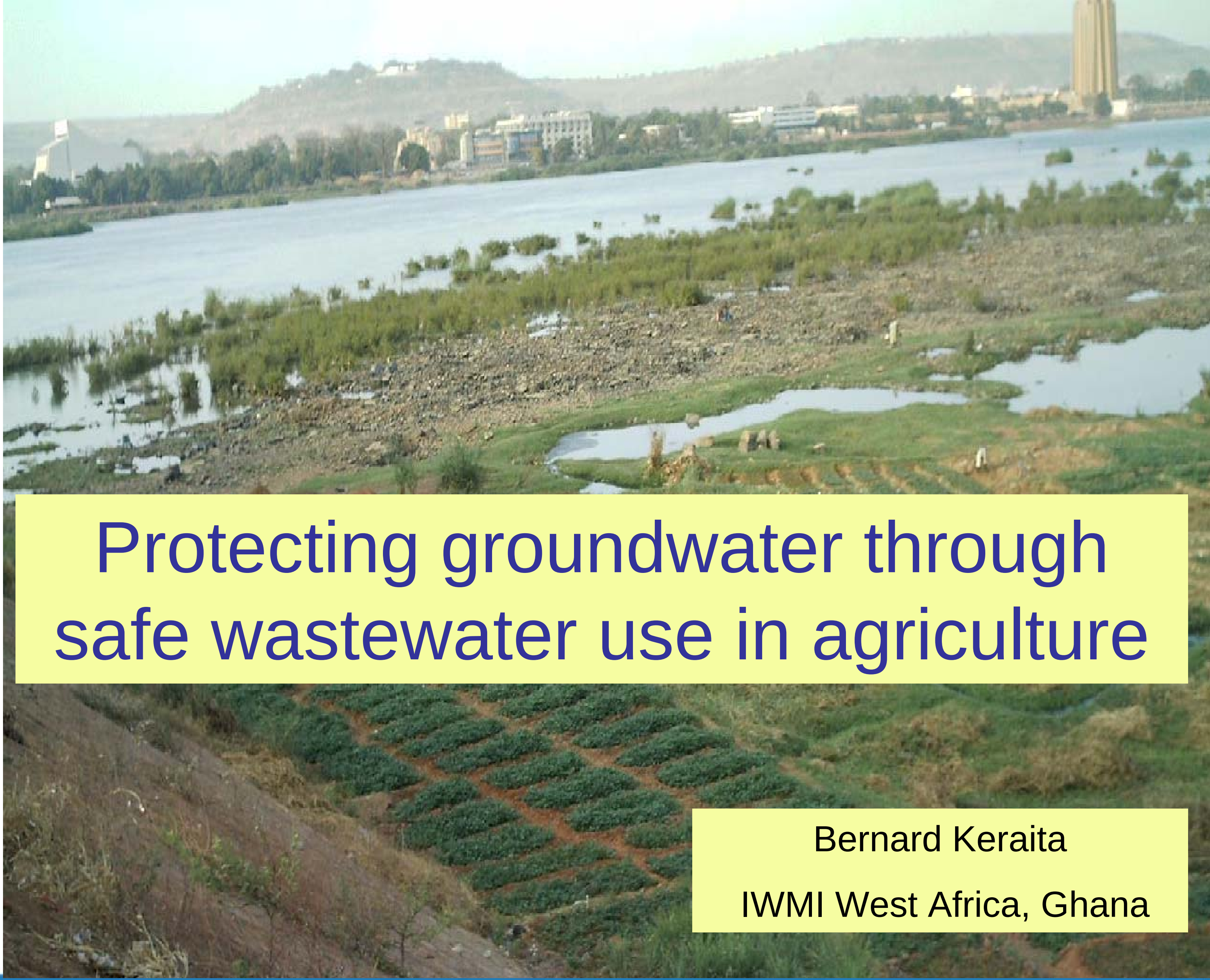
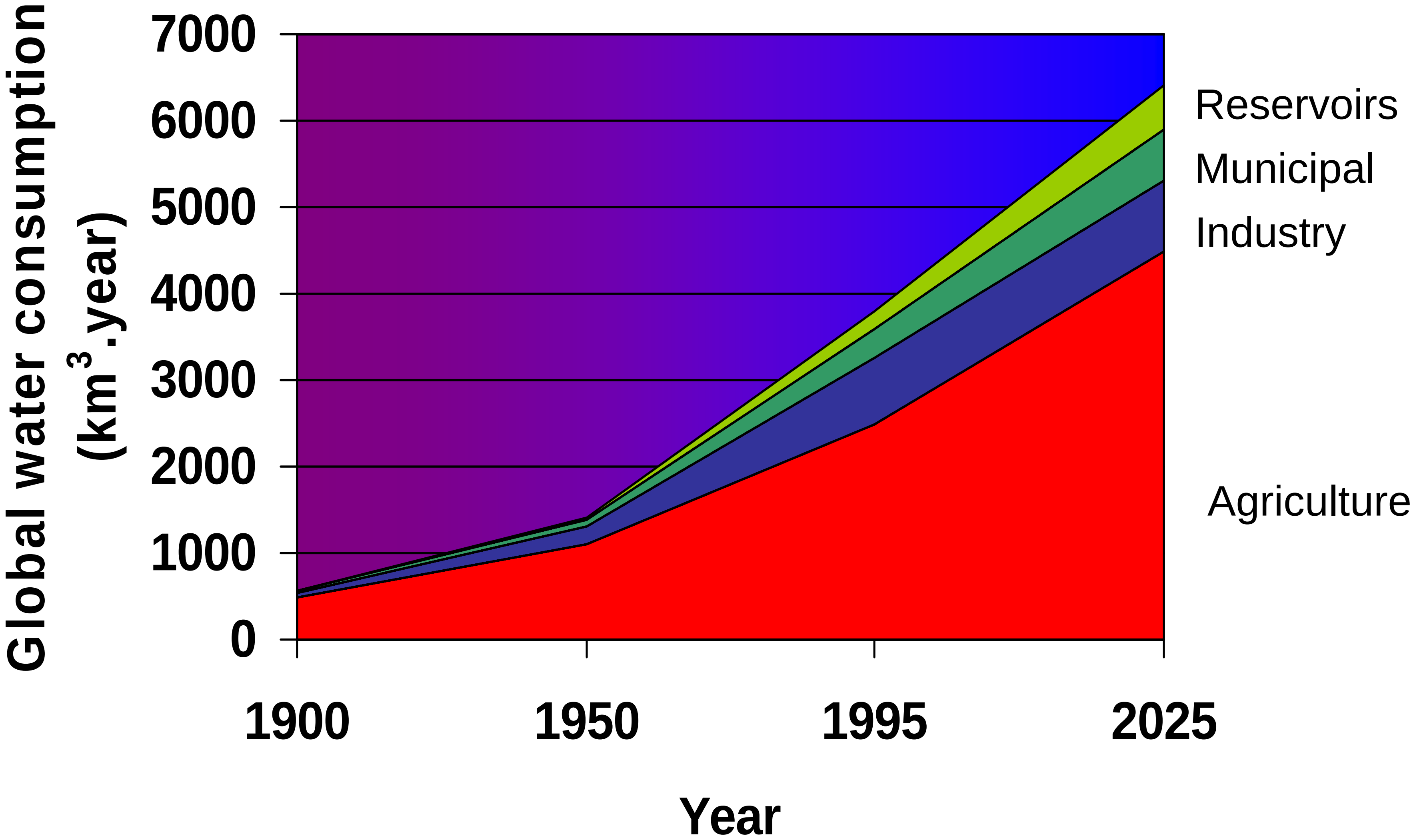
International Water Management Institute



Protecting groundwater through safe wastewater use in agriculture

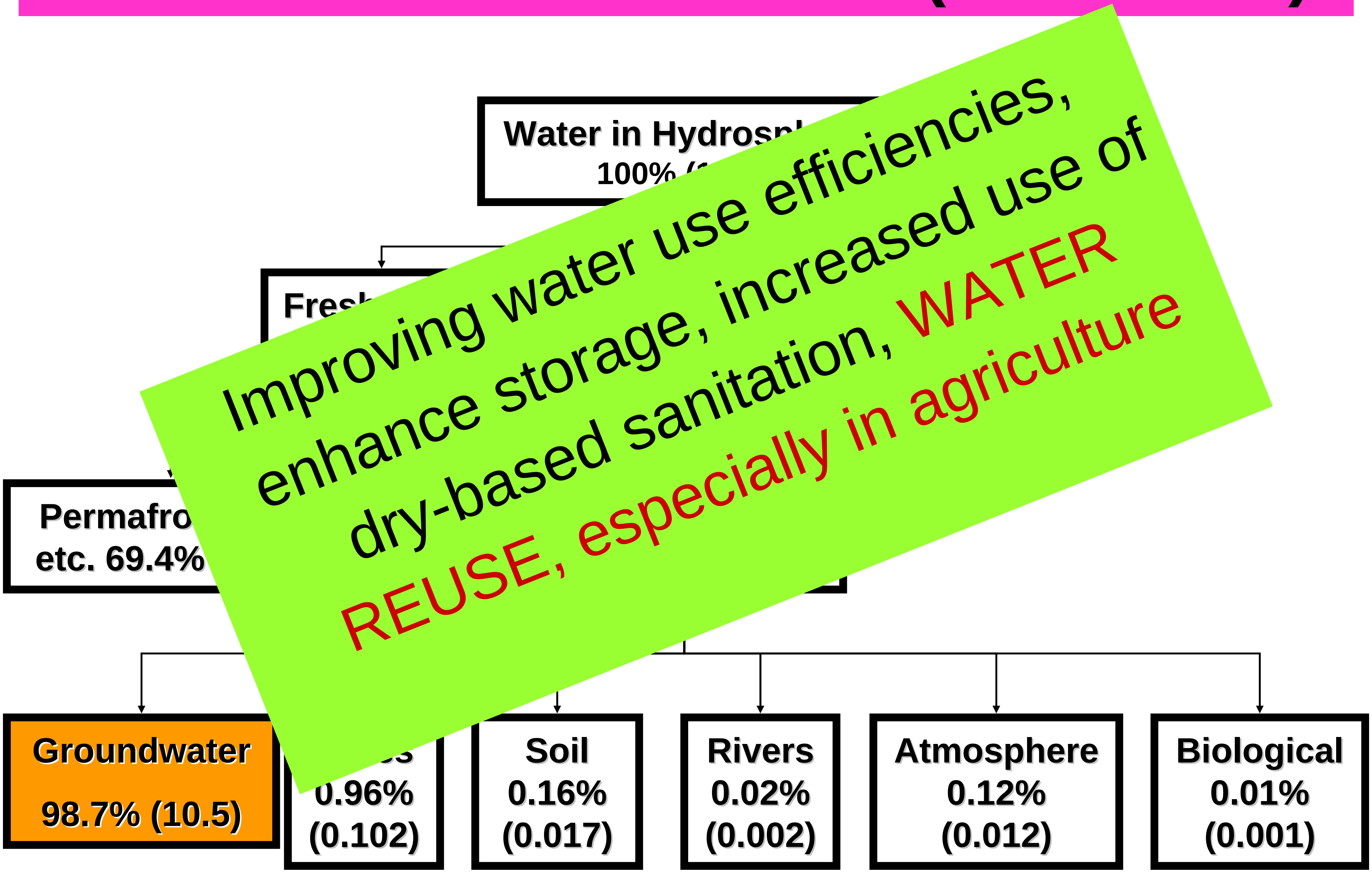
Bernard Keraita

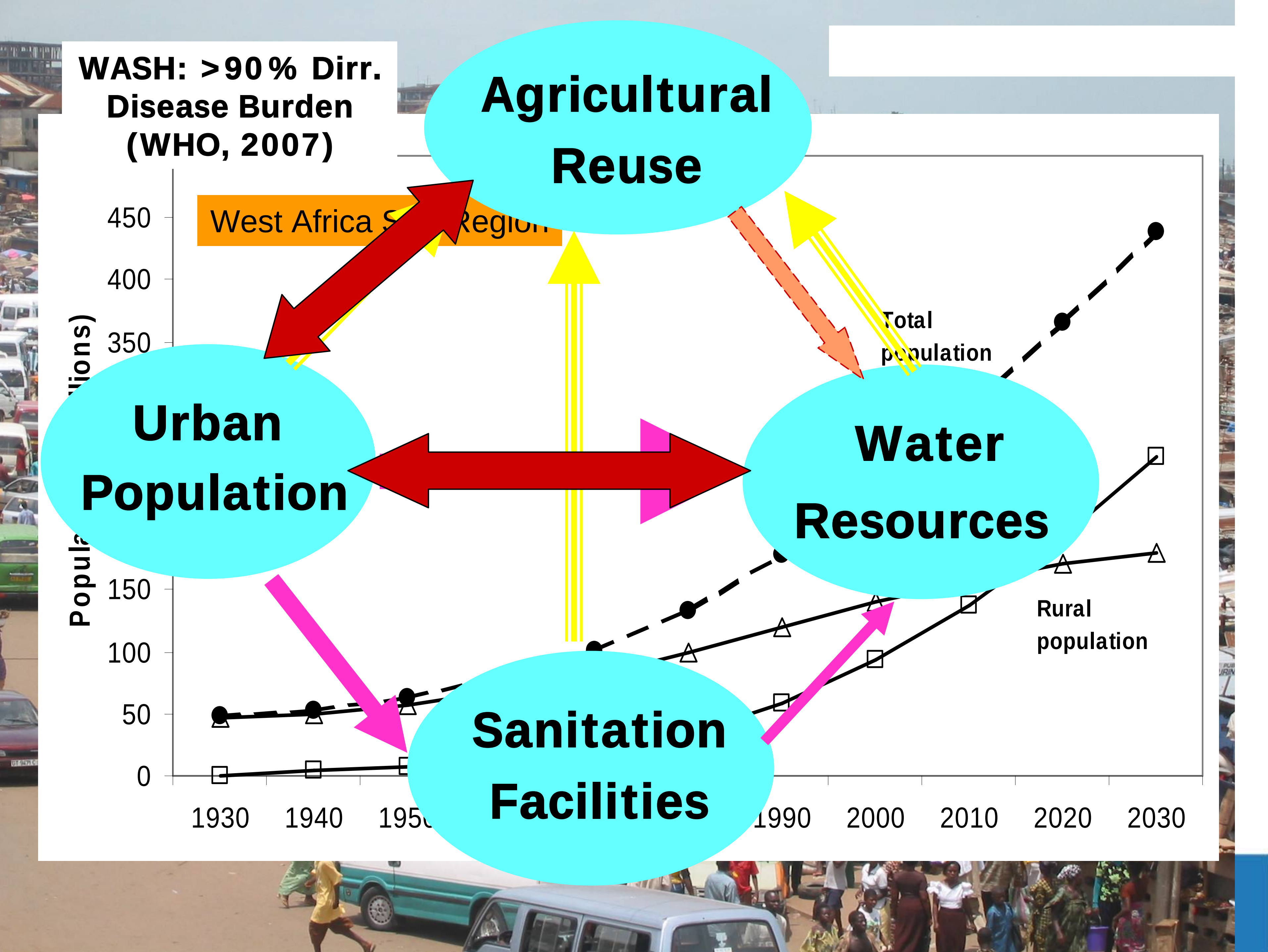
IWMI West Africa, Ghana



❖World population living in countries facing water scarcity will increase to about 40% by 2050 scarcity (Hinrichsen *et al.,* 1998).

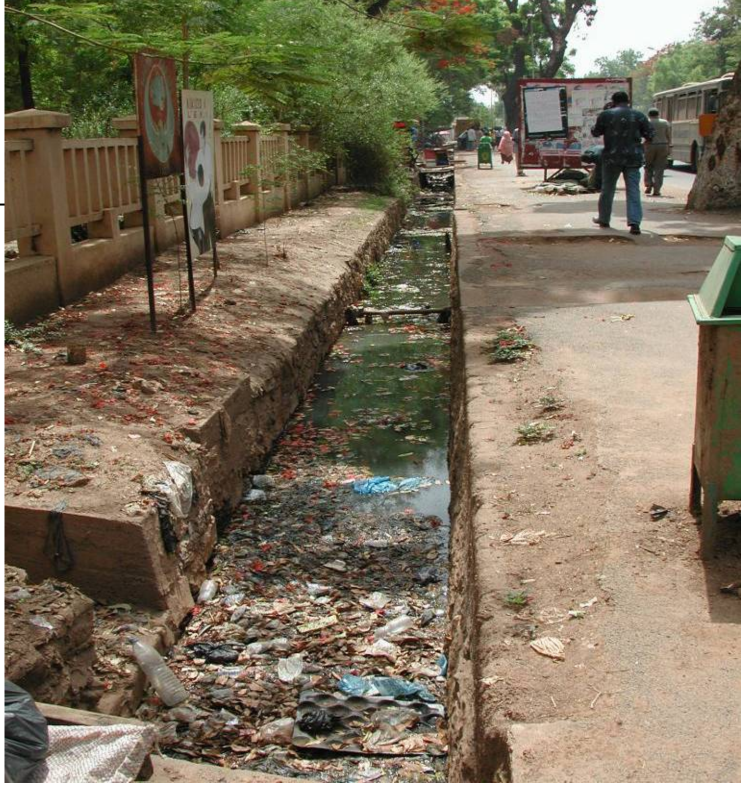
Water Resources on earth (x 1000km^3)





WASH: >90% Dirr. Disease Burden (WHO, 2007)
Agricultural Reuse
West Africa S Region
Urban Population
Water Resources
Sanitation Facilities
Total population
Rural population
450
400
350
150
100
50
0
1930
1940
1990
2000
2010
2020
2030

Inadequate collection of wastewater generated in urban area in SSA (<10%)



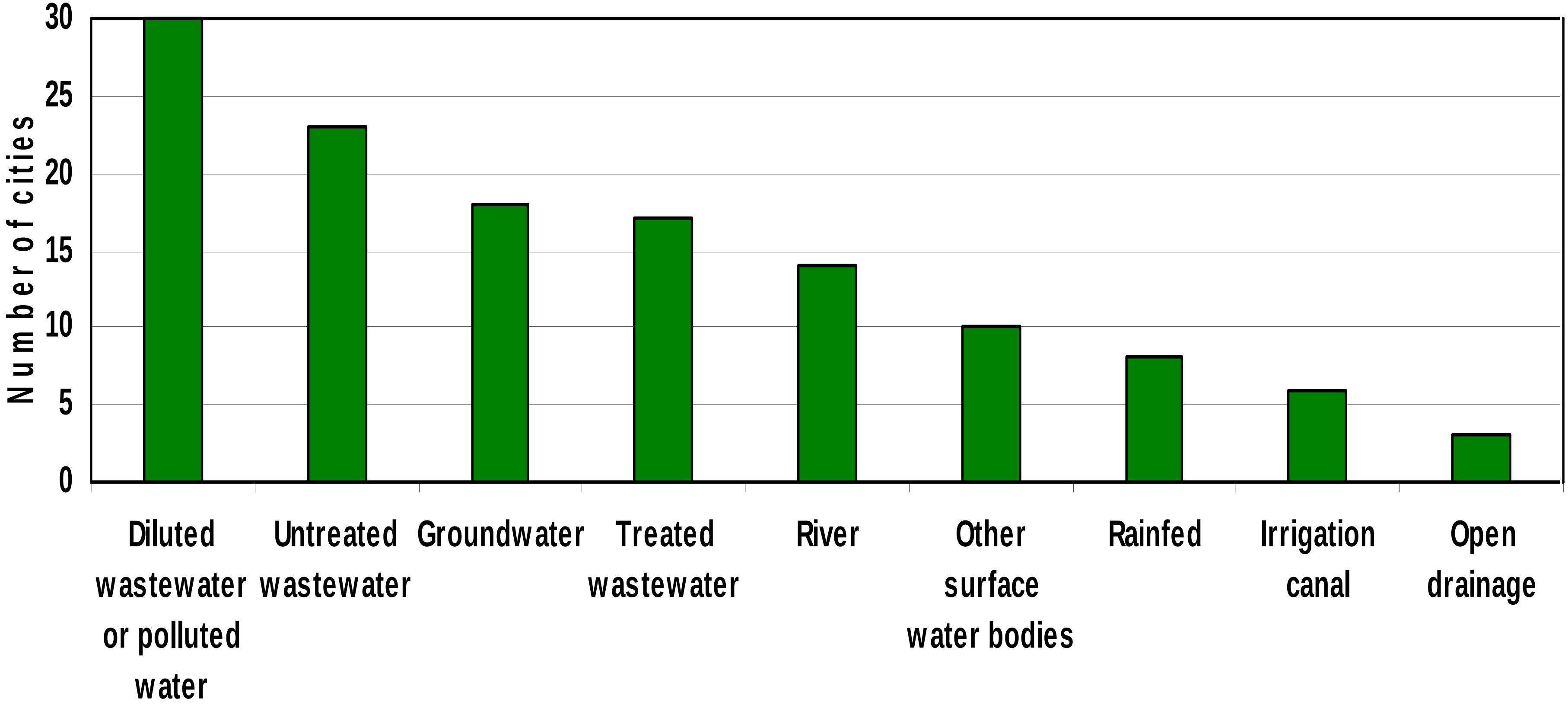
The few wastewater treatment plants available are usually non functional or overloaded (<1% in SSA is actually treated)


To you it's "Shit" To us it's
BREAD & BUTTER
Shit Business is Serious Business
K2700 II

Not only water, but also nutrients. Why pollute groundwater with N,P,K which can be used productively in agriculture?

At Mezquital valley (Mexico) farmers oppose installation of WWTPs – Prefer raw wastewater for nutrients

In and around *three of four* cities in the developing world farmers use polluted irrigation water for the production of high value crops



Source: 53 city study for Comprehensive Assessment, IWMI, 2008

Groundwater recharge: An example of Tula Valley, Mexico

- 90,000 ha irrigated with raw wastewater
- Groundwater recharge estimated at 25 m^3/s, 13.3 times more than natural recharge
- Water table risen and several springs appeared with flow 0.1-0.6 m^3/s
- Flow in River Tula increased from 1.6-12.7 m^3/s yearly

**Many countries like Tunisia, Israel, Australia and states like California relies heavily on wastewater for groundwater recharge

Addressing concerns related to sanitation induced groundwater pollution

- Nitrates
- Pathogens
- Heavy metals
- Salinity
- Others

Any increased risk to groundwater?

Table 2 Characteriza... percentage (ND: Not d...

Parameter in mg/L unless indicated	Wastewater	Site 1	%	Site 2c	%	Site 3	%
Fecal coliforms, MPN/100 mL	10^{04}–10^{10}	1–4	99.9	0–29	99.9	0–330	99.9
Salmonella (3 varieties), CFU/mL	0 - positive	ND	100	ND	100	ND	100
E. histolytica, cysts/L	0–1.5	ND	100	ND	100	ND	100
Shigella, CFU/mL	0 - positive	ND	100	ND	100	ND	100
Helminth ova, ova/L	12–24.5	0	100	0	100	0	100
Turbidity, NTU	100–249	0.1–2	99	0.03–2.5	99	0.3–5	99
TSS	83–153	ND-12	97	ND-12	98	ND-12	97
Conductivity, µmhos/cm	1,437–1,689	1,481–1,730	−3.4	1,535–1,801	−11.3	1,513–2,090	−25.7
Redox potential, mV	−16	−78 to −23	−215	−78 to −23	−173	−69 to −34	−222
BOD	166–167	2.4–5	98	1.–4.5	98	0.4–5	98
Total organic carbon	35–188	5.2–30	84	5–73	75	4.7–19	90
Aluminium	1.3–5.5	0.03–0.1	98	ND-0.14	96	0.03–0.1	98
Arsenic	ND-0.008	ND-0.005	71	ND-0.01	56	ND-<0.005	82
Copper	0.05–0.07	ND -0.07	77	ND-<0.02	67	ND-<0	82
Chrome	ND-0.04	ND-0.01	90	ND-0.01	91	2	90
Iron	1–1.2	<DL-0.07	96	<DL-0.94	86	<DL-0.34	92
Manganese	0.03–0.2	ND-<0.01	95	ND-0.06	88	ND-<0.01	95
Mercury	ND-0.001	ND-0.002	36	ND-0.005	−13	ND-0.001	64
Lead	0.09–0.1	ND-0.04	78	ND-0.08	78	ND-0.038	84
Sodium	198–206	80–317	13	75–264	17	97–384	−7
Calcium	41–445	57–90	−82	41–83	−71	69–132	−156
Magnesium	24–29	23–47	−13	28–83	−140	26–75	−76
Boron	1.–1.2	0.4–0.7	49	0.8–0.7	41	0.08–0.5	82
Cyanides	0.005–0.01	<0.018	13	ND<0.018	33	<0.018	17
Total nitrogen	37–38	ND-6	96	< 0.1–7	96	< 0.1–4.4	96
Ammonia nitrogen	24–32	ND-4.5	97	ND-0.2	100	ND-0.2	100
Nitrates	ND-1	1.5–77	−2,785	1.4–56	−2,007	1.5–50	−2,107
Nitrites	ND-0.001	ND-0.02	−741	ND-0.023	−521	ND-0.036	−1091
Phosphorus	2.7–3	ND-0.2	95	ND-<0.5	93	ND<0.05	93
Bicarbonates, mg $CaCO_3$/L	485	418–942	−21	447–850	−12	430–925	−18
Total hardness, mg $CaCO_3$/L	210–220	263–376	−50	438–484	−109	481–530	−128
Chlorides	155–248	131–180	26	160–216	11	142–317	−31
Fluorides	0.7–4	0.3–1	74.	0.8–1.3	53	0.04–0.8	86
Sulfides	3–3.5	ND<3.4	65	ND<3.4	70	ND<3.4	50
o−xylene, µg/L	3.8–4	ND-<5	100	ND<5	100	ND<5	100
Ethyl benzene	1.2	ND-< 5	100	ND<5	100	ND<5	100
m−xylene, µg/L	9.2	ND	100	ND	100	ND	100
p-cresol, µg/L	46.5	ND	100	ND	100	ND	100
Chloroform, µg/L	0.2–0.8	ND	100	ND	100	ND	100
Tetrachloroethylene, µg/L	2	ND	100	ND	100	ND	100

Pathogens:100% rem.

EC: slight incr.

BOD: 98% rem.

> 90% rem. P, N

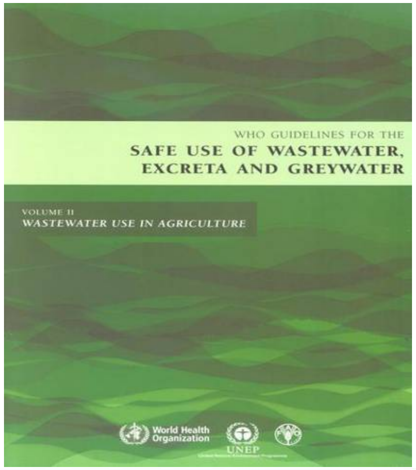
www.iwmi.org

Source: Jimenez & Chávez, 2004

Match nutrient and water applications with crop requirements

(many nutrient/irrigation programs available)

BUT, let farmers understand that!



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Plant crops good in nutrient uptakes – grass, leafy crops etc

(Need to understand nutrient uptakes by various crops)

Willow Coppice (Salix) plantation – For energy generation

Soil as a bio-filter for pathogens

- Pathogens like helminths and protozoa have larger sizes - easily be retained (straining, adsorption) in the soil
- Elimination from soils still need more understanding (other than natural die-off, predation)
- But bacteria and especially virus a transferred to groundwater

Use “less-polluting” Irrigation methods
(minimizes water used, soil wetting, deep percolation)

Avoid

Improv

IWMI
International Water Management Institute

Improve

www.iwmi.org

Better use drip irrigation, and now even cheaper **drip irrigation kits**

- Risk reduction: ≥ 4 log units of E. coli per 100 g of lettuce. No helminth eggs on lettuce leaves
- Reduces amount of water used (half that used in surface and overhead methods, so less

Heavy metals: Not usually a problem in SSA where industrial waste is rather localized

Work in Ghana, Senegal, Burkina Faso on aquatic macrophytes and constructed wetlands

Salinity: Domestic wastewater usually has tolerable salinity levels but..

- Treatment plants generate effluents with higher EC levels.

- Farmers in Faisalabad opposed treated wastewater and actually pay more for raw wastewater

- Farmers in Dakar, Senegal, are using raw wastewater to dilute salinity in groundwater


Appropriate siting of domestic groundwater sources
Kamina, Tamale, Ghana

Involve your stakeholders (farmers) and use "enticing" key messages

- "By applying extra nutrients and irrigation water, you'll be wasting your money and your labor"

- "By applying extra nutrients and irrigation water, you'll be polluting groundwater and increasing health risks"


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IWMI
International
Water Management
Institute

THANK YOU