The water footprint of humanity

The global dimension of water management

Arjen Hoekstra
University of Twente, the Netherlands

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The total water footprint of the average consumer in the world

3800 litre/day

3.8% of the water footprint relates to home water use

96.2% of the water footprint is 'invisible',
related to the products bought on the market

91.5% agricultural products, 4.7% industrial products

22% of the water footprint does not lie within the country of the consumer, but other parts of the world

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Source: Hoekstra & Mekonnen (2012) The Water Footprint of Humanity, *PNAS*

Cotton from the Aral Sea Basin, Central Asia

Cotton for export

Source: NASA

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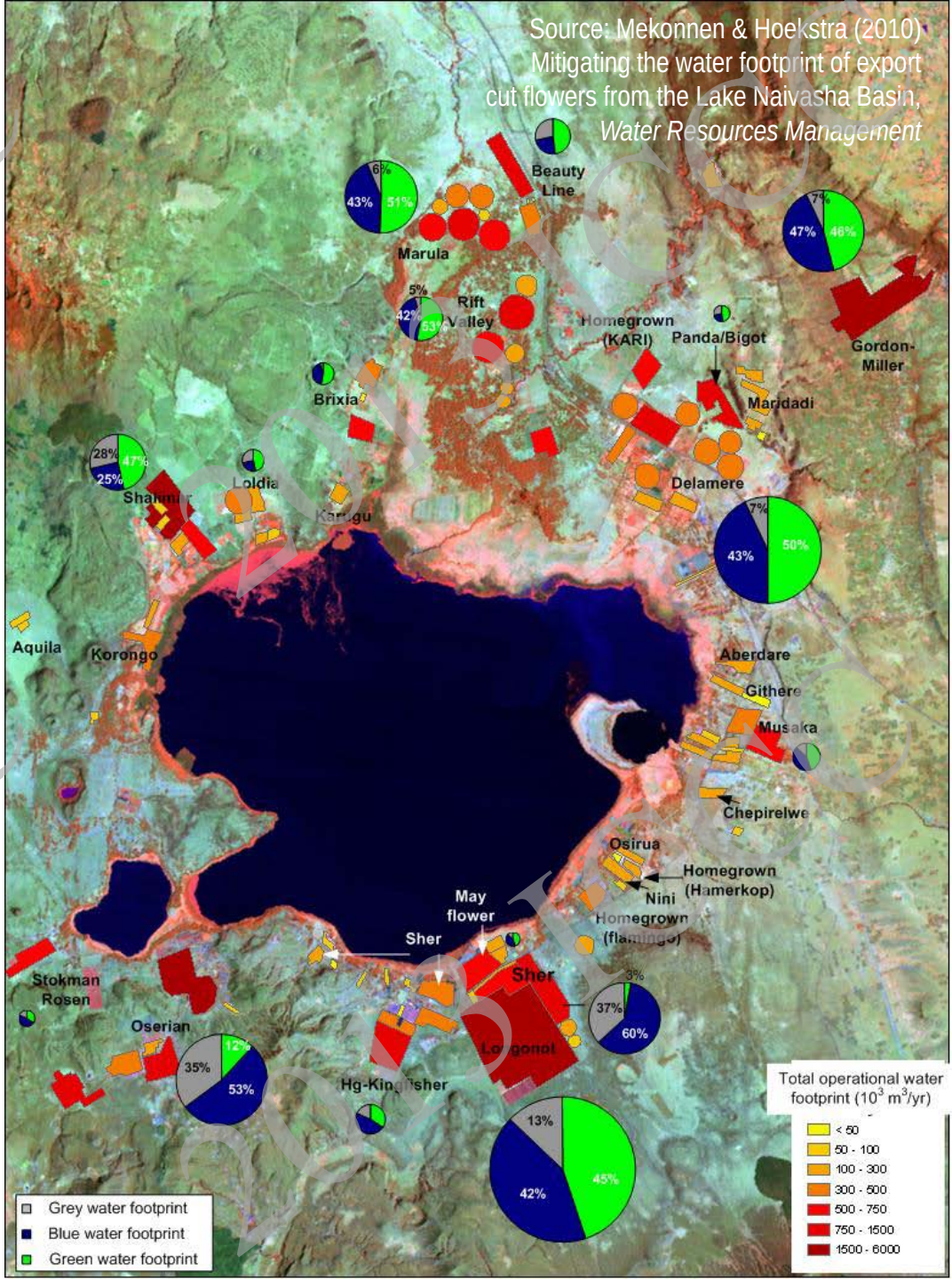
Flowers from Kenya

Decline of lake level in Lake Naivasha



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Globalization of water

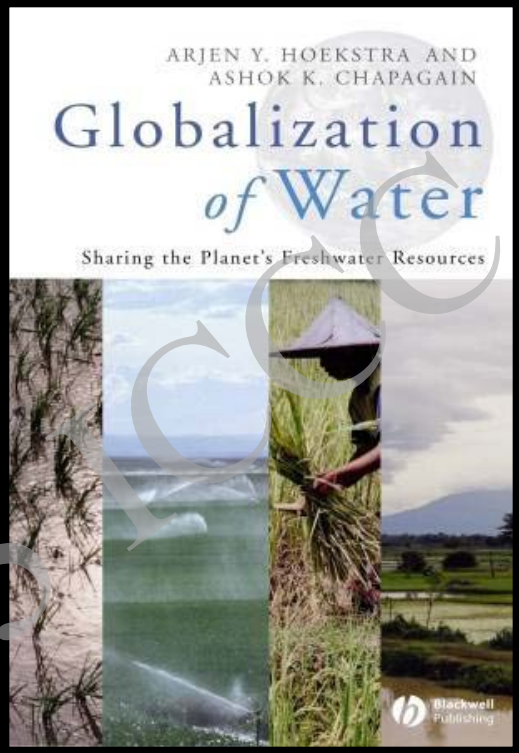
Production

Water consumption and pollution related to production for export; water is not factored into the price of traded commodities

Trade

Water saving, but also water dependency

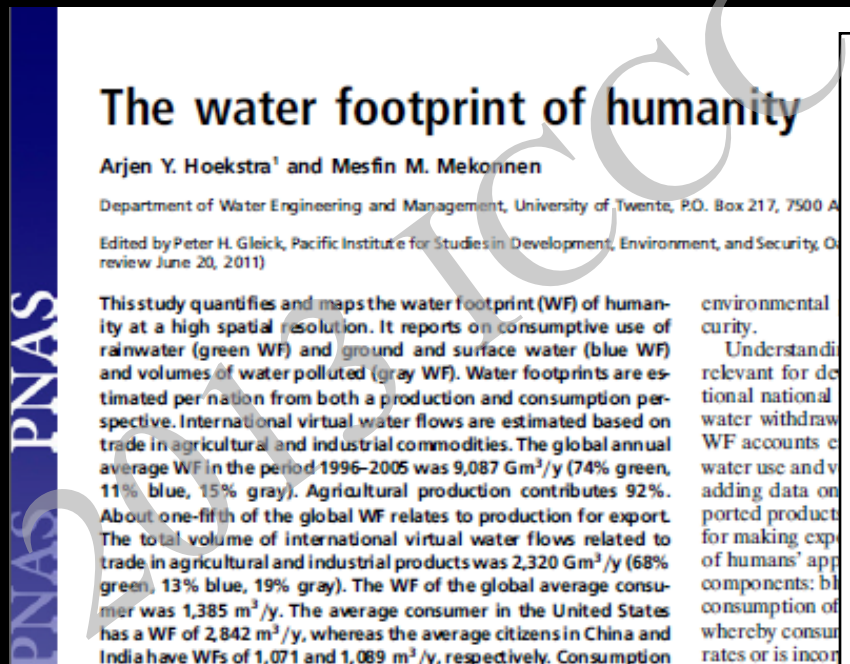
Consumption



Source: Hoekstra & Chapagain (2008) *Globalization of Water*, Blackwell, Oxford, UK

Overview of presentation

- The water footprint concept
- Water footprint of a product
- Water footprint of nations
- Water footprint of business
- What can we do?



PNAS PNAS

The water footprint of humanity

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Edited by Peter H. Gleick, Pacific Institute for Studies in Development, Environment, and Security. O
review June 20, 2011)

This study quantifies and maps the water footprint (WF) of humanity at a high spatial resolution. It reports on consumptive use of rainwater (green WF) and ground and surface water (blue WF) and volumes of water polluted (gray WF). Water footprints are estimated per nation from both a production and consumption perspective. International virtual water flows are estimated based on trade in agricultural and industrial commodities. The global annual average WF in the period 1996–2005 was 9,087 Gm^3/y (74% green, 11% blue, 15% gray). Agricultural production contributes 92%. About one-fifth of the global WF relates to production for export. The total volume of international virtual water flows related to trade in agricultural and industrial products was 2,320 Gm^3/y (68% green, 13% blue, 19% gray). The WF of the global average consumer was 1,385 m^3/y. The average consumer in the United States has a WF of 2,842 m^3/y, whereas the average citizens in China and India have WFs of 1,071 and 1,089 m^3/y, respectively. Consumption

environmental
curity.
Understandi
relevant for de
tional national
water withdraw
WF accounts e
water use and v
adding data on
ported product
for making exp
of humans' app
components: bl
consumption of
whereby consu
rates or is incor

OPEN ACCESS Freely available online

PLoS one

Global Monthly Water Scarcity: Blue Water Footprints versus Blue Water Availability

Arjen Y. Hoekstra[1,2]*, Mesfin M. Mekonnen[1], Ashok K. Chapagain[3], Ruth E. Mathews[2], Brian D. Richter[4]

1 Department of Water Engineering and Management, University of Twente, Enschede, The Netherlands, 2 Water Footprint Network, Enschede, The Netherlands, 3 World Wide Fund-United Kingdom, Godalming, Surrey, United Kingdom, 4 The Nature Conservancy, Charlottesville, Virginia, United States of America

Abstract

Freshwater scarcity is a growing concern, placing considerable importance on the accuracy of indicators used to characterize and map water scarcity worldwide. We improve upon past efforts by using estimates of blue water footprints (consumptive use of ground- and surface water flows) rather than water withdrawals, accounting for the flows needed to sustain critical ecological functions and by considering monthly rather than annual values. We analyzed 405 river basins for the period 1996–2005. In 201 basins with 2.67 billion inhabitants there was severe water scarcity during at least one month of the year. The ecological and economic consequences of increasing degrees of water scarcity – as evidenced by the Rio Grande (Rio Bravo), Indus, and Murray-Darling River Basins – can include complete desiccation during dry seasons, decimation of aquatic biodiversity, and substantial economic disruption.

Citation: Hoekstra AY, Mekonnen MM, Chapagain AK, Mathews RE, Richter BD (2012) Global Monthly Water Scarcity: Blue Water Footprints versus Blue Water Availability. PLoS ONE 7(2): e32688. doi:10.1371/journal.pone.0032688

Editor: Juan A. Añel, University of Oxford, United Kingdom

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The water footprint concept

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Water footprint milestones

2002 introduction of the concept (in science)
1st global water footprint assessment

2004 2nd global water footprint assessment

2007 start uptake of the concept by ngo's, companies, govt's
2008 foundation of the Water Footprint Network
2011 publication of the Global Water Footprint Standard

2012 3rd global water footprint assessment
launch of online Water Footprint Assessment Tool

The water footprint of a product

the volume of fresh water used to produce the product, summed over the various steps of the production chain.

when and where the water was used:
a water footprint includes a temporal and spatial dimension.

Source: Hoekstra et al. (2011) *The Water Footprint Assessment Manual*, Earthscan, London, UK

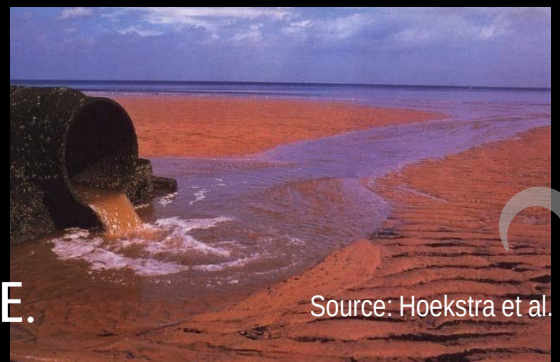
The water footprint of a product

Green water footprint

volume of rainwater evaporated or incorporated into a product

Blue water footprint

volume of surface or groundwater evaporated or incorporated into a product



Grey water footprint

volume of polluted water

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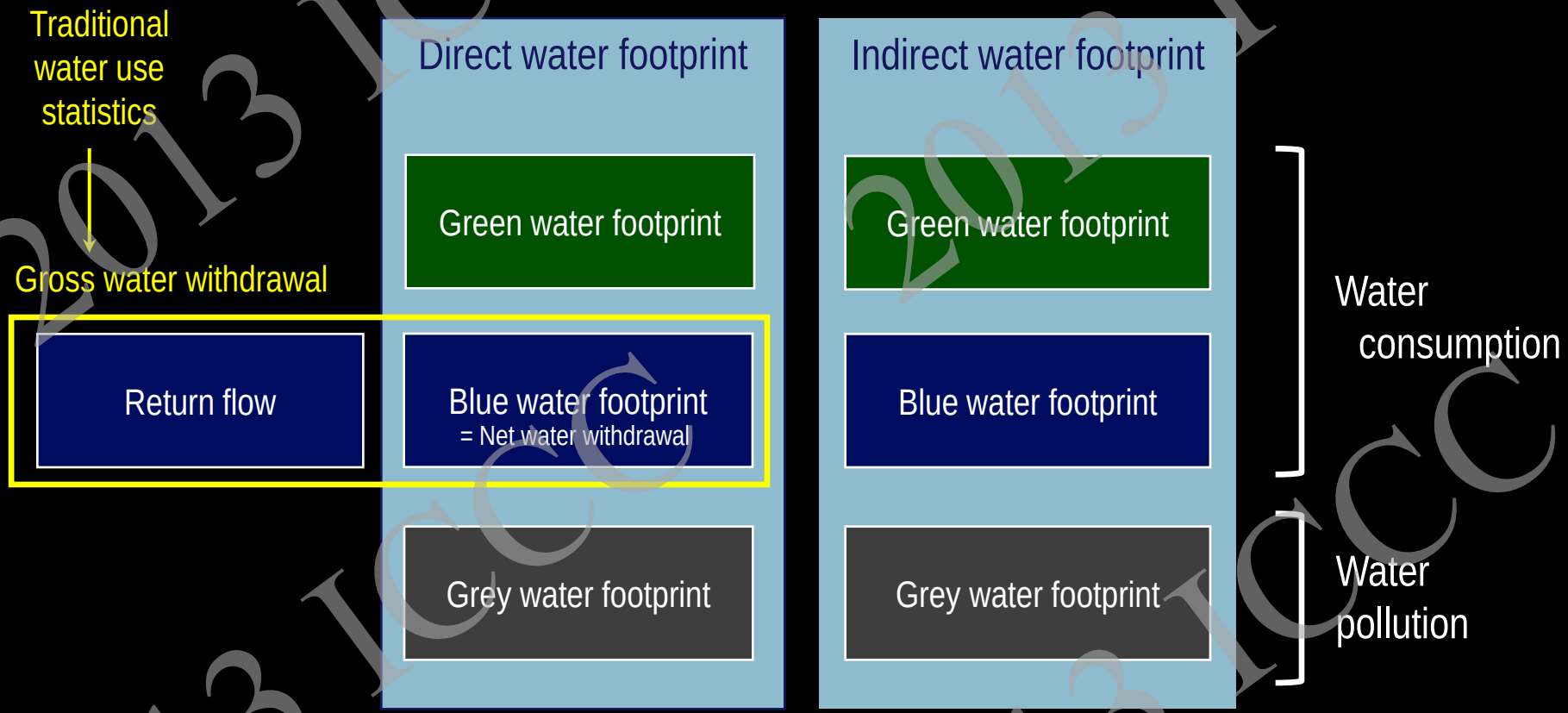
Source: Hoekstra et al. (2011) *The Water Footprint Assessment Manual*, Earthscan, London, UK

Components of a water footprint



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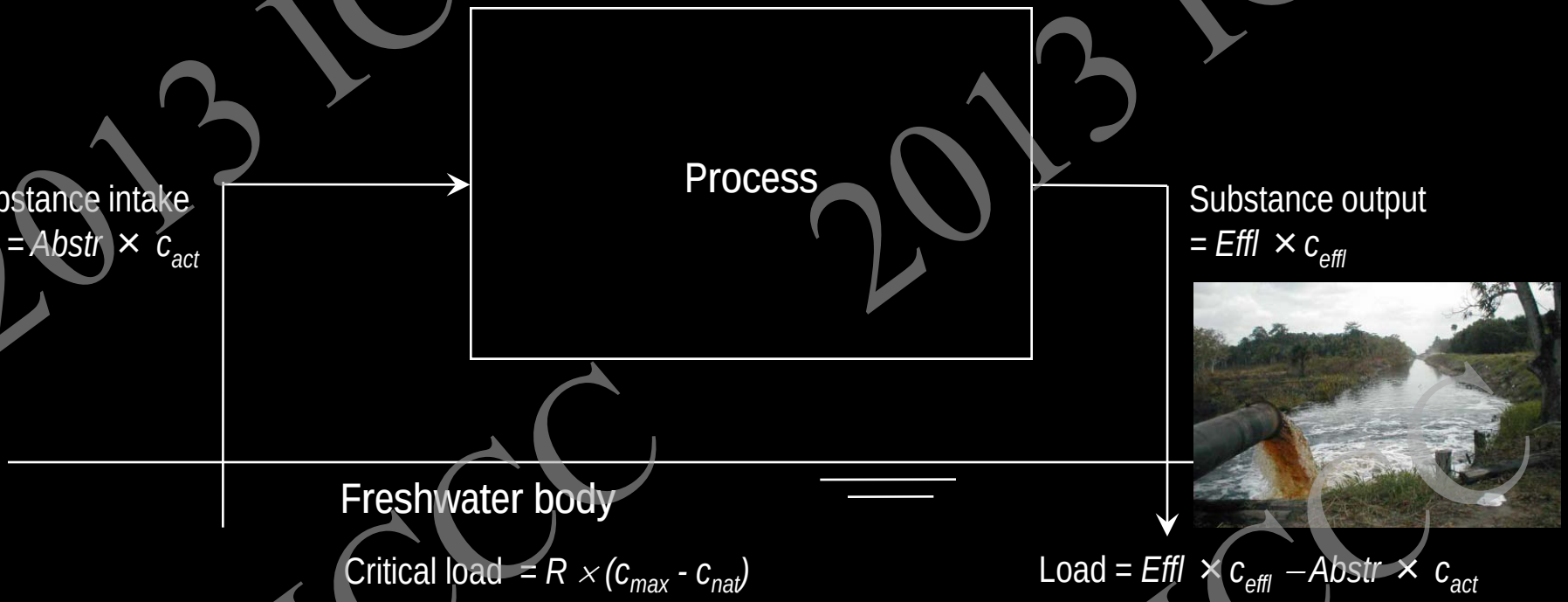
Source: Hoekstra et al. (2011) *The Water Footprint Assessment Manual*, Earthscan, London, UK

Grey water footprint

- volume of polluted freshwater that associates with the production of a product in its full supply-chain.
- calculated as the volume of water that is required to assimilate pollutants based on ambient water quality standards.

Source: Hoekstra et al. (2011) *The Water Footprint Assessment Manual*, Earthscan, London, UK

Grey water footprint



$$\text{Grey water footprint} = \frac{\text{Load}}{\text{Critical load}} \times R = \frac{Effl \times c_{effl} - Abstr \times c_{act}}{c_{max} - c_{nat}}$$

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Source: Hoekstra et al. (2011) *The Water Footprint Assessment Manual*, Earthscan, London, UK

The water footprint of a product

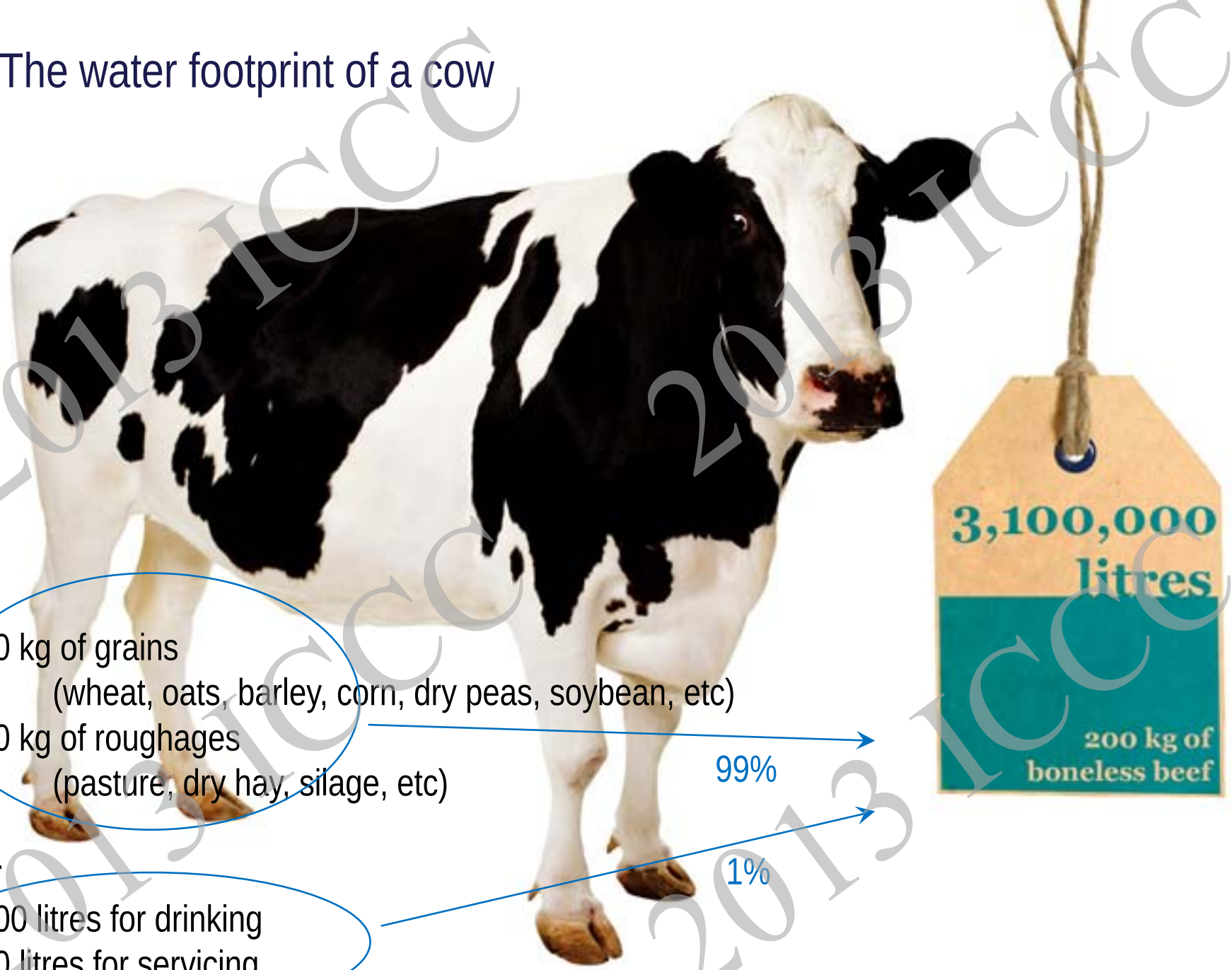
The water footprint of food

Global average water footprint

	litre/kg	litre/kcal
starchy roots	400	0.5
cereals	1600	0.5
sugar crops	200	0.7
pulses	4000	1.1
vegetables	300	1.3
fruits	1000	2.1
pork	6000	2.2
poultry	4000	3.0
beef	15000	10.2

Source: Mekonnen & Hoekstra (2012) A global assessment of the water footprint of farm animal products, *Ecosystems*

The water footprint of a cow



Food

- 1300 kg of grains
  (wheat, oats, barley, corn, dry peas, soybean, etc)
- 7200 kg of roughages
  (pasture, dry hay, silage, etc)

99%

Water

- 24000 litres for drinking
- 7000 litres for servicing

1%

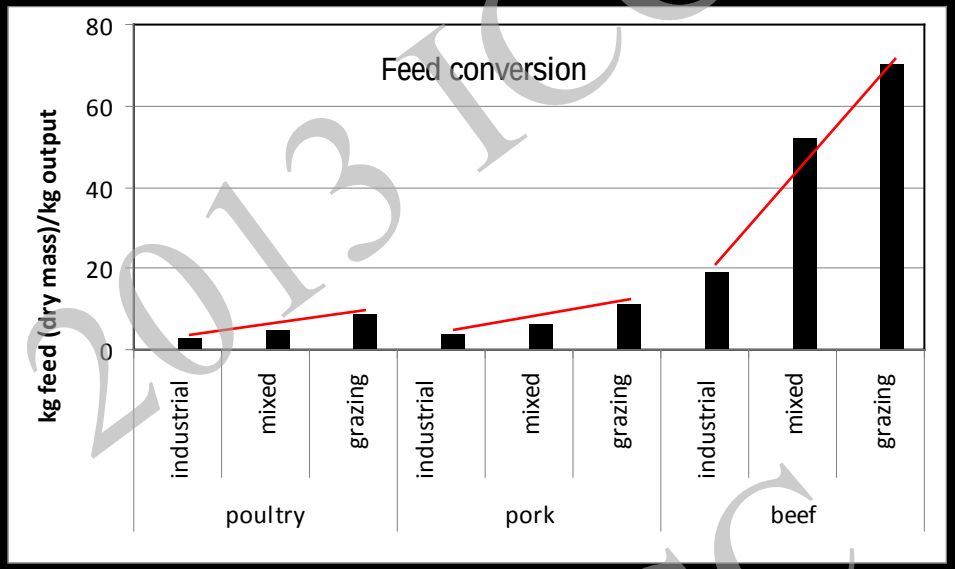
Source: Hoekstra & Chapagain (2008) *Globalization of Water*, Blackwell, Oxford, UK

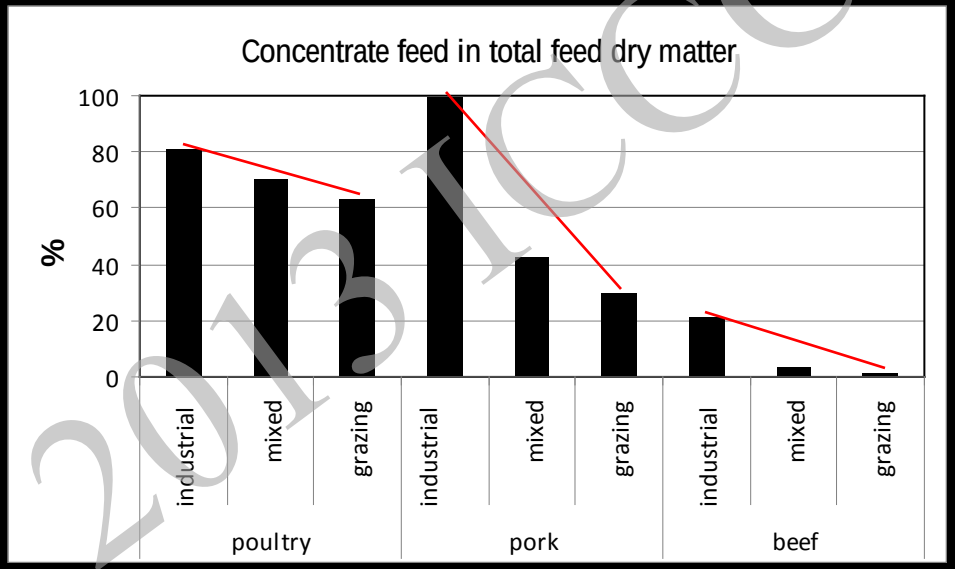
The water footprint of beef

Source: Hoekstra & Chapagain (2008) *Globalization of Water*, Blackwell, Oxford, UK

≠

The two major factors





- feed conversion improves from grazing to industrial systems.

- but at the cost of more high-nutrient concentrate feed with a larger water footprint than roughages.

Source: Mekonnen & Hoekstra (2012) A global assessment of the water footprint of farm animal products, *Ecosystems*

Meat versus vegetarian diet

Industrialised countries:

Meat diet	kcal/day	litre/kcal	litre/day
Animal origin	950	2.5	2375
Vegetable origin	2450	0.5	1225
Total	3400		3600

Source: Hoekstra (2013) The Water Footprint of Modern Consumer Society, Routledge, London, UK.

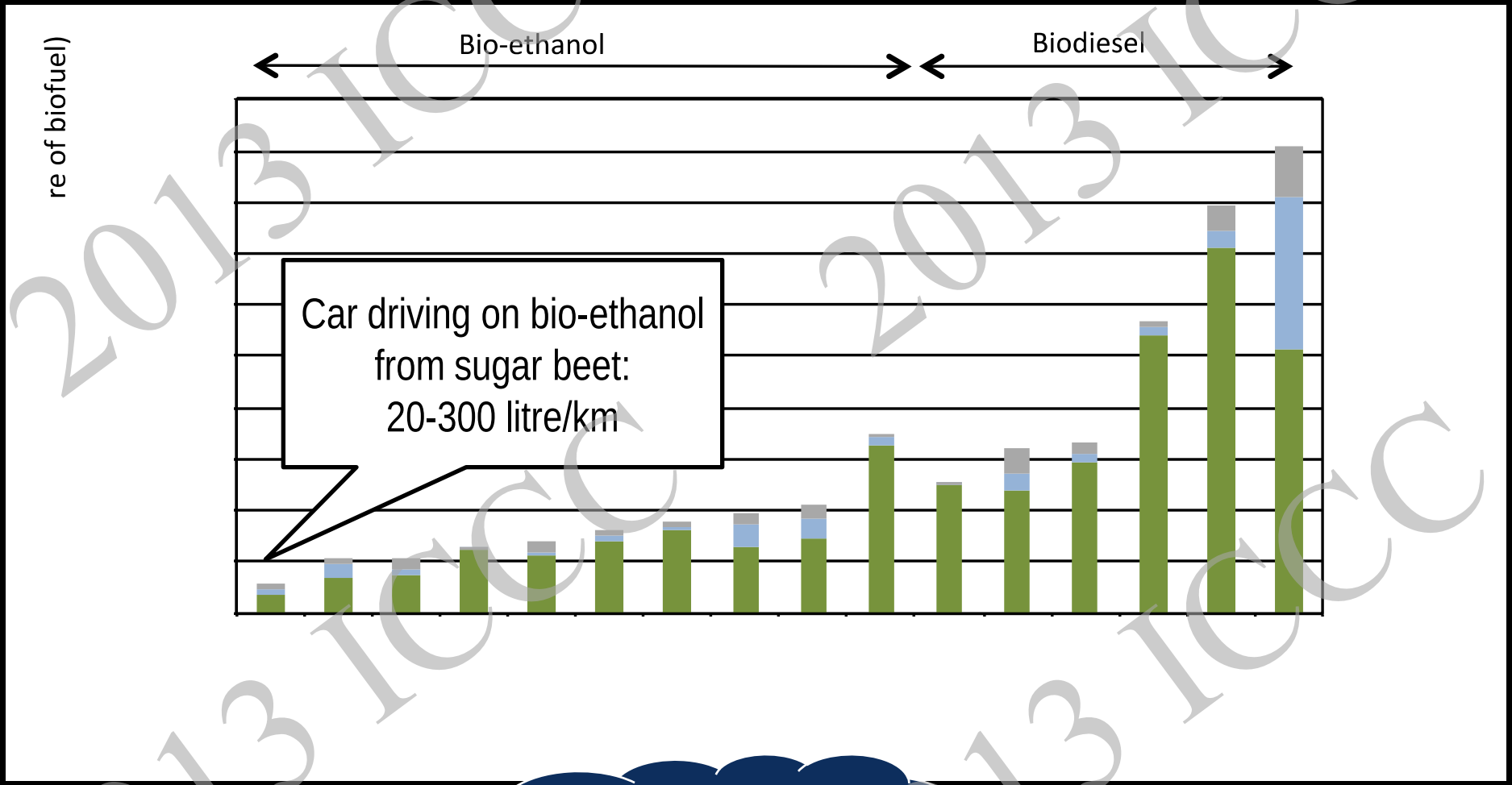
Meat versus vegetarian diet

Industrialised countries:

Meat diet	kcal/day	litre/kcal	litre/day	Vegetarian diet	kcal/day	litre/kcal	litre/day
Animal origin	950	2.5	2375	Animal origin	300	2.5	750
Vegetable origin	2450	0.5	1225	Vegetable origin	3100	0.5	1550
Total	3400		3600	Total	3400		2300

Source: Hoekstra (2013) The Water Footprint of Modern Consumer Society, Routledge, London, UK.

Water footprint of biofuels from different crops [litre/litre]



▸ coherent energy-water strategies?

Source: Mekonnen & Hoekstra (2011) The green, blue and grey water footprint of crops and derived crop products, *Hydrology and Earth System Sciences*

Water footprint of nations

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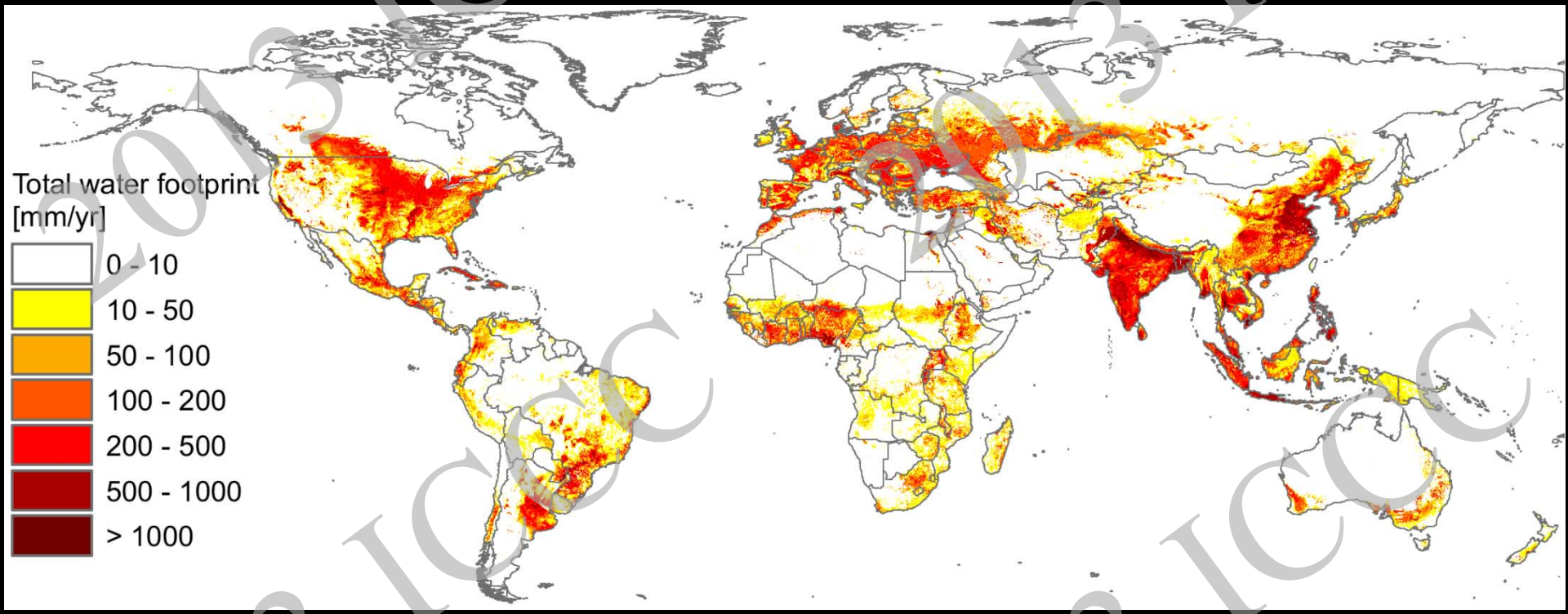
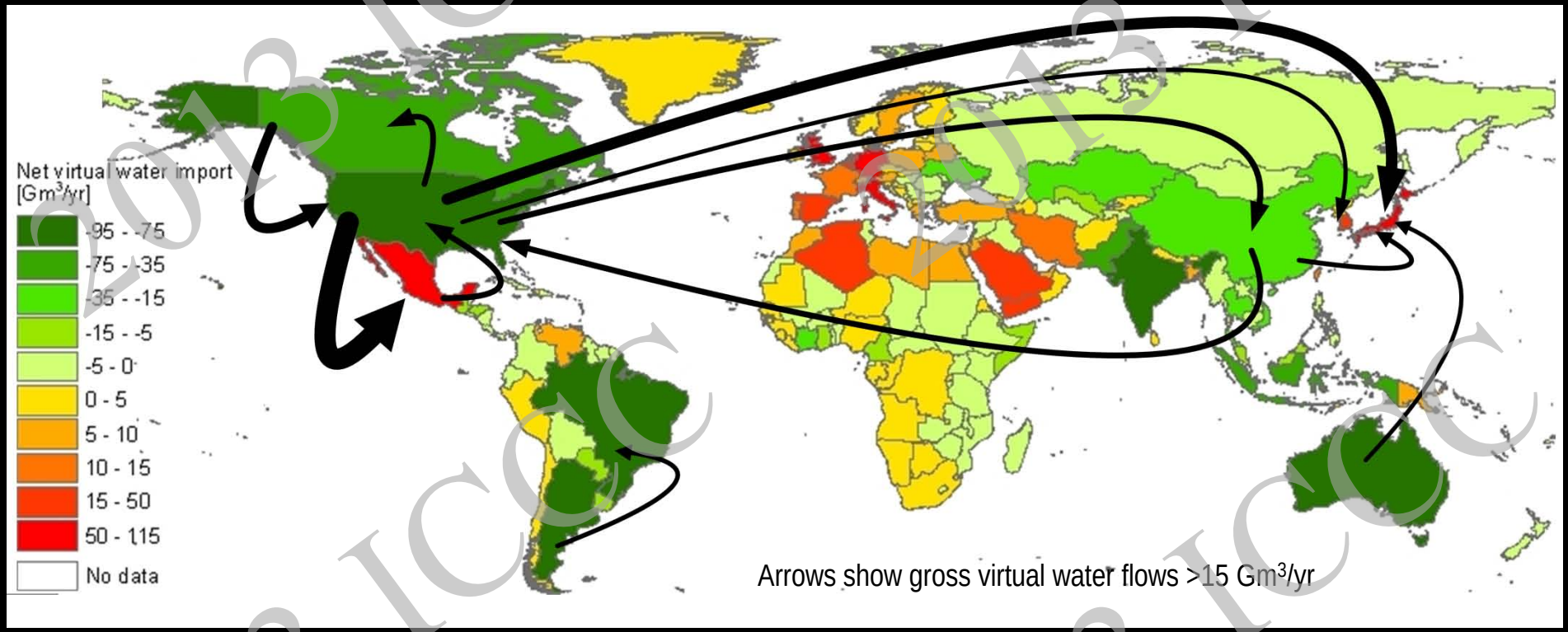
The spatial distribution of the water footprint of humanity



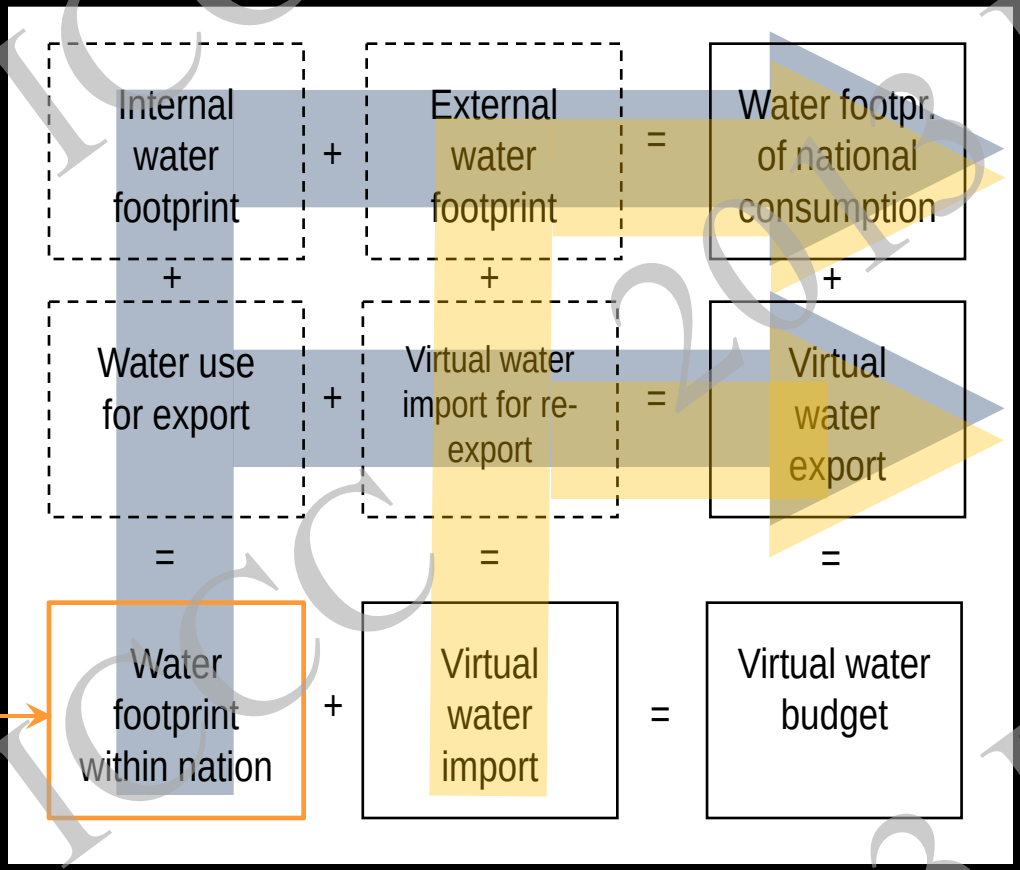
Source: Hoekstra & Mekonnen (2012) The Water Footprint of Humanity, *PNAS*

National virtual water balances



Source: Hoekstra & Mekonnen (2012) The Water Footprint of Humanity, *PNAS*

National water footprint accounting framework



Focus of traditional water use statistics

(and within that focus a limitation to blue water withdrawals)

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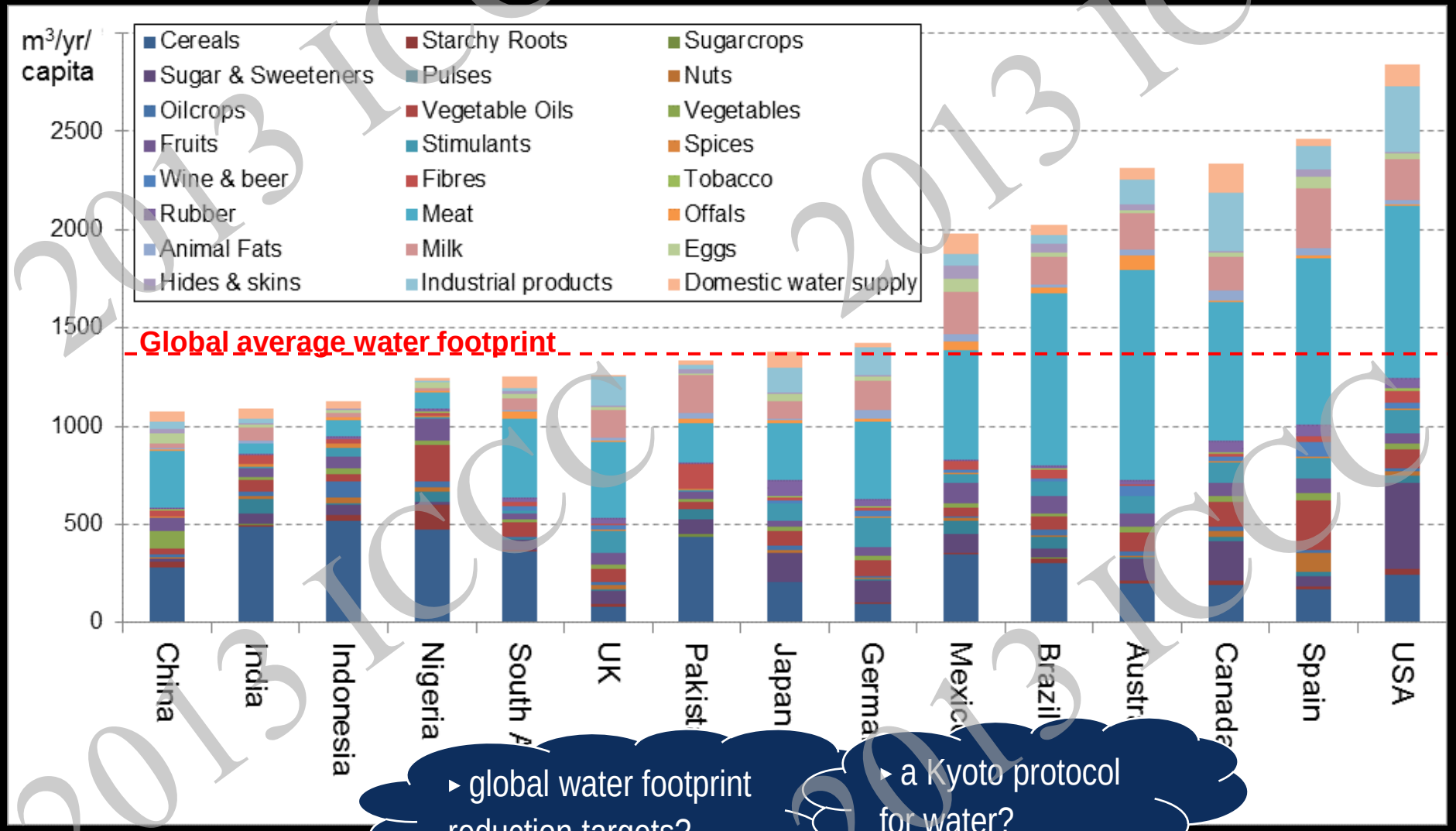
Source: Hoekstra et al. (2011) The Water Footprint Assessment Manual, Earthscan, London, UK

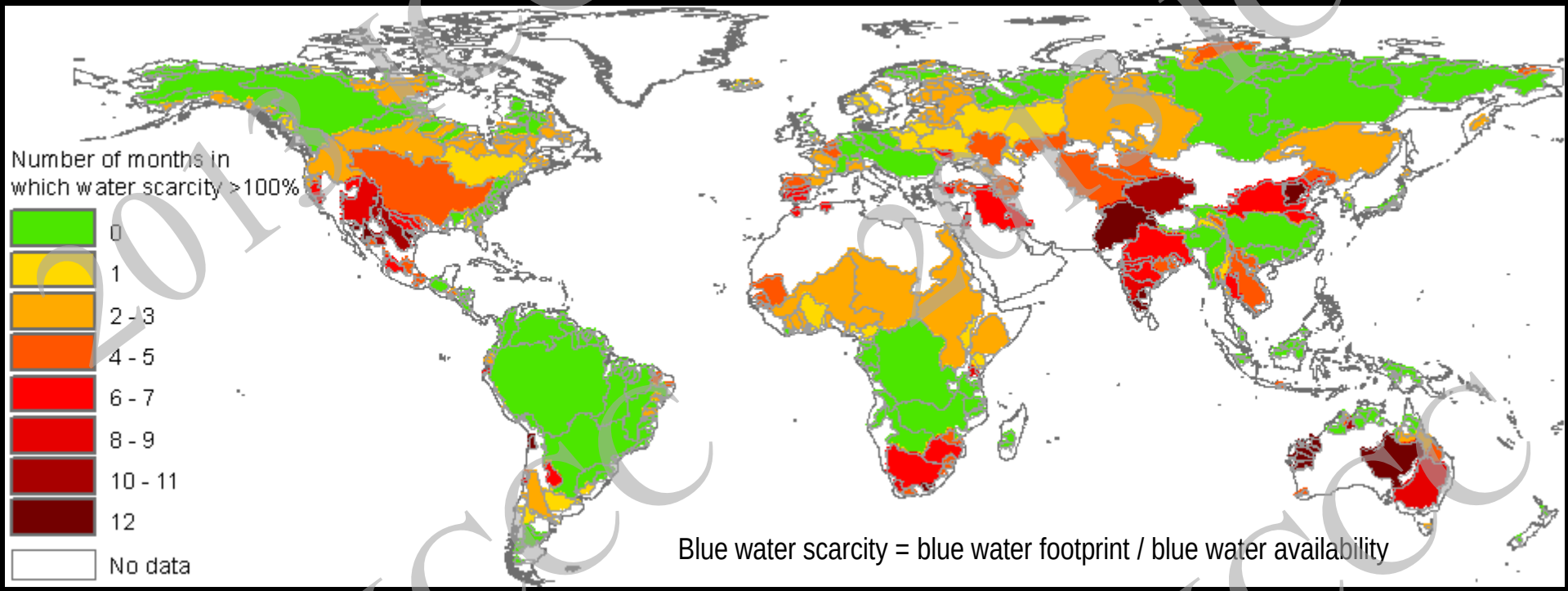
Water footprint of national consumption



- global water footprint reduction targets?
- a Kyoto protocol for water?

Source: Hoekstra & Mekonnen (2012) The Water Footprint of Humanity, *PNAS*

Number of months with blue water scarcity > 100%



Source: Hoekstra et al. (2012) Global monthly water scarcity: blue water footprints versus blue water availability, *PLoS ONE*

- an international water pricing protocol?
- minimum water rights

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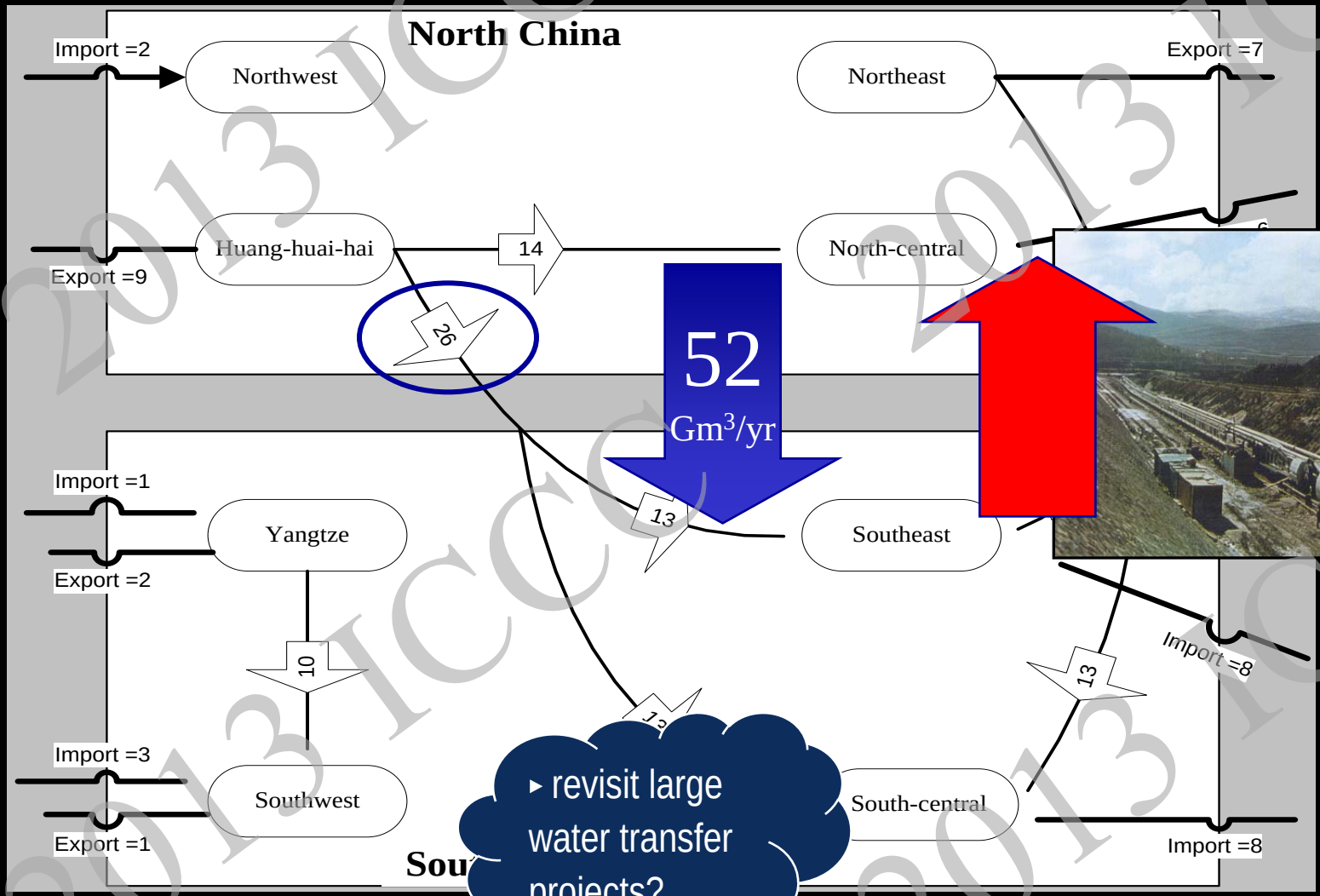
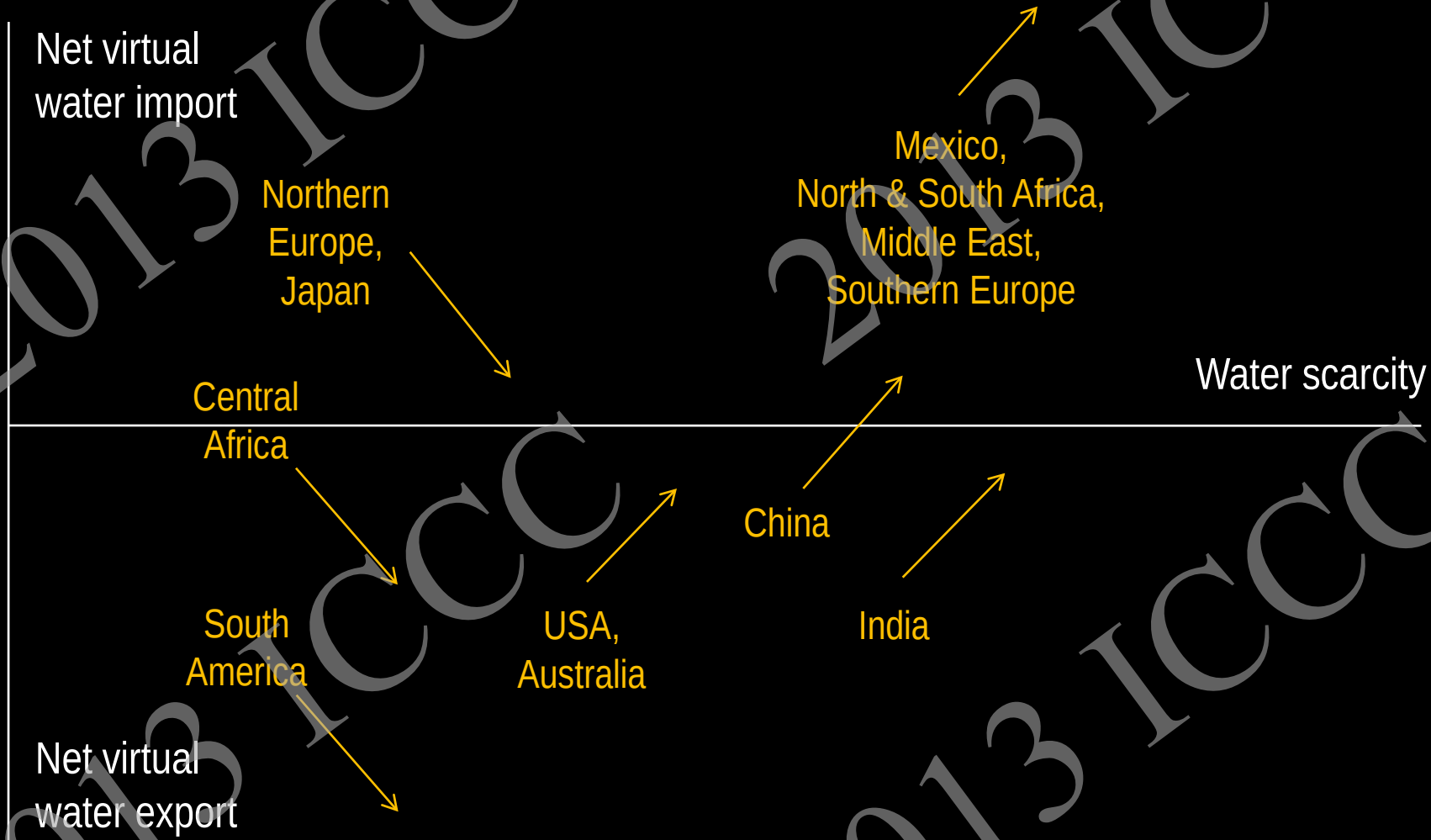
Virtual water transfers in China



Sources: Ma et al. (2006), Hoekstra & Chapagain (2008)

Future under growth and climate change



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Source: Hoekstra (2012)

The water footprint of business

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The Coca Cola Company

New Delhi, 4 Oct 2006

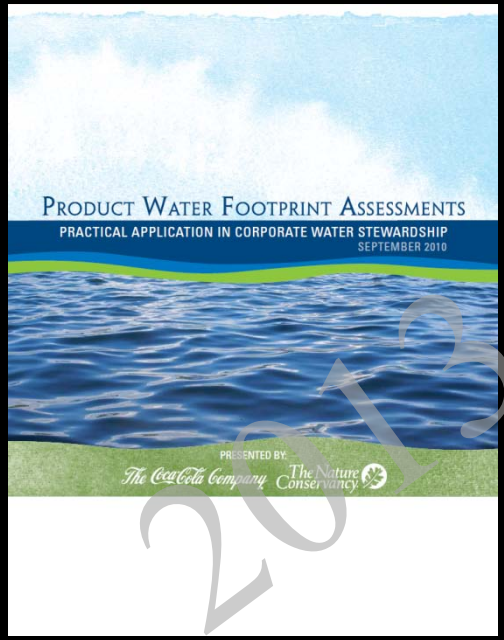
Water footprint of a Coke

Water footprint of a 0.5 litre PET-bottle coke
as produced in the Dongen factory, the Netherlands

0.44 litre water content
27.6 litre for sugar
5.3 litre for PET bottle and closure
3.0 litre for other ingredients & overheads

---

36 litre total



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Water footprint: why businesses are interested

Water risks for business

- Physical risk
- Reputational risk
- Regulatory risk
- Financial risk

Water opportunity for business

- frontrunner advantage
- corporate image

Corporate social responsibility

Water footprint: what's new for business

- From focus on own operations to supply-chain thinking
- From focus on water withdrawals to considering consumptive water use
- From securing the 'right to abstract' to assessing environmental & social implications of the company's direct & indirect water use
- From meeting 'emission permits' to assessing the company's contribution to pollution

What can we do?

Water footprint reduction: what can we do?

- Towards full water recycling in industries: zero blue water footprint
- Towards full recycling of materials and heat: zero grey water footprint

- Make rainwater more productive: lower green water footprint
- Towards supplementary or deficit irrigation & application of precision irrigation techniques: lower blue water footprint
- Towards organic or precision farming: zero grey water footprint

Reducing humanity's water footprint – Companies

Shared terminology & calculation standards

– Global Water Footprint Standard

Product transparency

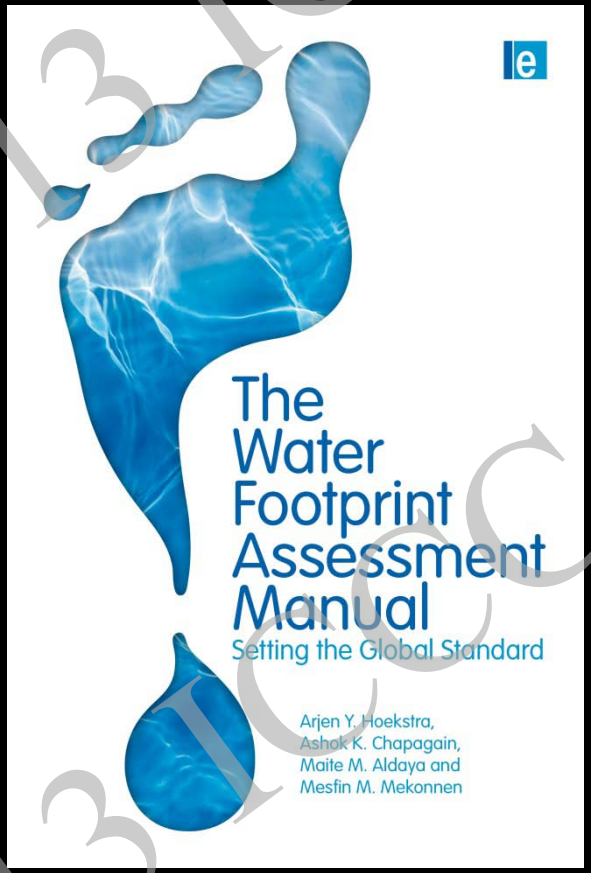
– water footprint reporting / disclosure

– labelling of products

– certification of businesses

Quantitative footprint reduction targets

– benchmarking



The Water Footprint Assessment Manual
Earthscan, London, UK, 2011

International water governance

- product labeling?
- certification of industries?
- water disclosure?

- global water footprint reduction targets?
- a Kyoto protocol on water?

- WTO trade rules?

- an international water pricing protocol?
- minimum water rights?

- coherent energy-water strategies?

The Water Footprint Network

Mission: Promoting sustainable, equitable and efficient water use through development of shared standards on water footprint accounting and guidelines for the reduction and offsetting of impacts of water footprints.

Network: bringing together expertise from academia, businesses, civil society, governments and international organisations.

Overview of partners Water Footprint Network

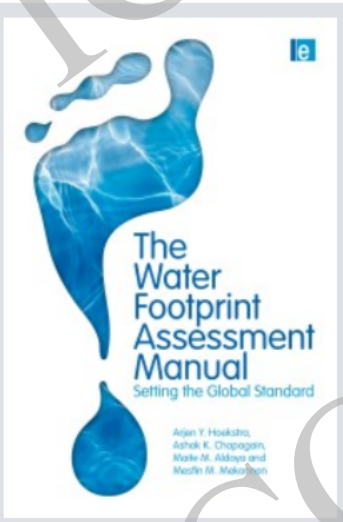
Partners by category	
XL company	30
Large company	10
Medium company	23
Small company	33
Government	10
International organisation	9
Academic Institute	29
Civil society / ngo	25

www.waterfootprint.org

Water Footprint

Water Footprint NETWORK

The Water Footprint Assessment Manual



The water footprint assessment manual: Setting the global standard

Authors:
Arjen Y. Hoekstra, Ashok K. Chapagain, Maite M. Aldaya, Mesfin M. Mekonnen

Publisher:
Earthscan

2011, ISBN: 978-1-84971-279-8
Hardcover, 224 pages

Download pdf.

Order the book through the publisher.

Partners of the Water Footprint Network can order the book at a discount of 20%. Click here for more info.

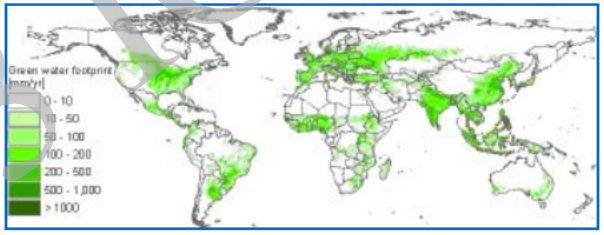
The book offers a complete and up-to-date overview of the global standard on water footprint assessment as developed by the Water Footprint Network. More specifically it:

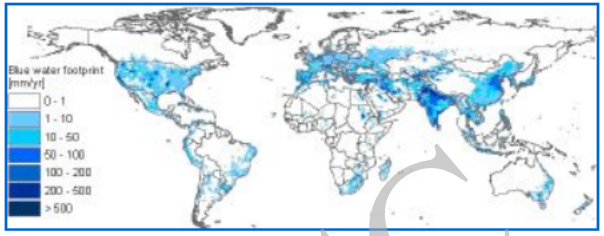
- Provides a comprehensive set of methods for water footprint assessment
- Shows how water footprints can be calculated for individual processes and products, as well as for consumers, nations and businesses
- Contains detailed worked examples of how to calculate green, blue and grey water footprints
- Describes how to assess the sustainability of the aggregated water footprint within a river basin or the water footprint of a specific product
- Includes an extensive library of possible measures that can contribute to water footprint reduction

Water Footprint

Water Footprint NETWORK

WaterStat





WaterStat is a database with water statistics maintained by the Water Footprint Network.

Product water footprint statistics
Find here statistics on green, blue and grey water footprints of crops, derived crop products, biofuels, and farm animal products. All data are available at national and sub-national level.

National water footprint statistics
Download here statistics on green, blue and grey water footprints of national production and consumption.

International virtual water flow statistics
Here you find detailed statistics on international virtual water trade flows and on water savings related to international trade.

Water scarcity statistics
This is the only database in the world providing data on blue water scarcity per river basin on a monthly basis.

www.waterfootprint.org

Introduction
Agenda
About WFN
Product Water Footprints
Your Water Footprint
National Water Footprints
Corporate Water Footprints
Global Water Footprint
Training Materials
Publications
Glossary
FAQ
Links
Contact

Your individual water footprint is equal to the water required to produce the goods and services consumed by you. Please take your time and feel free to use the extended water footprint calculator to assess your own unique water footprint. The calculations are based on the water requirements per unit of product as in your country of residence.

Note: put decimals behind a point, not a comma (e.g. write 1.5 and not 1,5).

Select a Country

Food consumption

Cereal products (wheat, rice, maize, etc.)	kg per week
Meat products	kg per week
Dairy products	kg per week
Eggs	number per week
How do you prefer to take your food?	High fat
How is your sugar and sweets consumption?	High
Vegetables	kg per week
Fruits	kg per week
Starchy roots (potatoes, cassava)	kg per week
How many cups of coffee do you take per day?	cup per day
How many cups of tea do you take per day?	cup per day

Domestic water use