Science-based Environmentally Friendly Layouts for Floating PV: First-Year Insights to Sustainability Assessment of FPV

EU PVSEC 2026
Rotterdam, 17.09.2026

Project STEWART

- CETPartnership project, 11/2024 – 11/2027, 6 partners, 4 countries
- Goal: performance, affordability and sustainability increase of FPV, delivering:
  - Comparative methods & results on key environmental/ecological aspects
  - Improvements in FPV layout, arrangement, design
  - Assessment of economic and legal feasibility
- 4 case studies: inland (DE, CH, TR) + near-shore (FR)

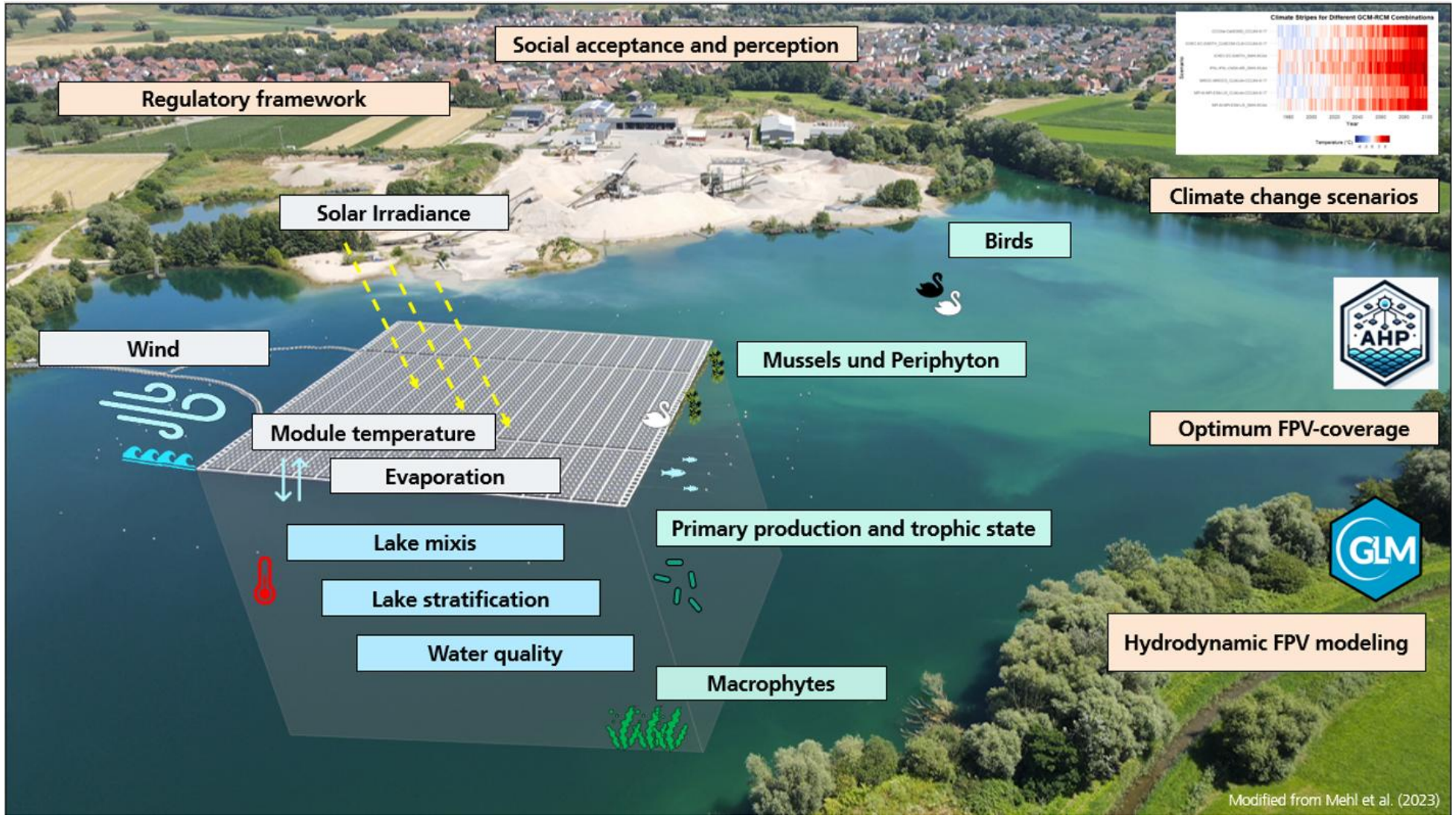


First-year insights: WP1 – Environmental Monitoring & Assessment

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STEWART Project Website:
https://stewart-fpv.net/#the-stewart-project

FPV-waterbody interactions

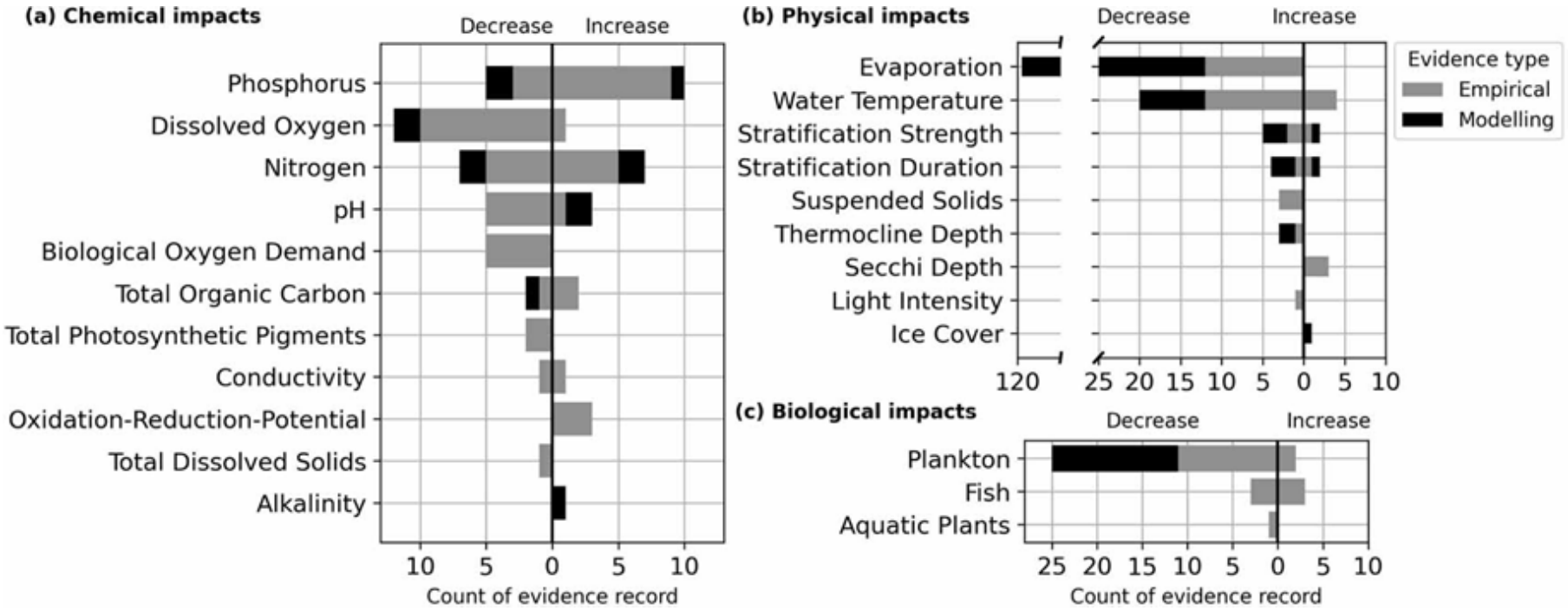


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Ilgen et al. 2026. STEWART: Guidelines for standardized FPV monitoring for inland water bodies and nearshore (Deliverable 1.1).

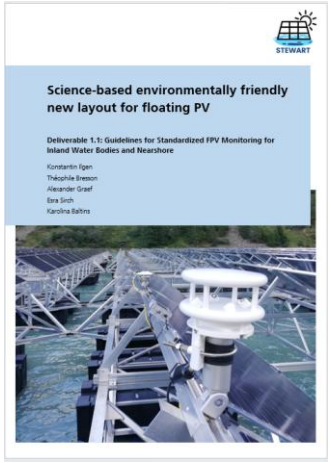
The relevance of FPV monitoring standardization

Variability in results:



But we need:

- **Holistic understanding of FPV impacts**
- **Site comparability, incl. nearshore**
- **Harmonized legal frameworks**



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Rocha et al. 2024: Environmental impacts of floating solar panels on freshwater systems and their techno-ecological synergies https://doi.org/10.1088/2634-4505/ad8e81

Development of FPV decision support tools

SQUAT: Early Project Stage. Site and System Pre-Screening

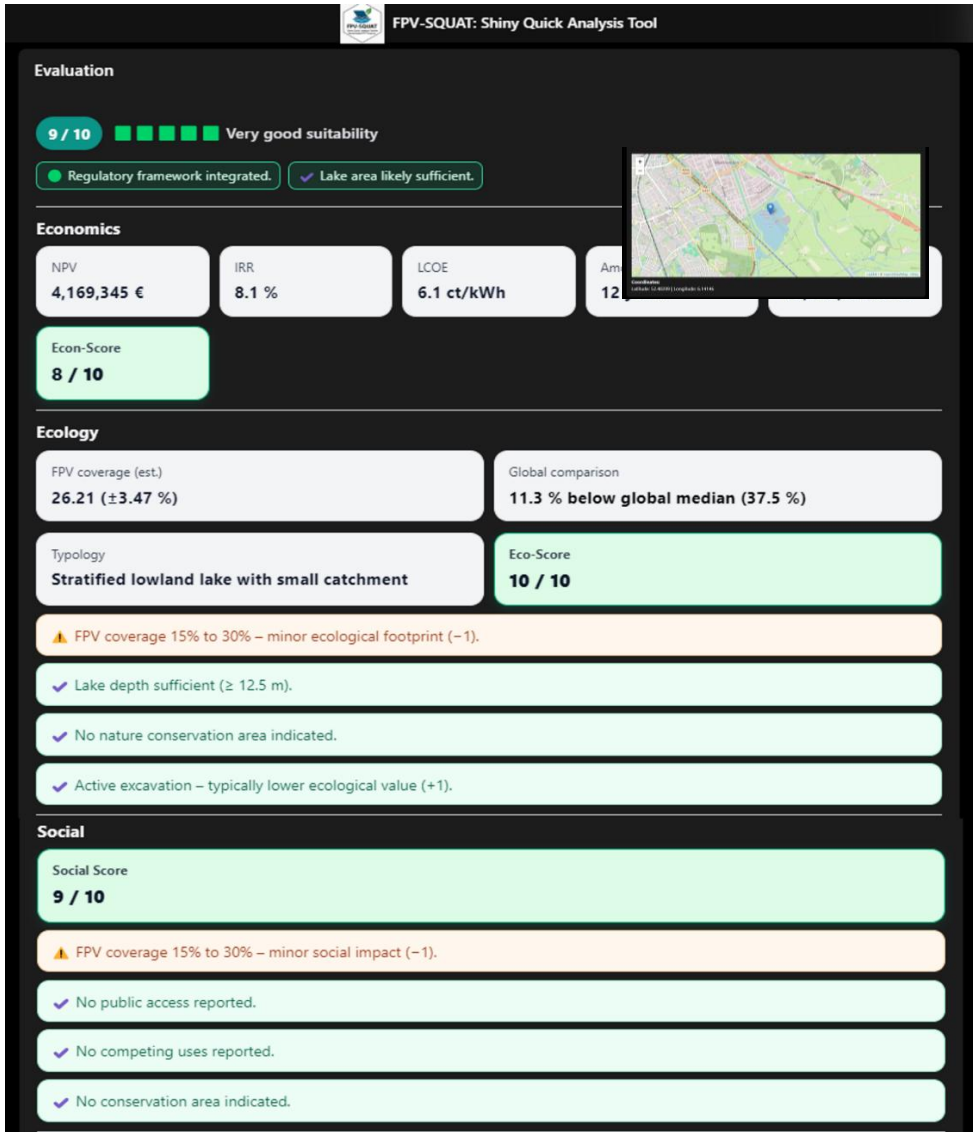
- Combines regulatory, environmental, and technical exclusion criteria
- Reduces planning risks in the early project phase
- Provides Go / No-Go decisions and key constraints

AHP: Permitting Stage. Balancing Competing Objectives

- Integrates environmental, economic, and social criteria
- Incorporates stakeholder preferences and priorities
- Identifies sustainable FPV coverage levels & location

MASI: Pre-Construction Stage. Ecological Impact and Monitoring

- Quantifies ecological sensitivity from key drivers
- Supports early screening and pre-deployment risk assessment
- Provides tiered monitoring recommendations



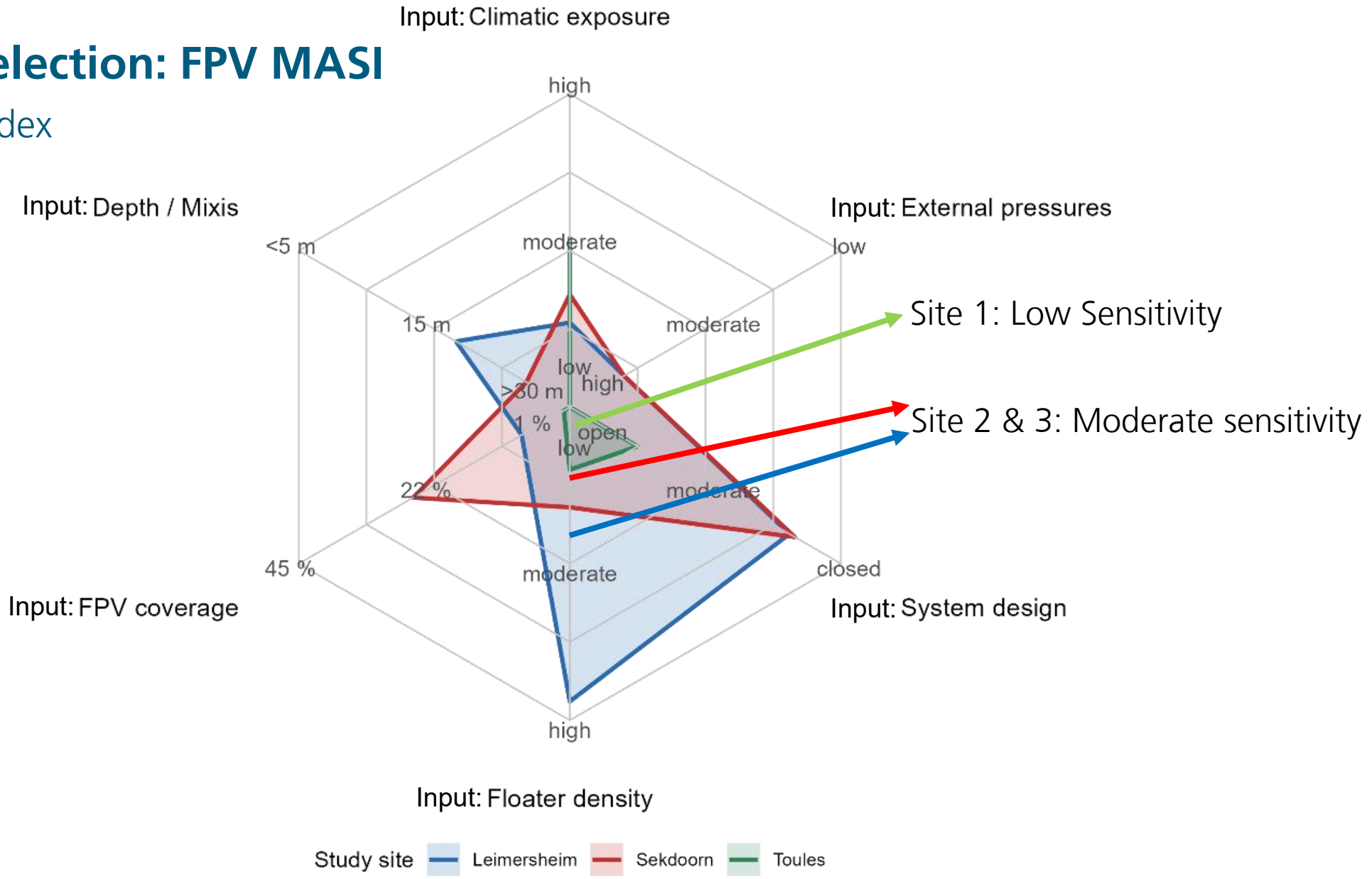
SQUAT Evaluation GUI providing project scoring

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Ilgen 2025: Enhancing climate resilience of lakes through yield-optimised floating photovoltaics, DOI: 10.6094/UNIFR/284036

Monitoring tier selection: FPV MASI

Multi-Axis Sensitivity Index

- Impact parameters: system, lake, climate, external pressures
- Cumulative sensitivity profile from a radar-based index
- High scores: increased likelihood for detection of FPV-induced effects



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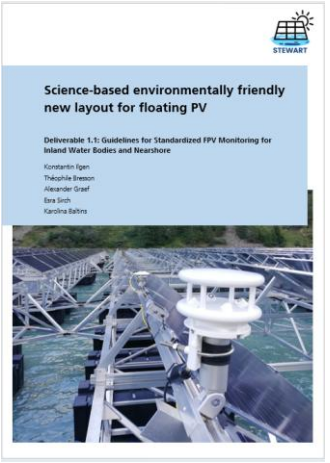
Ilgen et al. 2026. STEWART: Guidelines for standardized FPV monitoring for inland water bodies and nearshore (Deliverable 1.1).

Tiered monitoring concept

MASI score	Tier	Key parameters	Typical application
0.25 – 0.5	**Basic**	Core physical and chemical parameters: light, wind, temp., …	Commercial low-sensitivity sites
0.50 – 0.75	**Extended**	In addition: heat fluxes, periodic biological surveys, …	Moderately sensitive sites, regulatory requirements
0.75 – 1.00	**Advanced**	Hydrodynamics, pollutants and microplastics, …	Sensitive pilot and research installations

Also includes:

- Re-evaluation of intensity/focus at decision points (e. g. after 3 years)
- Staged mitigation strategy for negative ecological effects



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Ilgen et al. 2026. STEWART: Guidelines for standardized FPV monitoring for inland water bodies and nearshore (Deliverable 1.1).

First results: observations of bidirectional FPV-waterbird-interactions

FPV → birds:
Habitat: Loss or gain, nesting and resting

Birds → FPV:
Soiling, yield loss, additional O&M

Influential factors on bird abundance:

a. System design

b. Alternative habitats

c. Human activity

d. Bird community

a:



Images taken and observations carried out within STEWART by L. Melzl, O. Onmus, M. Ertem

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Further 1st year results

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

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Because we care

Techno-economics (LCA):

- Bayındır 1 MWp, cradle-to-grave
- 80 g CO_2eq/kWh, landfill
- 61 g CO_2eq/kWh, recycling: -24%

Legal framework:

- EU: RED III, WFD, EIA, Birds & Habitats, NZIA
- Italy: regional fragmentation
- Coverage caps 20-50%, buffers 50-300 m

Monitoring results/observations as input for LCA, legal guidelines and planning tools

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Conclusions and outlook



- Comparable, standardized FPV monitoring framework established
- Coupling with planning tools (SQUAT, AHP, MASI)
- Validation of monitoring approach at STEWART sites

Next steps:

- Completion of bird surveys and mitigation study, field campaigns 26/27
- Coupled eco-hydrological and yield modelling
- Integration with LCA, techno-economics and legal benchmarking, creation of holistic FPV guideline.

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STEWART project website:

Standardized monitoring guideline D1.1:



Thank you!

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Partnership

Tiered monitoring concept

Tier	Purpose	Key parameters	Typical application
Basic	Baseline characterization, trend detection	Core physical and chemical parameters: light, wind, water level, temp., DO, pH, conductivity, turbidity, chlorophyll-a	Commercial installations, low-sensitivity sites
Extended	Process-oriented assessment	In addition: heat fluxes, nutrients, DOC, sediments, periodic biological surveys	Moderately sensitive sites, regulatory requirements
Advanced	High-resolution, research-driven monitoring	Hydrodynamics, wave dynamics, flow velocity, pollutants and microplastics, full biological compartments	Sensitive sites, pilot and research installations

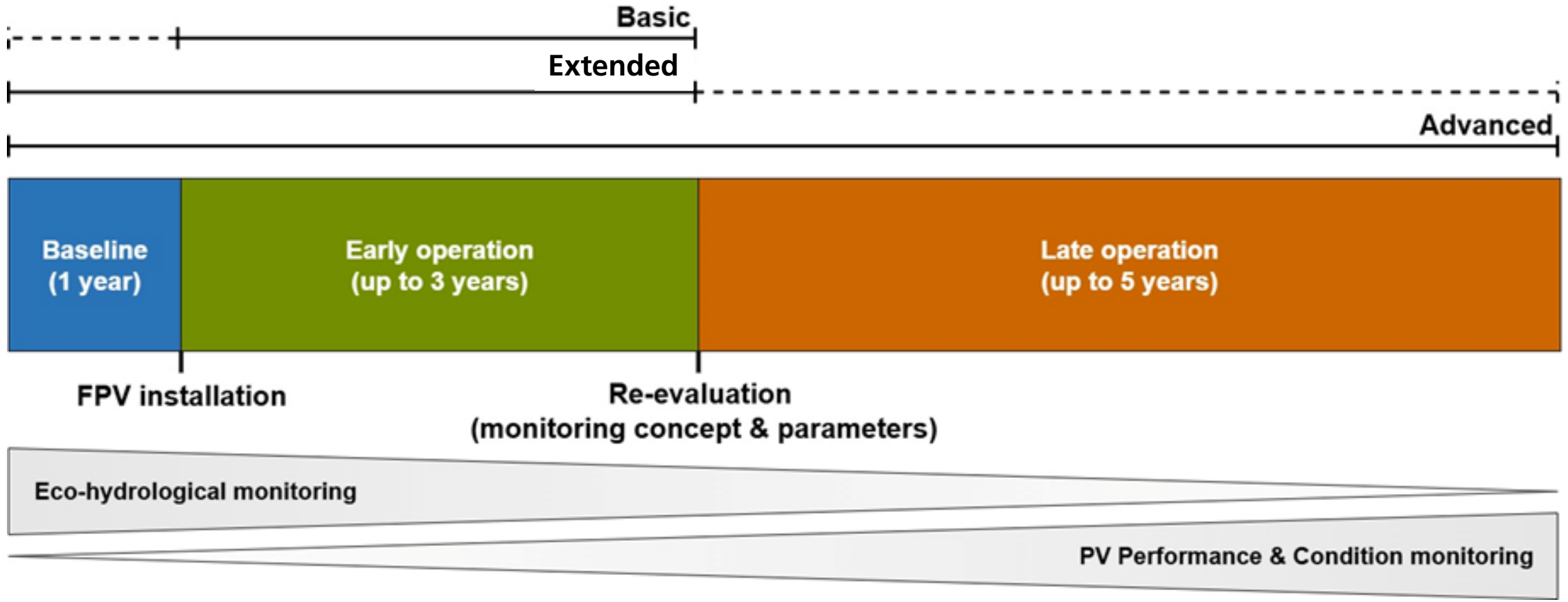
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Example tier-dependent sensor recommendation: water temperature

- **Reference concept identical across all tiers:**
  - FPV chain centrally beneath the array at the deepest feasible point
  - REF chain in open water at the deepest undisturbed point, at sufficient horizontal distance from the array edge
- **Basic tier**
  - three sensors per chain, capturing seasonal differences and coarse vertical stratification, robust and low-maintenance
- **Extended and Advanced tier**
  - 0.5 m spacing from surface to 10 m depth resolving epilimnion and thermocline, 5 m spacing in the hypolimnion
- **Sampling interval of 15 minutes in all tiers, recorded directly without aggregation**
- **Derived quantities: thermocline depth and strength, mixed-layer depth, internal heat content**
- **Application: calibration and validation of hydrodynamic models, e. g. the General Lake Model, for coverage and climate scenarios**

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Adaptive timing of the monitoring framework



Monitoring intensity and focus is re-evaluated at decision points along the FPC lifecycle.

From: Ilgen et al. 2026. STEWART: Guidelines for standardized FPV monitoring for inland water bodies and nearshore (Deliverable 1.1).

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Staged adaptive management strategy for adverse ecological effects

- Stage 0
  - Reference conditions and trigger values
- Stage 1
  - Verification, causal analysis
- Stage 2
  - Operational adjustments
- Stage 3
  - Technical mitigation
- Stage 4
  - Ecological compensation or restoration
- Stage 5
  - Partial or full removal – last resort only

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Learnings and derived strategies for monitoring setups

System design and hardware

- Accessibility
- Redundancy
- Cable Management
- Biofouling
- Long-term stability

Data, power and operations

- Time synchronisation
- Power supply
- Metadata
- Safety concept
- Data quality checks

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