



# World Water Challenge<sup>2025</sup>

## PROGRAM BOOK



Ministry of Climate, Energy  
and Environment



KOREA  
WATER FORUM





# World Water Challenge<sup>2025</sup>

## PROGRAM BOOK



Ministry of Climate, Energy  
and Environment



KOREA  
WATER FORUM





## Contents

<b>Main Topic</b>	<b>Environment Preservation Technology</b>	
<b>[Solution 1]</b>	Garuda WaterGuard: An integrated Smart Ecosystem for Water Quality Restoration and Monitoring in Degraded Freshwater Bodies	06
<b>[Solution 2]</b>	Monitoring of Water Consumption and Water Productivity in irrigated Lands of the Fergana	24
<b>[Solution 3]</b>	Aruna Revolution: Circular Fiber Innovation for Aquatic Health and Hygiene Equity	40
<b>Main Topic</b>	<b>Smart Water Technology</b>	
<b>[Solution 4]</b>	A scalable Machine-learned based Framework for cost-effective Sewer Leakage Detection	52
<b>[Solution 5]</b>	Small Habits, Big Thirst: Smart Behavioral Water Management in Pakistan & South Africa	60
<b>Main Topic</b>	<b>Appropriate Technology</b>	
<b>[Solution 6]</b>	NileSmart: Community-Centered Water Stewardship for a Resilient Egypt	70
<b>[Solution 7]</b>	Resilient Water Pods: Solar-Powered Water Access and Household Distribution in Rural Karakalpakstan	80





# Garuda WaterGuard: An integrated Smart Ecosystem for Water Quality Restoration and Monitoring in Degraded Freshwater Bodies

Oryza Sativa Afra Iftikar  
(University of Indonesia)



**Korea International Water Week 2025**

Session Title  
Garuda WaterGuard: An Integrated Smart Ecosystem for Water Quality Restoration and Monitoring in Degraded Freshwater Bodies

Speaker / Affiliation  
Oryza Sativa Afra Iftikar | University of Indonesia

Date  
November 12<sup>th</sup> (Wed) 15:00~16:00

Logos: UN Water, Ministry of Environment, Republic of Korea, Korea International Water Week 2025, K-water, Seoul Environment Foundation

**CONTENTS**

01. Executive Overview & Introduction	02. Integrated Technology (Workflow & Operational Phases)	03. Field Tested Outcomes	04. Competitive Landscape & Decisive Advantages
---------------------------------------	---	---------------------------	---





## CONTENTS

05. Handling  
Complex, Mixed  
Pollution & System  
Integration

06. Economic  
Viability, Cost  
Calculation &  
Resource  
Planning

07. Risks,  
Challenges &  
Mitigation

08. Conclusion  
& Next Steps

## 1. Executive Overview & Introduction (Geographic Content & Area Assessment)

## Executive Overview & Introduction

### Background Problems

Indonesia is facing an acute water pollution crisis. As of 2023, government monitoring of 4,480 locations on 1,480 rivers found **76.7% were polluted**—only 23.3% of river sites now meet basic water standards. Major rivers like the Citarum, Cikujang, and Cidurian—critical for drinking water, irrigation, and fisheries—are classified as “critically polluted,” with nearly all urban rivers failing quality tests.

- Root Causes** → Rapid urbanization, unregulated industrial waste, intensive agriculture, and domestic sewage have overwhelmed river systems.
- Consequences** → Unsafe drinking water, lost biodiversity, food safety issues, and major public health threats.
- Scale** → With the majority of Indonesia’s 33,000 rivers in jeopardy, which directly affects 15+ million people, the water crisis is not only one of environmental degradation but also threatens economic stability and national food security.



**Area Assessment**  
Reason for Selection → The Saguling Dam area is the most manageable and smallest of the horizon zones, with a defined geographic boundary and existing infrastructure.

### Why is this a decisive test for environmental preservation technology?

- The pollution is complex—a mix of heavy metals, nutrients, pesticides, and pathogens—making conventional single-solution treatments ineffective or too expensive.
- Centralized wastewater plants can’t reach scattered or rural settlements. New, integrated technological solutions are urgently needed that can monitor, treat, and adapt in real-time across diverse and degraded environments.

### Targeted Pilot Area – Geographic Context

#### Citarum River Overview

- The Citarum River is the longest and one of the most important rivers in West Java, Indonesia, stretching approximately 270 km with an average width of 50 meters. It serves as a vital water source for about 15 million people, providing water for domestic, agricultural, and industrial use.
- Unfortunately, it is severely polluted by domestic sewage, industrial discharges (especially textile dye effluents), and agricultural runoff.

#### Division of River Zones

The Citarum River is divided into several zones, identified based on geographic location and pollution characteristics:

- Upper Zone** → Mountainous, heavy textile industry pollution, high BOD and COD levels.
- Middle Zone** → Outcrops, urban and domestic sources, elevated nutrients like ammonium and phosphate.
- Saguling Dam Zone (Selected Target Pilot Zone)** → Smaller manageable area dominated by mixed agricultural and industrial pollution, ideal for pilot tests.
- Lower Zone** → Deltaic, extremely high pollution levels from dense population and industrial runoff, including heavy metals.

Parameter	Value
Area	3.1 km <sup>2</sup> (1210 hectares)
Average Depth	15 m
Estimated Water Volume	37,500,000 m <sup>3</sup>
Pollution Severity	Moderate to High
Key Pollutants	Nitrates, Heavy Metals

## Field Test Data Overview

### Field Test and Technology Readiness Overview - Kinanga Lake, University of Indonesia

Parameter	Description / Value	Notes
Location	Gemast University of Indonesia Campus, Depok, West Java (S: 362° E, 106.823° E)	Receives inflow from the Cikujang sub-basin and on-campus storm drains
Surface Area	≈ 3 hectares (0.00 km <sup>2</sup> )	Approx. 30,000 m <sup>2</sup>
Average Depth	≈ 5 m	Based on field and hydrologic estimations
Maximum Depth	≈ 10 m	Observed near the center and western depression zone
Estimated Water Volume	≈ 150,000 m <sup>3</sup>	Calculated as area × avg. depth
Water Source / Catchment	Cikujang sub-basin inflow + campus stormwater	High suspended solids and nutrient load after rainfall
Key Pollutants	Nutrients (N, P), heavy metals (Fe, Pb), organic contaminants (COD/BOD), microplastics, detergents	Major contributors from domestic runoff and nearby drainage
Pollution Severity (Qualitative)	Moderate-High	Periodic eutrophication and odor events reported
Dominant Hydrological Behavior	Semi-stagnant with low flushing rate	Favorable for controlled remediation pilot tests
Ecological Notes	Presence of duckweed, algae, and rooted macrophytes	Indicates nutrient loading suitable for FTW-based phytoremediation

A field technology validation study was conducted in Kinanga Lake, University of Indonesia, serving as a controlled environment for system testing and performance verification prior to large-scale implementation in diverse ecosystems such as the Citarum watershed.

- The pilot configuration includes:
- 1 Autonomous Surface Vehicle (ASV) for high-resolution monitoring and autonomous sampling.
  - 2 Modular Floating Treatment Wetland (FTW) (30 m<sup>2</sup> coverage) planted with *Scheuchzeria palustris* (Water Hyacinth) and *Scheuchzeria palustris* (Water Hyacinth).
  - 1 Photocatalytic Remediation Reactor (PWR) (10 m<sup>2</sup>) for advanced pollutant treatment, with solar-exposed TiO<sub>2</sub> catalyst panels.
  - 1 portable sensor module integrated with dissolved oxygen sensors for active monitoring and optimization.







## 2.

## Integrated Technology (Workflow & Operational Phases)

### Operation Stages & Key Components

#### 1st Component – Autonomous Surface Vehicles (ASVs)

A fleet of Autonomous Surface Vehicles (ASVs) acts as the mobile sensory nervous system of the operation, providing real-time, high-resolution water quality data across vast areas.



Layer	Function	Algorithm
Input Layer	ASV mapping (pH, DO, EC, NH <sub>4</sub> <sup>+</sup> , NO <sub>3</sub> <sup>-</sup> , PO <sub>4</sub> <sup>3-</sup> , turbidity, heavy metals).	Federated anomaly detection (edge).
Computation Layer	Cloud-based clustering & hotspot mapping.	k-Means, DBSCAN.
Decision Layer	Route & PFR scheduling optimization.	PPO + Adaptive FL Models.

#### Standardized Data Points

- Command: "Survey Zone L for nutrient hotspots."
- Sensor Spike: Nitrate rises from 2.0 to 9.5 mg/L.
- Edge AI: Initiates spiral path to map plume.
- Data Output: coordinates, NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup>, pH, phosphate 0.8, turbidity 25 NTU.
- Feedback: Contaminant cluster coordinates sent to PFR deployment team.
- Result: Hotspot tagged + PFR deployment recommendation.

#### Technical Specifications

- Platform: Compact solar-electric catamaran with 420 Wh Li-ion battery + 100 W solar module for 8 hr operation.
- Sensors: 16F multi-parameter array (pH, DO, EC, turbidity, ammonia, nitrate, phosphate, and light heavy metal probes).
- Compute Unit: Raspberry Pi 5 + Jetson Nano for edge AI processing and GPS-based navigation.
- Communication: 4G LTE + LoRaWAN link to the Central AI Hub.
- Data Handling: All readings geo-tagged and timestamped for spatial-temporal mapping.

#### AI & Learning Framework

- Architecture: Lightweight Federated Learning (FL) model combining edge and cloud training.
- Edge AI: Continuously executes simplified PPO policy for adaptive routing—detects anomalous upsurge/pollutant spike detection.
- Cloud AI (Central): Aggregates model updates from ASV + busy sensors, refines the route and operation schedule, then syncs back.
- Outcome: Continuous self-improvement loop with minimal bandwidth use and privacy preservation.

#### Fabrication & Integration

- Lightweight composite hull (3D-printed/foam).
- Integrated sensor array and propulsion module (outboard).
- Local collaboration using standard buffer solutions.
- All sensors and FL algorithms pre-installed before deployment.

#### Phase 1 – Intelligence & Monitoring

- Deployment: 1 ASV patrolling 5 zones (A-E) with 5 fixed buoys providing 10-min telemetry.
- Sensors record every 30-60 s; initiate mode every 10-15 s when anomalies occur.
- Rule: Targeted transect mapping and hotspot validation (e.g., turbidity or low DO).
- Data Flow: ASV → AI Hub → Central Cloud → Model update on parking.

#### Phase 2 – Central AI Processing & Decision Making

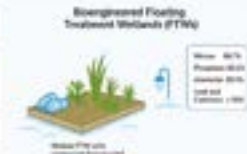
- Fusion: Combines buoy, ASV, and lab data into real-time anomaly heatmap.
- Optimization: PPO agent prioritizes next-day patrol routes and PFR spin time to match diurnal pollutant trends.
- Real-Time Action: AI can re-route ASV mid-mission when new anomalies appear.

Phase	Description
Phase 1 – Intelligence & Monitoring	1 ASV + 5 fixed sensor buoys across Zones A-E. Daily 3-4 hr patrol. Buoy provides continuous telemetry (10-min intervals).
Phase 2 – Federated Adaptation	ASV uploads local updates to the AI hub during docking. Cloud model refines global detection patterns.
Phase 3 – Data Integration & Decision Support	Integrated dashboard identifies high-risk nutrient zones for PFR placement and PFR shore siting.

### Operation Stages & Key Components

#### 2nd Component – Floating Treatment Wetlands (FTWs)

Aspect	Specification
Structure & Materials	Modular 1 x 1 m frames made from recycled HDPE pipes with PET bottle flotation and biodegradable coir mats as planting media.
Plant Species	Native macrophytes — Eichhornia crassipes (Water Hyacinth) & Sparganium angustifolium (Water Sparganium) — selected for high-nutrient and metal uptake.
Construction Protocol	1. Assemble HDPE frame and PET-bottle flotation. 2. Lay coir mat and plant 20-25 seedlings/m <sup>2</sup> . 3. Cure in calm water (2-3 weeks) for root establishment. 4. Deploy to ASV-identified pollution hotspots.
Enhancements (Optional)	Solar-powered aeration units (integrated into select modules) improve DO levels and enhance microbial nutrient cycling.
Phyto-Remediation Process	• Root uptake: Plants absorb nitrate, phosphate, ammonia, and trace metals. • Rhizosphere Action: Microbes degrade organic pollutants. • Anoxic-Aerobic Zones: Enable nitrification-denitrification for nitrogen removal.
Performance Metrics	Nitrate 90-95%, Phosphate 83-92%, Ammonia 88-93%, Pb/Cd > 90% (field & lab trials).
Lifespan & Maintenance	• Month 0-1: Root establishment. • Month 1-12: Peak remediation. • Annual Harvesting: remove biomass to extract pollutants. • HDPE frame lifespan > 7 years.
Budget Allocation (Est.)	FTW module fabrication & deployment = Rp 18 million (27% of total). Covers 12-15 m <sup>2</sup> prototype coverage with integrated DO sensor nodes.



- Low-cost, modular FTWs made from recycled materials use native plants to naturally remove excess nutrients and metals from Karangsari Lake. Integrated aeration boosts oxygen and microbial degradation, achieving >90% nitrate and >80% phosphate removal within months. Each module is reusable and supports long-term, low-maintenance water quality improvement.

- End of Life/Disposal/Reuse Plan (Removal/Control):**
  - Harvesting: Above-water biomass is cut and composted.
  - Contaminant Analysis: Plant tissue is tested for heavy metal concentration.
  - Disposal: Low Contamination: Composted for use in local food horticulture. High Contamination: Treated as phytoremediation waste. Incinerated in a controlled facility, with ash disposed of in a hazardous waste landfill.
- Cost Breakdown:**
  - HDPE and PET are UV-resistant with an expected functional lifespan of 7+ years.
  - Design withstands moderate wave action and minor impacts.

#### Phase 3 – Targeted Remediation Execution (Install & Position)

- FTW deployment & re-deployment: FTWs are modular and re-deployable. The AI recommends FTW placement in Zones A and D initially (inflow and stagnant shallow zones) and may initiate manual re-deployment to Zone C for local sourcing.
- Because KSR count = 1, redeployment of FTW modules is performed by a small boat crew (Autonomous/Manual) following AI guidance. The ASV assists by mapping access lines and recording anchor positions.

- FTW "Effective Treatment Volume"**
  - Conservative proof assumption: 1 m<sup>2</sup> FTW treats ~1.0 m<sup>3</sup>/day of the adjacent water column for measurable nutrient/TSS reduction (based on conservative rate of uptake for small modular FTWs).
  - Total FTW area = 2 m<sup>2</sup> → ~2 m<sup>3</sup>/day approximate influence (removal zone). Removal is primarily for nutrients, TSS, and supporting DO recovery via bottom aeration.
- Deployment Logic:**
  - FTWs: Place at or immediately downstream of identified inflow hotspots (intercept and reduce nutrient/TSS load). Anchor in calm zones where roots can extend into the plume. Modules can be clustered to form a larger effective raft. Use ASV mapping to identify hotspots (high NH<sub>4</sub><sup>+</sup>/NO<sub>3</sub><sup>-</sup> spikes).

### Operation Stages & Key Components

#### 3rd Component – Photocatalytic Nanofiltration Reactor (PFR)

Aspect	Specification
Purpose	Post-treatment unit for semi-treated or runoff water containing pesticides, pharmaceuticals, and microplastics.
Design	Compact hollow-fiber ceramic membrane integrated with TiO <sub>2</sub> /ZnO photocatalyst, responsive to solar and UV-visible light.
Structure	Includes pre-filter (100 µm), low-pressure diaphragm pump, and dual outlets for permeate (clean) and concentrate (reject).
Operation Principle	Solar-assisted photocatalysis + nanofiltration: light-activated TiO <sub>2</sub> /ZnO to produce hydroxyl radicals (•OH), breaking down organic pollutants while the membrane filters fine particles.
Performance	• Microplastic removal > 90%. • Pesticide removal (e.g., glyphosate, imazapyrid) > 85%. • Water recovery > 95%.
Processing Rate	~20 L/hr per module; 8-12 hr/day at scheduled cycles aligned with sunlight.
Energy Source	Primarily solar-assisted, reducing grid dependency; low-watt UV LEDs used during dawn/dusk conditions.
Reagent Management	5% concentrate stream stored in a sealed tank, transported periodically for evaporation or electrocoagulation treatment.
Integration with FTWs	Receives partially clarified water from upstream FTW zones to remove turbidity and extend membrane lifespan.
Footprint	Placed downstream near lake edge on stable foundation. Intake pipe connected from FTW outlet zone.
Budget Allocation (Est.)	PFR unit + pump + UV-LED + sensors = Rp 21 million (43% of total budget).



- A solar-assisted nanofiltration reactor that combines TiO<sub>2</sub>/ZnO photocatalysis with membrane filtration to remove residual pesticides and microplastics. It complements FTWs by providing clean, reusable water for small-scale environmental restoration.

#### Real-Performance with Turbidity Stress

- Challenge: High turbidity fouls membranes and attenuates UV light, drastically reducing efficiency.
- Solution: The PFR is deployed as a pre-treatment unit. The upstream FTWs act as a highly effective pre-filter, significantly reducing turbidity and organic load, thus protecting the PFR and ensuring optimal performance.
- Cleaning & Maintenance: periodic backwash. TiO<sub>2</sub> re-coating as scheduled every 6-12 months for pilot; membrane change annually depending on fouling.

#### Phase 3 – Targeted Remediation Execution (Install & Position)

- PFR Activation & Scheduling: PFR operates on an AI schedule determined by combined buoy + ASV measurements. Typical run: PFR at higher throughput during late morning to mid-afternoon when solar irradiance peaks and pollutant concentrations at the intake exceed a threshold.
- With a single ASV, PFR makes monitoring runs on (1) fixed buoy system (see PFR), (2) ASV validation missions, and (3) manual lab checks for membrane fouling indicators.

#### PFR Operational Schedule and Capacity Metrics

- Typical daily schedule: operates PFR 8-12 hours during daylight for leverage solar-assisted photocatalysis and reduce battery strain.
- Flow & Membrane Area: For hollow-fiber glass membranes, expect low-pressure operation (0.5-0.8 bar) and permeate flux in the order of 2-10 L/m<sup>2</sup>h depending on membrane and feed quality; membrane area must be sized to provide the 20 L/h target.
- Active AI schedules PFR start or stop, stops at 17:00 by default; can override for surge polishing if feedback triggers.

#### Deployment Notes

- PFR: place on shoreline / pier at the outlet of the FTW-treated zone or at designated discharge channel where water can be drawn (intake hydrodynamics stable, shallow dock/depth 0.5-2 m). PFR should be accessible for maintenance and solar exposure.





## Operation Stages & Key Components

### • 4th Components - Closed-Loop AI Optimization & Feedback

Agent	Specification
Architecture	Hybrid edge-cloud system integrating data from sensors, FTWs, PMFs, and a single ASV.
AI Model	Reinforcement Learning (PPO) algorithm that optimizes operations based on live water quality data.
Function	Continuously learns and updates the best placement for FTWs and operation schedule for PMFs according to pollution dynamics and hydrological patterns.
Sensor Suite	ASVs collect post-treatment data (e.g., nutrient levels, turbidity, dissolved oxygen) and send it to the cloud for analysis.
Optimization Loop	Observe: ASV resamples treated zones → Analyze: AI evaluates pollution reduction → Decide: Adjust FTW/PMF deployment and ASV patrol routes → Act: Updated commands sent automatically to field units.
Validation Phase	After each operation cycle, the ASV performs a focused resurvey mission to measure improvement (e.g., BOD, COD, nitrate) for feedback calibration.
Automation Level	Semi-autonomous; human input limited to supervision and maintenance.
Decision Latency	• Route & placement updates: every few hours • On-field response (ASV): within seconds.
Cost Allocation (Est.)	AI control (edge device, sensors, software integration): N/A (recurring)

### PHASE 4 - Validation & Closed-Loop Feedback (single ASV workflow)

#### Resurveying for validation

- After a remediation action (FTW redeployment or PMF operation window), the ASV is scheduled for a focused validation mission to resurvey the treated area. Because only one ASV is available, the AI prioritizes validation targets by expected marginal improvement.
- Validation includes in-situ sensor logging and photography; a subset of water samples are taken for lab confirmation (BOD/COD, nitrate) to calibrate remote sensor readings.

#### Feedback & policy update

- Validation results feed the central RL engine. Policy updates (route priorities, FTW placement heuristics, PMF runtime rules) are transmitted to the ASV during its docked idle window.
- Over sequential cycles, the RL agent learns which remediation portfolios produce measurable improvements for given effluent signatures.

Metric	Measurement
Water level (m)	1.5 (1.0m to 2.0m)
Temperature (°C)	20-25 (range based)
Flow rate (m³/s)	0.5 (low)
Dissolved Oxygen (mg/L)	~1.0 (sat. 14.6 mg/L)
pH	~7.0 (range 6.5-7.5)
Turbidity (NTU)	10-15 (low range)

### Closed-Loop Feedback & AI Optimization



- The AI-powered control system forms the brain of the Smart Ecosystem. It processes live data from ASVs, FTWs, and PMFs, continuously optimizing deployment and operation for maximum water quality improvement — all within a closed, adaptive loop that learns and evolves over time.

## System Overview Diagram

### • System Overview Diagram: The "Smart Ecosystem" (ASVs, FTWs, PMFs, AI feedback)



## Field Tested Outcomes

### • System Effectiveness & Quantitative Results

Parameter	Pre-Treatment (Baseline)	Post-Treatment (60 Days)	Efficiency (%)	Remarks
Heavy Metals	0.30 mg/L	0.235 mg/L	50%	Restored to neutral stability
Dissolved Oxygen (DO)	2.1 mg/L	4.3 mg/L	210%	Improved through aeration
Biological Oxygen Demand (BOD <sub>5</sub> )	35 mg/L	9 mg/L	74%	Bioremediation via FTW root biofilm
Chemical Oxygen Demand (COD)	85 mg/L	18 mg/L	72%	PMF photocatalysis oxidation effective
Total Nitrogen (TN)	5.5 mg/L	3.1 mg/L	64%	Nutrient uptake by wetland plants
Total Phosphorus (TP)	2.3 mg/L	0.8 mg/L	60%	Phytoremediation dominant
Turbidity	85 NTU	18 NTU	78%	Reduced by filtration & biofouling
Total Coliform	8200 CFU/100mL	640 CFU/100mL	92%	UV sterilization + microbial competition

### • Impact Assessment

Impact Dimension	Indicator / Parameter	Observed or Projected Result	Quantitative / Qualitative Metrics	Remarks
Environmental	Nutrient & Organic Load Reduction	75-78% pollutant reduction (COD, BOD, TN, TP)	BOD <sub>5</sub> ↓ from 35 → 9 mg/L; TP ↓ 65%	Substantial eutrophication mitigation
	Biodiversity Recovery	Reappearance of plankton and small fish	DO ↑ from 2.1 → 4.3 mg/L	Improved aquatic life resilience
	Carbon Footprint	Low-carbon operation via solar PMFs	~0.37 kWh/m³ energy use	50% lower energy vs. conventional aeration
Socio-Educational	Water Quality Upgrade	Class II → Class III (within 1 year)	90% TSS-2000 standard alignment	Suitable for recreational and educational use
	Student & Research Engagement	Involvement of ~18 students across Engineering	Cross-department (Chemical, Environmental, Electrical Eng.)	Promotes interdisciplinary innovation
	Academic Demonstration & Training	On-site demos and short training sessions	Conducted periodically for coursework or research	Coordinated with Chemical Engineering Lab
Campus Sustainability Alignment	Contributes to internet sustainability tracking	Contributes to internet sustainability tracking	Data shared with IT	Aligns with GreenMetric environmental performance indicators





## 4. Competitive Landscape & Decisive Advantages

### Competitive Landscape & Decisive Advantages

#### • Superiority of Garuda WaterGuard

Feature	Garuda WaterGuard System Advantage
Integrated Modular Architecture	Combines ADV + FTW + PMFR into one adaptive and interlinked platform. Each module is physically independent yet digitally connected, enabling scalable, tool-ready deployment.
Adaptive AI Management	Employs Federated Learning + Reinforcement Learning (FRL) to autonomously adapt operations based on real-time pollution data, ensuring higher efficiency with minimal human intervention.
Decentralized Intelligence	Every ADV is an independent node with on-board computation; only model weights are shared to preserve bandwidth and enable distributed decision-making.
Robust System Reliability	Operates as a single-vendor system, minimizing interoperability risks across software and hardware layers. All components are developed under one cohesive control logic.
Local Manufacturing & Cost Efficiency	Designed and fabricated using local materials and Indonesian engineering capacity, cutting costs by up to 40% compared to imported systems while improving sustainability and reparability.
Circular & Green Engineering	Employs recycled HDPE/PVC materials for FTWs and solar-driven PMFR systems, emphasizing low-carbon and circular economy principles aligned with Indonesia's Net Zero 2060 agenda.

#### • Risk Mitigation

Risk Category	Potential Issue	Mitigation Protocol
System Integration Risk	Hardware-software misalignment between ADV, FTW, and PMFR modules	Standardized communication protocols (MQTT + REST API), hardware modularity-validation, pre-deployment system tests
Single Point-of-Failure (SPOF)	Failure in main control node or AI command center	Redundant microcontrollers on ADVs; distributed edge intelligence allows autonomous fallback operation
Hardware Durability	Damage from floating debris, corrosion, or UV degradation	Marine-grade coatings, waterproofing (IP67), shock-resistant casings
Sensor Reliability	Calibration drift and data inaccuracy over long-term use	Automated calibration algorithms, dual-sensor redundancy for critical parameters
Environmental Conditions	Flooding, algae overgrowth, or extreme weather	Dynamic buoyancy adjustment in FTWs, real-time route adaptation for ADVs, emergency shutdown protocols
Cybersecurity	Data tampering or communication hijack	End-to-end encryption with cloud-based access control, continuous B model integrity checks

## 5. Handling Complex, Mixed Pollution & System Integration

### Handling Complex & Mixed Pollution - A Case Study

#### • Technical Decision Framework & Resilience Under Real-world Variability

The Garuda WaterGuard system employs an AI-driven decision matrix that prioritizes remediation actions dynamically based on sensor-reported pollution profiles. The logic integrates data from the ADV sensor suite (real-time pH, DO, turbidity, nitrate, phosphate,  $\text{Pb}$ ,  $\text{Cd}$ ,  $\text{Cr}$  levels) and feeds it into a hierarchical control logic for optimal outcomes.

Scenario - A simultaneous increase in nutrients ( $\text{N}$ ,  $\text{P}$ ) and heavy metals ( $\text{Pb}$ ,  $\text{Cd}$ ) detected at Zone 3 (Kerangka Lake inflow channel).

- Case Study: Kerangka Lake Inflow Data**
- AI Decision Logic Tree**
- Data Detection Layer (0-20 sec latency)
    - ADV sensors detect abnormal turbidity, phosphate  $>2 \text{ mg/L}$ ,  $\text{Pb}$   $>0.05 \text{ mg/L}$ .
    - AI assigns a pollution index score for each contaminant type based on severity weighting:
      - Nutrient Load Index = 0.68
      - Heavy Metal Index = 0.72
  - Federated Local Decision Layer (within 60 sec):
    - ADV's onboard model (Edge AI) ranks intervention priorities:
      - If Heavy Metal Index > Nutrient Load Index, it prioritizes PMFR activation.
      - If Nutrient Load Index > Heavy Metal Index, it prioritizes FTW allocation.
    - Concurrently, the ADV transmits aggregated severity data to the cloud for multi-agent reinforcement learning.
  - Central Optimization (1-2 min latency):
    - The RL-PMO Controller evaluates historical treatment efficiency curves for each module type.
    - Outputs optimized commands:
      - FTWs repositioned to nutrient hotspots.
      - PMFRs activated downstream for polishing heavy metals and residual organics.
  - Execution Layer (Real-time):
    - FTWs initiate phyto remediation and microbial degradation nutrients.
    - PMFR operates in parallel for photodegradation of metal complexes.
    - ADV performs continuous validation scanning, feeding new data for feedback AI learning.

- Latency & Control Specs**
- Edge Processing Delay:  $<1.5$  seconds per ADV
  - Cloud Command Cycle:  $<10$  minutes total (incl. round-trip)
  - FTW Repositioning:  $<20$  minutes per  $10 \text{ m}^2$  module (manual/autonomous)
  - PMFR Activation Response: Instant (within 1 min on-demand system)
- This hybrid decision framework ensures that mixed pollution spikes are handled synergistically, leveraging pollution reduction while minimizing operational redundancy.

Garuda WaterGuard is designed for long-term, real-world variability, accounting for both environmental and operational uncertainties. Scenario analyses were conducted to validate system resilience against fluctuating pollution and seasonal challenges in Kerangka Lake, which exhibits strong eutrophication cycles and variable hydrological inflow.

Scenario	Observed/Simulated Condition	Adaptive System Response	Expected Outcome
Dry Season Concentration Peaks	High evaporation + elevated pollutant concentrations ( $\text{DO}$ $<$ , nutrient $>$ )	AI prioritizes FTW redeployment to increase root zone density; PMFR operates intermittently during high incidence	Stabilized $\text{DO}$ $> 5 \text{ mg/L}$ , $\text{N}$ , $\text{P}$ reduced by 40-50%
Wet Season Inflow Surges	Sudden inflow of turbid, low- $\text{DO}$ water from Ciliwung runoff	ADV's swarm upstream, traps inflow contamination, and guide FTW anchoring at inflow points	Reduced inflow pollutant impact; improved water clarity (turbidity $< 50 \text{ NTU}$ )
Mixed Contaminant Pulse (Nutrients + Heavy Metals)	Detected $\text{Pb}$ , $\text{Cd}$ + threshold + phosphate surge	PMFR priority activation with simultaneous FTW reposition; adaptive rebalancing every 15 min	$\text{Pb}$ $< 0.05 \text{ mg/L}$ , phosphate $< 0.5 \text{ mg/L}$ after 48-hour operation
High Organic Load (Algal Blooms)	Dense microalgae and low oxygen	AI triggers aeration mode on ADV propellers; increases FTW buffer density	Algal biomass reduced; oxygen recovery $> 80\%$ of baseline
Equipment Degradation/ Sensor Drift	Prolonged use, calibration delay	AI detects data drift pattern; system triggers self-calibration or redundant sensor check	Maintains data integrity $> 90\%$ accuracy





## System Integration, Sensor Technology & Field Robustness

### • Durability Solutions

The Garuda WaterGuard system is designed to sustain long-term operations under tropical aquatic environments such as mangroves. Each subsystem incorporates field-proven durability measures:

- Submerged Resistance** – All submerged components—including sensor housings and FTW float units—are coated with non-toxic, hydrophobic fluoropolymer layers to prevent silt or bacterial buildup. Self-cleaning sensor housings use micro-vibration pulses every 12 hours to dislodge biofilm accumulation without manual intervention.
- Anti-Corrosion Coatings** – Metallic elements (mounts, frames, ADU propeller housings) are anodized or treated with marine-grade aluminum with epoxy plating to resist oxidation and corrosion from nutrient-rich water.

### • Calibration & Maintenance Protocols

To ensure continuous data reliability and operational accuracy:

- Automated Calibration** – ADUs feature onboard reference solutions allowing in-situ calibration for DO, pH, and conductivity sensors every 48 hours.
- Scheduled Manual Checks** – Human maintenance is performed biweekly for cross-validation against laboratory standards and cleaning of FTW sampling points.
- Sensor Replacement Cycle** –

Sensor Type	Expected Lifespan	Replacement Cycle
DO Sensor	12 months	Annually
pH/ORP Sensor	18 months	Every 1.5 years
Turbidity Sensor	24 months	Every 2 years
Heavy Metals/NO <sub>3</sub> Sensor	36 months	Every 3 years

### • Edge Computing & Battery Management

Each ADU is powered by a hybrid solar-LiFePO<sub>4</sub> battery pack providing 48 hours of continuous operation. Intelligent edge computing allows local AI inference to minimize data transmission load, enabling autonomous operation even under weak connectivity. Power allocation dynamically prioritizes propulsion, sensing, or computation depending on the mission phase, with automatic docking for solar recharge at the shoreline full.

### • Local Repair & Rapid Recovery Strategy

To maximize uptime and reduce dependency on imported components:

- Local Manufacturing** – Most structural and electronic components are sourced from domestic suppliers, enabling quick replacement within 72 hours.
- Modular Architecture** – Each subsystem (ADU, FTW, PWR) can be decoupled for independent repair without halting the entire operation.
- Fault Detection & Recovery** – The central AI continuously monitors sensor health via self-diagnostic indicators. Faults trigger contingency re-routing—ADUs instantly automatically cover failed units until maintenance is complete.

### • Integrated Operational Resilience

This robust integration of mechanical, electrical, and digital safeguards ensures the Garuda WaterGuard system can maintain high fidelity and continuity in complex, mixed-pollutant aquatic environments. The combination of floating resilience, modular redundancy, and adaptive edge intelligence creates a fully field-ready, self-sustaining smart ecosystem suitable for long-term deployment in both static and dynamic systems.

## Cost Calculation

### • Cost Breakdown

Category	Component	Qty	Unit Cost (IDR)	Total (IDR)	Notes
A. Autonomous Surface Vehicle (ASV)	Body & Propulsion	1 unit	12,000,000	12,000,000	Local fabrication using HDPE and PVC
	Sensor Suite	1 set	4,000,000	4,000,000	Recalibrated monthly
	Microcontroller & Telemetry	1 set	2,000,000	2,000,000	Connected to cloud platform
Subtotal ASV				28,000,000 (USD 1,396)	
B. Floating Treatment Wetlands (FTWs)	Frame & Floats	2 modules	4,500,000	9,000,000	Local materials
	Plant Media	2 sets	750	1,500,000	Native species from local nursery
Subtotal FTWs				10,500,000 (USD 432)	
C. Mini Photocatalytic Nanofiltration Reactor (PWR)	Reactor Shell	1 unit	7,000,000	7,000,000	400-25 L capacity
	Catalyst & Membrane	1 set	3,500,000	3,500,000	Solar/UV driven
	Control & Solar Panel	1 set	2,000,000	2,000,000	IoT-integrated
Subtotal PWR				12,500,000 (USD 752)	
D. Labor, Logistics & Installation	Field Deployment & Setup	Lump sum	3,000,000	3,000,000	2-day wrap
E. Cloud & AI System Setup	Cloud server, dashboard & initial training		3,000,000	3,000,000	PPG + data dashboard
TOTAL PILOT PHASE				~51,500,000 IDR (USD 3,676)	

## 6. Economic Viability, Cost Calculation, and Resource Planning

## Economic Viability

### • Full Scale-Up Scenario

Item (per hotspot zone)	Qty	Unit price (USD)	Subtotal (USD)	Notes / assumptions
ASV (Semi-ready, modular)	3	2	6	Small catamaran ADUs (modest sensors & propulsion) – 3 per zone for coverage
FTW modules (1 m <sup>2</sup> kits)	50	60	3	Modular recycled-HDPE/PPET units; 50 m <sup>2</sup> total footprint per zone
PWR modules (pilot-scale)	4	1.6	6.4	20 L-ft ceramic + TiO <sub>2</sub> /ZnO modules (parallel for throughput)
Edge & comm. gateway	1	2	2	LoRaWAN gateway + local edge server + local dashboard
Fixed sensor buoys	4	250	1	Single pH/DO/turbidity/EC nodes

### • Unit Economics

Parameter	Smart Ecosystem	Legacy Treatment (Conventional)
Cost per m <sup>2</sup> treated	~IDR 1,500-2,000 (USD 0.095 - 0.13)	IDR 3,000-4,500 (USD 0.2 - 0.3)
Energy Source	Solar-driven	Grid electricity
Operation Mode	Autonomous, adaptive	Manual, scheduled
Maintenance Frequency	Monthly calibration	Weekly
Data Value	Real-time environmental data	None

### • Local Sourcing & Supply Chain

- FTW Components** – 100% locally sourced (HDPE, foam mats from local latex suppliers).
- ASV Hardware** – Electronics via US microcontroller L101 & local solar integrators.
- Plants** – Mangrove and TiO<sub>2</sub>/ZnO catalytic framework via collaboration with PT UG Chemical Engineering Lab.
- Notes**
  - Supply chain delay (7-10 weeks) for imported NP membranes.
  - UV degradation of polymer floats—mitigation: coating with UV-resistant paint.





# World Water Challenge 2025

## Annual Operational Cost

• Annual Operational/Replacement Costs – Sensor/Waterpans, routine maintenance, labor

Component / Technology	Description	Estimated Lifespan	Maintenance Frequency	Annual Cost (USD)	Notes
Autonomous Surface Vehicle (ASV)	Battery-powered robotic unit for data collection, mapping, and monitoring.	5 years (hull & frame)	Battery replaced every 2 years; calibration every 6 months.	5,000,000 (USD 30k)	Includes motor and sensor cleaning, firmware updates.
Battery Module (Li-ion)	Power source for ASV and sensors.	2 years	Replace every 2 years	1,200,000 (USD 9k)	Degradation after ~400 cycles.
Floating Treatment Wetlands (FTWs)	Modular floating platforms with aquatic plants and root matrix.	6-7 years	Monthly inspection, partial replanting annually.	3,000,000 (USD 14k)	Plant replacement (15-20% per year).
Photocatalytic Nanofiltration Reactor (PMFR)	Solar-driven reactor for advanced oxidation and nanofiltration.	3-4 years	Filter membranes replaced annually; photocatalyst refreshed every 2 years.	6,000,000 (USD 30k)	TiO <sub>2</sub> coating and membrane maintenance cost included.
Water Quality Sensors (DO, pH, Turbidity, Conductivity, etc.)	Smart multi-parameter sensor array integrated with ASV & PMFR.	3 years	Calibration every 3 months; sensor replacement every 2 years.	4,000,000 (USD 34k)	Includes calibration fluid and spare probes.
Microcontroller & Edge Computing Unit	Onboard HMI unit for autonomous operation and data logging.	3-4 years	Firmware updates every 6 months.	2,000,000 (USD 12k)	Maintenance includes data syncing and diagnostics.
Solar Panels & Power Electronics	Provides power to PMFR and FTWs auxiliary systems.	5-10 years	Cleaning every 3 months; inverter replaced every 5 years.	1,500,000 (USD 9k)	Requires tropical sunlight exposure.
Aeration System	Provides oxygenation for biological activity under FTWs.	3 years	Routine cleaning quarterly.	2,500,000 (USD 15k)	Replacement of tubing and diffusers as needed.
Network & Data Transmission (LoT Gateway)	Data transfer via cellular or LoRaWAN to the dashboard.	3 years	Replace SIM and service annually.	1,000,000 (USD 4k)	Includes cloud storage fee.
Labor & Field Technicians	On-site monitoring, maintenance, sample testing, and reporting.	—	Monthly (2-person team)	12,000,000 (USD 72k)	Covers training, site visits, safety gear.
Miscellaneous (Spare parts, Logistics, Calibration Tools)	Safety margin for operational continuity.	—	—	2,000,000 (USD 12k)	Contingency 10-15% of total cost.

## Feasibility Note & Resource Planning

• Total Estimated Annual Operational Cost

- Per year subtotal: USD 22.4k
- CapEx (3 years): USD 67,200 (~CR 1.3k per year)
- Included: Hardware (ASVs, FTWs, PMFRs), local gateways, field tools, installation, training, 10% contingency.
- Not included: long-term central cloud subscription beyond 12 months, large civil works (ditch), advanced lab testing consumables beyond initial validation.

• Operational Highlights

- Sensor Lifespan: Average 2 years; replacement aligned with ASV calibration cycles.
- FTW Components: ~10-20% of vegetation requiring yearly renewal; nutrient uptake performance stable.
- PMFR Reactors: Catalytic re-coating biennially sustains >90% pollutant degradation efficiency.
- Maintenance Strategy: Proactive-based system—predictive diagnostics via AI data trends minimize downtime.
- Local Repair Network: AI-based technician team handles first-line maintenance, minimizing external cost.

• Feasibility Note & Pilot Scale Adjustment

- The Rp 51 million (USD 30k) budget covers only a functional prototype, not a full-scale deployment.
- Pilot: Validation of data integration, small-scale pollutant reduction, and community acceptance.
- Full-scale implementation would need 3-5x higher capital for scalable components, larger FTWs, and multi-ASV setup.
- Pilot data will be used to support scaling and funding proposal (e.g., Greenprints, PT UH ESG, or research grants).

• Value To Society

Impact Dimension	Quantified Benefit	Illustration
Health Impact	30-50% reduction in bacterial load and nutrient concentration	Lower waterborne disease risks for surrounding communities
Regulatory Compliance	Supports SDG 6 (Clean Water & Sanitation), 13 (Climate Action)	Pilot serves as green-tech demonstration
Economic Multiplier	Job creation + research + manufacturing ecosystem	Estimated multiplier <2.5 (local fabrication)

• Business Model Scenarios

Model Type	Description	Value Proposition	Revenue Stream
Product Sale Model	Selling modular FTWs, ASVs, PMFRs	Affordable decentralized treatment	Unit margin 15-20%
Service-as-a-Solution	Offering "Smart Water Remediation" subscription	Monthly service + data-driven maintenance	Recurring revenue
Data Analytics Platform	Selling environmental intelligence to	Predictive water quality analytics	Data monetization model

## Cost Projection

• 5 Year Operational Cost Projection (in USD)

Category	Initial (Year 0)	Year 1	Year 2	Year 3	Year 4	Year 5	Replacement Cycle	Depreciation (%)
ASV (incl. 1 unit)	5,141	126	126	144	126	144	Every 5 yrs (Battery, 5 yrs (unit))	10%
FTW System (Single Module)	774	65	65	126	65	126	Every 3 yrs (line-mat), 10 yrs (frame)	10%
Mini PMFR Module	640	65	65	65	65	65	Every 3 yrs (membrane & catalyst)	20%
Sensors & Electronics	256	65	65	126	65	65	Every 2-3 yrs	20%
Labor & Field Ops	—	367	367	367	367	367	Annual recurring	—
Data Platform SaaS Maintenance	126	65	65	65	65	65	Annual subscription & cloud fee	—
Consumables (Substrates, Cleaning)	—	65	65	65	65	65	Annual recurring	—
<b>Total (Annual)</b>	<b>5,81</b>	<b>641</b>	<b>641</b>	<b>1,004</b>	<b>641</b>	<b>671</b>	—	—
<b>Cumulative Total</b>	<b>3,03</b>	<b>3,676</b>	<b>4,317</b>	<b>5,348</b>	<b>5,987</b>	<b>7,658</b>	—	—

## Timeline Implementation

• 12-Week Phased Deployment & Testing Schedule

Phase	Week	Key Activities	Deliverables	Risk Points & Mitigation
Phase 1 – Concept Refinement & Design (2 weeks)	Week 1-2	Finalize 3D CAD design for ASV hull & PMFR housing Define sensor suite & LoT architecture Select local materials for FTW structure & plants Validate water system sizing	Final design documents Procurement list	Risk: Delay in material confirmation Mitigation: pre-identify local suppliers (chemicals & deposits) and reserve lab inventory for prototyping.
Phase 2 – Procurement & Fabrication (3 weeks)	Week 3-5	Fabricate ASV body & PMFR unit Assemble FTW modules (2 units) Purchase sensors, microcontrollers, batteries Begin hull power management & microcontroller logic	Functional ASV chassis, PMFR housing assembly, verified power system	Risk: Delivery delays or fabrication compromises Mitigation: maintain buffer stock; verify sensors & alternative local electronics vendors (e.g., Chindia, Tokopedia).
Phase 3 – Integration & Software Development (2 weeks)	Week 6-7	Integrate LoT sensors to ASV; Develop AI-based control (navigation & cleaning path) Calibrate PMFR flow & UV intensity Conduct closed-loop test in pilot scale	Fully assembled and connected system; Initial data stream validation	Risk: Software delay Mitigation: modular coding; fallback to semi-autonomous manual override mode for ASV.
Phase 4 – Field Deployment & Testing (3 weeks)	Week 8-10	Install prototype at Pilot Field Operate system under controlled observation Collect baseline and operational WQ data Adjust flow rate, FTW buoyancy, and water charge	Performance log (DO, COD, TSS, pH); Visual and quantitative performance data	Risk: Weather or turbidity issues Mitigation: flexible daily operation window & backup field days.
Phase 5 – Evaluation, Documentation, and Handover (2 weeks)	Week 11-12	Analyze data before vs. after deployment Prepare technical report & impact summary Conduct hands-on community training (operation + maintenance) Establish online data dashboard & remote support	Pilot evaluation report; Simplified SOP & user manual; Trained volunteer operators	Risk: Limited user adoption Mitigation: visuals, infographic-based training materials & 2-week shadowing by local team.





## 7.

### Risks, Challenges, and Mitigation

#### Risks, Challenges & Mitigation

##### Long-Term Maintenance

Category	Key Risk	Impact/Loss	Mitigation Strategy	Responsible Entity
Local Technical Expertise	Limited local expertise for high-tech system maintenance	High	Establish local training programs with certification for maintenance personnel	Project Management Unit (PMU), IT Engineering Faculty
Spares/Parts Availability	Delays in importing or procuring key components (e.g., sensors, membranes, ball valves)	Medium	Build local partnerships with component manufacturers; maintain a minimum stock of critical parts	Procurement & Supply Chain Division
Sensor Calibration & Degradation	Sensor drift or degradation over time reduces data accuracy	High	Implement quarterly calibration protocols; design modular sensor replacement design	Field Operations Team
Software & System Wear	Original software and hardware accumulation on PTO and PHT modules	Medium	Regular cleaning and anti-dusting; update applications; incorporate routine inspection logs	Field Technicians
Data System Security	Server or data storage failure causing monitoring interruptions	Medium	Cloud-based redundancy; automatic data synchronization	Data Management Division
Sustainability of Operations	Declining operational budget over years	Medium	Develop hybrid funding (public-private model) and offer data-as-a-service subscription	Finance & Policy Team

##### Open Source Value & Competition Risk

Category	Key Risk	Impact/Loss	Suboptimal Strategy	Sustainability & Value Enhancement
Open Source Exposure	Excessive sharing of designs, IP, algorithms, or software frameworks leading to imitation	High	Use modular code; reserve core proprietary algorithms; certain closed-source	Encourage academic collaboration while retaining proprietary edge
Competition Risk	Entry of competing systems with cheaper but less reliable hardware	High	Emphasize integrated performance, local adaptability, and data accuracy as differentiators	Develop exclusive partnership programs with local governments
Intellectual Property (IP) Protection	Lack of clear patent or IP filing for unique components	Medium	Register proprietary modules (API controls, logs, field-deployed under patents or rights)	Build technology branding and identify under "patents-in-progress"
Market Scalability	Short-term competition with unsustainable cost models	Medium	Focus on lifecycle cost efficiency and long-term environmental value	Strengthen social impact and ESG-based funding eligibility
Knowledge Diffusion	Open training leads to transfer of operational know-how	Medium	Licensed-based access for advanced operation manuals and training tools	Develop revenue from certification and training programs

#### Risks, Challenges & Mitigation

##### Technical Risks

Category	Specific Risk / Challenge	Impact	Mitigation Strategy
Technical Risks	Hardware Import Volatility – Delays or cost spikes in sensors, control boards, or membrane membranes sourced internationally	Medium-High	<ul style="list-style-type: none"><li>• Prioritize local component fabrication (e.g., PCBs, frames, mem. coatings)</li><li>• Establish dual-sourcing agreements and maintain a local inventory buffer.</li><li>• Utilize modular electronics for easy substitution.</li></ul>
	Reliance on Local Supply Chain Maturity – Limited domestic vendors for precision sensors or AI hardware	Medium	<ul style="list-style-type: none"><li>• Partner with universities and local startups for co-development</li><li>• Implement component certification program to assure quality</li><li>• Gradually localize manufacturing through government-supported programs (TNDA)</li></ul>
	Regulatory Delays – Extended approval time for permits or environmental assessments	Medium	<ul style="list-style-type: none"><li>• Conduct early stakeholder engagement with BBWS, Otarum, ECHO, and local administration</li><li>• Prepare template documentation for GNL-GPL and safety submissions</li><li>• Include a buffer timeline in project Gantt chart (min. + 2 months)</li></ul>
	Force Majeure & Physical Damage – Floods, debris impact, or vandalism	High	<ul style="list-style-type: none"><li>• Design anchoring redundancy (blast mooring, shock-absorbing cables)</li><li>• Install protective booms and debris screens near PTOs</li><li>• Implement CCTV or IoT-based surveillance integrated with AIS telemetry</li><li>• Community engagement for shared guardianship</li></ul>

## 8.

### Conclusion & Next Steps









# Monitoring of Water Consumption and Water Productivity in irrigated Lands of the Fergana

Jakhongir Iskhakov  
(Uzcosmos)



**Korea International Water Week 2025**

Session Title  
**Monitoring of Water Consumption and Water Productivity in irrigated Lands of the Fergana**

Speaker / Affiliation  
**Jakhongir Iskhakov - Uzcosmos**

Date  
**November 12<sup>th</sup> (Wed) 15:00-18:00**

Logos at the bottom include: UN Water, Ministry of Environment, Science and Climate, Republic of Korea, Ministry of Agriculture, Food and Rural Affairs, Republic of Korea, and others.

**CONTENTS**

<b>01. Contents</b> The Challenge: Water Scarcity and Inefficient Use of Resources in Agriculture	<b>02. Contents</b> Tracking Every Drop: Satellite- Driven Water Governance in Uzbekistan	<b>03. Contents</b> Water distribution by crop types	<b>04. Contents</b> Main Goals
--	--	---	-----------------------------------





## 1. The Challenge



### The Challenge: Water Scarcity and Inefficient Use of Resources in Agriculture

#### Context

- Central Asia faces increasing water scarcity due to climate change, population growth, and intensive irrigation.
- Over 80% of Uzbekistan's freshwater resources originate from neighboring countries, making national water management highly vulnerable to regional dynamics.
- Agriculture consumes more than 80% of available water, yet a significant portion is lost through inefficient irrigation and distribution systems.
- Existing monitoring methods rely on manual data collection and outdated reporting, which lack accuracy and timeliness.

#### Core Problem

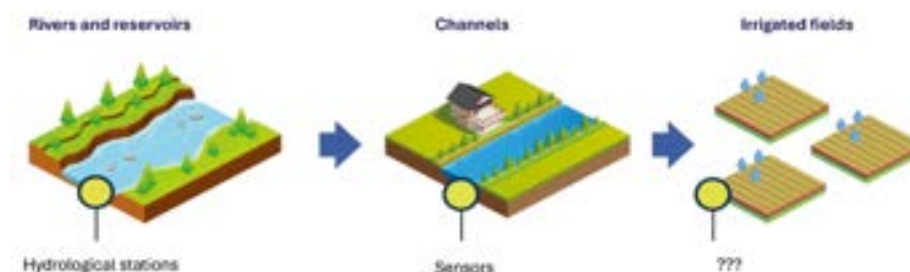
- No precise and up-to-date data on actual water consumption at the field level.
- Limited ability to detect water stress zones and inefficiencies in real time.
- Insufficient analytical tools for evidence-based decision-making at national and regional levels.

#### Why It Matters

- Unsustainable water use threatens food security, ecosystem health, and climate resilience.
- There is an urgent need for data-driven management systems to optimize water use and strengthen regional water security.

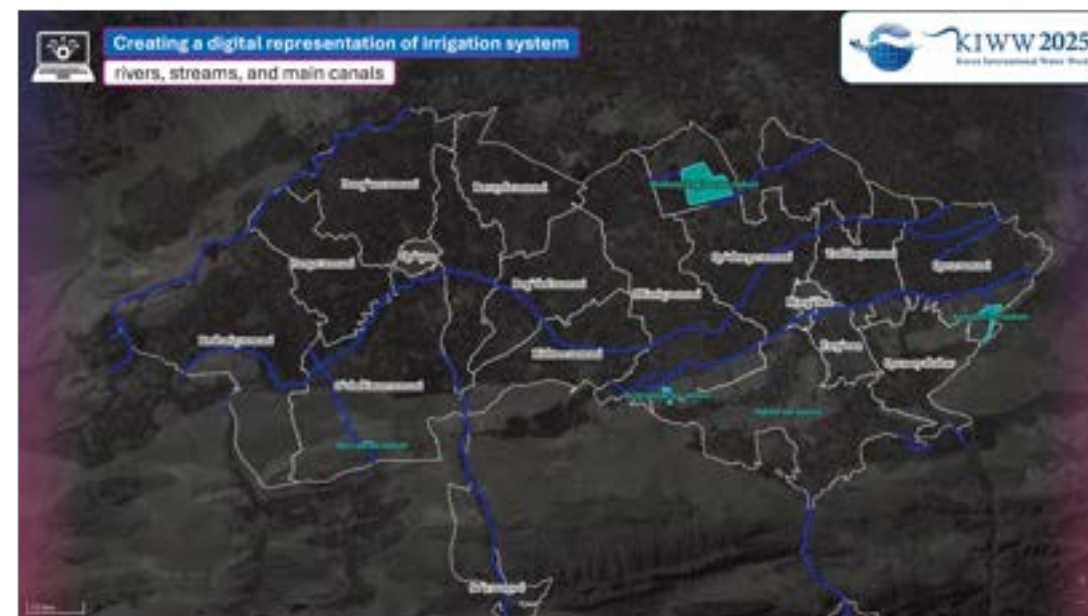
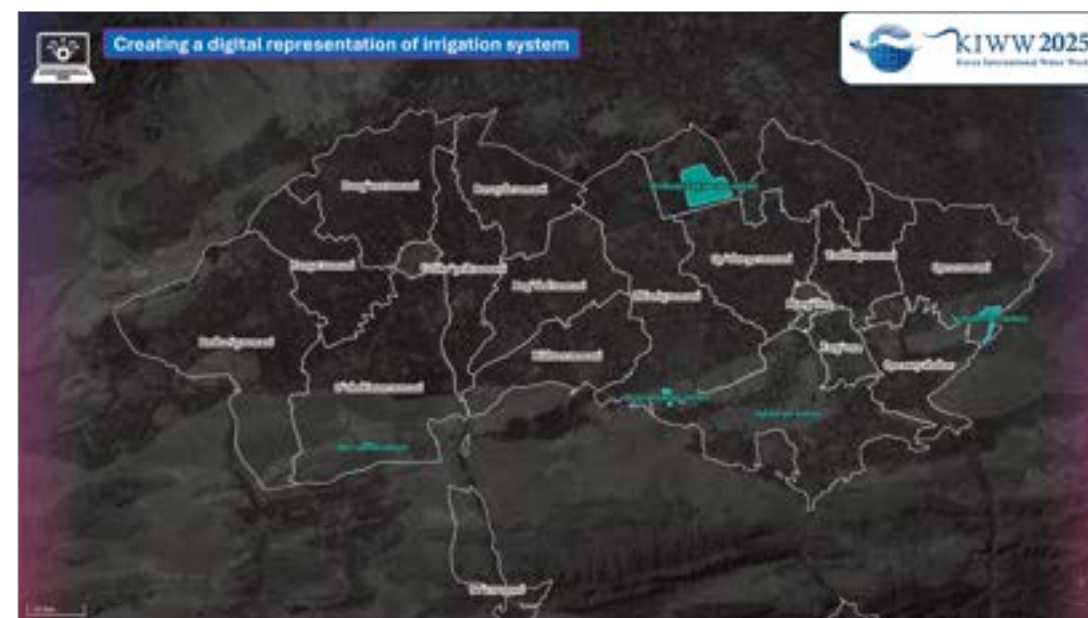
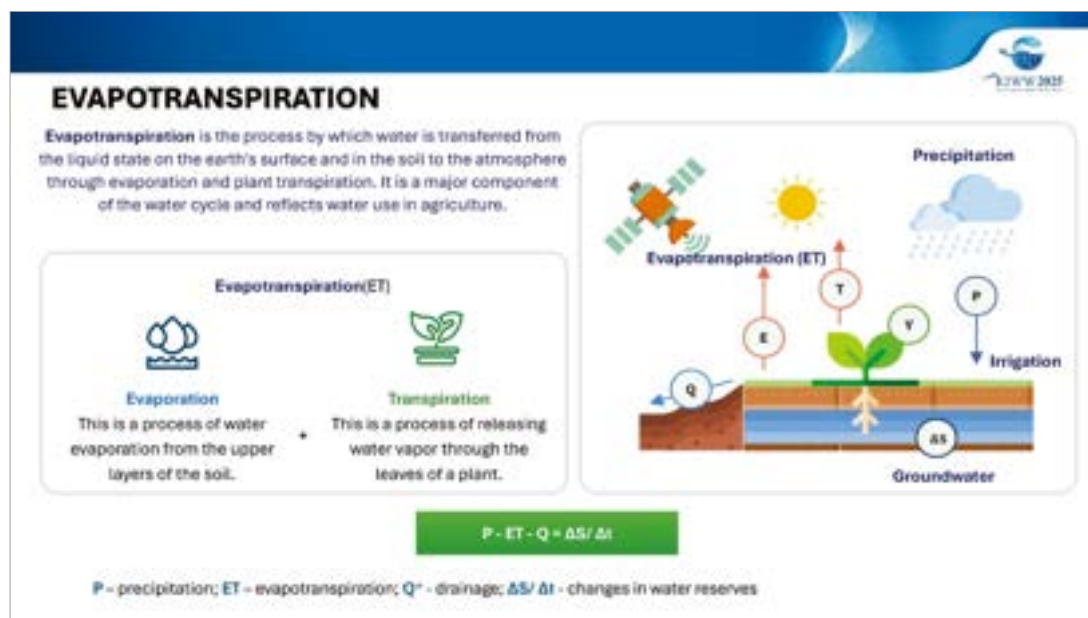


### "THE LAST MILE" IN WATER MEASUREMENT

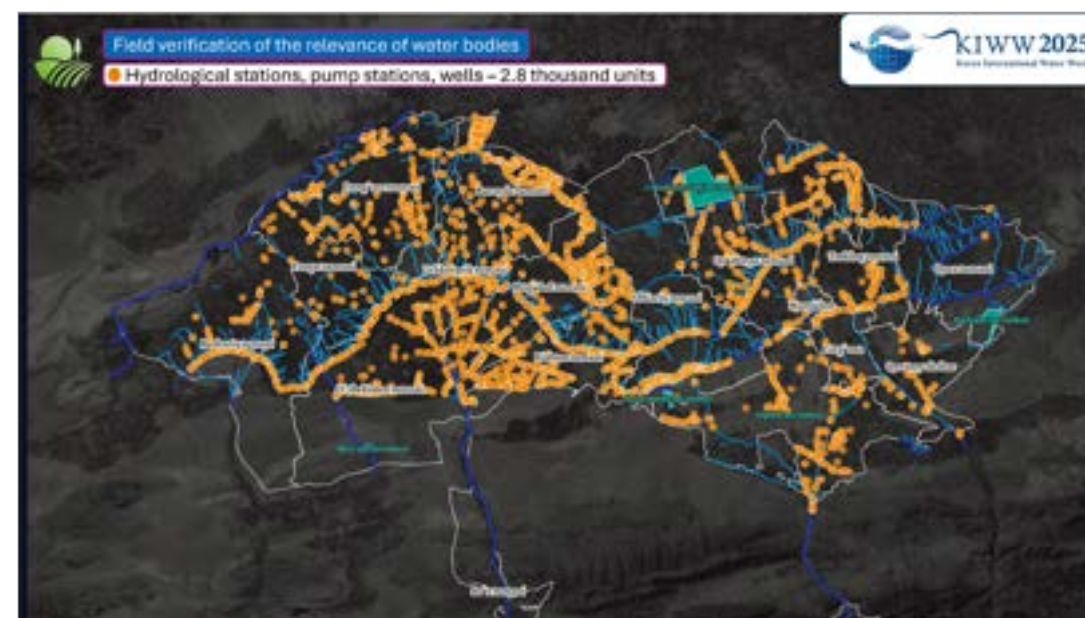
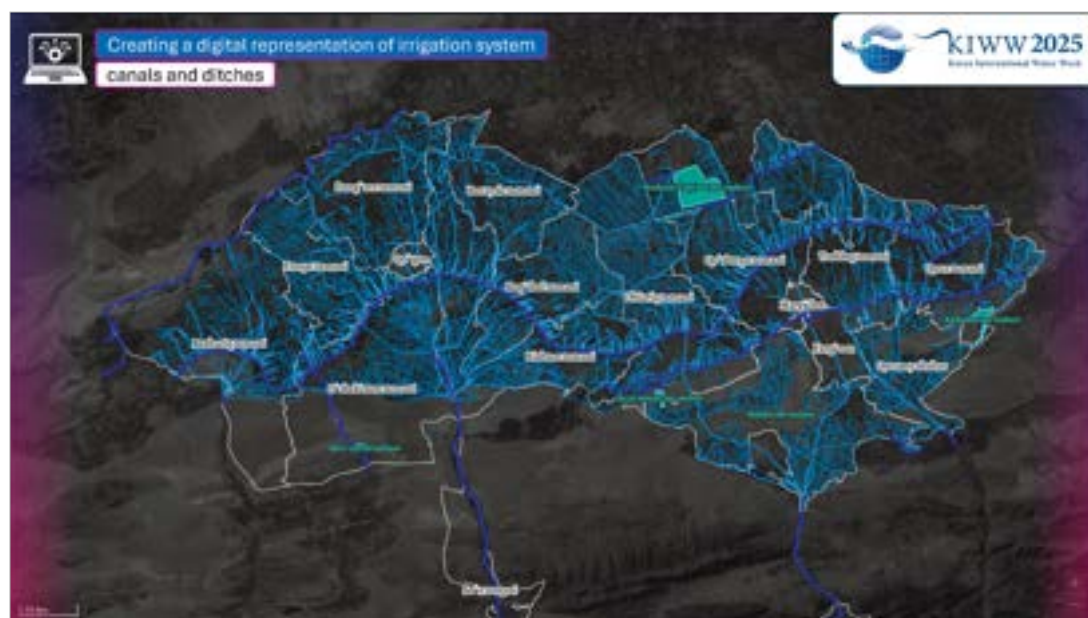
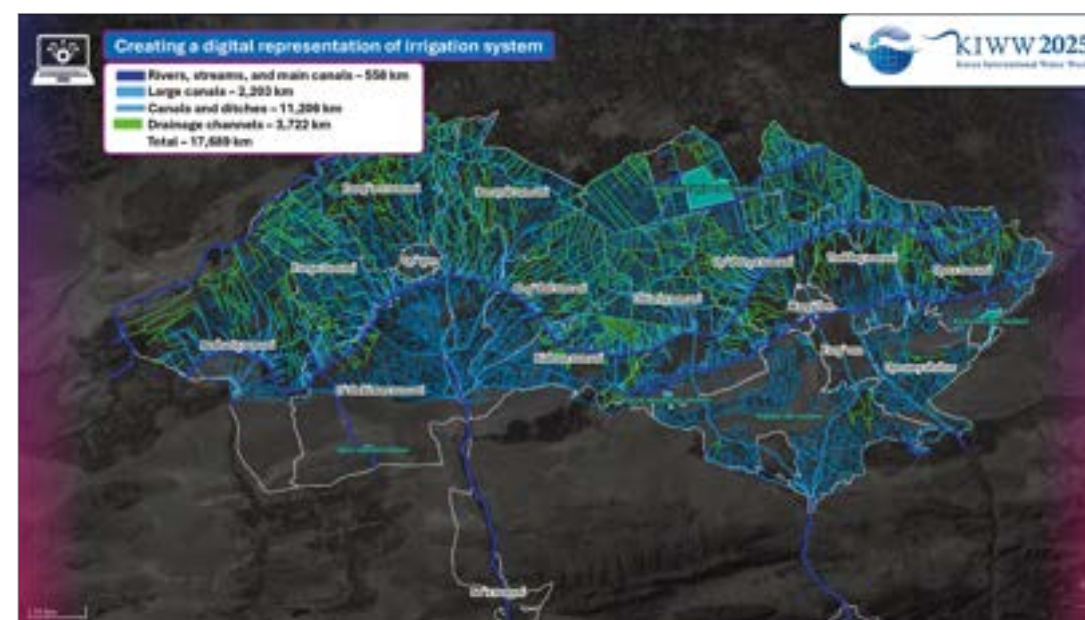


Satellite technologies help to track the dynamics and volumes of water consumption to the so-called "last mile" – to the level of an individual field

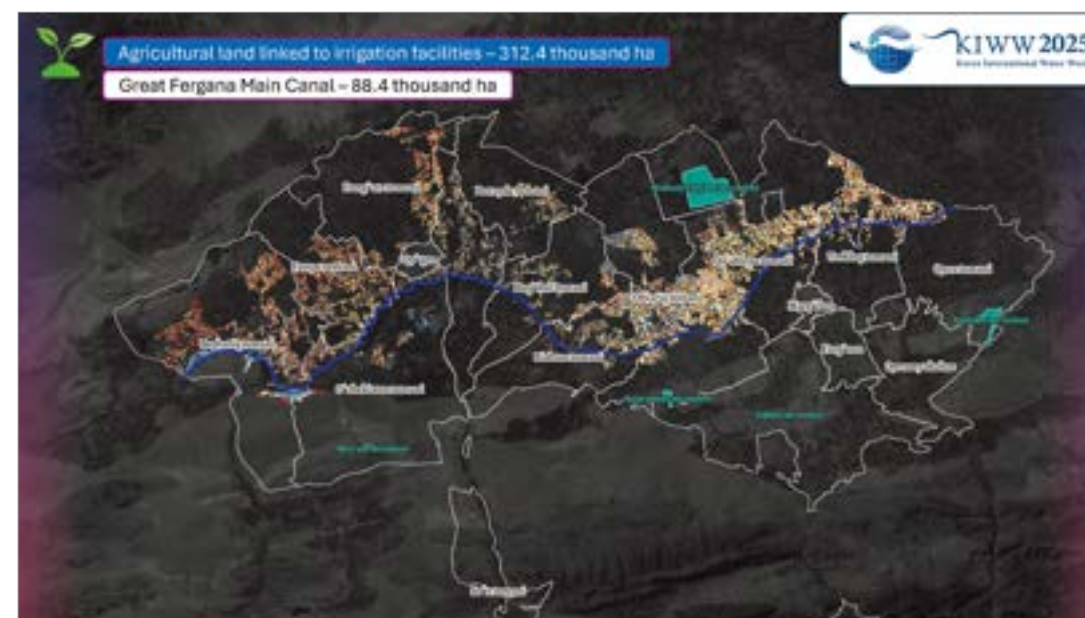
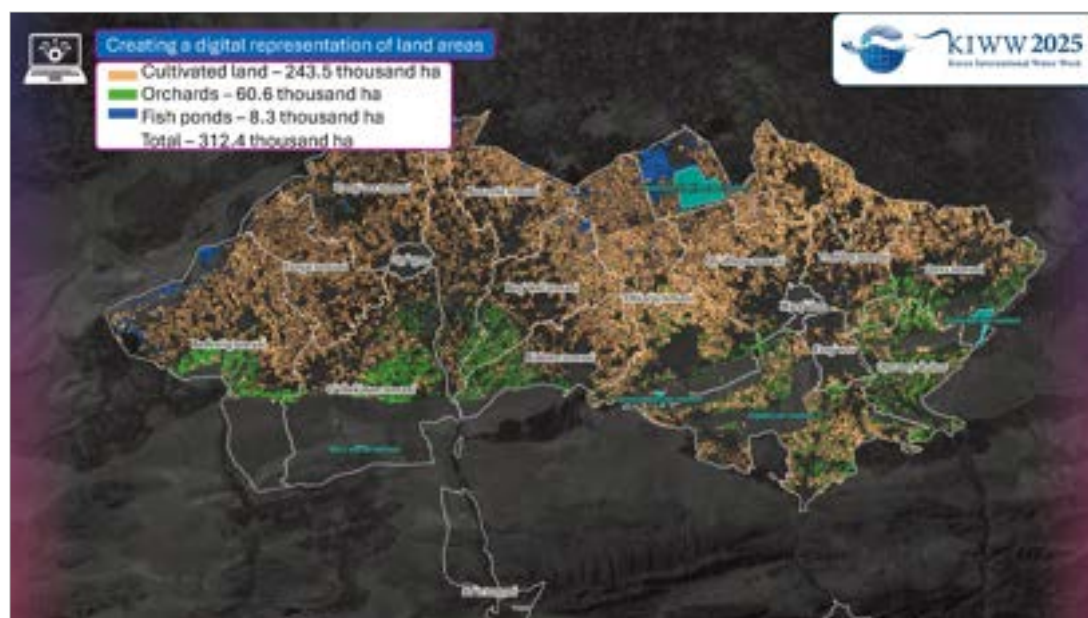
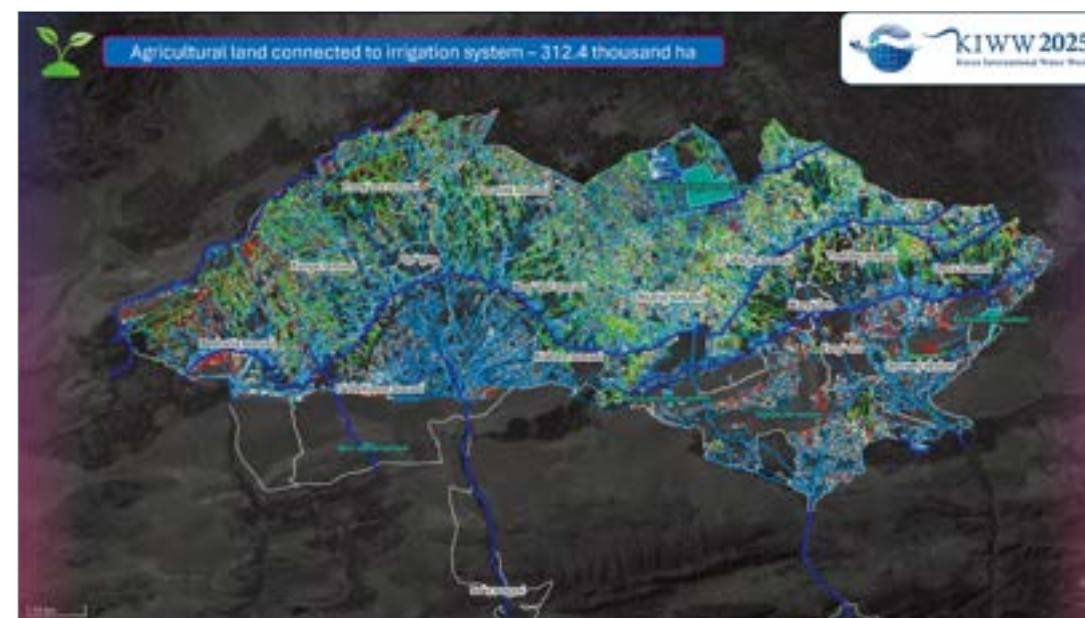




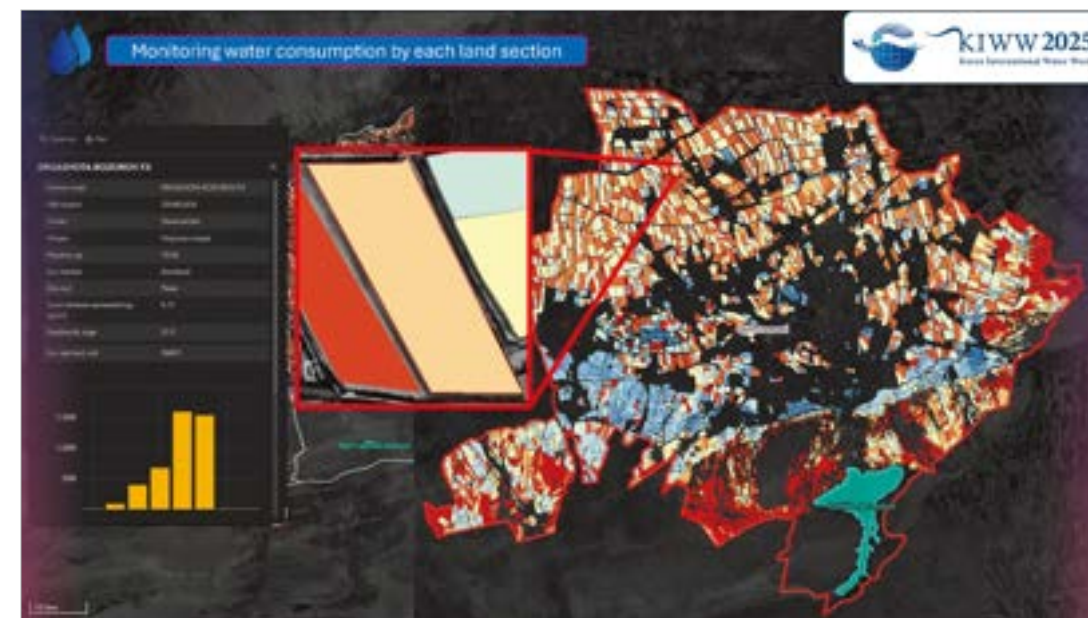
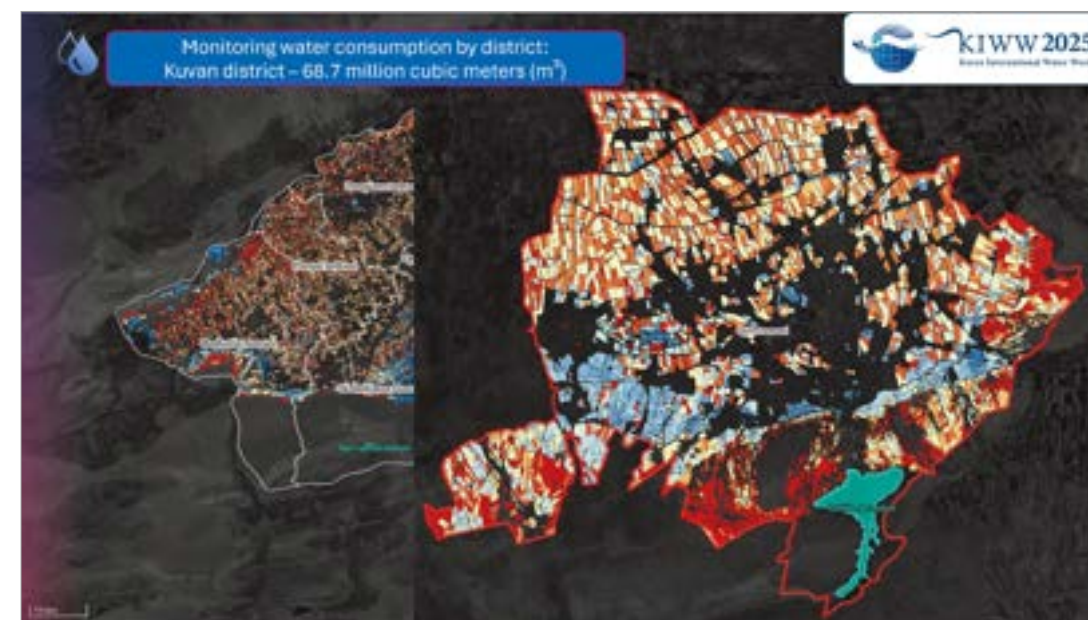
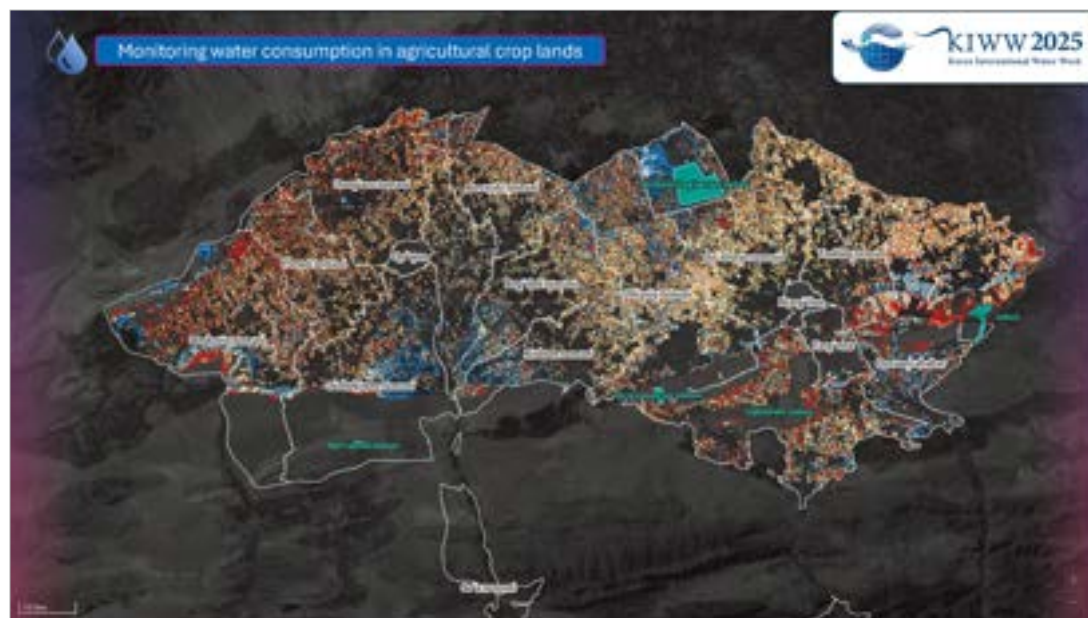
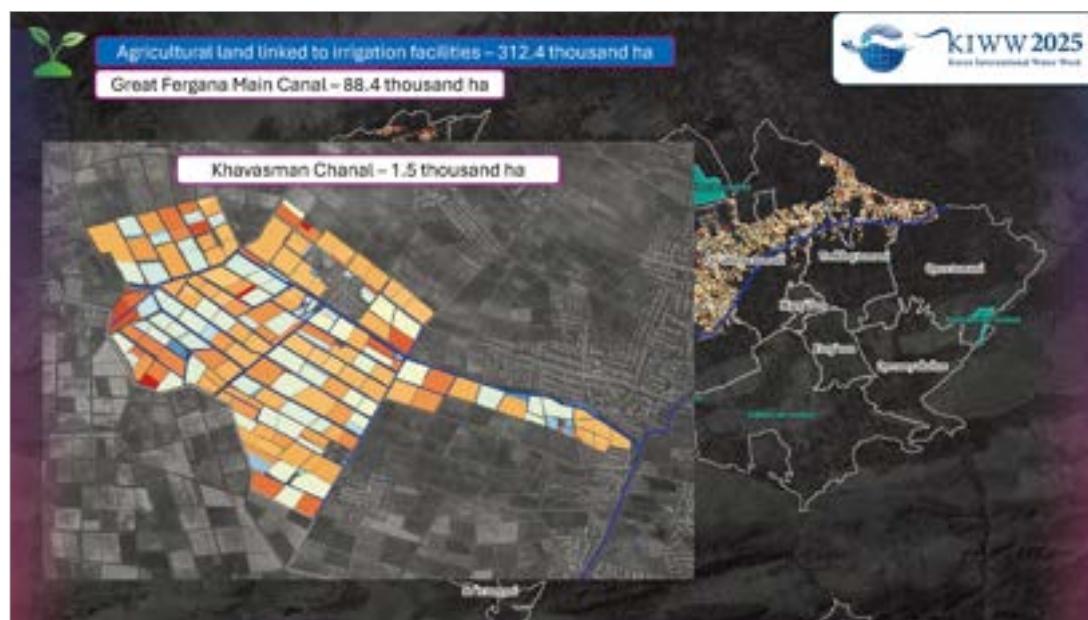




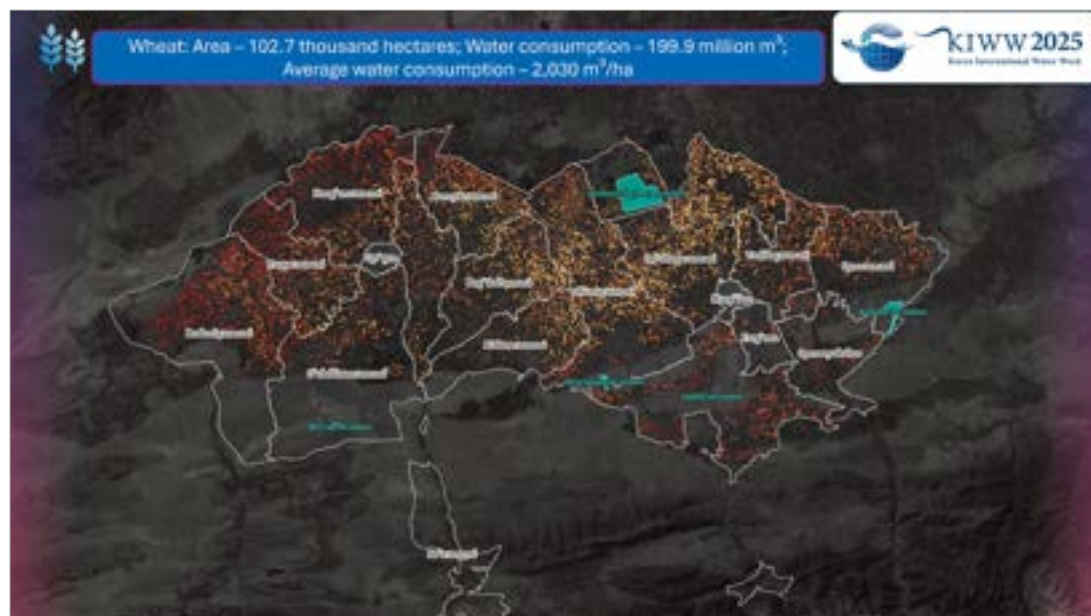
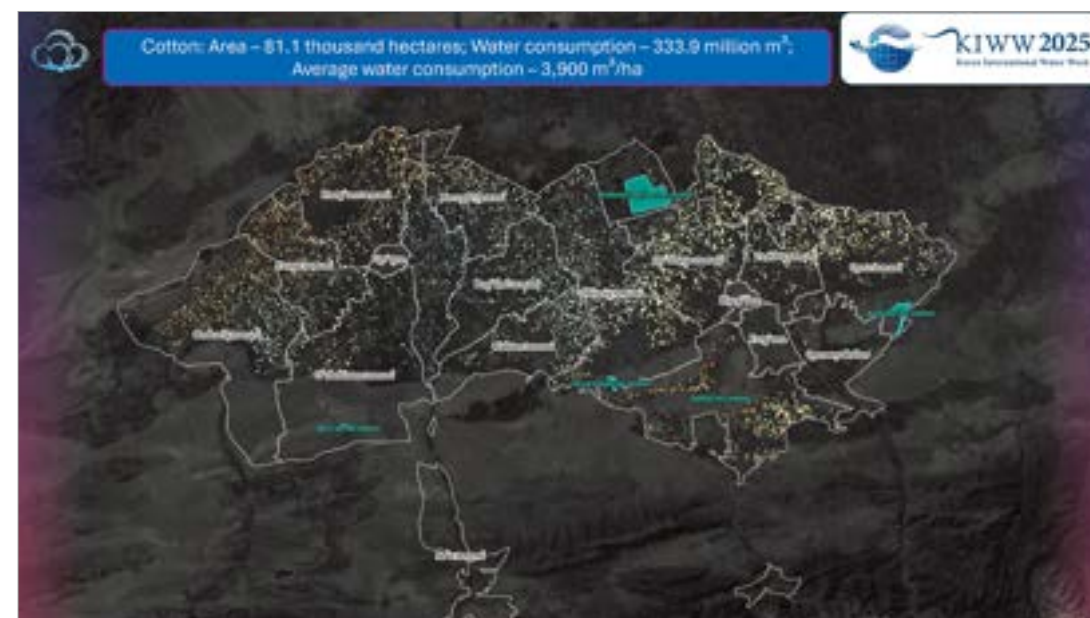
















**Korea International  
Water Week 2025**

Session Title

**Tracking Every Drop: Satellite-Driven  
Water Governance in Uzbekistan**

Speaker / Affiliation

**Jakhongir Iskhakov - Uzcocosmos**  
[j.iskhakov@spacemc.uz](mailto:j.iskhakov@spacemc.uz)

Sponsors:

- UNESCO World Water Institute
- Ministry of Natural Resources and Environmental Protection of the Republic of Korea
- Ministry of Agriculture, Food and Rural Affairs of the Republic of Korea
- Ministry of Environment of the Republic of Korea
- Ministry of Water Resources of the Republic of Korea
- Ministry of Land, Urban Planning and Construction of the Republic of Korea
- Ministry of Science and ICT of the Republic of Korea
- Ministry of Culture, Sports and Tourism of the Republic of Korea
- Ministry of Health of the Republic of Korea
- Ministry of Education of the Republic of Korea
- Ministry of Gender Equality and Family of the Republic of Korea
- Ministry of National Security of the Republic of Korea
- Ministry of Defense of the Republic of Korea
- Ministry of Veterans Affairs of the Republic of Korea
- Ministry of Disaster Management and Emergency Response of the Republic of Korea
- Ministry of Information and Communications of the Republic of Korea
- Ministry of Maritime Affairs and Fisheries of the Republic of Korea
- Ministry of Trade of the Republic of Korea
- Ministry of Economy and Finance of the Republic of Korea
- Ministry of Energy of the Republic of Korea
- Ministry of Industry and Trade of the Republic of Korea
- Ministry of Labor of the Republic of Korea
- Ministry of Social Security and Labor of the Republic of Korea
- Ministry of Justice of the Republic of Korea
- Ministry of Legislation of the Republic of Korea
- Ministry of Constitutional Affairs of the Republic of Korea
- Ministry of Government Administration of the Republic of Korea
- Ministry of General Services of the Republic of Korea
- Ministry of Public Safety and Security of the Republic of Korea
- Ministry of Police of the Republic of Korea
- Ministry of Fire and Disaster of the Republic of Korea
- Ministry of Environment of the Republic of Korea
- Ministry of Natural Resources and Environmental Protection of the Republic of Korea
- Ministry of Agriculture, Food and Rural Affairs of the Republic of Korea
- Ministry of Land, Urban Planning and Construction of the Republic of Korea
- Ministry of Science and ICT of the Republic of Korea
- Ministry of Culture, Sports and Tourism of the Republic of Korea
- Ministry of Health of the Republic of Korea
- Ministry of Education of the Republic of Korea
- Ministry of Gender Equality and Family of the Republic of Korea
- Ministry of National Security of the Republic of Korea
- Ministry of Defense of the Republic of Korea
- Ministry of Veterans Affairs of the Republic of Korea
- Ministry of Disaster Management and Emergency Response of the Republic of Korea
- Ministry of Information and Communications of the Republic of Korea
- Ministry of Maritime Affairs and Fisheries of the Republic of Korea
- Ministry of Trade of the Republic of Korea
- Ministry of Economy and Finance of the Republic of Korea
- Ministry of Energy of the Republic of Korea
- Ministry of Industry and Trade of the Republic of Korea
- Ministry of Labor of the Republic of Korea
- Ministry of Social Security and Labor of the Republic of Korea
- Ministry of Justice of the Republic of Korea
- Ministry of Legislation of the Republic of Korea
- Ministry of Constitutional Affairs of the Republic of Korea
- Ministry of Government Administration of the Republic of Korea
- Ministry of General Services of the Republic of Korea
- Ministry of Public Safety and Security of the Republic of Korea
- Ministry of Police of the Republic of Korea
- Ministry of Fire and Disaster of the Republic of Korea

# MEMO





# Aruna Revolution: Circular Fiber Innovation for Aquatic Health and Hygiene Equity

Rashmi Prakash  
(Founder)



## World Water Challenge 2025

**Korea International Water Week 2025**

Session Title  
**Aruna Revolution: Circular Fiber Innovation for Aquatic Health and Hygiene Equity**

Speaker / Affiliation  
**Rashmi Prakash | Founder**

Date November 12<sup>th</sup> (Wed) 15:00-18:00

Logos at the bottom include: UN Women, Ministry of Climate Change and Environment, Ministry of Environment, Korea International Water Week 2025, K-water, and Korea Environment & Development Cooperation.

**CONTENTS**

- 01. The Problem**  
Disposable hygiene products are polluting our water ways with microplastics and killing our wildlife
- 02. The Solution**  
Ocean degradable products that breaks down quickly and safely, and prevents harm
- 03. The Market**  
The \$220B USD market is growing, and governments and consumers are demanding for safe solutions for them and planet
- 04. The Team**  
We have a cross functional team that is dedicated to keeping our ocean clean and our bodies safe



## 1. The Problem



## The Problem - Harmful Fibers in Healthcare Products



**600 Billion+**

## Pollute our world yearly



## 500+ Years

### Sitting in Rivers & Oceans



## Carcinogens

### Like Lead, Arsenic, PFAS

## 2. THE SOLUTION



**Cleaner & Safer Healthcare, Powered by Aruna Fibers**



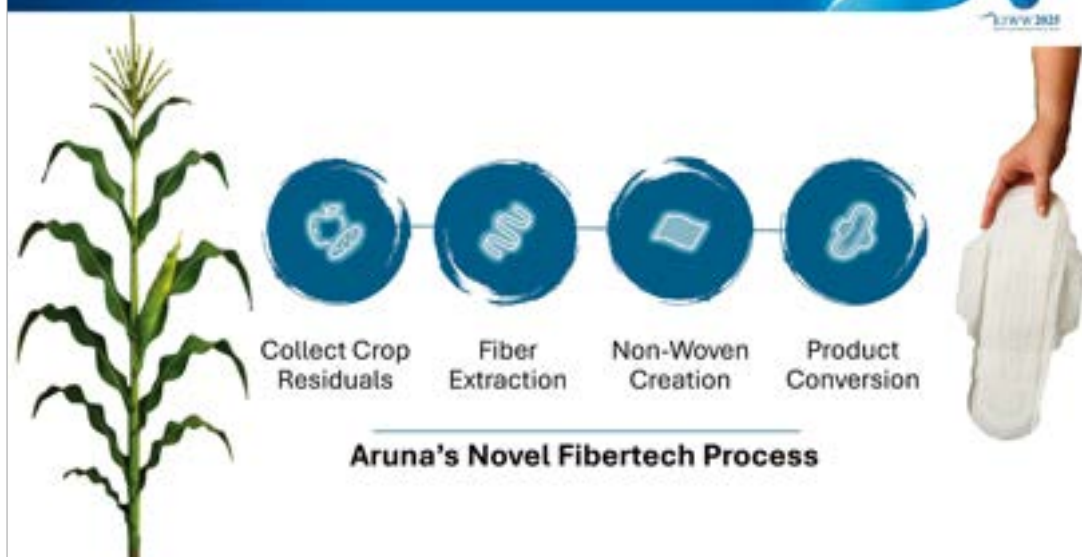
Aruna Revolution creates  
**Compostable & Ocean Safe,**  
**Toxin Free &**  
**High Performance Fibers**  
out of **Local Agri By-Products**







## Farm to Fiber Innovation



## The Revolution: Circular Fibers for Disposable Hygiene



## Feedstock Flexibility, Globally Scalable

Proprietary Process: Use any plant materials to make fibers

We can use all types of plant based feedstock -  
Corn, Soy, Canola, Hemp, Orange Peels, etc



## Aruna's Pipeline: Turning Off Water Pollution at the Source







## 3. THE MARKET

## Scalable, High Impact Growth

Aligned with Korea's ocean protection and circular economy initiatives



**Menstrual Pad Sales**  
Early revenue + brand & fiber awareness



**Fiber Licensing**  
High Margin, recurring B2B deals



**Carbon Credit Monetization**  
Verified emissions reductions

Why This Works:

- "Powered by Aruna Fibers" creates brand equity for channel partners.
- Licensing enables scale & recurring revenue without heavy CapEx.
- Proven model used by Nvidia, GoreTex & Intel Inside

## Unlocking a \$220 Billion Global Market

Total Addressable Market

Global Disposable Hygiene Product Market

**\$220 Billion** 2030, 4.6% CAGR



**Regulatory Tailwind**

Governments globally, including Korea and the EU, are advancing zero-plastic initiatives to protect waterways and oceans.

Major brands (P&G, Unilever, Kimberly-Clark) pledging to eliminate single-use plastics by 2030

## 4. THE TEAM





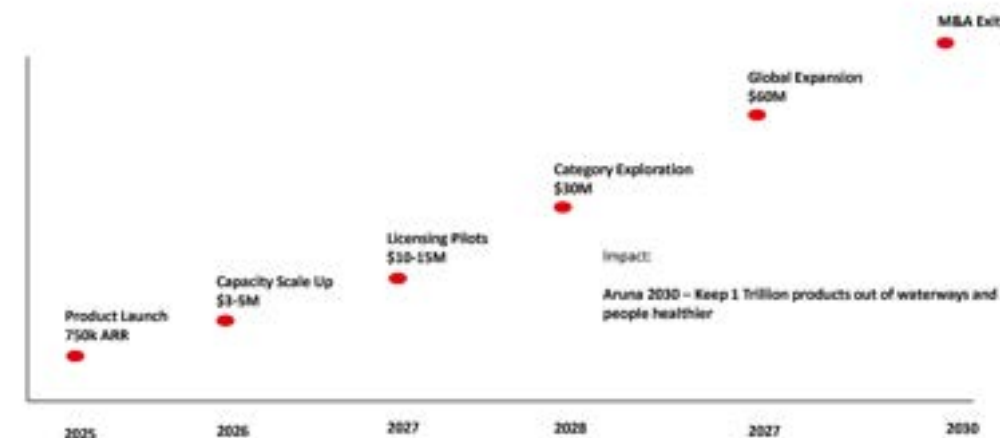
## Team Aruna – Engineered to Protect the Ocean & Planet



### Our Team's Key Milestones

- 1. Proven Market Demand**
  - \$750K ARR in 2025
  - In hospitals, airports, universities
  - Interest from 9+ Verticals
  - In discussion with KC for Huggies
- 2. Global Footprint & Organic Growth**
  - Sold in Canada, Singapore, UK, US, Monaco
  - 100% organic sales & growth
- 3. Validated & Protected Technology**
  - Third Party Verified & Certified
  - IP protected in multiple markets

## Economic Growth for Environmental Impact



## Team Aruna – Engineered to Protect the Ocean & Planet



**John P.**

30+ years

Hygiene Product  
Material Innovation  
Director

Johnson & Johnson

**Vlad N.**

30+ years

Hygiene Product  
Manufacturing  
Director

P&G

**Richard B.**

30+ years

Product & Business  
Development  
Executive

Nestlé

**ySpace**  
Markham

**CREATIVE**  
DESTRUCTION

Emera  
**ideaHUB**

**MaRS**

**L2M**  
Launch

**m51**

**LEAGUE of**  
INNOVATORS

## Aruna, Turning the Tide on Hygiene Waste



- 1) Environmental Impact – Keeps plastic and toxins out of oceans
- 2) Economic Impact – Builds local circular economies from waste
- 3) Social Impact – Promotes menstrual health and gender equity







## 51





## A scalable Machine-learned based Framework for cost-effective Sewer Leakage Detection

**Muratbekov Erkin**  
(USTA INTERNATIONAL)



**Korea International Water Week 2025**

Session Title  
A scalable Machine-learned based Framework for cost-effective Sewer Leakage Detection

Speaker 1 Affiliation  
Muratbekov Erkin

Date  
November 12<sup>th</sup> (Wed) 15:00~18:00

Logos: USTA International, Ministry of Environment, Republic of Korea, Korea Water Resources Research Institute, K-water, Korea Environment & Development Foundation

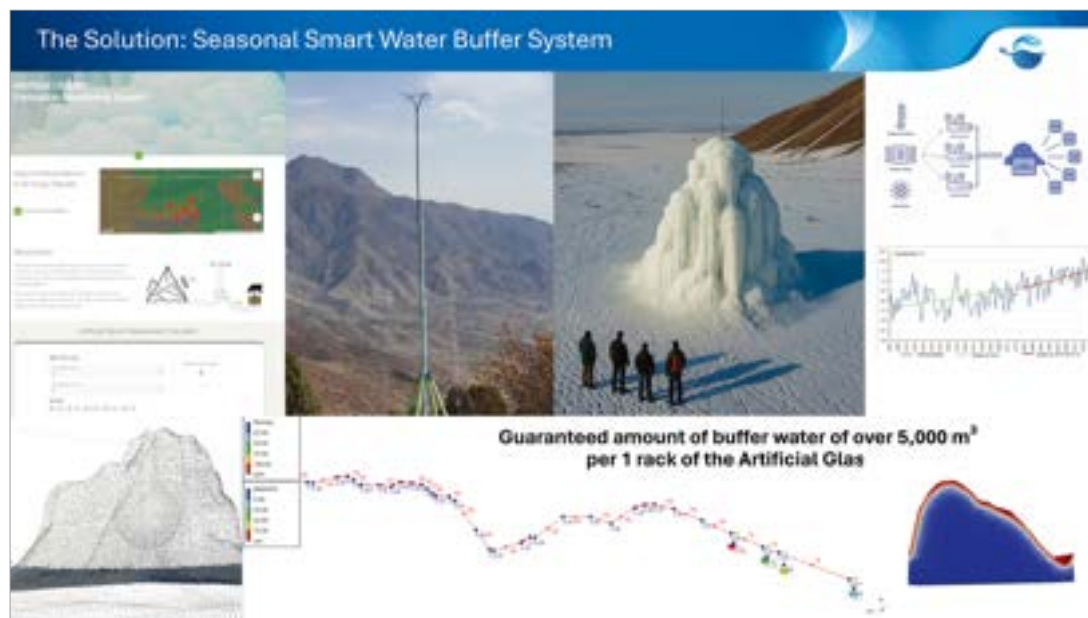
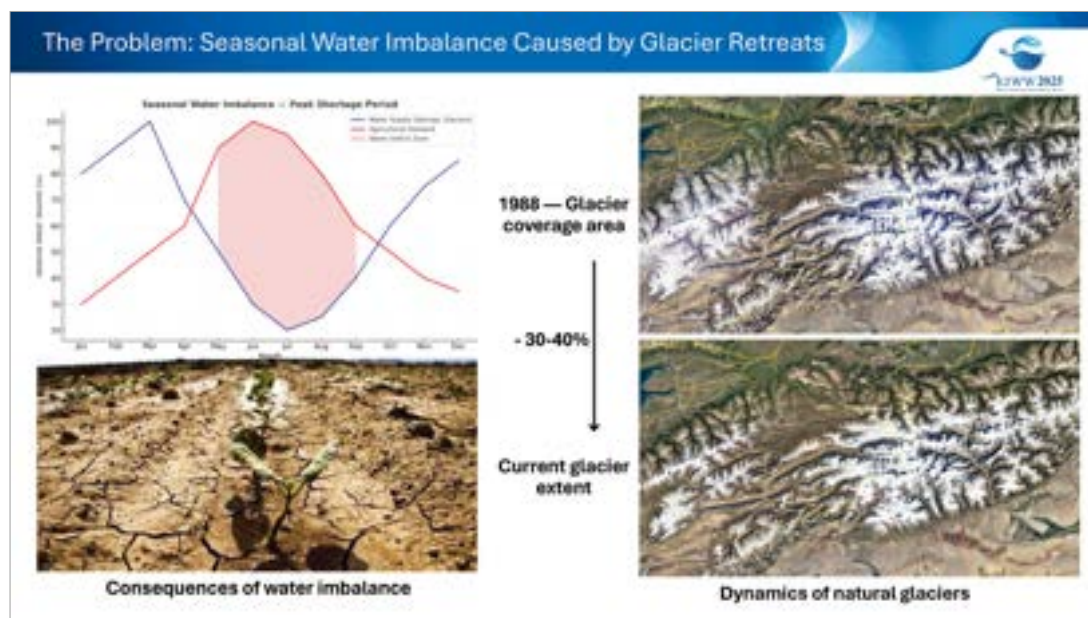
**Artificial Glaciers — Turning Climate Challenges into Water Security**

Engineering mountain resilience through AI-driven water systems and eco-tourism innovation

**Muratbekov Erkin**  
Founder & CEO, USTA International  
National Leader in Green Engineering, Kyrgyzstan

Logos: USTA INTERNATIONAL, Ministry of Environment, Republic of Korea, Korea Water Resources Research Institute, K-water, Korea Environment & Development Foundation





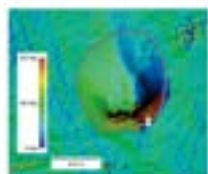




## Why Now ?



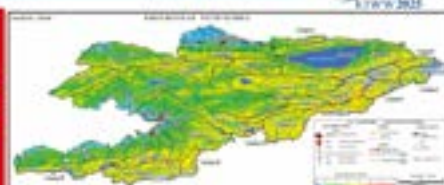
Central Asia is heating twice as fast as the global average



AI and IoT costs fell by >60 % in five years, making smart water systems affordable



Kyrgyz Republic's National Adaptation Plan 2024–2030 prioritizes mountain water storage and digital monitoring



Social demand & eco-tourism trend

## Competitive Advantages

1. Proven Technology in Real Mountains
2. Unique Integrated Ecosystem

3. Scalable and Low-Cost
4. Strategic Alignment with CAREC Goals



## Business Model: How Glacier.AI Creates Value

### Eco-Scientific Cluster Network

Eco-Tourism

Research & Education Programs

Artificial Glacier Demonstration

AI & Data Service Contracts  
(Glacier.AI SaaS + O&M)

Local Food & Crafts Sales



## From Glacier Engineering to Green Investment — the Journey Starts in Mady Kyrgyzstan



500 000\$



210 000\$



140 000\$/y.



28 %



3.5 years



24% (10 years)

**Location:** Mady Valley, Osh Region, Kyrgyz Republic

**Concept:** Eco-scientific tourism cluster with artificial glaciers as the central attraction

### Components:

- 10 artificial glaciers (Seasonal Smart Water Buffer Systems)
- Glamping park (20 eco-units)
- Science pavilion and climate lab
- Local food market & educational trails

**Construction starts in the second quarter of 2026**







## MEMO





# Small Habits, Big Thirst: Smart Behavioral Water Management in Pakistan & South Africa

Hafsa Masood  
(FFCG)



**Korea International Water Week 2025**

Small Habits, Big Thirst: Smart Behavioral Water Management in Pakistan & South Africa

Speaker | Affiliation  
**Hafsa Masood | FFCG**

Date November 12<sup>th</sup> (Wed) 15:00~18:00

Logos at the bottom include: UN Women, Ministry of Gender Equality and Family, Ministry of Environment, Science and Climate, Ministry of Water Resources, Ministry of Health, Ministry of Education, Ministry of Culture, Sports and Tourism, Ministry of Natural Resources and Environment, Ministry of Agriculture, Food and Rural Affairs, Ministry of Trade, Ministry of Industry and Trade, Ministry of Science and ICT, Ministry of Planning and Economic Cooperation, Ministry of Foreign Affairs, Ministry of Defense, Ministry of National Security, Ministry of Justice, Ministry of the Interior, Ministry of the Environment, Ministry of the Economy and Finance, Ministry of the Culture and Heritage, Ministry of the Education and Science, Ministry of the Health and Welfare, Ministry of the Labor and Employment, Ministry of the Social Security, Ministry of the Pension and Social Insurance, Ministry of the Tax and Finance, Ministry of the Customs and Excise, Ministry of the Korea Customs Service, Ministry of the Korea National Tax Service, Ministry of the Korea Revenue and Customs Service, Ministry of the Korea National Tax Service, Ministry of the Korea Revenue and Customs Service, Ministry of the Korea National Tax Service, Ministry of the Korea Revenue and Customs Service.

CONTENTS				
01. Introduction	02. Context & Scope	03. Causes & Effects	04. Methodology & Implementation Plan	05. Expected Outcomes & Impact





## 1. Introduction

### Introduction:

- Over-watering, open taps, and single-use bottles.
- Waste nearly 1.2 billion liters of drinkable water every year.
- Lahore, Pakistan loses about 20 million liters per day due to pipeline leaks.
- The "Day Zero" crisis reduced water use from 200L → 87L/day which shows the power of behavioral change.

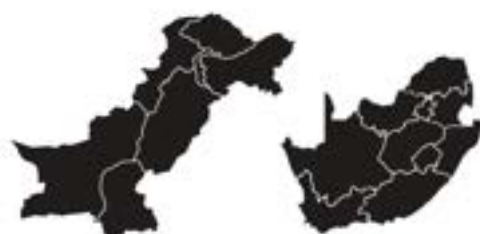


Figure 1. Vector Maps of Pakistan and South Africa

## 2. Context & Scope

### Context & Scope:

- **Geographic focus:**
  - Pakistan: Major urban centers (Lahore, Karachi) and peri-urban agricultural belts.



Figure 2. Vector Maps of Lahore and Karachi





## Context & Scope:

### • Geographic focus:

- South Africa: Cape Town metro area and adjoining farmlands.

### Provinces

- Northern Cape
- Western Cape
- North-West
- Free State
- Gauteng
- Limpopo
- Mpumalanga
- Eastern Cape
- KwaZulu-Natal

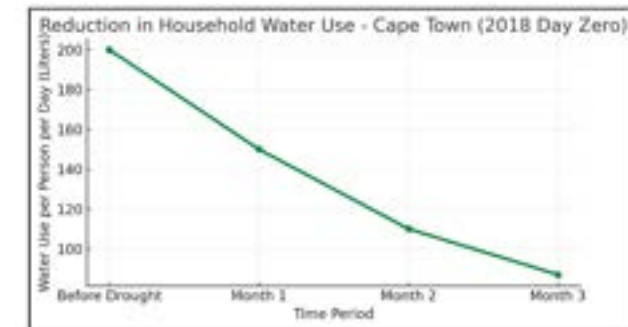


Figure 3. Vector Map of South Africa

## Context & Scope:

### • Local Data & Case Studies

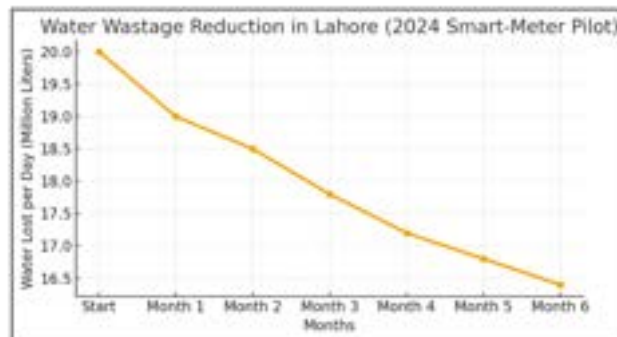
- **Cape Town, South Africa:** Day Zero drought (2018) reduced average household use from 200 L to 87 L/day; adoption of drip irrigation yielded a 40 % drop in garden water use within three months.



## Context & Scope:

### • Local Data & Case Studies

- **Lahore, Pakistan:** Municipal report (2024) records 20 ML/day lost through undetected household leaks; a pilot smart-meter program cut residential waste by 18 % in six months.



## 3. Causes & Effects





## Causes & Effects:



### Overwatering Gardens:

**Cause:**  
Cultural preference for lush lawns; absence of soil-moisture controls.

**Effect:**  
Strains municipal treatment and distribution, increasing per m<sup>3</sup> tariffs by 10–15 %.



### Overwatering Gardens:

**Cause:**  
People discard single-use plastic bottles instead of reusing or recycling them.

**Effect:**  
This increases water demand for making new bottles and worsens water scarcity.



### Overwatering Gardens:

**Cause:**  
Low public awareness during brushing, dishwashing, etc.

**Effect:**  
Municipal losses of 15 ML/day; higher energy use for pumping and treatment.

## 4.

## Methodology & Implementation Plan

## Methodology & Implementation Plan:



Phase	Activities	Timeline
<b>1. System Design &amp; Pilot</b> <ul style="list-style-type: none"><li>Pilot in 100 households (Cape Town)</li><li>Pilot in 100 households (Lahore)</li></ul>	<ul style="list-style-type: none"><li>Develop IoT sensor prototypes (leak, flow, soil-moisture)</li><li>Adapt sensors for the municipal network</li></ul>	Jul 2025 – Dec 2025
<b>2. Community Engagement &amp; Rollout</b> <ul style="list-style-type: none"><li>Deploy 500 sensors in Cape Town &amp; Karachi</li><li>Launch refill station network (10 sites)</li></ul>	<ul style="list-style-type: none"><li>Train local water utility staff &amp; farmers (Karachi region)</li><li>Workshop with City of Cape Town</li></ul>	Jan 2026 – Jun 2026
<b>3. Evaluation &amp; Optimization</b> <ul style="list-style-type: none"><li>Refine algorithms &amp; hardware</li><li>Optimize soil-moisture thresholds</li></ul>	<ul style="list-style-type: none"><li>Collect usage data &amp; user feedback</li><li>Analyze Cape Town pilot results</li></ul>	Jul 2026 – Dec 2026
<b>4. Scale-up &amp; Sustainability</b> <ul style="list-style-type: none"><li>Hand over to the local water boards</li><li>Establish maintenance &amp; funding model</li></ul>	<ul style="list-style-type: none"><li>Expand to 5 additional Pakistani cities</li><li>Expand to 5 additional South African metros</li></ul>	Jan 2027 – May 2027

## Methodology & Implementation Plan:



### Resources Required:

**Hardware:** 2,000 IoT sensors, gateway devices, mobile app maintenance

**Personnel:** 4 engineers, 6 community engagement officers, 2 data analysts

**Budget:** USD 250,000 (development, procurement, training, operations)

**Partners:** Local water utilities, municipal governments, NGOs

Risk	Likelihood	Mitigation
Technical failures	Medium	Redundant sensors; field-service protocol
Low user adoption	Medium	Incentives, user-training workshops, ongoing support
Funding shortfalls	Low	Phased budgeting, co-funding agreements with utilities
Data privacy concerns	Low	GDPR-style data policies, anonymized usage statistics





## 5. Expected Outcomes & Impact

### Expected Outcomes & Impact:

#### Long Term Vision:

- An open-source platform to help cities manage water more efficiently.
- Local water boards and authorities will lead operations and maintenance.
- Expansion planned for five additional cities in both Pakistan and South Africa.
- Communities stay actively engaged through accessible, real-time water data.



### Expected Outcomes & Impact:

- **Water Savings:** 1.2 million m<sup>3</sup> cumulatively saved by 2027 (~ 20 % reduction in non-revenue water).
- **Plastic Reduction:** 500,000 fewer plastic bottles purchased annually.
- **Economic Benefit:** USD 400,000 in utility cost savings; 15 % tariff stabilization.
- **Social Impact:** Increased community awareness; improved health outcomes from cleaner water.
- **Environmental Gain:** Reduced groundwater depletion; lower carbon footprint from decreased pumping.



Figure 4. Smart Behavioral Water Management System

### Small Habits, Big Thirst: Smart Behavioral Water Management in Pakistan & South Africa

#### Every Drop Counts Beyond Borders

Together, we can turn small habits into lasting change.

Let's make every drop count — for people, for cities, and for our shared planet.

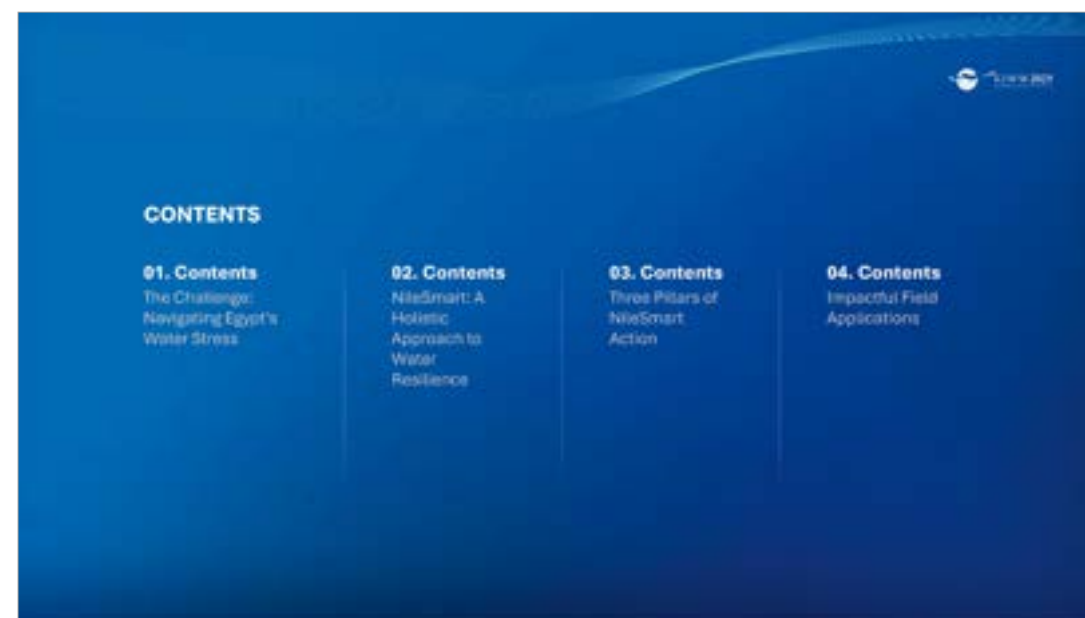


**Hafsa Masood**  
 Fauji Foundation College for Girls, Rawalpindi, Pakistan  
 Email: [hafsaabue@gmail.com](mailto:hafsaabue@gmail.com)  
 International Week of Water | Nov 2025





**Walid Rezk**  
(Suez University)







## 1. The Challenge

### NileSmart: A Holistic Approach to Water Resilience

NileSmart is a groundbreaking initiative designed to tackle water scarcity by fusing tradition, culture, and frugal innovation into a community-led model.

#### Traditional Knowledge

Leveraging centuries of water management experience from Nile cultures to inform modern practices.

#### Behavioral Change

Using cultural tools like storytelling and arts to instill a sense of water stewardship and sustainable habits.

#### Low-Tech Innovation

Deploying simple, locally-sourced, and affordable technologies for immediate, impactful results in water conservation. Our core objective is to reduce waste, improve local water governance, and build climate resilience at the grassroots level.

#### Three Pillars of NileSmart Action

- 1. **Smart Basin Literacy Campaigns**
  - Engaging communities through powerful cultural mediums—storytelling, poetry, and folk theatre—to shift mindsets toward responsible water use.
- 2. **Low-Cost Harvesting & Reuse Units**
  - Implementing simple, maintainable systems for harvesting rainwater and treating greywater for non-potable uses in households and communal areas.
- 3. **Women & Youth Water Committees**
  - Establishing local governance groups empowered by mobile technology for real-time reporting of leaks, misuse, and maintenance needs.

### The Challenge: Navigating Egypt's Water Stress

#### Nile Dependency

- Egypt relies almost entirely on the Nile River for its freshwater needs, making it highly vulnerable to external factors and resource management issues.

#### Compounding Stresses

- The nation faces severe water stress due to escalating climate change effects, upstream geopolitical challenges, inefficient traditional irrigation methods, and rapid population growth.

#### Growing Deficit

- Despite resourcefulness, Egypt's annual water deficit currently exceeds 30 billion cubic meters, necessitating urgent, scalable solutions.



### Impactful Field Applications

#### Applications

- Our pilot program demonstrated strong community ownership and sustainable practices in the Menoufia and Suez governorates.
- Community Integration**
  - Collaborations established with local schools, mosques, and agricultural unions for maximum reach and participation.
- Resourceful Tools**
  - Focus on utilizing local, readily available materials for unit construction, complemented by user-friendly mobile technology.
- Long-Term Ownership**
  - The community-led model ensures high local ownership, making the project inherently sustainable and resilient against external funding fluctuations.

#### Contributing to Global Sustainability

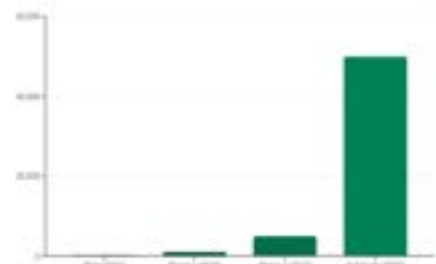
- Environmental**
  - Increases water reuse rates
  - Reduces pressure on Nile ecosystems
  - Promotes climate-smart agriculture
- Social**
  - Empowers marginalized women and youth.
  - Fosters social bridges water literacy gaps across generations.
  - Cohesion and local governance.
- Economic**
  - Creates local jobs in unit construction and maintenance.
  - Reduces household expenses on water and energy.
  - Prevents significant crop loss due to water stress.





## Cost-Effectiveness and Scalability

- **Frugal Design, Massive Reach**
- **Unit Cost:** Less than \$50 per household unit.
- **Materials:** Simple, locally sourced items like plastic barrels, gravel, sand, and mesh
- **Financing:** Achieved through community co-financing, supported by small microgrants and local government partnerships. The low-cost, decentralized nature allows for rapid adoption across the Nile Basin and similar African regions facing water stress.
- **Scalability:** The low-cost, decentralized nature allows for rapid adoption across the Nile Basin and similar African regions facing water stress.



## Our Vision for the Future

- NileSmart is ready to move beyond the pilot phase and become a foundational element of regional water management.
- **Regional Expansion:** Extend the model to other water-stressed regions across the broader Nile Basin.
- **Strategic Partnerships:** Collaborate with international NGOs, local civil society organizations, and universities for technical support and outreach.
- **Curriculum Integration:** Work with the Ministry of Education to formally integrate NileSmart's literacy concepts into national water education curricula.
- **Global Alignment:** Directly align project outcomes with the United Nations Sustainable Development Goals (SDGs) 6 and 13.
- **SDG 6**
- Ensure availability and sustainable management of water and sanitation for all.
- **SDG 13**
- Take urgent action to combat climate change and its impacts.

## Originality and Core Innovation

- NileSmart's uniqueness lies in its cultural deep-dive and commitment to accessible, low-barrier technology.
- **Cultural Fusion**
- We blend ancient Egyptian water culture and knowledge systems with modern participatory design principles.
- **Behavioral Arts**
- The use of poetry, folk theatre, and communal storytelling is a novel, high-engagement method for driving long-term behavioral change in water use.
- **Frugal Innovation**
- Prioritizing simple, affordable, and durable 'frugal innovation' over complex, capital-intensive technology, making it perfectly suited for rural and underserved communities.
- **Future Projection**
- With successful scaling, we project the NileSmart model can save 1 billion cubic meters of water per year by 2030.
- **Quantifiable Impact from Pilot Projects**
- Initial results from Menoufia and Suez demonstrate the project's powerful potential for immediate resource conservation.
- **70% Reduced Water Use**
- Percentage of participating households that reduced their water consumption by 20–30%.
- **500+ Children Engaged**
- Number of students who actively participated in water literacy and practical application programs.
- **15+ Incidents Prevented**
- Major leak and misuse incidents identified and resolved early through women's committee mobile reporting.
- Crucially, women-led maintenance efforts across the pilot sites ensured the longevity and sustained performance of the low-cost water units.















# Resilient Water Pods: Solar-Powered Water Access and Household Distribution in Rural Karakalpakstan

**SHAYXISLAM SEYTIBAEV**  
(UZB, BETA VERSION SOLUTIONS LLC, ceo)



### Resilient Water Pods: Solar-Powered Water Access and Household Distribution in Rural Karakalpakstan

Uzbekistan

Presenter: Shayxislam Seytibaev, CEO of Beta Version Solutions LLC

### Problem Statement

#### The Challenge

- Rural Karakalpakstan faces **water scarcity** and **high contamination** from the Aral Sea crisis.
- Over **60,000 people** lack stable access to clean water.
- Water transport is costly and relies on diesel-based systems.
- Lack of solar-powered, decentralized water access infrastructure.





## Problem Statement



### • The Challenge

- Rural Karakalpakstan faces **water scarcity** and **high contamination** from the Aral Sea crisis.
- Over **60,000 people** lack stable access to clean water.
- Water transport is costly and relies on diesel-based systems.
- Lack of solar-powered, decentralized water access infrastructure.

## Impact & Achievements



- **15,000 households (60,000 residents)** served in 2025.
- Reduction in **diesel consumption by 80%**.
- Increased access to **affordable clean water (70% cost per liter)**.
- **Empowered 25 women** trained as community operators.
- Strong support from **local government** and **community councils**.

## Solution



### • The Challenge

- **Modular solar-powered water purification pods** designed for rural areas.
- Converts **ground or canal water into potable water** using solar energy and ceramic filtration.
- **IoT dashboard** for monitoring usage and maintenance.
- Already **7 pilot pods installed** in Nukus District



## Scale-up Vision & Funding Need



- Goal: Expand to **100 pods** across 10 rural districts by 2027.
- Seeking **\$150,000 USD** co-financing for phase 2 deployment.
- Partnerships with **UNDP, OPEC Fund, and Korean tech partners**.
- Long-term goal: Integrate solar-water pods into **Uzbekistan's rural infrastructure policy**.





## Why Solar Water Pods Matter



- Aligned with **SDG 6 (Clean Water)** and **SDG 7 (Clean Energy)**.
- Community-driven innovation with **proof of success**.
- Replicable model for **Central Asia's water-stressed zones**.
- Together, we can ensure every rural family in Karakalpakstan drinks clean water.

## MEMO







# World Water Challenge<sup>2025</sup>