presented in other briefing notes in this series. Its purpose is to explore the extent of dependency of key industrial sectors on water in their operations and supply chains. The project initiated the collection of primary and secondary data from selected industries through audits conducted in the industrial sectors under the aegis of the above mentioned project. However, as such information is new; a detailed water footprint study has been conducted in each of the four target sectors in an effort to provide data on water footprint assessment for future endeavors.

The study was conducted by Dr Conor Linstead, Freshwater Specialist at WWF-UK, Sohail Ali Naqvi, Senior Project Officer, WWF-Pakistan, and Ali Hasnain Sayed, Manager Water Security and Stewardship, WWF-Pakistan. It has been technically reviewed by Dr Ashok Kumar Chapagain, Water Footprint Network. This effort is an initiation by WWF-Pakistan.

Abbreviations and Acronyms

BOD	Biochemical Oxygen Demand
BWF	Blue Water Footprint
BWMP	Best Water Management Practices
COD	Chemical Oxygen Demand
CPI	Cleaner Production Institute
EU	European Union
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
GDP	Gross Domestic Product
IFC	International Finance Corporation
NGO	Non Governmental Organization
PISD	Programme for Industrial Sustainable Development
SME	Small and Medium Enterprises
TDS	Total Dissolved Solids
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
USA	United States of America
UNEP	United Nations Environment Programme
WF	Water Footprint
WFN	Water Footprint Network
WSP	Water Stewardship Project
WWF	World Wide Fund for Nature

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Authors' Profiles

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Dr Conor Linstead is Freshwater Specialist, WWF-UK. He helps WWF-UK's business partners to identify and understand water-related risks, and to identify opportunities to mitigate those risks in ways that benefit both the businesses and freshwater ecosystems. He also works with offices around the WWF Network to assist them in implementing strategies and programmes for business water stewardship, with a particular focus on South Asia. Dr Conor is an environmental scientist with over 15 years' experience in freshwater ecosystem management in both academic institutions and NGOs. His technical background is in hydroecology and catchment management, but he has broad interdisciplinary experience across ecosystem management, hydrology, water quality and socio-economics.

Ali Hasnain Sayed

Ali Hasnain Sayed is an engineer by education and a development practitioner by profession. Ali is Manager Water Security and Stewardship at WWF-Pakistan. He holds a Master in Environment and Sustainability from Monash University, Melbourne, Australia. He has 15 years of professional experience both in Pakistan and abroad, gaining an extensive practice in the fields of environment, law, water-food-energy security nexus, education, policy management, sustainable development and resource management. Ali has worked with governments, bureaucracy, civil society, corporate sector and regulatory regimes on mainstream developmental issues at the policy level. Currently with his job at WWF-Pakistan, he is practicing policy level environmental and developmental considerations and safeguards regarding water-food-energy security nexus. He has been involved in trainings and academics since 2005. He was one of the founding members and instructor at Sui Northern Gas Pipelines Training Institute in 2005. He has taught at Monash University, Australia and is currently teaching as a visiting faculty at Forman Christian College (A Chartered University) and a part of the team which is setting up the environmental sciences department at the university. Ali continues to be a vibrant role player of advocacy and stakeholder engagement for water management across the region.

Authors' Profiles

Sohail Ali Naqvi

Sohail Ali Naqvi is Senior Project Officer ,WWF-Pakistan and Coordinator of River Ravi Commission (RRC). He oversees the technical execution of the work ofthe Freshwater Department. Sohail has an engineering background, with double masters in Environmental Engineering, Hanyang University, South Korea and Agricultural Engineering, Agricultural University, Faisalabad, Pakistan. He has been working in the government, NGOs, and national and international consultancies along the domain of water. His technical background is in groundwater surveys and modelling (1x1D), water management, wastewater treatments, water stewardship, urban waste management, water accounting and basin level strategy.

Reviewer's Profile

Dr Ashok Kumar Chapagain

Dr Askhok Kumar Chapagain is the Science Director of Water Footprint Network (WFN) and is responsible for developing and implementing WFN's research and training programmes. He leads face-to-face training courses in different parts of the world, e-learning courses and various other knowledge sharing activities organised by WFN and its partners. He is also part of the WFN team helping multinationals to understand global water risks, and support them to address the environmental impact of their water footprint by developing their business case to do so.

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Water Footprint Assessment in SMEs in Punjab and Pakistan

1.1 Introduction

This document provides an introduction to the concept of water footprint (WF). It is intended to support the reader in interpreting and evaluating the detailed water footprint accounts of key industrial sectors in Punjab. This has been developed as part of the Water Stewardship in Pakistan project of WWF-Pakistan, funded by the European Union (EU). The purpose of this document is to explore the extent of dependency of key industrial sectors (cotton textiles, leather tanning, sugar processing and paper manufacture) on water in their operations and supply chains.

WWF-Pakistan launched the project City-wide Partnership for Sustainable Water Use and Water Stewardship in SMEs in Lahore, Pakistan, funded by European Union in 2013, in partnership with Cleaner Production Institute (CPI) and WWF-UK. The basic objective of the project is to promote water efficient production and consumption as best practices in Pakistan's major industrial cities as part of a broad engagement of businesses in water management. The project targets water intensive cross-sectoral small and medium enterprises (SMEs) including textile, leather, sugar and pulp and paper industries of Punjab. The goal of the project is to facilitate industries in reducing their water consumption and pollution load through audits, trainings and workshops and implementation of best water management practices (BWMPs). The project necessitated collection of data regarding water consumption and discharge of the target SMEs. However, since such data is not available, a water footprint study has been conducted in each of the four target sectors in an effort to make data available on water footprint assessment for future endeavours.

1.2 What is a Water Footprint Assessment?

Water footprint assessment is a holistic framework of analysis of water use, starting from defining the scope of the study, estimating the volume of water use, understanding the sustainability of water use, and developing a necessary response strategy for sustainable use of water resources in concerned places. The idea of a water footprint draws on the concept of virtual water which is a measure of the volume of water used in the production process irrespective of locations of water use. The water footprint of a process, product or a geographically delineated area is the total water used (either evaporated or lost from the system by means of incorporation into the product, or physical transfers) measured along its whole value chain, and is often expressed as a volumetric figure with spatial and temporal distribution. For example, a can of cola contains 0.35 litres of water, yet it also requires an average of 200 litres to grow and process the sugar contained in that can, in locations where the sugar crop is grown and processed at certain times of the year. When the water used in production is included, the WF of a can of cola, therefore, is more than 200 litres. Similarly, on average about 2,900 litres of water is required to produce a cotton shirt weighing 250 g (including water used in all stages, from growing cotton in the fields to final processing in factories) and 8,000 litres to produce a pair of leather shoes, including the amount of water required to grow feed, support a cow, and process its skin into leather (Hoekstra and Chapagain, 2008).

1.3 Water Footprint Accounting

As total water consumption is consider along the value chain, water footprint accounts encompass water consumed at the point of origin of all components of a product, whether that happens locally, elsewhere in the same country, or internationally. For an industrial operation this includes, for instance, the direct water footprint of the water consumed in the factory, but also the indirect water footprint associated with consumption of water in the production of raw materials (e.g. for a textile weaving operation this includes the consumption of water from

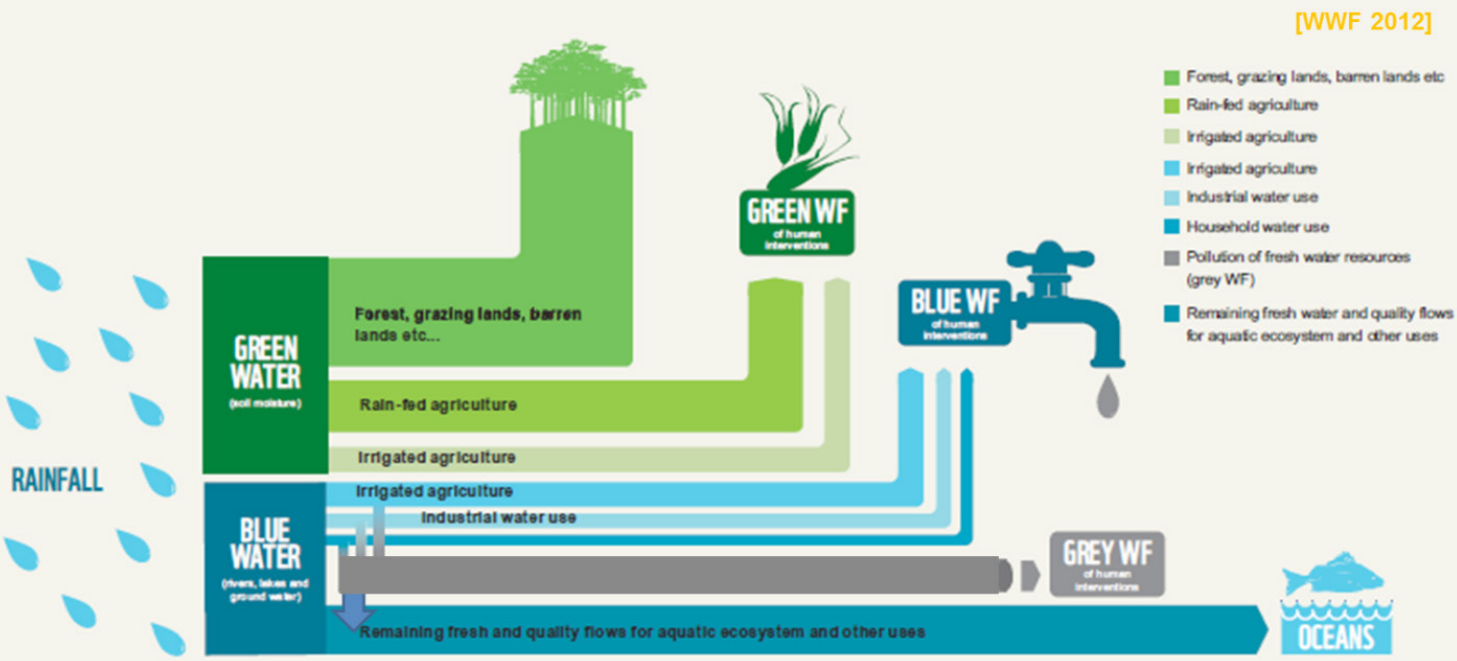


Figure 1.1: The Green and Blue Water Footprint in relation to a catchment (WWF & ADB, 2012).

a borehole on site as well as the water used to grow the cotton).

Both direct and indirect water footprints are composed of three parts: the green, blue and grey water footprint. Green water is the water which has evaporated from soil moisture, including through crops, trees and vegetation, which is derived from rainfall. Blue water is the water withdrawn from ground or surface water sources (e.g. for irrigation or directly by a factory).

A total of 70 per cent of existing global freshwater is withdrawn for irrigation in agriculture (UNESCO-WWAP, 2003). This, however, refers only to water from lakes, rivers and aquifers (blue water), and does not take into account addition water from rainfall (green water) stored in soil which is used in agricultural production. A portion of irrigation water returns to local water systems as a result of irrigation inefficiencies, while all evaporated water returns to the hydrological system somewhere, and at some other time.

Green water is essentially a gift, not requiring human intervention to deliver it to the land surface, and its use has different impacts from those of blue water pumped out of a river or an aquifer. Blue water has higher opportunity costs because it has a number of alternative uses such as agriculture, household or industrial supply.

The grey water footprint is an indicator of pollution (Hoekstra et al. 2011) and is defined as the volume of freshwater that is required to assimilate the load of pollutants released into the surface water environment, based on natural background concentrations and existing ambient water quality standards. It is a measure of the impact of polluted water on water resources associated with the production of goods and services, quantified as the volume of water that is required to dilute and disperse pollutants to such an extent that the quality of the ambient water remains above agreed water quality standards. In agriculture, the amount produced depends on the efficiency of use of fertilisers and pesticides in the field, and in industries depends on the quality of effluents. For crop production this is the volume of freshwater that should be reserved in the freshwater system to dilute pollutants leaching into the soil, such as fertilisers and pesticides, to agreed standards meet the receiving water bodies. The pictorial view of the green, blue and grey water footprint is explained in Figure 1.1.

An important aspect of the blue and green components of WFs is that only the water consumed from the available water resources within a catchment area is considered. In practice, this means that only the water lost to evaporation, water that is abstracted but returned to another catchment or the sea, or is incorporated into a product (e.g. a bottled drink), is included within the WF. Water that is withdrawn, used, and then discharged back to the same catchment without significant

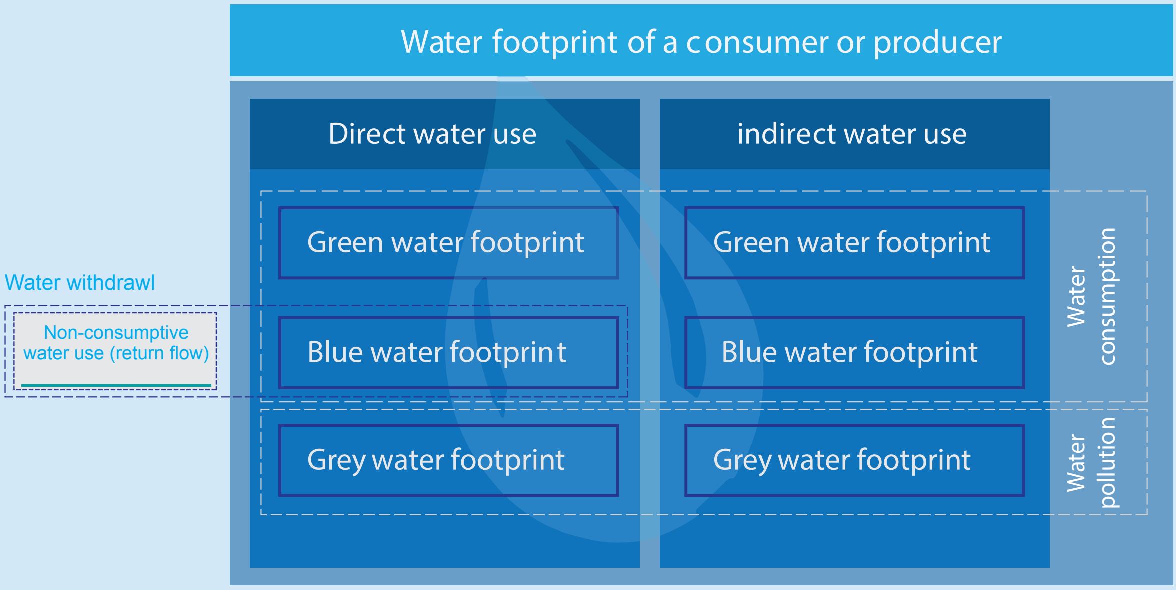


Figure 1.2: Schematic representation of the components of a water footprint, shows that the non-consumptive part of water withdrawals (the return flow) is not part of the water footprint. The diagram also shows that, contrary to the measure of water withdrawal, the water footprint includes green and grey water and the indirect water-use components. Hoekstra et al. (2011).

deterioration in its quality is not part of the water footprint as it is still available for other uses. If it is polluted it would, however, be counted as part of the grey water footprint. The non-consumptive part (i.e. the water that is returned to the same catchment), is not part of the water footprint as long as it is returned at a quality that can be used for other uses, including supporting ecosystems.

Where a raw material is used to produce more than one finished product, the water footprint assessment method apportions the total WF to the various useful products by considering the value fraction (relative share of market value of individual products to the total market value of all the products), and product fractions (weight of output product per unit of total input product) of each individual different output products (Hoekstra and Chapagain, 2008). For instance, harvested cotton can be used to produce several useful products, such as cotton seed oil or cotton lint, so not all of the water required to grow the cotton plant is attributed to the final product, cotton textile, although given the relatively higher volumes of harvested cotton is going to textiles per unit of raw cotton and a higher share of market value generated, the majority of water used in growing cotton crop is attributed to the final textile product. Similarly, animals can be used to produce both meat and hides, so only a portion of the water footprint of raising an animal is attributed to the hide, and subsequently to the leather, with the majority apportioned to the meat.

1.4 Why Does the Water Footprint Matter to Businesses?

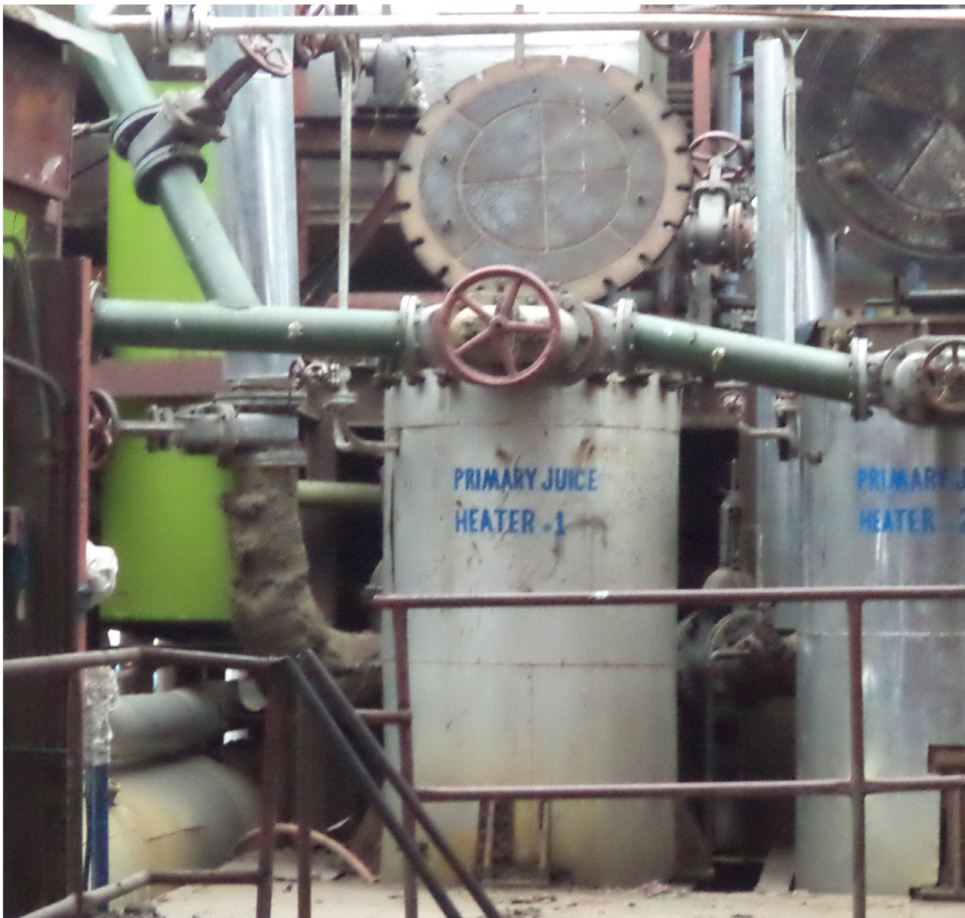
For a business, understanding its water footprint provides a first step in understanding how it depends on water through its supply chain, and where that dependency lies. The next step after understanding the water footprint count is to understand whether these footprints are sustainable or not and what appropriate response strategies are. Water footprints can reveal unexpected dependencies on water in supply chains or distant sourcing regions, and help businesses to balance considerations of local operational water use and water consumption in supply chains.

The sustainability assessment can reveal whether the WFs are located in regions with higher water scarcity or in regions with higher water pollution levels, now and under expected future scenarios. In considering how the water footprint of a business translates into water risks it is important to understand the state of water resources where water consumption is happening. If the geographical locations are not sustainable in itself, a business can face various kinds of water related risks such as the physical risk of not having enough water of good quality for its operations, the regulatory risk of arbitrary or unanticipated regulation as governments respond to water crises, or reputational risk as local communities or customers respond to the impacts of a business on water. If the water footprint is in a place where water is abundant then it will have less impact than the same footprint in a place (or at a time) where water is scarce. Paper and pulp with a WF of 1 m^3 green water in water abundant Canada has a very different impact to cotton with a 1 m^3 blue water footprint in water scarce Punjab. The impact of, and water risk to, supply chains is therefore highly dependent on the context of where that water footprint lies.

Particularly for sectors that use agriculturally derived raw materials, the water footprint of its supply chain is usually by far the most dominant component of the water footprint. Operational water use is often small in comparison. However, although small in relative terms, operational water use is still critical for business operations and businesses have greater direct control over this than supply chain water use. Consideration of where water footprints lay, the water situation in those places, and the nature of water risks to the business associated with them, helps a business formulate strategies to address water issues that are appropriate for the scale and type of risk, and the role and influence of businesses in overall value chains. For example, the business response to water scarcity and water footprint in local water sources used for operational use would be very different to the response required to address the distant, diffuse impacts and risks related to water dependency in supply chains, even if the supply chain water footprint is much larger. Similarly, if a company is located in a basin which is dominated by other unsustainable water uses, the response strategy would be to work outside its own operations and seek collaboration, as focusing solely on operational efficiency will not address water risks.

1.5 Conclusions

A water footprint assessment is a useful tool for businesses to address water related risks by understanding the water issues associated with their operations and supply chains, dependency on water along the supply chain, and how to formulate appropriate response strategies. It can help to raise awareness of water and demonstrate why a business should be concerned about water management issues beyond its own operations, at the scale of cities, states, river basins, or entire nations. Although water footprint accounting is the necessary first step in a complete water footprint assessment, accounts do not answer the why, when and where questions for businesses or policymakers. While an appreciation of a business's water footprint can assist in developing the priorities for a water strategy, a narrow focus on reducing the water footprint volume will not help reduce water risks. The intervention of a single business in reducing its own water footprint will not significantly improve the water scarcity or pollution situation on the ground. To mitigate the risks associated with the water footprint of a business requires engagement with other stakeholders, water users, and water management institutions so that collectively solutions can be found. The Water Stewardship in Pakistan project has specifically been developed to address this need for this collective engagement to respond to the awareness generated from the sectoral water footprints.



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Water Footprint Assessment of the Sugar Sector in Punjab, Pakistan

Chapter 2

Water Footprint Assessment of the Sugar Sector in Punjab and Pakistan

2.1 Introduction

This briefing note provides more detail on the water footprint accounts of the sugar sector in Pakistan. It is primarily based on a review of key scientific publications on the water footprint assessment of the sugar production sector that includes growing sugarcane, milling and processing and the key raw materials that go into the process, supplemented by data gathered from participants of the Water Stewardship in Pakistan project.

The purpose of this briefing note is to demonstrate the potential water dependencies of various stages on local (direct) and external (indirect) water resources along the full supply chain of sugar production in Pakistan, and point towards appropriate responses for individual businesses and the sector as a whole. The sections below discuss the water footprints of sugar processing in the supply chain (i.e. sugar mill operations), non-sugarcane raw materials supply chain (process chemicals etc.), and the overall water footprint of raw and refined sugar. Water quality considerations are also briefly discussed below, but are not the main focus of this note.

2.2 The Water Footprint of the Sugar Sector in Pakistan

2.2.1 Water Footprint of Sugarcane Production

The water footprint (WF) of growing sugarcane in Pakistan is composed of green, blue and grey components. Only the cane growing phase of sugar production has an appreciable green water footprint as it partially uses rainfall as water for the crop. The blue water footprint arises from the consumption of surface and/or groundwater for irrigation and the grey water footprint is due to the pollution from fertilisers and other agrochemicals. The relative proportions on these components vary across Pakistan, primarily in response to variations in rainfall. For Punjab, the green, blue and grey WFs are 90, 215, and 27 m^3 per tonne of sugarcane respectively. (Hoekstra et al., 2012)

2.2.2 Water Footprint of Sugar Processing

Sugar production in Pakistan is primarily based on sugarcane. There are three separate steps in the production of cane sugar. The first step is the agricultural stage where sugarcane is grown and stalks are harvested. In the second step, the raw sugar is separated from the plant in sugar mills. The third step is carried out in sugar refineries where raw sugar is refined into granulated sugar in the form directly usable by general consumers or in other food industry products. It is important to consider the green, blue and grey WF accounts for each stage separately.

The distinction between water use at a site level, in this case a mill or refinery producing sugar, and the water footprint of the finished product is an important one. While a sugar mill extracts and uses a large volume of water, for example from onsite boreholes, most of this water is discharged back to surface waters, evaporates and percolates back to groundwater. This means that it is potentially available for other water users to abstract and use, although the reduced water quality typically means that it cannot be used directly and may have impacts on other water users or ecosystems (see section below on water quality). The water footprint of sugar processing of sugar mills and refineries is a fraction of water use that is evaporated during the production process, and is therefore, for practical purposes, lost from the locally available water resources. As this water is supplied either through groundwater sources or from rivers or lakes via canals, it is the blue water footprint (BWF) of sugar processing.

Water use per tonne of cane crushed (i.e. the water that comes into the mill but is not necessarily lost to evaporation as part of the BWF) varies from mill to mill. Data collected from 22 sugar mills in Pakistan by the Programme for Industrial Sustainable

Development (PISD) project funded by the Embassy of the Kingdom of the Netherlands during 2007 to 2011, shows a wide range of raw water use (0.5—2.0 m^3/t of cane crushed). An average figure of 0.7 m^3/t of sugarcane as the total volume of water evaporated in the milling and refinery stages combined is given by the IFC (2007). This water is used in cooling and washing of evaporators, vacuum pans and other equipment, cooling of mill bearings, vacuum pumps and turbines, injection water at condensers to produce vacuum at evaporators, boiler feed water for steam requirements, and water for general purposes (floor washing, sanitation etc.).

The audit data in this project showed that the water consumption in the production of sugar from sugarcane is about 23 m^3/t of raw sugar produced, with wastewater of 19 m^3/t. So, the BWF is about 4.70 m^3/t of raw sugar produced.

The grey WF of sugar processing in mills and refineries is approximately 70 m^3/t of refined sugar. This estimate takes into account the average BOD5 and COD of the effluent loads released by sugar processing mills globally. Globally the grey WF is approximately seven per cent of the total WF of cane sugar whereas majority of the footprint is blue [79 per cent] and green [14 per cent]. Approximately 40 per cent of the grey WF is in the industrial phase and the remaining is at farm level (WFN, 2014).

In addition to the net water consumed in the processing stage, the water footprint for refined sugar should include the water footprints for all of the raw materials that are used in the process chemicals, such as phosphoric acid or decolouriser. Estimating the water footprint for the many complex products used by the sugar sector in Pakistan would be very challenging as these are mostly industrially derived using similar processes, the water use in producing these raw materials does not vary significantly globally. Hence, existing information from similar studies irrespective of geographical regions has been used to establish approximate water footprint figures for some of the key raw materials by weight. Based on the quantities used, total contribution to the water footprint of sugar can be estimated.

Raw materials other than sugarcane include calcium oxide (0.021 m^3/t of refined sugar) , phosphoric acid (0.0081 m^3/t of refined sugar), caustic soda (0.001 m^3/t of refined sugar) and decolouriser (0.066 m^3/t of refined sugar). The BWF of the above raw materials are less than 1 m^3/t of refined sugar.

The range of different types of chemicals, with different sources and production processes that can be used in the sugar production process makes it difficult to establish a definitive water footprint of the non-cane raw materials that go into the process. As chemicals and inputs other than sugarcane in the process are predominantly non-agriculturally based raw materials, their water footprint is very low on a per tonne basis in comparison with the sugarcane itself. Considering that small quantities are used as compared to the weight of sugarcane used (i.e. one tonne of sugarcane on average only produces 100 kg of refined sugar), their contribution to the overall WF of the finished product is proportionately even less. The estimated WFs of some of the main raw materials used to produce refined sugar are shown in Table 2.1. Together the non-cane materials present the range of the WF per tonne of refined sugar is 0.001– 0.07 m^3, which is much less than 0.01 per cent of the BWF of sugar itself. Even if the water footprints of all other inputs to the processing were considered it is unlikely that their combined total would be significant compared with the water footprint of the sugar itself.

2.2.3 Water Footprint of Raw and Refined Sugar

Mekonnen and Hoekstra (2010) provide estimates for the water footprint of raw and refined sugar as an average for Pakistan, by region as well as global averages. These estimates, presented in Table 2.1, shows a large variation in different regions, both in total water footprint and the partitioning between rain fed and irrigated (green and blue) water, primarily due to different climate and availability of irrigation infrastructure. It should be noted that the large increase in WF between sugarcane and raw/refined sugar is mainly due to the fact that each tonne of sugar represents approximately 10 tonnes of sugar cane and the figures in Table 2.1 are presented on a per tonne basis. On average, the blue water footprints for raw sugar and refined sugar in Pakistan are 1,833 m^3/t, and 1,961 m^3/t, respectively. For Punjab the blue water footprints for raw sugar and refined sugar are 1,707 m^3/t and 1,826 m^3/t.

Table 2.1: Pakistan average water footprints (m³/t) for raw sugar and refined sugar. G = Green WF, B = Blue WF, Gy = Grey WF (Mekonnen and Hoekstra, 2010)

Product stage		Federally Administered Tribal Areas	Balochistan	KPK	Punjab	Sindh	Azad Kashmir	Gilgit Baltistan	Islamabad	Country average	Global average
Sugar cane	G	194	83	147	90	53	272	107	278	88	139
	B	99	269	118	215	329	15	91	11	231	57
	Gy	46	29	34	27	29	42	28	40	29	13
Raw sugar	G	1539	656	1170	712	421	2160	849	2209	700	1104
	B	790	2137	935	1707	2617	119	720	84	1833	455
	Gy	366	234	271	217	230	333	224	322	229	104
Refined sugar	G	1646	702	1252	761	450	2310	908	2362	749	1184
	B	845	2285	1000	1,826	2799	127	770	90	1961	487
	Gy	391	250	290	232	246	357	240	344	245	111
Cane molasses	G	487	208	370	225	133	683	268	698	221	350
	B	250	675	295	540	827	38	228	27	579	144
	Gy	116	74	86	68	73	105	71	102	72	33

Scholten (2009) calculated the average water footprint of unprocessed sugar cane in Pakistan to be 457 m³/t, of which the blue, green and grey components are 402, 29 and 26 m³/t respectively. Once processed into sugar, Scholten (2009) estimates that the blue and green WFs are 2,469 m³/t and 179 m³/t respectively, on average for Pakistan. These estimates are somewhat higher than those from Mekonnen and Hoekstra (2010) given in table 2.1 but still serve to highlight the dependency on blue water for sugar production in Pakistan.

2.2.4 Blue Water Footprint for the Sugar Sector as a Whole

From the ranges of WF estimates presented here it can be seen that the overall water footprint of sugar in Pakistan is dominated by the water footprint of growing sugarcane as the water footprints of both the mill processing and non-cane raw materials are lower compared with the water consumed in growing the crop.

Scholten (2009) and Gerbens-Leenes and Hoekstra (2009) noted that, in a global context, the water footprint of sugarcane (m³/t) in Pakistan is high. Mekonnen and Hoekstra (2010) rank Pakistan second highest for total (green + blue + grey) WF (m³/t) and highest for BWF. At 321 m³/t (see Table 2.1) the green-blue WF of sugarcane in Pakistan is considerably higher than the global average of 197 m³/t, and almost three times the best performing 10 per cent of areas, which achieve 112 m³/t (Mekonnen and Hoekstra, 2014). Scholten (2009) attributes these high water footprints to the comparably low yields of cane reported for Pakistan, but climatic and water management factors are also likely to play a part. These figures serve to demonstrate the large scope for reducing the crop water footprint of sugarcane in Pakistan.

Sugarcane is one of the major cash crops in Pakistan. The total sugarcane production in 2012 was 58.4 million tonnes (FAO) on 1.06 millionHa . On average over the period 1998-2007 production has been 49.6 metric tonne (Mt) per year (FAOSTAT), with an increasing trend since 1960. Using the range of BWF presented above, therefore, the total blue water footprint for sugarcane in Pakistan is 13,490 – 23,476 million cubic metres per year (Mm³/yr). With Punjab accounting for 69 per cent of the total sugarcane production, (see Table 3) it also dominates the blue water footprint (67 per cent of the total, accounting for a value slightly lower than Pakistan average BWF in Punjab).

Table 2.2: Sugarcane production by province (Pakistan Sugar Annual Global Agriculture Information Network 2013)

	Sugarcane production ('000 tonnes)			
	2011/12	2012/13	2013/14	% of total production in Pakistan
Province				
Punjab	40,400	41,950	40,700	69
Sindh	13,740	14,400	13,660	23
KPK	4,500	4,800	4,600	8
Balochistan	40	50	40	0.1
Total	**58,640**	**61,000**	**59,000**	**100**

The Pakistan Sugar Mills Association provides figures for sugar production from cane of 5.03 Mt in 2012-2013, and 2.25 Mt of molasses. For Punjab, these figures are 3.17 Mt and 1.42 Mt, respectively. Based on the WF data provided in table 2.2, the total sugar and molasses BWF for Punjab and Pakistan are, therefore, 6,561 Mm^3 and 11,168 Mm^3, respectively. It should be noted that not all of the WF attributed to sugarcane can be assigned to sugar and molasses (some of the WF is, for example, attributed to bagasse) and, along with uncertainties in that underlying data, this accounts for the fact that the overall BWF for sugar and molasses is lower than that for sugarcane. Nevertheless, the figures are broadly similar.

2.2.5 Water Quality

Pollution from the agricultural part of the supply chain of sugar production is a concern, especially as excess nutrients and agrochemicals are applied to sugarcane crops, which can pollute surface and groundwater (Ramjeawon and Baguant, 1995 and Gunkelet al., 2007). As discussed above, this results in a grey water footprint for sugarcane of 27 m^3/t in Punjab, and 29 m^3/t on average for Pakistan.

Generally, effluent from the sugar processing sector is discharged into surface water either through a sewerage network or directly to surface water bodies. Pollution from dissolved solids, COD and BOD are of particular concern in the sugar sector which are highly impacting pollutants. According to WSP audit data, the BOD, COD and TDS loading was 9.75 kg/ton, 14.83 kg/ton and 22 kg/ton of sugar produced respectively on average per facility but other pollutants such as residual process chemicals are also important.

If this effluent is treated and meets the agreed quality standards for downstream uses then this water is available for other uses downstream as it will either add to river flows or recharge local groundwater and is not lost to the overall water resource. However, if this water is polluted then it is effectively lost to the overall water resource as it is not usable for any other purpose, and becomes responsible for the grey WF by effectively consuming the assimilation capacity of the rivers or lakes where it is discharged. In effect, polluted effluent requires a certain volume of freshwater resources reserved in the system such that the water quality levels do not exceed the maximum allowable limits. Essentially, this part of the freshwater gets locked for further uses reducing the water availability for other consumptive uses downstream. Mekonnen and Hoekstra (2010) estimate the grey water footprint to be 245 m^3/t of refined sugar, on average for Pakistan.

This briefing note is intended to demonstrate the water dependency of the sugar sector in Pakistan, which is the reason for the focus on the blue water footprint as this is the managed or potentially managed component of the overall water resource. Although no detailed consideration of the water footprint of pollution has been included in the estimates presented, water quality considerations are, of course, as important as considerations of water volumes.

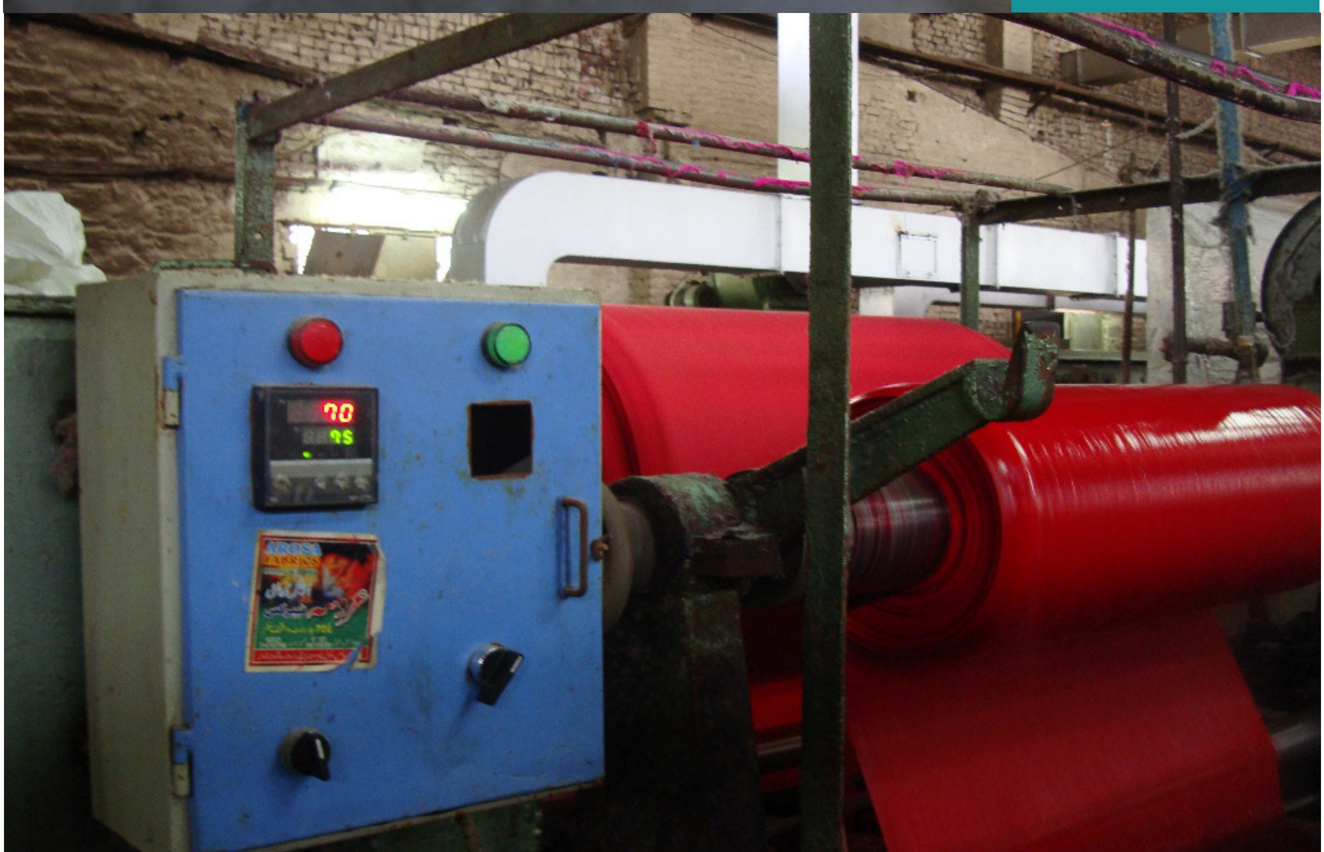
2.3 Summary

The analysis presented here shows that the water footprint of refined sugar in Pakistan is dominated by the water consumed in the growing of sugarcane. The blue, green and grey WFs of sugarcane in the country are 231, 88, and 29 m^3/t of sugarcane, respectively. The estimate total BWF for sugar cane in Pakistan is 13,490 – 23,476 Mm^3/yr. The additional blue water (i.e. surface and groundwater) consumed in the processing stage represents less than one per cent of the BWF per tonne of sugarcane processed. The blue WF of refined sugar represents 66 per cent of the overall WF. Approximately 40 per cent of the grey WF is in the industrial phase and the remaining is at the farm level.

The current water situation in Pakistan is not sustainable. The Indus River basin faces severe water scarcity for eight months of the year (Hoekstra et al., 2012). Given that the refined sugar supply chain is a major water consumer, and there is significant scope to improve the water consumption of sugarcane in Pakistan, the sugar sector has an important role to play in ensuring sustainable water management.

The contribution of the sugar sector should be both at the level of mills/refineries, in terms of their own water consumption and pollution, but also in improving practices within the supply chain and as an active participant in dialogues on water management in Pakistan. The Water Stewardship in Pakistan project is actively working to help SMEs to achieve improvements in the quality of water discharge, as well as reduce overall water use, and is helping SMEs to engage in water policy discussions. As such a deeper engagement with the sugar sector is welcomed.

3



Water Footprint Assessment of the Cotton Textile Sector in Punjab, Pakistan

Chapter 3

Water Footprint Assessment of the Cotton Textile Sector in Punjab and Pakistan

3.1 Introduction

This chapter is intended to provide an introduction to the water footprint accounts of the cotton textile sector in Pakistan. It is based on a review of the key published literature of textile water footprint assessments, those of the raw materials used in processing, and data gathered from participants of the Water Stewardship in Pakistan (WSP) project. Further background information on water footprint assessment is provided in the accompanying Water Footprint Briefing Note 1, which describes what a water footprint account shows, and what it does not, and how to interpret and use the outputs to assess the sustainability of water use.

The purpose of this chapter is to demonstrate the potential water dependencies of the textile sector by highlighting water consumption in different parts of the supply chain, and point towards appropriate responses for individual businesses and the sector as a whole. The sections below discuss the water footprints of cotton agriculture, the processing part of the supply chain, the non-cotton raw materials supply chain (process chemicals etc.), and the overall water footprint of finished fabric.

3.2 The Water Footprint of the Textile Sector in Pakistan

3.2.1 Water Footprint of Growing Cotton

Within Pakistan, the total WF of seed varies from 3,308 m^3/t in Khyber Pakhtunkhwa (KPK) to 4,719 m^3/t in Balochistan, with the variation reflecting different climates between regions (Mekonnen and Hoekstra, 2010). Those provinces with higher total water footprints also tend to have a higher proportion of blue water footprint, reflecting the greater water demand and lower rainfall in arid regions. The blue WF components represent 78 per cent of the total WF in Balochistan and 16 per cent in KP. The grey WF varies from 15 to 21 per cent of the total across different provinces.

The blue WF of cotton seed is 1,898 m^3/t in Punjab (Mekonnen and Hoekstra, 2010). As more than 65 per cent of the weight of cotton becomes either waste, cotton cake, or oil producing approximately 18 per cent market value (Chapagain et al., 2006), the blue WF of the non-textile product in Punjab can be calculated (Hoekstra et al, 2011) as 526 m^3/t (1898 x 0.18/0.65=526), with the remainder being allocated to cotton fabric and finished textiles.

Table 3.1: Green, Blue and Grey water footprints for cotton seed by province and Pakistan average (m3/ton)

Cotton seed	Federally Administered Tribal Areas	Balochistan	Khyber Pakhtunkhwa	Punjab	Sindh	Islamabad	Pakistan	Global average
Green	738	331	2071	1122	534	2244	982	2282
Blue	3000	3678	546	1898	3161	581	2156	1306
Grey	666	710	692	709	719	689	711	440

3.2.2 On-site water footprint

The distinction between water use at a site level, in this case a business converting yarn or grey fabric into finished textile or a textile product, and the water footprint of the finished product is an important one. While a textile processor may extract and use a large volume of water, for example from onsite boreholes, most of this water is discharged back to surface waters or percolates back to groundwater. This means that it is potentially available for other water users to abstract and use, although the reduced water quality typically means that it cannot be used directly and may have impacts on other water users or ecosystems (see section below on water quality). The water footprint of the processing part of the supply chain is the fraction of water supplied/withdrawn that is evaporated during the production process and is therefore, for practical purposes, lost from the locally available water resources. As this water is supplied either through groundwater sources or from river or lakes it is blue water, and forms part of the blue WF of cotton textiles.

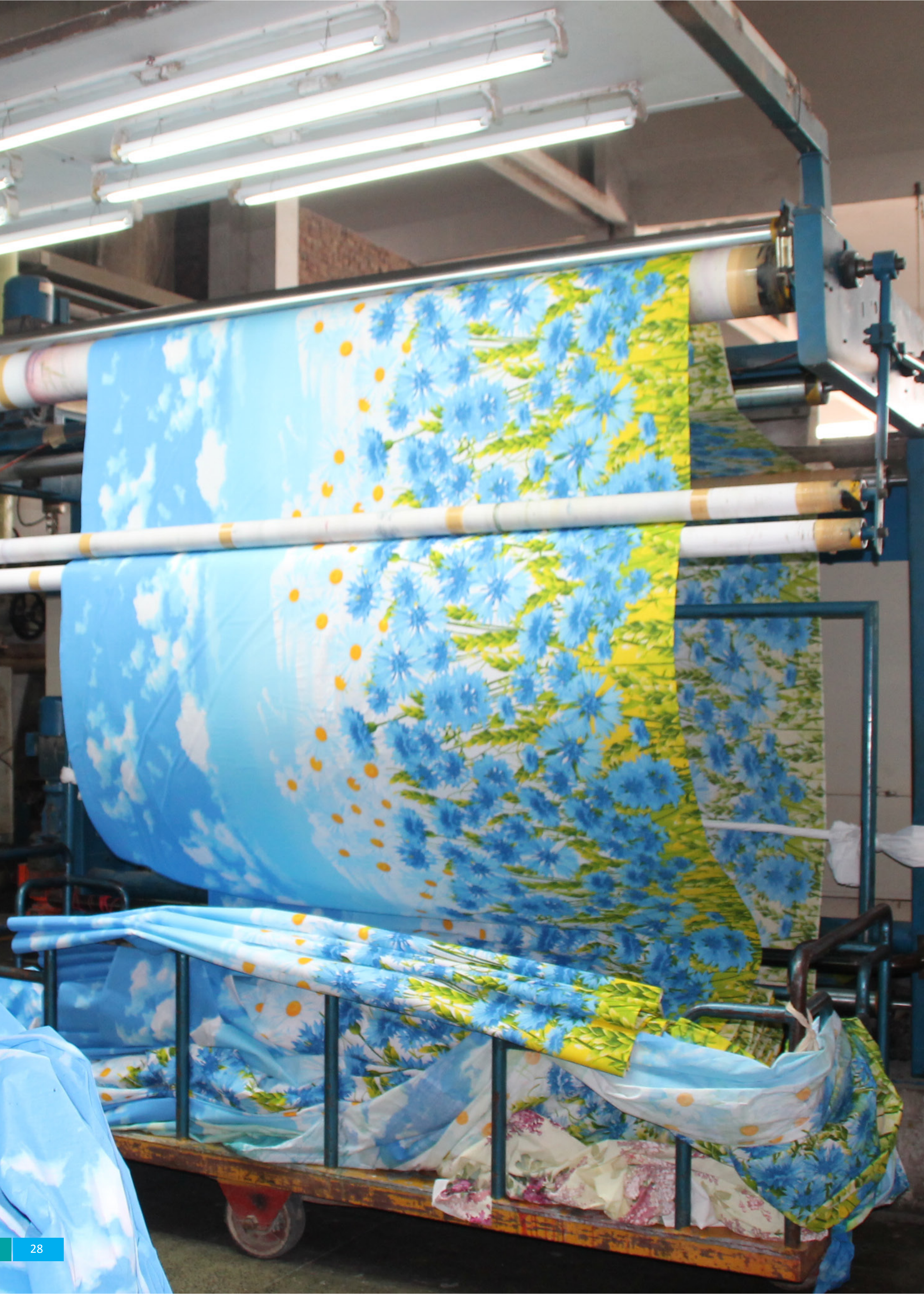
Franke and Matthews (2013) found that depending on the particular processes being undertaken in different operations, and the type of textile being produced (e.g. woven or knitted), the blue WF of textile processing varies widely with a median value of 5-15 m^3 of water per tonne of finished textile.

Based on data collected as part of the WSP project from case studies of businesses, the average total process water abstracted per tonne of finished textile (i.e. dyed and printed fabric) is 169 m^3/t. Measured effluent volumes are on average 143 m^3/t. The difference between the inflow of water and the outflow of effluent represents the water loss through the process and, assuming there are no other unmeasured losses of water, is the BWF for textile processing. Based on the actual measurements of water consumed in the processing of textiles, therefore, the blue water footprint of processing textiles in Punjab is 26 m^3/t. This figure is comparable to the estimate of Franke and Matthews (2013).

Generally, effluent from the textile sector is discharged to surface water either through a sewerage network or directly to surface water bodies. If this effluent is treated and meets the agreed quality standards then it is available for other users downstream as it will either add to river flows or recharge local groundwater, and is not lost to the overall water resource. However, if this water is polluted to an extent that it cannot be used for other purposes then it is effectively lost to the overall water resource and gives rise to a grey WF (as explained in chapter 1) as the polluted effluent after treatment requires a volume of clean water resources to dilute it to a level where it can be used by others. According to data collected during audits for the WSP project, the wastewater discharged by the textile processing sector is about 143 m^3 per tonne of finished textile with organic loading of BOD, COD and TDS are 63 kg/t, 174 kg/t and 440 kg/t of fabric processed, respectively. Franke and Matthews (2013) included the grey water footprint of textile processing in their analysis and concluded that it accounts for over 99 per cent of the total water footprint (green + blue + grey) of finished cotton articles. In some respect, this is the easiest component of the WF to address. With cleaner production technologies, the use of chemicals in cotton industries can be reduced by 30 per cent, with a reduction of COD content in the effluent of 60 per cent (Visvanathan et al., 2000).

3.2.3 Water footprint of raw materials other than cotton

In addition to the water consumed in processing, the water footprint for finished textile should include the water footprints for all non-cotton



raw materials that are used in the process, such as chemicals. Estimating the water footprint for the many complex products used by the textile sector in Pakistan would be very challenging. However, approximate water footprint figures have been established using information published by others of the key raw materials by weight. Based on the quantities used, total contribution to the water footprint of finished textiles can be estimated.

As chemicals and other non-cotton inputs to the process are predominantly non-agriculturally based raw materials, in comparison with cotton inputs, their water footprint is very low on a per tonne basis. Given that small quantities are used in comparison with the volume of cotton used (i.e. much less than a tonne of each raw material is used to produce a tonne of finished textile), their contribution to the overall WF of cotton is proportionately even less. Table 3.1 shows the estimated WF of raw materials used to produce one tonne of finished cotton fabric. All raw materials listed contribute less than 0.01 per cent to the overall water footprint of finished cotton textile. Moreover as the locations where these chemicals are sourced are often difficult to trace, the sustainability of blue WF resulting from the use of these chemicals becomes even more complicated. For these two reasons, blue WF related to the use of chemicals can be safely disregarded in the sustainability assessment.

Table 3.2: Water footprints of key non-cotton raw materials into cotton textile processing

Raw material	Blue water footprint of raw material (m^3/t)	Quantity of raw material used per tonne of finished fabric (tonne)	Raw material BWF per tonne of finished textile (m^3/t)[1]	Data source
Caustic soda	3.2	0.063	0.20	Derived from data in Hong *et al.*2014
Sodium silicate	0.069	0.021	0.001	Zah and Hischier 2007
Soda ash	3.76	0.0025	0.009	Unger *et al.* 2013
Dyes	4 – 9.5			Based on data in Wu and Chiu 2011.[2]

3.2.4 Water footprint of finished cotton textile

Mekonnen and Hoekstra (2010) estimate that the blue water footprint of finished textile is 5,258 m^3/t on average in Pakistan, and 4,650 m^3/t for Punjab, the difference primarily reflecting climatic differences between Punjab and the Pakistan average (see Table 3.3).

Table 3.3: Green, blue and grey water footprints for seed cotton by province and Pakistan average

Cotton fabric and finished textiles	Federally Administered Tribal Areas	Balochistan	Khyber Pakhtunkhawa	Punjab	Sindh	Islamabad	Pakistan	Global average
Green	1740	781	4885	2646	1260	5295	2317	5384
Blue	7249	8848	1459	4650	7630	1544	5258	3253
Grey	1876	1981	1938	1979	2002	1931	1982	1344

3.3 Findings

Despite the inherent uncertainties involved in calculating the blue water footprint for finished cotton textile, particularly when focusing on a particular region, the data presented here serve to highlight the very large differences in blue water footprint of the different parts of the supply chain. The water footprint of non-cotton raw materials in textile processing, and the direct blue water footprint of processing, together contribute less than one per cent of groundwater and river flow consumption of the finished product. The water required to grow cotton represents over 99 per cent of the water requirement.

Looking at the water consumption of the textile sector from a wider perspective, provided by the water footprint approach, serves to highlight that water dependency of the sector lies not only in the water that comes into the factory site but also in the water used to irrigate cotton fields that provide its key raw material. This has profound implications for the sector as a whole and how, collectively and as individual businesses, textile processors engage with discussions on water management.

While availability of water at the site level is of critical importance for immediate business operations, such a narrow focus will lead to the biggest water risks to the textile sector being missed: the water risks associated with growing cotton. The business water risks, and the underlying drivers, associated with the supply of water to the site and the supply of water to cotton agriculture are very different. While the site level risks are immediate and tangible, the effects on the business of water risks in the agricultural part of the supply chain are felt longer term, are more diffuse and more difficult to manage.

The water footprint assessment outlined here demonstrates how interlinked the site and supply chain water risks are, and how response strategies should be designed holistically to address the overall water risk to the business. As the largest consumer of water, how water is managed in agriculture is one of the key determinants of the local availability of the resource for surrounding and downstream business operations, and in many cases will have a direct impact on the availability of water for site processes. How water is managed for agriculture is also a key determinant of the long term viability of cotton production: without sustainable production of cotton there will not be a sustainable textile processing sector.

The entire sector should reconsider how it approaches water, moving from thinking only about water as a site issue to a holistic view of how water is managed in the entire cotton supply chain 'from field to fabric'. The WSP project is actively working to help SMEs achieve improvements in the quality of water discharge, as well as reduce overall water use, and is helping SMEs to engage in water policy discussions that will mitigate their water risks at the same time as addressing impact on water resources and the environment. A deeper engagement with the textile sector to help in addressing these important issues is welcomed.

3.4 Summary

The textile sector in Pakistan is predominantly based on cotton which is grown and processed within the country. In the growing of cotton the WF includes green, blue and grey WFs. The green WF is only applicable to the crop growth stage, and is the rainfall consumed by the crop, the blue water is the surface or groundwater consumed for irrigation, and grey WF in the agricultural stage is due to fertilisers and the use of pesticide in the fields. The blue water footprint (BWF) of cotton seed in Punjab and Pakistan is 1,898 m^3/t, and 2,156 m^3/t respectively.

The water footprint (WF) of finished textile is based on the WF in all stages of the supply chain. In textile processing, all the water consumed is blue water from ground water abstraction. Green water is not significantly consumed in the processing stage. The blue WFs in processing stages is due to the evaporation of ground and surface water supplied to the factories. The grey WF in this stage results from the pollutant loads in the effluent that is discharged into freshwater bodies without treatment. The water abstracted for textile processing is about 169 m^3/t of finished fabric, of which approximately 26 m^3/t is consumed (i.e. the BWF of textile manufacture) with the remaindered being discharged as waste water. The water footprint of chemical inputs is not very high in comparison to the other parts of the supply chain(less than 1 m^3/t). Overall, the blue WF of finished textile in Punjab is 4,650 m^3/t, and 5,258 m^3/t on average in Pakistan.

The dominance of agricultural water use in the WF of the cotton textiles demands that the sector engages with water management issues beyond immediate processing operational needs. The Water Stewardship Pakistan project can help to achieve this.

4

Water Footprint Assessment of the Tannery Sector in Punjab, Pakistan

Chapter 4

Water Footprint Assessment of the Tannery Sector in Punjab and Pakistan

4.1 Introduction

This chapter is intended to provide an overview of the water footprint (WF) accounts of the leather tanning sector in Punjab and Pakistan in order to highlight the importance of water use through the supply chain for businesses in this sector. It provides general information on the water requirements of the supply chain of the leather sector, tannery operation, and raw materials used in the tanning processes. It is based on a review of key published literature of leather water footprints, those of raw materials used, and data gathered from participants of the Water Stewardship in Pakistan project.

The purpose of this briefing note is to demonstrate the potential water dependencies of the leather tanning sector by highlighting the water consumption in different parts of the supply chain, and provide appropriate responses for individual businesses and the sector as a whole. The sections below discuss the water footprints of processing in the supply chain, the non-hide raw materials supply chain (process chemicals etc.), and the overall water footprint of finished leather.

4.2 Water Footprint of the Tannery Sector in Pakistan

4.2.1 Water footprint of raw hides

Mekonnen and Hoekstra (2010) provide estimates for the water footprint of raw hides in Pakistan as country averages. These estimates are shown in Table 4.1, and highlight the large differences in WF that arise due to different agricultural production methods and types of animals. The green water footprint dominates the overall water footprint, accounting for 83-100 per cent of the total WF, depending on the animal type and type of production system (grazing, industrial or mixed). Industrial production systems have higher blue water requirements than other production systems as a result of the use of animal feed grown with irrigation. On average, the blue water footprints

Table 4.1: Pakistan average water footprints (m³/t) for bovine, sheep and goat raw hides. G = Green WF, B = Blue WF, G = Grey WF. Mekonnen and Hoekstra (2010). Water footprint of raw materials other than hides

		Grazing	Mixed	Industrial	Weighted average			Grazing	Mixed	Industrial	Weighted average
Bovine hides, whole, fresh or wet-salted	G	20655	11894	3819	11502	**Bovine and equine leather, tanned or retanned**	G	41310	23788	7638	23003
	B	0	177	324	192		B	0	375	669	404
	G	0	25	148	38		G	0	49	295	76
Sheep or lamb skins, raw, with wool on	G	8049	4333	1839	4407	**Sheep or lamb skin leather, tanned or retanned**	G	9415	5068	2151	5154
	B	0	146	150	144		B	0	199	203	197
	G	0	142	217	132		G	0	166	254	155
Goat or kid hides and skins, raw	G	14451	7916	3387	8187	**Goat or kid skin leather, tanned or retanned**	G	16056	8796	3763	9097
	B	0	214	246	222		B	0	260	295	268
	G	0	18	61	24		G	0	20	67	27

for bovine, sheep and goat raw hides in Pakistan are 192 m^3/t, 144 m^3/t, and 222 m^3/t, respectively.

The water footprint for finished leather includes the water footprints for all raw materials that are used in processing, such as tanning chemicals. Estimating the water footprint for the many complex products used by the tannery sector in Pakistan would be very challenging. However, using information published by others the approximate water footprint figures for some of the key raw materials have been established by weight and, based on the quantities used, their total contribution to the water footprint of finished textiles can be estimated. The Pakistan Institute of Trade and Development (2012) indicates that 90 per cent of the dyes and chemicals used in the tanning sector in Pakistan are imported, mainly from Germany, Spain and Italy, while the remaining 10 per cent is from domestic production by international companies (mainly Sandoz, Bayer, BASF and Clarient). As such the water footprint of these raw materials is mainly outside of Pakistan.

The raw materials other than hides are having very low BWF such as:

- Fat liquor (200-600 m^3/t)
- Mimosa (12-87 m^3/t)
- Dyestuff (0.67-2.68 m^3/t)
- Chrome (1.65-2.75 m^3/t)
- Sodium Sulphide (1.58 m^3/t)
- Sodium Bicarbonate (0.56 m^3/t)
- Salt (0.8 m^3/t)
- Syntan (1.34 m^3/t)

For these raw materials the WF per tonne of finished leather is approximately 200 - 700 m^3/t, depending on whether the tanning agent is chrome or vegetable based. It should be noted, however, that the WF estimated for mimosa is total (green + blue) water footprint and is likely to be dominated by green water in most production contexts, whereas other estimates are for the blue water footprint only.

The wide range of different types of chemicals, with different sources and production processes that can be used in the tanning process make it difficult to establish a definitive water footprint of non-hide raw materials that go into processing. Agriculture is the primary water consumer and as chemicals and inputs other than hides are predominantly non-agriculturally based raw materials, their water footprint is very low on a per tonne basis. The main exceptions to this are animal and plant derived fat liquors and vegetable tanning agents, as these ultimately depend on evapo-transpiration from crops. In cases where these are not used, or mineral alternatives are used, the associated blue water footprints can be lower in magnitude by several orders.

4.2.2 Water footprint of tanning processes

The distinction between water use at a site level, in this case a business tanning leather, and the water footprint of the finished product is an important one. While a tannery may extract and use a large volume of water, for example from onsite boreholes, most of this water is discharged back into surface water or percolates back to groundwater. This means that it is potentially available for other water users to abstract and use, although the reduced water quality typically means that it cannot be used directly and may have impacts on other water users or ecosystems (see section below on water quality). The water footprint of processing in the supply chain is the fraction of water use that evaporates during the production process, and is therefore, for practical purposes, lost from the available water resources. This water footprint is entirely from blue water as the water sources for tanneries are either groundwater or from surface flows. In addition to the water footprint of the processing stage, the water footprint of the finished leather incorporates an appropriate proportion of the water that is consumed in raising the animals that provide the hides, and the water that is consumed to make other raw materials, such as process chemicals (as described in the sections above).

Buljan et al. (2000) estimate that the average water intake for tanneries is 40 m^3/t of wet salted hides processed, although it notes that 25-30 m^3/t is achieved quite commonly. The United Nations Environment Programme (UNEP, 2010) gives a slightly lower figure of 15-30 m^3/t as a benchmark for water intake in tanneries. However, not all the water withdrawn evaporates and is lost from the system. About 0.4 m^3 of water is physically embedded per tonne in the wet salted raw hides. Close to 0.7 m^3 of water evaporates per tonne of hide in processing and the rest goes out from the system as an effluent. Buljan et al. (2000) suggests that water outflows from the tanning process very closely match the water input figures, indicating a low blue water footprint (BWF) for the tanning process itself. From the figures presented above, the BWF of wet tanned hides can be estimated as 0.7 + 0.4 = 1.1 m^3/t. Data from tannery water audits carried out as part of the Water Stewardship in Pakistan (WSP) project indicate a water usage rate of 81 m^3 per tonne of raw hides processed and found effluent volumes of 56 m^3 per tonne of raw hide, indicating a BWF of 25 m^3 per tonne of raw hide. While there is no certainty that all of the outflows were captured, given these different sources of data it can be reasonably certain that the BWF for tanning is in the range 1 - 25 m^3 per tonne of raw hide, or 1 – 98 m^3/t of leather.

4.2.3 Water footprint and finished leather

Mekonnen and Hoekstra (2010) provide estimates for the water footprint of tanned leather as an average for Pakistan, which are shown in Table 3. These figures mirror the WF of raw hide presented above, and show the dominance of green water in the overall footprint and the large differences that arise due to different agricultural production methods. On average, the blue water footprints for leather from bovine, sheep and goat leather in Pakistan are 404 m^3/t, 197 m^3/t, and 268 m^3/t, respectively. The green water footprint dominates the overall water footprint, with the BWF accounting for 1.7 per cent, 3.8 per cent and 2.9 per cent of the green WFs for bovine, sheep and goat leather, respectively.

Table 4.2: Pakistan average water footprints (m^3/t) for bovine, sheep and goat leather. Gn = Green WF, B = Blue WF, Gr = Grey WF. (Mekonnen and Hoekstra (2010)).

		Water footprint of leather, tanned or untanned [m^3/t]			
		Grazing	Mixed	Industrial	Weighted average
Bovine and equine leather, tanned or retanned	Gn	41,310	23,788	7,638	23,003
	B	0	375	669	404
	Gr	0	49	295	76
Sheep or lamb skin leather, tanned or retanned	Gn	9,415	5,068	2,151	5,154
	B	0	199	203	197
	Gr	0	166	254	155
Goat or kid skin leather, tanned or retanned	Gn	16,056	8,796	3,763	9,097
	B	0	260	295	268
	Gr	0	20	67	27

4.2.4 Grey Water Footprint of leather

Generally, effluent from the leather sector is discharged into surface waters either through a sewerage network or directly to surface water bodies. Chromium pollution is of particular concern in the tanning sector but other pollutants such as BOD and process chemicals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are also important. Organic loading from leather industries varies on the basis of production but WSP data shows that average BOD, COD and TDS loading is 55 kg/t, 140 kg/t and 401 kg/t of raw hide processed respectively before any treatment systems. Pollution of groundwater as a result of disposal of solid waste residues to land is also a concern.

The water audit data gathered as part of the WSP project shows that the wastewater discharged from tanneries is in the range of 35-100 m^3/t of finished product, with an average of 55 m^3/t. Given that the total production of leather in Punjab is estimated to be 60,000 – 68,000 tonnes , this suggests that 3.3 – 3.7 million m^3 of wastewater is discharged from the tannery sector per year in Punjab.

If the effluent is treated and meets the agreed quality standards then this water is available for other uses downstream as it will either add to river flows or recharge local groundwater, and is not lost to the overall water resource. Depending upon the water quality standards of freshwater systems, any river or lake can assimilate pollutant load to a certain amount only. If effluents pollute to an extent that water resources cannot be used for other purposes then it effectively lost to the overall water resource and gives rise to a grey WF (see Water Footprint Briefing Note 1) as the polluted effluent after treatment requires a volume of clean water resources to dilute it to a level where it can be used by others.

4.2.5 Total Water Footprint of leather

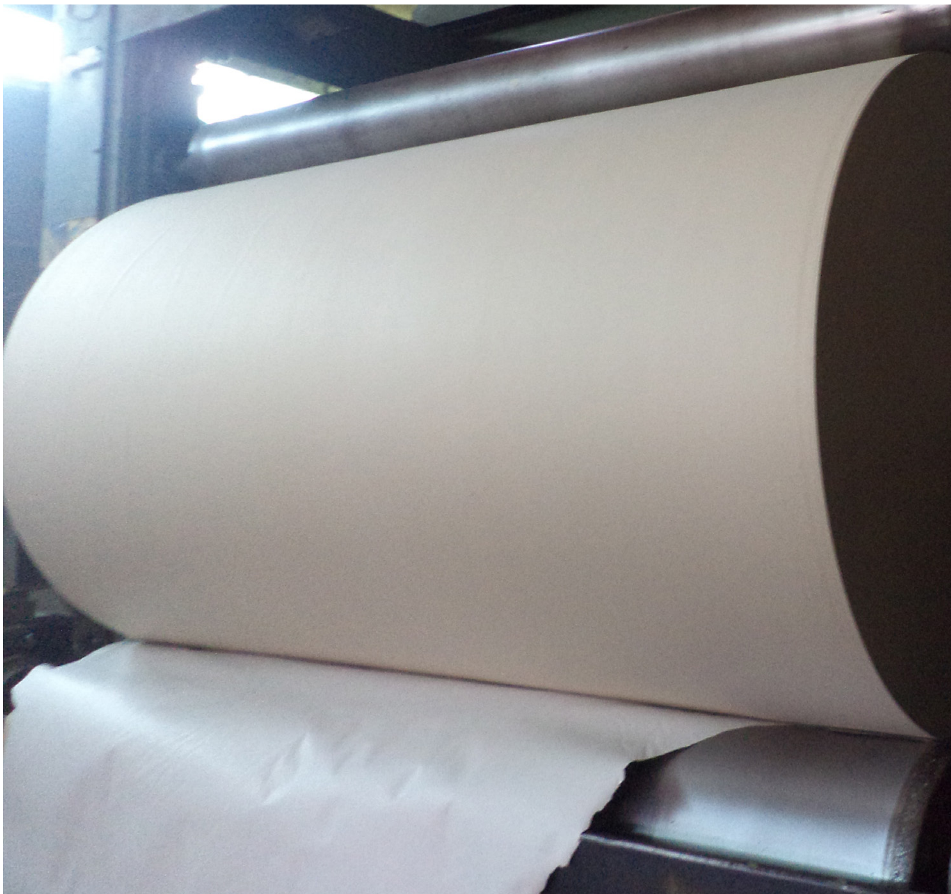
The estimated production capacity for tanned leather in Pakistan is 90 million m^2, with actual production being 60 million m^2, (Pakistan Institute of Trade and Development, 2012). Using a figure of 1.2 kg/m^2 for the typical mass of leather (Buljan et al., 2000) this indicates an overall production weight for the sector of approximately 108,000 t per year. Taking account of the relative weight of different types of hide and their differing BWF (Table 3), the overall BWF of leather production in Pakistanis approximately 40.7 Mm^3 per year (37.1 Mm^3 from buffalo/cow, 2.0 Mm^3 from goat, and 1.6 Mm^3 from sheep).

From the ranges of WF estimates presented here for the different stages of leather production, it can be seen that in any water footprint analysis of the sector the particular farming practices used to raise the livestock and the sources of raw materials used (in particular whether they have an origin of vegetable/animal or mineral based) are the key governing factors for the overall water footprint. Hides from extensively grazed cattle that are tanned with plant based tanning agents and fat liquors from rain-fed crops will have a water footprint greater than 40,000 m^3/t, but it will all be green water (see Table 3). Hides from intensively reared cattle tanned with plant based tanning agents and fat liquors from irrigated crops would have a lower water footprint (approximately 8,000 m^3/t) but this would be almost 10 per cent blue water, and would therefore have a potentially bigger impact on water resources. In addition to the effect of farming systems, the upper end of the range of estimates derived (Table 4.2) for the WF of non-hide raw materials going into leather production (200 -700 m^3/t) and the process BWF (1 - 98 m^3/t), are of a similar order of magnitude to the overall BWF calculated by Mekonnen and Hoekstra (2010). In the case of the leather sector, therefore, it appears that differences in production processes can be as significant for the overall BWF as the type of raw hide.

The complexity and variety of supply chains, raw materials and processes in the leather sector, along with the highly variable nature of the overall water footprint depending on the specific circumstances for each business, means that it is particularly important that businesses in the leather sector understand their supply chains fully in order to assess their water risk. The generally low BWF compared with other sectors (see other Briefing Notes in this series) means that the highest acute physical water risk for the sector is likely to be associated with local access to water resources for operations rather than water resource scarcity in the supply chain. However, as the supply chain for raw hides in Pakistan has a high green WF (i.e. is dependent on rainfall), the sector remains exposed to water risks arising from droughts which can affect the supply of its main raw material.

4.3 Summary

This briefing note demonstrates the water dependency of the tannery sector in Pakistan. The total WF of finished leather in Pakistan is highly variable, depending on the agricultural system used to raise the animals and the nature of the non-hide process raw materials (crop/ animal based or synthetic). On average, the blue water footprints for leather from bovine, sheep and goat leather in Pakistan are 404 m^3/t, 197 m^3/t, and 268 m^3/t, respectively, and the overall BWF of leather production in Pakistan is approximately 40.7 Mm^3 per year. Reducing water use and improving the water quality of effluents is of critical importance for the sector to reduce water related risks. The Water Stewardship in Pakistan project can help to achieve this and is actively working to help SMEs to achieve improvements in the quality of water they discharge, as well as reduce overall water use.



5

Water Footprint Assessment of the Paper Sector in Punjab, Pakistan

Chapter 5

Water Footprint Assessment of the Paper Sector in Punjab and Pakistan

5.1 Introduction

Briefing Note 1 in this series provides an introduction to the concept of water footprint assessment (WFA), and describes what a water footprint account shows and what it does not, and how to interpret and use the output to assess the sustainability of water use and formulate appropriate response strategies. This briefing provides more details of the water footprint accounts of the paper sector in Pakistan. It is based on a review of key scientific publications on the WFA for the sector. It also reviews the water footprint (WF) of the raw materials used in the process of paper manufacture. The data from publications used in this brief is also supplemented with data gathered in the Water Stewardship in Pakistan (WSP) project.

The purpose of this briefing note is to demonstrate the potential water dependencies of the paper manufacturing sector by highlighting the water consumption in different parts of the supply chain, and identify appropriate responses for individual businesses and the sector as a whole. The water footprint of paper as a finished product is not just the water consumed in the manufacturing process but also includes the water that is consumed to grow and prepare the pulp (straw or wood), to make other raw materials (such as process chemicals) and to process raw materials in paper factories. The sections below discuss the water footprints of the processing in the supply chain (i.e. the paper mill operations), the main paper feedstock source (waste paper, straw, virgin wood etc.), and the other raw materials required for production (process chemicals etc.).

5.2 Water Footprint of the Paper Sector in Pakistan

5.2.1 Water footprint of paper manufacturing processes

There is an important distinction between water use within a factory fence, in this case a business making paper, and the water footprint of the finished product. While a paper mill may extract and use a large volume of freshwater, for example from onsite boreholes, most of this water is discharged back to surface water or percolates back to groundwater. This means that it is potentially available for other water users to abstract and use, although the reduced water quality typically means that it cannot be used directly and may have impacts on other water users or ecosystems (see section below on water quality). The blue WF of the paper manufacturing process of the supply chain is the volume of water that is evaporated during the production process (i.e. in the paper mill), and that is therefore, for practical purposes, lost from the locally available water resources. This is part of the blue WF as the source of this water

Table 5.1: Approximate water footprints for some key raw materials in paper production. (Unless otherwise stated figures refer to blue water footprint)

Raw material	Blue water footprint (m^3/t)	Quantity used per tonne of finished paper (tonne)	Total raw material BWF per tonne of finished paper (m^3/t)	Data source
Soap stone	3.29	0.01	0.03	Unger *et al.* 2013
Caustic soda	3.2	0.002	0.006	Derived from data in Hong et al.2014
Chlorine	0.51	0.00051	0.0003	Unger *et al.* 2013
Sulphuric acid	2.68	0.003	0.008	Unger *et al.* 2013

is either from groundwater or from rivers or lakes.

Water consumption per tonne of paper varies from mill to mill. The water audits carried out for the WSP project show water use is about 98 m^3 per tonne of finished paper on average. Measured wastewater outflows from participants in the WSP project were up to 87 m^3 per tonne of paper produced. The difference between the inflow of water and the outflow of effluent represents the water loss through the process and, assuming there are no unmeasured losses of water, is the blue WF for the paper manufacturing process. The blue WF is thus estimated to be 11 m^3/t which is higher that the estimate given by van Oel and Hoekstra (2012) for the USA of 5.5 m^3/t but reflects actual measured practices in the sector in Pakistan and is more representative for Pakistan than the estimate from van Oel and Hoekstra (2012).

5.2.2 Water Footprint of raw materials other than pulp

In addition to the water consumed in the processing stage, the water footprint for finished paper includes the water footprints for all raw materials that are used in the process, such as caustic soda or chorine.

The range of different types of chemicals, with different sources and production processes that can be used in the paper production process makes it difficult to establish a definitive water footprint of the raw materials other than recovered paper, straw or wood that go into the process. As these inputs are predominantly non-agriculturally based raw materials, their water footprint tends to be very low on a per tonne basis in comparison with the paper feedstock itself. Considering that small quantities are used in comparison with the weight of paper (i.e. less than a tonne of each raw material is used to produce a tonne of paper), their contribution to the overall WF of the finished product is proportionately lower. Using information published by others, table 1 shows the estimated WFs of some of the main raw materials used to produce paper. Together the four materials presented in Table 1 typically account for more than 50 percent of the weight of raw materials, excluding the main feedstock for paper production (WSP project data). For the raw materials considered in Table 1 the total WF per tonne of paper is 0.05 m^3, which is less than 0.02 per cent of the WF of paper itself. Even if the water footprints of all other inputs in the process were considered it is unlikely that their combined total would be significant compared with the total water footprint of paper.

5.2.3 Water Footprint of Paper Produced in Pakistan

Compared with agricultural products, there is relatively little information published on the water footprint of paper and paper manufacturing. Figure 1 shows that paper production in Pakistan is dominated by straw-based pulp and pulp from recovered paper. According to Mekonnen and Hoekstra (2010) the water footprint of straw is about zero as the water footprint of growing the crop is mostly attributed to the high value grain rather than the low value straw. Van Oel and Hoekstra (2012) suggest that the water footprint of recovered paper is also zero, given that the water footprint associated with paper is assigned to its first use. As such, the large proportion of straw and recovered paper used as feedstock in Pakistan needs to be accounted for in calculating an average WF as it will result in a lower WF than countries where wood-based pulp is used.

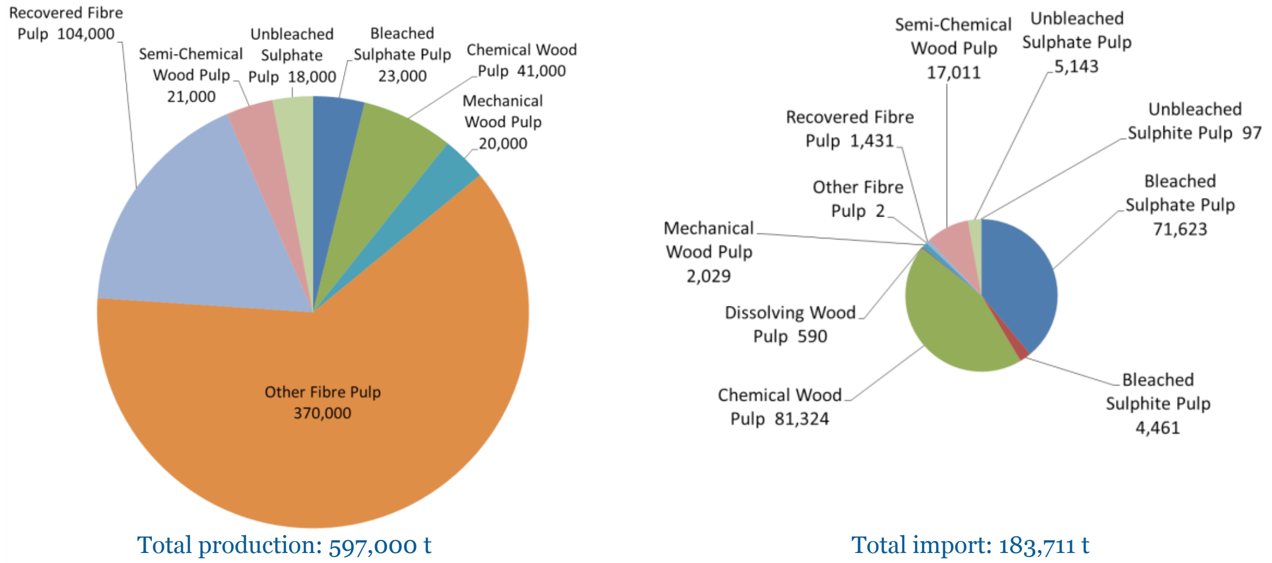


Figure 5.1: Pulp production and import for Pakistan in 2012. Figures are metric tonnes air dried weight i.e. 10% moisture content (source: FAOSTAT). Within Pakistan, the 'other fibre pulp' category refers to wheat straw. FAOSTAT shows that total pulp exports is 1,912 t. As this represents only 0.2% of production and trade flows this has been excluded.

In order to estimate the average WF for paper produced in Pakistan relative proportions were established. The WFs for the four main categories of pulp used are shown in figure 1: imported wood-based pulp, domestically produced wood-based pulp, straw-based pulp, and pulp produced from recovered paper.

- Wood-based pulp

Van Oel and Hoekstra (2012) provide one of the only studies into the WF of paper with a global scope. This study focussed on the national water footprints of paper production from wood in the main pulp producing countries. Although it does not make specific references to Pakistan, the authors include data for India in their study. Given similar climatic conditions, it is reasonable to assume that the WF is similar between the two countries. Rep (2011) also provides a detailed WF for paper manufacturing but, as this is for a single site in northern Europe, the WF calculations may not be transferrable to Pakistan.

Based on the figures from van Oel and Hoekstra (2012) the average water footprint of different types of paper in Pakistan can be estimated to be approximately 1,045 m^3/t for wood-based paper. These figures are the combined green and blue water footprints as it is not possible to separate them for wood-based products (van Oel and Hoekstra, 2012) given that deep rooted trees access both soil moisture and groundwater.

- Straw-based pulp and recovered paper pulp

Given that the WF of straw and recovered paper are zero, for the reasons mentioned above, the WFs for both for straw-based pulp and recovered paper pulp are only the process blue WF, which has been estimated as 11 m^3/t.

- Imported pulp

In order of importance (by value) the main countries from which pulp is imported are the USA, Sweden, Chile, Indonesia, Canada and Finland, which together account for 70 per cent of the value of pulp imported to Pakistan (UN Comtrade). Taking an average of the WF (green + blue) for different paper types from these countries as reported by van Oel and Hoekstra (2012), weighed by the value imported from the different countries, the WF (green + blue) of paper produced from imported pulp is estimated to be 1,215 m³/t. In a case study published by UPM Nordland Papier, it is found that the total WF of a paper is mainly composed of green [60 per cent] and grey [39 per cent] components with only one per cent for blue WF.

- Relative proportions of different feedstock

Pulp production and trade figures from FAO (FAOSTAT) allow an estimate of the feedstock base of paper production in Pakistan to be made, in particular the relative proportions of the four categories for which WFs can be calculated. The FAO reported that total pulp production in Pakistan (2012) was 597,000 t, with import being 183,711 t, and export being 1,912 t. The FAOSTAT data shows that imports of recovered paper in Pakistan in 2012 was 137,173 t, and domestic production of recovered paper was 163,000 t. UN Comtrade data show that the UAE, Netherlands, USA and UK are the primary sources of recovered paper imported to Pakistan, together accounting for 55 per cent of the total weight of recovered paper imported. Assuming that the proportions of finished paper produced in Pakistan reflect the relative proportions of import and domestic production of the different pulp types presented in the FAO statistics, estimates of proportions of source materials are shown in Table 2. It should be noted that, despite inclusion in the FAO statistics of a significant quantity of domestically produced wood-based pulp, the use of domestically produced wood-based pulp was not reported by participants within the study and, as such, the figure in Table 2 may be an overestimate.

There is also an apparent discrepancy between the FAO figures for recovered paper pulp and the import and domestic production of recovered paper. Cleaner Production Institute data suggests that recovered paper is converted to finished paper at a conversion rate of 80 per cent (i.e. 100 t of recovered paper produces 80 t of finished paper). However, FAO figures for import and domestic production of recovered paper are 137,173 t and 163,000 t respectively, suggesting that total domestic recovered fibre pulp production should be in excess of 240,000 t (accounting for 10 per cent moisture content), whereas FAO puts this figure at 104,000 t.

Based on the data presented in Table 2, this briefing note estimates the WF of paper in Pakistan to be 348 m³/t, and the majority (98 per cent) of this is outside Pakistan in the main pulp producing countries. The average WF per tonne of paper is therefore low when compared with other countries, given the high proportion of straw and recovered paper-based production in Pakistan.

Table 5.2: Estimated WF of paper from different feedstock in Pakistan, and proportions of total production derived from those feedstocks

Feedstock	Paper from domestically produced wood – based pulp	Paper from imported pulp	Paper from domestic straw-based pulp	Paper from recovered-paper pulp (imported and domestically produced)
Proportion estimate based on FAO	16%	23%	47%	14%
Proportion estimate based on WSP study[1]	0%	28%	56%	16%
WF estimates m3/t (for finished paper)	1045	1226[2]	11[3]	11[4]

Total paper production in Pakistan in 2012 was 2.78 million tonnes (FAO). Based on this, the estimate of the WF for paper production in Pakistan is 1 billion m³/y, out of which only 17 million m³/y is from water resources in Pakistan and the rest is from use outside Pakistan.

5.2.4 Grey Water Footpront

Generally, effluent from the paper manufacturing sector is discharged into surface water, either through a sewerage network or directly into surface water bodies. Pollution from total dissolved solids (TDS), COD and BOD are of particular concern in the paper sector but other pollutants such as residual process chemicals are also important.

If this effluent is treated and meets agreed quality standards then this water is available for other uses downstream as it will either add to river flows or recharge local groundwater and is not lost to the overall water resource. However, if this water is polluted then it is effectively lost to the overall water resource as it is not usable for any other purpose. In effect, polluted effluents require a volume of clean water resources to dilute it to a level where it can be used by others. This volume is considered to be its grey water footprint (see Water Footprint Briefing Note).Within this project, the average pollution loads observed per tonne of finished paper were: 0.02 t pollution/t paper, 0.06 t pollution/t paper, and 0.17 t pollution/t paper for BOD, COD and TDS, respectively. This suggests that total pollution loads from the sector as a whole are 68 kilo tons, 172 kilo tons, and 479 kilo tons for these pollutants.

5.3 Summary

From the range of WF estimates presented here it can be seen that the overall water footprint of paper mills in Pakistan depends strongly on the feedstock used. Both wheat straw and recovered paper feedstock have negligible water footprints. The only feedstock with a significant associated water footprint is imported pulp. In the case of imported pulp, this water footprint is, by definition, located in other countries. The water footprints of chemical inputs are low compared with wood-based feedstock and the BWF of paper mill operations. This note estimates the green-blue WF of paper in Pakistan to be 348 m^3/t, and that the sector as a whole has a green-blue WF of 1 billion m^3. Due to the nature of the feedstock used in Pakistan 98 per cent of this WF lies outside the country.

This briefing note is intended to demonstrate the water dependency of the paper sector, which is the reason for the focus on the blue water footprint as this is the managed or potentially managed component of the overall water resource. Although no detailed consideration of the water footprint of pollution in the estimates presented here has been included, water quality considerations are, of course, as important as considerations of water volumes. The Water Stewardship in Pakistan project is actively working to help SMEs achieve improvements in the quality of water they discharge, as well as reduce overall water use, and is helping SMEs to engage in water policy discussions. As such a deeper engagement with the paper sector is welcomed.

6

Summary of Water Footprint Assessment of Key Industrial Sectors in Punjab, Pakistan

Chapter 6

Summary of Water Footprint Assessment of Key Industrial Sectors in Pakistan

6.1 Introduction

Detailed water footprint accounts for four key industrial sectors in Punjab and Pakistan (textiles, tanning, sugar and paper) have been developed for the WSP in Pakistan project and are presented as briefing notes in this series. This summary briefing note is intended to provide a wider context to the individual sector briefings and draw out some observations.

Water footprints (WFs) from the individual sector assessments in this series are collated in Table 6.1, which provides best estimates for sector WFs of the four sectors included within the Water Stewardship in Pakistan project. The details of how these figures were derived are given in the respective sector briefing notes in this series. While the grey WF of these sectors are not calculated in these briefs, estimates of overall grey WF by sector are provided in Table 6.2.

Table 6.1: Total country level water footprints for the four sectors included in the Water Stewardship in Pakistan project

Sector	Blue Water footprint (m^3/t)	Total Pakistan production (tonnes/year)	Total Blue WF for sector (MCM/year)	WF type	Notes
Cotton textiles	5,258	3,203,000[1]	16,841	Blue WF	2006 production figure Data are all Pakistan totals
Leather tanning	377	108,000	41	Blue WF	
Sugar **Molasses**	1961 579	5,030,129 2,252,751	9,864 1,304	Blue WF	WF is total for sugar and molasses
Paper	348	2,780,000	967	Combined Blue WF and Green WF	98% of WF located outside Pakistan
Total			**29,017**		

Table 6.2: Estimates for total country level grey WF by sector in Pakistan

Sector	Grey water footprint (m^3/t)	Total WF for sector (MCM/year)
Cotton textiles	3,825	12,251
Leather tanning	76	8
Sugar	245	1,232
Molasses	72	162
Paper	1,392	3,870
Total	**17,524**	

The total blue WF varies greatly for the sectors assessed. Cotton textiles and sugar products dominate the overall blue water consumption from the four sectors, accounting for 58 per cent and 38 per cent respectively of the blue water use of these sectors. This series of briefing notes focuses on the key industrial sectors in Punjab with agricultural supply chains. The blue water footprint of these sectors should be viewed in the context of water consumption of agriculture as a whole, taking into account agricultural production that for the most part does not enter industrial supply chains. Table 6.3 shows the total production and water requirements (green and blue) for the major crops in Pakistan, calculated on the basis of local estimates of crop water requirements. The total water requirements of cotton and sugar are similar to the sectoral blue water footprint estimates presented in Table 6.1, as calculated in the other briefing notes in this series. Differences between the two estimates are likely as the estimates in table 1 include the full supply chain, which for the most part only accounts for blue water use, and from different approaches to calculate the water use. Nevertheless, the similarity in the figures for total water consumption provides a useful check. It should be noted that both wheat and rice take more portion of water than either sugar or cotton (wheat and rice is cultivated on more area than cotton and sugar) but, as these crops do not provide inputs to industrial sectors clustered in the WSP project area, have not been included in this briefing note series.

Table 6.3: Water crop requirements (i.e. theoretical maximum evaporation including blue and green WFs) of major crops in Pakistan (2011-12)

Crop	Area 2011-12	Production 2011-12	Yield 2011-12	Crop water requirement	Estimated total crop water consumption 2011-12[1]
	Million ha	**000' tonnes**	**Kgs/ha**	**mm**	**Million m^3 per year**
Wheat	8.65	23,473	2,714	405	35,033
Rice	2.57	6,160	2,396	1,028	26,420
Sugarcane	1.06	58,397	55,196	1,180	12,508
Cotton	2.84	2312.51	816	650	18,460
Maize	1.087	4,338	3,991	341[2]	3707

The sector analyses also reveal that awareness of the supply chains for raw materials going into production processes is essential to understand where the impact from water consumption, and associated water risks, might be. For example, the sector-specific briefing notes demonstrate that the water footprint of the cotton textile sector lies mostly in cotton growing in Pakistan rather than in the processing stage, and is dominated by blue water consumption. In contrast, the water footprint of leather production is dominated by green water with a relatively low blue water footprint. For leather, a significant component of the blue water footprint (potentially up to 50 per cent) is associated with plant and animal based raw materials other than hides. These raw materials can be importedand therefore a significant component of the water footprint of specific tanneries can lie in other countries, depending on the supply chains of individual tanneries.

6.2 Putting the Water Footprint of Industrial Sectors Assessed in Context

The industrial sectors and their supply chains assessed in this series largely sit within the Indus River basin. In order to establish the importance of the water footprint of these sectors their WF needs to be placed in the context of the availability and use of water resources in the Indus River basin. While the volumes presented in Table 6.1 and Table 6.3 can be viewed as large in absolute terms, it is important to understand if they are significant in comparison with the available blue water resources, i.e. the flow of the Indus. The annual flow of the Indus in the 1950s, prior to the development of the Tarbela and Mangla dams, and the Kotri Barrage, was 100,000 Mm^3 per year near the mouth of the river, and the flow is currently approximately 53,000 Mm^3 (Karim and Veizer, 2002). Estimates of the total water footprint of the four sectors (approximately 30,000 Mm^3) are therefore a very significant component of the overall flow of the Indus.

While these sectors consume a large quantity of water that would otherwise contribute to the flow of the Indus, they also contribute to the pollution load of the river, with associated impacts on the biodiversity. They underpin livelihoods and make a significant contribution to the economy and food security of Pakistan. For example, the textile sector (including cotton and non-cotton textiles) contributes eight per cent to Pakistan's GDP and employs 40 per cent of the labour force (Pakistan Economic Survey 2012-2013), and the leather sector accounts for five per cent of GDP (Pakistan Tanners Association). The sugarcane crop accounts for 3.4 per cent of value addition from agriculture and contributes about 0.7 percent to Pakistan's GDP. These industrial sectors are also, of course, underpinned by the agricultural sector, which supplies the raw materials and as a whole accounts for 21 per cent of GDP, and employs 45 per cent of the labour force (Pakistan Economic Survey 2012-2013). This water footprint study helps to make these trade-offs between economic development/livelihoods and the flow in the Indus, with its associated ecosystem services (e.g. coastal protection, water availability downstream, biodiversity) explicit.

Given the reliance of these key industrial sectors on water in an increasingly water scarce country, and their importance to the economy of Pakistan, it is essential that industry collectively begins to make a positive contribution to debates on water management and encourage better water management in their supply chains. The projected future constraints on water resources means that sectors demonstrating the greatest contribution to social and economic metrics per unit of water consumed are likely to be in a more favourable position. Unless sectors take a positive and proactive approach to supporting the delivery of sustainable water resources they will find themselves at a disadvantage.

The water scarcity context described above defines the physical risk to industry of not having enough water of good quality for its operations or to maintain its supply chains. There are also regulatory risks that derive from arbitrary or unanticipated regulation as governments respond to water crises. Another key dimension to water risk is the reputational risk associated with perceptions of customers of Pakistan's industrial sectors. Retailers in Europe and North America, in particular, are showing increased interest in demonstrating that they are good water stewards. They are scrutinising their supply chains to ensure best practice on water, and other environmental and social issues (WWF, 2013). Businesses in Pakistan that can demonstrate that they are mitigating their water risks, by implementing best practice in their operations and ensuring sustainable water management in their supply chains, can gain a competitive advantage.

6.3 Conclusions

6.3.1 Water in supply chains and operations

Industrial sectors have a key role to play in water management. How water risks are addressed in different sectors will be variable, with a different emphasis from industry to industry and location to location. From the detailed assessments in this series of briefing notes it can be seen that the WF of sourcing the raw materials is volumetrically and by far the most dominant component of the total water footprint in most instances. For those businesses in sectors with large supply chain water footprints within Pakistan and the Indus River basin (e.g. sugar and cotton textile production) the management of water at the basin level should be of critical concern, given the scale of water consumption within the supply chain of these sectors compared with the available water resources, and their importance for the economy. Water management decisions taken at a policy level, with respect to infrastructure, water allocations, environmental flows, and agricultural water management, have fundamental implications for these sectors as a whole, and for people and the environment. These risks are not as acute and immediate as those associated with operational water use within factories, but they do exist and pose a risk to these sectors as a whole in the medium to longer term.

The operational water use, though small in relative volumetric terms, is still critical for business operation and can be the source of the most acute and short term water risk for an individual business. If a business needs that water to operate then its value can greatly exceed its price, and the risk to the business of not having access to that water can be very high if it forces shutdowns. Unsustainable water use means an unsustainable business.

Businesses should therefore seek to understand where the balance of risk lies in their direct operations and supply chains, and the different types of responses that are needed to address risks at these different scales. They should seek to support the establishment of sustainable water management in both the water resources needed for their own operations and their supply chains.

6.3.2 Business responses

For businesses to secure their water supply requires water management at various levels. For example, the Water Stewardship in Pakistan project has shown how critical groundwater is for the operation of businesses in Lahore. This groundwater is recharged from both the Ravi River and Chenab River. Despite being in a different catchment, canal water for irrigation from the Chenab supplements the groundwater resource that the city depends on through percolation in agricultural fields and leakage from the canals. Without considering these connections to the wider river basins that contribute to local water resources, thinking beyond the city boundary to the larger scales of the Ravi and Chenab rivers, and working towards sustainable management of water at this scale, local water sources cannot be assured.

Businesses with large supply chain water footprints need to think at scales larger, as some of their longer term, systemic, risks are driven by water management decisions and actions at the scale of the whole Indus and Pakistan itself.

For businesses to engage with water management issues beyond their own operational water use can, however, bring its own risks. While there are clear and compelling arguments for businesses to address the wider context of the risks they face from water and engage with water governance, there are potential new risks from not approaching it in the correct way. The importance of water to the environment and communities, as well as its relevance to issues of food and energy security means that ultimately water policy and its implementation is, quite rightly, a government mandate and businesses should respect the division between public and private roles and seek to support but not supplant or act counter to government policy and its implementation. A key risk for business is if they are perceived to, or are, using undue influence with government to ensure water policies favourable to business interests at the expense of others: referred to as policy capture. It is essential that if businesses are to engage with water management they should do so collaboratively and transparently with other stakeholders on a shared platform.

Every business can take simple measures to be more efficient with their water and less polluting, often with an associated cost saving to the business. Larger businesses with the capacity and influence to engage at this level can also act as sector leaders in this area by demonstrating and disseminating good water stewardship practices to their peers. Not every business has the capacity to engage with water management policy, but there is a clear role for representative bodies of industry sectors (e.g. chambers of commerce, or other representative bodies) to represent their member's interests at this level in water policy debates. The Water Stewardship in Pakistan project has specifically been set up to help facilitate this and establish mechanisms to achieve water

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WWF-Pakistan was formed in 1970 to address the growing environmental and conservation issues in Pakistan.

WWF-Pakistan is part of the global WWF Network, one of the world's largest and most experienced conservation organizations, with almost five million supporters in more than 100 countries.

The Water Stewardship Project aims to create broad awareness through enhanced understanding and sharing knowledge of the impacts of unsustainable water use.