Keynote Irrigated and Dryland Farming

Water for Agriculture: A Global Systems Analysis Perspective

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“We need a Blue Revolution in agriculture that focuses on an increasing productivity per unit of water - more crop per drop“

Kofi Annan, Secretary General of UN, Report to the Millenium Conference, October 2000

Outline

Part I. Concepts and approaches

- “Green“ and “blue“ water
- Water productivity
- Multi-scale integrated scenario approach

Part II. Global modeling of irrigation water requirements

(as part of the global water resources and use model WaterGAP)

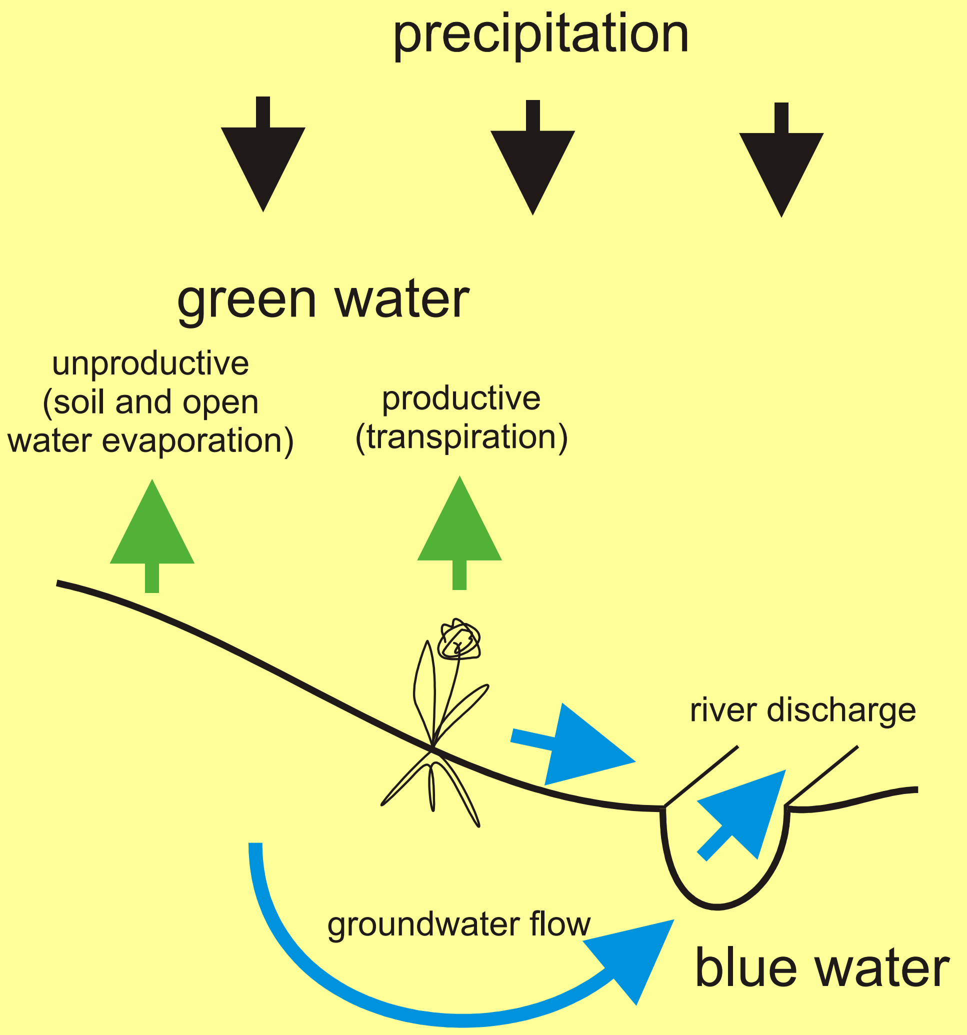
Part I: Concepts and approaches

Water for agriculture:

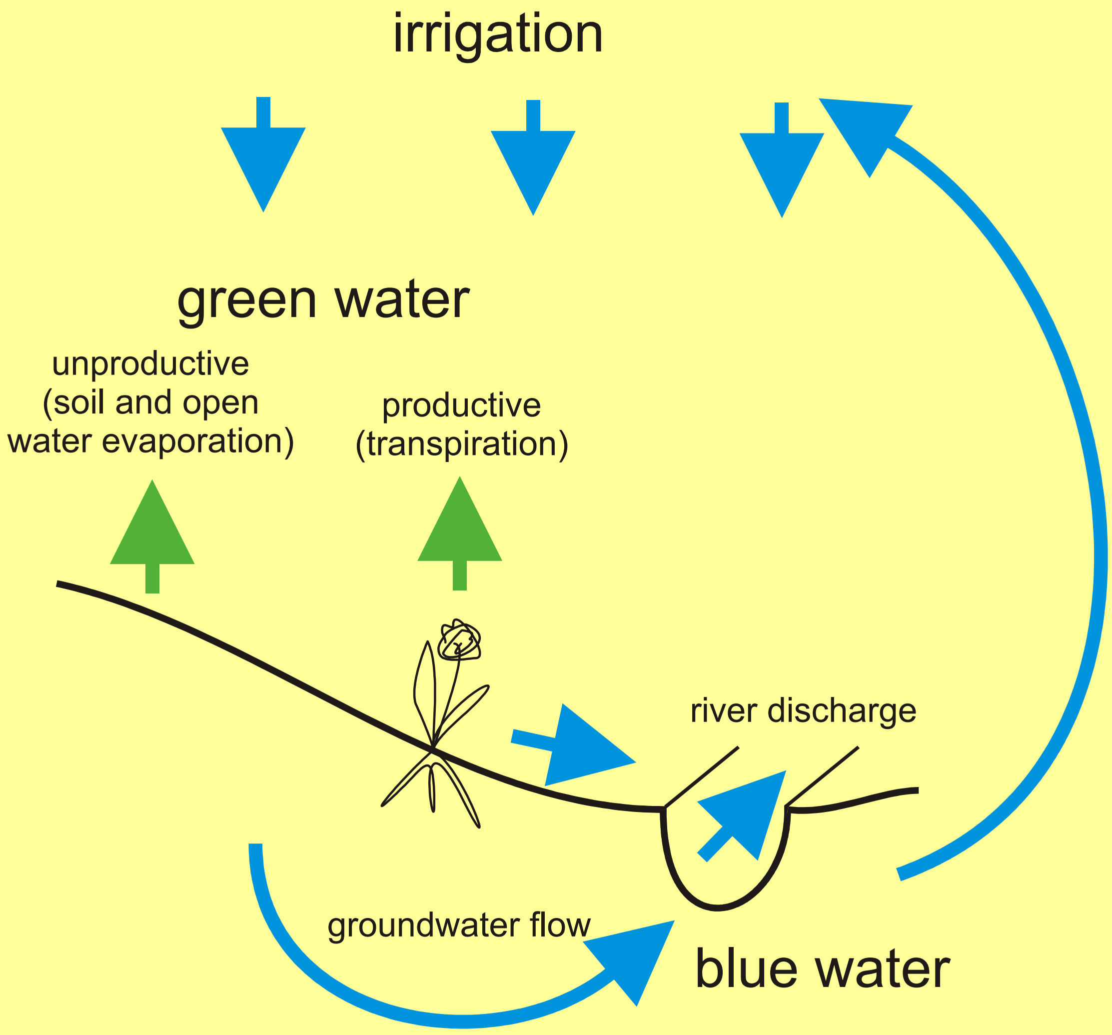
Sustainable plant production requires a sustained provisioning of water

either as green or as blue water

"Green" and "blue" water (Malin Falkenmark, FAO)



Irrigation: blue to green water conversion



Global values of long-term average annual green and blue water fluxes

Green water

total 70,000 km^3/yr total

for agriculture: 18,000 km^3/yr

Blue water

total 35,000 km^3/yr (renewable water resources)

for irrigated agriculture: 1,000 km^3/yr

(consumptive use, withdrawals 2500 km^3/yr)

Water productivity vs. water use efficiency

Water use efficiency = consumptive water use / withdrawal

- Scale dependent concept due to return flows; project efficiencies generally less than basin efficiency
- Increased efficiency of upstream water user will lead to decreased water availability for downstream user if water withdrawals of upstream user remain the same
- In a river basin with many consecutive irrigation water users, an improved water use efficiency at project level does not increase the amount of irrigated crop that can be produced with a given volume of available water.

Water productivity vs. water use efficiency

water productivity = produced crop mass / water volume*

or

= economic value of crop / water volume*

Molden (1997) *(applied, consumed or depleted)

- applicable both for dryland and irrigated agriculture
- trade-offs!
  (e.g. irrigated rice with higher water productivity requires increased nutrient and pesticide input)

Integrated multi-scale scenario development to support land and water management

Need to integrate

- Land and water
- Technological, economical, social and ecological aspects
- Farm, community, river basin, country, global

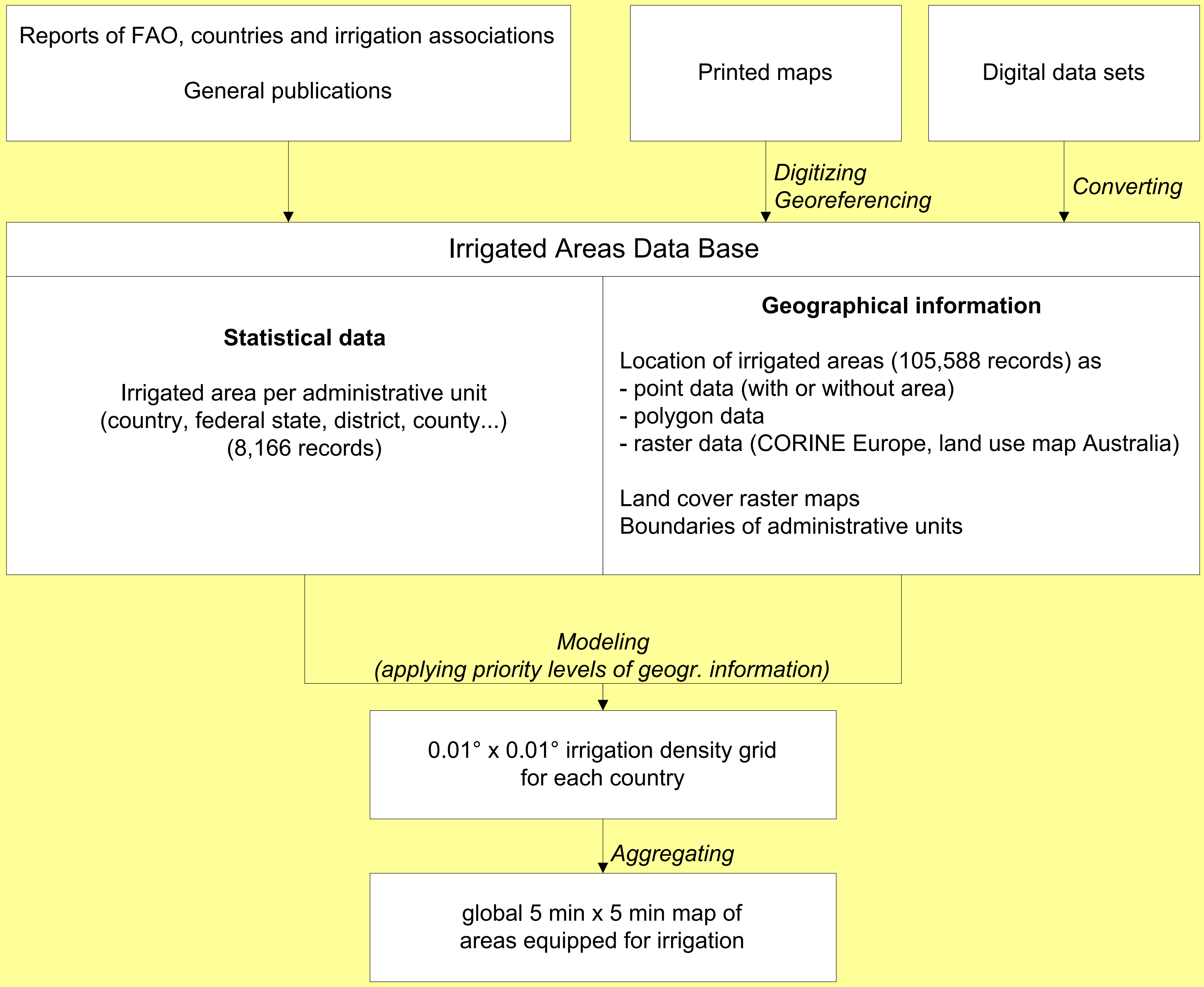
Scenario development (including qualitative and quantitative, e.g. modeling, elements) is a means to support integrated sustainability-oriented planning.

Part II. Global modeling of irrigation water requirements

with Stefan Siebert, University of Kassel

- Global map of areas equipped for irrigation around 1995
- Global Irrigation Model GIM

Global map of irrigated areas - method



Global map of irrigated areas - example Spain

Global map of irrigated areas - Mediterranean

Fraction of 5 min grid cell area equipped for irrigation around 1995, in percent

Version 2.1, September 2002
University of Kassel and FAO

Global map of irrigated areas - Australia

Fraction of 5 min grid cell area equipped
for irrigation around 1995, in percent

Version 2.1, September 2002
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Global map of irrigated areas

Fraction of 0.5° grid cell area equipped for irrigation around 1995, in percent

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Global Irrigation Model GIM

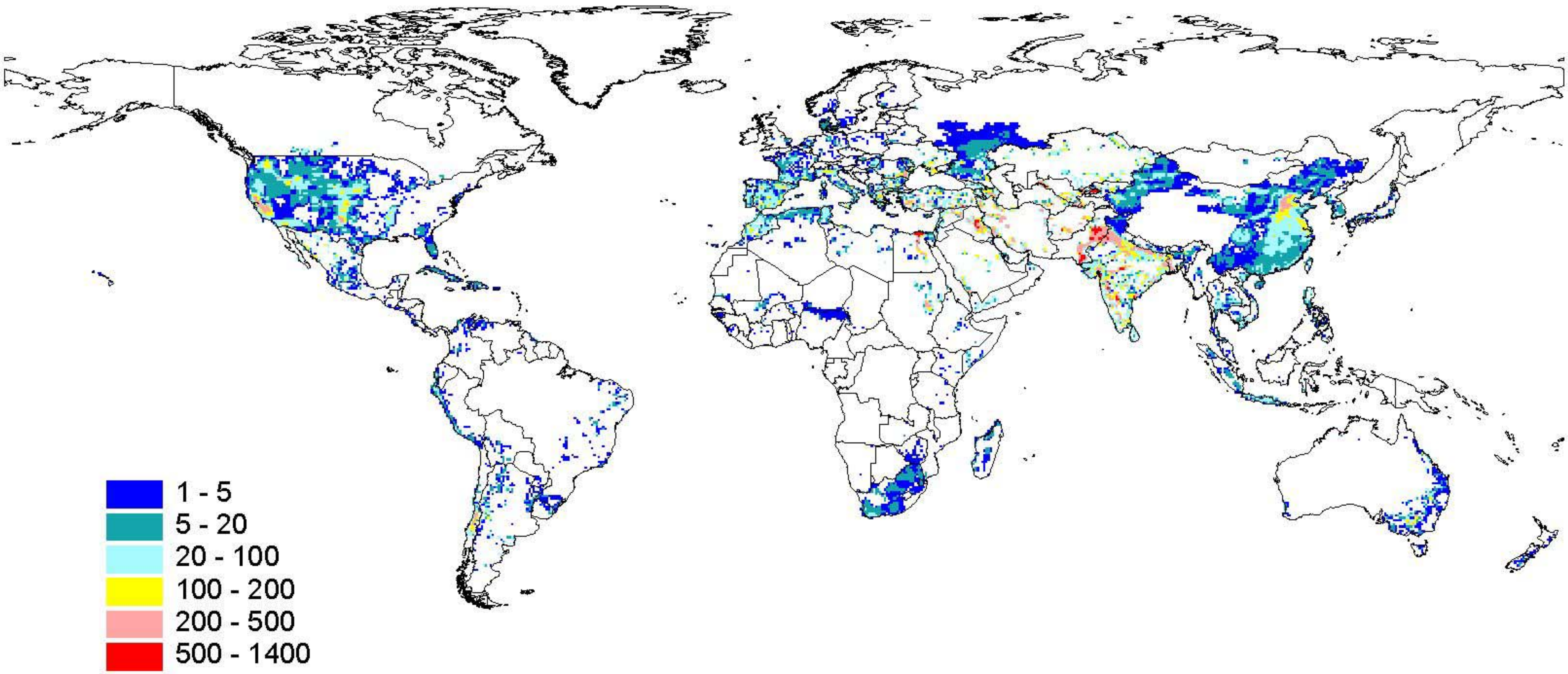
Model output

- Net and gross irrigation requirements per 0.5° grid cell
- Cropping pattern and growing seasons of rice and non-rice considering multicropping

Model input (selected)

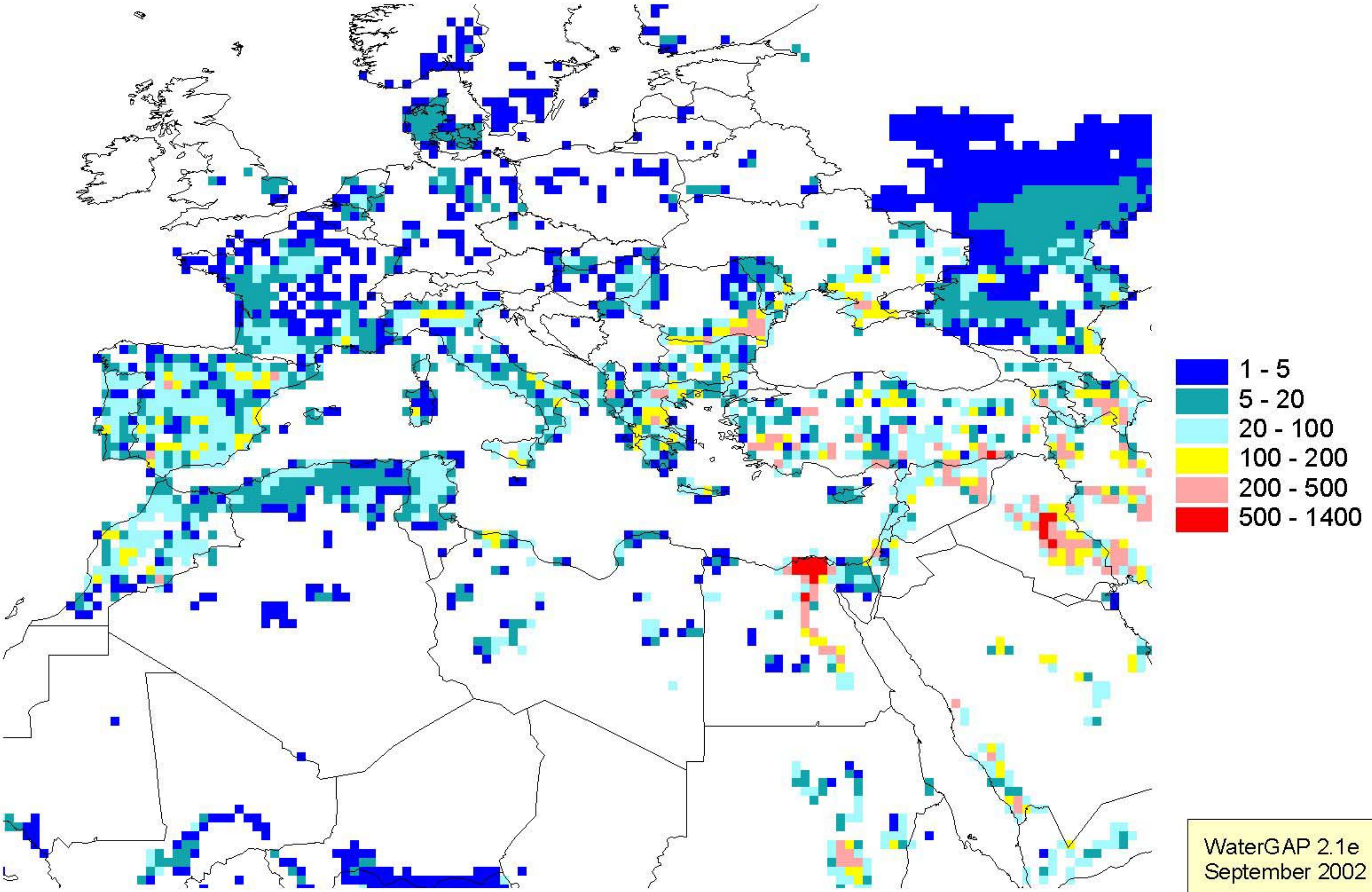
- Time series of monthly climate variables 1901-1995
- Global map of irrigated areas
- Rice cropping areas, FAO soil suitability for rice

Net irrigation water requirements, in mm per cell area
(irrigated area 1995, climate 1961-90)

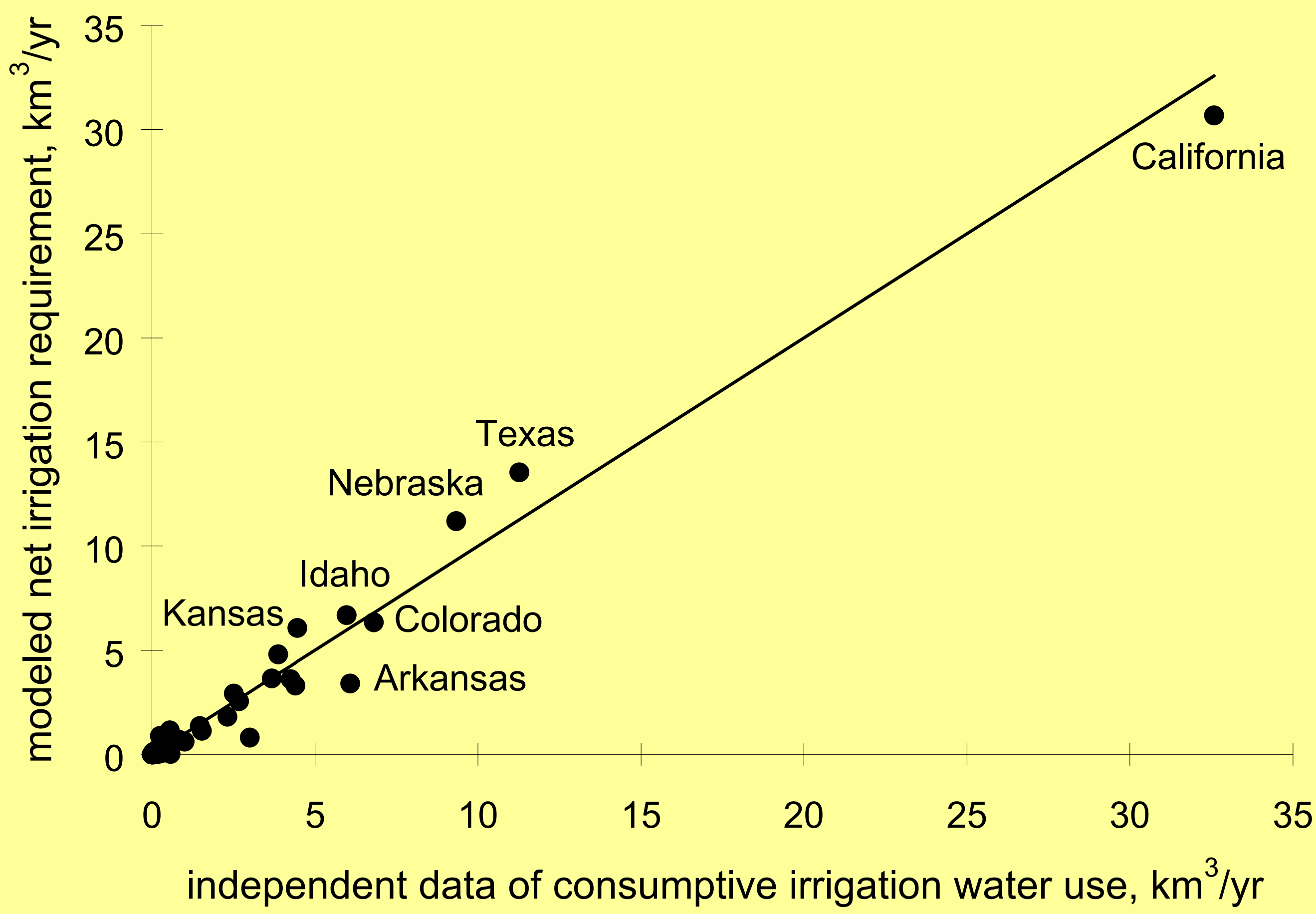


WaterGAP 2.1e
September 2002

Net irrigation water requirements, in mm per cell area (irrigated area 1995, climate 1961-90)

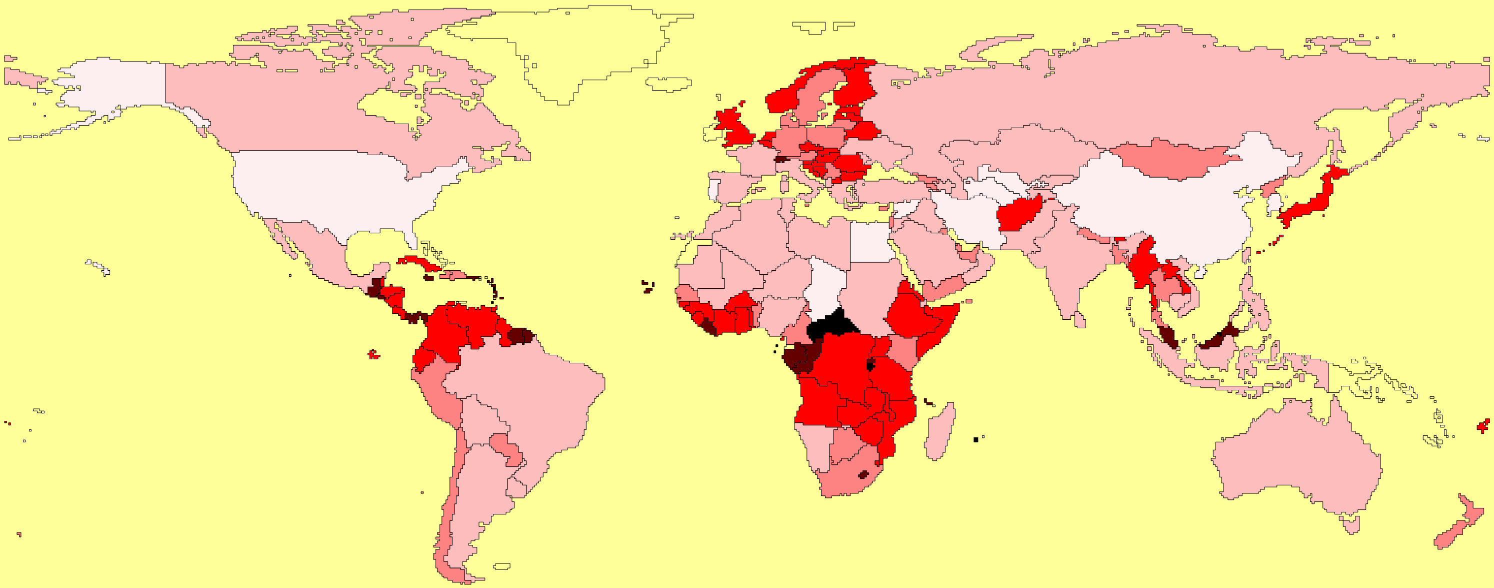


Validation of GIM



Uncertainty analysis (Siebert, 2002)

a)



Coefficient of variation

- < 0,25
- 0,2 - 0,2999
- 0,3 - 0,3999
- 0,4 - 0,5999
- 0,6 - 0,9999
- >1

(for global value: 0.2)

WaterGAP 2.1d, April 2002
University of Kassel

Impact of climate change on net irrigation requirement

Global net irrigation requirement according to GIM, in km^3/yr (30-year-average, 2.5 million km^2 irrigated area)

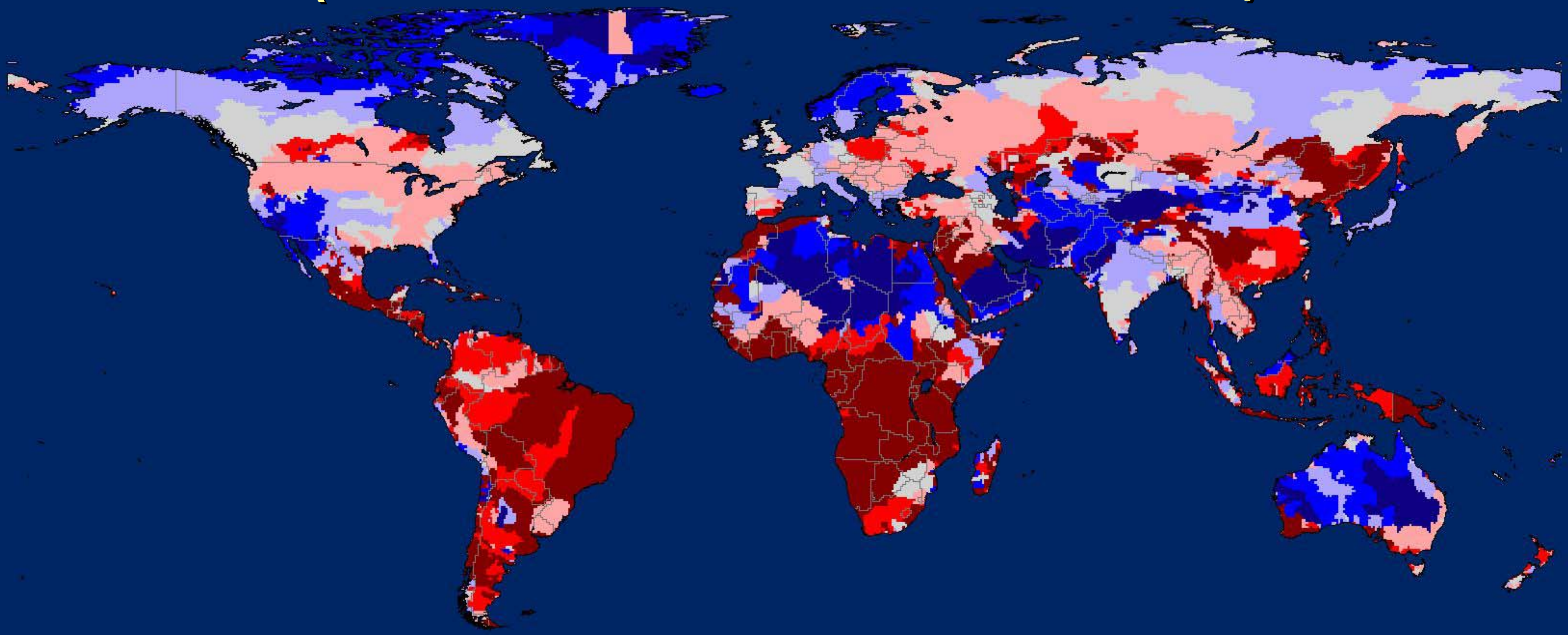
1961-90	1091
2020s	ECHAM4: 1128, HadCM3: 1147
2070s	ECHAM4: 1151, HadCM3: 1177

Expansion of irrigation in the future World Water Vision scenario 2025

Scenarios	Global change relative to 1995
“Business-as-usual“	+1.5% (only in India, Turkey and Brazil)
„Technology, Economics and the Private Sector“	+23% (-24% in Saudi-Arabia to +122% in Brazil)
“Values and Lifestyles“	+5% (-100% in Saudi-Arabia to +56% in Benin)

Pressure on Water Resources

(2020s : BAU + Max Planck GCM)



Changes in Pressure on Water Resources

Decrease			Stable			Increase
	-50%	-25%	-5%	+5%	+25%	+50%

(c) Center for Environmental Systems Research, University of Kassel, Nov 2000 - WaterGAP 2.1

Conclusions

- The concepts of blue and green water as well as of water productivity are useful for land and water management
- Development of multi-scale integrated scenarios, which combine storylines with modeling, can support sustainability-oriented land and water management
- Global modeling of irrigation water requirements helps to assess water scarcity; in the future, a coupling with agricultural productivity and agro-economic models is desirable.