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Environmental flow deficit at global scale – implication on irrigated agriculture

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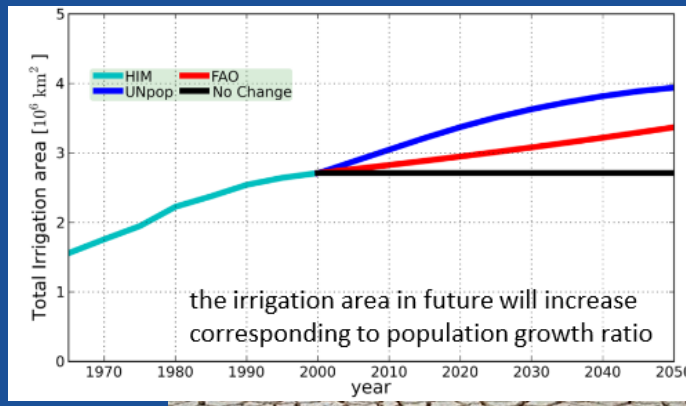
SSS10.1/HS5.12
Irrigated agriculture: Natural Resources Management for the sustainability of the terrestrial ecosystem maintaining productivity (co-organized)

Outline

- Environmental flow requirement (EFRs) concept
- Implementation of EFRs in global models
- Global environmental flow deficit
- Implication for irrigated agriculture

Context / Motivation

- Irrigated land nearly x 2 (1950-2000) to supply 40% of our food
- Water consumption x 3
- Use it or loose it !
- Some rivers do not reach the sea anymore (Colorado, Nile, Indus)
- 35 % loss of river species worldwide (Loh et al., 2010)
- Displacement of indigenous community
- Passion with rivers…

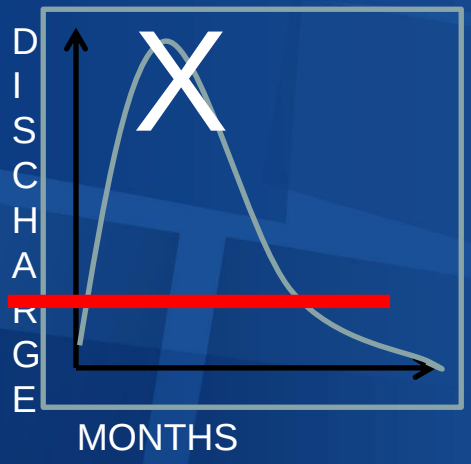


Food production

Environmental flows

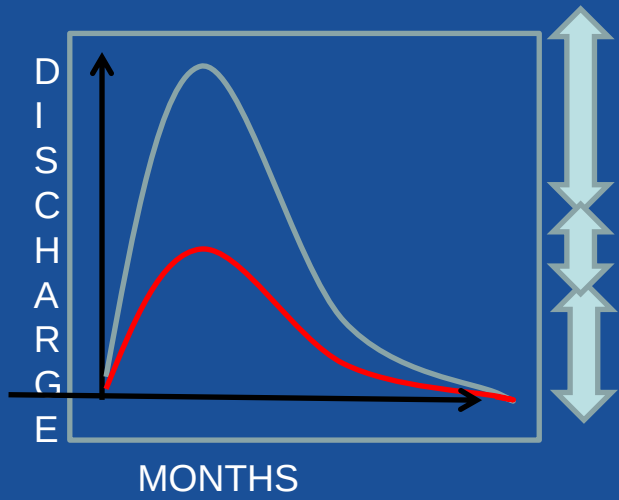
ENRIONMENTAL FLOW CONCEPT

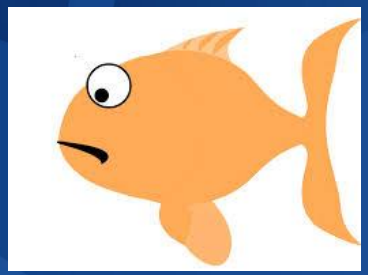
Environmental flows describe the **quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems** and the human livelihoods and well-being that depend on these ecosystems (The Brisbane Declaration, 2007).

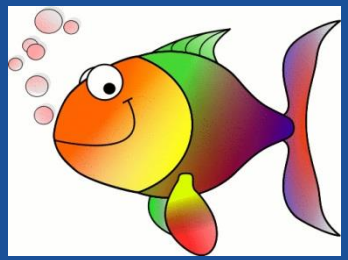


VMF method (Pastor et al. 2014)

- High flow requirements = 30% monthly flow
- Intermediate flow requirements = 45% monthly flow
- Low flow requirements = 60% monthly flow



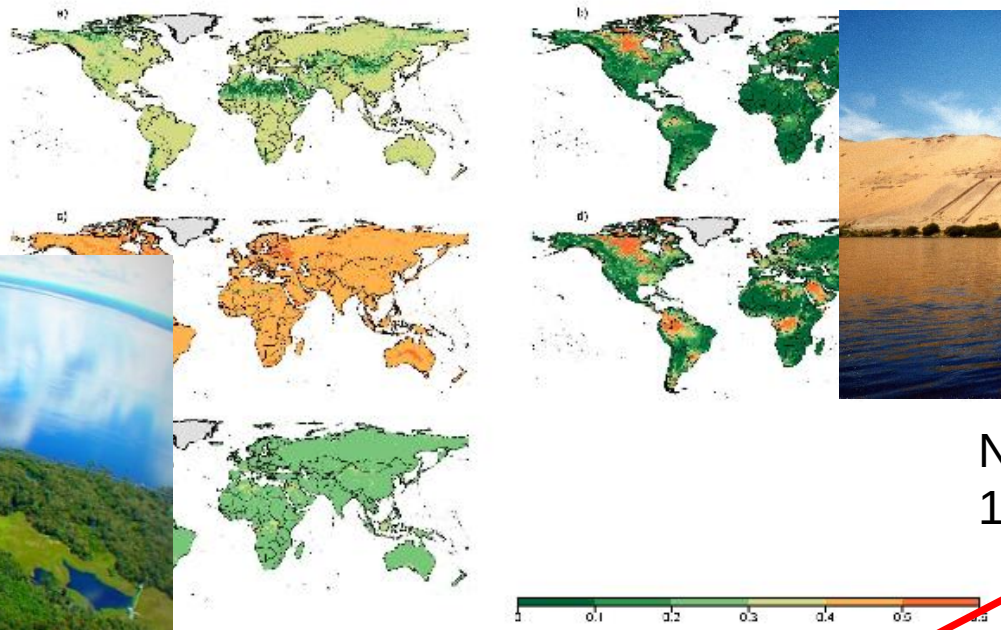




Pastor, A. V., Ludwig, F., Biemans, H., Hoff, H., and Kabat, P.: Accounting for environmental flow requirements in global water assessments, Hydrol. Earth Syst. Sci., 18, 5041-5059, doi:10.5194/hess-18-5041-2014, 2014.

NILE NEEDS
10-50% FLOW

AMAZON
NEEDS 30-70%
FLOW



ual environmental flow by annual natural flow within **(a)** Variable Monthly Smakhtin, **(c)** Tessmann, **(d)** $Q_{90}\_Q_{50}$, **(e)** Tennant environmental flow methods.

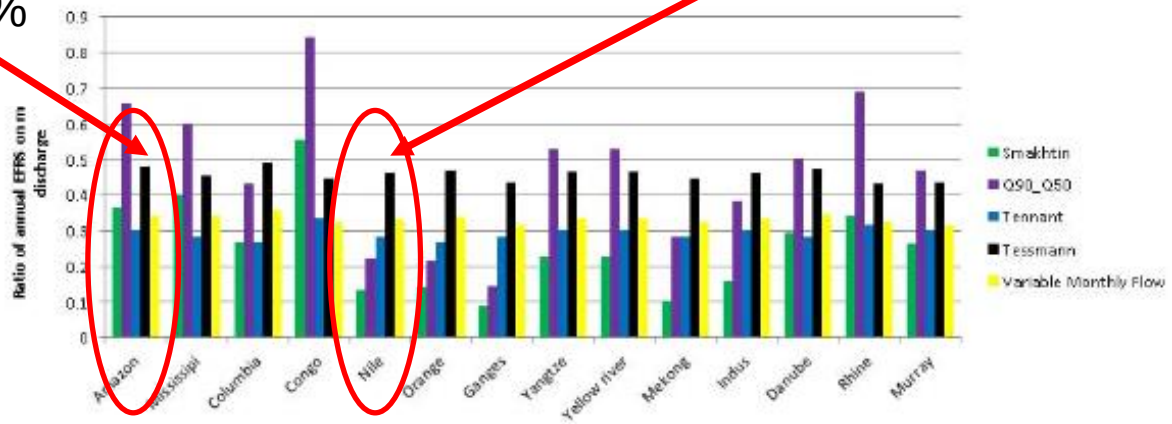
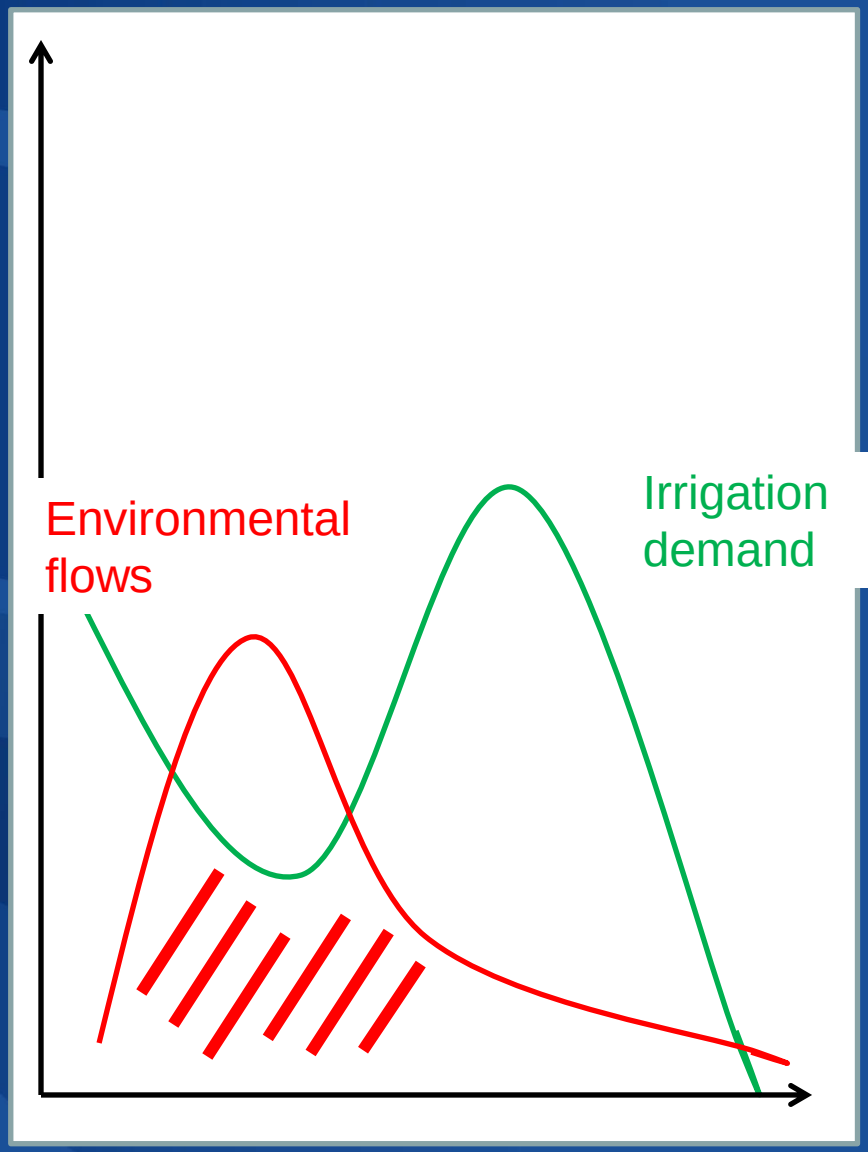


Fig. 6. Comparison of 5 environmental flow methods at the outlet of 14 river basins.

Pastor, A. V., Ludwig, F., Biemans, H., Hoff, H., and Kabat, P.: Accounting for environmental flow requirements in global water assessments, Hydrol. Earth Syst. Sci., 18, 5041-5059, doi:10.5194/hess-18-5041-2014, 2014.

Concept

1. Actual EFR deficit with actual irrigation:
    1. Climate data CRU-GPCC data..
    2. VMF method: “fair conditions”
    3. Scale: 0.5*0.5 deg or river basin
    4. *Run IRES (discharge) – EFR -> only deficit from surface water at cell level*
    5. Alternative: INO – Wd_irrig_potential – Wd_others – EFRs - *water withdrawal from total water resources – scale: river basin*



River flow

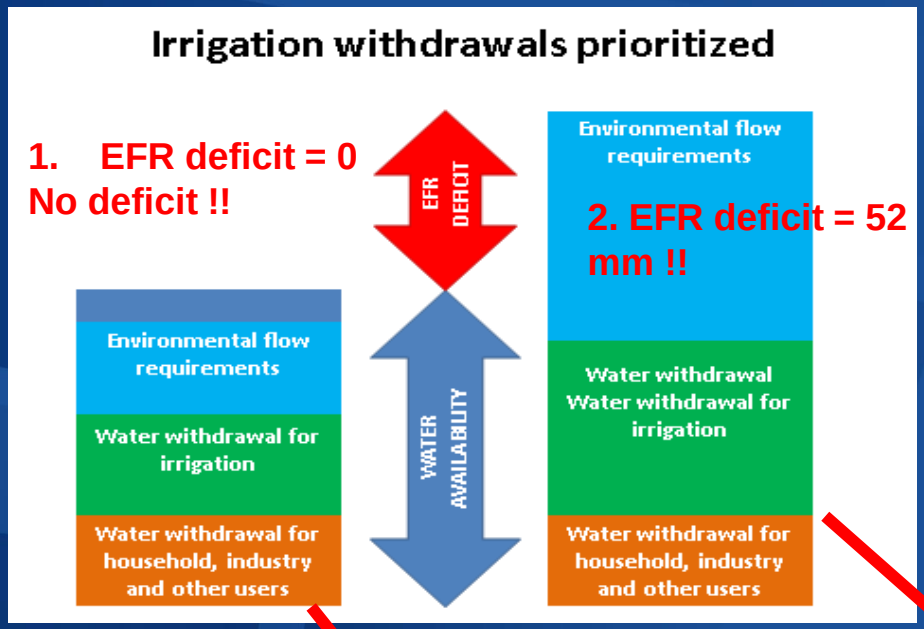
Environmental flows

Irrigation demand

High flow period

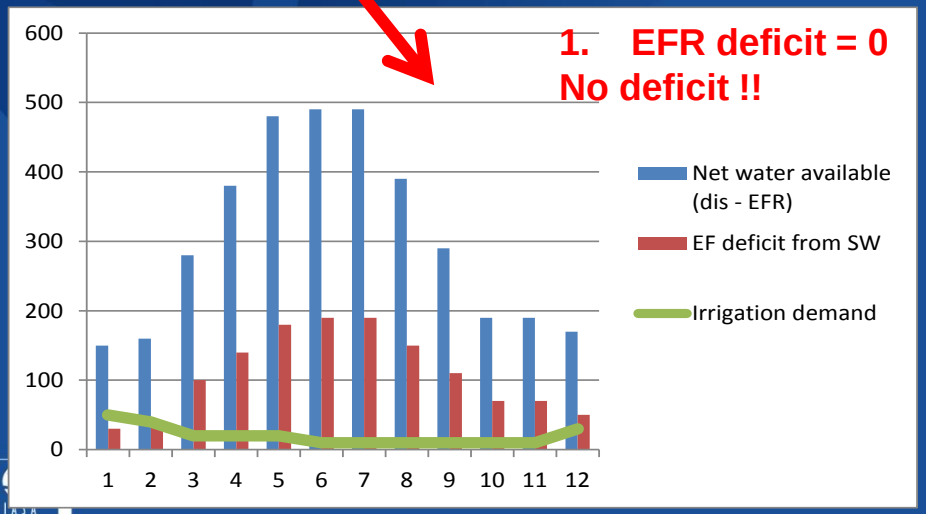
Low flow period

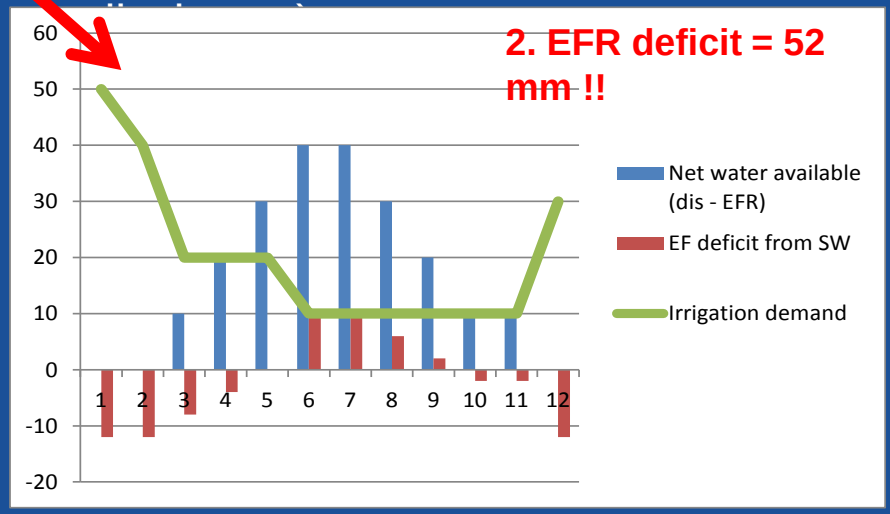
Concept of EFR deficit



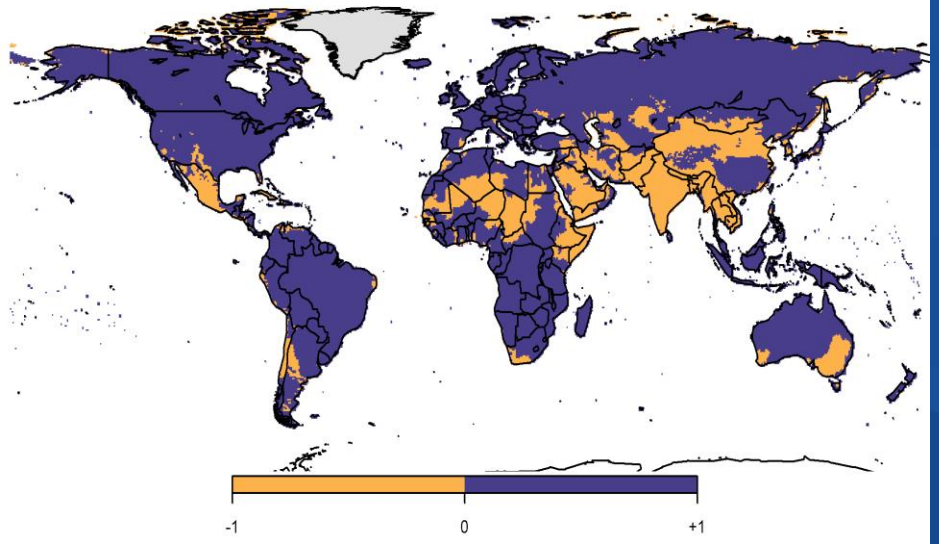
- EFR deficit: is there some water left..
- EFR deficit =
- water availability
  - water wd from other users
  - water wd from irrigation

- Case 1: EFRdef > 0 => no deficit
- Case 2: If EFRdef < 0 = deficit for freshwatere ecosystem
- EF deficit = 52mm (13% of available

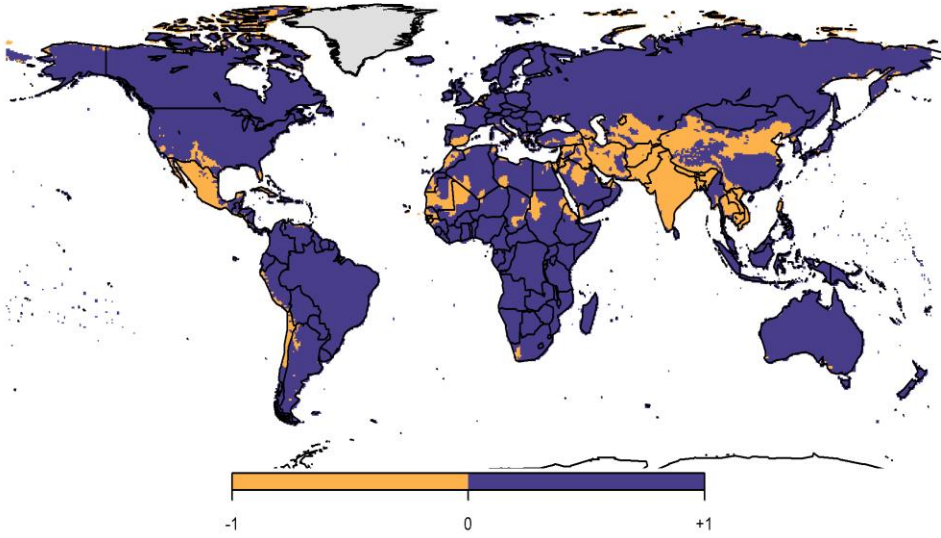




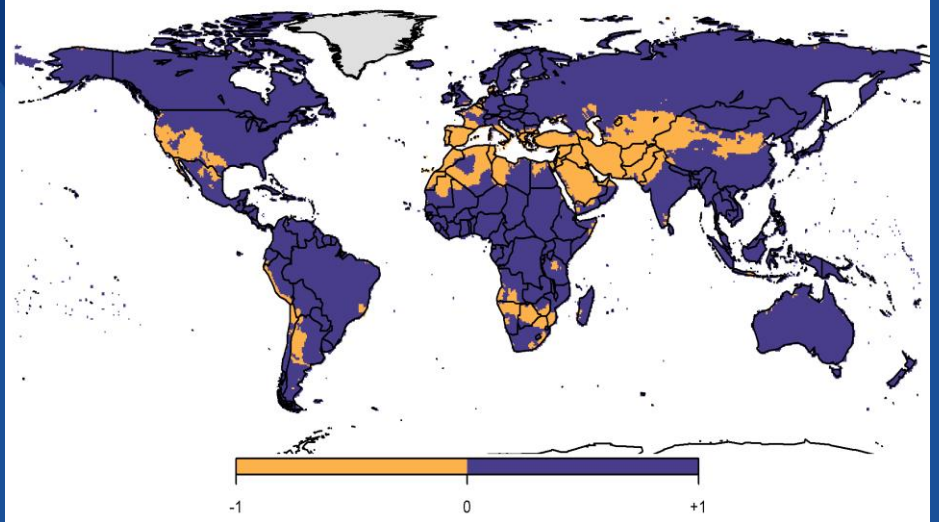
EFR deficit, January (1990-2009)



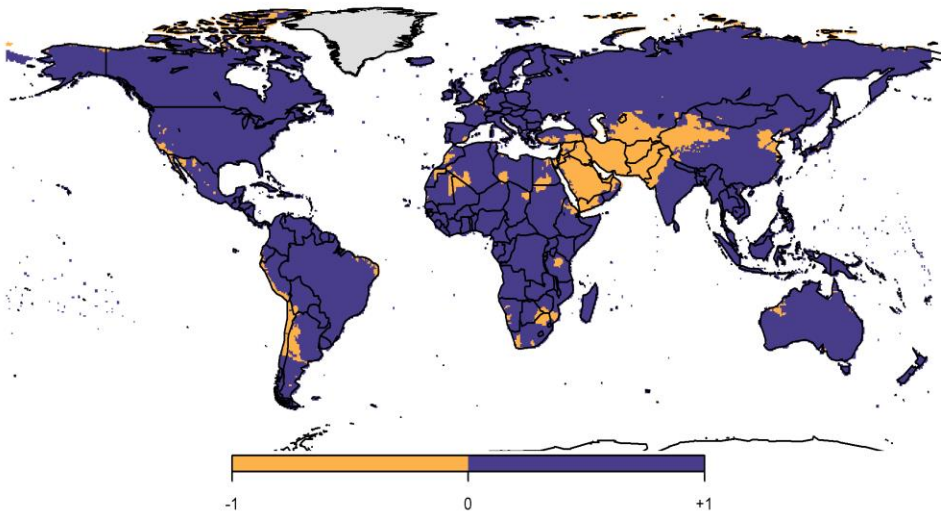
EFR deficit, April (1990-2009)



EFR deficit, July (1990-2009)



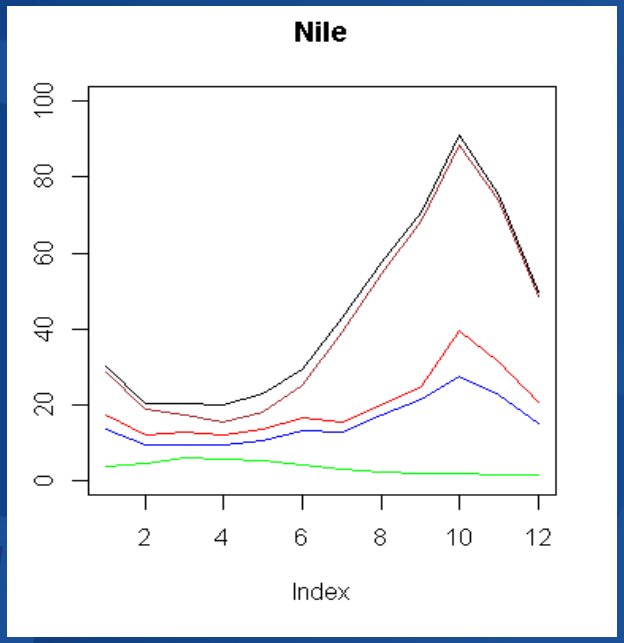
EFR deficit, October (1990-2009)

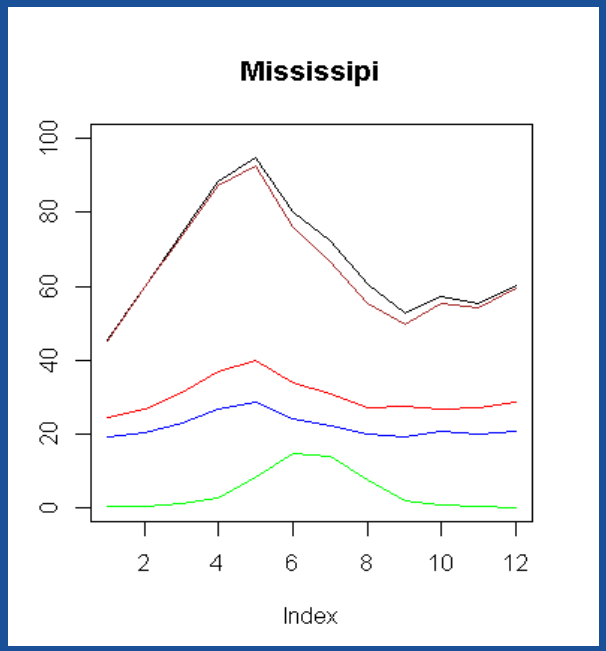


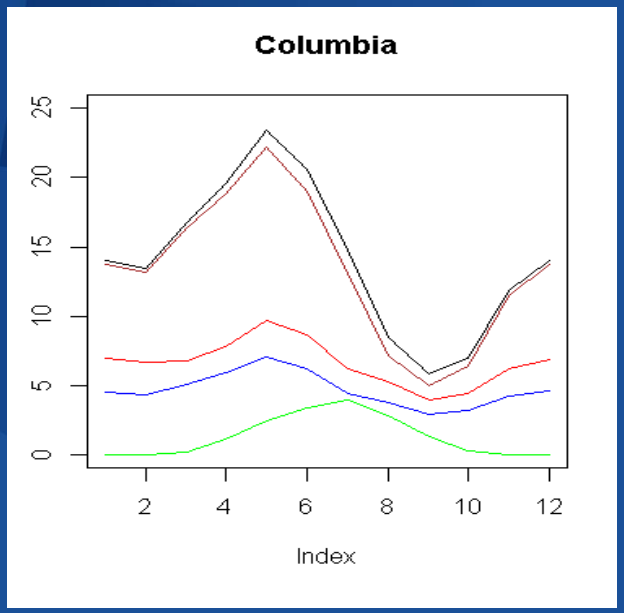
Results EF deficit per continent (sum of monthly deficit $km^3\ yr^{-1}$)

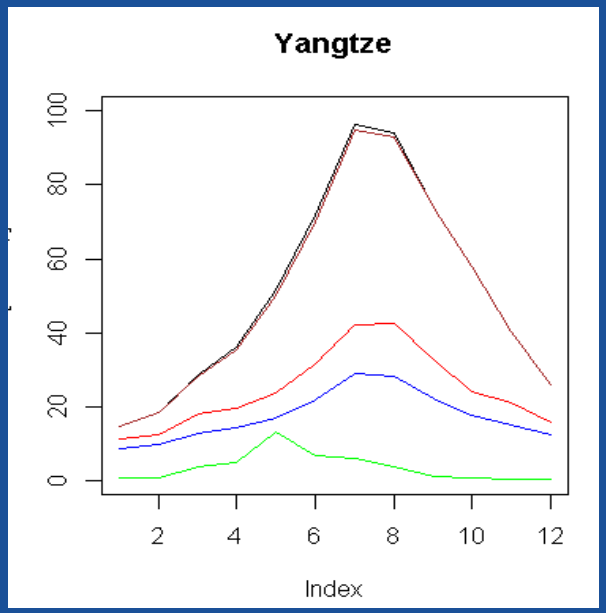
River basin	Water available	VMF_EFR Pastor et al. 2014	Irrigation (km3)	Other_users	EFR deficit	EFR deficit %
NA	5646	1888	262	109	-215	-6%
SA	13679	4589	63	81	-60	-1%
EU	1786	597	84	154	-102	-9%
Africa	6675	2188	129	66	-112	-3%
Asia	14339	4763	1828	514	-1792	-19%
Oceania	1233	406	29	9	-19	-2%
World	43361	14434	2398	935	-2301	-8%

No EFR deficit

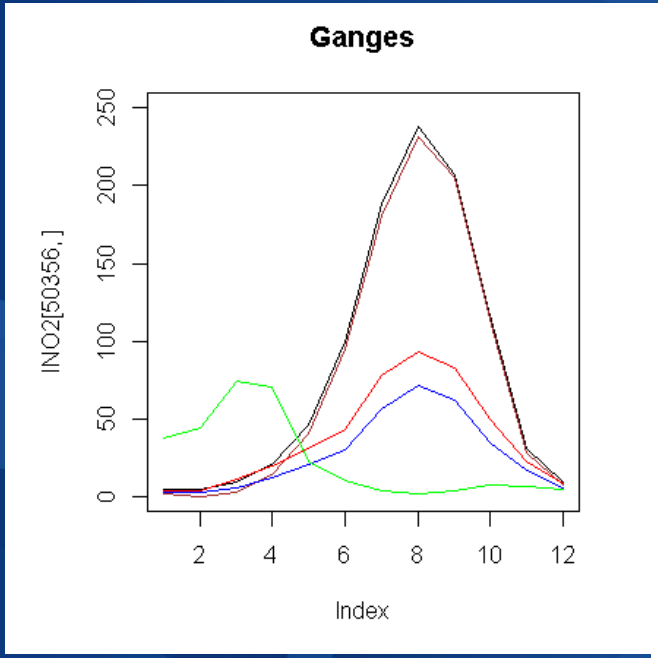


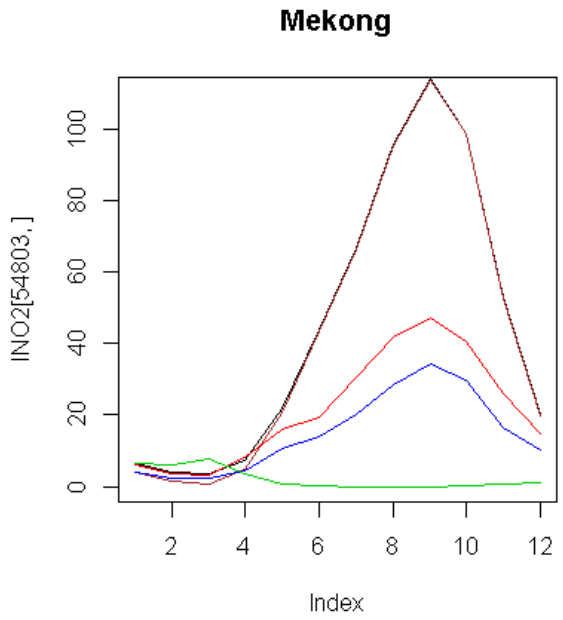


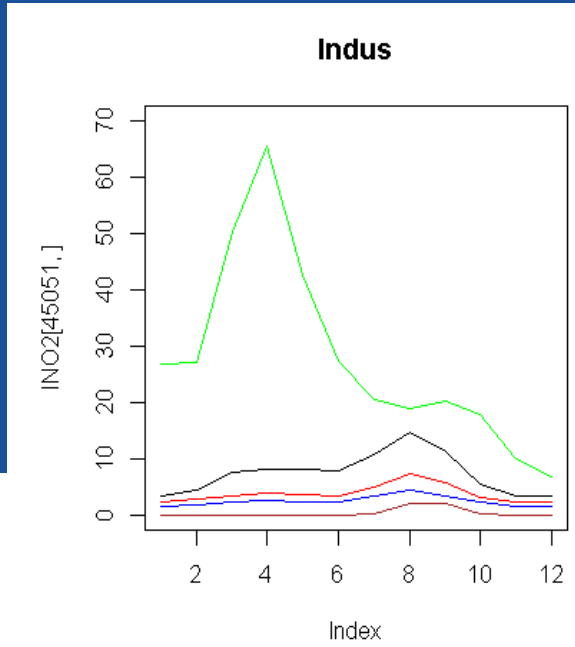




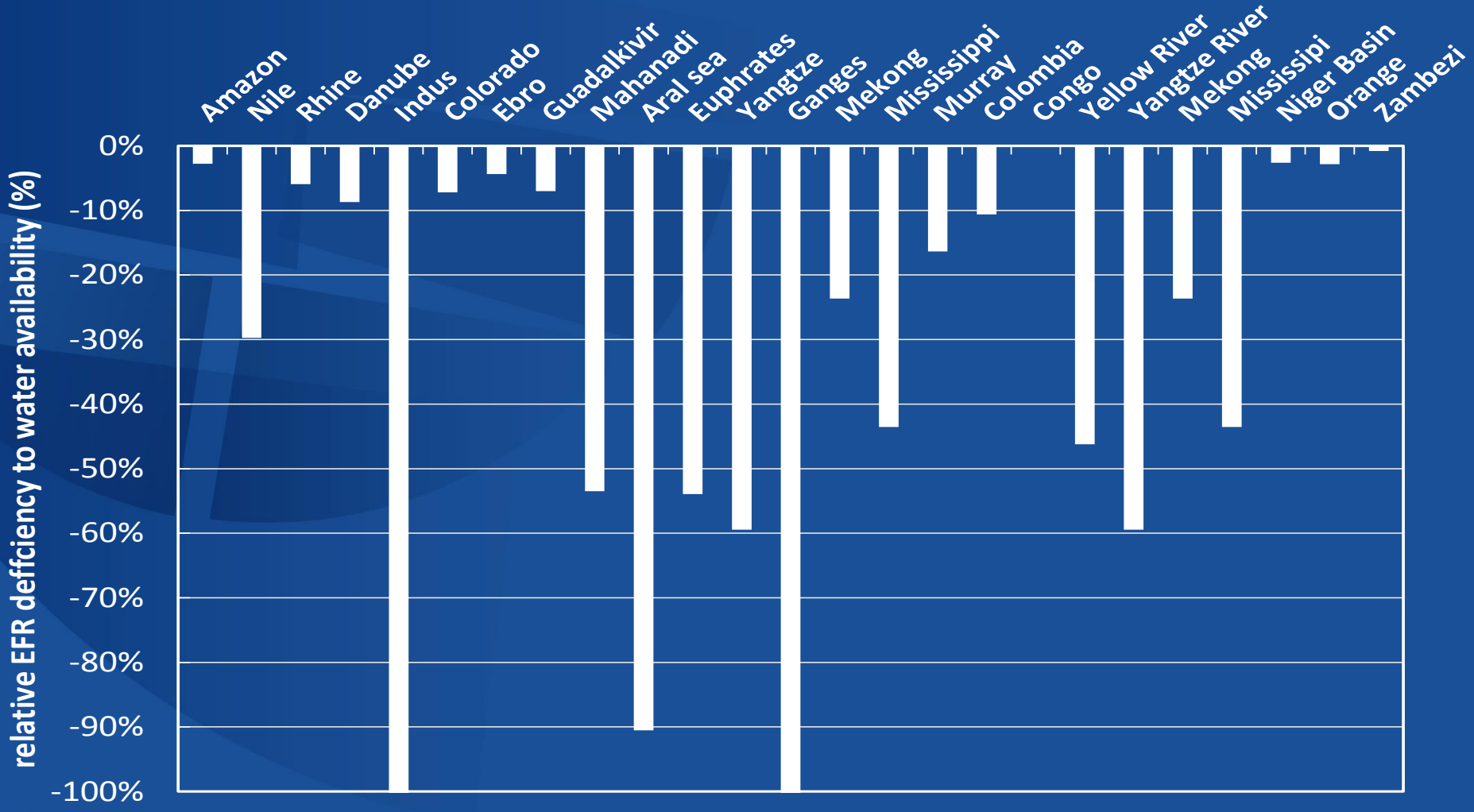
EFR deficit > 0







EFR deficit per basin (%) of water available



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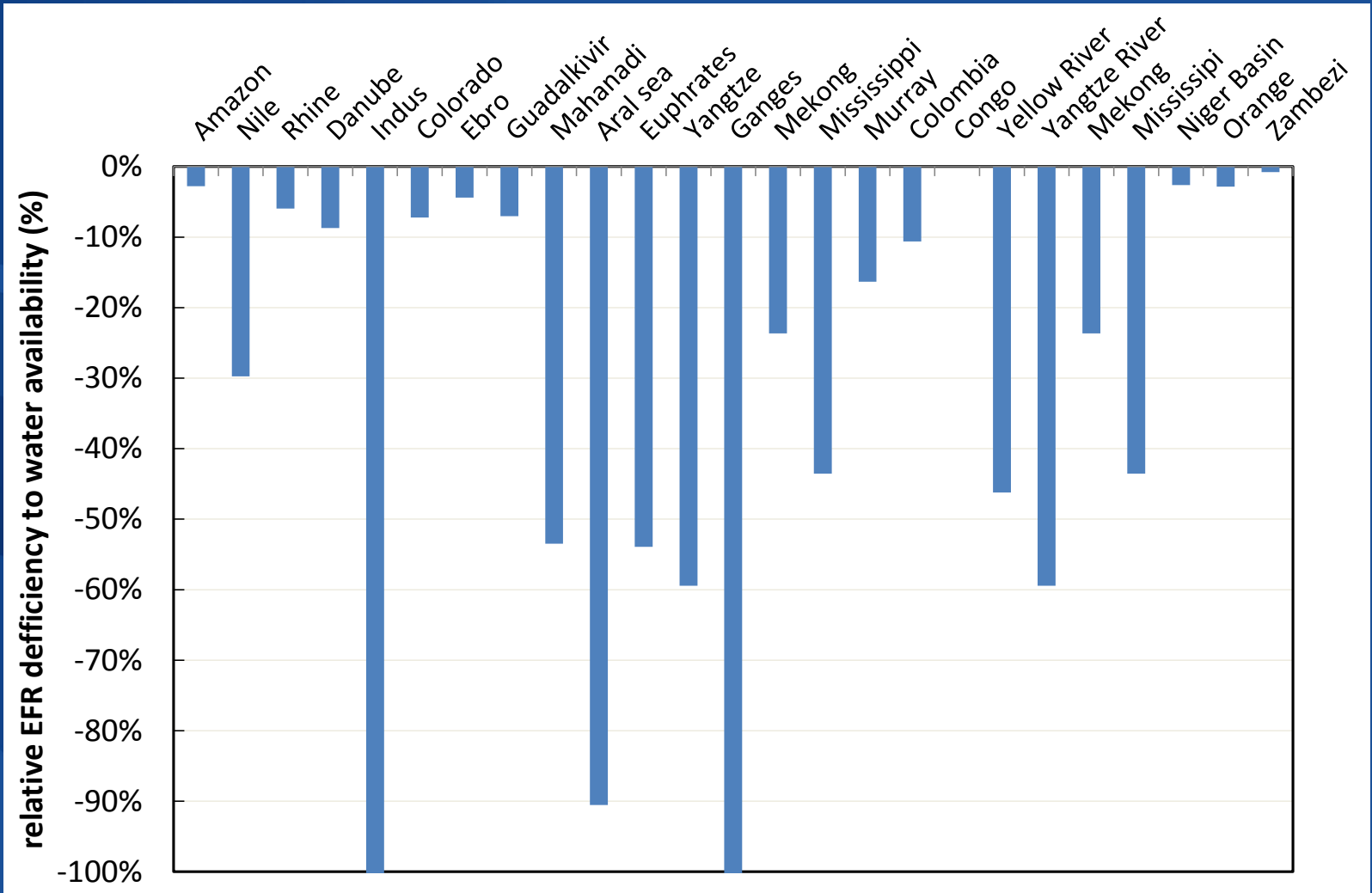

Conclusion

- Freshwater ecosystems are being heavily degraded
- Water is become more scarce by climate change and for producing food
- Environmental flow are not satisfied in many part of the world during dry periods and conflict with agriculture
- With EFRs implementation, irrigated area would have to be reduced by 20%