Controlled drainage with subirrigation: a water management measure to discharge, retain and recharge freshwater

Janine A. de Wit[1,2], Marjolein H.J. van Huijgevoort[1], Gé A.P.H. van den Eertwegh[3], D. van Deijl[3], Ruud P. Bartholomeus[1,2,]

1. KWR Water Research Institute, Nieuwegein, the Netherlands
2. Wageningen University, Soil Physics and Land Management Group, Wageningen, the Netherlands
3. KnowH2O, Berg en Dal, the Netherlands

Sufficient freshwater is needed for water dependent sectors as agriculture, nature, drinking water, and industry. However, even in low-lying, flood prone countries like the Netherlands, climate change, weather extremes, economic growth, urbanization, land subsidence and increased food production will make it more complex to guarantee sufficient freshwater for all sectors. Specifically, the range of weather extremes from extremely dry to extremely wet is expected to increase and extremes are expected to occur more frequently.

Over the last decades, drainage, land consolidation and urbanization resulted in declining groundwater tables. Additionally, the freshwater demand of different sectors caused an increased pressure on the regional groundwater system. As a consequence, the annual groundwater table in the Dutch sandy soil areas dropped over time with the effect that, nowadays, freshwater is becoming scarce in dry periods. Agriculture needs to anticipate on these conditions in order to prevent both drought and waterlogging. However, the current Dutch agricultural water management system is historically focused on water discharge and not designed to anticipate on both weather extremes.

One of the solutions could be to modify the current pipe drainage systems (already existing in 34 % of the agricultural land) to drainage systems with three purposes, called: controlled drainage with subirrigation. First, the drainage systems could discharge water if the risk of waterlogging increases. Second, the drainage system could store water during rainfall in the soil (retain water). Third, (external) water can be actively pumped into the drainage network to raise groundwater tables (recharge water).

We focus on the data and model output of four experimental sites in the Pleistocene uplands of the Netherlands, where controlled drainage with subirrigation is applied. Field data is collected over ± the years 2017-2021, like water supply, groundwater table, soil moisture content. Water balance components as actual transpiration, drainage and downward seepage are modelled with SWAP (Soil-Water-Atmosphere-Plant model). The effects on crop yield and configuration of the management are also quantified with the model.

The construction of controlled drainage with subirrigation, topographical location, and a proper management of these systems are important. First, results show that through subirrigation, water can be stored in the soil instead of discharged. The water storage leads to an increase in groundwater tables of ± 0.70 m during the growing season, leading to higher crop yields. By storing external water at the field scale, fast drainage was prevented, which decreased drought vulnerability. Second, results of the four experimental sites show that effects of subirrigation on the water balance components are strongly site dependent. For example, an impermeable layer at a shallow depth is needed for enough resistance to increase the phreatic groundwater level. Furthermore, ditch levels surrounded by the field are important as a shallow groundwater table with low ditch levels results in lateral drainage, an unfavorable effect. Third, results of the experimental sites show that proper management of these systems is important to prevent clogging of the system.

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Controlled drainage with subirrigation

A management measure to discharge, retain and recharge fresh water

Janine de Wit (KWR & WUR)
Marjolein van Huijgevoort (KWR), Gé van den Eertwegh (KnowH2O), Dion van Deijl (KnowH2O), Ruud Bartholomeus (KWR & WUR)

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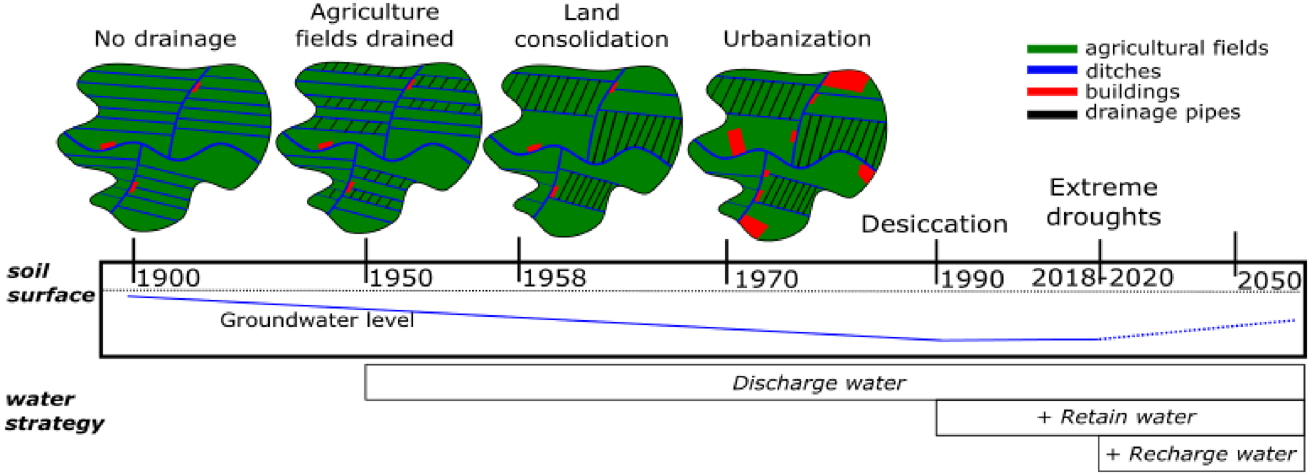
Situation + challenges in the Netherlands

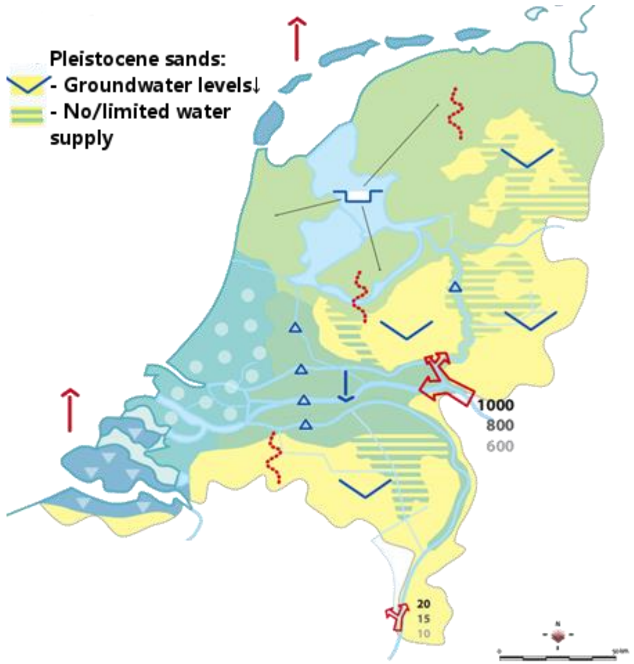
Balance between 1) water demand and water supply & 2) discharge and retention

- Groundwater level dropped → Drainage, economic growth, increased food demand, climate change, weather extremes
- Water strategy: *drainage* (only when needed), *retain* and *recharge* when and where possible



De Wit et al. (2022)

De Wit, J.A., Ritsema, C.J., Van Dam, J.C., Van den Eertwegh, G.A.P.H., Bartholomeus, R.P., 2022. Development of subsurface drainage systems: Discharge – retention – recharge. Agricultural water management. DOI: 10.1016/j.agwat.2022.107677



Deltaprogram for Climate Adaptation

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Agricultural water supply

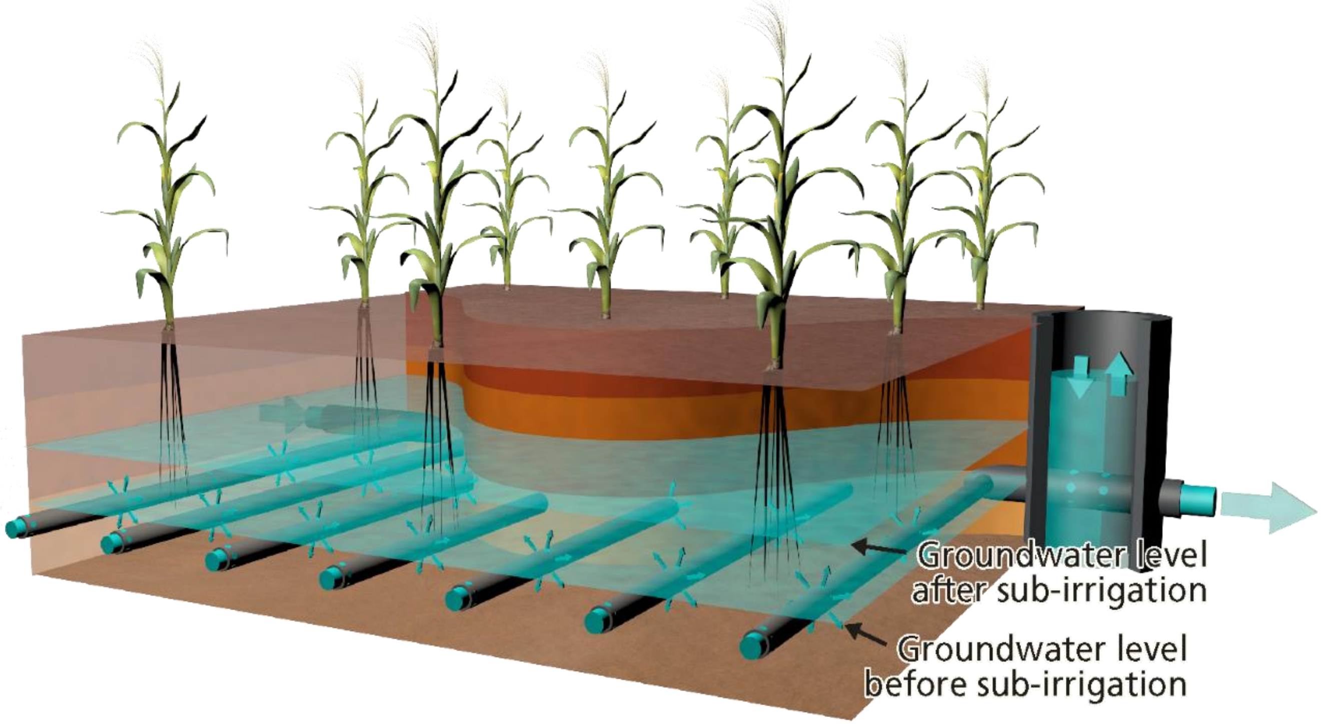
Active supply through subsurface irrigation

- Controlled drainage system (pipes):
  1) Drainage (only when needed)
  2) Water supply

- Goal: raise groundwater level for optimal soil moisture availability

- Success depends on continuous water supply

- Climate Adaptive Drainage (CAD) with subirrigation:
  Measurements + weather forecast + model calibration →
  required drainage crest level for optimal groundwater table
  (van den Eertwegh et al. (2013) and Bartholomeus et al. (2015))



Narain-Ford et al. (2020)

Narain-Ford, D.M.; Bartholomeus, R.P.; Dekker, S.C.; Van Wezel, A.P. Natural purification through soils: Risks and opportunities of sewage effluent reuse in sub-surface irrigation. Rev. Environ. Contam. Toxicol. 2020.

van den Eertwegh, G.A.P.H., van Bakel, P.J.T., Stuyt, L., van Iersel, A., Kuipers, L., Talsma, M., Droogers, P., 2013. KlimaatAdaptieve Drainage - Een innovatieve methode om piekafvoeren en watertekorten te verminderen - Samenvatting resultaten Fase 2 'Onderzoek en Ontwikkeling'. FutureWater, Wageningen.

Bartholomeus, R.P., Simons, G.W.H., van den Eertwegh, G.A.P.H., 2015. Anticipating on amplifying water stress: Optimal crop production supported by climate-adaptive water management. KWR 2015.062. KWR, Nieuwegein

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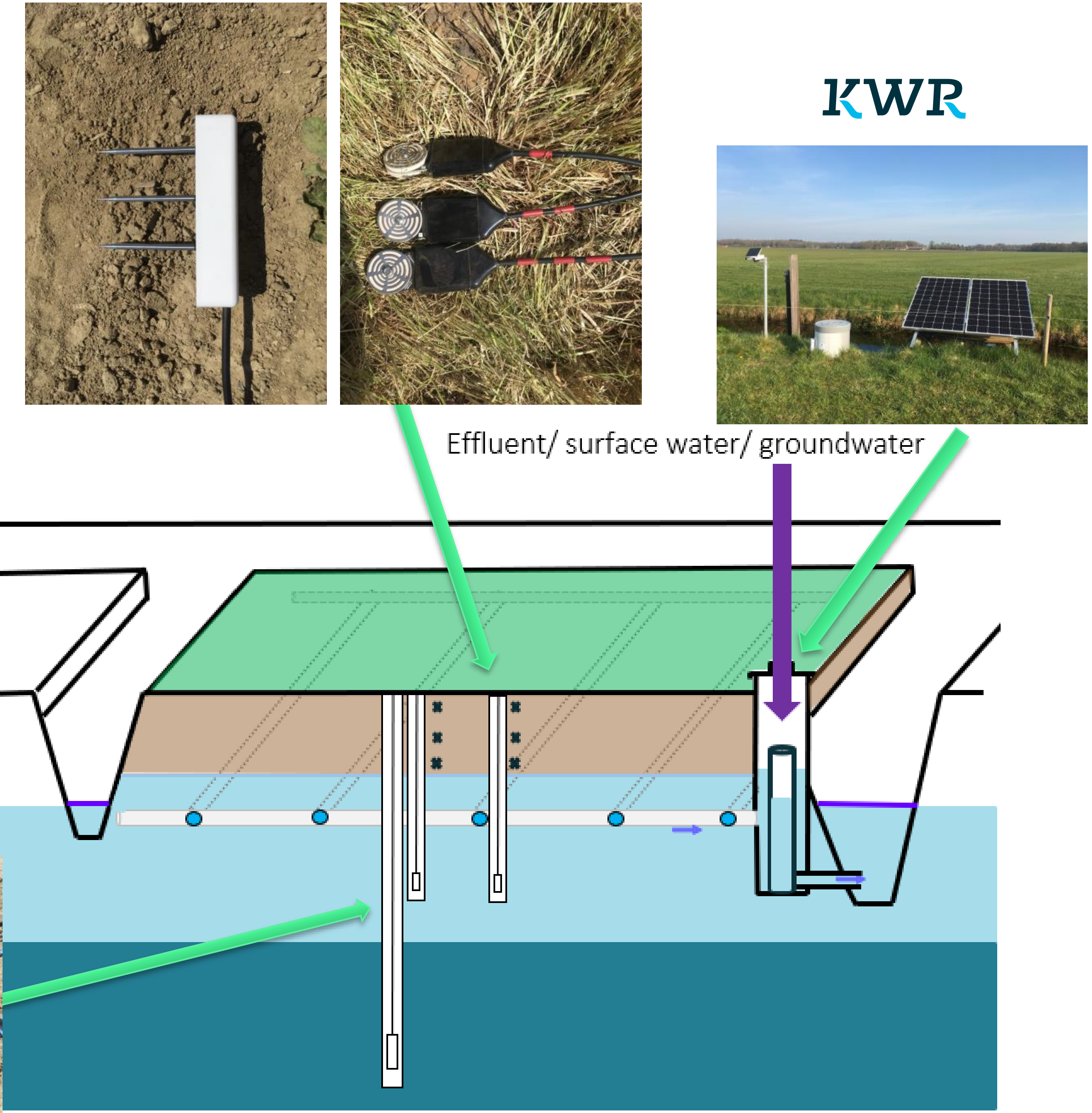
Field experiments in NL

Subirrigation

- 4 field sites with controlled drainage with subirrigation
- Water supply source: surface water, treated waste water (industry), treated waste water (domestic), groundwater



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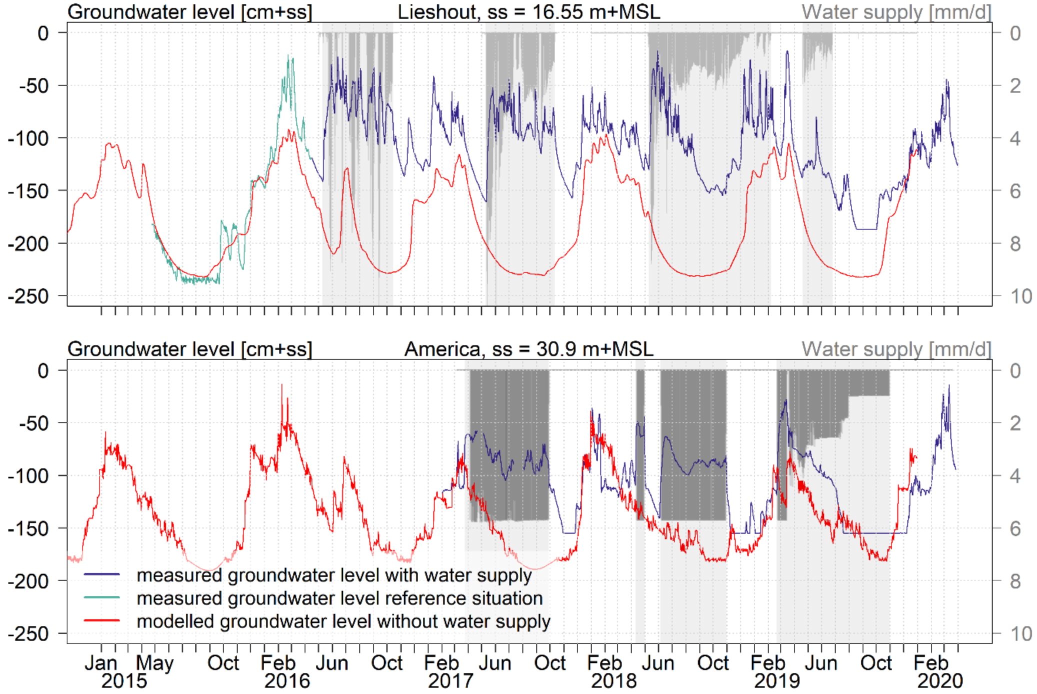
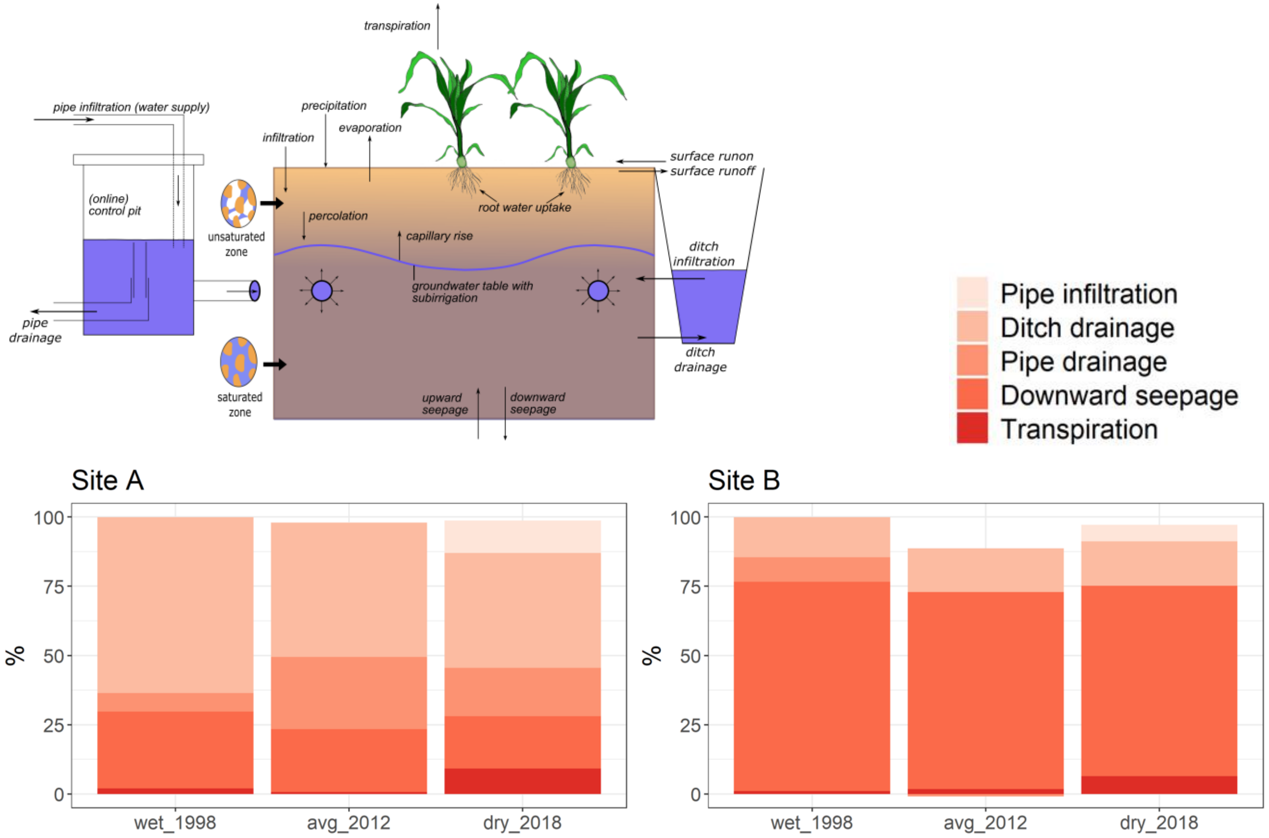
Results – field modelling (SWAP)

- Groundwater level raises via subirrigation with ±100cm
- Subirrigation alters the water balance components





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KWR

Groningenhaven 7
3433 PE Nieuwegein
The Netherlands

T +31 (0)30 60 69 511
E info@kwrwater.nl
I www.kwrwater.nl

@KWR_Water

KWR

KWR_Water

Janine de Wit

janine.de.wit@kwrwater.nl
+31 6 15616926

And colleagues