

Global Food Production – Share from Sustainable and Unsustainable Groundwater Use

Karen G. Villholth

Principal Researcher, South Africa

Aditya Sood

Nirosha Liyanage

IWMI

Yoshihide Wada, IIASA

Tingju Zhu, IFPRI



25-29th
September 2016

43rd
IAH
congress

Montpellier, France
CORUM CONFERENCE CENTER



A water-secure world



www.iwmi.org

Background

- Groundwater plays an increasing role in food production world wide
- 43% of irrigation water globally is derived from groundwater (*Foster et al., 2015; Döll et al., 2012*)
- Groundwater depletion (GWD) has tripled from 1960 to 2000 (*Wada et al., 2012*)
- Evidence of GWD exists from India, China, Pakistan, Northern Africa, Middle East, Mexico and USA

Objectives

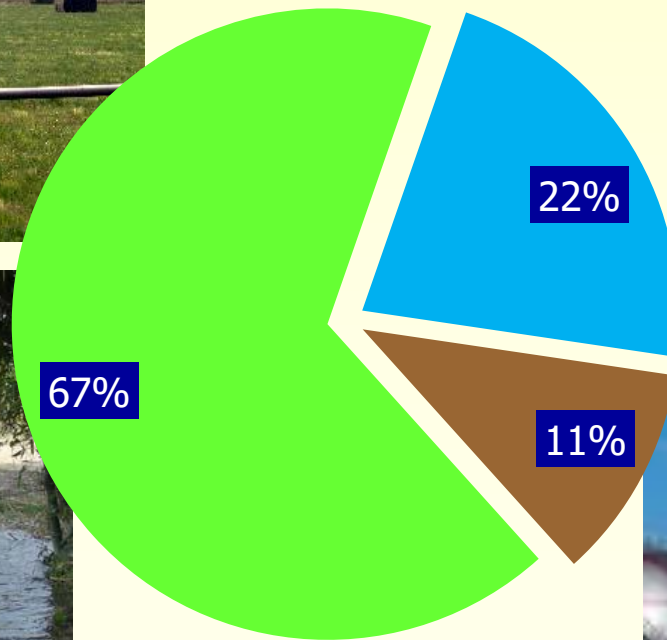
- Estimate the role of GW in global food production
- Estimate the contribution of unsustainable GW use
- Understand the regional and crop-wise distribution of global food production from GWD
- Provide pointers for policy

Earlier estimates of the role of groundwater depletion in (global) food production

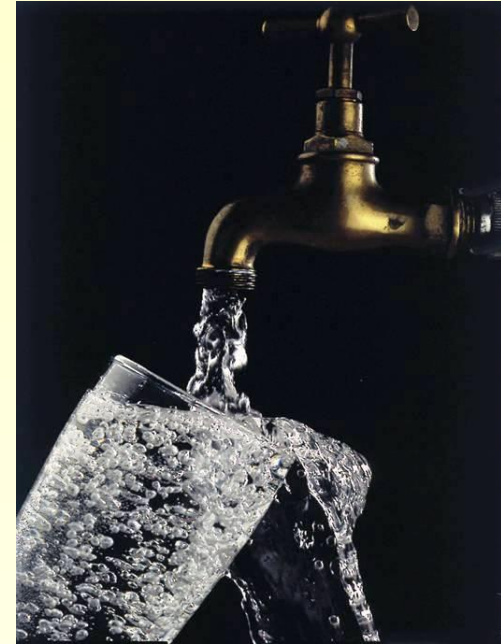
- 10% of the **world's** agricultural food production depends on using mined groundwater (*World Water Commission, 2000*)
- 15% of **India's** food supply is produced by mining groundwater (*World Bank, 2005*)
- Mined groundwater accounts for 15-27% of total crop production in **China** (*Grogan et al., 2015*)

Agriculture is the largest GW user

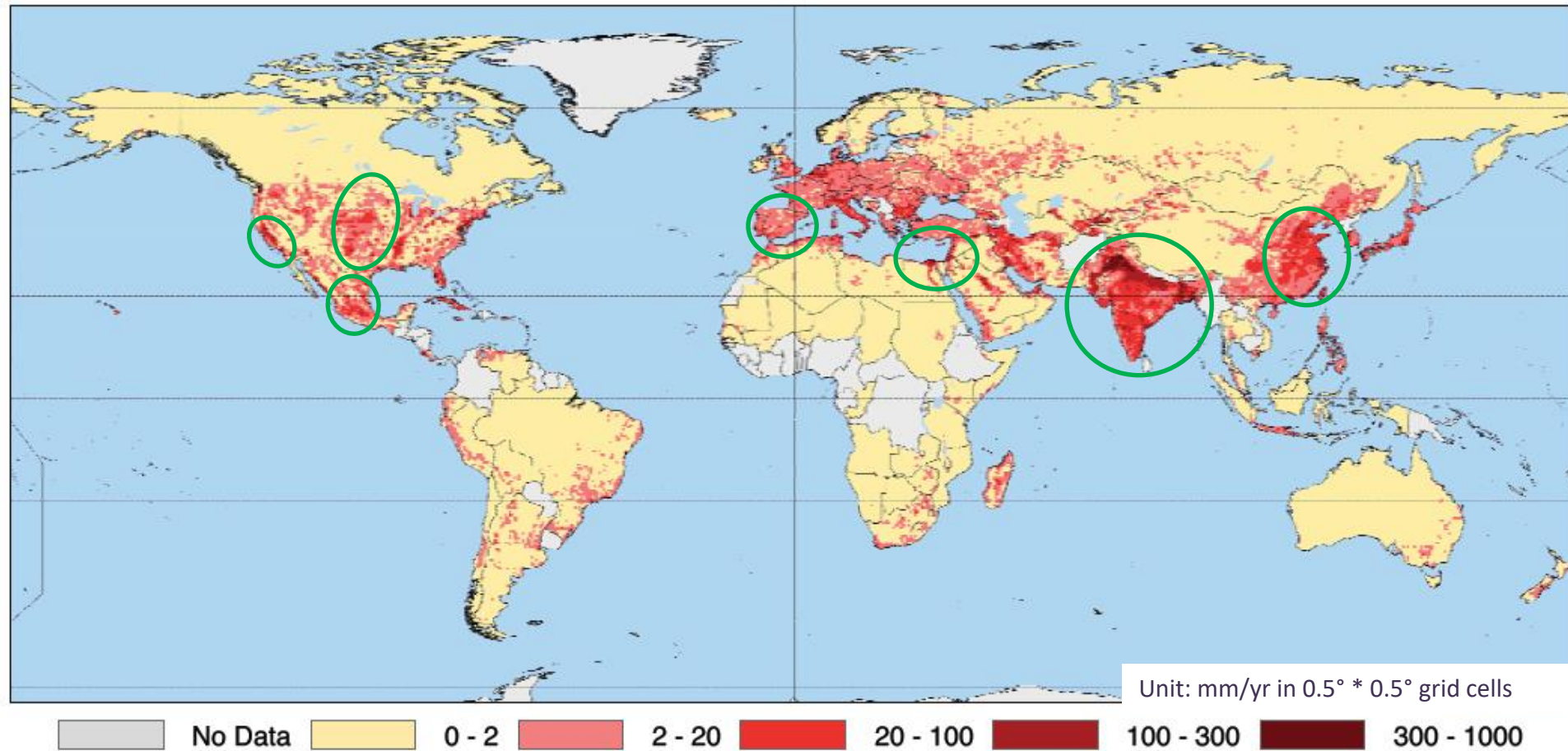
globally



van der Gun, 2012



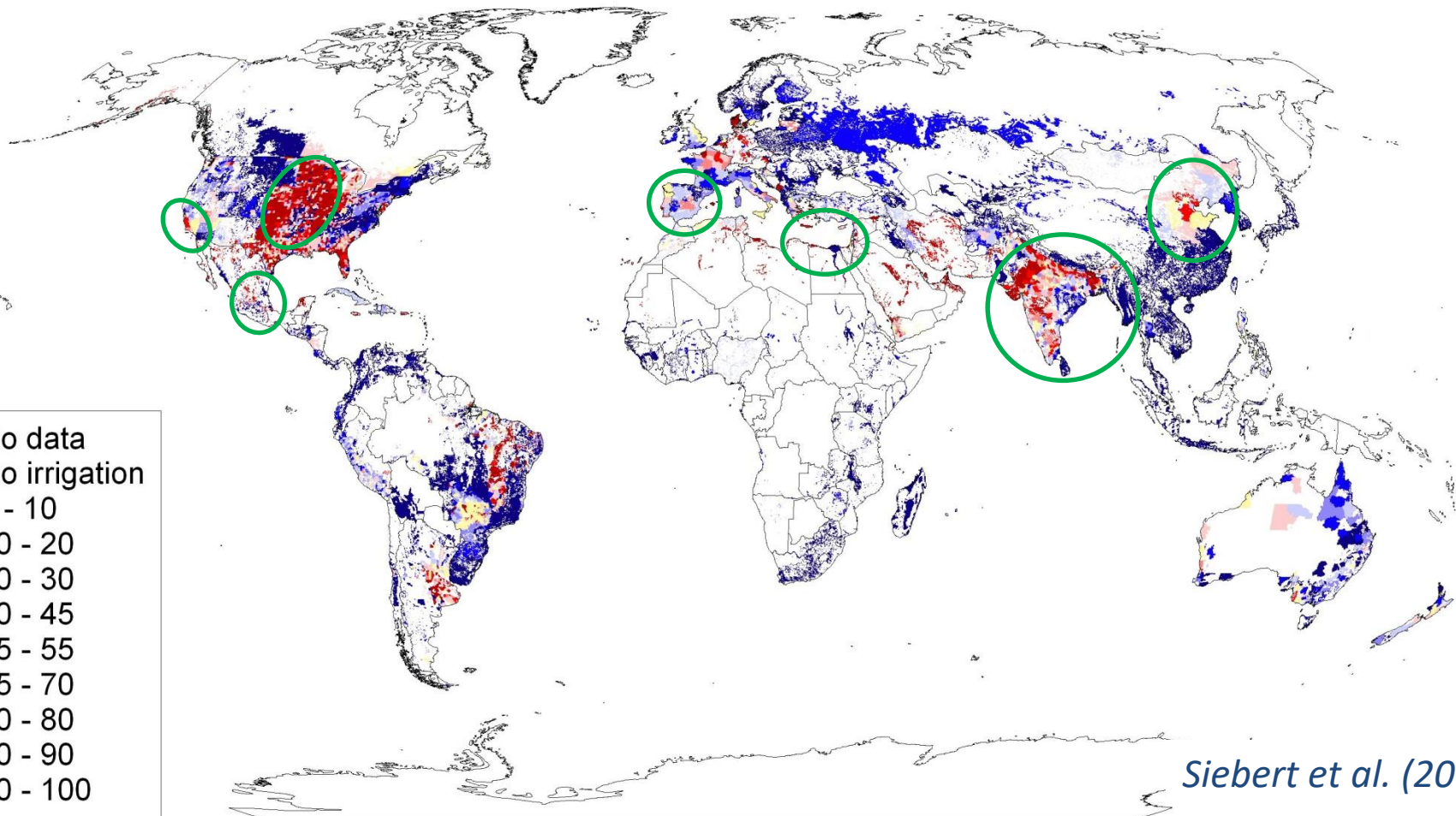
Global GW abstraction ...coincides with....



Wada et al. (2012)

..... Global GW irrigation intensity

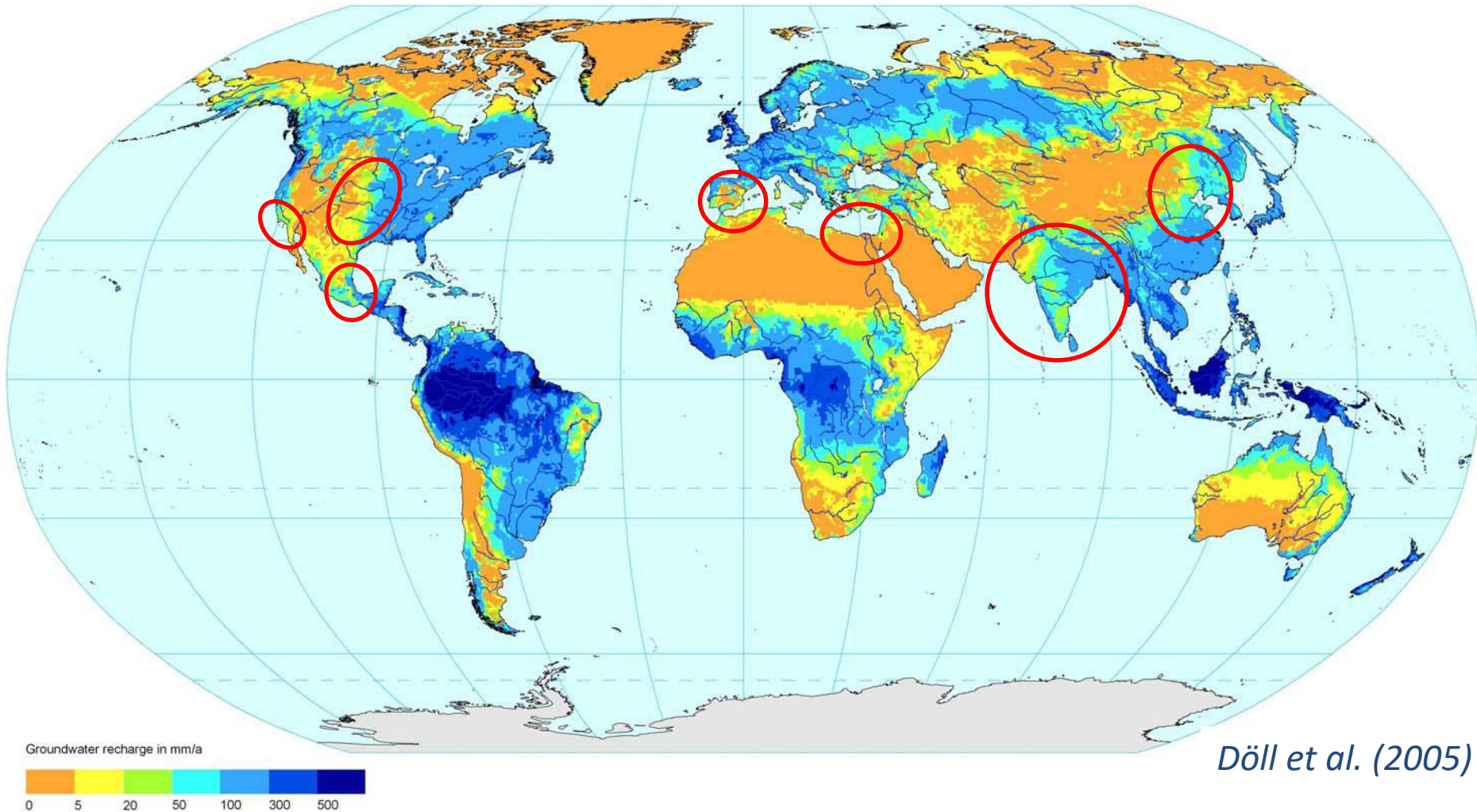
Percentage of irrigated area supplied by ground water (in irrigated grid cells)



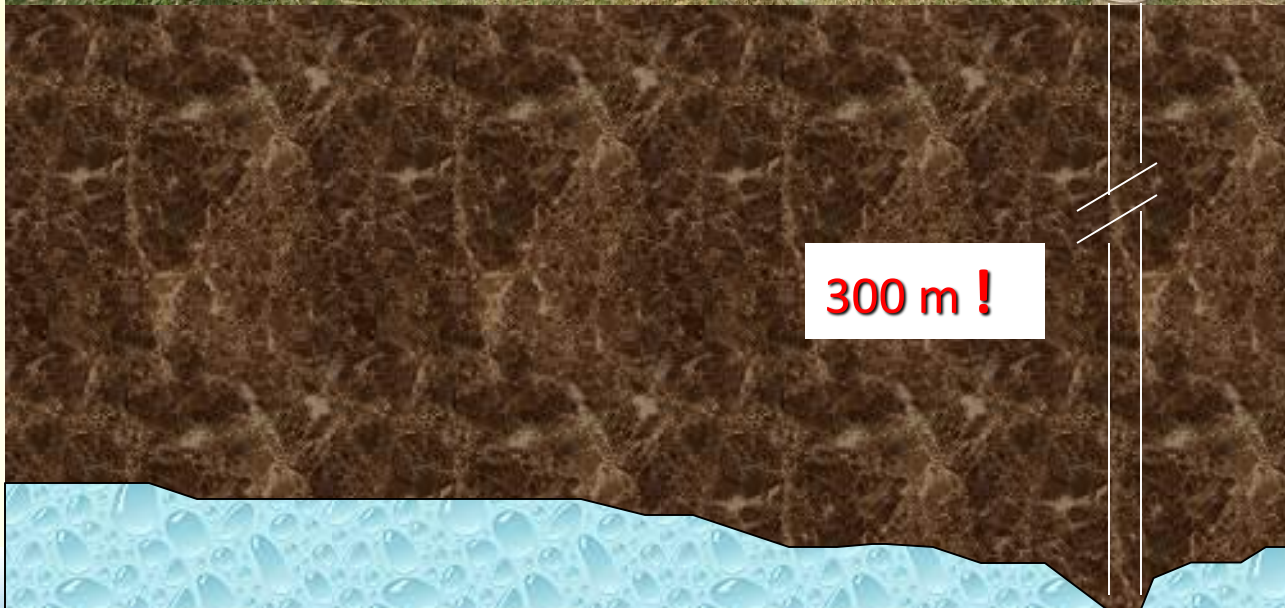
Siebert et al. (2010)

.... and limited renewability of GW

Average annual groundwater recharge 1961 - 1990



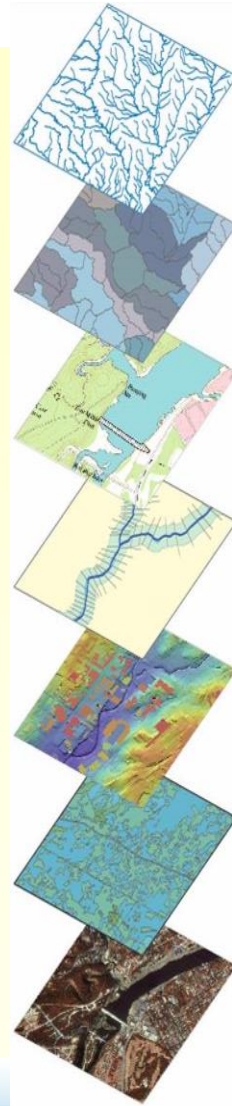
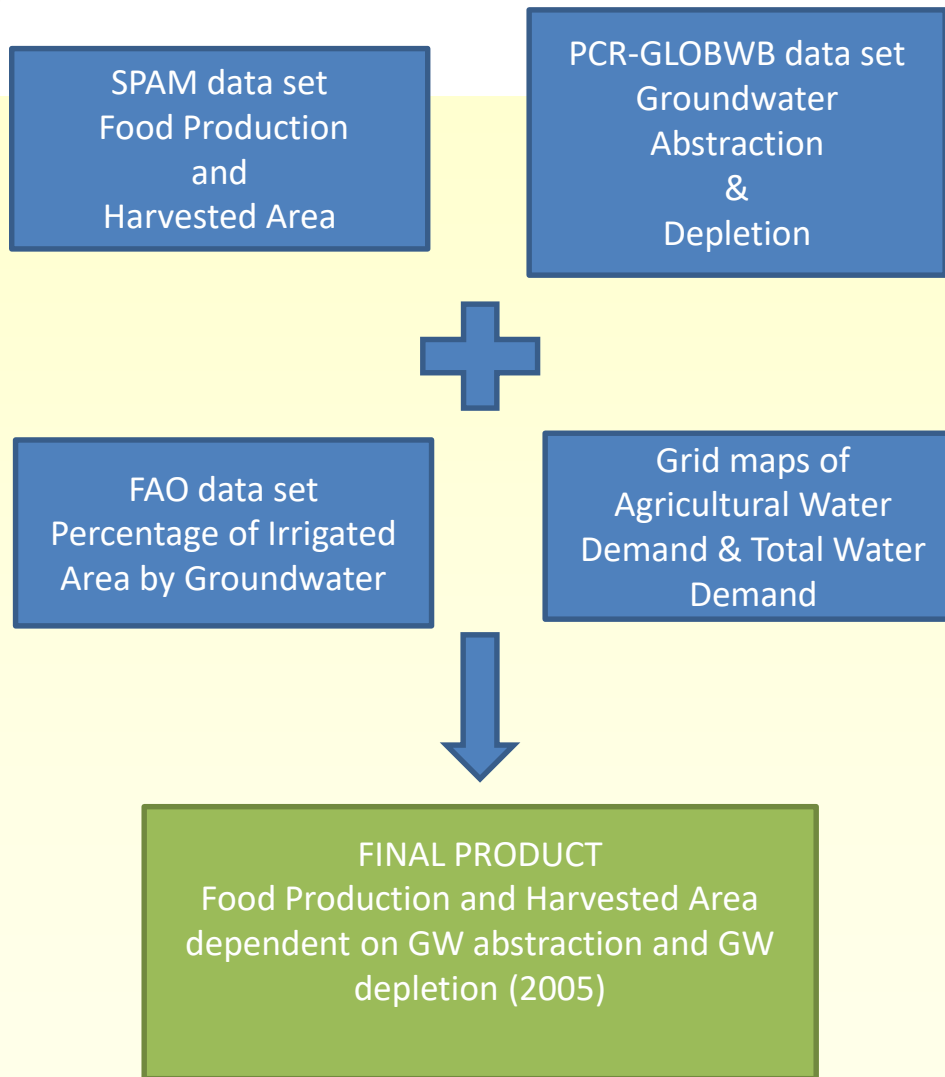
The hidden drought



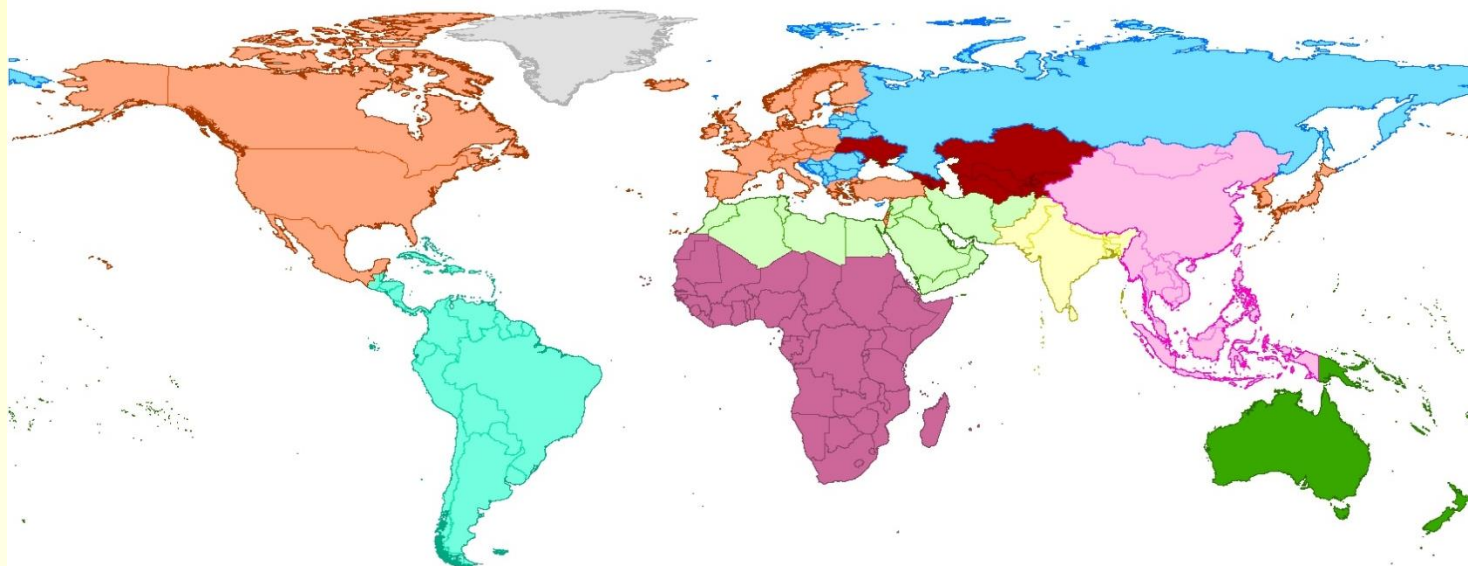
When GW depletion is felt



How much food derives from GW?



Regional aggregation



* without Australia, New Zealand & Chile



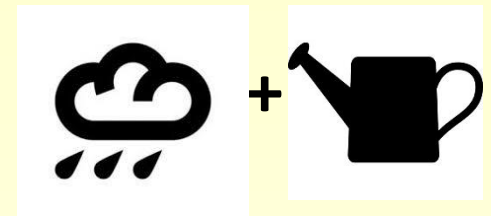
Crop aggregation

Crop Group	Crop Name	Crop Group	Crop Name	
Beverage and spice crops	Arabica coffee	Oilseed Crop	Coconut	
	Cocoa		Groundnut	
	Robusta coffee		Oil palm	
	Tea		Other oil crops	
Cereals	Barley		Rapeseed	
	Maize		Sesame seed	
	Other cereals		Soybean	
	Pearl millet		Sunflower	
	Rice		Other Crops	Rest of crops
	Small millet		Roots and Tubers	Cassava
	Sorghum	Other roots		
	Wheat	Potato		
	Sweet potato			
Leguminous crops	Other pulses	Yams		
	Bean	Sugar beet		
	Chickpea	Sugarcane		
	Cowpea	Vegetables and Fruits	Banana	
	Lentil		Plantain	
Pigeon pea	Temperate fruit			
Non-Food Crops	Cotton	Tropical fruit		
	Other fiber crops	Vegetables		
	Tobacco			

Key findings

- Groundwater irrigated areas globally comprise about 83.1 mill. ha, or about 41% of total irrigated areas
- Of the groundwater irrigated areas, 15.5 to 18.5% are supplied by depleting aquifers
- GW depletion rate in agriculture: 129.3 – 165.6 km³/a, accounting for approx. 89% of total GW depletion

Contribution of GW to global food production



**From GW
abstraction**

100%

43.5%

13.0%

**From GW
depletion**

14.0-16.9%

6.1-7.4%

1.8-2.2%

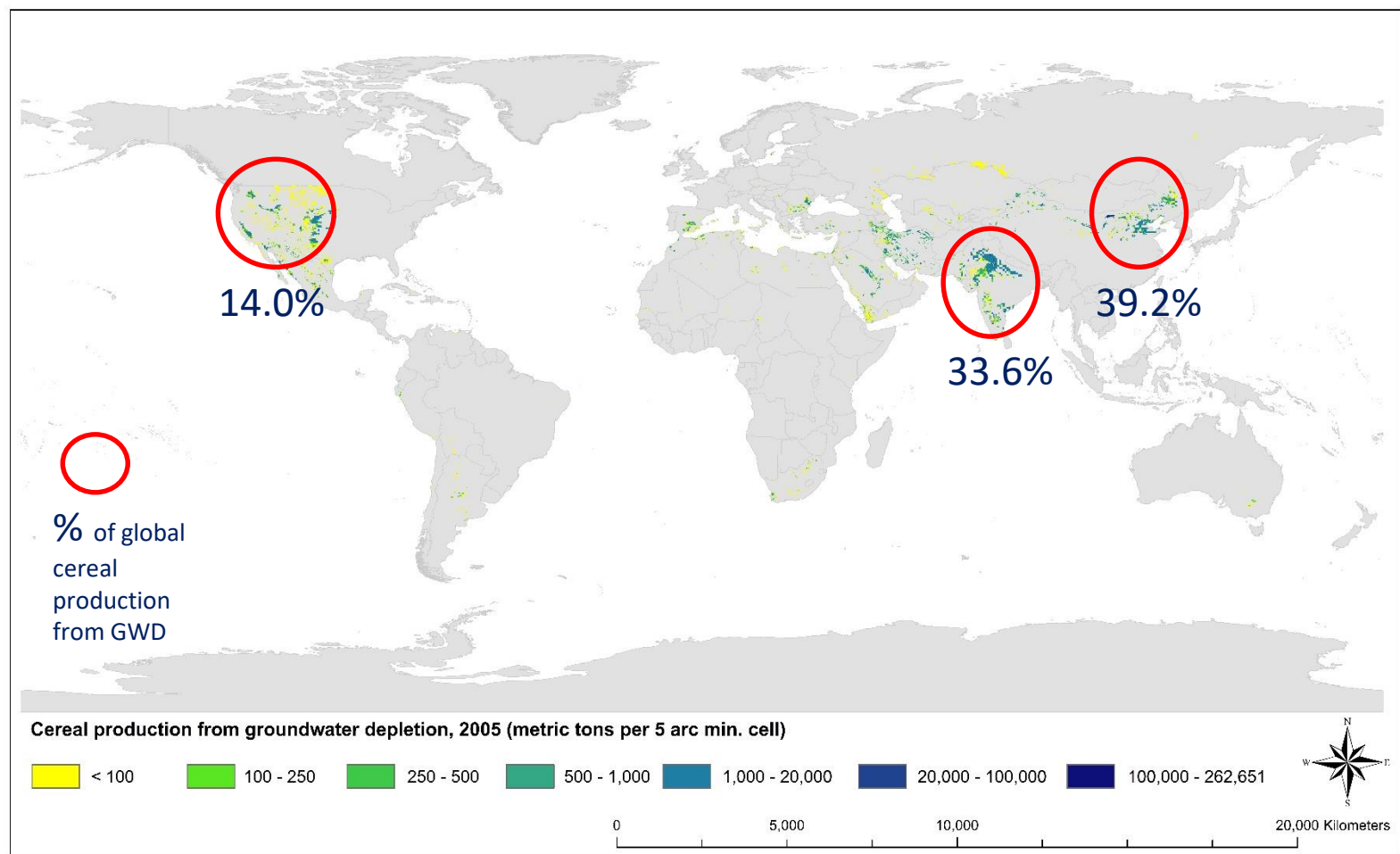
Regional distribution

Region	Food production (10 ⁶ t/a)				Food production from GWD as a fraction of	
	From GWD	From GWD (% of total)	From irrigation	From irrigation and rainfed	Irrigated production	Total production
Australia/Oceania	0.06	0.0%	28.58	96.28	0.2%	0.1%
Central Asia	0.12	0.1%	23.57	151.96	0.5%	0.1%
East Asia	30.55	22.3%	595.02	1997.86	5.1%	1.5%
Latin America and the Caribbean	0.66	0.5%	287.38	1063.58	0.2%	0.1%
Near East/North Africa	10.94	8.0%	113.04	207.72	9.7%	5.3%
OECD	32.77	23.9%	310.35	1593.73	10.6%	2.1%
Other European Countries	0.56	0.4%	16.09	277.09	3.5%	0.2%
South Asia	61.32	44.7%	605.73	904.33	10.1%	6.8%
Sub-Saharan Africa	0.20	0.1%	62.76	518.41	0.3%	0.0%
Total or average	137.17	100.0%	2042.52	6810.96	6.7%	2.0%

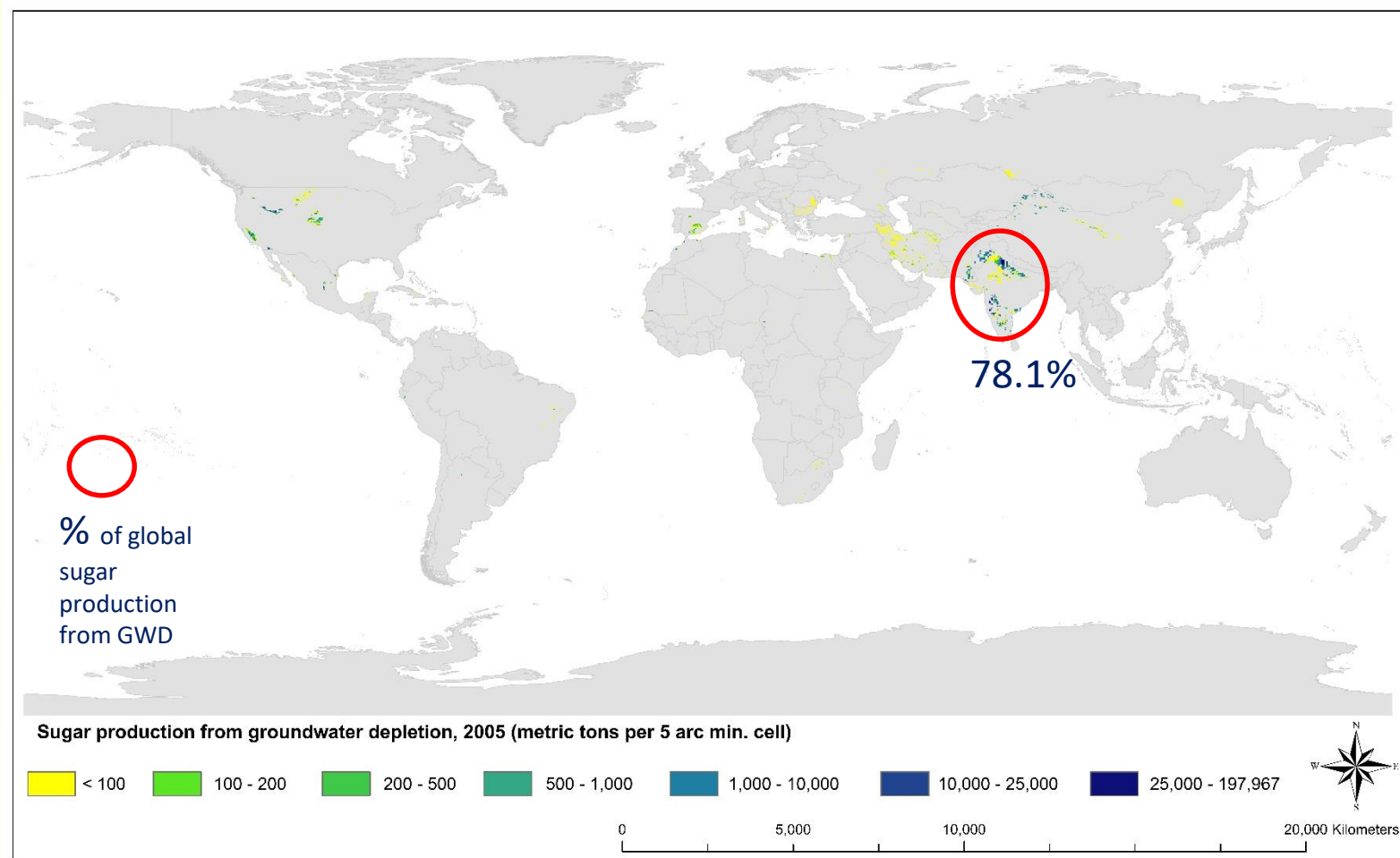
Crop distribution

Crop group	Food production (10 ⁶ t/a)				Food production from GWD as a fraction of	
	From GWD	From GWD (% of total)	From irrigation	From irrigation and rainfed	Irrigated production	Total production
Beverages	0.00	0.0%	0.63	15.32	0.0%	0.0%
Cereals	60.41	44.0%	902.23	2260.27	6.7%	2.7%
Leguminous crops	0.85	0.6%	9.25	60.63	9.1%	1.4%
Non-food crops	4.03	2.9%	41.16	82.64	9.8%	4.9%
Oilseed crops	2.65	1.9%	42.91	593.75	6.2%	0.4%
Other crops	0.32	0.2%	1.68	29.60	19.0%	1.1%
Roots and tubers	15.45	11.3%	109.17	723.58	14.2%	2.1%
Sugar crops	43.04	31.4%	801.26	1613.48	5.4%	2.7%
Vegetables and fruits	10.48	7.6%	134.21	1431.70	7.8%	0.7%
Total or average	137.21	100.0%	2042.50	6810.97	6.7%	2.0%

Cereal production from GWD



Sugar production from GWD



Conclusions

- Global food production depends on depleting GW for 2.0% of total, 6.7% of irrigated, and 15.4% of GW-irrigated fractions in 2005
- Reliance on non-sustainable GW for increasing parts of global food production requires urgent attention
- Solutions to be found in broader global food policies and interventions in both developing and developed part of the world

References

- Calow, R.C., N.S. Robins, A.M. MacDonald, M.J. MacDonald, B.R. Gibbs, W.R.G. Orpen, P. Mtembezeka, A.J. Andrews, and S.O. Appiah, 1997. Groundwater management in drought-prone areas of Africa. *Water Resour. Dev.*, 3, 2, 241 - 261.
- Döll, P., H. Hoffmann-Dobrev, F.T. Portmann, S. Siebert, A. Eicker, M. Rodell, G. Strassberg, and B.R. Scanlon, 2012. Impact of water withdrawals from groundwater and surface water on continental water storage variations. *J. Geodyn.* 59-60, 143-156.
- Döll, P. and M. Flörke, 2005. Global-scale estimation of diffuse groundwater recharge. Frankfurt Hydrology Paper 03, Institute of Physical Geography, Frankfurt University, Frankfurt am Main, Germany, 21 pp.
- Foster, S., G. Tyson, L. Konikow, E. Custodio, K. Villholth, J. van der Gun, and R. Klingbeil, 2015. Groundwater in Food Security. International Association of Hydrogeologists. Professional Strategic Overviews, 6 pp.
- Siebert, S., J. Burke, J.M. Faures, K. Frenken, J. Hoogeveen, P. Döll, and F.T. Portmann, 2010. Groundwater use for irrigation - a global inventory. *Hydrol. Earth Syst. Sci. Discuss.*, 7, 3977–4021.
- van der Gun, J., 2012. Groundwater and Global Change: Trends, Opportunities and Challenges. UN World Water Assessment Programme. WWDR. 38 pp. ISBN 978-92-3-001049-2
- Wada, Y., L.P.H. van Beek, and M.F.P. Bierkens, 2012. Nonsustainable groundwater sustaining irrigation: A global assessment. *Wat. Res. Resear.*, 48, W00L06, doi:10.1029/2011WR010562.
- World Bank, 2005. India's Water Economy: Bracing for a Turbulent Future. Report No. 34750-IN. 82 pp. Washington, DC: World Bank.
- World Water Commission, 2000. A Water Secure World. Vision for Water, Life and the Environment. Vision Commission Report. World Water Commission, Marseille, 70 pp.



Thank you!

Contact:
k.villholth@cgiar.org



A water-secure world



www.iwmi.org