D1.1 – Smart solutions preliminary parameters identified by end users

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[1] **Type** _[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other_
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Revisions

List of Acronyms

RAINS	Resilient Agri-based Integrated Nutrient and irrigation Solutions
D1.1	Deliverable 1.1
IoT	Internet of Things
API	Application Programming Interface
UX	User Experience
GDPR	General Data Protection Regulation
EU	European Union
SMS	Short Message Service

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Keywords list

Stakeholder engagement, Co-creation, Smart irrigation, Nutrient management, Water scarcity, Soil health, Bio-based solutions, Digital agriculture, Climate resilience, Water reuse, Decision support tools, User interface design, Modular systems, Interoperable data, Sustainable farming, Compost bricks, Biofertilizers, WaterIQ system, Optifangs-IA.

Disclaimer

Table of Contents

1. Summary

The RAINS project seeks to enhance the resilience of European agriculture to water scarcity and climate extremes through the development of innovative, stakeholder-driven irrigation and nutrient management technologies. This document (Deliverable D1.1) presents the preliminary outcomes of a co-creation process involving farmers, advisors, cooperatives, public authorities, and researchers across three pilot regions in Spain and Greece. Using a multi-actor, participatory approach, the project identified end-user requirements across five key thematic areas: integrated data usage, irrigation strategies, soil health (physical and fertility), and user interface design. Inputs were gathered through direct engagement and unstructured discussions with selected actors from a database of 270 stakeholders, with a strong emphasis on practical relevance and usability. The findings highlight a shared demand for modular, interoperable, and low-maintenance solutions that align with existing systems, comply with regulations, and provide real-time decision support. Strategic takeaways underscore the importance of integration, climate resilience, transparency, and user-centric design in driving adoption and impact. These insights form the foundation for ongoing co-creation workshops and future development phases of the RAINS smart solutions.

2. Introduction

The goal of RAINS project is to enhance the resilience of European agriculture to water scarcity through the deployment of innovative and optimized irrigation and nutrient management technologies and practices. These smart solutions are designed to increase the efficiency of water and nutrient use in agriculture while mitigating the impacts of extreme climate events – particularly droughts and floods – on agricultural production.

A key emphasis of RAINS lies in stakeholder-driven design. From the outset, the project has adopted a co-creation approach, whereby end users – including farmers, cooperatives, agricultural advisors, local and regional authorities, and other stakeholders – are actively engaged in shaping the smart solutions. Through workshops, surveys, and consultations, the project collects the needs, preferences, and requirements of users to ensure that the proposed technologies are adapted to real-world problems and rural priorities. This multi-actor model, involving the so-called "quadruple helix" (farmers/businesses, research institutions, public authorities, and civil society), guarantees that the outcomes of RAINS will be both practical and widely accepted by the farming community.

Within this framework, Deliverable D1.1 – "Smart solutions preliminary parameters identified by end users" – aims to document the preliminary outcomes of this co-creation process. Specifically, D1.1 collects and substantiates the initial parameters and requirements identified by end users for RAINS smart solutions. In other words, it captures the expressed needs, preferences, and desired features of farmers and other stakeholders regarding the proposed solutions – from preferences in irrigation strategies and soil health management practices to requirements for integrated data use and user-friendly digital interface design. This information is critical, as it will directly guide the next phases of development and programming of RAINS smart solutions, ensuring alignment with end-user expectations and field conditions.

The methodological approach of stakeholders' engagement in order to collect their inputs is presented in Chapter 3, and the output of this process as a list of inputs and smart solutions is provided in Chapter 4, organized in 5 thematic categories. The interpretation of outcome in Chapter 5 translates stakeholder feedback into actionable guidance, helping ensure that the development and deployment of RAINS solutions are aligned with real-world constraints, priorities, and opportunities. Finally, Chapter 6 summarizes the key conclusions and outlines next steps – including how the D1.1 findings will be used in future phases (e.g., co-creation workshops up to month 18 and field demonstration activities), to ensure a smooth transition from user requirement definition to solution implementation.

3. Methodological approach

In Task 1.1 of the RAINS project, a comprehensive stakeholder mapping and engagement strategy was implemented to ensure that the solutions developed would directly reflect the practical needs and constraints of real-life agricultural systems. This process resulted in the creation of **three structured stakeholder databases**, each corresponding to a pilot region of the project: Segura/Valencia region (Spain), Thessaloniki (Central Macedonia, Greece), and Lesvos (North Aegean, Greece).

Stakeholder selection was based on geographical representativeness, ensuring regional coverage, and functional relevance, targeting actors involved in farming, research, irrigation systems and fertilizers manufacturers, public authorities and private entities involved in water management and environmental organizations. The inclusion criteria prioritized **primary end users**, such as farmers and farm managers. The initial databases include **273 stakeholders in total from the targeted areas of Greece and Spain**, of which more **than 50% are active farmers**, and depend on irrigation to sustain their agricultural productivity. These are complemented by representatives from farmers' cooperatives, local and regional authorities, irrigation and fertilizer providers, agricultural advisors, research institutes, and technology developers. All stakeholder identification and data handling processes adhered strictly to the General Data Protection Regulation (GDPR).

For the needs of D.1.1 an initial **list of inputs and smart solutions from selected stakeholders** was collected, to guide the deployment of the RAINS systems within a realistic context. The collection of inputs was performed through direct **person-to-person meetings and contacts** with available individuals from the database, following a multifactor approach to collect input from farmers, advisors and decision makers as the main end-user groups of the project. The initial inputs and smart solutions were collected through non-structured discussion with the stakeholders, in which they were engaged to freely express their thoughts and ideas in relation to the RAINS tools. These inputs were classified in 5 main categories including:

- *Requirements for integrated data usage*
- *Preferences for irrigation strategies*
- *Preferences for soil health management with focus on soil physical properties*
- *Preferences for soil health management with focus on soil fertility*
- *Insights for user interface design for maximum usability*

The overall goal of this process was to explore stakeholders' perception and requirements and make an initial identification of preferences in order to adjust the parameters and the programming of the RAINS systems. Considering that stakeholders are **central contributors** to the project's success, their experiential knowledge, preferences, and contextual understanding are instrumental in identifying potential challenges and shaping the design of tools/solutions to ensure usability, efficiency, and acceptance.

4. List of stakeholders' inputs and solutions

Table 1 Preliminary list of inputs and smart solutions from stakeholders to adjust the parameters and the programming of the systems

Preliminary list of inputs and smart solutions from stakeholders to adjust the parameters and the programming of the systems			
Categories	**Stakeholders perspective**		**Relevant RAINS products/solutions**
	Inputs (Requirements/Implications)	**Smart solutions** (Proposed characteristics)	
Requirements for integrated data usage	❖ *Combine local field data (e.g. from IoT sensors, farmer logs, information on management) with external data sources (e.g. satellite imagery, soil use maps, climate forecasts, water quality databases).* ❖ *Stakeholders should be able to use or adapt to interoperable data formats and*	-Use of sensors for high-frequency data (daily/weekly) on water and nutrient status -Systems should support APIs and data schemas that enable, if possible, integration with existing	• *WaterIQ System* • *Optifangs-IA* • *Water-N-P model*

	standards (e.g. for irrigation logs, weather data, crop types, soil profiles).	tools (e.g. farm management platforms and satellite sources)	
	❖ *Systems must evolve with stakeholder input through iterative feedback and updates*	- Regular UX surveys to evaluate pain points - Usability feedback as dashboard design should be considered (e.g. creating a user interface that visually represents key data and performance indicators in a concise and accessible way)	
	❖ *Calibration and validation of model outputs through existing field-level data*	Validate model predictions against real observations (when available)	
	❖ *Alignment with policy and regulatory frameworks*	Systems should support compliance with relevant policies and thus include legislative thresholds	

Preferences for irrigation strategies	❖ *Compatibility with existing irrigation infrastructure* ❖ *Capacity and resilience* ❖ *Decision Support for Irrigation Scheduling*	Solutions should integrate easily with existing drip, sprinkler, or flood systems. (e.g. Fog collectors must deliver to storage systems that can connect to distribution systems. Reclaimed water requires compatibility with filters) -Systems should buffer against droughts and supply interruptions supporting diversification of irrigation methods/sources -Documentation of capacity/performance e.g., fog water or solid water as a backup during shortages. -Data-driven insights to recommend irrigation plans. -Include threshold-based alerts and seasonal planning tools	• *Solid water* • *Reclaimed wastewater* • *Fog-collectors* • *WaterIQ System* • *Water-N-P model*

	❖ *Water quality considerations* ❖ *Low operational and maintenance burden*	Water source quality must be appropriate to crop and soil health: -Reclaimed wastewater must meet phytosanitary and regulatory safety standards. -Solid water should avoid harmful residues. -WaterIQ System should monitor salinity, and pH in real time. Solutions should be low-cost, durable, and easy to manage including characteristics such as: -Minimal technical complexity and training needs -Biobased products should be biodegradable and require no special disposal. - Fog collectors should be self-cleaning or easy to maintain.	

Preferences for soil health management: Soil physical properties	❖ *Improvement of soil structure and porosity*	Preferred characteristics include: -Bio-based nets should reduce surface compaction and promote root penetration. -Compost brick ladders should increase macroporosity, improving aeration and water movement. -Preference for materials that help form stable soil aggregates.	• *Bio-based nets* • *Compost brick ladders*
	❖ *Surface runoff control, enhancement of water infiltration and retention*	-Solutions should help retain moisture near the root zone without causing waterlogging. - Bio-based nets should stabilize soil on slopes or bare fields (acting as mulch-like layers). -Compost bricks should slow water movement, acting as physical barriers to erosion	

Comentado [LL1]: I didn´t find a logic in capital letters in some words and not ibn others of the same table, therefore I remove them, if i misunderstood something, please ignore this change

	❖ *Support for root development and plant anchorage*	-Products must enable unrestricted root expansion and deeper rooting. -Preference for materials that decompose in sync with root development cycles.	
	❖ *Practicability, modularity and scalability*	-Bio-nets should be adaptable to field shapes, row spacing, or tree basins, be easy to unroll and secure on various terrain types. -Compost bricks should be stackable or form ladders of different configurations (e.g. for slope stabilization, terrace edges), non-fragile, field-stable during handling. -Preference for lightweight, field-deployable formats.	

Preferences for soil health management: Soil fertility	❖ *Nutrient availability and predictability* ❖ *Organic matter enrichment* ❖ *Safe and compliant input*	-Optifangs-IA must be able to match nutrient needs with nutrient availability in the sludge in order to avoid over- or under-fertilization. -Compost bricks should be able to provide a slow, steady release of nutrients. -Biofertilizers with stable nutrient content — no nutrient spikes, no mysterious deficiencies halfway through the season. -Compost bricks are should improve the C:N ratio and long-term soil fertility. -Biofertilizers should support microbial consortia that promote nutrient cycling -Ensure absence of heavy metals, pathogens, or harmful residues. Products must meet strict EU safety standards	• *Compost brick ladders* • *Sewage sludge* • *Biofertilizers* • *Optifangs-IA* • *Water-N-P model*

	❖ *Efficient nutrient management and compatibility with cropping sSystems*	-Water-N-P model be able to simulate nutrient budgets under different irrigation and management regimes to be upscaled in order to support strategic planning and regional decision making -Biofertilizers able to be integrated with irrigation schedules (fertigation) Compost bricks need to integrate with planting systems (not clogging machinery) Should integrate well with drip irrigation (bio-nets as mulch), fertilizer placement, cover crops or agroecological practices	
	❖ *Proven cost-effectiveness and return on investment*	Fertility improvements must lead to higher yields or lower input costs. Thus cost-benefit analysis should be performed to justify adoption.	

Insights for user interface design for maximum usability	❖ *Each stakeholder type should have access to a tailored interface showing only relevant data and tools.* ❖ *Interfaces must be mobile-friendly and support offline access for users in rural/low-connectivity areas.* ❖ *Language and terminology should be able to adapt to local contexts.*	Potential tools per user: -Farmers: Simple, visual dashboards for field conditions, irrigation schedules, weather alerts. -Advisors/Agronomists: Access to comparative analytics, model outputs, and recommendations across farms. Mobile and offline functionalities: -Offline data entry with later synchronization. -Responsive design for both smartphones and tablets. -Push notifications and SMS options for alerts. Multilingual and Localized Content solutions: -Multiple language support. -Customizable labels or tooltips for clarity.	• *WaterIQ System* • *Optifangs-IA*

	❖ *Decision-Oriented Visualization (Insights must be actionable and intuitive — not just raw data).*	Visualization solutions: -Color-coded maps (e.g. soil moisture, crop stress). -Clear icons and symbols (e.g. "irrigation needed," "nitrogen overapplied"). -Trend graphs and threshold alerts	
	❖ *Minimal data entry and automation*	The interface should minimize manual inputs through: -Pre-filled data from sensors -Drag-and-drop uploads (e.g. shapefiles, Excel).	
	❖ *Embedded training and help resources*	Integrated help and support including: -Interactive tutorials, tooltips, and FAQs within the interface. -Contextual help pop-ups based on user activity. -Downloadable manuals and multilingual videos.	

5. Interpretation of outcomes

Rather than offering a descriptive summary of technical specifications or feature requests, this section seeks to **uncover the operational and strategic implications** behind stakeholder preferences as these have been explored in the initial stage of RAINS project. It identifies how the requirements for integrated data usage, adaptive irrigation and fertilization strategies, soil health management (both physical and fertility-related), and user interface design reflect broader trends in agricultural innovation, sustainability, and digital transformation.

These insights illustrate the **interconnected nature of expectations** across farmers, policymakers, advisors, agronomists, and industry actors. For example, the emphasis on modularity, real-time decision support, and ease of use shows a shared demand for **solutions that are both technically robust and practically deployable**. Similarly, recurring themes such as compliance with regulatory standards, support for circular practices both at the local and the reginal scales, and resilience to climate variability indicate a strong preference for systems that are not only effective in isolation but also **integrated into a wider ecosystem of policy, environmental, and economic considerations**.

In essence, this section translates stakeholder feedback into **actionable guidance**, helping ensure that the development and deployment of RAINS solutions are aligned with real-world constraints, priorities, and opportunities. It also serves as a forward-looking framework for **design iteration, co-creation, and adoption planning**, reinforcing the project's commitment to delivering scalable, user-centered, and impact-driven innovations.

<u>Integrated Data Usage – Interpretation</u>

The input requirements suggest that **stakeholders increasingly value systems that are interconnected, responsive, and interoperable**. The insistence on combining IoT, satellite, and local records means the RAINS solutions must function not as isolated tools but as **part of a larger digital ecosystem**. There is a clear push toward:

- ***Open standards** and **API integration**, allowing tools like Optifangs-IA or the WaterIQ System to plug into farm management systems.*

- **Iterative development**, driven by feedback loops and real-field calibration, signifying that stakeholder trust hinges on **transparency and adaptability**.
- The need to **meet legislative thresholds** confirms that data integration is not just about efficiency—it is also a tool for **regulatory compliance and reporting**.

Implication: RAINS solutions must function as modular components in the wider data infrastructure of agriculture. Stakeholders won't adopt tools they can't align with their existing data ecosystems or regulatory responsibilities.

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Irrigation Strategies – Interpretation

The preferences show that **stakeholders prioritize flexibility, robustness, and quality assurance** in irrigation. Compatibility with current infrastructure indicates a **strong resistance to system overhauls**—adoption will depend on **ease of retrofit and clear return on investment**.

The demand for **resilience and diversified water sources** (e.g., fog, reclaimed water, solid water) shows a recognition of climate uncertainty. However, water quality control remains a **non-negotiable threshold**, particularly for reclaimed or novel sources.

Implication: RAINS irrigation tools must be framed not as replacements, but as **enhancers or backups** to what already exists—especially in high-risk or drought-prone zones. Decision support tools must be grounded in **real-time actionable insights**, not just general recommendations.

Soil Health – Physical Properties – Interpretation

Stakeholders' expectations here reflect a **shift from productivity-first to resilience-first** thinking. Compost bricks and bio-based nets are expected not only to physically stabilize the soil but also to serve **multifunctional roles**: erosion control, water retention, and biological support.

Modularity and scalability are critical—if a product isn't **adaptable to different farm sizes or topographies**, it won't be adopted, regardless of its agronomic performance. Practicality and field resilience (e.g. non-fragility, ease of handling) are **make-or-break factors**.

Implication: The physical solutions in RAINS must be treated as **user-friendly, high-impact infrastructure**, especially for regenerative practices. These materials must be **low-labor and intuitive**, especially in low-tech, decentralized systems.

Soil Health – Fertility – Interpretation

There is clear alignment between stakeholders on the **importance of stable nutrient delivery and microbial soil life**. RAINS bio-inputs (compost bricks, sludge, biofertilizers) are expected to contribute to **a longer-term soil fertility strategy**, not just act as short-term amendments.

Precision tools like Optifangs-IA and Water-N-P must **bridge the gap between actual field conditions, input potential, regional nutrients availability and strategic decision making**. Their usefulness lies in **translating variability into clarity**—helping users know not only **how much, where, and when** to apply fertilizers (farmers) but also to **strategically asses implications** and set large scale priorities (policy/decision makers).

Safety and compliance concerns (especially regarding sludge) signal that regulatory oversight and public perception remain major **barriers to trust and scalability**.

Implication: Fertilization solutions must be presented as **climate-smart, system-friendly, circular economy-oriented, and fully auditable**. They should enable traceability and demonstrate performance through **quantifiable yield gains or input savings and surplus reduction**, ideally both.

User Interface Design – Interpretation

Stakeholders don't want just another dashboard—they want tools that **speak their language, work offline, and simplify decision-making**. This category reflects a mature understanding that the **best algorithms mean little without intuitive delivery**.

There is a call for **role-specific customization**: farmers need simplicity; advisors and policymakers want comparative analytics and traceability. The consistent demand for **mobile-first and offline access** reflects the real-world constraint of poor connectivity in many farming areas.

Implication: Usability is not a luxury—it's a **requirement for adoption**. The design must reflect **daily workflows**, be **fail-safe and language-adaptable**, and help users transition from data collection to **confident action**.

6. Overall Strategic Takeaways for RAINS

The strategic takeaways distill the cross-cutting insights drawn from stakeholder perspectives and initial interactions with the RAINS project. These may serve as guiding principles for aligning the design, implementation, and scaling of smart agricultural solutions with the practical needs of end users and the overarching goals of sustainability, resilience, and digital integration. These takeaways reflect not only what stakeholders require on a functional level but also how innovation must be positioned to drive systemic change. As such, they provide a shared compass for coordinating development across diverse RAINS solutions—from digital models to biodegradable materials—ensuring that they are embedded within a coherent, user-responsive, and future-ready framework. The overall strategic takeaways for RAINS project include:

1. **Integration over Isolation**: Each RAINS solution must "plug in" seamlessly with existing infrastructure and data systems.
2. **Resilience & Circularity**: Whether it's water reuse or organic fertilizers, stakeholders expect innovations to be climate-adaptive, sustainable, and circular.
3. **Trust through Transparency**: Compliance, calibration, and user control are key to building stakeholder confidence—especially for inputs like sludge or reclaimed water.
4. **Smart Simplicity**: Precision tools must hide scientific complexity behind clear, actionable interfaces tailored to user roles.
5. **Field-First Thinking**: Every solution—from sensors to compost bricks—must deliver measurable impact at field level without increasing operational burden.

Taken together, these strategic principles underscore the importance of developing RAINS solutions that are not only technologically advanced but also socially embedded, economically viable, and environmentally responsible. To this direction the present list of inputs will provides a solid discussion basis to the on-site co-creation workshops of Task 1.2, which are held in the 3 pilot areas. These workshops serve as both consultation and collaboration spaces, where stakeholders are called to express their opinion and willingness to adopt RAINS water-based solutions, while voicing their needs, concerns, practical limitations, and expectations for future smart irrigation and nutrient management tools. They reaffirm the value of co-design, transparency, and modular integration as critical enablers of trust and adoption across stakeholder groups. By embracing these insights as operational imperatives rather than optional considerations, the RAINS project is well-positioned to catalyze meaningful impact at the field level while contributing to broader European and global objectives for sustainable agriculture and climate resilience.

7. Annex I. List of Stakeholders

For confidentiality reasons, the detailed stakeholder database is not disclosed in this document. The complete list is maintained by the consortium and can be made available to the European Commission/Agency upon request, strictly for verification purposes.