Water systems resilience at the catchment scale

Jack Beard, FutureWater

UKIA Conference, 6/7/22

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Case study 1: Understanding Real Water Savings at the Catchment Scale

Key questions:

> How can we increase catchment scale water use efficiency?

> Are efficient irrigation techniques essential in water scarce areas?

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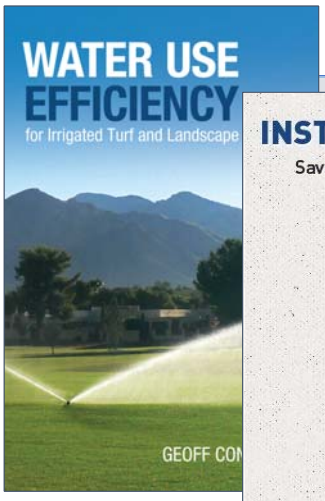
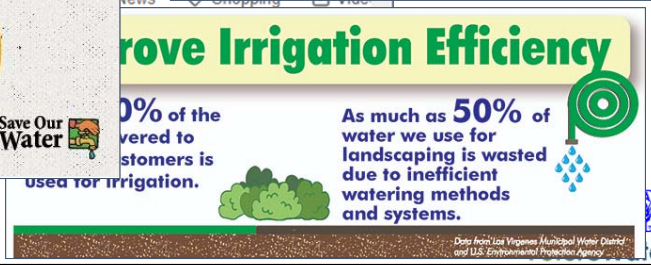
Water Use Efficiency





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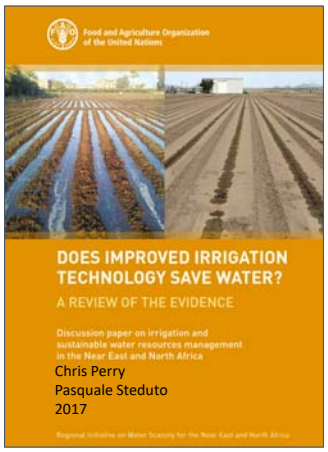

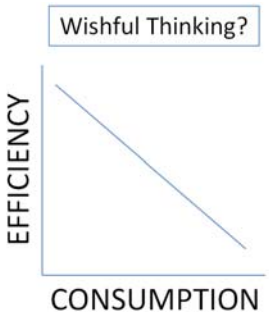

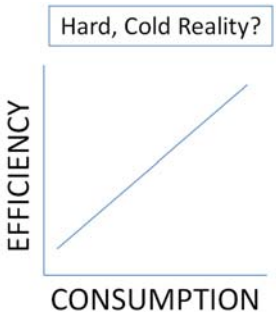

Real Water Savings Training Package: Jevon's Paradox (...

https://youtu.be/BiLEjPgSoXc

"However, introducing hi-tech irrigation in the absence of controls on water allocations will usually make the situation worse: consumption per unit area increases, the area irrigated increases, and farmers will tend to pump more water from ever-deeper sources."

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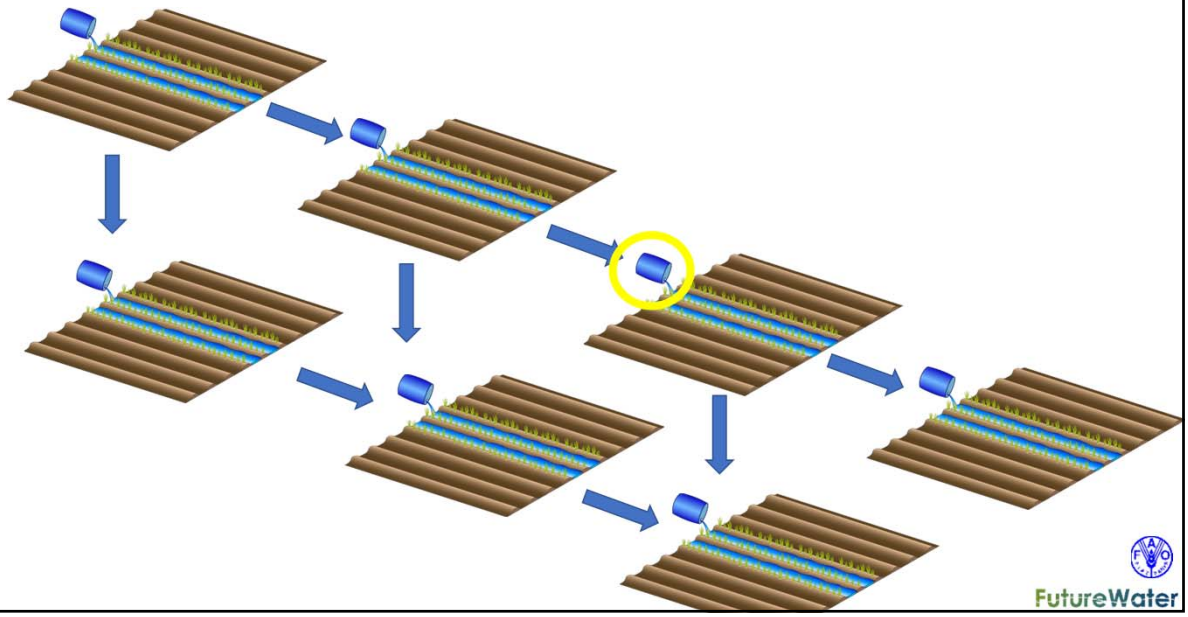
Water Savings in Agriculture



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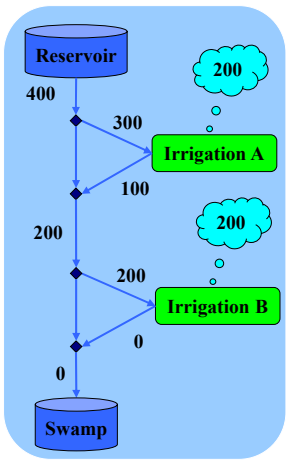
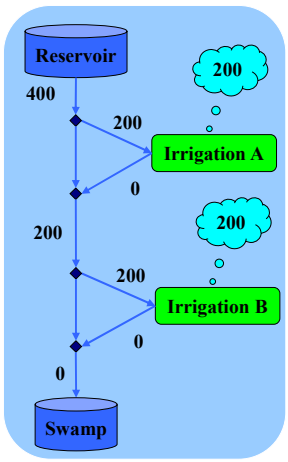


Efficiencies: **67%** and 100%
Consumed: (=crop in return): 400

Current



Efficiencies: 100% and 100%
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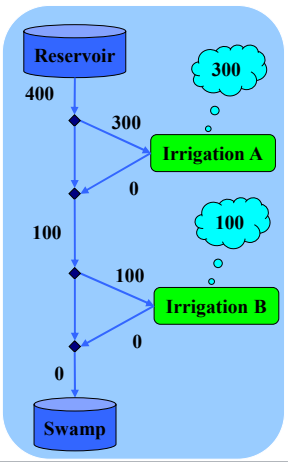
Hypothetical
after efficiency improvements

Supply reduction to Irr_A (from 300 to 200) after investments to increase efficiency will not be accepted!



Efficiencies: 100% and 100%
Consumed: (=crop in return): 400

Realistic
after efficiency improvements

Irrigation A gets same water, but consumes more, Irrigation B less water

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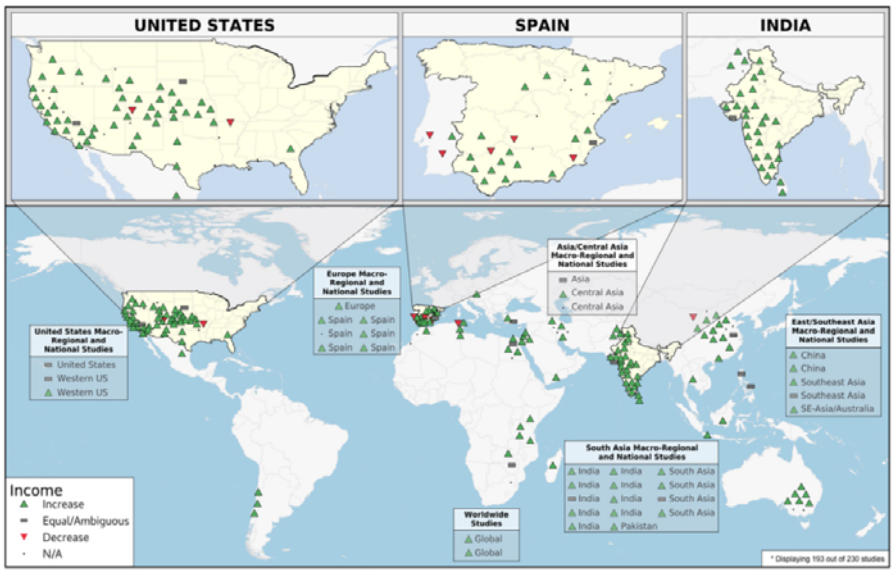

Impact of modern irrigation technologies on (a) adopters' income (measured through profit), (b) water consumption and (c) net water savings/water conservation, based on a global review of the empirical literature on farmers' responses to modern irrigation technologies.

Source: C Dionisio Pérez-Blanco, Adam Loch, Frank Ward, Chris Perry, David Adamson. 2021. Agricultural water saving through technologies: a zombie idea Environmental Research Letters, Volume 16, Number 11

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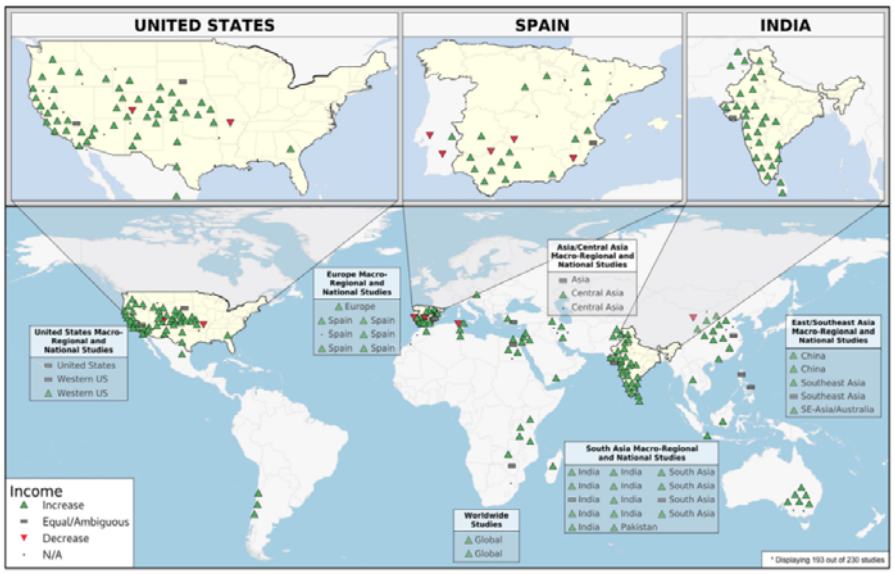

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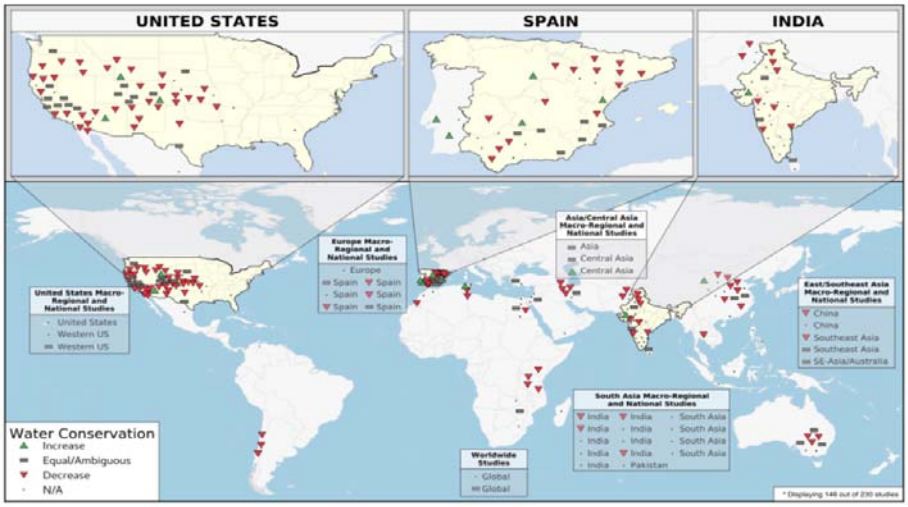

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Follow the Water approach

Supply
Rainfall, allocations

Consumptive use

- **Beneficial**
  - crop transpiration;
  - evaporation from wetlands;
  - cooling towers
- **Non-Beneficial**
  - evaporation from open water
  - evaporation from soils;
  - transpiration by weeds

Return Flows

- **Recoverable**
  - downstream user
  - returning to a river
  - groundwater recharge
- **Non-Recoverable**
  - flowing to the sea
  - flow to salty groundwater
  - flow to polluted river

What category (or categories) needs to be reduced to achieve 'real water savings'?

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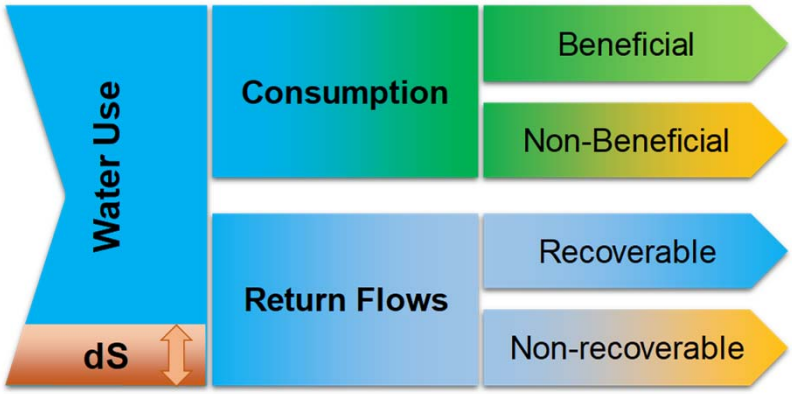
REWAS, Real Water Savings in Agricultural Systems

> The **main objective** of REWAS is to assess quickly the impact of field scale crop-water interventions on system scale water savings.
> REWAS approach is to "**Follow the Water**"



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Summary, conclusions

> Irrigation engineers and planners are trained to look at field scale efficiencies or irrigation system efficiencies at most.

> Many of the tools used by irrigation engineers are field scale oriented (e.g. FAO tools Cropwat, AquaCrop, CropSys)

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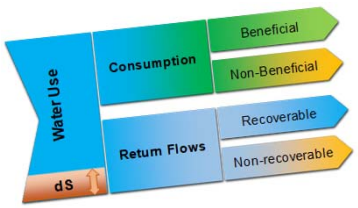
Summary, recommendations

> Apply "new" concepts
  – Water accounting, water productivity, irrigation in the basin context, "Follow the Water"

> Avoid using words as:
  – Efficiencies
  – Losses



> Quantify the hydrologic impacts of any new investment, intervention or policy in the water sector.

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Case study 2: Indirect (waste)water reuse in the Netherlands

Key questions:

> To what extent is wastewater **indirectly** being reused in irrigated systems?

> To what extent are rivers and streams impacted by wastewater?

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BACKGROUND

Problem definition

- Lots of research and investment into direct wastewater reuse
- Many studies on wastewater related contaminants in surface water network of NL

Research gap: No studies defining distribution of wastewater within national surface water network of NL

Without this key step, **impossible to characterise de facto wastewater reuse**

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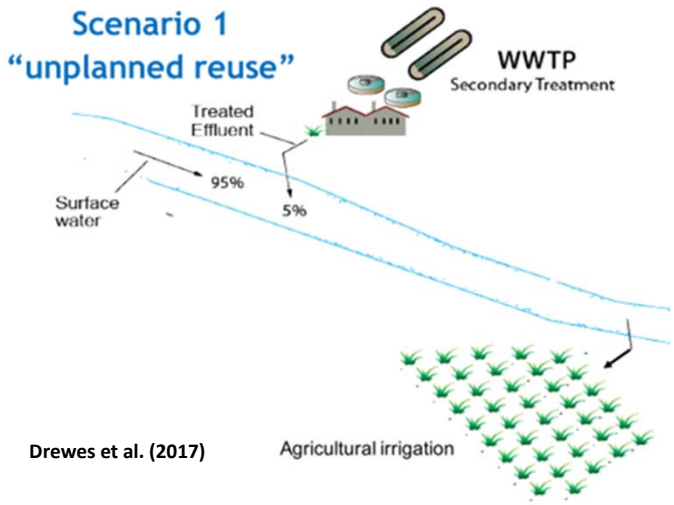
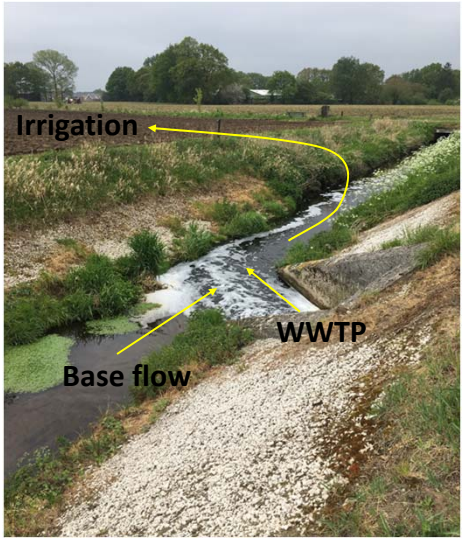
BACKGROUND

Indirect wastewater reuse



Drewes et al. (2017)



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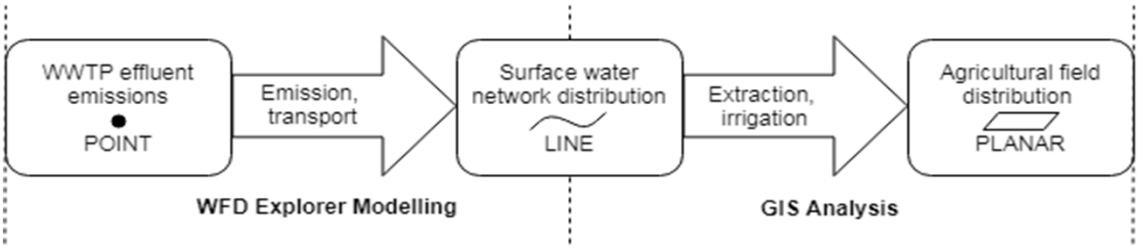
METHODOLOGY

"Following the Water"



Idea: follow treated wastewater emissions (point source) through the surface water network (linear) to irrigation on agricultural fields (planar)

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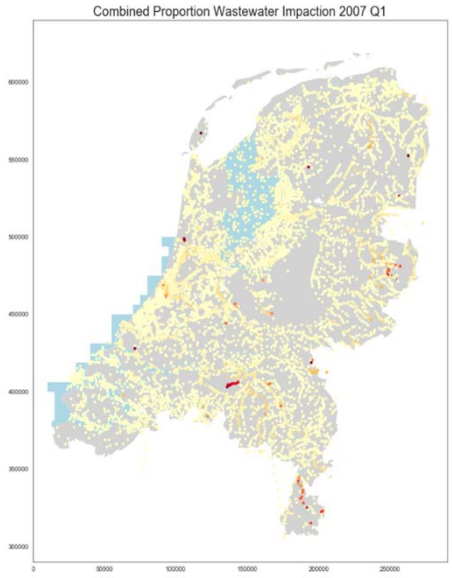
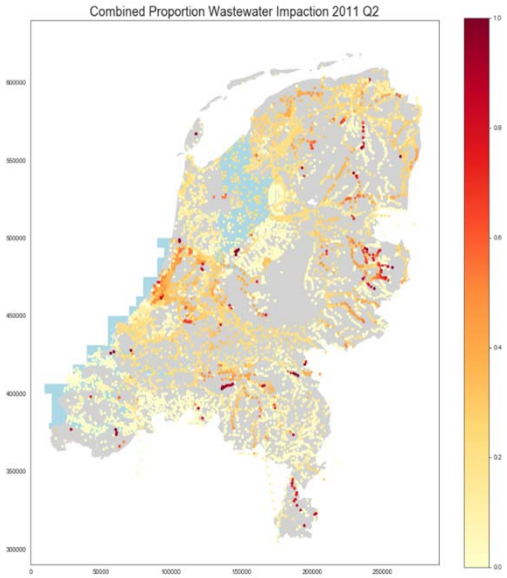
RESULTS

Model results



Wet period - Q1 2007



Dry period – Q2 2011

Key result:

Wastewater a **much more** prevalent component of Netherlands hydrological system than previously thought during low flow conditions

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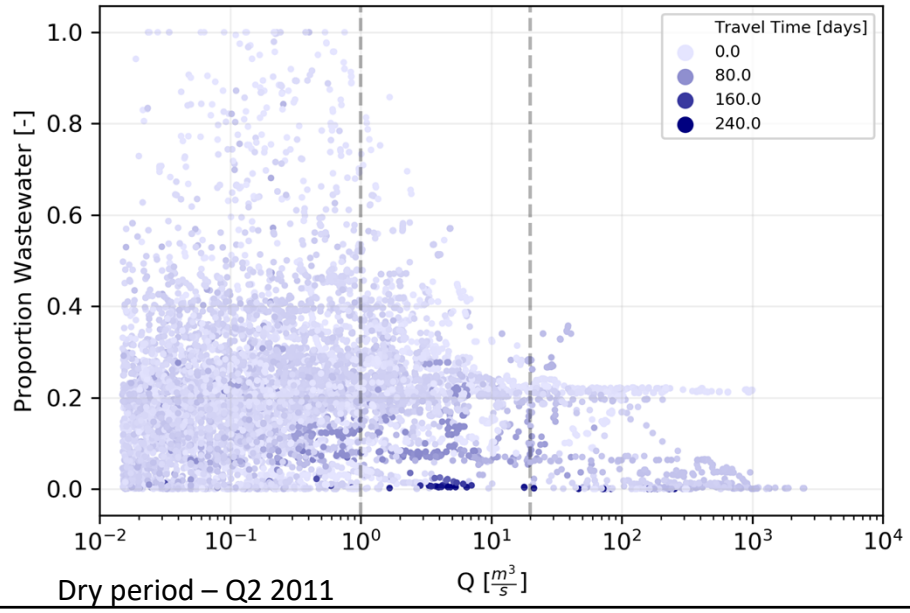
RESULTS

Discharge and impaction



Dry period – Q2 2011

Key result:

Only small (<1m^{3}s^{-1}) streams were heavily (>80%) impacted

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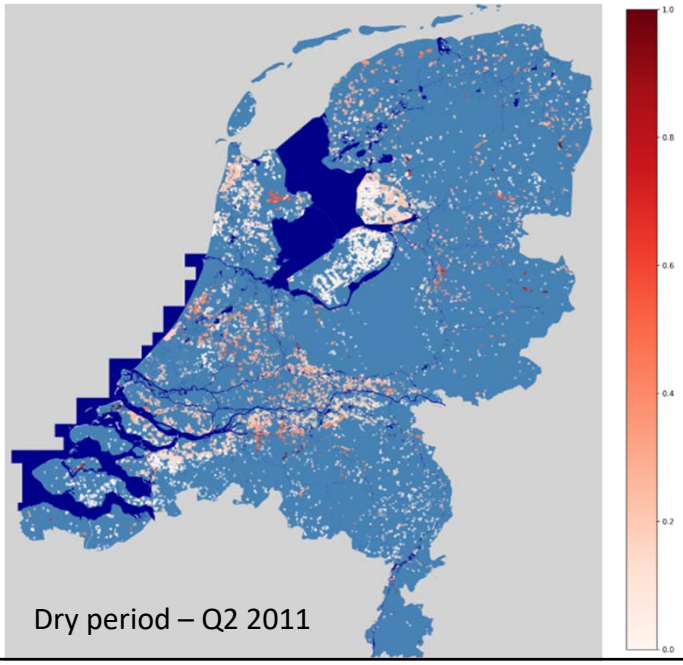
RESULTS

Reuse in irrigation

Key results:

- Indirect wastewater reuse shown to be widespread
- High levels of indirect reuse shown in several distinct areas



Dry period – Q2 2011

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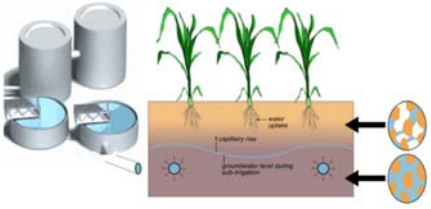
DISCUSSION

Key points

Wastewater reuse is already widespread in dry periods!



Ideal outcomes:

- Discussion re: where and when is it appropriate to use surface water for irrigation?
- Designing appropriate systems for water reuse

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Case study 3: Nature-based Solutions for water systems resilience in Norfolk, UK

Key questions:

> Can NbS help improve water availability at the catchment scale?

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Water security risks to growth

NORFOLK WATER STRATEGY PROGRAMME

Eastern England is...

Driest region in the UK

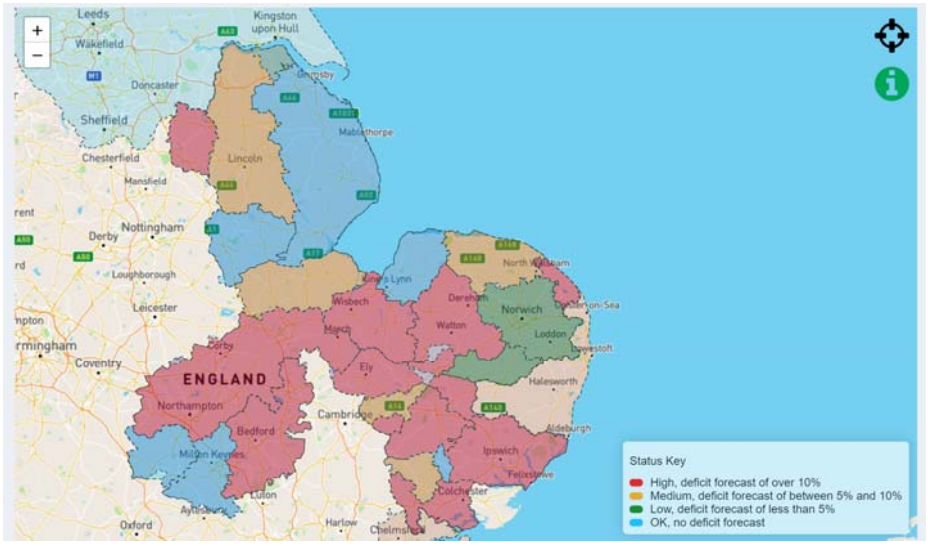
Seriously water stressed

Highest forecast growth outside London

Leading agricultural producer

Internationally important environments

...and Norfolk is already short of water



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NbS for water availability

NORFOLK WATER STRATEGY PROGRAMME

Regenerative farming techniques

River and floodplain restoration

Offline storage creation

Sustainable drainage systems

Wetland creation

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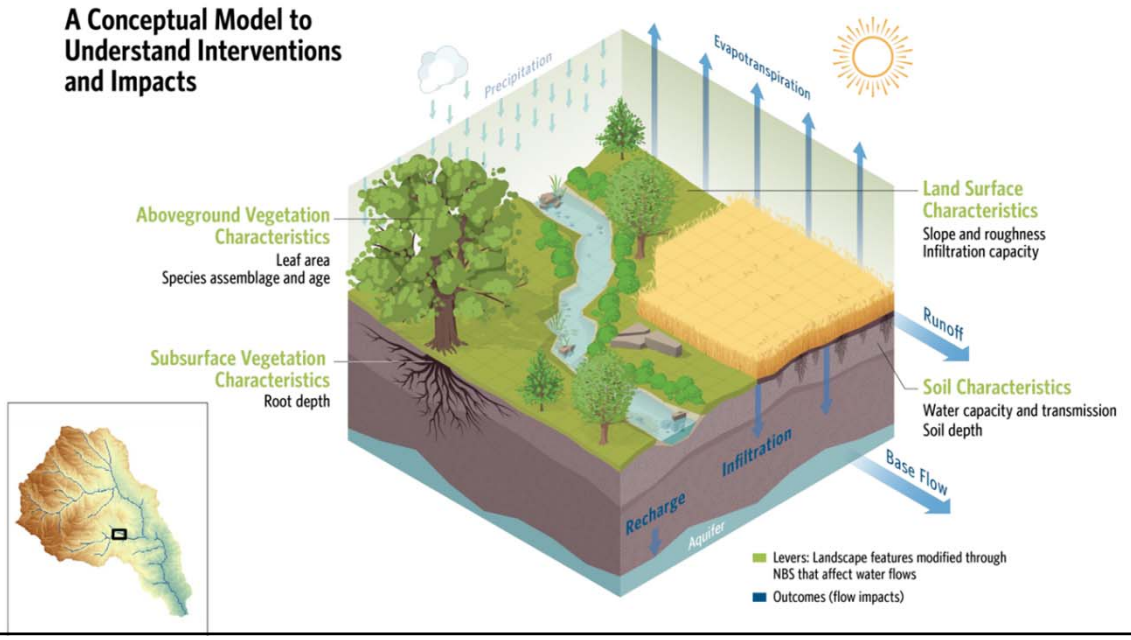
Understanding levers and outcomes

NORFOLK WATER STRATEGY PROGRAMME



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Research context

NORFOLK WATER STRATEGY PROGRAMME

Assessing the water quantity benefits that flow from nature-based solutions

A Science for Nature and People Partnership project

Summary of Findings, Principles, and Guidance
May 2021

"NBS will not create more water in an absolute sense, but they facilitate the retention, movement, timing, and/or reallocation of water around the landscape"

"NBS can have large effects on water quantity… When they are applied over very large areas of the watershed"

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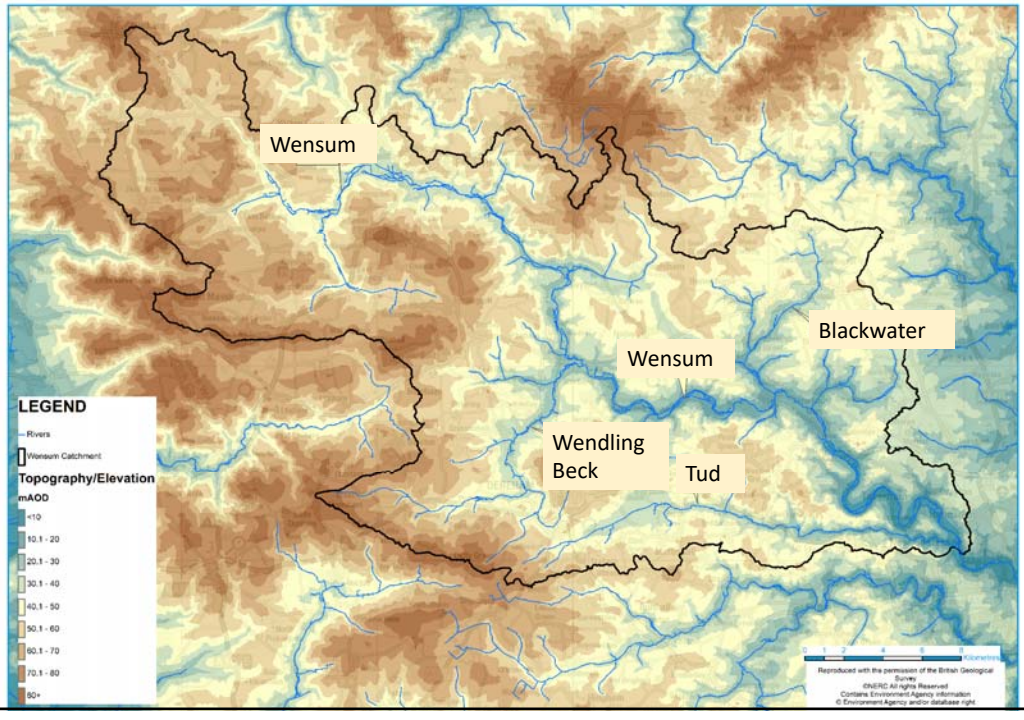

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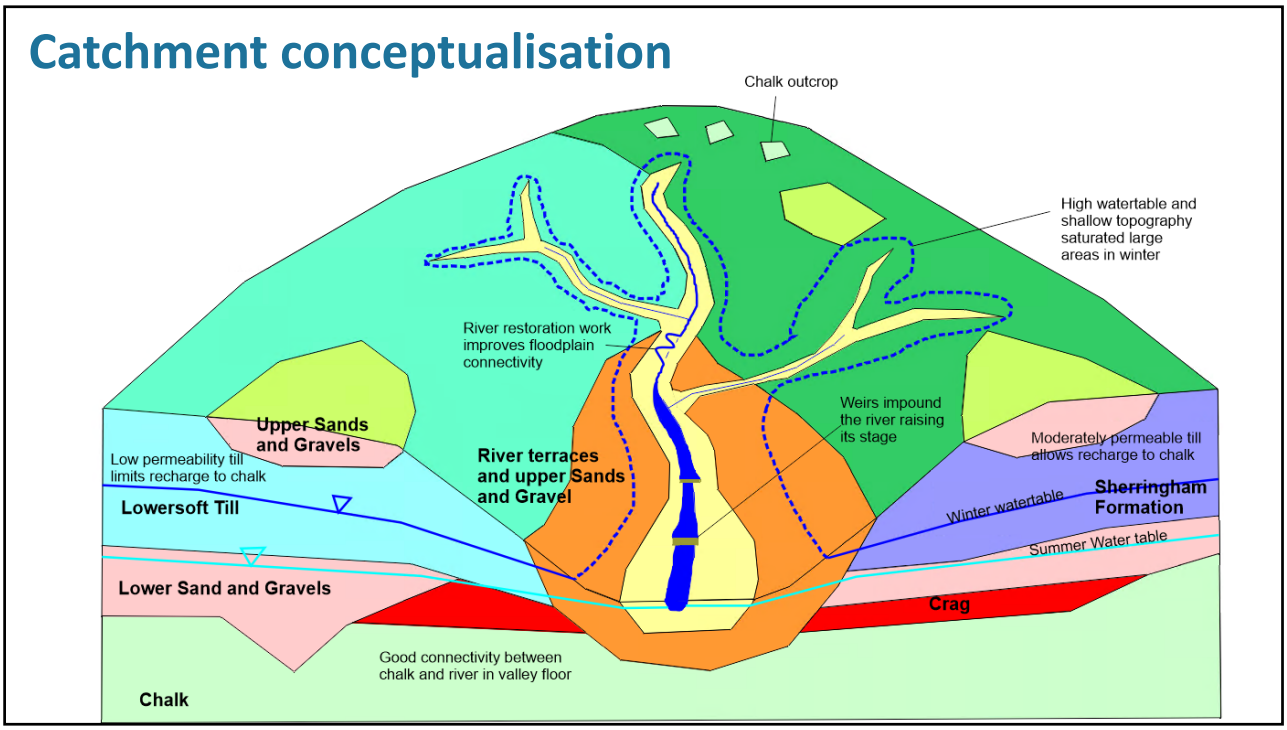
Catchment conceptualisation



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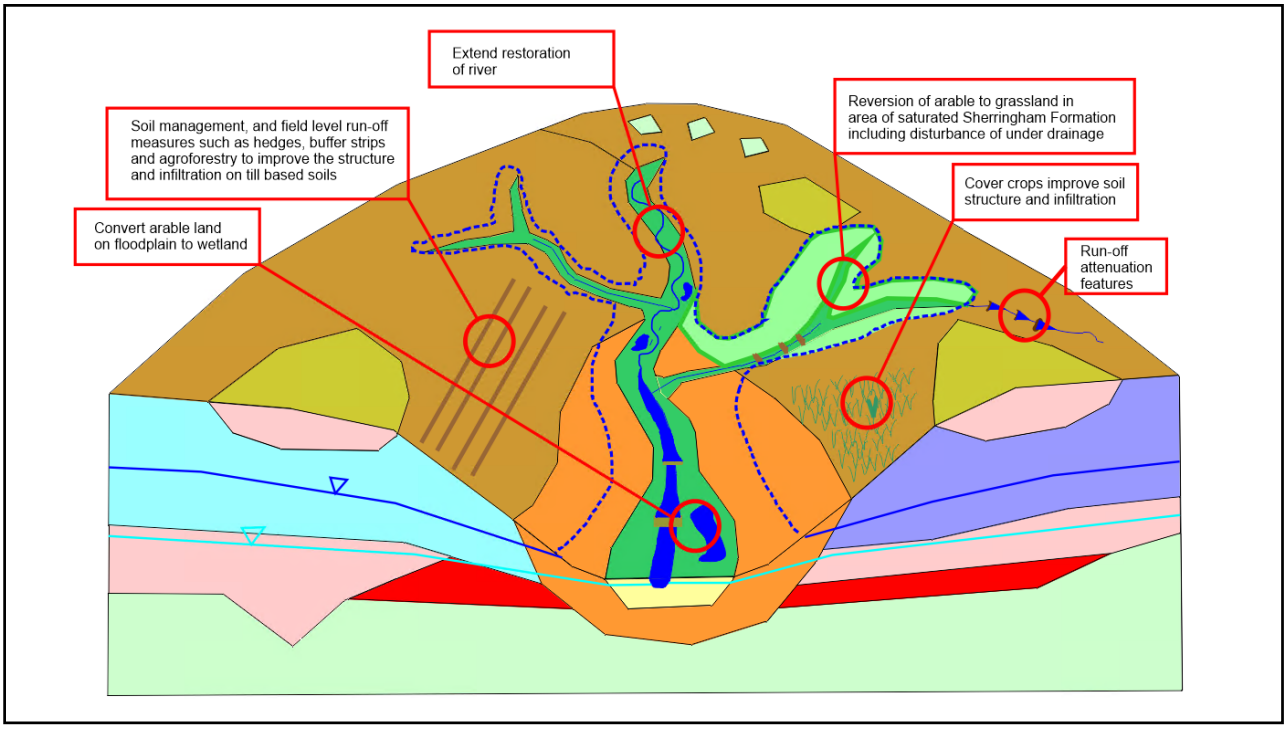

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Opportunity mapping

Orange = Opportunities for Riparian Restoration

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Modelling

Next steps: Feeding GIS outputs into surface water / groundwater model

Modelling questions

- With 100% implementation, how much water availability benefit can be achieved?
- Are there "inflection points" where more implementation **does not** lead to more benefit?

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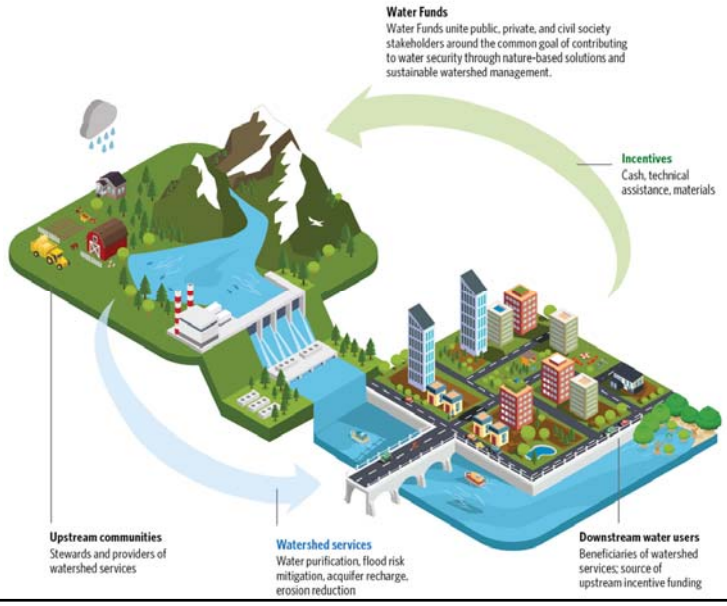
A water fund for Norfolk



All water funds share some characteristics:

(1)Science-based plan
(2)Multi-stakeholder governance
(3)Long-term financing
(4)Implementation capacity

Over the last 15 years TNC have helped to establish ~30 Water Funds and supported many more.

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Key points on water availability and NbS

> Need catchment scale implementation of NbS to fully realise benefits
> Timing of benefits is key
> Lots of work needed to determine impacts on water availability → monitor monitor monitor!

> NbS will not replace grey infrastructure, but can play supporting and complimentary roles in systems resilience!

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Overarching message

We need cross-sectoral, catchment+ scale thinking to ensure water systems resilience

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