6th THAICID NATIONAL SYMPOSIUM

แนวคิดในการบริหารจัดการน้ำสำหรับข้าว ในประเทศไทยโดยอาศัยหลักการวอเตอร์ฟุตพริ้นท์

Water Management for Rice Production in Thailand based on the Concept of Water Footprint

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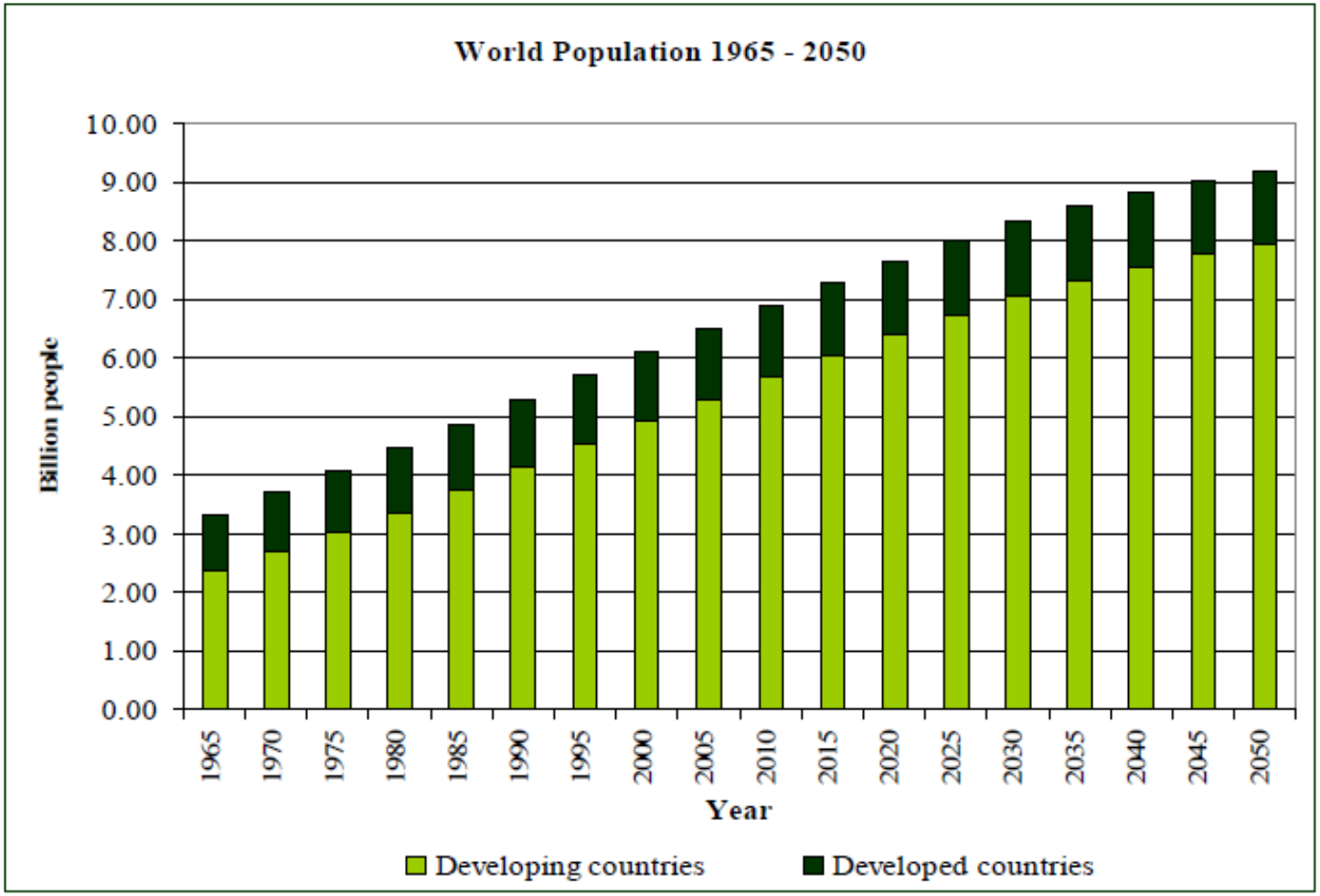
Royal Irrigation Department[1,2,3,4,5,6]

21 June 2011

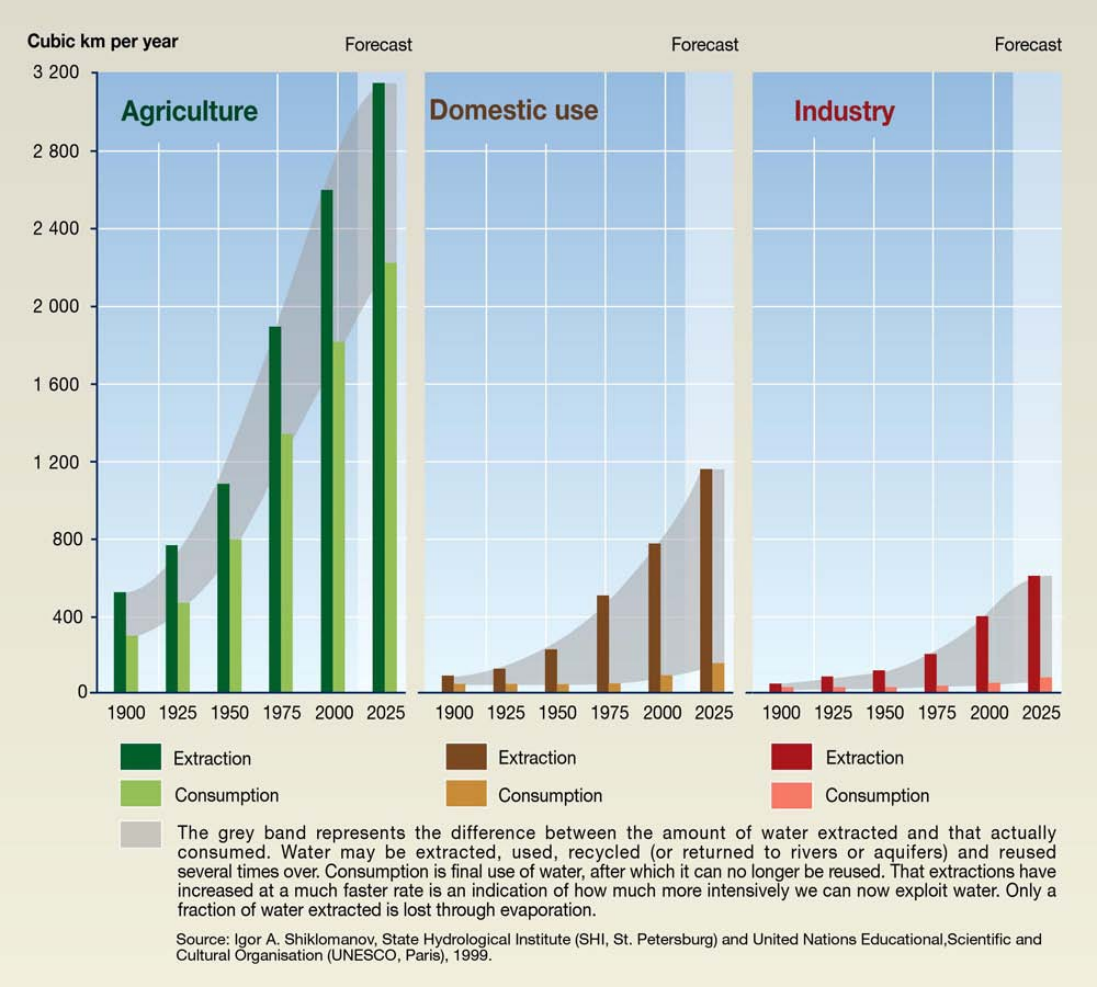
Background of Water Footprint

World population growth:



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)

Trends in global water use by sector



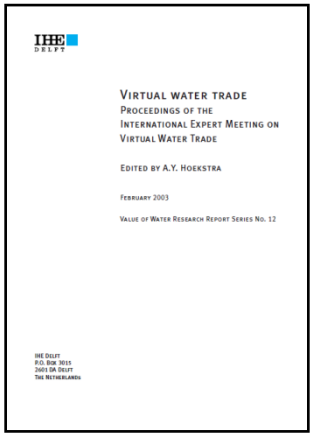
Source: UNEP (2008)

Drought

Water pollution

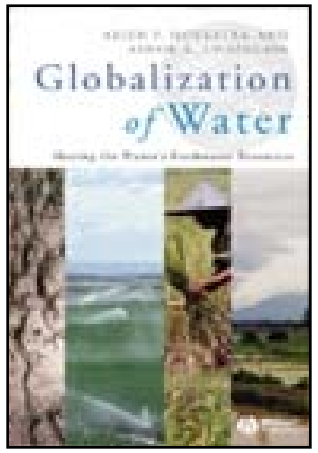
Introduction of Water Footprint

WF introduced by Prof.Hoekstra (U of Twente) Dec. 2002



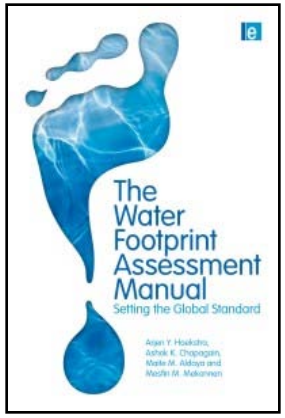
2003

2004

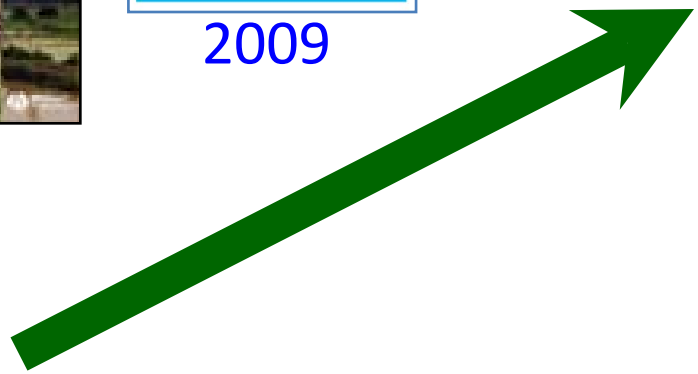


2008

2009



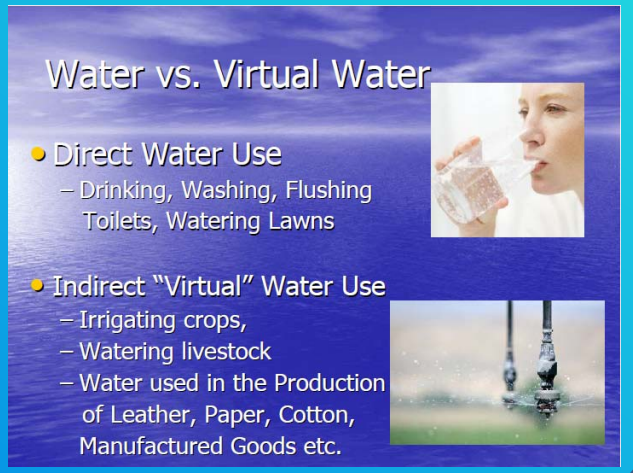
2011



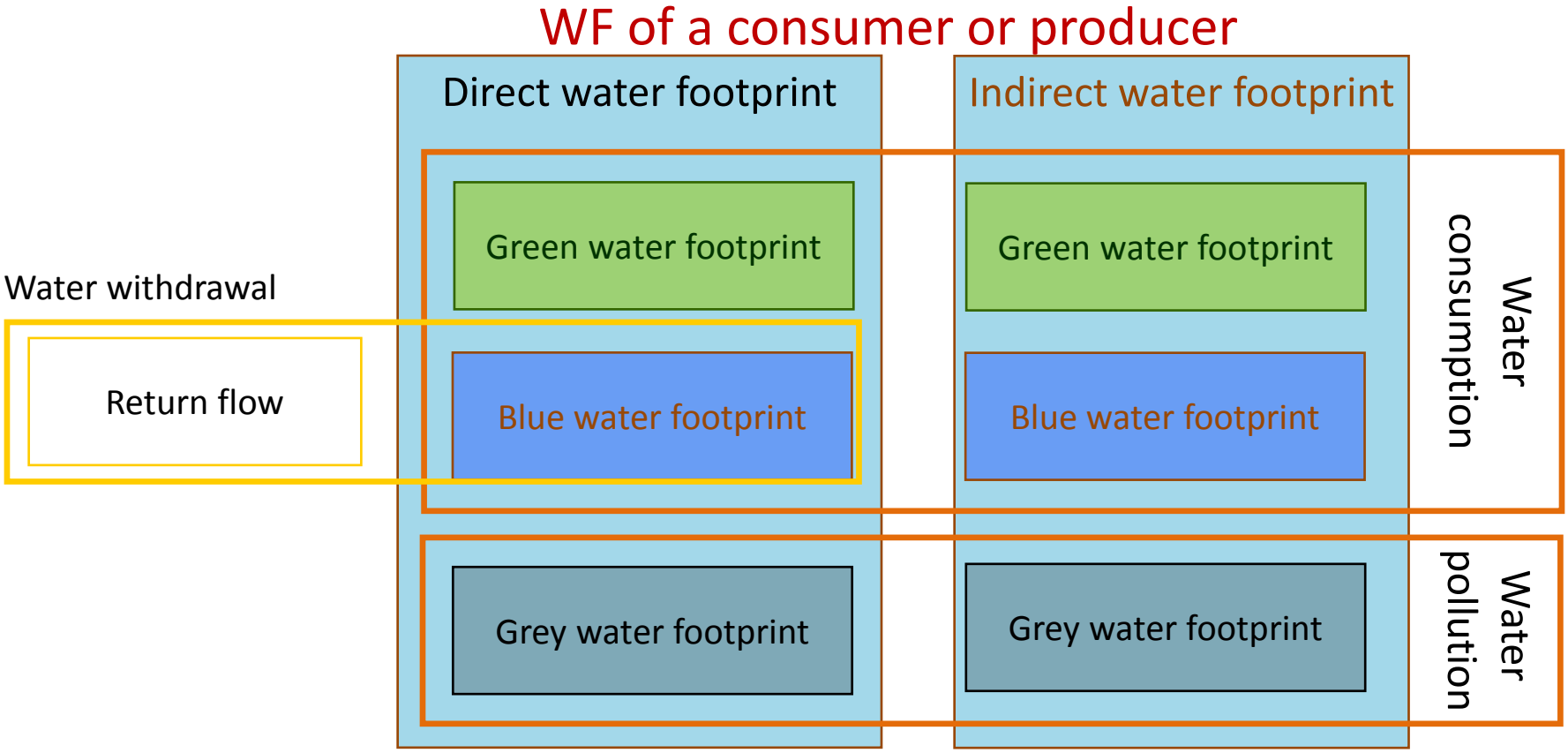
What is Water Footprint ?

Water Footprint: An indicator of freshwater use, which considers in both direct and indirect water use of a consumer or producer.

- It refers water volume used,
- where the WF is located
- what source of water is used
- when the water is used.



Components of Water Footprint



Green WF : Volume of rainwater consumed during the production = CWU_{green} / Y

Blue WF : Volume of surface and groundwater consumed as a result of the production of a good or service = CWU_{blue} / Y

Grey WF : Volume of freshwater required to assimilate the load of pollutants $=(\alpha AR)/(Cmax-Cnat)/Y$

[Hoekstra et al., 2011]

What advantages of Water footprint? A strong tool for WM

- Improvement of water management (WM) by:
  - decreasing water demand: water saving in HH
  - improving the efficiency of water use (water recycle)
- Concentrate more about water depletion or pollution through imported products (water used, leaching)
- Awareness raising, policy formulation

Source: Schreier *et al., 2007, Hoekstra et al. 2011*

Sorts of WF

Consumer
(ΣWF all products consumed)
Ex. Individual

Product
(ΣWF process steps)
Ex. Rice, wheat, meat

Community
(ΣWF its members)
Ex. Provinces of Indonesia

Within a geographically delineated area
(ΣWF all processes in the area)
Ex. Guadiana River basin (Spain)

National consumption
(ΣWF its inhabitans)
Ex. Netherlands, Spain, India

Business
(ΣWF final products produced)
Ex. Coca-Cola, Nestle

WF Partnership

Water labels

Elovena Oat Flake

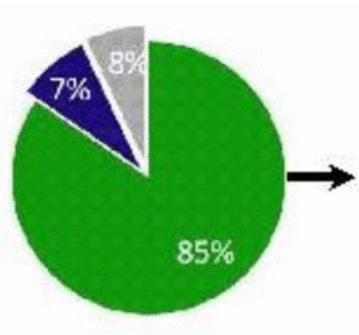
(Raisio, Finland)

May 2009

Steam shower

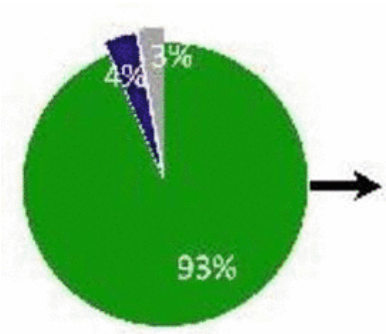
http://www.waterrating.gov.au/consumers/index.html

Water footprint of products



1000 litres water

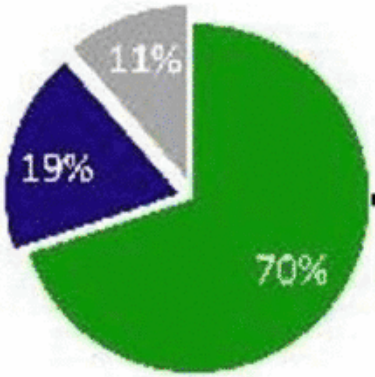
1 litre milk



15400 litres water

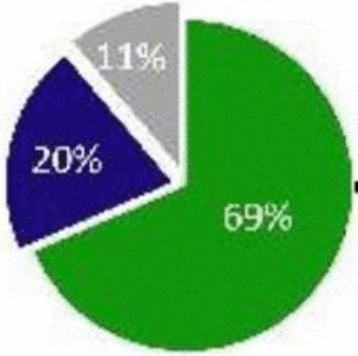
1 kg beef

Water footprint of products



1600 litres water

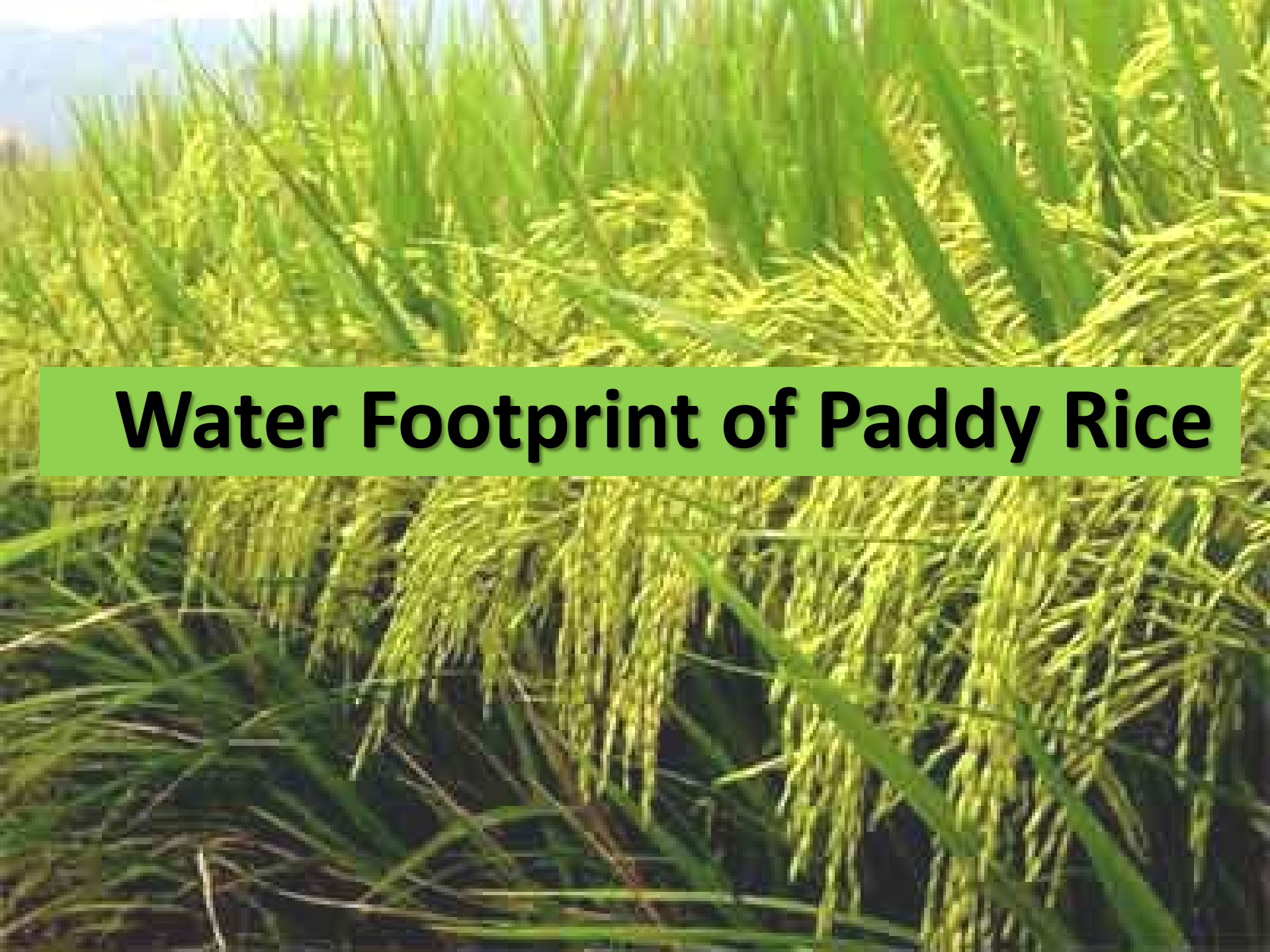
1 kg wheat bread



2500 litres water

1 kg rice

Source: http://www.waterfootprint.org



Water Footprint of Paddy Rice

Table 5: WF and percolation per unit of paddy rice produced (m^3/ton) in the 13 major rice –producing countries during 2000-2004

Country	Water footprint				Percolation		
	Green	Blue	Grey	Total	Rain water	Irrigation water	Total
China	367	487	117	971	338	448	785
India	1077	826	116	2020	794	609	1403
Indonesia	583	487	118	1187	505	422	927
Bangladesh	549	577	103	1228	550	578	1128
Viet Nam	308	203	127	638	420	277	697
Thailand	942	559	116	1617	787	467	1253
Myanmar	846	378	50	1274	763	341	1103
Japan	341	401	61	802	348	409	757
Philippines	844	423	78	1345	775	388	1163
Brazil	791	670	61	1521	691	585	1276
USA	227	835	101	1163	141	517	658
Korea, Rep.	356	388	84	829	303	331	634
Pakistan	421	2364	88	2874	248	1394	1642

Source: Chapagain *et al.* (2010b)

Statistics for the 13 largest rice producing countries during 2000-2004

Country	Average production (ton/yr)*	Global share (%)*	Average area harvested (ha/yr)*	Average yield (ton/ha)*
China	177,657,605	30.0%	28,670,030	6.19
India	126,503,280	21.4%	43,057,460	2.93
Indonesia	52,014,913	8.8%	11,642,899	4.47
Bangladesh	37,217,379	6.3%	10,641,271	3.50
Viet Nam	33,960,560	5.7%	7,512,160	4.52
Thailand	26,800,046	4.5%	10,038,180	2.67
Myanmar	22,581,828	3.8%	6,431,364	3.51
Philippines	13,322,327	2.3%	4,056,577	3.28
Brazil	11,068,502	1.9%	3,371,562	3.28
Japan	10,989,200	1.9%	1,706,000	6.44
USA	9,520,015	1.6%	1,285,671	7.40
Pakistan	6,910,650	1.2%	2,339,200	2.95
Korea, Rep.	6,808,450	1.2%	1,045,173	6.51
Sub total	535,354,755	90.5%	131,797,547	-
Global total	591,751,209	100%	150,666,851	4.49

* Source: FAO (2009).

** Average fertilizer use in rice cultivation. Source: IFA *et al.* (2002).

Vietnam
A=47x10^6 rai
Y=723 kg/rai

Thailand
A=62.7x10^6 rai
Y=416 kg/rai

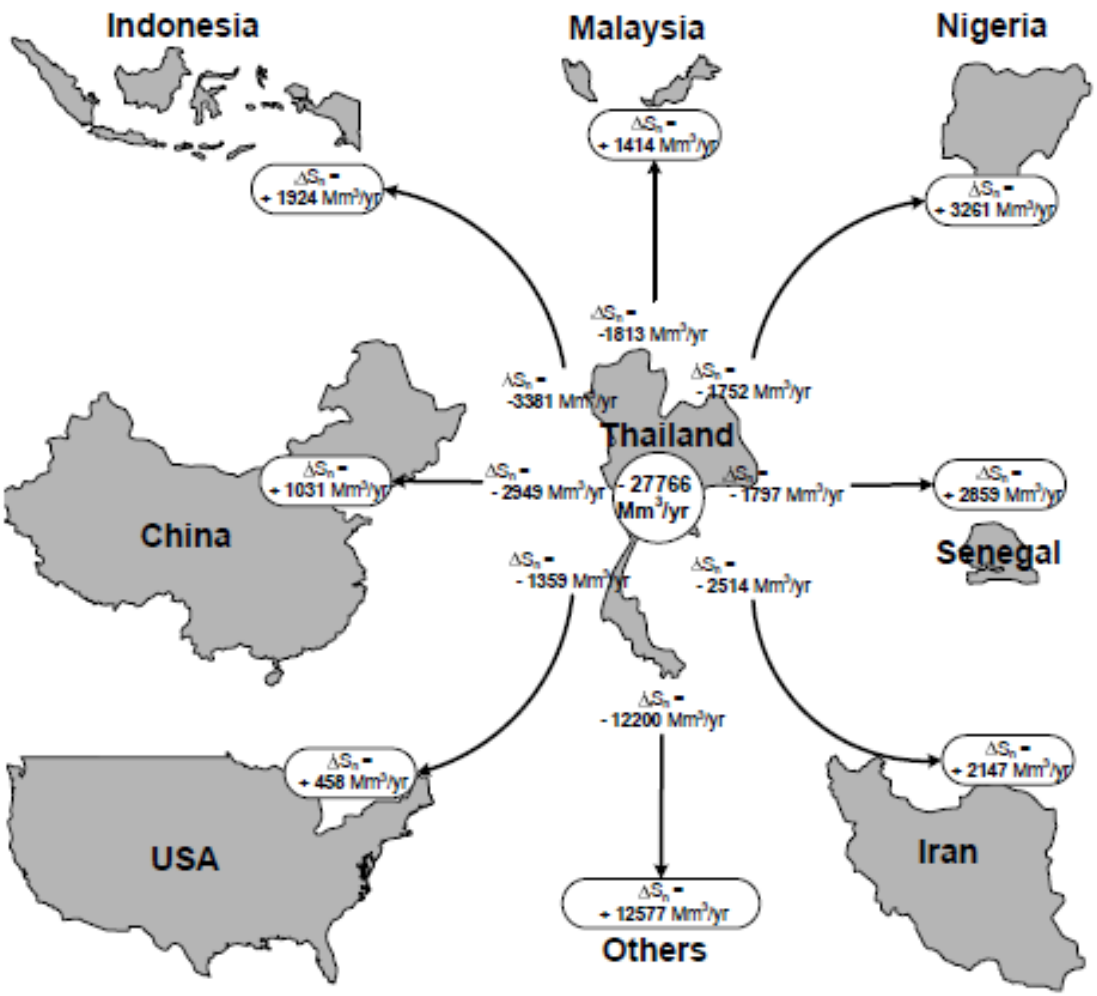
Global
A=942x10^6 rai
Y=718 kg/rai

Top-15 of countries with the largest WF of rice consumption during 2000-2004

	Total water footprint (Mm^3/yr)				Water footprint per capita
	Green	Blue	Grey	Total	($m^3/cap/yr$)
India	133,494	102,425	14,385	250,305	239
China	65,154	86,050	20,680	171,884	134
Indonesia	31,097	26,005	6,262	63,364	299
Bangladesh	20,560	21,574	3,846	45,980	317
Thailand	19,640	11,654	2,421	33,714	547
Myanmar	18,989	8,483	1,118	28,591	612
Viet Nam	9,860	6,496	4,074	20,430	256
Philippines	11,736	6,020	1,137	18,893	238
Brazil	9,186	7,869	757	17,812	99
Pakistan	2,480	13,935	521	16,936	117
Japan	4,084	4,923	748	9,755	77
USA	1,924	5,779	719	8,422	29
Egypt	3,467	3,203	599	7,269	105
Nigeria	3,478	3,005	548	7,031	54
Korea, R	2,491	2,732	592	5,814	122

Source: Chapagain *et al.* (2010b)

National water loss related to the net rice export of Thailand (1997–2001)



Water loss from rice export = -27,766 MCM/yr

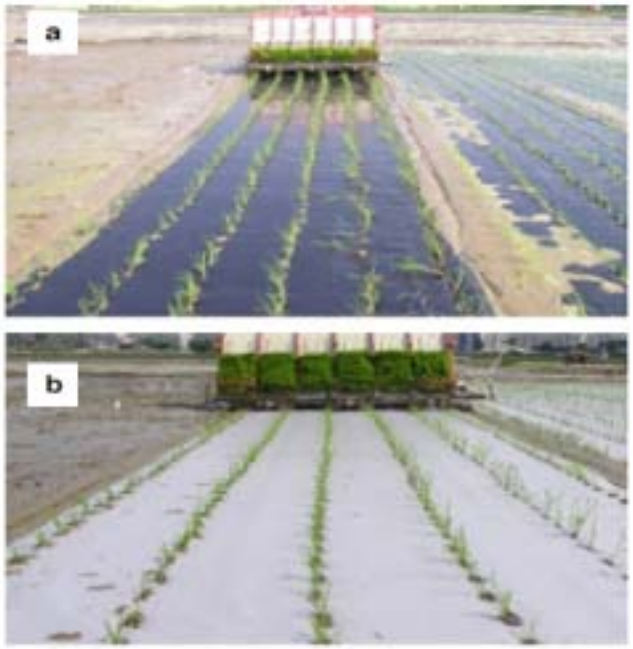
Bhumiphol Dam Storage capacity 13,462 x 2 =26,924 MCM

Source: Chapagain *et al.* (2006)

Options to reduce WF

Measure to reduce WF

- **Options for crop farmers to reduce their WF**
  - **Reduce Green WF in crop growths**
    - **Increase land productivity (yield, kg/rai) by improving agricultural practice**
    - **Mulching of the soil (for reducing evaporation from soil surface)**



Rice seeding transplanting in the black film and paper mulching treatment (Suwon, Korea)

Measure to reduce WF

– **Reduce Blue WF in crop growths**

- **Shift to an irrigation technique with lower evaporation loss e.g. pipe system, micro irrigation**
- **Improve the irrigation schedule by optimizing timing and volumes of application**

Water-Less Rice

Measure to reduce WF

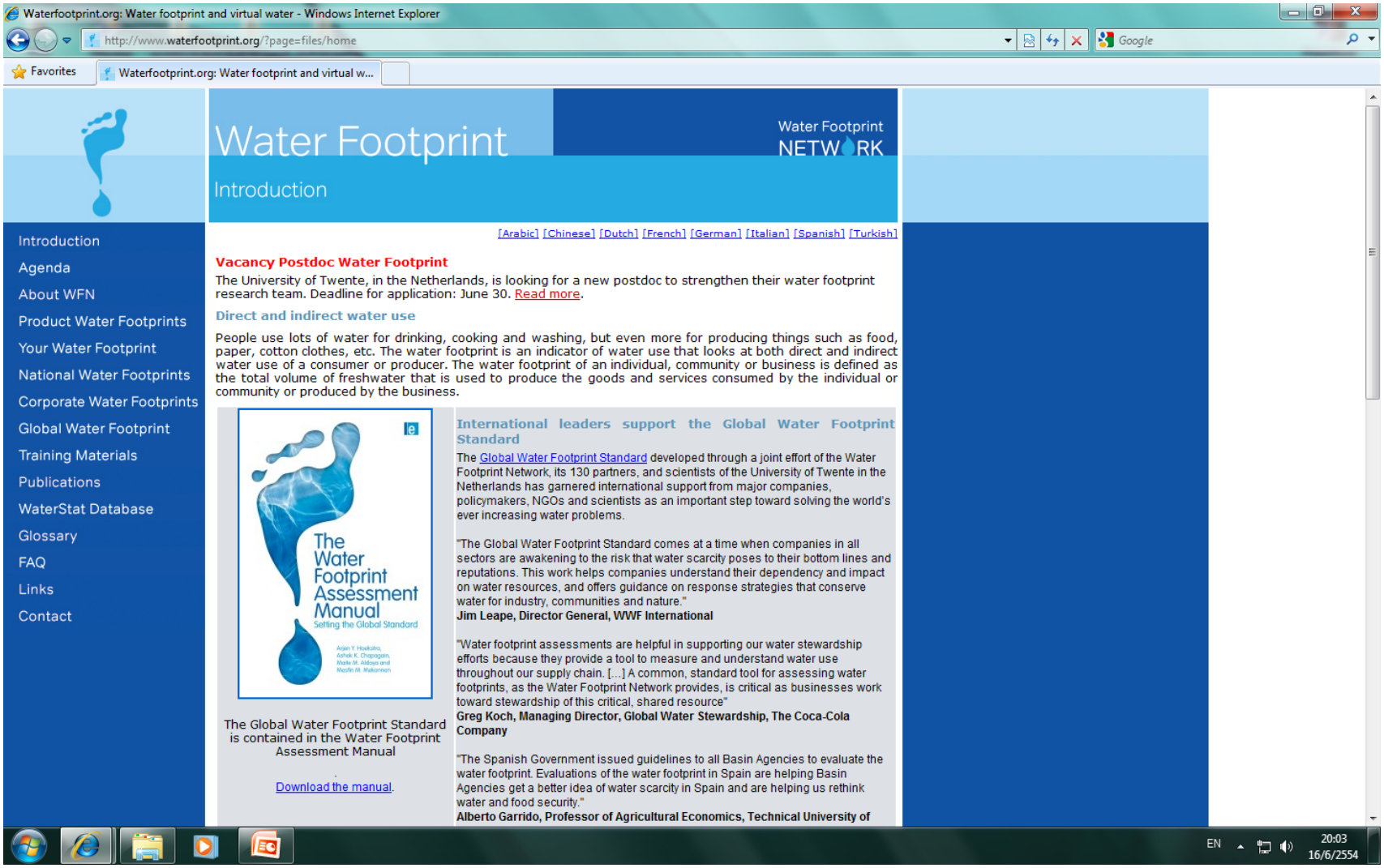
- Reduce Grey WF in crop growths
  - Apply less or no chemicals (artificial fertilizers, pesticides) e.g. Organic farming
  - Apply fertilizers or compost in form that allows easy uptake (Need less leaching & runoff): ปุ๋ยหมักชีวภาพ
  - Optimize the timing and technique of adding chemicals (Need less leaching & runoff

Measure to reduce WF

- **Options for Gov. to reduce WF (national agri. policy)**
  - Include the goal of sustainable use of available domestic WR in formulating national food security policy
  - Support investments in Irg. Systems & techniques that conserve water: Pipe system, Micro irrigation
  - Promote farmers to reduce the use of chemical fertilizers, pesticides, & insecticides
  - Promote WF reduction in Agri. e.g. awareness raising, subsidies for Irg. Techniques.

Source: Hoekstra et al. (2011)

www.waterfootprint.org



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Jeon WT, et al. (2011) Effects of green manure crops and mulching technology on reduction in herbicide and fertilizer use during rice cultivation in Korea

Thank you for your attention!

For Q&A

Terminology

- **Water footprint** – The water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated) and/or polluted per unit of time. A water footprint can be calculated for a particular product, for any well-defined group of consumers (e.g. an individual, family, village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or economic sector). The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations.

Direct WF of a consumer or producer : The freshwater consumption and pollution that is associated to the water use by the consumer or producer. It is distinct from the indirect water footprint, which refers to the water consumption and pollution that can be associated with the production of the goods and services consumed by the consumer or the inputs used by the producer.

Indirect WF of a consumer or producer: The freshwater consumption and pollution 'behind' products being consumed or produced. It is equal to the sum of the water footprints of all products consumed by the consumer or of all (non-water) inputs used by the Producer.

- **Virtual-water content – The virtual-water content of a product is the freshwater** 'embodied' in the product, not in real sense, but in virtual sense. It refers to the volume of water consumed or polluted for producing the product, measured over its full production chain. If a nation exports/imports such a product, it exports/imports water in virtual form. The 'virtual-water content of a product' is the same as 'the water footprint of a product', but the former refers to the water volume embodied in the product alone, while the latter term refers to that volume, but also to which sort of water is being used and to when and where that water is being used. The water footprint of a product is thus a multidimensional indicator, whereas virtual-water content refers to a volume alone.

WF of national consumption

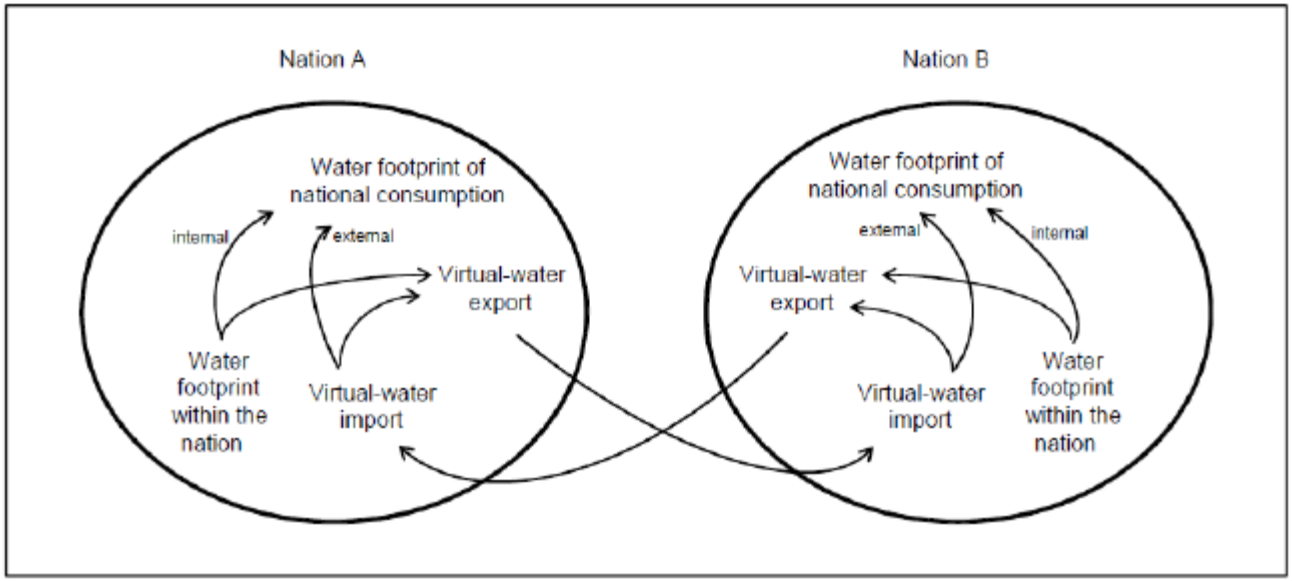
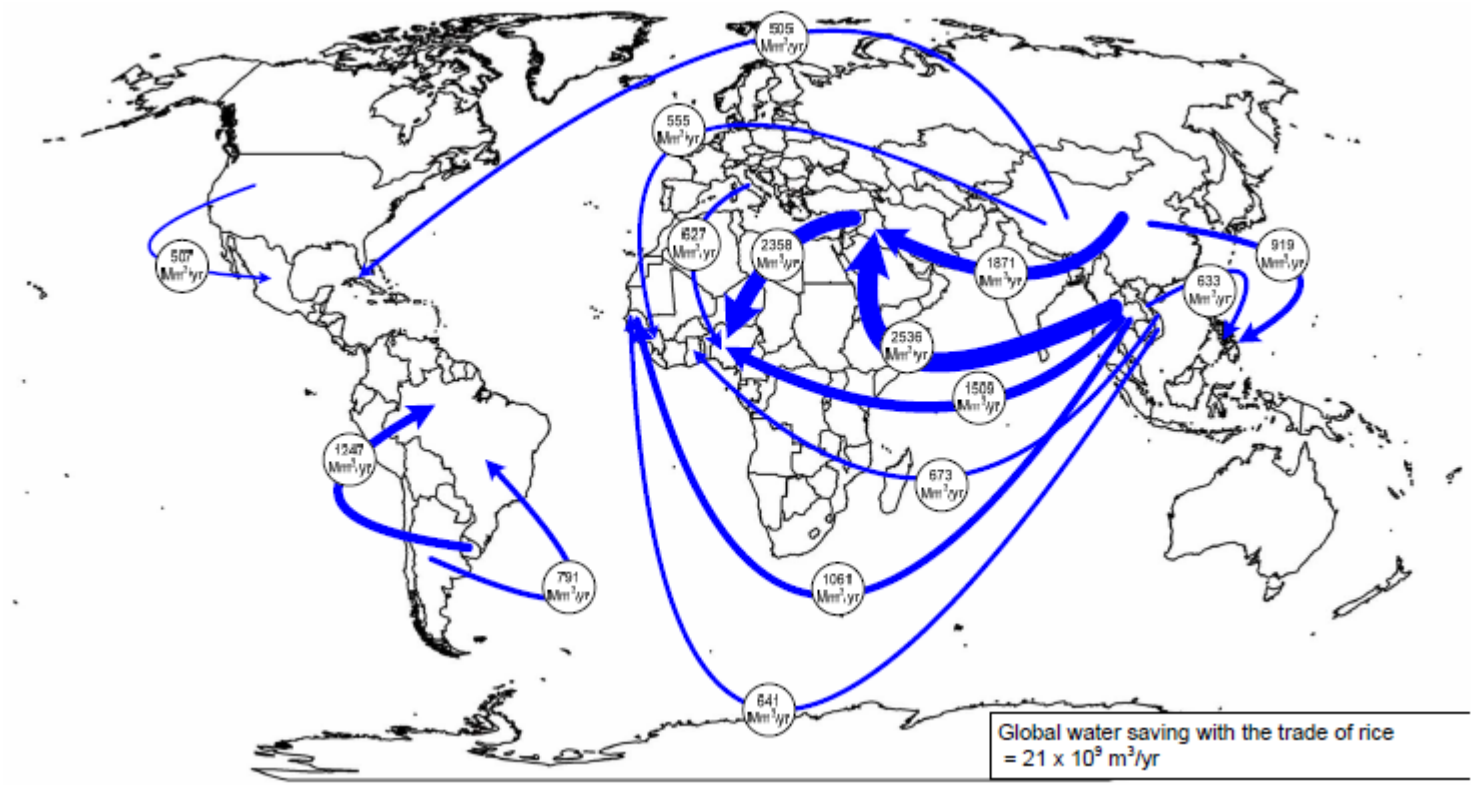


Fig.1 The relation between the water footprint of national consumption and the water footprint within a nation in a simplified example for two trading nations

Source: Hoekstra *et al.* (2009)

Virtual water trade of Rice



Total water consumption of Elovena Oat Flakes

"From field to an end product "

CONSUMER

OATS CULTIVATION

Rainfall

Evaporation

PROCESSING 0.57%

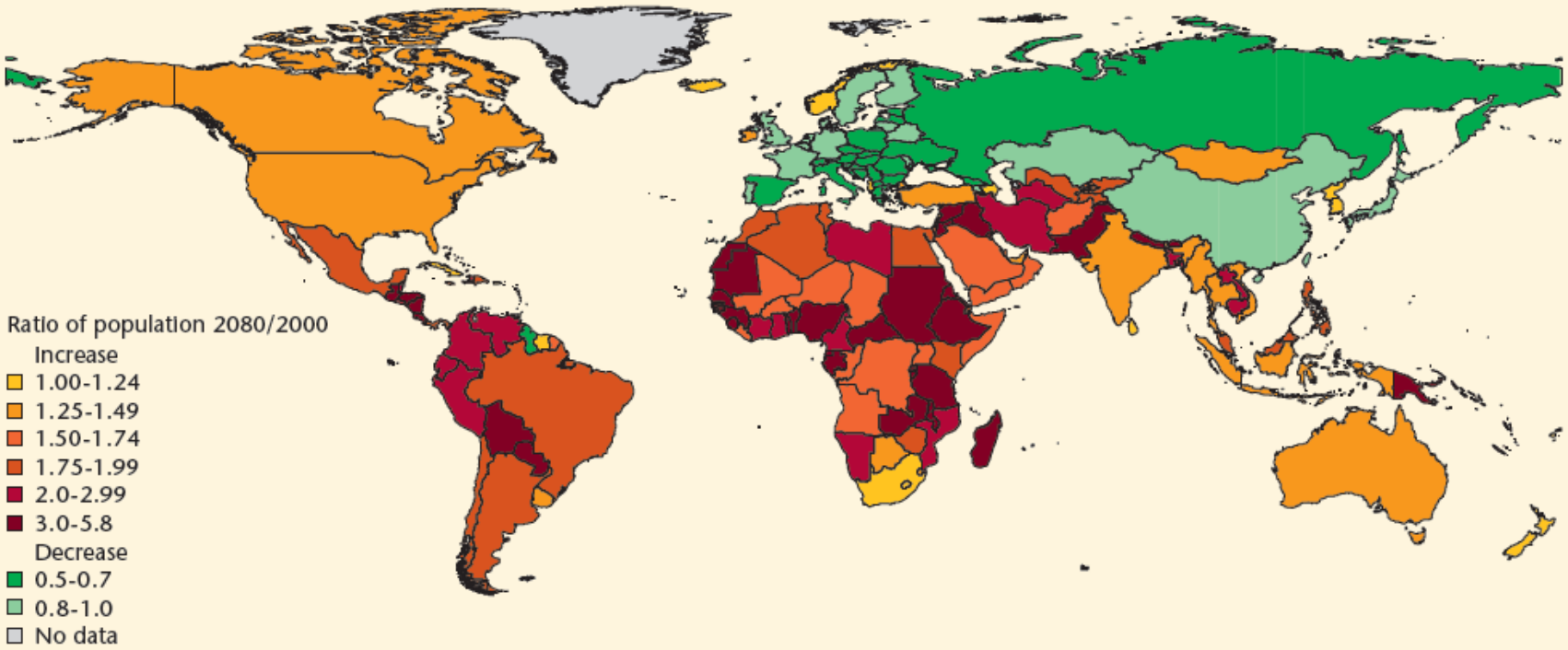
Use of water in processing Steaming Energy

PACKAGING MATERIALS 0.16%

Use of water in manufacturing of the packaging materials

RAISIO

Map 2.1 **Expected areas of population growth and decline, 2000-2080**



Source: Lutz, Sanderson, and Scherbov 2008.

CDM

Virtual Water – A World View of Sustainability

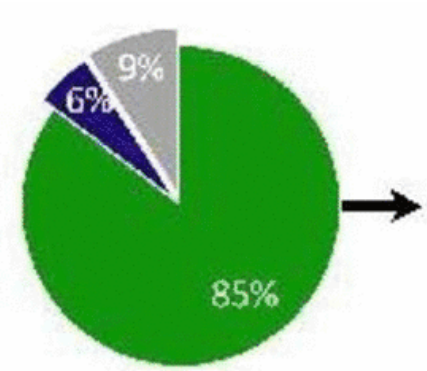
James J. Pescatore, P.E., BCEE

NEWWA Annual Conference

September 19, 2009

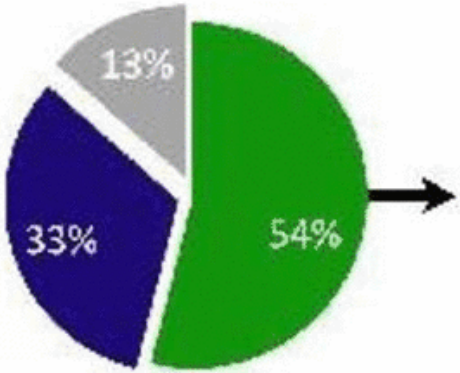
Water vs. Virtual Water

- Direct Water Use
  - Drinking, Washing, Flushing Toilets, Watering Lawns
- Indirect "Virtual" Water Use
  - Irrigating crops,
  - Watering livestock
  - Water used in the Production of Leather, Paper, Cotton, Manufactured Goods etc.



300 litres water

1 litre beer



10000 litres water

1 kg cotton

- **Ecological Footprint** (Wackernagel & Rees, 1996)
  Def.: human pressure on the planet in terms of the aggregate demand that resource-consumption and CO_2 emissions places on ecological assets.

- **Water Footprint** (Hoekstra, 2002)
  Def.: human appropriation of natural capital in terms of the total freshwater volume required (blue, green, grey) for human consumption.

- **Carbon Footprint** (multiple authors, ~2000 / 2008)
  Def.: human pressure on the planet in terms of the total GHG emissions (associated with an activity or accumulated over the life stages of a product) and human contribution to climate change.

one planet economy network

ECOLOGICAL FOOTPRINT	CARBON FOOTPRINT	WATER FOOTPRINT
• Temporally explicit and multi-dimensional indicator that can be applied to single products, cities, regions, nations and the whole biosphere. • More than 200 countries for the period 1961-2007 are tracked (Ewing et al., 2010). • It has a consumption-based point of view and thus considers trade.	• Multi-dimensional indicator that can be applied to products, processes, companies, industry sectors, individuals, governments, populations, etc. • 73 nations and 14 regions for the year 2001 only are tracked (Hertwich and Peters, 2009). • It has a consumption-based point of view and thus considers trade.	• Geographically explicit and multi-dimensional indicator: calculated for products, organizations, sectors, individuals, cities and nations. • 140 nations for the period 1997-2001 (Chapagain and Hoekstra, 2004). • It has a consumption-based approach and considers trade.

one planet
economy network

Table 10 Options for crop farmers to reduce their water footprint

Reduce green water footprint in crop growth

- Increase land productivity (yield, ton/ha) in rain-fed agriculture by improving agricultural practice; since the rain on the field remains the same, water productivity (ton/m^3) will increase and the green water footprint (m^3/ton) will reduce.
- Mulching of the soil, thus reducing evaporation from the soil surface

Reduce blue water footprint in crop growth

- Shift to an irrigation technique with lower evaporation loss.
- Choose another crop or crop variety that better fits the regional climate, so needs less irrigation water.
- Increase blue water productivity (ton/m3) instead of maximizing land productivity (yield, ton/ha)
- Improve the irrigation schedule by optimizing timing and volumes of application.
- Irrigate less (deficit irrigation or supplementary irrigation) or not at all.
- Reduce evaporation losses from water storage in reservoirs and from the water distribution systems.

Reduce grey water footprint in crop growth

- Apply less or no chemicals (artificial fertilizers, pesticides), for example, organic farming.
- Apply fertilizers or compost in a form that allows easy uptake, so that leaching and run-off are reduced.
- Optimize the timing and technique of adding chemicals, so that less is needed and/or less leaches or runs off.

Source: Hoekstra *et al.* (2011)

Table 11 Options for governments to reduce water footprints relevant to national agricultural policy

• Include the goal of sustainable use of available domestic water resources in formulating national food security policy.
• Do not subsidize water-intensive agriculture in water-scarce areas.
• Promote crops that are suitable and adapted to the local climate in order to reduce irrigation demand.
• Support investments in irrigation systems and techniques that conserve water.
• Promote farmers to avoid or reduce the use of fertilizers, pesticides and insecticides or better apply so that less chemicals reach the water system.
• Promote water footprint reduction in agriculture – see Table 10. This can be done in various alternative or complementary ways: regulation or legislation (for example, on license, quota, full-cost water pricing, tradable water use permits, subsidies for specific irrigation techniques, compulsory water metering, awareness-raising.

Source: Hoekstra *et al.* (2011)