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IWRA

The Scottish Government
Riaghaltas na h-Alba

Universidade do Minho

Sefficiency (Sustainable efficiency) and Reallocation of Water Using Agricultural and Urban Scenarios

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Why Efficiency

"With 90% of the global economic activity dependent on water, protection of this key resource is highly relevant to Juncker's top priority to boost jobs growth, and investment." WssTP, 2015

"Efficiency is thus not a goal in itself. It is not something we want for its own sake, but rather because it helps us attain more of the things we value." Stone (2002)

Concept vs Computation

Flawed Indicators

CE = $(ET - PP)_b$ / (VA - ΔS) (or similar ones)

CE = Classical Efficiency (%)

Much used: UN, China, EU, USA, …

Reasons

i. **Lack of generalized application of Usefulness Criterion**
ii. **Mixing up of hydrology and agronomy**
iii. **Incompleteness of water flow considerations**
iv. **Objectives and scale mismatches**

WP = yield / ET (or similar ones)

WP = Water Productivity (kg / lit)

Much used: …

Reasons

i. **it is not derived systemically according to a universal principle or a foundational framework**
ii. **See youtube Wichelns 2013**
iii. **See Haie 2015**

Sefficiency and Water Security

Water Security: a working definition (UN-Water 2013)

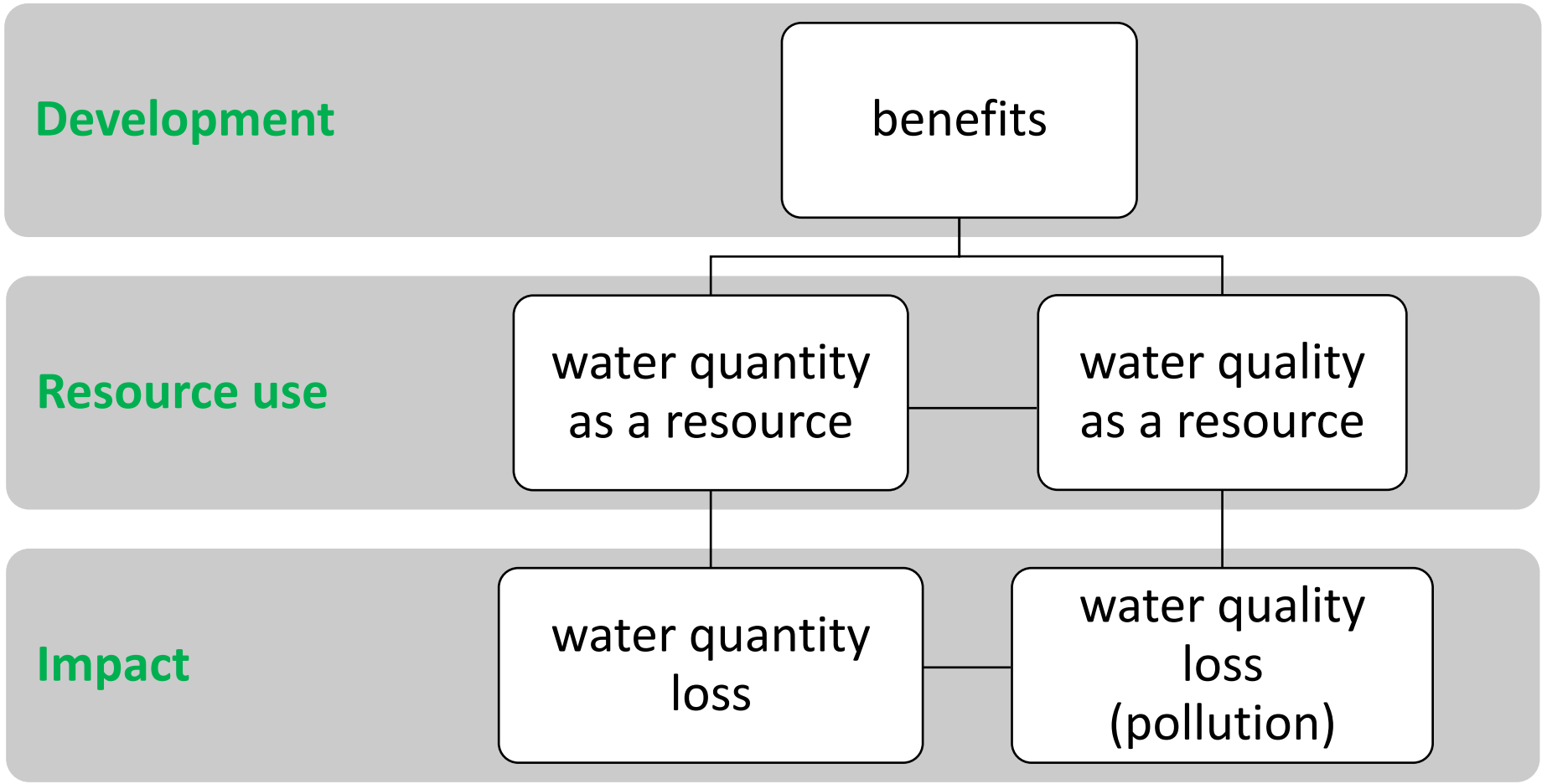
"The capacity of a population to safeguard sustainable access to adequate **quantities** of acceptable **quality** water

for [*the following* ***benefits***]

- sustaining livelihoods
- human well-being
- socio-economic development
- protection against water-borne pollution
- protection against water-related disasters
- preserving ecosystems

in a climate of peace and political stability."

Sefficiency and Water Security



(Haie, 2015)

Sefficiency and Water Governance

Organisation for Economic Co-operation and Development (OECD)

Principles on Water Governance:

-**Efficiency** of water governance
-Effectiveness of water governance
-Trust and engagement in water governance

Gurria, Angel: Secretary General, OECD,
7th World Water Forum, Korea,
13 April 2015

UN-WWAP (2012) defines governance as

"Decisions that
grant power, or
verify **performance**."

Most importante performance indicator is **efficiency**.

True knowledge is power.

Sefficiency and Water Governance

UNDP: water governance assessment framework: three main components
1) power, as analysed from the perspective of stakeholders, institutions and interests
2) principles, in particular transparency, accountability and
3) performance, including **efficiency** and effectiveness of government in delivering and achieving its goals

"to assess performance, which is an umbrella term referring to the capability of an initiative
-to be effective (achieve the desired result),
-to be **efficient** (produce the result with as little input as possible), and
-to comply with process criteria (conduct the right activities and steps in the process that are needed for achieving the desired result)."

Equity ← Performance → Efficiency

Jacobson et al. 2013

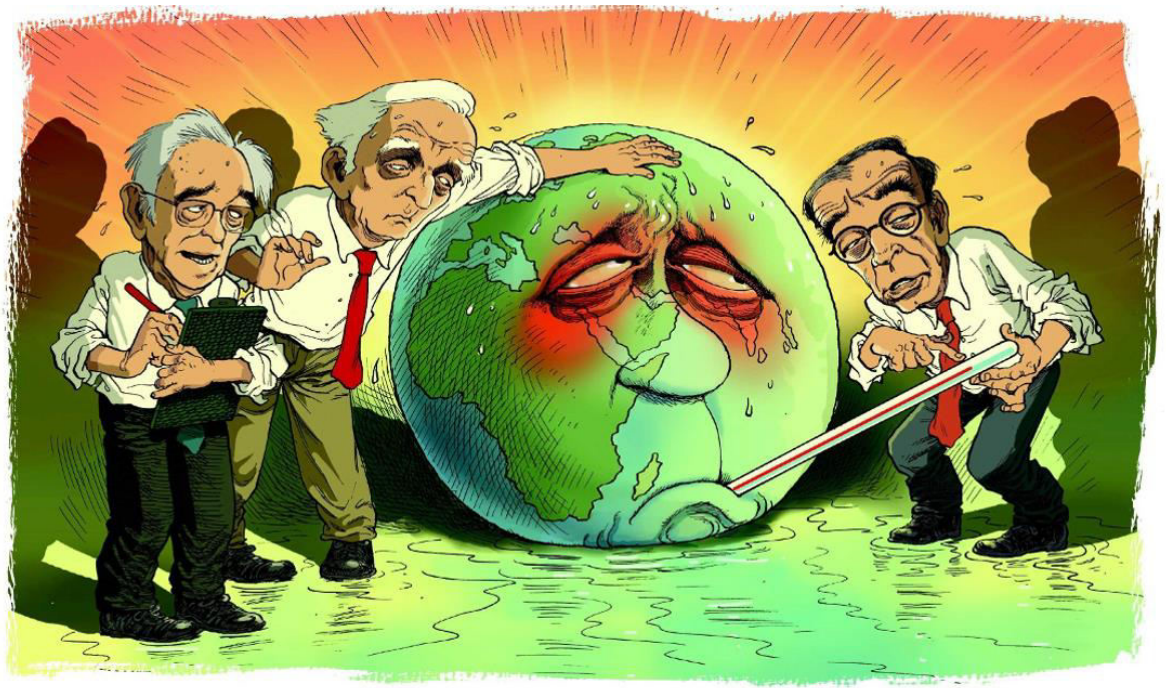
Requirements for efficiency indicators

Systemic
Comprehensive
Levels

Quantity
Quality
Benefits

Climate Change

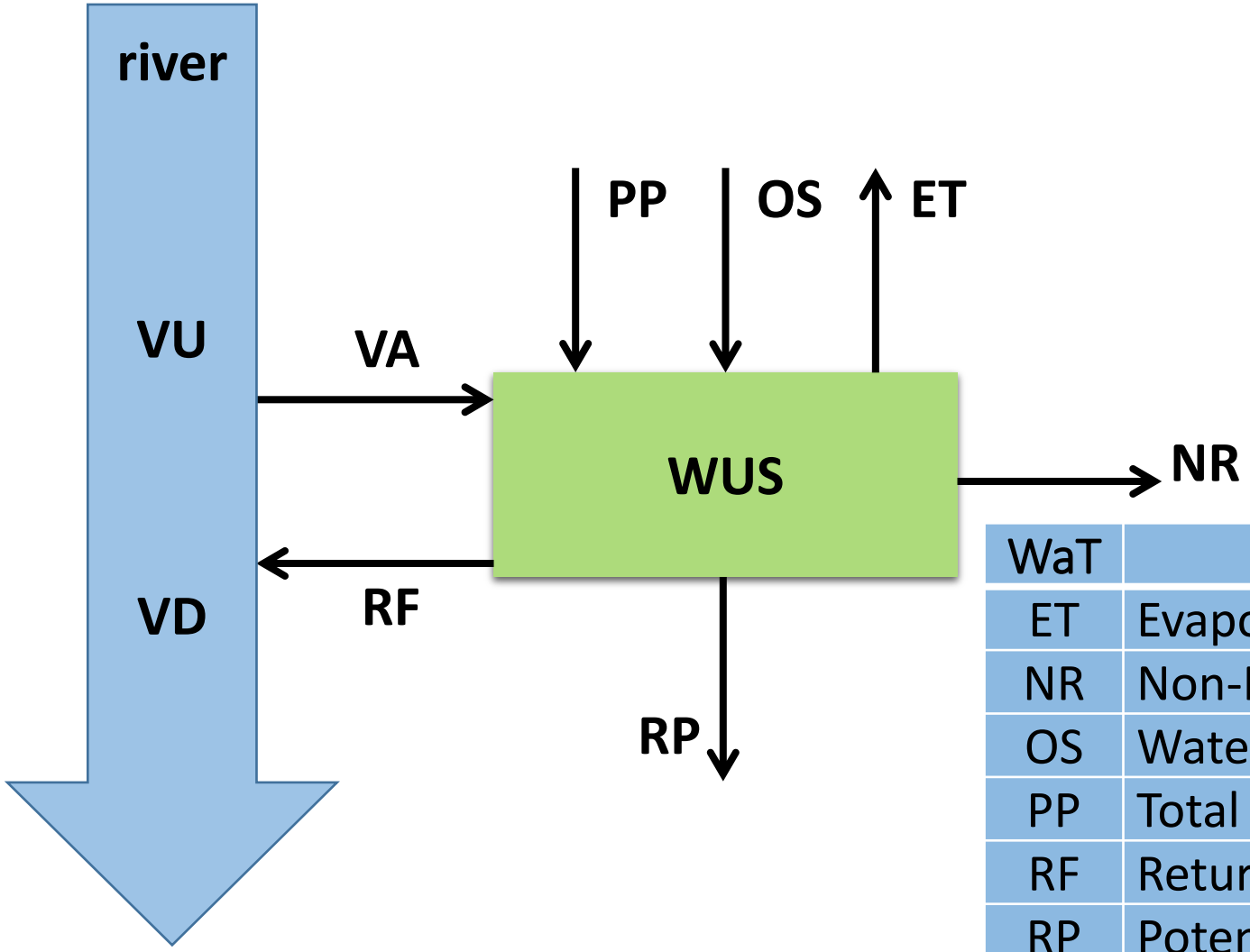
Stakeholder



Cartoon is published in the Journal Nature; from Luiz Gylvan Meira Filho (2013)

The Law of Conservation of Mass
or
Water Balance

Water Use System (WUS)

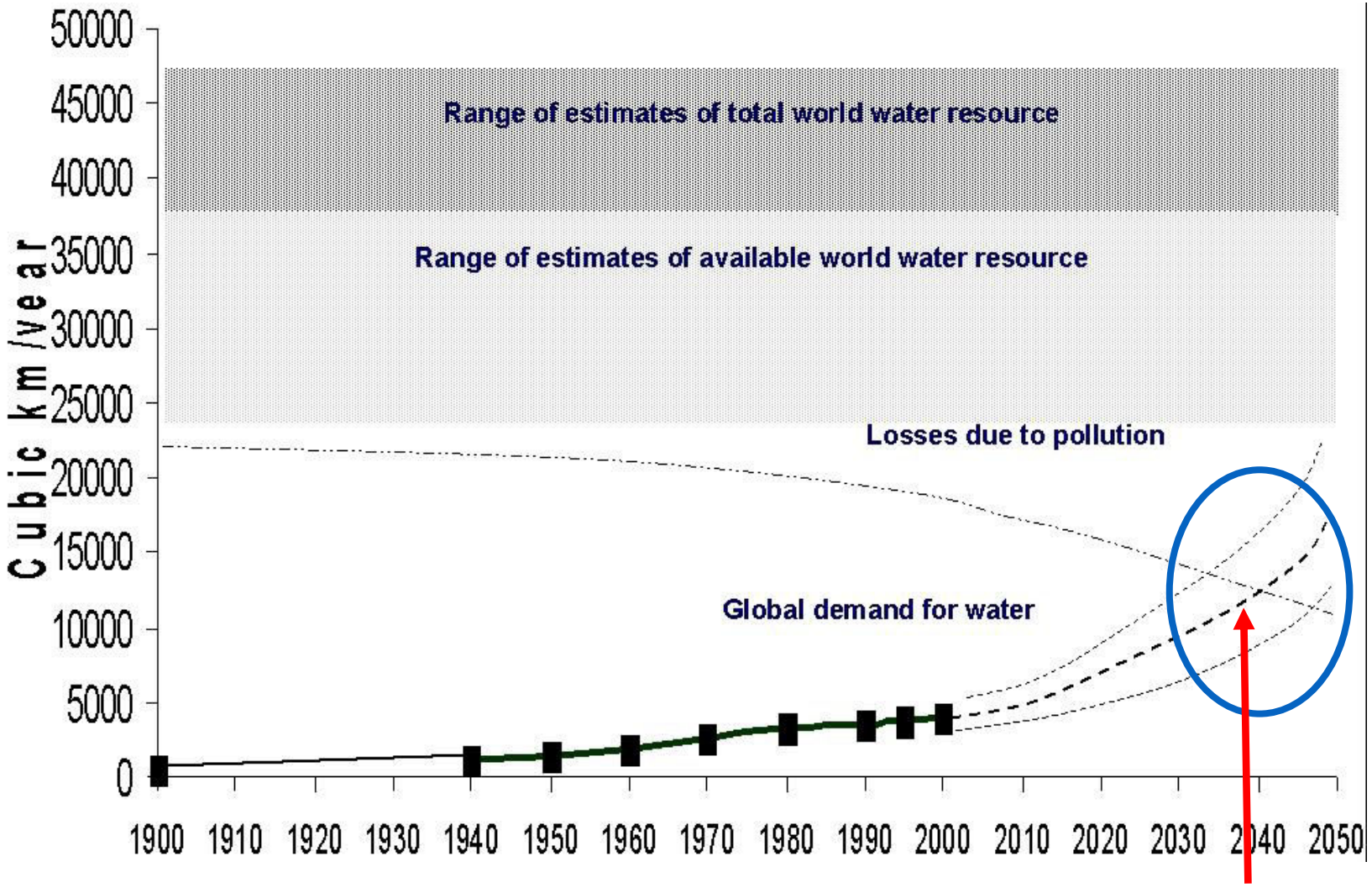


WaT	Description
ET	Evapotranspiration
NR	Non-Reusable
OS	Water from Other Sources
PP	Total Precipitation
RF	Return Flows
RP	Potential Return (not to the main source)
VA	Abstracted/Applied water from the main source
VD	Volume of water Downstream after RF
VU	Volume of water Upstream before VA
V1	Volume of water at section 1 (VU or VA)
V2	Volume of water at section 2 (VD or RF)

WaT = Water path Type

Water Quality

Water Crisis even without climate change!



Nobre, C (2011)

Usefulness Criterion

$$X_q = W_qX * X$$

$$X_b = W_bX * X$$

$$X_S = W_SX * X$$

$$W_SX = W_qX * W_bX$$

W_q = quality weight

W_b = beneficial weight

W_S = usefulness weight

X = one of the Water path Types (WaTs)

Sefficiency

Efficiency (%) defined:
ratio of useful outflow to its corresponding total flow

Applying Usefulness Criterion to the combined Water Balance equation would give Sefficiency.

mathematical proof in Haie & Keller (2012)

Sefficiency

Macro, Meso, and Micro-Efficiency (3ME) levels

$$\mathrm{MacroE_s} = \left[\frac{\mathrm{ET} + \mathrm{NR} + \mathrm{i}\left(\mathrm{VD} + \mathrm{RP}\right)}{\mathrm{VU} + \mathrm{OS} + \mathrm{PP} - \mathrm{c}\left(\mathrm{VD} + \mathrm{RP}\right)} \right]_s$$

$$\mathrm{MesoE_s} = \left[\frac{\mathrm{ET} + \mathrm{NR} + \mathrm{i}\left(\mathrm{RF} + \mathrm{RP}\right)}{\mathrm{VA} + \mathrm{OS} + \mathrm{PP} - \mathrm{c}\left(\mathrm{RF} + \mathrm{RP}\right)} \right]_s$$

$$\mathrm{MicroE_s} = \left(\frac{\mathrm{ET} + \mathrm{NR}}{\mathrm{VA} + \mathrm{OS} + \mathrm{PP}} \right)_s$$

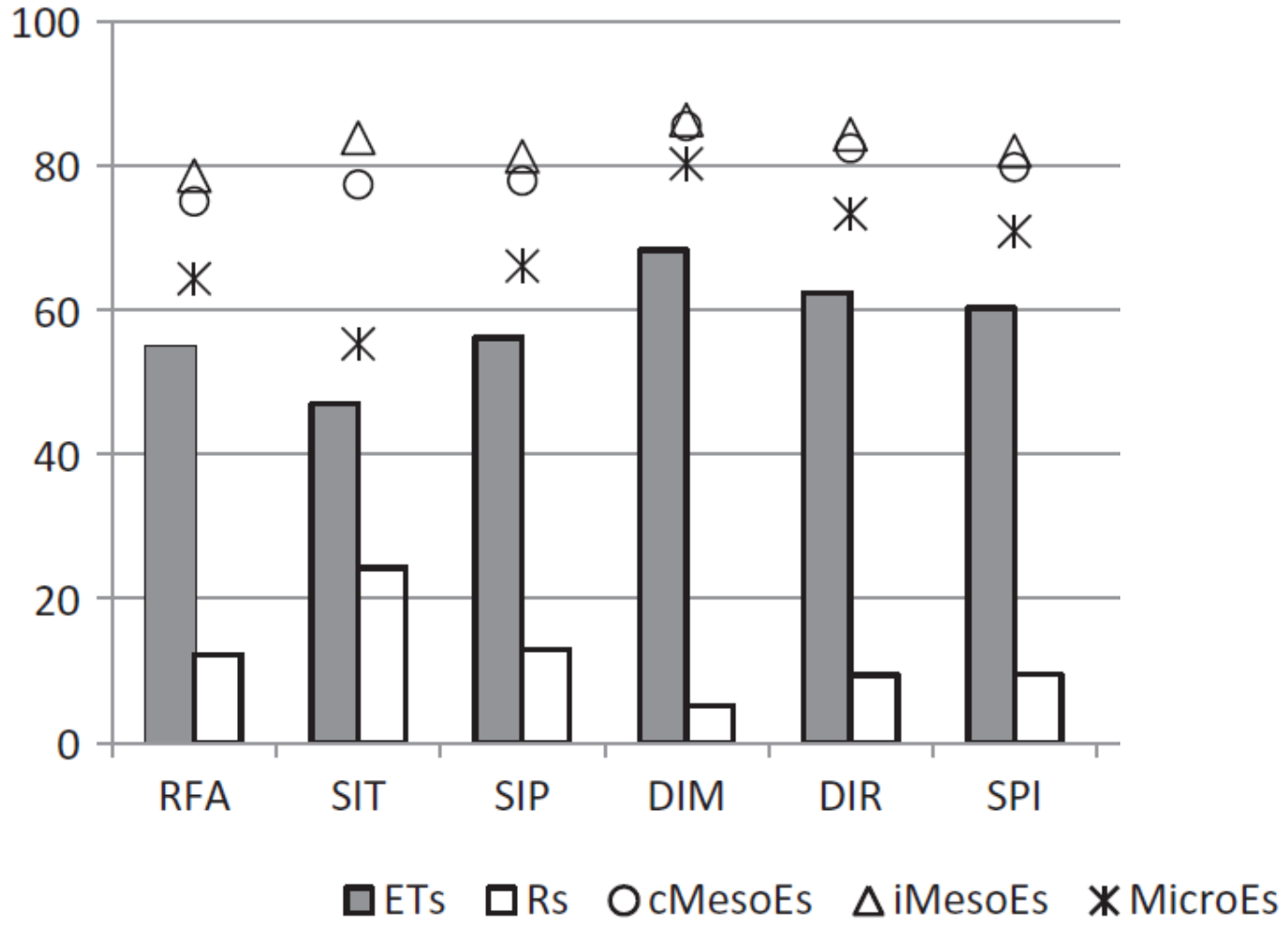
- Macro-Efficiency (MacroE): indicates the impact of a WUS on a basin, e.g., the major river where water was abstracted.
- Meso-Efficiency (MesoE): indicates, for example, the impact of return flows generated by a WUS.
- Micro-Efficiency (MicroE): indicates the useful outflow generated by a WUS for itself.

Haie and Keller (2012 or 2014)

Sefficiency,

Water in Agriculture and

Methods / Technologies



- RFA (Rainfed Agriculture) no irrigation
- SIT (Traditional Surface Irrigation)
- SIP (Precision, leveled, surged, etc. Surface Irrigation)
- DIM (Marketed Drip Irrigation) “marketed” means performing as promoted or advertised
- DIR (Real Drip Irrigation) constitutes most of the field drip systems
- SPI (Sprinkler Irrigation)

Haie & Keller 2014

Relevant publications about Sefficiency

Haie, Naim & Keller, Andrew A. (2012) Macro, Meso, and Micro-Efficiencies in Water Resources Management: A New Framework Using Water Balance. Wiley, Journal of the American Water Resources Association (JAWRA), 48:2, pp235–243.

Haie, Naim & Keller, Andrew A. (2014) Macro, Meso, and Micro-efficiencies and terminologies in water resources management: a look at urban and agricultural differences. Water International, Taylor & Francis Ltd, UK. 39:1, pp35-48.

Haie, N. (2015) Sefficiency (Sustainable efficiency) of Water-Energy-Food Entangled Systems. International Journal of Water Resources Development (accepted)

Thank you!

More info: search Google for **naimhaie5**