

NEXUS BRIDGING PLAN

RICHWATER software tool



Axarquía, **Spain**



This project is part of the PRIMA programme supported by the European Union.



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RICHWATER software tool

in Axarquía, **Spain**

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Framework Implementation in the
Mediterranean (BONEX), 2025

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BONEX Project is funded by PRIMA program



BONEX
Boosting Nexus Framework
Implementation in the Mediterranean



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PRIMA programme supported
by the European Union.



Executive summary

The Axarquía region in Southern Spain faces several challenges, primarily driven by chronic **water scarcity**, increasing agricultural water demands, and climate variability. Over the past decades, the expansion of subtropical fruit cultivation, particularly avocados and mangoes, has intensified irrigation demand, contributing to the overexploitation of surface and groundwater resources. This situation is further aggravated by prolonged droughts, increasing competition between urban and agricultural water uses, and growing energy demands for water distribution.

As part of the [BONEX project](https://bonex-prima.eu)¹, the WEFé Bridging Framework (WEFéF) was applied to evaluate potential solutions to the region's WEFé Nexus challenges and propose implementation pathways. The WEFéF provides a structured approach to evaluating and implementing interventions that address the complex interconnections of the WEFé Nexus in Axarquía and integrates multiple methods, including participatory workshops, stakeholder interviews, literature reviews, and surveys.

The present Nexus Bridging Plan (NBP) is the main outcome of this exercise. This NBP focuses on the assessment of the RICHWATER software tool, an innovation developed by BIOAZUL, aimed at optimizing nutrient management in irrigation with reclaimed water.

While the RICHWATER software tool demonstrates significant potential, stakeholder discussions identified implementation pathways to facilitate the uptake of RICHWATER software tool in the Axarquía region, including:

- **Targeting the Right Users and Facilitating Access** – Engaging farmers, cooperatives, and agricultural advisors to ensure effective adoption.
- **Implementing a Tiered Business Model** with

Demonstrations – Offering accessible pricing structures and real-world demonstrations to build confidence in the tool.

- **Building Trust and Enhancing Market Adoption** – Providing clear economic benefits, user testimonials, and transparent data on cost savings and efficiency.
- **Leveraging Institutional and Policy Support** – Aligning with regional agricultural and water management policies to ensure integration into broader governance frameworks.
- **Overcoming Connectivity and Digital Access Issues** – Ensuring offline functionality for areas with limited internet access and offering user-friendly digital solutions.
- **Promoting Behavioural Change and Adoption of Digital Agriculture** – Conducting training

sessions and awareness campaigns to support a transition toward precision irrigation practices.

- **Expanding Funding and Research Opportunities** – Securing public and private investment to enhance long-term viability and expand research on reclaimed water use.

The insights from this NBP serve as a foundation for future decision-making, guiding investments, policy design, and innovation toward a resilient and resource-efficient agricultural system in Axarquía.

This NBP focuses on the assessment of the RICHWATER software tool, an innovation developed by BIOAZUL, aimed at optimising nutrient management in irrigation with reclaimed water.

¹ <https://bonex-prima.eu>

Methodological approach

The **BONEX project** has implemented a comprehensive WEFe Bridging Framework (WEFEF) methodology to assess the interconnections within the Water-Energy-Food-Ecosystem (WEFe) Nexus and identify suitable interventions. WEFEF integrates multiple methods, including interviews, literature reviews, questionnaires, and participatory workshops. It relies on stakeholder feedback to pinpoint key challenges, prioritise interventions, and co-develop solutions. A central component of

WEFEF
can support policy processes for selecting technologies or interventions. However, it can also serve as a tool for experts who have already selected a technology based on their expertise, allowing them to analyse and evaluate its contribution to the Nexus and its potential to address existing challenges from a Nexus perspective



this approach is the use of Causal Loop Diagrams (CLDs) to visualise system dynamics through participatory processes. The culmination of this effort is the development of the present Nexus Bridging Plan (NBP).

WEFEF can support policy processes for selecting technologies or interventions. However, it can also serve as a tool for experts who have already selected a technology based on their expertise, allowing them to analyse and evaluate its



contribution to the Nexus and its potential to address existing challenges from a Nexus perspective. This NBP has followed the latter approach, assessing the RICHWATER software tool, which was proposed by the innovation company BIOAZUL.

RICHWATER is the outcome of extensive innovation efforts and previous research projects, and it plays a key role in enhancing the cost-effectiveness and sustainability of reclaimed water use in agriculture. By promoting efficient nutrient management, RICHWATER aligns with regional government policies, ensuring that efforts to expand reclaimed water utilisation remain consistent with existing water management strategies and environmental regulations.

Context description

The 'Axarquía' region is located in the eastern part of Málaga province, covering 1,025 km² and consisting of 31 municipalities (Figure 1). It is characterised by rugged terrain with limited plains and a Mediterranean climate, marked by sparse and torrential rainfall, complicating water management¹. The region's primary water resource is the Viñuela Reservoir, with a capacity of 165.4 hm³, serving both agricultural irrigation and drinking water supply. It falls under subsystem II-1 of the Mediterranean Basin Authority, which aligns with its administrative boundaries and contributes an **average annual flow of 129.6 hm³** from 10 surface water bodies. However, the demand for water, particularly from agriculture, is putting pressure on these limited resources².

Persistent droughts and increasing demand have **lowered reservoir levels to historic lows**, while groundwater reserves are showing signs of overexploitation, leading to declining piezometric levels and an increased risk of **saltwater intrusion** in coastal aquifers³. The **annual water deficit** is estimated to be between **17 and 32 hm³**, with irrigation accounting for the highest water consumption.

Authorities have responded with supply-side measures, such as integrating reclaimed wastewater and planning desalination infrastructure. In this context, the Axarquía region has been affected by several interventions regulated under the so-called Drought Decrees issued by the regional government of the *Junta de Andalucía* in response to the prolonged scarcity of water resources. These decrees include measures such as the implementation of tertiary treatments in wastewater treatment plants to increase the availability of reclaimed water for agricultural irrigation. As a result, the Axarquía **will have a total volume of 19.14 hm³ of reclaimed water for irrigation**. The public investment by the Junta de Andalucía to provide reclaimed water to the farmers of the Axarquía **exceeds 42.14 million euros** across the approved Drought Decrees⁴.

Recent developments have expanded the availability of reclaimed water. Following the implementation of tertiary treatments at the *Torrox-IARA* and *Torrox-Arroyo Manzano* wastewater treatment plants (WWTPs), **a temporary authorisation has been granted for 1.14 hm³ annually, benefiting 570 hectares** belonging to the Central Users Board of the South of *Guaro*, while the definitive concession is being processed⁵. Similarly, the *Algarrobo* WWTP received **temporary authorisation on June 23 for**

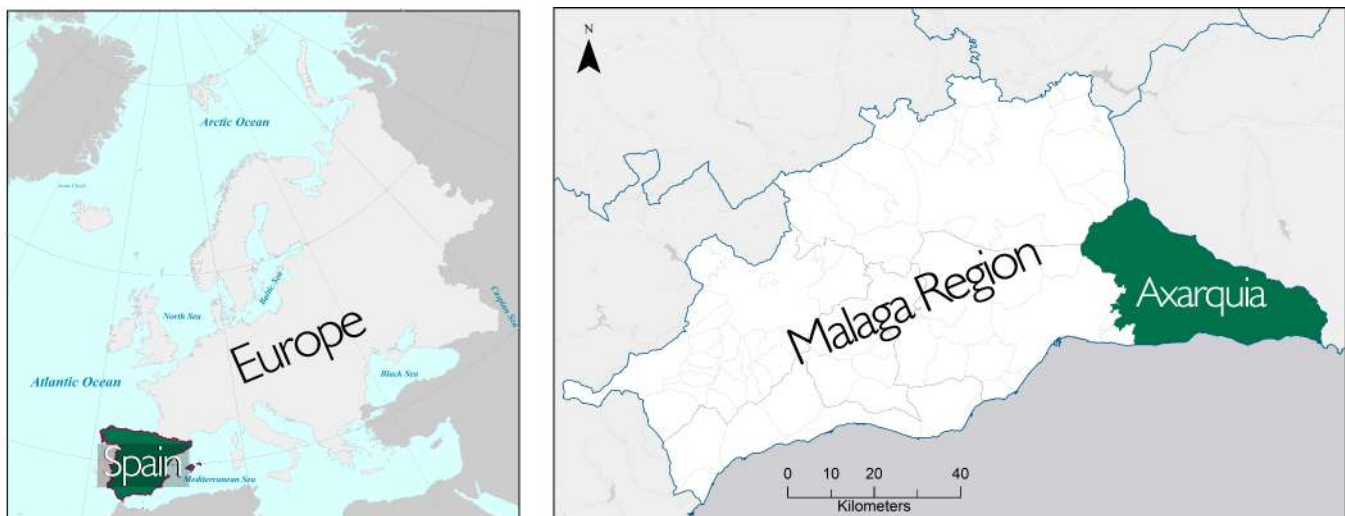


Figure 1 – Map of the region of 'Axarquía' ('Málaga', Spain).



0.77 hm³, benefitting over 400 hectares within the Algarrobo Irrigation Community, pending a final concession^{5,6,7}. These initiatives contribute to the region's growing reliance on unconventional water sources for sustainable agricultural practices.

The region has undergone a major agricultural transformation, with a shift from traditional crops to subtropical fruit cultivation, such as avocados and mangoes, **which now consume 76% of total agricultural water use³**. The shift toward these high-value, water-intensive crops has significantly increased irrigation demand, far exceeding the official water concessions allocated by the basin authority⁴. Farmers often rely on deficit irrigation techniques, groundwater extraction (both legal and illegal), and trade between water entitlement owners to sustain production, further straining water resources.

Unconventional water sources, such as reclaimed water, have been introduced as part of short-term solutions, with ongoing efforts to integrate them into long-term agricultural water management strategies. However, reclaimed water quality remains variable, with challenges related to salinity, nutrient content, and pollutant removal, requiring substantial investments in monitoring technologies and irrigation infrastructure upgrades⁸.

Population growth, driven by migration and tourism, has significantly increased water demand. The population expanded **from 143,000 in 1998 to over 228,000 in 2023⁹**, with tourism pushing **seasonal water consumption 60% higher than the national average¹⁰**. High water losses in urban infrastructure exacerbate the problem, **with distribution network losses exceeding 24%¹¹**.

WEFe Nexus issue

The first participatory workshop, Water-Energy-Food-Ecosystem (WEFe) Nexus challenges in the Axarquía region are driven primarily by structural water scarcity, agricultural intensification, and climate variability. The expansion of subtropical fruit cultivation (avocados and mangoes) has led to increased irrigation demand beyond official water allocations. This over-reliance on irrigation has resulted in overexploitation of surface and

groundwater resources, exacerbated by prolonged droughts and a highly seasonal rainfall pattern. The consequences of these pressures extend across the WEFe nexus, creating significant environmental, economic, and social trade-offs. The imbalance between water supply and demand has been a central issue identified in the first participatory BONEX workshop. This is clearly reflected in the Causal Loop Diagrams (CLD) ([Figure 2](#)).

¹ IFAPA -IFAPA - Instituto de Investigación y Formación Agraria y Pesquera, 2025. List of Weather Stations In Málaga Province [in Spanish]. [URL](#)

² Junta de Andalucía, 2025. Viewer of Andalusian reservoirs [in Spanish]. [URL](#)

³ Hurtado, A. R., Díaz-Cano, E., & Berbel, J. (2024). The paradox of success: Water resources closure in Axarquía (southern Spain). *The Science Of The Total Environment*, 946, 174318. [URL](#)

⁴ Axarquía Plus. (2023, 17 agosto). *La Junta autoriza el uso de nuevas aguas regeneradas a regantes de la Axarquía para aliviar el impacto de la sequía. AxarquíaPlus*. [in Spanish]. [URL](#)

⁵ Zea, Á. (2023, 17 agosto). *La Junta autoriza el uso de nuevas aguas regeneradas a regantes de la Axarquía para aliviar el impacto de la sequía. Europapress.es*. [in Spanish] [URL](#)

⁶ Málaga Hoy. (2023, 17 agosto). *La Junta autoriza el uso de nuevas aguas regeneradas a regantes de la Axarquía. Málaga Hoy*. [in Spanish] [URL](#)

⁷ El Español. (2023, 17 agosto). *La Junta de Andalucía saca pecho de su política del agua en La Axarquía frente a la «dejadez» del Gobierno. El Español*. [in Spanish] [URL](#)

⁸ Junta de Andalucía, 2024. Annual Land Price Survey 2023 [in Spanish]. [URL](#)

⁹ INE - Instituto Nacional de Estadística. (2025). *Málaga: Población por municipios y sexo. INE*. [URL](#)

¹⁰ Cabezas, E. (2023, 6 july). Municipalities of the Axarquía are unable to reach a consensus on measures to save water. *Diario Sur*. [in Spanish] [URL](#)

¹¹ Cabezas, E. (2023a, june 30). Velez-Málaga and at least five other villages of the Axarquía cut water at night. *Diario Sur*. [in Spanish] [URL](#)

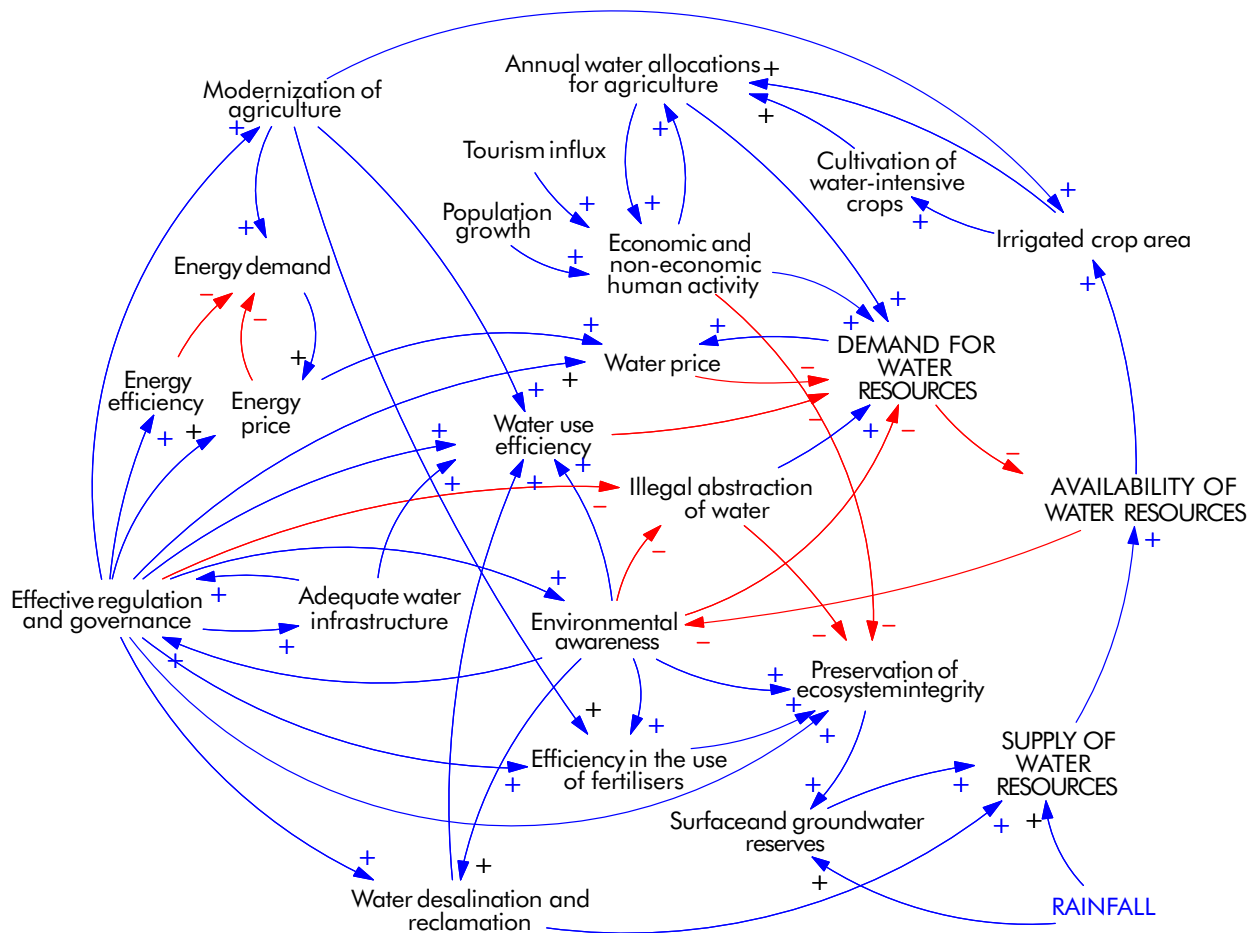


Figure 2: Causal Loop Diagram for Axarquía. A version of this figure has been published with open access in: (Hurtado et al., 2024)³.

The use of reclaimed water is one of the most promising solutions of interest to stakeholders, and significant efforts have been made by regional authorities to facilitate its use for irrigation. However, stakeholders, especially farmers, raised concerns about **high salinity levels** in this water, detrimental to salt-sensitive subtropical crops. This salinity issue stems from **seawater intrusion into wastewater systems**, which current treatment plants are not able to eliminate. Additionally, there is a **knowledge gap among farmers** regarding effective irrigation management with reclaimed water, particularly in leveraging its nutrient content to reduce fertiliser usage. While reclaimed water can provide essential nutrients, improper management can lead to either nutrient deficiencies or excesses, increasing the risk of soil degradation and diffuse pollution. The workshop highlighted the necessity for

enhanced planning and infrastructure to ensure water quality and the development of **tailored management tools** to optimise reclaimed water use in agriculture.

Environmental groups and activists did not participate in the workshop but were interviewed to share their perspectives. These stakeholders generally highlight that the shift to monoculture farming has contributed to biodiversity loss, soil degradation, and increased dependence on chemical inputs, affecting water quality and ecosystem health. Additionally, the energy demands of intensive irrigation and water transportation have elevated agriculture's carbon footprint, increasing its vulnerability to rising energy costs and emissions regulations. Saltwater intrusion in coastal aquifers further threatens water quality, adding complexity to future resource management.

Non-monetary values

A **non-monetary value assessment** was conducted in *Axarquía* to identify and assess the various types of value and dimensions of human-nature connections, which extend beyond the monetary or market-based values associated with WEF components. It seeks to uncover the additional benefits that the WEF nexus can generate within a specific social-ecological context or local community.

Through **14 surveys** with actors in agriculture, water management, and local development, the study revealed a strong **emphasis on the practical value of natural resources**, particularly **water and energy**, which are seen as essential for the region's **agricultural economy**, especially for subtropical fruit production.

While economic concerns were predominant, many respondents also acknowledged **the cultural, emotional, and ecological significance** of the land. These included deep ties to **local**

ecosystems, cultural heritage, and a shared belief in the **fundamental importance of nature**, highlighting a strong commitment to sustainability) (*Figure 3*).

The findings show a predominantly **positive connection to the environment**, although concerns about **climate change and resource scarcity** remain. Respondents demonstrated a good understanding of local ecosystems but identified room to enhance awareness and involvement.

Interestingly, the results revealed a **contrast between stakeholder input in surveys and workshops**. Workshop discussions were more focused on **immediate, sector-specific solutions** like expanding reclaimed and desalinated water use, while the surveys reflected **broader values**, including long-term **ecological and cultural considerations**. This highlights how **engagement formats influence stakeholder expression**, underlining the importance of combining methods for a more comprehensive understanding of priorities within the WEF Nexus.

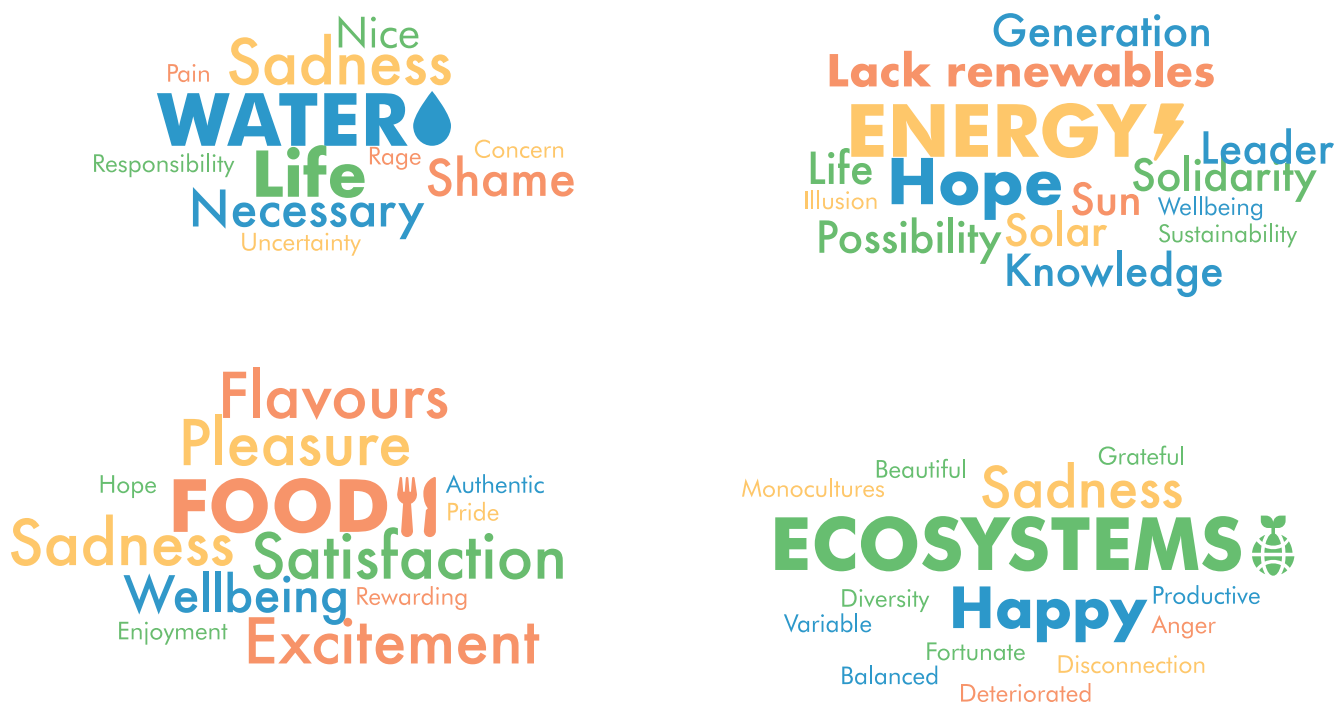


Figure 3 – Word cloud from interviews conducted.

WEFe solution: RICHWATER tool – a software app

The intervention in *La Axarquía* focuses on improving nutrient management in reclaimed water used for agricultural irrigation. At its core is the RICHWATER software tool, developed under the BONEX demonstration project by Bioazul and SmartLogger, to support efficient and sustainable fertigation practices.

This initiative responds to a critical environmental challenge: the risk of nutrient overload and diffuse pollution from improper use of reclaimed water. Stakeholders have voiced concerns about the impact of these imbalances on water quality and ecosystem health. At the same time, they advocate for supply-side solutions, such as reclaimed water, to address the region's severe water scarcity. The intervention aims to ensure that reclaimed water contributes not only to agricultural resilience but also to the preservation of ecosystems, a key but often neglected element of the WEFE (Water-Energy-Food-Ecosystems) Nexus.

The **RICHWATER tool** helps farmers calculate the nutrient contribution of reclaimed water and

determines the optimal, cost-effective fertiliser mix needed to complete crop nutrition. This is based on a regional database of commercial fertilisers, allowing tailored recommendations that are both agronomically effective and environmentally safe. The **RICHWATER tool** delivers key benefits for agriculture in *Axarquía*. It helps prevent **nitrate contamination of groundwater** by avoiding over-fertilisation, reduces fertiliser costs by accounting for nutrients already present in reclaimed water, and cuts the carbon footprint of farming by decreasing reliance on synthetic fertilisers (Figure 4).

Barriers and facilitating factors

Barriers and opportunities to implement RICHWATER software tool were collaboratively identified with stakeholders during the 2nd BONEX participatory workshop (Figure 5). 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 findings from this session (i.e. barriers and opportunities) are shown below and serve as a



Figure 4 – Calculation advantage of the application.



foundation for developing a well-informed and tailored implementation strategy (see next section), ensuring that the tool aligns with the needs, expectations, and operational realities of end users.

Barriers:

- **Costs:** The RICHWATER software tool will operate through a subscription model. Some farmers may not perceive enough value in the tool to justify the subscription cost. The price of the tool has not yet been set but is expected to range between €100–150/month.
- **Abundance of tools:** The high competition in the smart irrigation tools market makes it difficult for **RICHWATER tool** to position itself as the preferred option. Many other smart or precision irrigation tools exist, and this abundance of information and solutions may discourage farmers from adopting in such a competitive market.
- **Need for training:** Although the tool is designed to be easy to use, some farmers may require additional training to use it effectively, including understanding input data, interpreting recommendations, and troubleshooting technical issues.
- **Connectivity issues:** In remote areas, the lack of internet connectivity or reliable electricity access may hinder the use of digital tools.
- **Resistance to change:** Some farmers may be reluctant to adopt new technologies or modify

traditional practices, especially if they perceive that the benefits will only materialise in the long term or are uncertain.

Opportunities:

- **Network of stakeholders:** There is an established relationship with farmers and local authorities, strengthened by previous projects such as RICHWATER.
- **Continuity of funding:** The trajectory of innovation projects at this experimental site, which is considered a “Living Lab,” presents an opportunity to secure additional projects that expand the tool’s functionalities, provide further information on the impact of reclaimed water use, and gather more real-scale data.
- **Environmental and economic benefits:** The tool optimises nutrient management, reducing the need for fertilisers and minimising nutrient runoff.
- **Personalised recommendations:** RICHWATER tool offers tailored recommendations for the specific crops of the *Axarquía* region (such as subtropical crops) and local conditions.
- **Regulatory alignment:** RICHWATER tool helps farmers comply with environmental regulations and initiatives. For example, it supports compliance with the EU Nitrates Directive by monitoring and managing applied nutrients. One of the functionalities under consideration is the potential to generate a field notebook as required by the Nitrates Directive.



Figure 5 – Second BONEX participatory workshop.

- **Training activities in projects:** Workshops and meetings organised by the BONEX project and other related projects in the region, such as *AXARQUÍA SOSTENIBLE* or P2GREEN, facilitate knowledge-sharing, success stories, and best practices.

Implementation pathways

To ensure the successful implementation of the RICHWATER software tool in La Axarquía, a strategic and multifaceted approach is essential—one that brings together technological innovation, stakeholder engagement, financial feasibility, and supportive policies. Recognising the complexity of adopting digital solutions in agriculture, the BONEX project organised a third participatory workshop to identify practical measures to boost adoption and ensure long-term impact. The outcomes of this workshop point to several key areas for action:

1. Tailoring the Tool to the Right Users and Bridging Knowledge Gaps

Although farmers are the main beneficiaries, they may not be the most consistent users of digital tools due to time constraints and digital unfamiliarity. Participants emphasised the role of agricultural technicians, cooperatives, and irrigation communities in promoting and managing the tool. Moreover, they stressed the need for training not just on the tool itself, but also on nutrient management practices when using reclaimed water—a context where traditional fertilisation strategies often fall short. Empowering users to interpret soil and water analysis data emerged as a critical enabler of adoption.

2. Adapting the Business Model and Demonstrating Value

Cost was not seen as a barrier itself, as long as the tool demonstrates economic savings. Participants suggested a tiered subscription

model adapted to various user profiles, including smallholders, cooperatives, and commercial farms. To encourage uptake, a free trial period and live demonstration plots were proposed as effective ways to showcase real-world benefits such as improved yields and reduced input costs. Integrating features like a fertiliser footprint tracker could also help visualise environmental impact and bolster the tool's sustainability value.

3. Building Trust and Strengthening Market Adoption

Scepticism toward new technologies remains a hurdle. Farmers are more likely to adopt a tool when they see results for themselves—preferably through trusted channels. Therefore, marketing efforts should focus on economic advantages, using clear messaging and testimonials from successful users. In parallel, official endorsements, such as a quality certification or inclusion on government websites, can boost credibility. Aligning the tool with sustainability certification programs like GLOBAL.G.A.P or organic farming standards would further increase its appeal.

4. Securing Institutional and Policy Support

Although public institutions wield significant influence, their involvement often depends on clear policy incentives. The workshop underlined the importance of engaging regional administrations, environmental agencies, and water governance bodies in the process. By integrating features that support compliance with the EU Water Reuse Regulation, the Nitrates Directive, and water efficiency rules, RICHWATER can become a valuable tool for policy implementation—and thus benefit from broader institutional backing.

5. Tackling Connectivity Challenges

In many parts of *Axarquía*, poor internet connectivity and unreliable electricity limit access to digital tools. Participants called for a robust



offline functionality that allows farmers to use the tool in the field and sync data when a connection is available, ensuring usability even in remote areas.

6. Promoting Behavioural Change and Digital Readiness

Resistance to change is common, particularly when the benefits of digital agriculture are not immediate or tangible. To shift mindsets, it's vital to share real success stories through local media, farmer networks, and events, making the tool's advantages visible and relatable. Continuous engagement through community-based awareness campaigns will help normalise its use.

7. Ensuring Long-Term Financial and Technical Viability

Finally, ensuring that RICHWATER evolves, and scales requires sustained investment. This includes accessing European and regional funding programs (e.g. Horizon Europe, PRIMA, LIFE+) and fostering public-private partnerships with cooperatives, agritech firms, and fertiliser companies. Ongoing research collaborations with academic institutions will also be key to keeping the tool scientifically robust and technologically relevant.

Other complementary actions within the Nexus approach

The RICHWATER tool plays a crucial role in enhancing the WEFE Nexus by optimising nutrient management in agriculture, ensuring a more efficient, sustainable, and integrated approach to resource use. However, it cannot be regarded as a standalone solution to address all the challenges outlined in the WEFE Nexus framework. Additional complementary measures must be adopted beyond the proposed solutions. Key actions include:

- **Enhancing irrigation efficiency:** The adoption of advanced irrigation techniques, such as drip irrigation, deficit irrigation, and precision fertigation, can significantly reduce water consumption while maintaining or even improving crop productivity. Encouraging farmers to adopt smart irrigation scheduling systems based on real-time data can further optimise water use.
- **Preventing water losses in the distribution network:** Leakage prevention and maintenance programs should be prioritised to minimise water losses in irrigation and urban water supply networks. Investments in modernising aging infrastructure, installing smart meters, and implementing real-time monitoring systems can improve water management efficiency and ensure that available resources are utilised effectively.
- **Transitioning to more climate-resilient crops:** Given the increasing climatic pressures and water scarcity in the region, shifting towards drought-resistant, high-value crops is a crucial adaptation strategy. Crops such as passion fruit and dragon fruit, which require less water than traditional subtropical crops, offer a promising alternative for farmers in *La Axarquía*. Insights from the operational group *Axarquía Sostenible* should be incorporated to guide farmers in selecting resilient and economically viable crops that align with sustainable agricultural practices.
- **Promoting agroecology and regenerative farming:** Moving towards agroecological approaches can enhance soil health, water retention, and biodiversity, reducing dependency on synthetic inputs while improving farm sustainability. Encouraging cover cropping, crop rotation, organic matter enrichment, and conservation tillage can help farmers adapt to water constraints while maintaining long-term productivity.

By integrating these measures into a comprehensive Nexus-based strategy, La Axarquía can strengthen its water security, improve agricultural sustainability, and enhance the resilience of local ecosystems, ensuring a balanced and future-proofed approach to resource management.

Performance Indicators

While the tool applies to any type of crop, its primary aim is to optimise nutrient management, particularly in water-intensive crops such as avocados and mangoes. The tool helps reduce the need for chemical fertilisers which can lead to significant cost savings.

The performance of the tool can be measured through reductions in fertiliser use. For instance, in modelled cases of young mango and avocado plantations, the use of fertilisers decreased by 68% and 79%, respectively. These are very promising figures, demonstrating the tool's effectiveness in reducing the reliance on chemical fertilisers. This reduction in fertiliser results in cost savings and also helps lower the environmental impact of agriculture.

Overall, the intervention integrates all four components of the WEFE Nexus—ensuring water efficiency, supporting food production, reducing energy-intensive inputs, and safeguarding ecosystems—thus contributing to a more sustainable and resilient agricultural system in the region.

REWEFe analysis for 'Axarquía' region

As part of the BONEX project, the REWEFe (Resource Efficiency within the Water-Energy-

Food-Ecosystems Nexus Framework) was applied to the Axarquía region to assess the impacts of improved nutrient management practices in agriculture, particularly when using reclaimed water for irrigation. The analysis explored how different nutrient management strategies affect the interconnected dimensions of the WEFE Nexus—water use, food production, energy inputs, and ecosystem health.

The results presented focus on scenario S1 and S2 (Figure 6), allowing comparison with the baseline to highlight the synergies, trade-offs, and sustainability benefits of adopting precision fertigation practices supported by tools like RICHWATER.

Key outcomes:

- Better nutrient management has a positive impact on the ecosystem as there is less nutrient leaching and less CO₂ emissions driven from fertilizer application.
- Due to the higher nutrient uptake fraction, food production is higher in S1 and S2, where the nutrient management system is in place. This is also reflected in the nutrient stress levels reported for all the scenarios, with no nutrient stress prevalent in the upscaled scenario.
- The system reports an overall blue water stress of 35%, which indicates that the demands within the nexus unit are higher than the blue water available. Blue water is the sum of runoff, desalinated water, groundwater pumped, external inflows and reclaimed water.
- Improved nutrient management minimises fertiliser application and subsequent nutrient leaching, contributing towards a healthier ecosystem. It also results in higher food production as the nutrient stress levels faced by the crops are minimised. No trade-offs are reported for this scenario analysis as the use of reclaimed water and efficient nutrient management positively impact both the environment and food production.



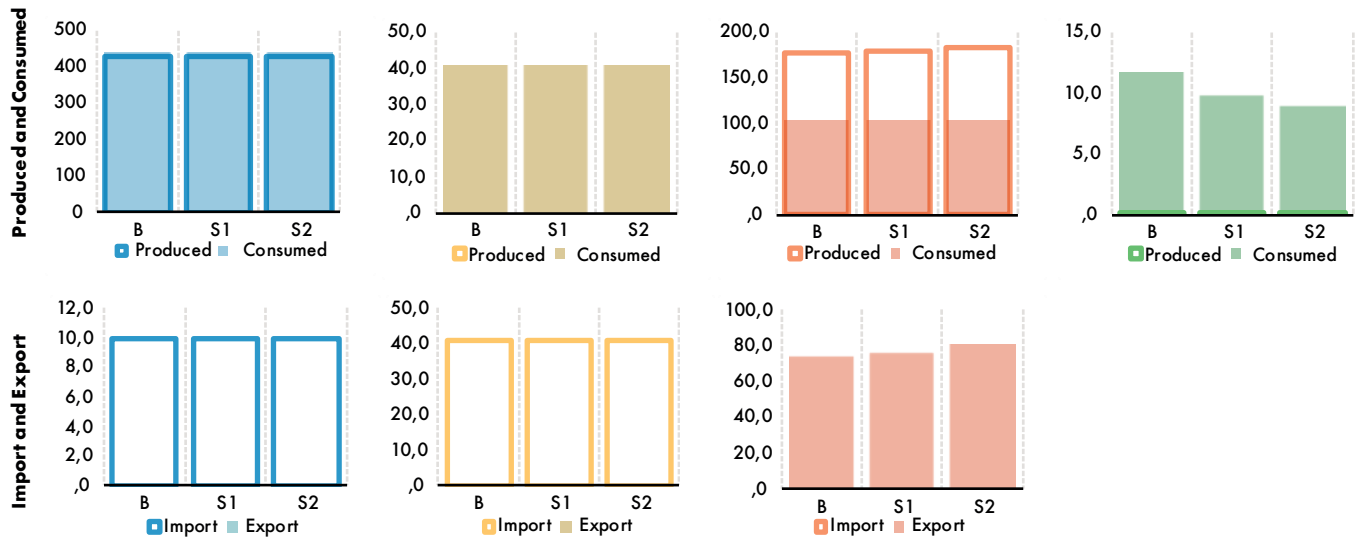

WATER
(MCM/y)


ENERGY
(GWh/y)


FOOD
(Mkg/y)


ECOSYSTEM
(mEUR/y)

RESULTS



CHANGE COMPARED TO BASELINE

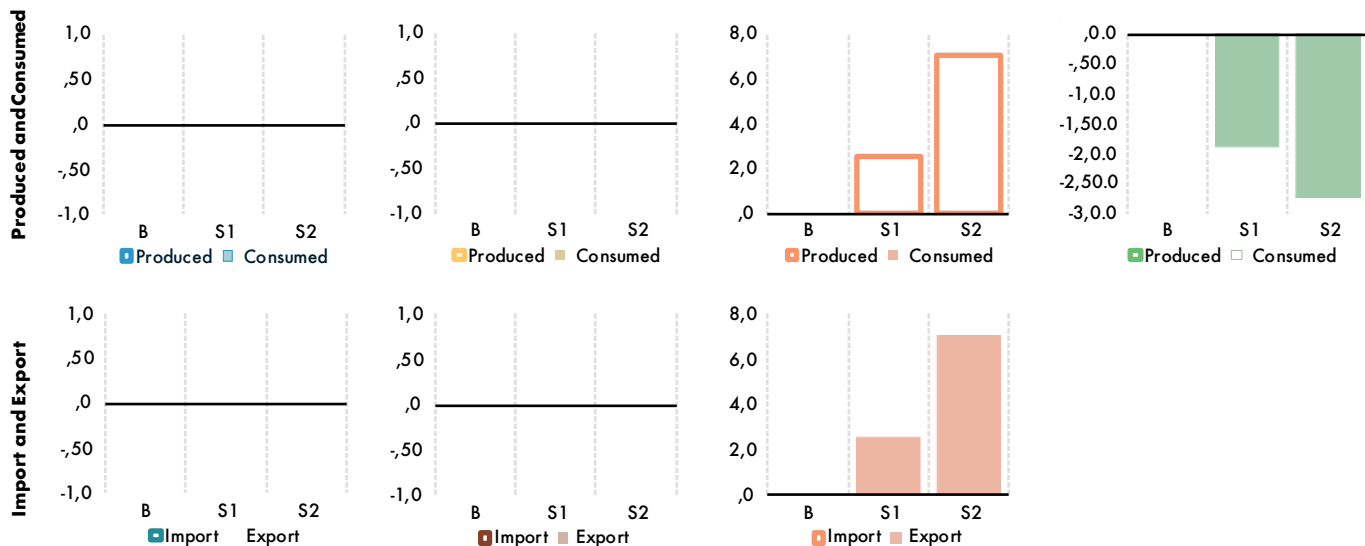


Figure 6 – Results of the three REWEF scenarios: **Baseline (B)** - Reflects current conditions in 'Axarquía', where no formal nutrient management system is in place; **Scenario 1 (S1)** - Assumes increased efficiency in fertiliser application; **Scenario 2 (S2)**: Represents an upscaled scenario with broader adoption of optimal nutrient management by farmers.

Conclusion

The Nexus Bridging Plan (NBP) for Axarquía has provided a comprehensive evaluation of the WEF Nexus challenges and assessed the potential of RICHWATER, a digital tool for nutrient management in reclaimed water irrigation, as a promising intervention.

The analysis confirms that the RICHWATER tool can contribute to addressing key water and agricultural challenges, particularly by enhancing the efficiency of reclaimed water use in irrigation, reducing fertiliser overuse, and minimising environmental pollution. By supporting more precise nutrient application, the tool also has the potential to reduce input costs for farmers and improve soil and water quality, reinforcing a more sustainable agricultural system.

However, while RICHWATER presents an important step forward, it is not a standalone solution to Axarquía's WEF Nexus problems. Its successful implementation and upscaling require complementary measures that address both technical and socio-economic barriers. The use of reclaimed water remains limited not only due to salinity and water quality concerns but also because of farmers' hesitancy and knowledge gaps regarding its effective use. To maximise RICHWATER's impact is required an investment in water treatment, especially salinity control, as well as capacity-building programs so farmers can effectively adopt reclaimed water irrigation practices.

Moreover, the adoption of digital tools in agriculture often requires economic incentives or policy-driven support to overcome reluctance toward new technologies.

The findings of the NBP also highlight that broader WEF Nexus challenges in Axarquía demand a holistic strategy that extends beyond nutrient management in reclaimed water. While digital solutions like RICHWATER optimise efficiency at the farm level, they do not address structural water scarcity, ecosystem degradation, or energy dependency, which are deeply interconnected in the region's socio-environmental system. Future interventions should explore advancing irrigation efficiency through smart technologies, investing in alternative water sources such as desalination, and promoting sustainable land use

planning to diversify cropping patterns and reduce the overreliance on high-water-demand crops. Additionally, the issue of groundwater overexploitation remains a persistent challenge that must be addressed through stronger governance measures, ensuring more equitable water distribution while curbing illegal extractions.

Looking ahead, climate change and socio-economic trends will further shape the region's resource challenges, making long-term planning essential. Prolonged droughts and shifting precipitation patterns will increase pressure on water availability, potentially exacerbating competition between urban and agricultural users. Rising energy costs may limit energy-intensive solutions like desalination or advanced irrigation, reinforcing the need to integrate renewable energy sources in water and agricultural management. Shifting agricultural markets and regulations will likely shape farmer decision-making, particularly as sustainability standards and environmental restrictions become stricter at national and European levels.

The present NBP serves as a strategic tool to navigate these complexities, offering both an evaluation framework and a roadmap for action. Policymakers, water managers, and stakeholders can use this document to prioritise interventions, ensuring that solutions are not only technologically sound but also socio-economically viable and environmentally sustainable.

Ultimately, the NBP should be seen as a living document, one that can be revised and expanded as new data emerges and as regional challenges evolve. It offers a multi-sectoral perspective that is essential for guiding future investments, governance reforms, and technological advancements, ensuring that Axarquía's water, energy, food, and ecosystems are managed in a truly integrated and sustainable manner.



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 Jordan

German Jordanian University
IUCN-ROWA

 Lebanon

American University of Beirut
NOVAENERGIA

 Morocco

Agronomic and Veterinary Institute Hassan II

 Tunisia

SmartLOGGER
National Institute for Research in Rural
Engineering Water and Forests - INRGREF



This project is part of the
PRIMA programme supported
by the European Union.