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Harnessing AI Safely: Addressing the Challenges of Autonomous Systems

AI Potter

Autonomous Irrigation 2.0:

Explainable AI for Sustainable & Secure Farming

Ensuring *transparency, fairness, and efficiency in irrigation across Southern Europe*

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Farming under Pressure: Water Scarcity,AI Challenges & Food Security Risks

Farming under Pressure:

Water Scarcity, AI Gaps & Food Security Risks in Southern Europe

Challenges in Southern European Irrigation Systems (Citrus & Wheat Farming)

Unpredictable rainfall and drought cycles threaten

🌱

Crop Security & Quality

(Ensuring stable yield, avoiding droughts & improving plant health)

Unfair Water Distribution

💧

Sustainability & Fairness

(Preventing overuse & ensuring equitable access to water)

Unstable Food Security

🍚

Food Security at Scale

(Managing irrigation for regional & national food stability)

Untrustable AI

🤖

Explainability & AI Trust

(Building trust in AI-driven irrigation decisions for farmers)

- Without a reliable, autonomous system, irrigation remains inefficient & unsustainable in Southern Europe

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Why Irrigation Still Fails: The Risks & AI Gaps

Why Irrigation Still Fails: The Risks & AI Gaps

Problem	Key Risk (What's going wrong?)	Why AI Fails? (The Gap in Current Systems)
🌱 Crop Security & Quality	❌ AI misjudges water needs → Citrus & wheat crops loss & lower quality	📉 AI lacks real-time soil & weather data (decisions are outdated)
💧 Sustainability & Fairness	❌ Water access remains unequal → Small farmers in Spain & Italy struggle	🚰 AI doesn't consider local water policies (unfair distribution)
🍚 Food Security at Scale	❌ AI fails to adapt to regional crises → Droughts impact citrus & wheat production	🌍 AI can't predict regional shortages (climate shocks unaccounted)
🤖 Explainability & AI Trust	❌ AI is a black box → Farmers don't trust or follow it	🏭 AI recommendations are unclear (Farmers don't trust the system)

- In Spain, citrus farmers follow AI-based water allocation, but sudden heatwaves disrupt their expected yield due to inaccurate predictions.

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Methodology: How We Approach the Problem

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- Research-Based Analysis → Studied AI-driven irrigation challenges across France, Spain & Italy
- Case Studies → Evaluated existing AI irrigation projects (John Deere, Lacroix, TODO…)
- Technical Framework → Studied explainable AI (XAI) techniques for agriculture
- Policy Review → Analyzed European Green Deal, water governance & AI regulations

👉 A multidisciplinary approach combining **technology, governance, and farmer needs**

References & citations: TODO: link of git/notion

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The Solution – Trustworthy, Transparent AI for Smarter Irrigation

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Problem	How We Fix It	What This Solves
🌱 Crop Security & Quality	📊 AI uses real-time weather, soil & crop health data	✅ Citrus & wheat farmers receive accurate and timely irrigation recommendations
💧 Sustainability & Fairness	⚖️ AI follows water policies & ensures fair allocation	✅ Prevents overuse & ensures equitable irrigation
🍚 Food Security at Scale	🌍 AI predicts climate risks & adjusts irrigation strategies	✅ Protects citrus & wheat food supply by preventing drought-related losses
🤖 Explainability & AI Trust	🧠 LLM-powered chatbot + expert-driven AI decisions	✅ Farmers understand AI recommendations & trust the system

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Our Technical Approach: AI-Driven Irrigation Decision-Making

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Problem	AI-Driven Fix (Our Solution)	How It Works Technically
🌱 Crop Security & Quality	✅ AI predicts optimal irrigation to prevent over/under-watering	🎯 Reinforcement Learning (RL) learns from citrus & wheat-specific soil moisture, temperature & evapotranspiration data
💧 Sustainability & Fairness	✅ AI allocates water based on real-time farm conditions & fairness policies	⚖️ GANs simulate irrigation scenarios to ensure water is distributed equitably across citrus & wheat farms
🍚 Food Security at Scale	✅ AI forecasts regional drought risks & adapts irrigation plans	🌍 GANs generate future climate scenarios to prevent citrus & wheat shortages
🤖 Explainability & AI Trust	✅ AI provides clear, understandable recommendations to farmers	🧠 LLM-powered chatbot explains AI decisions in local farmer dialects, increasing trust

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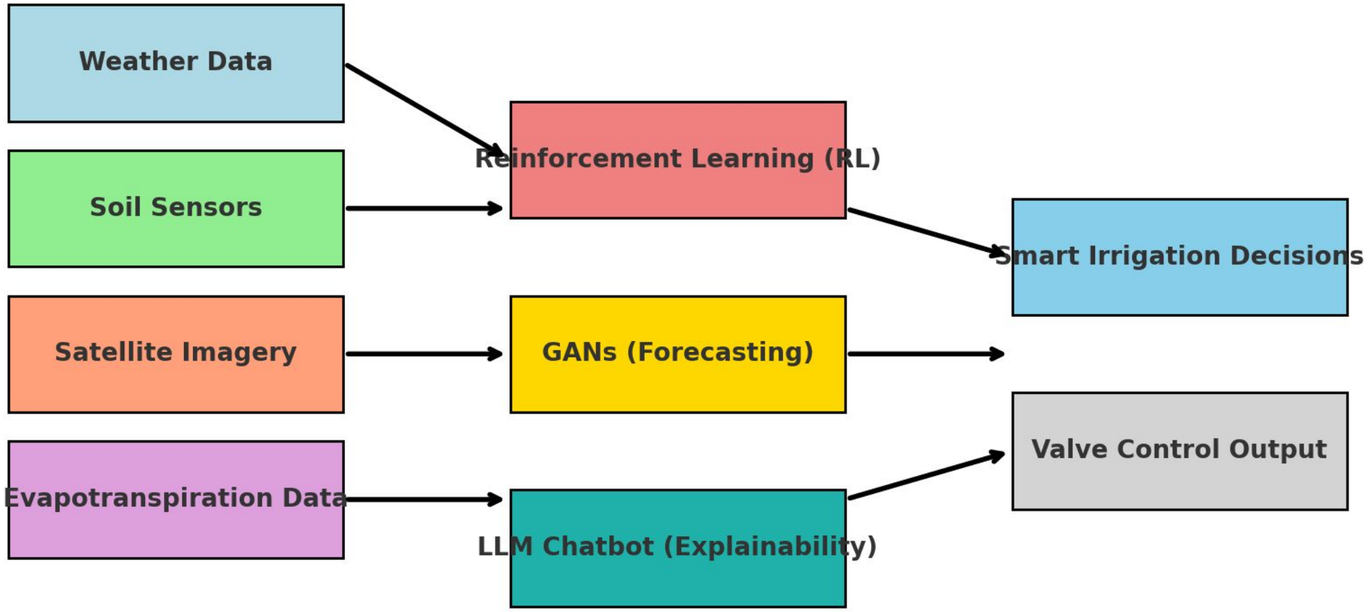
AI Innovations: LLM + RAG + GAN for Smart Irrigation

Technical Pipeline – From Data to AI-Driven Irrigation



RL

10000 samples
- static data hourly (meteo station)
- sensor data (15 minutes --> soil_moiture, temperature, something of the plant in case you have many sensors), max 5 sensors every 10000 m2
- soil_ph, satellite imagery
- evapotranspiration (solar_radiation)

Irrigation decision as message to the valve on a continuus scale of 1 to 10

GAN (takes the same data but could take other data and output irrigation decision/scenario/forecast) what difference there is between the RL and the GAN

AI Innovations: LLM + RAG + GAN for Smart Irrigation

- **LLMs (Large Language Models)** → Help farmers interpret AI suggestions in natural language, adapting to Spain & Italy's local contexts
- **RAG (Retrieval-Augmented Generation)** → AI retrieves real-time weather, soil, and water data to optimize irrigation in drought-prone regions
- **GAN (Generative Adversarial Networks)** → AI generates simulated crop growth scenarios to fine-tune irrigation strategies or predict drought events for citrus & wheat

👉 Combining these AI techniques ensures **precision irrigation while maintaining explainability & adaptability**

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Real-World Benefits – AI in Action

Our Technical Approach: AI-Driven Irrigation Decision-Making

Problem Solved	Real-World Improvement	Metric of Success
🌱 Crop Security & Quality	✅ Healthier citrus & wheat crops with better water precision	🌾 Higher yield per hectare
💧 Sustainability & Fairness	✅ 30% less water waste by balancing usage in Spanish & Italian farms	💧 Water savings per farm
🍚 Food Security at Scale	✅ Predicts drought risks & prevents shortages in citrus & wheat farming	📉 Reduction in crop failure rates
🤖 Explainability & AI Trust	✅ Farmers understand AI decisions & adopt tech	📊 Increased AI adoption by farmers

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Companies Driving AI-Powered Irrigation

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- **LACROIX** → AI-powered connected water management for remote irrigation control
- **InstaDeep** → AI startup partnering with **Syngenta** to optimize crop & irrigation models
- **Koan Irrigation** → Provides **real-time irrigation & fertilization control** with minimal water usage
- **IBM & FAO Smart Agriculture** → AI-driven tools for **global farm water management**

👉 How can industry collaborations advance fair & transparent AI adoption in agriculture?

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Expanding AI-Driven Irrigation: The Road Ahead

Expanding AI-Driven Irrigation: The Road Ahead

- Deploy AI solutions in more Southern European farms, covering additional crops.
- Integrate ????-based water tracking for better transparency in irrigation.
- Enhance policy alignment with EU agricultural regulations to improve farmer adoption.
- Introduce localized AI interfaces in Spanish, Italian & Portuguese to boost usability.

📌 Scaling AI for better sustainability, fairness, and trust in irrigation

DEMO

Recorded demo

Closing: Why We Must Act Now

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The Future of AI in Irrigation: Smarter, Fairer, & More Sustainable

- AI must be explainable, accountable, and adaptable.
- Farmers, developers, and policymakers must collaborate to ensure fair AI adoption.
- The future of food security depends on AI that is transparent and accessible to all.

💡 With AI that farmers can understand and trust, irrigation in Southern Europe moves from being a risk to a solution.

📌 AI that ensures Citrus & Wheat farmers receive sustainable water access, food security, and trust in technology.

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Questions & Discussion

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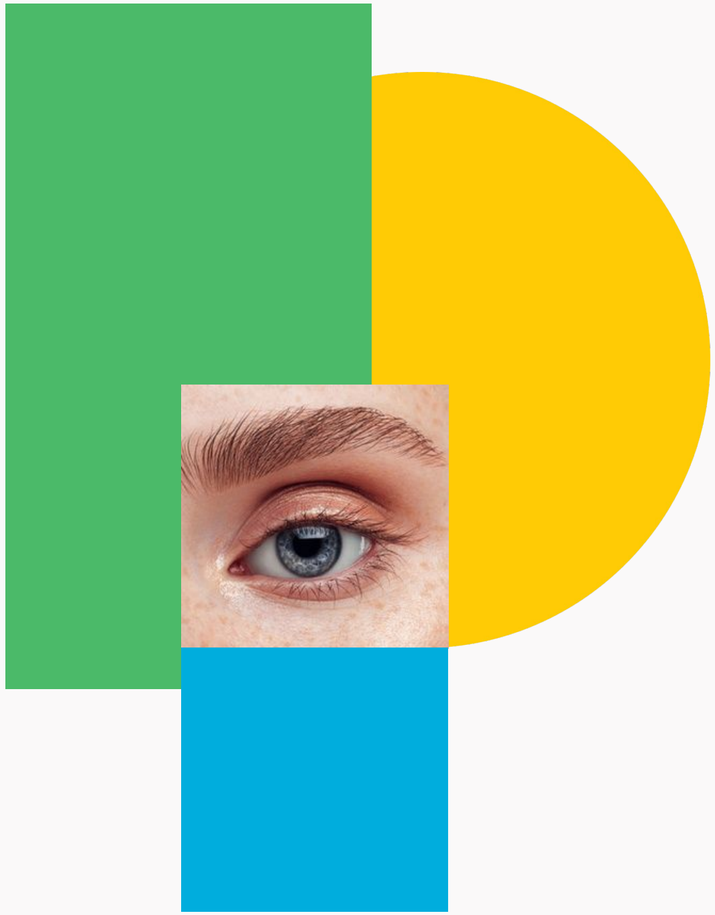

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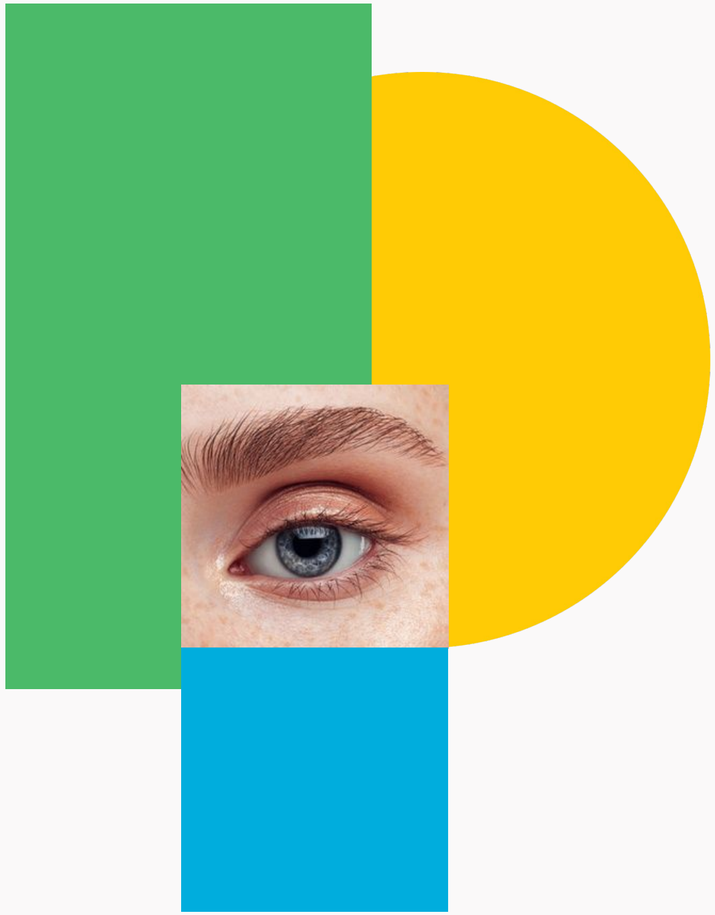

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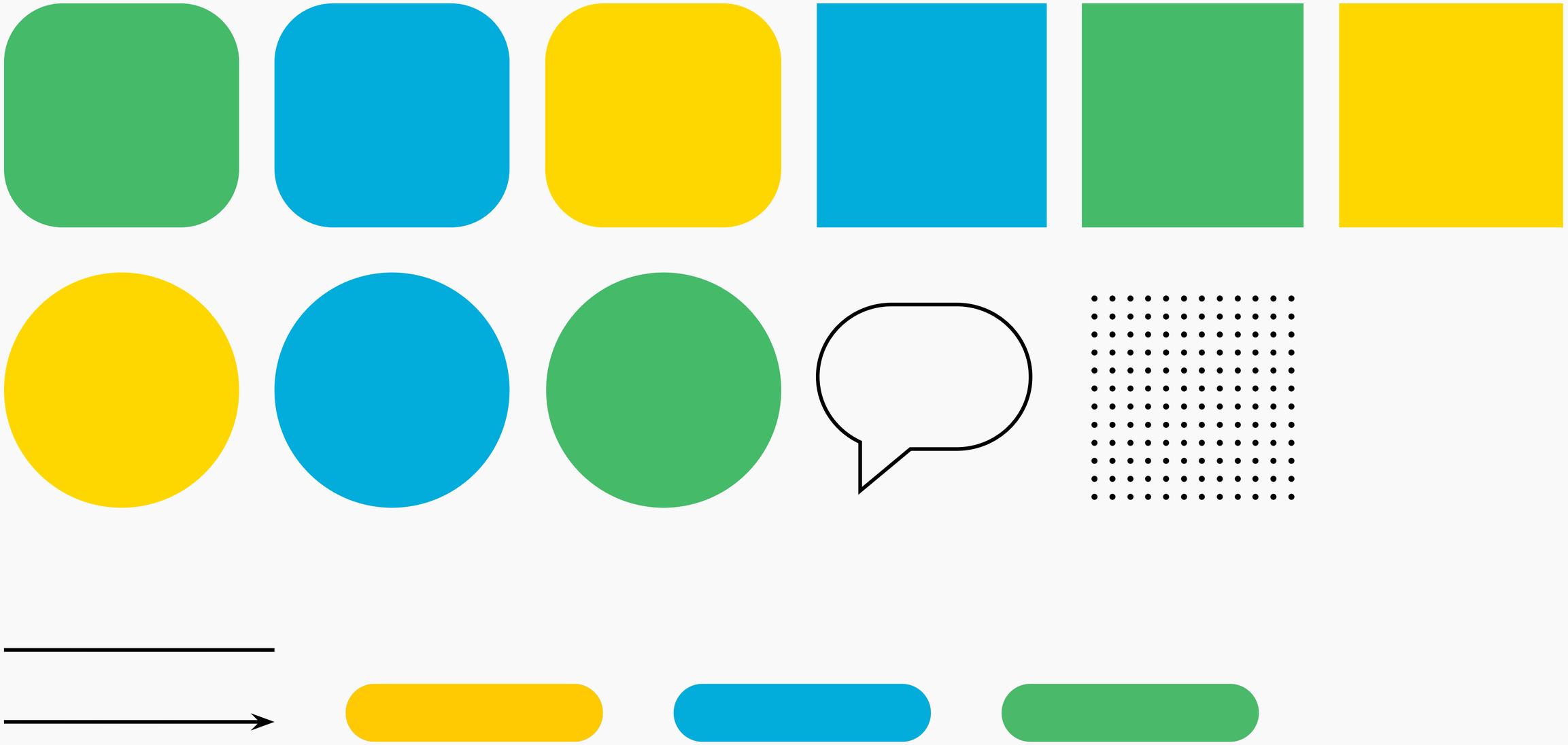

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