



BONEX

Boosting Nexus Framework Implementation in the Mediterranean

Report

2nd BONEX workshop organised in DP Spain (Region of Axarquía)

Analysis of Barriers and Facilitating Factors

The second stakeholder workshop was held on November 14th, 2024, in the Axarquía region (Málaga, Spain) as a key step in the participatory application of the **WEFE Nexus Bridging Framework (WEFEF)** within the BONEX project. The main objective was to critically and collectively assess the barriers and enabling factors affecting the adoption of the intervention selected for the Spanish Demonstration Project: a nutrient management tool for the use of reclaimed water in agriculture.

While WEFEF can guide technology selection within policy processes, it also serves as a valuable tool for evaluating already-selected solutions through a Nexus lens. The Spanish Demonstration Project has adopted this second approach, applying the WEFEF framework to analyze the BONEX Decision Support System (DSS) for nutrient management in terms of its systemic impact on water, energy, food, and ecosystems.

The evaluation followed **analysis of barriers and facilitating factors**, embedded within the WEFEF approach. This framework emphasizes the interconnections and trade-offs among WEFE sectors and ensures that solutions like the BONEX DSS are assessed not only for technical feasibility but also for their institutional, social, environmental, and economic implications.

The exercise was structured around a comparative analysis between the BONEX intervention and a **Business as Usual (BAU) scenario**—defined in this case as the use of reclaimed water without a nutrient management tool. This comparison enabled participants to identify specific needs, constraints, and opportunities related to implementation across key areas: resource requirements, regulatory and institutional contexts, and WEFE Nexus dimensions.

The insights generated through this participatory process have informed the development of a **Nexus Bridging Plan (NBP)**—a strategic roadmap for enhancing the sustainable use of reclaimed water in Axarquía. Grounded in WEFE principles and regional priorities, the NBP proposes actionable measures to improve governance, foster adoption, and address the broader systemic challenges in agricultural water reuse.

1 Context of the DP and BONEX intervention

The Axarquía region, located in the eastern part of Málaga province in **South Spain** and covers 1,025 km² and comprises 31 municipalities. In recent decades, the region has faced mounting water-related challenges due to chronic scarcity, the expansion of irrigation-intensive subtropical crops (notably avocados and mangoes), and growing competition between agricultural and urban water uses. These pressures have been compounded by climate variability, prolonged droughts, and rising energy demands associated with water extraction and distribution.

To mitigate this crisis, authorities have implemented several **supply-side responses**. These include integrating reclaimed wastewater into the system and initiating plans for desalination infrastructure. The regional government (Junta de Andalucía) has enacted multiple Drought Decrees to address the ongoing scarcity, which have facilitated investments in tertiary treatment infrastructure to increase the availability of reclaimed water for agriculture. As a result, Axarquía is expected to have access to **19.14 hm³ of reclaimed water for irrigation** during 2025. Public investment under these decrees exceeds €42.14 million.

Nevertheless, the use of reclaimed water for irrigation is relatively new in the Axarquía region, and most farmers and stakeholders still lack practical experience in managing this resource. Reclaimed water represents a reliable and continuous source of supply, particularly valuable in coastal areas like Axarquía, where treated effluents discharged into the sea would neither contribute to ecological flows nor be reused downstream. As such, its use constitutes a genuine addition to available water resources and can help alleviate the region's acute water scarcity. However, the application of the WEF Nexus approach encourages a broader perspective beyond mere water availability, highlighting the need to consider potential implications for soil health, environmental quality, and energy consumption. Notably, reclaimed water contains significant concentrations of nutrients which can benefit agriculture by reducing the need for synthetic fertilizers. This not only lowers production costs for farmers but also decreases reliance on fossil-fuel-derived inputs, thereby reducing associated greenhouse gas emissions. Nonetheless, if nutrient loads are not carefully monitored and managed, their excessive accumulation can lead to eutrophication and the degradation of surface and groundwater bodies, undermining environmental sustainability and creating new risks for the territory.

Within this context, the BONEX Demonstration Project in Spain focuses on improving the sustainable use of reclaimed water by addressing a critical environmental and agronomic challenge: nutrient management. The selected intervention—developed by Bioazul and SmartLogger—is the BONEX DSS, designed to optimize fertigation practices when using reclaimed water in irrigation.

BONEX DSS supports farmers in calculating precise fertilizer requirements, taking into account the nutrient content of reclaimed water. This helps prevent over-fertilization, safeguards groundwater quality, and ensures efficient crop nutrition. The tool directly responds to stakeholder concerns by promoting the integration of reclaimed water as a reliable, non-conventional source, while maintaining productivity and environmental safeguards. In a region like Axarquía—where securing water for agriculture is critical—such an approach offers a pathway to balance resource use with long-term sustainability.

2 Workshop methods

Barriers and opportunities to implement BONEX DSS were collaboratively identified with stakeholders during the 2nd BONEX participatory workshop. This interactive exercise allowed participants to highlight key factors that could either facilitate or hinder the implementation of the solution. By engaging directly with stakeholders, the workshop provided valuable insights into practical challenges, regional constraints, and potential drivers of adoption.

The session began with a general explanation of the objectives and the methodology, after which participants were divided into small working groups.

Each group was supported by two members of the project team: one served as moderator, facilitating the discussion, guiding participants through the structured questions, and resolving any doubts; the second took detailed notes to document the group discussions. In cases where only one project representative was available, the moderator also assumed the note-taking role. Additionally, each group selected a rapporteur from among the participants to present a summary of the discussions during the final plenary session.

The group discussions were guided by a structured question template organized into three thematic blocks. For each block, participants were first asked to reflect on the **Business as Usual (BAU)** scenario—defined as the use of reclaimed water in agriculture without nutrient management tools. After exploring the BAU context, participants were then invited to identify what **additional resources or considerations** would be necessary to implement the nutrient management tool developed in the BONEX project.

Block 1: Resource Requirements

This block examined the human, technical, and operational resources needed for the use of reclaimed water, including:

- Personnel availability and the need for additional human resources.
- Availability of qualified professionals and training needs.
- Required infrastructure (e.g. tertiary treatment, ponds, pumps, pipe networks).
- Land or space requirements and potential land-use conflicts.
- Necessity of long-term planning and its current status.
- Vulnerability to climatic and geographic risks, and existing mitigation measures.

Participants were also asked to consider what **additional resources** (e.g. analytical capacity, monitoring systems, advisory services) would be necessary to support **advanced nutrient management**.

Block 2: Regulation and Institutions

This block explored the institutional and regulatory framework, including:

- Current regulations governing reclaimed water use and anticipated changes.
- Practical feasibility and enforcement of legal requirements.
- Availability of legal permits and water rights for implementation.
- Need for coordination or collective action among stakeholders (public, private, civil society).
- Nature and quality of relationships between actors.
- Existence of platforms or structures (e.g. water user associations) to support collaboration.
- Potential objections or support from involved actors.
- Necessity of public awareness campaigns.
- Political and bureaucratic enablers or obstacles, including administrative delays and rigidity that may affect project implementation.

Block 3: WEFE Nexus Dimensions

The final block assessed the potential risks and opportunities related to the intervention across the four WEFE nexus dimensions:

- **Water:** impacts on water availability, quality, and allocation.
- **Energy:** implications for energy demand and efficiency in reclaimed water use.
- **Food:** effects on agricultural productivity and food security.

- **Ecosystems:** risks or benefits for surrounding natural systems and biodiversity.

Participants were encouraged to reflect on whether the intervention could affect the physical, social, or economic functioning of the system and whether it might enhance or compromise long-term community resilience and sustainability.

This methodology enabled the collection of comprehensive, stakeholder-driven insights that will serve as a foundation for developing the Nexus Bridging Plan (NBP) for Axarquía, ensuring that proposed solutions align with local capacities, institutional dynamics, and the broader WEFE nexus perspective.



Figure 1: Second BONEX participatory workshop in Axarquía

3 Results

The evaluation exercise identified a range of barriers and opportunities affecting the adoption of the BONEX nutrient management tool for reclaimed water irrigation in Axarquía. These insights were drawn from stakeholder discussions during the group sessions and reflect both technical and contextual considerations.

Barriers

Financial and Economic Constraints: The adoption of the BONEX DSS involves direct and indirect costs that can be a deterrent for farmers, especially smallholders. The BONEX DSS operates under a subscription-based model, and in the absence of clear short-term economic benefits, some farmers may find it difficult to justify the investment. Additionally, continuous monitoring of nutrient content of reclaimed water may place a financial burden on irrigation communities. Public subsidies are limited and often complex to access, while private financing might be discouraged by uncertainties around long-term return on investment. These economic limitations are further compounded by inadequate tariff structures and fragmented fiscal responsibility among institutions.

Technical and Infrastructural Limitations: In rural areas, limited internet access and inconsistent electricity supply constrain the deployment of digital solutions like the BONEX DSS. The technical capacity of the public administration to issue permits and supervise infrastructure installations is also insufficient, delaying necessary developments.

Knowledge and Experience Gaps: Most farmers in Axarquía have limited experience with reclaimed water irrigation and its management. Although irrigation technologies are not new to them, they often lack specific knowledge regarding the properties and risks associated with reclaimed water—such as nutrient content, salinity, or trace contaminants. This knowledge gap extends to local advisory services, which are generally not trained to provide guidance on reclaimed water use. As a result, the potential benefits of nutrient reuse remain underestimated, while the risk of environmental harm—such as nutrient leaching and aquifer contamination—remains poorly understood or unaddressed.

Administrative and Regulatory Hurdles: While reclaimed water reuse is increasingly supported by public policy, the integration of nutrient management into this framework remains poorly defined. There is currently no specific regulatory guidance on how nutrients contained in reclaimed water should be accounted for in fertilization planning, which creates uncertainty for both farmers and advisors. The lack of standard procedures for integrating digital decision-support tools into official nutrient management practices—such as those required under the EU Nitrates Directive—further limits the perceived institutional legitimacy of BONEX tool. Farmers also express concerns about potential legal liabilities related to nutrient applications derived from reclaimed water, particularly in the absence of harmonized protocols or certified decision-making tools. This regulatory ambiguity can discourage adoption and creates an uneven playing field for innovative tools designed to enhance sustainability.

Market and Social Perception Challenges: Farmers are confronted with a wide range of digital tools on the market, leading to saturation and difficulty in evaluating which platforms offer the most reliable and context-specific benefits. In this competitive environment, gaining the trust of users is a major challenge for BONEX DSS. Additionally, concerns over data privacy, particularly related to nutrient use and yield data, can deter farmers from engaging with digital platforms. Cultural resistance to change persists, especially among older or more conservative farmers, who may be reluctant to abandon traditional practices without strong evidence of economic and agronomic benefits.

Lack of Environmental Risk Awareness: Despite the real and scientifically documented risks associated with the use of reclaimed water—such as nutrient leaching and the potential for aquifer contamination—many farmers in Axarquía do not perceive these environmental impacts as a priority concern. The urgency of securing water for irrigation under drought conditions often overshadows longer-term sustainability considerations. As a result, practices that could mitigate environmental harm, such as tailored nutrient application based on reclaimed water composition, are frequently neglected. This low level of environmental risk awareness limits the motivation to adopt nutrient management tools like BONEX, which are designed precisely to prevent these impacts. Without a stronger culture of environmental stewardship and institutional support to raise awareness, the long-term viability of water reuse in the region could be undermined by unintended consequences such as soil degradation and water body eutrophication.

Enabling Factors and Opportunities

Institutional Support and Funding Alignment: The BONEX DSS benefits from co-financing through the PRIMA initiative and strong institutional partnerships with local developers (BIOAZUL and Smart-Logger) and municipalities. The project builds on a decade of collaborative initiatives, including EU-funded projects like RICHWATER, which have established an innovation ecosystem of water reuse experimentation in Axarquía. This continuity of effort enhances stakeholder familiarity and increases the likelihood of long-term institutional support and integration into public programs.

Environmental and Economic Benefits: Reclaimed water contains significant concentrations of nutrients such as nitrogen and phosphorus. When effectively managed, these nutrients reduce the need for synthetic fertilizers, offering economic savings to farmers and reducing greenhouse gas emissions associated with fertilizer production. BONEX tool enables farmers to capitalize on this potential by optimizing nutrient applications, reducing environmental pollution risks, and supporting agroecological transition strategies.

Tailored and Locally Relevant Design: BONEX DSS is designed adapted to the specific agronomic conditions of Axarquía, including the needs of subtropical crops like avocado and mango. The tool integrates localized soil and water data to deliver context-specific recommendations. This tailored approach increases usability, relevance, and farmer confidence in the tool's recommendations. The potential development of functionalities such as automatic field notebooks can further increase its regulatory and practical value.

Stakeholder Engagement and Knowledge Sharing: The region benefits from well-organized irrigation communities and active collaboration between farmers, researchers, and local authorities. Entities such as IHSM-La Mayora, IFAPA, and the University of Málaga provide robust scientific backing for water reuse practices and tool development. BONEX has proactively built on this network through a series of workshops

and participatory events that ensure feedback loops between developers and end-users. This engagement enhances social acceptance and provides a foundation for early adoption.

Technological Flexibility and Future Scalability: BONEX DSS is designed as a modular, scalable platform capable of incorporating new features over time. It can potentially operate in offline mode for use in areas with poor connectivity. Furthermore, its data-driven structure allows for integration with other farm management systems and evolving policy requirements. These characteristics position it as a flexible digital solution with relevance beyond the current project scope.

Policy and Regulatory Synergies: BONEX tool supports policy goals under European and national strategies related to sustainable agriculture, water reuse, and climate change mitigation. Its functionalities align with legal requirements such as those of the Nitrates Directive, helping farmers track total nutrient input—including from reclaimed water—and comply with environmental standards.

4 Conclusions

The second BONEX stakeholder workshop in the Axarquía region provided a valuable platform for identifying key barriers and enabling factors related to the use of reclaimed water in agriculture and the implementation of the BONEX Decision Support System (DSS) for nutrient management. Conducted under the WEFE Nexus Bridging Framework (WEFEF), the workshop emphasized the importance of adopting a systems approach that considers the interconnected impacts of water reuse on energy, food production, and ecosystems.

Stakeholder discussions revealed a diverse set of challenges. Financial constraints, particularly the costs associated with the BONEX DSS subscription model and on-farm infrastructure, emerged as significant barriers—especially for smallholder farmers. Technical limitations, including poor digital connectivity in rural areas and insufficient public sector capacity to process permits, further hinder implementation. A widespread lack of familiarity with reclaimed water quality and nutrient dynamics was also noted, highlighting a need for targeted training and advisory services. Critically, the absence of clear regulatory guidance on nutrient accounting for reclaimed water use—and the limited institutional recognition of digital tools like BONEX DSS—undermines user confidence and slows adoption. Additionally, participants identified a limited perception among farmers of the long-term environmental risks associated with nutrient mismanagement, suggesting that more awareness-raising and education efforts are required.

Despite these barriers, several enabling factors provide a strong foundation for success. The region benefits from a mature innovation ecosystem, with long-standing collaboration among research institutions, local authorities, and farming communities. The BONEX DSS is well aligned with both agronomic needs—such as those of subtropical crops—and European environmental policy goals, including the Nitrates Directive. Its potential to reduce fertilizer use and greenhouse gas emissions offers compelling environmental and economic incentives. Moreover, ongoing stakeholder engagement activities foster trust, generate real-time feedback, and enhance tool usability and acceptance.

The insights generated from this participatory process will directly inform the development of the Nexus Bridging Plan (NBP) for Axarquía. The NBP will articulate a shared vision and propose actionable measures to overcome implementation challenges, promote nutrient-aware reuse practices, and ensure that reclaimed water use contributes positively to the region's water security, agricultural sustainability, and environmental integrity. Continued coordination among public institutions, farmers, and technology providers will be essential to translate this vision into lasting impact.