Policy Paper
Seeing the Field: IoT and Satellite Evidence for Smarter Irrigation

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1.Highlights

The Issue: Irrigated agriculture is expanding across Europe under climate change, yet the water it consumes is still largely self-declared. Authorities are asked to enforce water-related obligations without any continuous, objective, field-scale measurement of actual water use.

The Findings: Field water status can be assessed reliably without a soil probe in every field. An evapotranspiration-based soil water balance driven by local meteorological data reproduced in-situ soil moisture readings well ($R^2 = 0.78$), and satellite-derived evapotranspiration tracked those local estimates ($R^2 = 0.62$), allowing field water status to be mapped beyond instrumented fields. Satellite soil moisture products were weaker ($R^2 < 0.5$) but reproduced the timing of drying events.

The Recommendations: Sustain support for long-term, multi-season validation of IoT–EO water indicators, explore their use in CAP monitoring on a pilot basis, encourage harmonised protocols for combining in-situ and satellite water data, and help regions where irrigation is only now emerging to build a monitoring baseline.

The Impact: Agriculture accounts for around 29% of EU water abstraction and could reduce use by up to a fifth through smarter irrigation. Affordable, field-scale evidence makes that reduction measurable and gives both farmers and authorities a common factual basis for irrigation decisions.

2. Context of the Issue

Policy landscape: The EU Water Resilience Strategy (2025) sets out to restore the water cycle, improve water management and stimulate innovation, and identifies agriculture – responsible for roughly 29% of total EU water abstraction – as a sector that could cut consumption by up to 20% through smart farming and improved irrigation. Alongside it, the Common Agricultural Policy makes support conditional on sustainable water management, and the Farm to Fork strategy commits the food system to a neutral or positive environmental impact. Outside the EU, the same pressure is more acute. Israel manages agricultural freshwater allocations dynamically in response to hydrological conditions, and following severe drought the national freshwater allocation for agriculture was reduced by 24%. Its longer-term water security strategy for 2018–

2030 combines demand management with expanded desalination, reclaimed-water infrastructure, inter-regional water conveyance and greater system resilience. Latvia, at the opposite end of the gradient, names agriculture and forestry among the six priority areas of its National Adaptation Plan.

The Challenge: The effective implementation of these instruments depends on accurate, spatially explicit information on agricultural water use. Compliance reporting rests predominantly on farmer self-declaration and periodic inspections, which are costly to audit and blind between visits, and many irrigation withdrawals go unmonitored because no local-scale monitoring framework exists. Climate change is meanwhile enlarging the share of European agricultural area that needs irrigation at all, extending the problem into regions such as Latvia where irrigation has never been standard practice and no monitoring baseline exists.

Project Gap: Two approaches address this gap from opposite directions without yet meeting. IoT soil probes deliver accurate, high-frequency ground truth, but instrumenting every field is prohibitively expensive and readings are specific to a sensor design and a soil type. Earth Observation delivers spatially continuous coverage, but large-scale estimation of irrigation water use remains uncertain precisely because local-scale validation is scarce. The Water Productivity Lab works in that middle ground, testing how far cheaper data sources can substitute for dense sensor networks and quantifying the accuracy lost at each step.

3. Policy Recommendations

Recommendations

- **Sustain Support for Multi-Season, Multi-Region Validation**

Action: Continue funding validation campaigns that test IoT–EO water status assessment across several growing seasons, soil types, agricultural practices and crops, and that derive transferable soil- and crop-specific irrigation thresholds.

Urgency / Impact: Medium to high. Threshold transferability is the main obstacle between a working demonstrator and an operational service, and it can only be resolved with more seasons and more sites.

- **Explore Field Water Status Indicators within CAP Monitoring on a Pilot Basis**

Action: DG AGRI and the national paying agencies that administer CAP funds could test IoT–EO field water status indicators alongside existing Area Monitoring System workflows, running in parallel with current procedures so that the level of confidence required before an indicator is treated as evidence can be agreed in practice.

Urgency / Impact: Medium. Satellite imagery is already used to verify conditionality; extending it to irrigation is a natural next step, but one that should be tested before it carries regulatory weight.

- **Encourage Harmonised Protocols for Combining In-Situ and Satellite Water Data**

Action: The "Agriculture of Data" partnership and the Common European Agricultural Data Space could take up harmonised sensor calibration and EO processing protocols of the kind tested here, so that water productivity indicators become comparable across regions and borders.

Urgency / Impact: Medium. Standardisation is what allows individual demonstrators to add up to a monitoring capability rather than remaining isolated results.

- **Help Emerging-Irrigation Regions Build a Monitoring Baseline**

Action: Support the deployment of modest sensor networks and open EO processing pipelines in regions where irrigation is not yet widespread, so that a reference record exists before irrigation demand grows.

Urgency / Impact: High. Latvia illustrates the case: irrigation is still rare, but the capacity to monitor it is far cheaper to build in advance than to retrofit once demand has grown.

Considerations

Economic & Governance: A sensor-light, EO-heavy approach lowers the cost barrier for smallholders and public agencies, but sustained public co-funding is needed to keep open EO and IoT infrastructure viable for users who cannot bear the full cost. Without a designated operational owner inside a paying agency or water authority, these outputs remain research products.

Social & Environmental: Precision irrigation reduces abstraction and pumping energy, limits waterlogging and nutrient runoff, and helps protect yields under drought. These benefits materialise only if farmers trust the indicator enough to act on it, which argues for transparency about uncertainty rather than single undifferentiated numbers.

Data Governance: The Israel–Latvia pairing spans water-scarce and water-transitioning contexts, but harmonised cross-border data sharing requires agreed protocols on ownership, access rights and privacy before replication can scale.

4-5 Evidence and Analysis - Key Results

- **From sensor readings to a decision:** In-situ soil moisture readings translate directly into an operational field water status classification. Using standard tensiometer ranges – 0–10 cb wet, 10–30 cb optimal, 30–60 cb moderately dry, 60–100 cb dry and requiring irrigation, above 100 cb severe drought stress – probe readings from four irrigation regimes (0%, 33%, 67% and 100%) were converted into a map a farmer can act on (Figure 1).
- **Cheaper data, comparable answer:** A simplified soil water balance, $Dc = D_p + ET - P - Irr$ (previous-day soil water deficit plus evapotranspiration, minus precipitation and applied irrigation), computed from local meteorological station data showed a strong relationship with measured soil moisture ($R^2 = 0.78$). One meteorological station and a record of applied irrigation can therefore substitute for a dense probe network.
- **Upscaling with Earth Observation:** Evapotranspiration data products supplied by DHI Group agreed reasonably well with local meteorological estimates ($R^2 = 0.62$) and were used to compute soil water deficit and map field water status independently of ground sensors (Figure 2). EO soil moisture products performed less well against probe readings ($R^2 < 0.5$) but reproduced the timing of drying events, suggesting value for irrigation triggering even where absolute values cannot yet be relied on.

Visual Aids

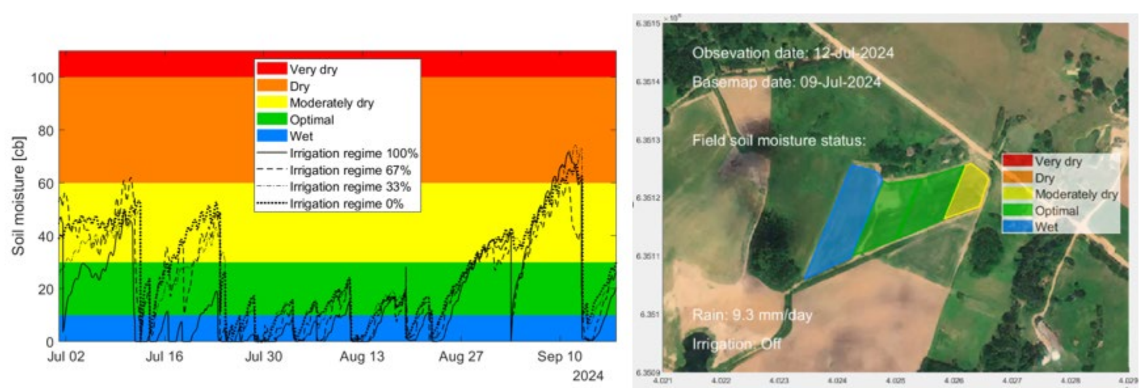

Figure 1. Soil moisture readings from peppermint fields in Vidzeme, Latvia converted into field water status classes under four irrigation regimes (left), and the resulting field water status map (right).

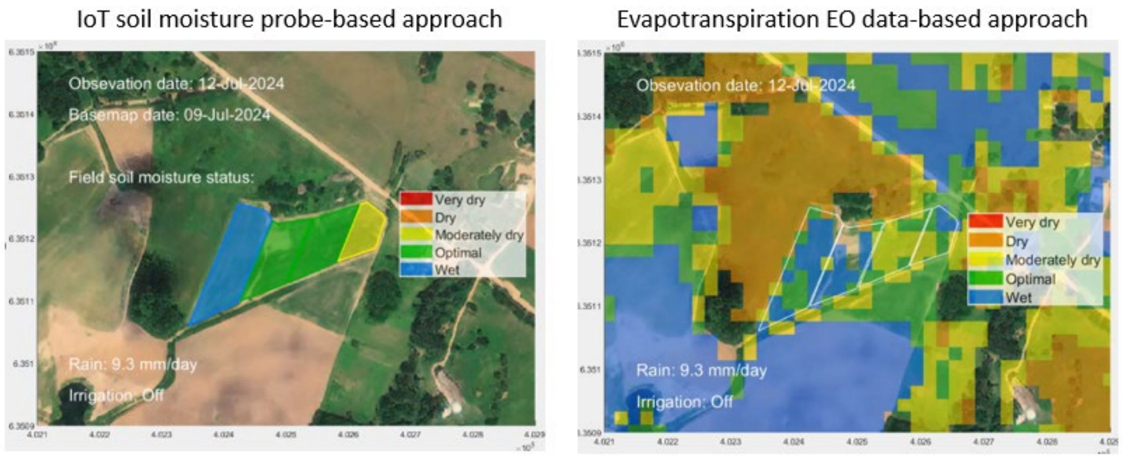

Figure 2. Field water status for 12 July 2024 derived from IoT soil moisture probes (left) and from evapotranspiration EO data products (right), showing agreement in pattern alongside the resolution limits of the satellite-based route.

Methodology

The demonstrator runs on commercial fields in two contrasting agroclimates: the Vidzeme region of Latvia, where peppermint (Mentha × piperita) and chamomile (Matricaria chamomilla L.) are grown and irrigation is a local innovation rather than routine practice, and the Hula Valley of northern Israel, where quinoa (Chenopodium quinoa) is grown and irrigation is existential. Both sites carry soil probes and a meteorological station; EO soil moisture and evapotranspiration products were supplied by DHI Group. In-situ soil moisture served as the reference against which the evapotranspiration-based and EO-based routes were evaluated, using the coefficient of determination (R^2) as the metric. The work is carried out with the participating farmers, so thresholds, delivery formats and map representations are tested against real irrigation decisions.

Limitations

The results reported here come from a demonstration rather than an operational service, and further validation is needed before they can carry regulatory weight. Across two seasons the Lab has met a recurring obstacle: demonstrating a drought-response tool requires drought, which cannot be scheduled. In 2024, late seedling delivery in Latvia confined irrigation to a short window in July before precipitation exceeded the climatic norm, while in Israel a failure in the farm's main water supply pipe delayed sowing into the peak of summer and germination was very poor. The summer of 2025 was exceptionally wet in Latvia, so irrigation could not be applied at all; testing continues with a switch from peppermint to chamomile. Three technical caveats also matter for policy use: irrigation thresholds are specific to sensor and soil type and are not yet transferable; the spatial resolution of current EO products is coarse relative to individual fields, as Figure 2 shows; and EO products require calibration against local reference data before their absolute values can be relied on. Additional seasons, additional sites and a larger spatial scale would be needed to establish the robustness that operational use requires.

Strategic Alignment

Green Deal / Farm to Fork: The Farm to Fork strategy seeks a food system with a neutral or positive environmental impact. Precision irrigation built on IoT and EO data serves each of its pillars at once: it reduces water abstraction and pumping energy (climate), limits waterlogging and nutrient runoff that degrade aquatic ecosystems (biodiversity), and helps sustain yields under intensifying drought (food security). The Lab's contribution is to make these effects measurable at field scale, which is where Green Deal ambitions have to be converted into verifiable outcomes.

SDGs:

SDG 2 (Zero Hunger): field-level evidence that precision irrigation maintains yields while reducing water and energy inputs speaks to indicator 2.4.1 on the area under productive and sustainable agriculture.

SDG 6 (Clean Water and Sanitation): EO-derived evapotranspiration combined with IoT soil moisture provides spatially explicit estimates of agricultural water consumption – the primary data need behind indicators 6.4.1 (water use efficiency) and 6.4.2 (water stress), and the same logic underpinning the FAO WaPOR framework.

SDG 12 (Responsible Consumption and Production): quantifying water consumed per unit of output is a direct measure of resource efficiency in food production, contributing to indicator 12.2.1.

SDG 13 (Climate Action): spatially explicit monitoring of soil water status and evapotranspiration strengthens adaptation to drought and increasing climate variability, enabling more efficient irrigation and providing field-scale evidence for climate-resilient water management, in line with Target 13.1 on resilience and adaptive capacity to climate-related hazards.

SDG 15 (Life on Land): precision irrigation informed by IoT and EO data can reduce over-irrigation, waterlogging, nutrient losses and pressure on soils and terrestrial ecosystems, supporting sustainable land management and contributing to Target 15.3 on combating land degradation.

Partnerships: The "Agriculture of Data" partnership aims to combine Earth Observation, environmental and agricultural data to strengthen policy monitoring, and identifies farm-level IoT and precision farming data as its main unexploited resource – precisely what this Lab produces. The EU Mission "A Soil Deal for Europe" names irrigation efficiency as a research priority; the Lab's in-situ soil moisture monitoring, validated against EO data in living-lab conditions, contributes to its objective of monitoring how management practices affect soil health. The Israel–Latvia pairing also serves as a replication blueprint: deploy IoT soil sensors following a harmonised calibration protocol, connect to freely available Copernicus Sentinel imagery through the established processing pipeline, and cross-validate the fused output against local ground truth over at least one full growing season.

6. References

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