Term Paper

Submitted as part of the Circular Innovative Bootcamp 2025 for the STARS EU Blended Intensive Programm (BIP), organized by: Universidad de la Laguna (Spain), Hochschule Kempten – University of Applied Sciences (Germany), Instituto Politécnico de Bragança (Portugal), Kaunas university of technology (Lithuania) and Universiteti “Aleksandër Moisiu” Durrës (Albania)

Circular Economy in Tenerife: Case Studies & Joint Recommendations for a Sustainable Future

Author: All 31 Students of the Circular Innovative Bootcamp 2025

Course: Circular Innovative Bootcamp

Submission Date: 30.11.2025

Table of Contents:

List of Figures

1. Introduction:

1.1 Relevance of Sustainability & Circular Economy for Tenerife

The relevance of sustainability and the circular economy for Tenerife is beyond an idealistic goal, it is an absolute necessity for its survival and future prosperity. The island's environment and economic model make this change urgent and critically important.

Tenerife is a microcosm of biodiversity and unique landscapes, but its resources are finite. Therefore, the island faces real issues related to:

- Water scarcity: traditional agriculture and tourism consume vast amounts of water. The circular economy promotes water reuse and recycling, treating and reusing greywater and blackwater for agricultural irrigation and golf course maintenance, reducing the strain on aquifers and desalination plants, which are energy-intensive consuming; and rainwater harvesting, implementing systems to capture and store rainwater for non-potable uses.
- Waste management: the current "take-make-dispose" linear model is unsustainable. Shifting to a circular model means treating waste as a resource. Organic waste can be composted for agriculture; plastic, glass and paper can be recycled into new products; and non-recycle waste can be explored for energy recovery, drastically reducing landfill use.
- Biodiversity and land protection: sustainability ensures that economic activities do not degrade its natural assets such as Teide National Park. This includes controlling urban sprawl, protecting natural habitats from pollution, and promoting organic farming that preserves soil health.

Tenerife's economy is overwhelmingly dependent on tourism. A degraded environment directly threatens its primary industry, since modern travelers are increasingly "eco-conscious", so they choose destinations based on their environmental credentials. By embracing sustainability, Tenerife can future-proof its tourism industry. A clean, green, and well-preserved island is a more attractive and competitive destination. This includes promoting eco-tourism, green hotels, and local, sustainable experiences. Moreover, the circular economy creates new business opportunities beyond tourism. This includes businesses in recycling, repair, remanufacturing, renewable

energy installation, and sustainable agriculture. As an island, Tenerife imports a great amount of its goods, including food and energy, making it vulnerable to supply chain disruptions and high costs. Therefore, promoting a “local loop” by supporting local agriculture, using local materials in construction, and generating its own renewable energy, increases economic sovereignty and keeps money within the local economy.
Sustainability is also about creating a liveable, healthy, and equitable society for the local people in Tenerife. For example, local production of food and energy can help stabilize and reduce prices for residents; cleaner air from reducing the usage of fossil fuel, less pollution in the sea and on land, produce directly improve local public health; and sustainable models often strengthen local communities by supporting small-scale farmers, artisans, and entrepreneurs, preserving the Canarian culture against the homogenizing effect of mass tourism.
All in all, for Tenerife, sustainability and the circular economy are the only viable path forward. It is a strategy to protect its fragile and world-renowned environment; future-proof its vital tourism economy; build a more resilient, diversified and prosperous economy; and ensure a high quality of life for its residents. The shift is already underway but accelerating it is essential for Tenerife to remain a paradise, not just for tourists, but for generations of Tinerfeños to come.

1.2 Project CIB25 and Task Description

This Circular Innovation Bootcamp is framed in Europe’s agenda for sustainable growth and, specifically, in the Circular Economy Action Plan (CEAP) adopted by the European Commission in March 2020. It responds to the need for an economic model that reduces pressure on natural resources by decoupling economic growth from the consumption of finite resources, aiming to transform our current linear economic model — which is unsustainable — into a robust circular one.

In this framework, the 9th edition of CIB (designed as a Blended Intensive Programme, BIP) introduces circular thinking with the goal of applying it to business model innovation and eco-design. It trains students to analyse and develop business ideas that are desirable, viable, and circular at the same time, adapting to the global challenges currently being faced. The programme is structured around four learning pillars: circularity, innovation, teamwork, and business practice.

CIB25 is divided into three phases to build successfully the skills needed in circularity and sustainable business modelling, offering both theoretical knowledge and practical challenges. After the initial phase (online sessions) and the mobility phase comes the phase relevant for the final task: the documentation phase.

In this third phase, and after working with firms in Tenerife that are facing sustainability challenges that can be addressed with the theoretical concepts learned in the previous phases, we must capture the insights gained and the solutions developed in both oral and written documentation.

This document is the collective result of each team's individual work, describing what has been learned from CIB25 and the outcomes of the consulting work carried out for each firm.

1.3 Aim, Structure and Methodology of the Paper

The aim of this paper is to analyse the sustainability and circular economy practices of six organisations in Tenerife—Hotel Tigaiga, Balten, Tagua, WOOPTIX, Teidagua and Loro Parque—to identify existing gaps, improvement potentials and strategic levers that can accelerate the island's transition toward a more circular and sustainable economic system. This is guided by the central research question: ***"Which gaps and improvement potentials exist in the sustainability and circular economy practices of Tenerife's companies, and how can targeted solutions strengthen the island's long-term environmental, social and economic sustainability?"***

To address this question, the paper follows a structured approach. **Chapter 2** outlines the theoretical foundations of sustainability, sustainable business models, circular economy principles and the stages of circular transformation. **Chapters 3–8** present the six case studies, following a structure including company profiles, assessment of current sustainability practices, improvement potentials and proposed solutions, as well as an assessment of environmental, social and economic impacts. Building on the individual case analyses, **Chapter 9** synthesises the cross-case findings, compares circularity impacts and formulates joint recommendations for Tenerife. A detailed overview of individual work contributions is provided in **Appendix 1 (Work Contribution Table)**.

This paper applies a qualitative, multi-method research design that combines documentary analysis, comparative case studies, and structured analytical frameworks to examine circular economy practices across six organisations in Tenerife. Primary data sources include sustainability reports, environmental statements, company documents, on-site observations, and interviews or conversations conducted during company visits, complemented by scientific and institutional literature.

Overall, the structure and methodology of this paper are designed to provide a coherent, research-based and practice-oriented assessment of Tenerife's current circularity landscape, enabling the identification of targeted interventions that can meaningfully enhance the island's sustainability performance.

2. Theoretical Framework

This chapter establishes the theoretical foundation of the paper by defining and contextualising the key concepts of sustainability, sustainable business models and the circular economy. These concepts provide the analytical lens through which the following case studies are examined and enable a systematic assessment of sustainability and circular economy practices among the analysed companies in Tenerife.

2.1 Definition Sustainability & Sustainable Business Models

In order to analyse and evaluate sustainability practices in real-world organisations, a shared conceptual understanding of both sustainability and sustainable business models is essential. The following section therefore introduces and clarifies these concepts, forming the basis for the subsequent analytical discussions.

2.1.1 Definition Sustainability

Sustainability is a highly contested and multi-interpretable concept that lacks a universally accepted definition. The following subsections therefore seek to clarify its meaning, distinguish it from related concepts and introduce its key dimensions within an academic context (Dimitrov, 2010).

2.1.1.1 General Definition of Sustainability

There is an ever-increasing number of definitions of sustainability in academic literature, the media and the public domain, reflecting the diverse ways in which the concept is interpreted and applied (Dimitrov, 2010). It has been described as a highly charged and debated term that evokes strong reactions across a range of intellectual and academic disciplines (Dimitrov, 2010). Many of these definitions combine elements of scientific fact, theoretical interpretation and moral justification, with some rooted in historical discourse and others based on normative or intuitive reasoning (Cheney et al., 2004, as cited in Dimitrov, 2010).

A decisive milestone in the sustainability discourse was the publication of the Brundtland Report, which defined sustainable development as meeting present needs without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987, as cited in Dimitrov, 2010). Although this definition is frequently used as a starting point in sustainability-related discussions, it has not fully resolved the conceptual ambiguity surrounding the term (Dimitrov, 2010).

In addition, scientific, political, cultural and symbolic interpretations of sustainability are often used interchangeably, further reinforcing its ambiguous character (Dodds, 1997, as cited in Dimitrov, 2010). More recent research likewise confirms that the absence of a standardised and universally agreed definition remains one of the fundamental challenges in sustainability studies (Moore et al., 2017).

2.1.1.2 Distinction between Sustainability, Corporate Social Responsibility and Environmental Protection

Although the terms sustainability, corporate social responsibility (CSR) and environmental protection are often used synonymously, they represent conceptually distinct approaches (Heinberg, 2010).

Sustainability refers to a long-term, systemic concept that seeks to balance environmental, social and economic dimensions in order to maintain the viability of both natural and human systems without exceeding ecological limits (Heinberg, 2010).

Environmental protection, in contrast, focuses more narrowly on preventing environmental degradation through measures such as pollution control, biodiversity conservation and ecosystem restoration (Bansal, 2013). CSR, meanwhile, refers to voluntary corporate responsibilities towards society and stakeholders, including ethical labour practices, environmental engagement and community involvement. However, it is frequently criticised for failing to fundamentally transform existing business models (Sánchez-Teba et al., 2021; Carroll, 1999, as cited in Sánchez-Teba et al., 2021).

In summary, environmental protection addresses specific ecological issues, CSR frames corporate social and ethical responsibilities, whereas sustainability constitutes a broader and more integrated long-term concept that encompasses and extends beyond both approaches (Heinberg, 2010; Sánchez-Teba et al., 2021; Bansal, 2013).

2.1.1.3 The Three Pillars of Sustainability

In response to the conceptual ambiguity surrounding sustainability, academic and political discourse commonly refers to the three-pillar model, which distinguishes between the environmental, social and economic dimensions of sustainable development (Purvis et al., 2019). Often visualised as overlapping circles, the model places sustainability at their intersection, emphasising that long-term viability depends on the balanced consideration of all three dimensions. Despite its widespread use in research, policy and corporate practice, there is no clear consensus on how these pillars should be prioritised, making its application inherently context-dependent (Purvis et al., 2019).

2.1.1.4 Working Definition of Sustainability for this Project

For the purpose of this paper, sustainability is understood as the ability of organisations and communities to operate in a way that preserves and restores environmental systems, strengthens social well-being, and ensures long-term economic viability without exceeding ecological limits or compromising the needs of future generations. In the context of Tenerife and its resource-constrained island economy, sustainability specifically refers to the efficient and circular use of water, energy and materials, the reduction of waste and emissions, the protection of biodiversity, and the promotion of resilient, locally embedded economic and social structures. This working definition forms the basis for analysing and evaluating the current practices and improvement potentials of the selected case study companies.

2.1.1.5 Sustainable Business Models

The sustainability approach has become increasingly popular across industries over the last few years. The industrial sectors were under mounting pressure from society to adopt sustainable development practices. From an industrial point of view, the idea of sustainability places a strong emphasis on industrial processes and interactions with stakeholders that centre on the desired outcomes of sustainability at the corporate, environmental, and social levels (Karuppiah et al., 2023). The industrial sectors must develop sustainable economic, ecological, and cultural values through extended, sustainability-oriented plans and business models to ensure business sustainability. A business model primarily addresses value creation, supply-driven processes, market-capture strategies, key customers, customer relations, value propositions, business channels, manufacturing operations, finances, stakeholders, capital investments, and streams of income (Karuppiah et al., 2023). Businesses gained advantages from their sustainability efforts in several ways, including expanding their business activities, developing innovative products and processes, and reducing costs. For these reasons, the corporate environment has shown great interest in developing a business model that incorporates sustainability. While sustainable business models integrate cultural and environmental variables alongside economic facets, traditional business models focus mainly on economic components (Karuppiah et al., 2023).

2.1.1.6 Fundamentals of Sustainable Business Models

A business model discloses how an organization runs. Most importantly, it encompasses how to generate value for customers, the value structure and implementation, and value capturing for the business and its various stakeholders (Nerurkar, 2017). It looks at how to generate revenue and the economic reasoning that enables the provision of value at a fair price (Brunner, et al., 2025). However, sustainable businesses, on the flip side, incorporate sustainability as an essential aspect by focusing on preservation of the environment, societal wellness, and long-term economic profitability of the business, which are the three pillars of sustainability (Cardeal et al., 2020). According to the United Nations (2024, as cited in Brunner et al., 2025), sustainable business models are essential to sustainable development as they help the United Nations achieve its 17 Sustainable Development Goals (SDGs). Internationally, these objectives have been recognised and set to be achieved by 2030, and they apply to all nations and territories. They seek to enhance the lives of countless people in developed and developing nations by targeting economic and social problems (Brunner, et al., 2025). Furthermore, according to Cardeal (et al. , 2020), the business model canvas is one of the tools that is most used by businesses to create and put together business ideas. Conversely, this model fails to capture both the environmental and social components of a sustainable business.

Sustainable business ideas are becoming increasingly popular in the corporate world, encouraging businesses to include a business model canvas that takes care of sustainability and an assessment method to examine it (Cardeal, et al., 2020). It is a customized version of the conventional Business Model Canvas that focuses on integrating sustainability concepts into an organization's operations (Businessmodelcanvas.guru, 2025).

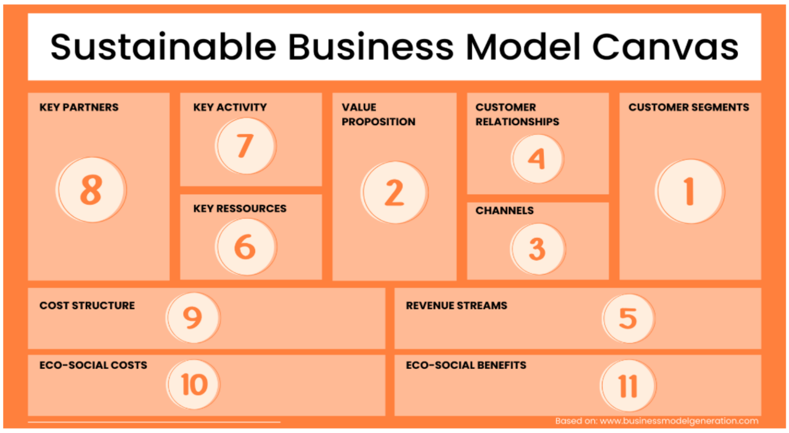

Figure 1:Sustainable business model canvas (Source: Businessmodelcanvas.guru, 2025)

2.1.1.7 Sustainable Business Model Archetypes

Sustainable business model archetypes can be used to describe categories of methods and solutions that may help establish a sustainable company model. The purpose of these archetypes is to provide a shared vocabulary that can be utilised to speed up the establishment of sustainable business models in both theory and practice (Bocken, et al., 2014).

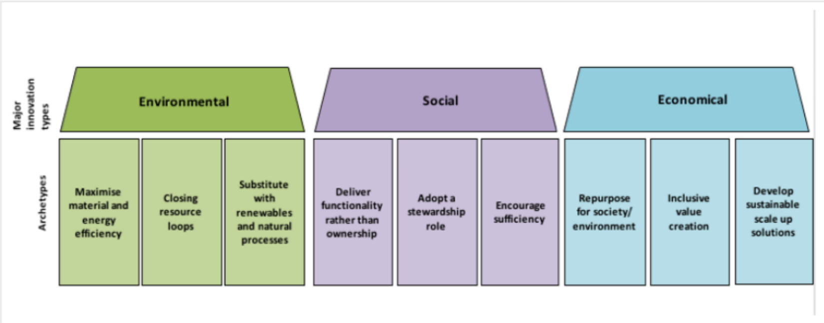

Figure 2: Sustainable business model archetypes (Source: Bocken et al., 2014)

2.1.1.8 Sustainable Business Models: Importance for Island Economies

Waste management in the Canary Islands is influenced by a variety of factors, including waste generators' environmental consciousness, the tourism industry, limited treatment infrastructure, a large population and safeguarded regions, and the state of the economy, education, and technological availability. This level of density, which is substantially more than the typical Spanish rate, largely impacts the island of Tenerife (Santamarta, et al., 2023). In addition, the Canary Islands, like Tenerife, have solid reasons to put into place sustainable business models (SBMs), because their major dependence on tourism causes higher carbon emissions, doubles waste generation, and intensifies seasonal demand for resources (Tenerife, eco tours, 2025). Sustainable business models like decarbonization, net zero, carbon emissions reduction, transitioning to cleaner energy sources, and adoption of environmentally friendly activities are all initiatives that must be undertaken collectively. This positively impacts the environment while also having an impact on every aspect of the organization, from improved energy reliability and efficient use of resources to lower costs and fewer dangers to the business, its customers, and the communities they represent (Arcadis, 2025). Sustainable business models are not a stagnant goal; rather, they are an ongoing initiative that demonstrates how businesses may not only decrease environmental hazards but additionally increase their creative thinking, loyalty to customers, and adaptability. Either through sustainable supply networks, usage-driven pricing models, or decentralized manufacturing, the aim is to realign the business model strategically (Kiel, 2025).

2.2 Definition & Dimensions of Circular Economy

2.2.1 Definition of Circular Economy

2.2.1.1. Ellen MacArthur Foundation's Definition

The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources.

The circular economy is based on three principles, driven by design:

- Eliminate waste and pollution

  It is to eliminate waste and pollution. Currently, our economy works in a take-make-waste system. We take raw materials from the Earth, we make products from them, and eventually we throw them away as waste. Much of this waste ends up in landfills or incinerators and is lost. This system can not work in the long term because the resources on our planet are finite.

- Circulate products and materials

  It is to circulate products and materials at their highest value. This means keeping materials in use, either as a product or, when that can no longer be used, as components or raw materials. This way, nothing becomes waste and the intrinsic value of products and materials are retained.

- Regenerate nature

  It is to regenerate nature. By moving from a take-make-waste linear economy to a circular economy, we support natural processes and leave more room for nature to thrive.

2.2.1.2. European Parliament's Definition

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.

In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible thanks to recycling. These can be productively used again and again, thereby creating further value.

This is a departure from the traditional, linear economic model, which is based on a take-make-consume-throw away pattern. This model relies on large quantities of cheap, easily accessible materials and energy.

2.2 Dimensions of Circular Economy

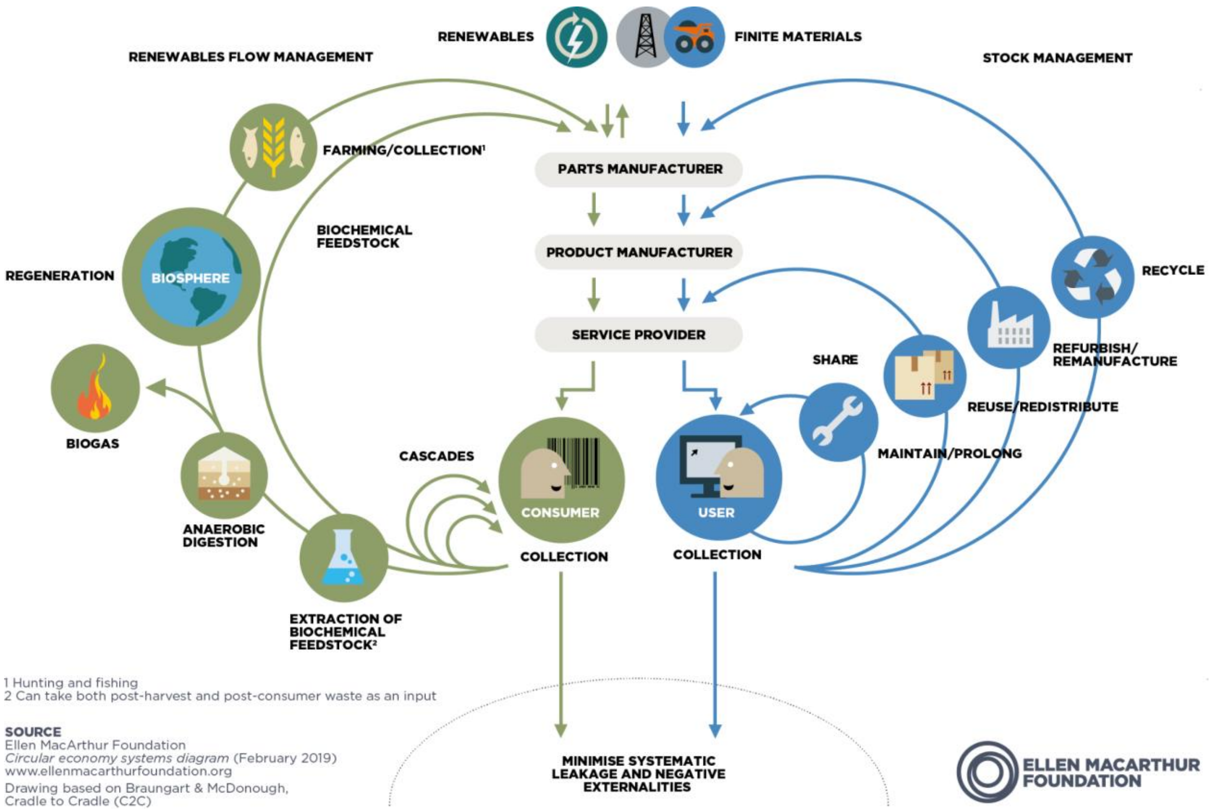

Figure 3: Butterfly diagram (Source: Ellen MacArthur Foundation et al., 2021)

The circular economy system diagram, known as the butterfly diagram, illustrates the continuous flow of materials in a circular economy. There are two main cycles the technical cycle and the biological cycle. In the technical cycle, products and materials are kept in circulation through processes such as reuse, repair, remanufacture and recycling. In the biological cycle, the nutrients from biodegradable materials are returned to the Earth to regenerate nature.

The technical cycle of the butterfly diagram

On the right-hand side of the butterfly diagram is the technical cycle, relevant for products that are used rather than consumed.

Sharing is the first port of call in the technical cycle and, while not appropriate for all products in the economy, it has the power to dramatically increase the utilisation of many products.

If sharing is a way to increase the intensity of product use, another way to maximise the value of a product is by prolonging its usable life. Maintenance is an important way of keeping products at a high quality and guards against failure or decline.

Like sharing and maintaining, Reuse keeps products in use in their original form and for their original purpose. Reuse business models are cropping up all over the economy, notably in packaging.

Redistribution is another way to keep products in use and stop them becoming waste. By diverting products from their intended market to another customer, the product is put to valuable use.

Returning products to good working order is a way to restore their value. This could include repairing or replacing components, updating specifications, and improving cosmetic appearance.

The next stage of the technical cycle is remanufacturing. This is done when products cannot remain in circulation in their current state and need more intensive work to be used again. Remanufacturing involves re-engineering products and components to as-new condition with the same, or improved, level of performance as a newly manufactured one. Remanufactured products or components are typically provided with a warranty that is equivalent to, or better than, that of the newly manufactured product.

The final step in the technical cycle is recycling. This is for when a product can no longer be used and is beyond refurbishment or remanufacture, or isn’t suitable for those steps. It is the final way of keeping in use the materials from which the product is made so they don’t become waste.

The biological cycle of the butterfly diagram

On the left-hand side of the butterfly diagram is the biological cycle, which is for materials that can biodegrade and safely return to the earth.

At the heart of the biological cycle is the concept of regeneration. It is the third principle of the circular economy. Instead of continuously degrading nature, as we do in the linear economy, in the circular economy we build natural capital.

We can manage farms, and other sources of biological resources such as forests and fisheries, in ways that create positive outcomes for nature. These outcomes include, but are not limited to, healthy and stable soils, improved local biodiversity, improved air and water quality, and storing more carbon in the soil. They can be achieved through a variety of practices and can together help regenerate degraded ecosystems and build biodiversity and resilience on farms and in surrounding landscapes.

Composting is the microbial breakdown of organic matter in the presence of oxygen. It can be used to turn food by-products and other biodegradable materials into compost, which can be used as a soil enhancer, returning valuable materials to farmland in place of artificial fertilisers. The process is biological and involves naturally occurring microorganisms, such as bacteria and fungi.

These loops of the biological cycle make use of products and materials already in the economy. This could mean, for example, using food by-products to make other materials, such as textiles made from orange peel, or designing new food products using ingredients usually considered waste, like ketchup made from banana peel. It could also mean using the material for applications such as animal feed. When products or materials can no longer be used, they move to the outer loops of the biological cycle where they are returned to the soil.

Taking both post-harvest and post-consumer biological materials as feedstock, this step involves the use of biorefineries to produce low volume but high value chemical products.

2.3 Core principles of Circular Economy (9-10 R strategies)

2.3.1. Introduction

The traditional global economy has long relied on a linear "take-make-dispose" system, causing resource depletion, waste generation, and environmental harm (Ellen MacArthur Foundation, 2017). The Circular Economy (CE) offers a regenerative alternative which is aiming to keep materials and products at their highest value for as long as possible (Boulding, 1966). The 10R framework provides a structured hierarchy which guides this transition. Understanding this hierarchy is essential because strategies applied early—such as refusal and rethinking—yield the greatest environmental benefits. This paper summarizes the 10R principles across three tiers and connects them with personal observations and experience.

2.3. 2. The visual model of 10R Hierarchy of the Circular Economy

Figure 4: Circular Economy: 9R/10R Strategies [AI-generated image]. OpenAI.

2.3.2.1. Tier I: Preventing Resource Use (R0–R2)

The first tier includes the most effective circular strategies: Refuse, Rethink, and Reduce. These actions avoid environmental impact at the design and consumption stages (Potting et al., 2017).

R0: Refuse – Avoiding unnecessary products reduces waste at the source. In Tenerife, eco-guides encouraged tourists to refuse single-use plastics by using refillable bottles.

R1: Rethink – Rethinking promotes access over ownership. Shared mobility systems in Germany, like bikes and e-scooters, showed me how fewer products can serve more people.

R2: Reduce – Reducing cuts material and energy use. Tenerife's refill stations naturally lowered the need for disposable bottles.

2.3.2.2. Tier II: Extending Product and Component Lifetime (R3 - R7)

Once a product has been manufactured, the second tier focuses on maximizing its use phase and extending its life as a functional item. These strategies retain the product's embedded energy and labour, offering high value retention compared to material-level recovery.

R3: Reuse – Reuse keeps items in circulation. I often bought second-hand items for my student housing in Germany, avoiding new production.

R4: Repair – Repair extends product life. Germany's repair cafés motivated me to fix items instead of replacing them.

R5: Refurbish – Refurbishing restores old products. At Blue Seal Textile Ltd., refurbished machines reduced costs and resource consumption.

R6: Remanufacture – Remanufacturing rebuilds used products to original standards. Many textile firms use remanufactured parts to avoid producing new ones.

R7: Repurpose – Repurposing gives old items new uses. In Tenerife, old tires were turned into playground and garden features.

2.3.2.3. Tier III: Material Recovery (R8 - R9)

The final tier deals with materials that can no longer serve their purpose as products or components. While necessary, these strategies are considered lower in the hierarchy because they require high energy input for processing and typically result in a loss of material quality (downcycling).

R8: Recycle – Recycling converts waste into secondary materials. Tenerife promotes recycling, though high tourism strains the system.

R9: Recover – Recovery extracts energy from waste and is the last option. Tenerife's move toward renewable energy reduces reliance on waste-to-energy processes.

2.3.3. Practical Observation:

Our visit to Tenerife provided practical insight into how the 10R principles operate in real contexts. The island has well-developed recycling systems (R8), with separate bins in public and tourist areas. Eco-friendly tour operators strongly promote high-tier strategies such as Refuse (R0) and Reduce (R2), encouraging reusable bottles and limiting disposable items. In addition, the presence of solar and wind energy installations reflects an effort to reduce reliance on fossil fuels and integrate energy recovery (R9). However, challenges remain. During peak tourism seasons, the volume of waste increases dramatically, putting pressure on recycling infrastructure. This demonstrates that relying mainly on lower-tier actions like recycling is not enough. Stronger emphasis on higher-tier strategies such as Rethink and Reduce is necessary for long-term sustainability. This observation reinforced my understanding that circular economic success depends on collaborative action from tourists, businesses, and public authorities6.

Conclusion

The 10R framework offers a clear and effective pathway toward a circular economy. Strategies at the beginning of the hierarchy—Refuse, Rethink, reduce—are the most powerful because they prevent waste creation. Mid-tier strategies such as Reuse, Repair, and Refurbish extend product life and preserve value; while recycling and energy recovery should remain last-resort solutions.

2.4 Five Stages of Circular Transformation

2.4.1 Introduction

The transition to a circular economy is not a simple switch but a maturity journey. Organizations evolve through distinct stages, moving from basic operational adjustments to fully systemic, regenerative models. This framework outlines the five key stages of this transformation: **Conventional, Green, Sustainable, Restorative, and Regenerative**. Each stage represents a deepening of commitment, strategy, and impact, shifting the focus from "doing less harm" to "creating net-positive value" for society and the environment.

2.4.2 The Conventional Stage

The Conventional Stage is the entry point where organizations begin to engage with circular economy concepts. However, they have not yet transformed their core business models, design practices, or value chains. This stage is often characterized as "operational" or "compliance-driven" circularity. (Circular Economy, 2024)

2.4.2.1 Characteristics

- **Focus on Waste Management:** Efforts are concentrated on downstream issues—what to do with waste—rather than upstream prevention or redesign. The primary activities include basic recycling, waste reduction, and disposal optimization. (United Nations Environment Programme (UNEP)., 2015)
- **Efficiency Over Transformation:** The goal is incremental efficiency, such as consuming fewer raw materials or saving energy. This aligns with traditional lean practices but does not challenge the linear "take-make-dispose" model.
- **Linear Product Design:** Products are not redesigned for repair, modularity, or reuse. Circularity is treated as an add-on, not a design philosophy.
- **Internal Focus:** Organizations largely act alone within their own boundaries. There is limited engagement with suppliers or the broader ecosystem regarding circularity.
- **Compliance-Driven:** Adoption is motivated by regulatory pressure, waste management requirements, or corporate social responsibility (CSR) expectations, rather than strategic opportunity.

2.4.2.2 Why it matters

Although limited, the Conventional Stage builds initial awareness across the organization and creates foundational skills in resource efficiency. It helps reveal material hotspots where future redesign efforts can be focused. (Pearce, D. W., & Turner, R. K. 1990)

2.4.3 The Green Stage

The Green Stage represents an intermediate maturity level where circularity begins to integrate into strategy, product development, and operations. Organizations shift from a mindset of "doing less harm" to "doing good more consistently," transitioning from eco-efficiency to eco-effectiveness. (World Business Council for Sustainable Development (WBCSD), 2000).

2.4.3.1 Characteristics

- **Strategic Priority:** Unlike the Conventional Stage, the Green Stage recognizes circularity as a competitive advantage. Companies set circular goals, roadmaps, and KPIs.
- **Circular Design Principles:** The focus shifts upstream to the design phase. Products are designed for durability, repairability, recyclability, and reduced material intensity. (McDonough, W., & Braungart, M., 2002).
- **Sustainable Materials:** There is a meaningful replacement of virgin resources with sustainable or secondary materials, such as increasing the percentage of recycled content or adopting bio-based materials.
- **Value-Chain Collaboration:** Organizations start engaging suppliers on sustainability requirements and may partner with recyclers or repair networks.
- **Pilot Business Models:** Companies experiment with circular models like repair services, rental pilots, or take-back schemes, though these are often limited in scope.

2.4.3.2 Challenges

Organizations at this stage often face barriers such as the higher cost of sustainable materials, difficulty scaling pilot projects, and legacy product designs that are hard to adapt to.

2.4.4 The Sustainable Stage

The Sustainable Stage is an advanced midpoint where circularity becomes the dominant operational and strategic lens of the organization. It is characterized by a fully integrated sustainability framework embedded across design, operations, procurement, and culture. (World Commission on Environment and Development (The Brundtland Commission).1987)

2.4.4.1 Characteristics

- **Full Lifecycle Integration:** Companies adopt "Cradle-to-Cradle" thinking, managing the entire lifecycle from design and production to use and recovery.
- **Standardized Circular Design:** Design for disassembly, modularity, and upgradability becomes standard practice rather than an experiment.
- **Scaled Circular Supply Chains:** Circularity moves beyond pilots to wide-scale implementation. This includes high-performing reverse logistics systems and closed-loop industrial symbiosis.
- **Mature Circular Business Models:** Models like Product-as-a-Service (PaaS), resale, and refurbishment become primary revenue drivers rather than side programs.
- **Advanced Metrics:** Measurement becomes sophisticated, utilizing tools like Lifecycle Assessment (LCA) and Material Circularity Indicators (MCI) to track performance.

2.4.4.2 Differentiation

While the Green Stage focuses on pilots and selective redesign, the Sustainable Stage achieves circularity at scale. It represents a move from partial supplier engagement to a circular supply-chain ecosystem. (Cradle to Cradle Products Innovation Institute., 2021).

2.4.5 The Restorative Stage

In the Restorative Stage, organizations move beyond simply reducing negative impacts to actively repairing and revitalizing ecological and social systems. The focus shifts to "creating positive impacts for nature and society". (Ellen MacArthur Foundation., 2013)

2.4.5.1 Characteristics

- **Restorative Design:** Products and processes are designed to restore natural systems. Examples include using materials that improve soil health or enhance biodiversity.
- **Net-Positive Outcomes:** Business models shift to create net-positive ecological and social value. For instance, a PaaS model might have built-in contributions to ecological restoration.
- **Restorative Supply Chains:** Supply chains act as ecological stewards, investing in ecosystem services like pollination and carbon capture.
- **Carbon Negative Energy:** Energy systems go beyond "carbon neutral" to "carbon negative," utilizing sources that stabilize climate systems.
- **Social Restoration:** The scope extends to restoring community well-being, fair labor practices, and local economic resilience.

2.4.5.2 Importance

This stage is crucial because it bridges the gap between sustainability and true regeneration. It aligns business operations with planetary boundaries and begins to heal the natural capital on which the economy depends. (Polman, P., & Winston, A., 2021).

2.4.6 The Regenerative Stage

The Regenerative Stage is the pinnacle of circular transformation. It describes a state where organizations and ecosystems achieve continuous renewal. In this stage, nature and society are better off because the organization exists. (Fullerton, J. 2015)

2.4.6.1 Characteristics

- **Net-Positive System Impact:** Organizations create environmental and social value that far exceeds their resource consumption. This includes net-positive biodiversity, carbon, and water cycles.
- **Optimized Closed Loops:** Material flows operate with zero waste, zero pollution, and infinite recyclability. Biological loops enrich ecosystems, while technical loops are powered by renewable energy.

- **Biomimicry:** Design strategies mimic nature's efficiency. Manufacturing and logistics become fully nature compatible.
- **Regenerative Culture:** The organization functions like a living ecosystem. Governance focuses on long-term ecological well-being, and employees are empowered as regenerative thinkers.
- **Regenerative Business Models:** Profit streams are generated directly from green and restorative activities. Models like full industrial remanufacturing and cascading resource loops dominate.

2.4.6.2 Conclusion

The Regenerative Stage is the ultimate vision of the circular economy. It represents a shift from linear extraction to a state where industries operate in harmony with natural cycles, continuously creating conditions for life to flourish. It transforms organizations into restorative forces that secure long-term economic stability and community resilience. (Reed, B., 2007)

3. Hotel Tigaiga

This chapter provides a comprehensive analysis of Hotel Tigaiga's sustainability performance and its potential for advancing sustainability and circular economy practices.It follows a structured approach that begins in **Section 3.1** with an overview of the hotel's profile and its Business Model. **Section 3.2** provides a detailed assessment of Tigaiga's current sustainability practices. Building on these insights, **Section 3.3** identifies key improvement potentials and introduces three solution concepts—*Smart Gardening*, *Sustainable Employee Mobility* and *Smart Communication*—designed to enhance Tigaiga's circularity performance. Subsequently, an impact assessment evaluates the environmental, social and economic value of these interventions (**3.4**), while the following section discusses anticipated implementation challenges and opportunities (**3.5**). The chapter summarizes with a Conclusion and Outlook on Tigaiga's transition toward enhanced circularity (**3.6**) and a brief reflection on the project and the team's learning outcomes within the CIB25 project (**3.7**). This paper partly draws on non-public information from expert interviews with Irene Talg conducted on 10 and 12 November 2025. For linguistic and stylistic refinement, the AI tool ChatGPT was used selectively, while all analyses, interpretations, and conclusions were developed independently by the author.

3.1 Company Profile

Hotel Tigaiga is a family-run, four-star hotel located in Puerto de la Cruz, Tenerife, operating since 1959. The long-standing family management style contributes to its warm atmosphere, strong guest relationships, and long-term vision.

The hotel is recognized as a sustainability pioneer on the island, holding prestigious certifications such as ISO 14001 and EMAS, which highlight more than two decades of continuous environmental improvement. These certifications appear repeatedly in Tigaiga's sustainability timeline (solar installation in 1982, EMAS in 1998, carbon footprint measurement in 2012). (Tigaiga, 2023)

Tigaiga's botanical garden covering 5,200 m² and hosting hundreds of plant species forms the emotional and ecological core of the hotel's value proposition. This is highlighted throughout the environmental chapter of the 2023 sustainability report. (Tigaiga, 2023)

The hotel's guest profile has historically been dominated by seniors (60+), many of whom return annually, but recent trends show a shift toward younger adults seeking nature, wellness, and sustainability experiences. This shift is described in the Hotel Tigaiga Presentation, which notes the evolving guest segment.

Business Model Canvas for Hotel Tigaiga

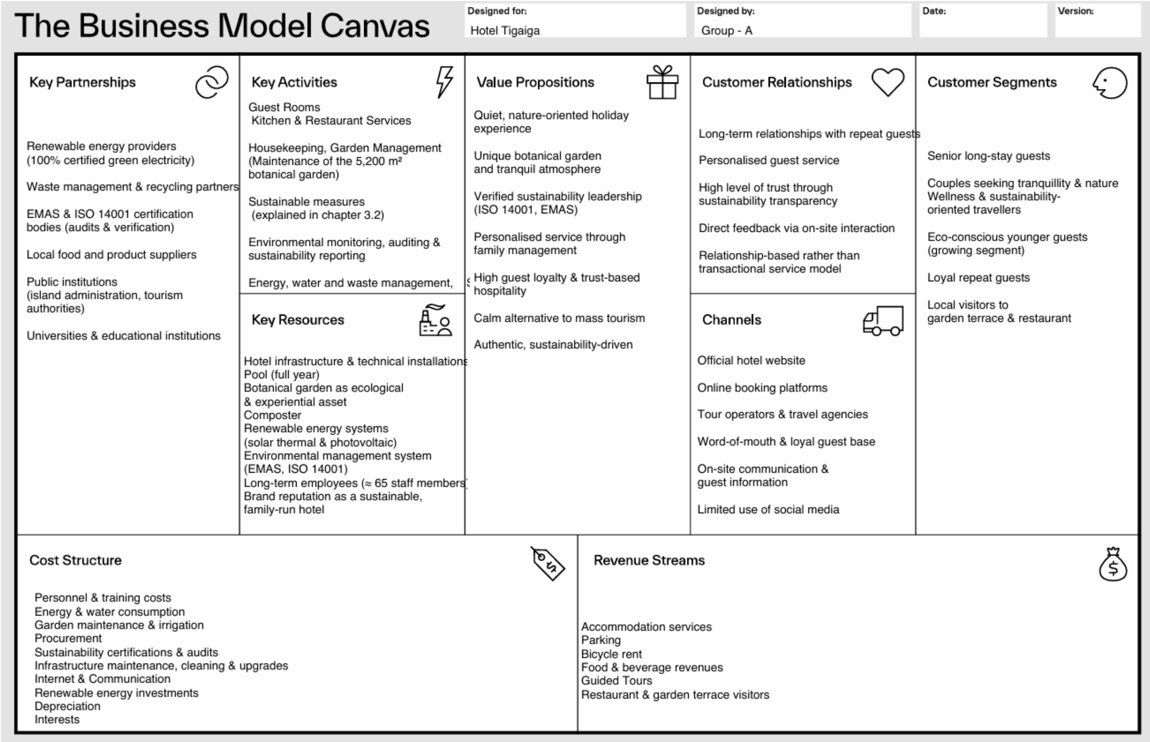

Figure 5: Business Model Canvas Hotel Tigaiga (own illustration)

Key Partnership

Hotel Tigaiga collaborates with several strategic partners who support its operational, environmental, and community activities. These include the renewable energy provider EDP, from which the hotel purchases 100% certified renewable electricity (Sustainability Report 2023, Energy Section). Waste management partners such as ATA-RETACO enable recycling and circular material flows (Waste Management Section). Annual audits are conducted by EMAS and ISO 14001 certification bodies, ensuring transparency and compliance. The hotel also maintains links with associations such as ASHOTEL and collaborates with local educational institutions to promote sustainable tourism (Tigaiga, 2023).

Key Activities

Core activities include day-to-day guest hospitality, maintenance of its 5,200 m² botanical garden, and operation of irrigation systems (Water Management Chapter). The hotel also produces compost from kitchen waste, which is reused in the garden (Circular Practices Section). Regular environmental audits, monitoring, and data reporting form part of its EMAS obligations (Tigaiga, 2023).

Key Resources

Hotel Tigaiga's most distinctive resource is its extensive botanical garden, which forms a central part of its guest experience (Tigaiga Website – “Jardín”). Additional resources include a highly trained, long-tenured workforce with hotel infrastrcture and technical installations, noted in the HR section of the sustainability report, and photovoltaic installations that contribute to on-site energy generation (Energy Milestones). The hotel also holds over 20 years of environmental performance data thanks to EMAS (Indicators Section).

Value Proposition

The hotel offers a unique nature-based, quiet holiday experience, reinforced by the atmosphere of its botanical ecosystem. Its verified sustainability credentials (EMAS, ISO 14001) create a high level of trust among environmentally aware guests. The hotel’s family-run identity, highlighted across the website and sustainability report, adds to its personalized, relationship-driven service approach. (Tigaiga, 2023)

Customer Relationships

Tigaiga emphasizes close personal connections, listening actively to guests, maintaining long-term loyalty, and gathering structured feedback (Quality & Customer Satisfaction Section). Many visitors return annually, reinforcing the hotel’s relational capital. (Tigaiga, 2024)

Customer Segments

The primary customer segments include senior long-stay guests, couples seeking a quiet nature-oriented holiday, younger eco-conscious travellers, and a large base of repeat loyal customers. These segments were identified in your project presentation and are supported by demographic insights in the sustainability report. (Tigaiga, 2024)

Revenue Streams

The hotel generates revenue primarily through lodging, supplemented by food and beverage services, and experiences interconnected with its garden and quiet natural setting. These revenue streams align with the hotel’s positioning across its website and sustainability documentation. (Tigaiga, 2024)

Channels

The hotel reaches customers through its website, blog, newsletters, and direct bookings, supported by strong repeat visitation. Online channels communicate both services and sustainability achievements. (Tigaiga, 2023)

Cost Structure

Major cost drivers include water use and irrigation infrastructure (Water Consumption Section), staff wages and ongoing training, annual sustainability certification, and EMAS audits. Costs also arise from energy use, maintenance of facilities, and continuous investment in environmental improvements. Also, other costs include inventory of all the supplies, depreciation of the equipment. (Tigaiga, 2023)

3.2 Current Sustainability Practices

The following assessment of Tigaiga's sustainability practices is based on an operational system boundary covering all direct activities for which reliable information is available. Upstream supplier processes and downstream guest activities outside the hotel premises are excluded unless data is explicitly available.

At Hotel Tigaiga sustainability is embedded as a core organisational value, guiding strategic decision-making and daily operations. (Talg and Talg, 2022, p. 1) Tigaiga applies sustainability measures across all core operational areas housekeeping, guest rooms, kitchen and restaurant services, and garden management within the domains of energy management, water management, waste management, sustainable procurement and local sourcing, social sustainability, and guest engagement and awareness. (Hotel Tigaiga, 2024, pp: 13-21; 2025a, pp. 1-15) This structured approach enables systematic monitoring of environmental indicators, supports continuous improvement, and balances the sometimes-competing objectives of environmental protection, regulatory compliance and guest comfort. The hotel's sustainability commitment is reinforced through internationally recognised certifications: ISO 14001 and EMAS. (Hotel Tigaiga, 2025b)

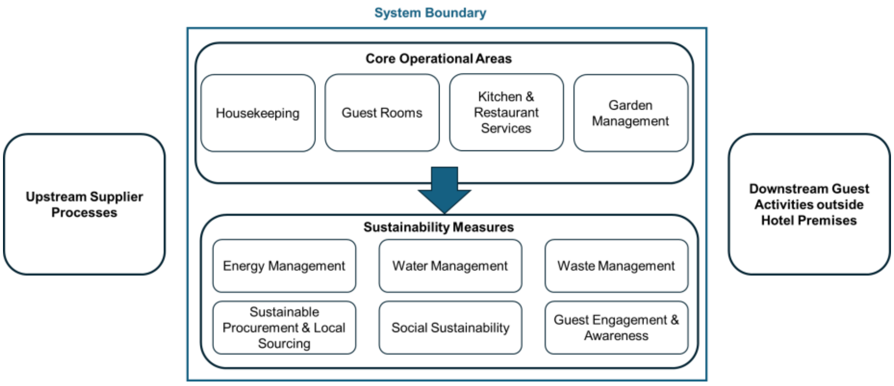

Figure 6: Hotel Tigaiga's core sustainability measures (own illustration

Energy management represents one of Tigaiga's most mature areas of sustainability practices. The hotel's bioclimatic architectural design reduces energy demand through optimal building orientation, enhanced daylight use, and natural ventilation. Tigaiga holds an A-level energy efficiency certification, while the Suites are rated B. (Hotel Tigaiga, 2024, pp. 13-19) As an early pioneer in renewable energy, Tigaiga installed a solar thermal system already in 1982 and expanded its photovoltaic capacity to roughly 100 MWh in 2024. Further, the hotel participates in a local photovoltaic energy community, adding a further 132 MWh per year. Collectively, these systems cover roughly 44% of the hotel's total electricity consumption, the remaining demand is covered through contracting certified green electricity. (Hotel Tigaiga, 2024, pp. 2-3; 2025a, p. 13) Energy efficiency is further enhanced through the widespread use of LED lighting, sensor-controlled systems, intelligent elevator controls, optimised hot-water circulation, improved insulation and selective room-level shut-off mechanisms. These efforts mitigate atmospheric emissions resulting in a positive net-positive CO_2-banace and reinforce long-term climate resilience. (Hotel Tigaiga, 2023b, 2024) For Tigaiga the central KPI for energy management is the energy consumption per overnight stay (kWh/pax), which averaged 22.6 kWh/pax in 2024 – substantially below the industry reference value of 27.6 kWh/pax. (Albino Silva et al., 2023, pp. 9-12; Hotel Tigaiga, 2025a, p. 3)

Water management constitutes another critical sustainability priority, particularly in light of the Water Emergency declared by the Tenerife Island Water Council in 2024. (Cabildo de Tenerife, 2024; Hotel Tigaiga, 2023a, p. 2) The hotel identifies need in the reduction of water consumption, which averaged 252 litres per guest-night in 2024, substantially above the Sector Reference Document (SRD) benchmark of 140 litres. This deviation is partly attributable to the hotel's category, climatic conditions, gardening activities and the presence of a swimming pool. Garden irrigation represents the largest share of consumption, reaching 474 L/m² and contributing to a total annual water use of 15,545 m³. (Hotel Tigaiga, 2025a, pp. 2-3) To improve efficiency, the hotel has implemented water-saving filters, optimised hot-water circulation systems, towel-reuse programmes and selective shutdown of water circuits. In garden areas, the use of compost derived from kitchen waste reduces irrigation demand and improves soil quality. (Hotel Tigaiga, 2024, pp. 13-20) Nevertheless, the hotel recognises the need for further progress and aims to continue investigating additional measures to move closer to the SRD benchmark. (Talg, 2025)

Tigaiga has implemented a comprehensive **waste management** system that prioritises reduction, reuse and circular resource flows. Waste separation is systematically implemented across all operational areas and is supported by some recycling partnerships and regional compliance mechanisms coordinated with the regional hotel association. Circularity is further strengthened through the conversion of used cooking oil into biodiesel and the widespread use of reusable spray bottles, and reduced plastic consumption in laundry operations. Additionally, more than ten tons of biodegradable kitchen waste are composted annually and reused in the gardens, resulting in healthier soils, reduced irrigation needs, lower dependence on chemical fertilizers and decreased transport volumes. (Hotel Tigaiga, 2024, pp. 9-20) Further circular practices include modular flooring solutions that allow partial replacement instead of full disposal, as well as the donation of furniture to local retirement homes once items reach the end of their useful life. (Talg, 2025)

Sustainable procurement and local sourcing form further pillars of Tigaiga's sustainability approach. (Hotel Tigaiga, 2023a) The hotel prioritises regional products, particularly in its kitchen and restaurant operations, sourcing fruits, vegetables, and homemade goods such as jams and muesli from local suppliers. (Hotel Tigaiga, 2024, p. 21) This approach strengthens regional supply chains, reduces transport-related emissions and reinforces the hotel's integration into the local economy. (Glišić and Stamenković, 2025, pp. 289-292) However, the availability of local products is constrained by seasonal fluctuations and supply limitations, requiring a continuous trade-off between sourcing ambitions, operational continuity and guest expectations. (Talg, 2025)

Social sustainability at Hotel Tigaiga is characterised by long-term employment stability and staff development. (Talg and Talg, 2022) The hotel employs around 65 staff members, many with decades of tenure, and conducts regular team meetings to promote continuous improvements in occupational safety and guest comfort. However, no sustainability-specific training is currently offered, and no structured employee mobility solution is in place, meaning staff members largely rely on individual commuting arrangements. Despite this, Tigaiga offers training programs based on the German vocational model, hosts interns and maintains clear organisational structures. (Hotel Tigaiga, 2024, pp. 5-9; Talg, 2025) Together, these practices strengthen retention, skills development, and equitable labour conditions.

Guest engagement and awareness represent an important supportive dimension of Tigaiga's sustainability approach. Guests are encouraged to adopt resource-efficient behaviour through in-room signage that allows them to decide on cleaning frequency and towel replacement, as well as through lighting control measures. (Hotel Tigaiga, 2024, p. 15) Environmental information and a botanical garden catalogue further enhance guest awareness and experiential learning. (Hotel Tigaiga, 2025b) However, despite the hotel's strong operational sustainability performance, its communication of these practices remains limited, restricting the strategic use of sustainability as a differentiation factor. (Talg, 2025)

Overall, Hotel Tigaiga demonstrates solid progress across the environmental, economic and social dimensions of sustainability. Within the 9-R framework, the hotel effectively applies strategies such as Refuse, Reduce, Reuse and Recycle. Elements of Rethink and Recover are visible in its increasing reliance on renewable energy systems and composting loops, while Repair, Refurbish, Remanufacture and Repurpose are not yet fully developed. In summary, Tigaiga's sustainability practices position the hotel as a regional benchmark for sustainable tourism and establish a strong foundation for further circular innovation. Nevertheless, significant improvement potentials remain, particularly with regard to employee mobility, reduction of water consumption and strategic sustainability communication.

3.3 Improvement Potentials & proposed Sustainability Solutions

The analysis of Hotel Tigaiga's sustainability practices shows that the hotel already performs very well across economic, environmental, and social dimensions. Its long-standing commitment, supported by EMAS and ISO certifications, demonstrates a strong foundation of responsible operations and continuous improvement.(Tigaiga, 2023)

At the same time, the assessment highlights clear opportunities to go further particularly in improving water efficiency in the garden, introducing sustainable mobility options for employees, and strengthening the communication of sustainability achievements. The following sections therefore present three targeted proposals: Smart Gardening, Sustainable Employee Mobility, and Smart Communication. Each build on

Tigaiga's existing strengths while addressing the most relevant gaps to enhance environmental performance, employee well-being, and long-term competitiveness.

3.3.1Smart Gardening

The garden that extensively surrounds Hotel Tigaiga is one of its distinguishing features. From the beginning, the park has been an essential part of the establishment and has been steadily expanded over the decades, now including around 35 different species of palms. The garden represents Canary Islands' plant life, but because native flora mainly blooms in spring, the hotel complements it with numerous tropical and subtropical species so that, thanks to staggered flowering periods, the grounds are always presented in a fresh and appealing way.

Nevertheless, this majestic botanical garden requires a substantial amount of water, especially because some non-native species need to be irrigated more frequently, given that the local climate and soil are not their ideal environment.

Although the hotel has already implemented some water-saving measures (as previously discussed in chapter 3.2, they acknowledge that there is still room for improvement. The following proposed solutions are classified as short-term and medium/long-term strategies.

Short-term measure: sensor-based, precise irrigation

First, as an affordable and relatively immediate approach, we propose introducing **sensor-based irrigation zones** and real-time water measurement. Hotel Tigaiga has already implemented selective shutdown of certain water circuits, but more precise and efficient options are available.

On the one hand, installing sensors and remote controllers on the existing sprinklers could allow the hotel to monitor and manage exactly how much water is used in each area of the garden. Rather than simply programming periodic irrigation cycles, they could manually — or automatically — choose where, when, and how much water is delivered, accounting for the specific needs of each plant profile and for weather data. This would enable a much more efficient irrigation, avoiding over-watering. There are advanced sprinkler models that include rain sensors, soil-moisture sensors, and automatic controllers that irrigate based on real-time data. A company like Toro provides a wide variety of such options, suitable for implementing these smart irrigation zones.

On the other hand, replacing traditional sprinklers with **Wi-Fi controlled** ones could further improve manageability. Such systems could be controlled via an app, allowing the gardening staff to adjust irrigation schedules and volumes remotely — a practice that has been used for years in many professional landscapes. Established companies such as Rain Bird and Hunter, with over 80 and 40 years respectively in the irrigation business, offer extensive catalogues of Wi-Fi-enabled controllers, valves, and sprinkler heads.

Implementing any of these smart irrigation systems would result in higher water-use efficiency, reducing the amount of water used for irrigation thanks to more accurate calculations of needs by area. In addition, it would save time for gardeners (who could control irrigation remotely at any time), and improve the quality of care, leading to healthier plants and a more sustainable garden.

Medium / long – term measure: greywater reuse. Turning Tigaiga into a pilot for circular water use

Water consumption is not the only water-related challenge that Hotel Tigaiga faces. All the water currently used for irrigation is potable (clean) water — which, while not overly expensive, is unsuitable given the Water Emergency declared on Tenerife and the guidelines established in the Sector Reference Document.

Therefore, as a more visionary long-term solution, we propose a pilot project in cooperation with the municipal administration and Teidagua to **use treated greywater for garden irrigation**.

Using a greywater recycling system — that is, collecting water from showers, sinks, laundry, etc. (in the hotel), treating it, and reusing it for irrigation — is a well-established practice in sustainable hospitality. For instance, the I*HG voco Brussels City North Hotel* collects shower water from 58 rooms and, after treatment by Hydraloop units, reuses it for toilet flushing and garden irrigation, saving over 1.2 million liters of potable water per year.

Implementing such a system at Hotel Tigaiga — especially in collaboration with *Teidagua* — would make it a pioneering pilot project on the island, showing how historic hotels can adapt to water scarcity and circular economy principles. *Teidagua's* existing infrastructure is already designed to reuse and redistribute treated water.

From an environmental point of view, reusing greywater would relieve pressure on potable water supplies — an essential benefit in times of drought — and would contribute to long-term resilience. From an economic point of view, the hotel would likely reduce its water bills considerably, and reinforce its sustainability credentials, which is increasingly demanded by guests and by green certifications.

Furthermore, by using treated greywater, the hotel avoids wasting a valuable resource; water that would otherwise be discharged becomes a useful input. This aligns perfectly with the circular economy mindset promoted by CIB25: transforming waste (or wastewater) into resources, closing material loops, and reducing dependence on finite resources.

3.3.2Sustainable Employee Mobility

Hotel Tigaiga's employee commuting is characterized by a heavy reliance on private cars, leading to three core problems: significant CO_2 emissions, high personal costs for staff, and intense pressure on parking infrastructure. The absence of shuttle services or formal car-pooling options, combined with limited public transport, creates environmental, economic, and social strains. This situation undermines the hotel's sustainability ambitions and its positioning as a responsible employer.
A relevant and successful benchmark is the Omni Providence Hotel (Rhode Island, USA), which partnered with the local public transit authority (RIPTA) in the "Wave to Work" program to reduce transportation barriers for its approximately 260 employees. The program provides a framework where the employer partially subsidizes monthly bus passes for staff, using a smart card system for ease of use. This initiative directly supports employees by lowering commuting costs, helps the hotel in recruiting and retaining staff, and reduces environmental impact by promoting public transport use (Rhode Island Public Transit Authority [RIPTA], 2023).
Employees require mobility that is fast, reliable, affordable, predictable, and low-stress. However, the current lack of these very qualities presents the primary barrier

to satisfaction. The key motivators for adopting a new system are therefore the potential for significant cost savings, reduced driving stress, stronger team cohesion, and more efficient use of time.

Stakeholders affected by the suggested mobility transformation include employees, hotel management, local partner hotels, the local public mobility provider TITSA and the Tenerife hotel association.

The following proposed mobility solution transforms Tigaiga´s current individualized commuting model into a shared mobility ecosystem. As a first MVP, a low-investment car-sharing pilot is recommended due to its fast adoption potential and minimal infrastructural requirements. This initial approach provides the necessary foundation for a more sophisticated mobility system. The roadmap for the sustainable mobility ecosystem encompasses 7 phases.

In Phase one, Tigaiga enters a strategic mobility cooperation with its four partner hotels – Tui Blue Atlantic Hills, Hotel Taoro Garden, Hotel Gran Taoro and Hotel Parque San Antonio. Through this cross-hotel partnership, a larger user pool is created, enabling efficient ride-matching and shared governance. This initial phase requires minimal investment and tests real-world adoption.

Building on this foundation, Phase two introduces a systematic needs analysis using a digital employee survey to map employee locations, shifts, and mobility preferences.

Based on these insights, Phase 3 operationalises an intelligent routing and matching logic, using spatial and schedule data to create efficient employee groups and dynamic routes.

To encourage participation, Phase 4 launches a reward system (e.g., vouchers) and a clear campaign to build trust and participation.

With these conditions in place, Phase 5 runs a 3-months monitored pilot to track CO_2 reductions, costs, and feedback.

Following the pilot, in Phase 6 the results are evaluated. A low-adoption scenario (0–30%) would generate limited emission reductions but offer valuable behavioural insights and clarify the need for stronger incentives. A medium-adoption scenario (30–60%) would demonstrate measurable CO_2 reductions, reduced parking pressure, and improved employee cost savings. A high-adoption scenario (60–100%) would produce substantial environmental benefits and provide the necessary scale to justify transitioning toward a more sophisticated shuttle system. In this analysis, sensitivity

factors such as fuel prices, the number of participating hotels, seasonal workforce fluctuations, digital platform usability, and shift pattern variability must be considered to ensure realistic forecasting.
Depending on the acceptance and the insights generated during the pilot, Phase 7, based on pilot success, assesses a coordinated shuttle service for employees and eventually guests, aligning with Tenerife's circular tourism goals.
The proposed mobility system aims to create an integrated ecosystem for employees and eventually guests, supporting Tenerife's circular tourism goals. It offers a triple win: reducing the hotel's CO_2 emissions and parking pressure, lowering commuting costs for employees, and enhancing Tigaiga's brand as a sustainable employer. While risks such as employee reluctance and coordination complexity exist, they can be mitigated through transparent communication and phased implementation. Ultimately, this initiative positions Tigaiga as a leader in sustainable mobility, turning an operational challenge into a strategic competitive advantage.

3.3.3Smart Communication

Despite its strong operational performance and two decades of certified environmental leadership, Hotel Tigaiga currently underuses sustainability as a strategic communication asset. A key insight from the management interview was that “we do many things, but we don’t know how to communicate them.” This gap reduces the visibility of Tigaiga’s achievements, weakens guest awareness, and limits the hotel’s differentiation potential—especially as its customer base evolves from predominantly 60+ long-stay guests toward a growing segment of younger visitors seeking nature, calmness, and mental well-being.

To address this issue, the Smart Communication concept proposes a structured, professional, and multi-channel communication strategy that increases transparency, enhances guest engagement, and translates sustainability into a visible component of the hotel’s value proposition. It comprises three interconnected intervention streams:

(1) professionalization of digital content production,

(2) multi-platform sustainability storytelling, and

(3) on-site experiential communication, including a proposed Green-Room and a guest-centered visual installation.

Professionalization of Digital Content Production

Hotel Tigaiga currently maintains active Instagram and Facebook profiles, which are frequently updated but vary significantly in quality. TikTok, in contrast, contains only six low-quality videos and has been largely abandoned. Considering that TikTok now plays a central role in inspiring younger travelers—particularly those seeking nature, calm, and stress-relief—this gap limits Tigaiga's reach in emerging guest segments.

To raise the overall quality and consistency of visual communication, we propose that Tigaiga establishes a collaboration with design, audiovisual, or communication students from the University of La Laguna (ULL). This approach offers professional-level output at accessible cost while strengthening local educational partnerships, aligning with Tigaiga's long-standing emphasis on community engagement.

A small professional equipment set would enable high-quality production without requiring major investment. Recommended options include:

Camera bodies (entry-level professional):

– Sony α6400 or Sony ZV-E10 (excellent video performance and low-light capability)

– Canon EOS R50 (compact, high-quality color science)

Lenses:

– 24mm f/1.8 or 35mm f/1.8 (for storytelling, interiors, portraits of staff)

– 11–20mm wide-angle lens (for gardens, lobby, architecture, and the pool area)

Stabilization and audio:

– DJI RS3 Mini gimbal

– Rode Wireless GO II microphone for interviews or voiceovers

These tools enable students or young professionals to produce visually coherent, emotionally engaging content that aligns with the expectations of each platform:

Facebook: storytelling for older loyal guests — history, staff recognition, garden updates.

Instagram: high-quality photography, reels showing sustainability actions, behind-the-scenes content.

TikTok: fast, light-hearted, highly visual narratives targeted at younger visitors (e.g., “A day in the life of Tigaiga’s gardeners,” “How your breakfast becomes compost,” “3 sustainability facts you didn’t know about Tigaiga”).

This professionalization directly addresses the current inconsistency in visual quality and ensures that the hotel’s sustainability achievements are communicated with clarity and emotional resonance.

Multi-Platform Sustainability Storytelling

Given Tigaiga’s EMAS & ISO 14001 certifications, its composting loops, water-saving measures, renewable energy systems, and biodiversity-rich garden, the hotel has a unique sustainability story—but this story is not yet fully visible.

The Smart Communication concept introduces a structured editorial calendar that highlights:

Sustainability in action: composting processes, selective waste separation, greywater potential, photovoltaic production, water-saving devices, biodiversity in the botanical garden.

Human-centered stories: portraits of long-tenured employees, gardeners’ knowledge of species, seasonal work in the garden, behind-the-scenes operations.

Historic storytelling: origins of the hotel, evolution of the garden, architectural decisions (pool design, color choices of the rooms), meaning behind the name “Tigaiga,” and stories from the family’s decades of stewardship.

Certification transparency: short explainer videos on what EMAS means, why ISO 14001 matters, and how KPIs have improved over the last 20 years.

This narrative strategy transforms sustainability from a “hidden operational strength” into a differentiating factor that is visible before, during, and after the guest stay.

On-Site Experiential Communication: GreenRoom & Guest Engagement

To complement digital storytelling, the Smart Communication concept includes two on-site interventions to strengthen experiential awareness:

<u>The GreenRoom</u>

A dedicated space in the hotel where guests can learn about Tigaiga's history of sustainability. This room would display:

EMAS and ISO 14001 certificates

Awards and recognitions

Historical photos of environmental milestones (e.g., solar installation in 1982)

Interactive panels explaining composting, energy generation, biodiversity, and water challenges in Tenerife

A small dashboard with annually updated environmental KPIs.

This space reinforces transparency, strengthens guest trust, and enhances Tigaiga's image as a pioneering sustainability leader.

<u>Mural of Polaroids (Reception Area)</u>

To increase emotional engagement, we propose creating a Polaroid memory wall at the hotel entrance. Staff would take voluntary photos of guests during their stay, printing them on recyclable or sustainably sourced Polaroid film. This installation creates:

- A sense of belonging and recognition
- A living visual archive of Tigaiga's guest community
- A unique experience aligning with the hotel's warm, family-owned identity

The Polaroid wall also functions as an organic storytelling tool, strengthening word-of-mouth and offering a visually appealing welcome experience.

Overall Impact

The Smart Communication strategy generates substantial value for Hotel Tigaiga across environmental, social, and economic dimensions. By professionalizing content creation, strengthening multi-platform sustainability storytelling, and enhancing on-site experiential communication, the proposed interventions enable the hotel to fully capitalize on its long-standing sustainability leadership and family-driven identity. Importantly, these actions create both **short-term impacts**, observable within months, and **long-term structural impacts** that reinforce Tigaiga's competitiveness and resilience over the coming decade.

Short-Term Impacts (0–12 months)

In the short run, the professionalization of digital content—supported by student collaborations and low-cost audiovisual equipment—translates into immediate improvements in communication quality and consistency across platforms. Enhanced visual storytelling on Instagram, Facebook, and TikTok elevates brand perception and increases visibility among both loyal senior guests and the growing base of younger visitors seeking nature-based well-being escapes. Clearer sustainability communication also encourages more resource-efficient guest behavior (e.g., reduced towel washing, lower water use, greater waste separation), producing immediate environmental benefits and reducing operational costs. Internally, involving staff in storytelling and guest-facing communication fosters a sense of pride and ownership, improving morale and contributing to a more cohesive service culture.

Long-Term Impacts (1–5 years)

Over the long term, the strategy strengthens Hotel Tigaiga's position as a sustainability pioneer on Tenerife. The proposed GreenRoom institutionalizes a culture of transparency and continuous environmental learning, both for guests and employees. It also reinforces the hotel's alignment with European trends toward regenerative tourism and the expectations of next-generation travelers. Digitally documenting the hotel's history, environmental milestones, and circular practices contributes to a living archive that protects Tigaiga's identity as a family-owned establishment while increasing intangible brand value. Moreover, sustained, high-quality communication enhances competitive differentiation, supports higher guest retention, and may enable price premiums associated with verified sustainability experiences. The Polaroid memory wall, in turn, fosters long-term emotional attachment and strengthens loyalty among repeat visitors.

Viewed holistically, the Smart Communication concept transforms sustainability from a predominantly operational achievement into a **strategic asset** that enhances Tigaiga's visibility, trustworthiness, and experiential uniqueness. It creates a coherent narrative that links the hotel's heritage, its botanical garden, its EMAS-certified environmental performance, and its community values. By aligning digital, physical, and human-centered communication, the strategy not only amplifies Tigaiga's environmental leadership but also supports long-term competitiveness, resilience, and guest engagement in an increasingly demanding tourism market.

3.4 Impact Assessment (Environmental, Social, Economic)

The impact of the proposed sustainability measures—Smart Gardening, Sustainable Employee Mobility, and Smart Communication—was assessed through an integrated environmental, social, and economic lens. This assessment considers both direct operational effects and indirect behavioural changes among guests, employees, and partner organisations.

From an **environmental perspective**, **Smart Gardening** provides the most immediate and substantial potential for resource optimization. By shifting from a uniform irrigation scheme toward sensor-based watering tailored to plant needs, the hotel can considerably reduce water losses in its gardens—currently the property's most water-intensive area. In the context of Tenerife's declared water emergency, such reductions directly support regional conservation objectives and contribute to a more responsible use of scarce local resources. The **Sustainable Employee Mobility** initiative likewise yields significant environmental gains. Reducing the number of individual car commutes through coordinated car-sharing networks decreases overall CO_2 emissions, alleviates traffic congestion, and reduces hotel-related parking pressure and land use. Scenario-based projections indicate that medium to high adoption levels could result in substantial emission reductions, with the potential to lay the groundwork for a low-carbon shuttle system shared among multiple hotels. Collectively, these measures advance the hotel's alignment with Tenerife's regional climate strategy. **Smart Communication** supports environmental impact indirectly by increasing guest and employee awareness of resource-efficient behaviours. Enhanced visibility of sustainability practices can stimulate behavioural shifts—such as lower room-level resource consumption—thereby amplifying the hotel's existing environmental efforts. (Gössling et al., 2015, pp. 158-171; Pérez-Martín & Hernández-Cordero, 2023, pp. 569-585)

Social implications emerge most clearly in the Sustainable Employee Mobility concept. By reducing commuting time, cost, and stress, the initiative directly improves employee well-being and job satisfaction. Enhanced predictability and support in daily mobility can strengthen retention, cohesion, and organisational commitment—crucial factors for service quality in the hospitality sector. Additionally, the cross-hotel cooperation required for the mobility system encourages inter-organisational collaboration and community-building within the local tourism cluster. Smart Gardening also contributes to social value by preserving the aesthetic and recreational qualities of the hotel's botanical environment, which is a central component of the guest experience. A healthier, more resilient garden enhances guest satisfaction, supports Tigaiga's heritage identity, and reinforces the hotel's role as a peaceful nature-oriented retreat. Smart Communication amplifies the social dimension through educational and participatory effects. Clearer and more accessible sustainability communication increases transparency, fosters trust, and encourages guests to engage in environmentally responsible behaviour. It also provides employees with a clearer understanding of the hotel's sustainability goals, thereby strengthening internal alignment and shared purpose. (Martínez-García & Raya, 2020, pp. 77-130; Ortega & Díaz-Pérez, 2022, pp. 98-120)

Economically, the proposed measures contribute to both cost savings and long-term value creation. **Smart Gardening** has the potential to reduce water expenditure, while also lowering long-term plant replacement and fertilisation costs due to improved soil quality and more efficient irrigation. The **Sustainable Employee Mobility** system generates economic benefits for employees, which save on fuel, maintenance, and parking costs, increasing disposable income and enhancing job satisfaction. For the hotel, reduced parking demand, lower operational congestion, and potential reductions in staff turnover translate into measurable efficiency gains. At higher adoption levels, the mobility solution may achieve economies of scale sufficient to justify a multi-hotel shuttle service, potentially lowering transport-related costs further. **Smart Communication** creates economic value by differentiating Tigaiga in an increasingly sustainability-oriented tourism market. Improved sustainability visibility enhances the hotel's brand positioning, attracts environmentally conscious guests, and strengthens loyalty among returning visitors. In the long term, these effects can increase occupancy rates, improve Net Promoter Scores, and reinforce the hotel's competitive advantage. (Garrido-Sánchez et al., 2022; Jones et al., 2016, pp. 36-67)

Taken together, the assessment demonstrates that Smart Gardening, Sustainable Employee Mobility, and Smart Communication generate mutually reinforcing environmental, social, and economic benefits for Hotel Tigaiga. Each measure addresses a distinct operational challenge, yet their combined effects strengthen the hotel's overall sustainability and circularity performance.

3.5 Anticipated Challenges & Opportunities for Implementation

The implementation of the proposed measures—Smart Gardening, Sustainable Employee Mobility, and Smart Communication—offers significant potential for advancing Hotel Tigaiga's sustainability and circularity performance. However, each initiative also entails operational, organisational, and behavioural challenges that must be considered to ensure successful adoption. The following section outlines the key anticipated challenges and corresponding opportunities associated with the three proposals.

Challenges:

Operational Complexity and Resource Requirements

Introducing sensor-based irrigation systems requires technical installation, calibration, and ongoing data monitoring. Although the hotel already has experience with selective irrigation, transitioning to real-time, plant-specific systems may demand temporary disruptions and additional coordination with gardening staff. Similarly, exploring greywater reuse in collaboration with Teidagua involves regulatory approval, technical feasibility assessments, and long implementation timelines. These factors may delay visible results and require sustained investment.

Behavioural Resistance and Adoption Barriers

The Sustainable Employee Mobility initiative is highly dependent on behavioural change. Employees accustomed to private car usage may initially hesitate to join shared mobility systems due to concerns about convenience, privacy, route reliability, or coordination of shifts. Reaching medium and high adoption levels requires trust, transparency, and consistent communication. Furthermore, cross-hotel cooperation introduces coordination challenges surrounding governance, scheduling, and data management across partner establishments.

Consistency and Capacity in Communication

Professionalising content production for social media and establishing a structured communication strategy requires consistent effort and skills that are not currently available in-house. Reliance on external contributors, such as ULL students, may pose continuity challenges if collaborations are not formalised. Ensuring consistent tone, quality, and strategic alignment across TikTok, Instagram, and Facebook requires editorial discipline and monitoring. Internally, employee readiness to participate in storytelling or appear in videos may vary, necessitating sensitivity and training.

Regulatory and Reputational Risks

Given Tenerife’s water emergency, sustainability-related communication must balance transparency with accuracy. Overstating impacts or miscommunicating goals may create reputational risks. Similarly, initiatives such as greywater reuse require strict compliance with safety and hygiene standards to avoid negative perceptions among guests. Mobility initiatives must also be compliant with insurance, liability, and transport regulations across multiple cooperating hotels.

Opportunities:

Strengthening Environmental Leadership and Innovation Capacity

Implementing Smart Gardening solutions positions Tigaiga as a pioneer in circular water management within the region. Becoming a pilot site for greywater reuse can attract partnerships, contribute to regional sustainability agendas, and reinforce the hotel’s identity as an environmental benchmark. Long-term water savings also enhance resilience against climate-related risks that are increasingly affecting tourism destinations.

Enhancing Employee Well-Being and Organisational Cohesion

The Sustainable Employee Mobility initiative offers significant social benefits. Reduced commuting stress, lower costs, and strengthened cross-hotel collaboration can increase morale, retention, and organisational loyalty. These improvements positively influence service quality—an essential performance driver in hospitality. Moreover, involving employees in sustainability initiatives strengthens internal culture and shared purpose.

Differentiation in an Evolving Market

Smart Communication opens new avenues for brand differentiation, especially among younger travellers seeking authentic, low-impact experiences. By showcasing its heritage, daily operations, and certified environmental achievements more effectively, Tigaiga can expand its market appeal and strengthen long-term loyalty. The creation of a GreenRoom and the Polaroid memory wall adds experiential value to the guest journey, enhancing emotional connection and returning visitor rates.

Unlocking Long-Term Economic Benefits

All proposed measures generate cumulative economic advantages. Water efficiency reduces operational costs; improved staff satisfaction may lower turnover; and enhanced communication can lead to stronger occupancy rates and price premiums associated with sustainable tourism. In mobility, a mature car-sharing network may eventually justify shared shuttle services, producing economies of scale and reducing infrastructure strain.

Reinforcing Strategic Partnerships and Community Integration

Collaboration with ULL students for content creation, with partner hotels for mobility, and with Teidagua for circular water use strengthens Tigaiga's network within the local ecosystem. These partnerships support knowledge exchange, innovation, and long-term alignment with Tenerife's sustainable tourism vision.

In summary, the proposed solutions present a combination of manageable challenges and substantial opportunities. Their successful implementation depends on phased execution, continuous communication, stakeholder engagement, and adaptive management. If approached strategically, these initiatives can significantly enhance Tigaiga's environmental performance, social contribution, and economic resilience while advancing the hotel's long-standing commitment to responsible tourism.

3.6 Conclusion & Outlook

Hotel Tigaiga stands at a strategically advantageous moment in its sustainability journey. With more than two decades of EMAS and ISO 14001 certifications, a deeply rooted environmental culture, and a strong family-led identity, the hotel possesses a solid foundation upon which to build the next stage of its circular transformation. The analysis conducted throughout this chapter demonstrates that Tigaiga's existing practices already outperform regional benchmarks in several domains, yet meaningful opportunities remain to strengthen operational efficiency, employee well-being, and long-term competitiveness.

The proposed measures—Smart Gardening, Sustainable Employee Mobility, and Smart Communication—offer complementary pathways toward this advancement. Smart Gardening addresses the hotel's most pressing environmental challenge: water consumption in the botanical garden. Through sensor-based irrigation and the potential adoption of greywater reuse in collaboration with Teidagua, Tigaiga can significantly enhance its climate resilience and serve as a regional pilot for circular water management. Sustainable Employee Mobility tackles a long-standing social and environmental gap by reducing reliance on private vehicles, lowering CO_2 emissions, and improving employee quality of life through coordinated, community-driven mobility solutions. Smart Communication, meanwhile, unlocks the full strategic value of Tigaiga's sustainability leadership by transforming largely invisible operational practices into a coherent, accessible, and engaging narrative that resonates with both older loyal guests and the increasingly prominent segment of younger, wellness-seeking visitors.

Taken together, these proposals have the potential to reposition Hotel Tigaiga as a leading example of regenerative hospitality in Tenerife. They not only address operational needs but also reinforce the hotel's heritage, cultural identity, and human-centered philosophy. Their phased implementation allows for gradual adoption, risk mitigation, and continuous learning, ensuring that progress is both realistic and resilient.

Looking ahead, the hotel's long-term outlook is promising. By strengthening its communication strategy, embracing circular water solutions, and fostering sustainable mobility networks, Tigaiga can consolidate its reputation as a pioneer in sustainable tourism while deepening guest loyalty and elevating the visitor experience. Continued collaboration with local partners—including universities, neighbouring hotels, and infrastructure providers—will be essential to realising these opportunities. With its strong commitment to environmental stewardship and its unique combination of tradition, nature, and family hospitality, Hotel Tigaiga is well positioned to continue shaping the future of circular tourism on the island.

3.7 CIB25 Project and Team Reflection

The project offered a valuable opportunity to engage with sustainability and circular economy concepts in a real organisational setting and to translate theoretical knowledge into practice-oriented insights for Hotel Tigaiga. By analysing the hotel's environmental and social practices and developing targeted improvement proposals, the team gained a deeper understanding of how sustainability is embedded in daily operations and how organisational constraints, stakeholder expectations, and resource limitations shape practical implementation.

A central learning outcome was the realisation that sustainability initiatives rarely operate in isolation. Improvements in gardening, mobility, or communication affect not only environmental performance but also employee well-being, guest experience and long-term economic viability. The on-site visit further strengthened this understanding by revealing nuances—such as irrigation routines, staff mobility challenges and the visibility of sustainability efforts—that cannot be fully captured through documents alone.

The project also highlighted the importance of adaptive teamwork under time pressure. Balancing individual responsibilities with collective coherence required flexibility, efficient communication and continuous alignment. Responsibilities were distributed according to individual strengths—ranging from data interpretation to conceptual design and academic writing—which increased efficiency and ensured that each team member contributed meaningfully. This process strengthened collective ownership of the final output and fostered a supportive work environment in which constructive criticism was used to improve arguments and refine proposals.

Equally important were the insights gained from working collaboratively in an intercultural team. The group consisted of members with different cultural backgrounds, communication styles and ways of structuring work. This diversity proved to be an asset but also demanded active coordination and clarity. Through regular discussions and joint decision-making, the team developed a shared analytical direction. Moments of differing viewpoints became productive when addressed through evidence-based reasoning and respectful dialogue, reinforcing psychological safety and supporting higher-quality outcomes.

Working in an intercultural context also sharpened the team's awareness of implicit assumptions, especially when evaluating social impacts and communicating sustainability. Varied cultural perspectives enriched the discussion on employee well-being, mobility habits and guest expectations. These diverse viewpoints enabled a more holistic understanding of how sustainability measures are perceived and adopted in practice.

Overall, the project enhanced not only the team's analytical competencies in sustainability assessment but also its interpersonal, intercultural and collaborative abilities. It demonstrated the value of combining diverse perspectives, engaging in open communication and embracing iterative learning. These experiences will remain relevant for future academic work and for any professional context that requires interdisciplinary teamwork and the development of practical sustainability solutions.

4. Balten

4.1 Introduction to BALTEN

BALTEN, formally known as Balsas de Tenerife, is the main irrigation utility on the island of Tenerife.[1] It has operated since 1988 and supplies more than 90% of all agricultural water.[1] The organization manages a 1,500 km network of ponds, pipelines, and desalination plants.[2] BALTEN serves over 12,000 farmers with sustainable, solar-supported water.[2] Recent reservoir levels have improved significantly after Storm Claudia in 2025, reaching up to 28% capacity in some areas.[3] BALTEN has implemented advanced digital billing systems in partnership with Idrica.[4] The utility also uses a modern ERP system developed with Xylem to streamline operations.[5] Water supply restrictions were introduced in several Tenerife regions to balance demand and sustainability.[6] BALTEN aligns its activities with broader Canary Islands renewable-energy initiatives, including solar-powered desalination.[7] As a key public entity, BALTEN demonstrates how innovative technologies can meet both agricultural and environmental needs.[2]

4.1.1 Entrepreneurial Strategy Compass

BALTEN follows a value-chain orientation, collaborating with incumbents to drive green-energy innovation.[8] Key partners include technology providers, the Cabildo, government bodies, universities, and farmers.[8] BALTEN's core role is to build and operate reservoirs, desalination plants, and storage facilities.[9] The desired outcome is the integration of innovative desalination and wastewater reuse with renewable energy.[9] This strategy places BALTEN in the "Value Chain" quadrant of the Entrepreneurial Strategy Compass, emphasizing execution and control through partnerships.[8] University collaborations support intellectual-property development for Tenerife-specific solutions.[8] Disruption occurs through improved energy efficiency using the Canary Islands' abundant solar and wind resources.[10] Government backing ensures long-term project viability, including offshore hydrogen initiatives.[11] Overall, the compass guides BALTEN toward resilient, eco-friendly infrastructure that supports EU sustainability goals.[12]

4.2 The Challenge

The Isla Baja complex consumes 612,013.42 kWh of energy annually, imports 460,604.55 kWh from the grid, and generates 174,740.99 kWh from PV.[13] This results in a surplus of 65,372.01 kWh per year.[13] The first task is to size a battery for daily surplus storage and recommend suitable technology.[13] The second task requires an economic study of all options, including battery cost range, Net Present Value (NPV), and Internal Rate of Return (IRR).[13] Tenerife's public buildings show high PV potential, creating further surplus-management opportunities.[13] Grid imports highlight the need for local storage to reduce dependency in isolated island systems.[14] Effective short-term load balancing is essential for daily energy smoothing.[15] Declining battery prices make storage systems increasingly viable.[16] NPV and IRR calculations provide clear benchmarks for investment decisions.[17]

4.3 Proposed Technologies

Battery storage is ideal for short-term load balancing, offering ~85% round-trip efficiency and a lifespan under 10 years.[18] Green hydrogen (PEM electrolysis) converts surplus renewable energy into clean fuel for seasonal storage, with 40% efficiency and over 25 years lifespan.[19] Advanced Compressed Air Energy Storage (A-CAES) provides long-lifespan mechanical storage for multi-day shifting, with 70% efficiency and over 35 years durability.[20] Power-to-Liquid (PTL) e-Diesel transforms excess electricity into synthetic fuels for aviation and transport, with 30% efficiency and more than 20 years lifespan.[21] Lithium-ion batteries typically achieve 85–92% efficiency, perfectly matching BALTEN's daily surplus profile.[18] PEM hydrogen systems generate external revenue through fuel sales.[19] A-CAES produces minimal emissions and suits variable renewable inputs.[20] e-Diesel supports decarbonization of hard-to-electrify sectors.[21] Each technology addresses different storage durations, from hours (batteries) to seasons (hydrogen).[22] Integration of these solutions will reduce BALTEN's grid reliance and environmental footprint.[23]

4.4 NPV, IRR & Payback

Batteries deliver positive NPV (€10,000), IRR near 10%, and payback under 10 years.[24] Hydrogen options show higher NPV (€30,000) and IRR ~20%, but longer payback due to higher capex.[24] A-CAES yields moderate NPV (€15,000), IRR ~15%, and payback around 15 years.[24] e-Diesel produces negative NPV (~-€25,000), IRR -5%, and payback beyond 20 years.[24] NPV discounts future cash flows to evaluate long-term viability.[25] IRR identifies the break-even return rate for technology comparison.[25] Payback period measures time to recover initial investment.[25] Multi-use applications can improve IRR through stacked revenue streams.[24] Subsidies significantly enhance NPV across all technologies.[26] Batteries therefore offer the most favorable economics for BALTEN's surplus.[24]

4.5 Collaborative Space

Naturgy manages a 160 MW lithium-ion BESS portfolio in the Canary Islands.[27] BasquEvolt provides advanced technology for longer battery lifespan.[27] PLOCAN leads Spain's first offshore renewable hydrogen plant (15,000 kg/year) off Gran

Canaria.[28] Instituto Tecnológico de Canarias operates hydrogen pilot plants and biorefineries in Tenerife.[29] Highview Power is developing up to 2 GWh of liquid-air energy storage across Spain.[30] EDP participates in Spain's storage pipeline with potential for A-CAES innovation.[30] Moeve partners with Armas to supply 40,000 tons of 2G biofuels in Canary ports.[31] Iberia is investing in sustainable aviation fuel plants in the Canary Islands.[31] These partnerships accelerate renewable integration into BALTEN's operations.[27]

4.6 Subsidies and Grants

Spain allocated €840 million to 144 projects, adding 2.4 GW of battery capacity in 2025.[32] The EU offers an additional €700 million capex subsidy (up to 85%) for standalone BESS.[33] Spain announced €1.2 billion in new green-hydrogen subsidies.[34] Royal Decree 451/2022 enables direct hydrogen subsidies in the Canary Islands.[35] The EU approved a €400 million Spanish green-hydrogen subsidy scheme.[36] A further €840 million supports 143 innovative renewable projects totaling 9 GWh.[37] €1.2 billion funds 2.3 GW of renewable liquid fuels, including synthetic options.[38] AeH2 supports Spain's draft Royal Decree for e-fuels.[39] EU-funded PUSH-CCC positions Spain as a leader in sustainable fuels.[39] These grants make all four technologies financially attractive for BALTEN.[32]

4.7 Environmental Impact – Current and Future

Current groundwater overuse has depleted Tenerife's aquifers.[40] Energy-intensive desalination generates significant CO_2 emissions.[41] Brine discharge and chemicals cause soil pollution.[42] Battery storage will reduce emissions by maximizing renewable use.[43] Green hydrogen eliminates fossil-fuel dependency in transport and industry.[44] A-CAES preserves soil and water resources through low-emission mechanical storage.[45] e-Diesel provides cleaner fuels for aviation and shipping.[46] Desalination's carbon footprint is higher than groundwater extraction, but renewables mitigate this impact.[41] Sustainable practices in Tenerife balance water demand with environmental protection.[40] Global climate urgency, highlighted by Tuvalu's Minister Simon Kofe, underscores the need for immediate action.[47]

4.8 Conclusion

BALTEN’s electricity-storage project integrates proven technologies to solve surplus challenges and reduce environmental impact.[23] Strong partnerships and generous subsidies ensure rapid, cost-effective implementation.[27][32] Future deployment will deliver lower emissions, greater energy independence, and resilient infrastructure for Tenerife.[43] Together, we can build a greener, cleaner future.[12]

5. Tagua

The objective of this chapter is to provide a comprehensive analysis of Tagua's business model, as well as the challenges the company faces in achieving sustainable performance and its potential for dealing with these challenges and advancing awareness, sustainability and other sustainable practices.

The chapter outlines with Section 5.1, a general overview of Tagua as a company in the Canary Islands.

Section 5.2 provides a comprehensive analysis of the challenges currently being confronted by TAGUA in the context of sustainable and circular economic models. To investigate these challenges, Section 5.3 builds on these insights and provides two solution concepts.

5.1 Introduction to Tagua

The Spanish company TAGUA S.L., headquartered in Santa Cruz de Tenerife in the Canary Islands, specialises in the integral management of the water cycle, providing solutions across capture, treatment, distribution, sanitation and depuration of water. With more than 30 years of experience in the water-management sector, TAGUA positions itself as a technological partner offering tailored, high-specialisation services delivered by a multidisciplinary team.

Originally established to exploit and manage subterranean water resources, especially relevant in the Canary Islands context, the company has evolved to cover the full “water-cycle” spectrum from raw-water capture through to wastewater treatment and reuse. sectors of operation for TAGUA include agriculture, tourism, public administrations, industries and water-supply & sanitation infrastructures.

Having built its core competencies in the Canary Islands, TAGUA has increasingly sought internationalisation opportunities. Participation in the ICEX Next programme enabled the company to structure its export strategy by its own account its international business accounts for about 15 % of total turnover, with presence in West-Africa and plans for further expansion.

Figure 7: Illustration of TAGUA's Integrated Water Cycle System

5.1.2. Mission, Vision and Values

TAGUA emphasises providing customised solutions, high technical specialisation and a strong focus on environmental sustainability and service quality. Its own description states: *"Tu socio tecnológico de confianza"* ("your trustworthy technological partner"). The company stresses the importance of its multidisciplinary professional team and its capability to provide high-value services across all phases of the water cycle.

5.1.3. Business Activities and Service

- **Capture & Treatment**: extraction of groundwater or sea-water followed by physical/chemical treatment to render it suitable for human, industrial or agricultural use.
- **Desalination**: in the context of the Canary Islands, desalination of sea water is a strategic service provided.
- **Distribution**: delivery of treated water through the network infrastructure to end-use.

- **Sanitation & Depuration**: collection and treatment of wastewater to ensure environmental protection and potential reuse.
- **Engineering / Consultancy**: design and execution of water infrastructure works, including turnkey projects and maintenance services.

These activities are applied across multiple sectors: agriculture (irrigation water supply), tourism (water supply and sewage treatment in resorts), public administrations (municipal water services) and industry (process water treatment).

5.1.4. Corporate Context and Relevance for the Project

Operating in the Canary Islands gives TAGUA a strategic vantage point: the region faces water-management challenges (scarcity of freshwater resources, dependence on desalination, tourism pressure) which shape the company's competencies. In turn, this makes TAGUA a relevant case study for projects addressing sustainable water infrastructure, integrated water cycle management and the interplay of technical, environmental and institutional factors.

In our case-project in Tenerife, the collaboration with TAGUA offered insight into real-world water infrastructure operations in a sensitive environment linking technical systems (capture, treatment, distribution) with environmental, regulatory and economic dimensions. The company's evolution toward international markets and its emphasis on sustainability and innovation likewise provide a useful backdrop for reflecting on best practices and strategic challenges in water-cycle engineering.

5.2 Tagua's Challenge and the Perception of Reused Water

Tagua understands that the challenge lies in convincing the people of Tenerife to accept desalinated and reclaimed water. It is necessary to investigate the manner in which cultures are aware of the quality of water. There are millions of people who continue to participate in traditional purification ceremonies in India's Ganges River, despite the fact that the river is extremely polluted with microorganisms and chemicals during mass bathing festivals (Tyagi et al., 2013). This makes the Ganges River a useful example to compare. According to Sachdeva et al. (2016), despite the fact that the water is inherently dangerous, it enjoys a significant cultural significance as a symbol of spiritual purity. This paradox illustrates a larger societal trend, which is that common conceptions of water are influenced not just by the scientific quality of water, but also by symbolic, emotional, and cultural aspects of water. Despite the fact that both desalinated water and treated wastewater are in compliance with strict safety rules and separate water distribution networks,Tagua is confronted with the same problem as previously, but in a different way. According to research conducted by Dolnicar and Schafer (2009), people frequently have the perception that desalinated water is "unnatural" and that reclaimed water is potentially dangerous, despite the fact that both these types of water meet the quality requirements that have been established people believe that desalinated water is "unnatural" and that treated wastewater is always harmful. The similarities demonstrate that Tagua's problem is more about social concerns that are created by the same psychological and cultural elements that affect how people all over the world think about water. These factors are known to have an effect on how people perceive water. This example shows how deeply held cultural beliefs and emotional connections can affect how people judge the purity of water, which is an insight that is highly relevant to the social acceptance challenge Tagua faces (Tagua, 2024)

Tenerife is home to a paradox that is very similar. Certain individuals continue to harbor skepticism, despite the fact that desalinated water satisfies all of Europe's drinking water safety criteria and that secondary-treated wastewater is acceptable for applications that do not involve drinking water. For example, according to Rozin et al. (2015), psychological research places a strong emphasis on the "yuck factor," which is characterized by feelings of disgust that take precedence over rational evaluations of treatment procedures and safety measures. Because of this, there is a gap between the real water quality and how people feel about it, which has a direct impact on Tagua's company. Rather than focusing on technical capabilities, this problem is primarily associated with the Social (S) dimension of the ESG framework. This is because the most important aspects are trust, public perception, and community engagement. According to Fielding and Roiko (2014), the public's trust in the entity that is in charge of the project, the communication of risks, and the degree to which the project appears to be transparency are all significant factors that influence how people feel about the utilization of both desalinated and recycled water methods. ESG guidance also states that in order to reach the norms of socially responsible governance, organizations in the water sector need to demonstrate accountability, create social legitimacy, and respond to the concerns of the community (UNEP, 2023). Tagua's task is made even more difficult by the fact that the water infrastructure on the island is utilized by a wide variety of community organizations. Hotels, golf courses, cities, farmers, residents, and businesses that cater to tourists all recognize the significance of water; nevertheless, each of these groups has a unique set of reasons for wanting water and a different amount of risk associated with it. (Smith et al., 2018) Research conducted on water reuse in tourism-dependent regions reveals that visitor-oriented industries frequently opt for a cautious approach to public communication. This choice is driven by worries regarding the potential for unfavorable reactions from customers. Consequently, hotels might not want to actively encourage the use of reclaimed water for irrigation, despite the fact that it is theoretically acceptable to use for irrigation purposes. Clearly, this demonstrates that the acceptability of water is the result of a complex web of social and economic issues that are all interconnected. Changing behavior is an essential component of the ESG Social pillar because of the dynamics described above. The findings of research indicate that only providing information is not adequate for changing attitudes; rather, acceptance can be improved by continuous exposure, a clear description of treatment phases, social validation, and possibilities for direct involvement, such as facility tours (Leong, 2020). For the purpose of normalizing the use of desalinated and reclaimed water as important components of a circular water paradigm, it is essential to have public education, school programs, community outreach, and participatory communication. Tagua views this matter as an opportunity to make a constructive contribution to the betterment of society. Not only is sustainable innovation in the water sector becoming increasingly dependent on technological developments, but it is also becoming increasingly dependent on social programs that build trust, promote awareness, and make water systems easier for non-experts to understand (Minea et al., 2025). People's perspectives on water can be altered through the implementation of open-plant days, collaboration with educational institutions, transparent labeling of reclaimed-water irrigation, and collaborative efforts with government agencies to promote awareness. This will demonstrate that they care about responsible environmental, social, and governance policies while also reducing the stigma associated with them. The corporation and the local institutions need to be able to connect what people think with what science says and what is actually happening on the island in order for desalinated drinking water and wastewater that has been safely reused to be beneficial in the long run. According to a number of studies (Wester et al., 2016), widespread disapproval, perceived danger, and trust in institutions are crucial yet malleable factors that influence public acceptability. By incorporating these social insights into ESG-driven strategies, Tagua is able to contribute to the shifting of culture that is necessary for the development of a robust, circular, and socially supported water system in Tenerife.

These social factors not only affect people's views, but they also affect how well the island's water governance model will work in the long run. In areas where water is scarce and tourism puts a lot of pressure on the environment at certain times of the year, public acceptance becomes an operational need instead of a secondary concern. People in a community that knows about and supports desalination and water reuse are more likely to support new investments, work with conservation efforts, and use water responsibly. Studies on sustainable water transitions indicate that when institutions practice transparent communication, exhibit accountability, and ensure continuous participation, acceptance rates rise and resistance diminishes with time (Fielding & Roiko, 2014). So, making sure that public opinion matches scientific evidence is not only a social goal of ESG, but also a strategic part of making sure that Tenerife's change to circular water management stays stable, efficient, and socially acceptable for a long time to come.

5.3 Approach, Analysis & Solutions Summary

5.3.1 Strategic market analyses

Building on this foundational understanding of the ESG challenges, which are faced by tagua, an analysing of the current market has been made.

The primary source of TAGUA's revenue was disclosed by the CEO, Luis Gonzales. Tagua receives all of its revenue from both the private and public sectors. Tagua's definition of the public sector encompasses a wide range of entities, including hotels, golf clubs, slaughterhouses, bakeries, glass factories, and numerous other establishments. Conversely, the public sector will be divided into distinct categories, including institutions of higher education, town halls, sports facilities, and libraries.

By deciding to adapt a or launch a new product or service to the public and private market, it is necessarily to understand the audience. The TAM, SAM, SOM method represents all markets and helps to understand and address opportunities. (Athanasios Davalas 2023)

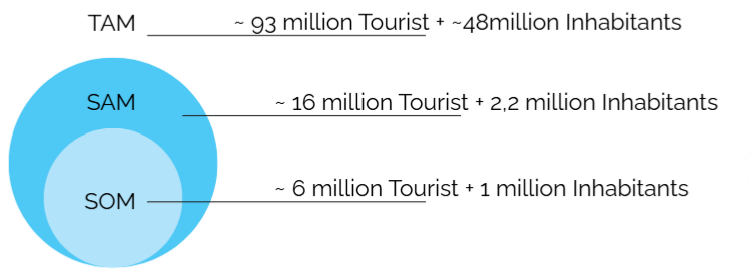

Figure 8: TAM/SAM/SOM Model on Teneriffe, Canary Island and Spain (Own Illustration)

The Analysis with TAM, SAM, SOM methods shows the enormous potential of tagua with Teneriffe, Canary Island and Spain.

It is imperative for companies to prioritize the core message and the primary target audience when implementing new systems. The development of a buyer persona facilitates the precise alignment of a new product or service with the needs of the identified target demographic. Personas are typically derived from the brand positioning, facilitating a targeted implementation that is optimally aligned with the needs of potential consumers (Häusel & Henzler, 2018).

5.3.2 Commercial Implications

The analysis of TAM, SAM and SOM yielded clear results. Considering that tourism is the main source of income for the Canary Islands and has considerable growth potential, the relevance of this sector became clear. Public reports show that tourism figures continue to rise annually. (Viva Canarias Online 25.11.2024) As the developed persona had a significant influence on our methodological considerations, it seemed sensible to systematically incorporate our own life realities and individual points of view.

Using the example of our persona the Erasmus student Samira, it becomes evident how targeted measures for awareness-building can be implemented across various points of contact to enhance both understanding and sustainable behavior.

Upon her arrival in Tenerife, Samira encounters the first awareness-raising elements. The provision of a public water fountain at the airport and the visible placement of the Tagua slogan serve as low-threshold informational touchpoints. Additionally, a publicly accessible water dashboard displaying real-time data on water quality increases transparency regarding the local water supply and strengthens trust in the use of tap water. These measures exemplify evidence-based communication strategies that rely on information visibility and user accessibility.

Within the university environment, Samira’s awareness is further deepened through formal educational offerings. Guest lectures delivered by company representatives and the integration of real-world case studies enable practice-oriented knowledge transfer. This form of university–industry collaboration not only enhances the company's visibility but also supports the development of critical, scientifically grounded understanding of key topics. Moreover, project-based learning formats foster Samira’s motivation to further engage with sustainability-related issues, ultimately leading to her collaboration with the company for her bachelor’s thesis.

Awareness measures can also be effectively implemented in non-academic contexts. The company’s sponsorship presence in sports and other activities creates additional low-barrier contact zones that anchor awareness of sustainable water use in everyday life.

Overall, the example illustrates how a strategy consistently oriented toward people's awareness and education can contribute to sustainably influencing knowledge, perception, and behavior. By combining transparently communicated information, educational formats, and visible presence in daily life, a company can not only fulfill its social responsibility but also strengthen its outreach and credibility. (Carbonell-Alcocer et al. 2025)

5.3.3 Technical Implications

The implementation of circular sludge management in treatment plants requires a combination of technical processes that allow for both energy and resource recovery. The literature highlights three main approaches: energy recovery (e.g. biogas), biochar production, and composting or co-composting. In Addition, another promising approach is anaerobic digestion. A recent study showed that this digestion with subsequent recovery of heat and electricity at a municipal sewage treatment plant in Mexico reduced energy consumption by 14% and significantly reduced operating costs. This means that part of the energy required by the sewage treatment plant can be covered by the biogas obtained from the sludge. (Garda-López et al.)

However, the technical implementation of such circular strategies necessitates meticulous planning. To proceed with the necessary analysis, it is imperative to first consider the material composition and moisture content of the sludge. In addition, the available infrastructure must be taken into account, including, but not limited to, digestion towers, dryers, and composting facilities. Furthermore, the energy requirements must be taken into consideration, as well as the local framework conditions. Furthermore, an integrated life-cycle assessment can facilitate a systematic comparison of the environmental, energy, and cost impacts of different scenarios, as demonstrated in comparative studies. (Qrenawi und Rabah 2021) (Garda-López et al.)

5.3.4 Conclusion

It is important to note that our study only covers a certain view, limit data access, and limited term paper pages. The study does not provide information on actual numbers of revenue, actions which tagua is already taken neither the acceptance of the target group. A long-term study that goes more into detail about what actions are already being taken, what actions have room for improvement, whether target groups.

6. WOOPTIX by ReNova

This chapter provides an integrated analysis of WOOPTIX through the lenses of circular knowledge, innovation management, and corporate consulting. Section 6.1 introduces the company and outlines its strategic challenges. Section 6.2 presents a circularity analysis of the current organisational knowledge system. Sections 6.3 and 6.4 describe two innovation concepts, an upgraded website and the WOOPATHON, followed by a consulting application (6.5) and concluding reflections (6.6).

Preface: Non-public information derives from interviews with CEO José Manuel Rodríguez and senior engineer Roberto Pangallo (Interviews, 10–12 November 2025).

6.1 Introduction and problem definition

6.1.1 Company Profile

WOOPTIX is a European deep-technology company headquartered in Tenerife, with additional offices in Madrid and San Francisco. The company specializes in Wavefront Phase Imaging (WFPI), a patented optical metrology method that enables nanometer-scale semiconductor inspection. The origins of WOOPTIX can be traced back to a period of over a decade of astrophysics and adaptive optics research at the University of La Laguna (ULL), under the leadership of the current CEO, José Manuel Rodríguez Ramos. This research marked the inaugural development of a technological spin-off from the ULL, signifying a significant milestone in the realm of scientific advancement within the Canary Islands. The company employs approximately 80 specialists, with projections indicating a target of 130 by 2026. Approximately 25% of these specialists hold PhDs, and the company has more than 13 active WFPI-related patents. Despite its geographic distance from major semiconductor hubs, Wooptix collaborates with ASML, Samsung, IMEC, and Intel, thereby underscoring its technological relevance. (Rodríguez, personal communication, 12 November 2025; WOOPTIX, 2025)

6.1.2 Strategic Context: The Global Semiconductor Landscape

The semiconductor industry is globally distributed and highly specialized: Taiwan dominates advanced manufacturing, the United States leads in chip design and IP, South Korea in memory, the Netherlands in EUV lithography, Japan in materials and specialty equipment, and Europe in research excellence through IMEC, CEA-Leti, and Silicon Saxony (McKinsey & Company, 2023). Knowledge circulates fluidly in these hubs through dense university–industry networks, talent mobility, and collaborative research cultures. Tenerife, by contrast, lacks semiconductor fabs, suppliers, and research consortia (Pangallo, personal communication, 10 November 2025; Rodríguez, personal communication, 12 November 2025). Guido D'hert (2025) emphasizes that early visibility and strong educational ecosystems are essential for attracting high-skill semiconductor talent; yet such an ecosystem does not exist regionally. WOOPTIX must therefore develop its own internal mechanisms for talent generation, knowledge circulation, and innovation intake, functions normally supplied by a broader cluster.

6.1.3 Current Sustainability Practices at WOOPTIX

WOOPTIX demonstrates substantive sustainability practices that, although not yet systematically communicated, contribute meaningfully to the company's social, organisational, environmental, and regional resilience. The current Sustainability webpage (status November 10-14, 2025) remains high-level and is not aligned with frameworks such as the UN Sustainable development goals (SDG´s) or ESG reporting; enhancing this page is therefore part of the consulting intervention. In the field of human and talent development, WOOPTIX maintains close collaboration with the ULL, overseeing student research projects from undergraduate to doctoral levels and jointly developing Europe's inaugural microcredentials in semiconductor metrology. The interviews reveal an organisational culture that is characterised by a strong family-oriented ethos. This is defined by a commitment to scheduling based on trust, open communication channels and leadership that is approachable and accessible. From an environmental perspective, WFPI contributes to enhanced resource efficiency in the semiconductor fabrication process by facilitating earlier defect detection. This, in turn, results in a reduction in wafer scrap, material consumption and energy use (WOOPTIX, 2025). Regionally, the company anchors high-value research and employment in the Canary Islands, supporting economic diversification in an outermost European region. These practices provide a strong foundation for sustainability, though they remain insufficiently visible without improved communication.

6.1.4 WOOPTIX´s Core Challenges

WOOPTIX faces three interdependent challenges: talent scarcity, knowledge fragmentation, and limited global visibility. Advanced metrology roles are globally undersupplied (McKinsey & Company, 2023), and WOOPTIX´ distance from semiconductor clusters further restricts its applicant pool. WFPI expertise is highly tacit and concentrated in a few senior engineers, creating operational risk (Accenture, 2023). Visibility in global talent markets is limited. These conditions form a negative reinforcing loop: low visibility reduces applicants, experts become overburdened, knowledge bottlenecks intensify, innovation slows, and visibility declines further (see Figure 5). A circular, systemic approach to talent and knowledge management is therefore required.

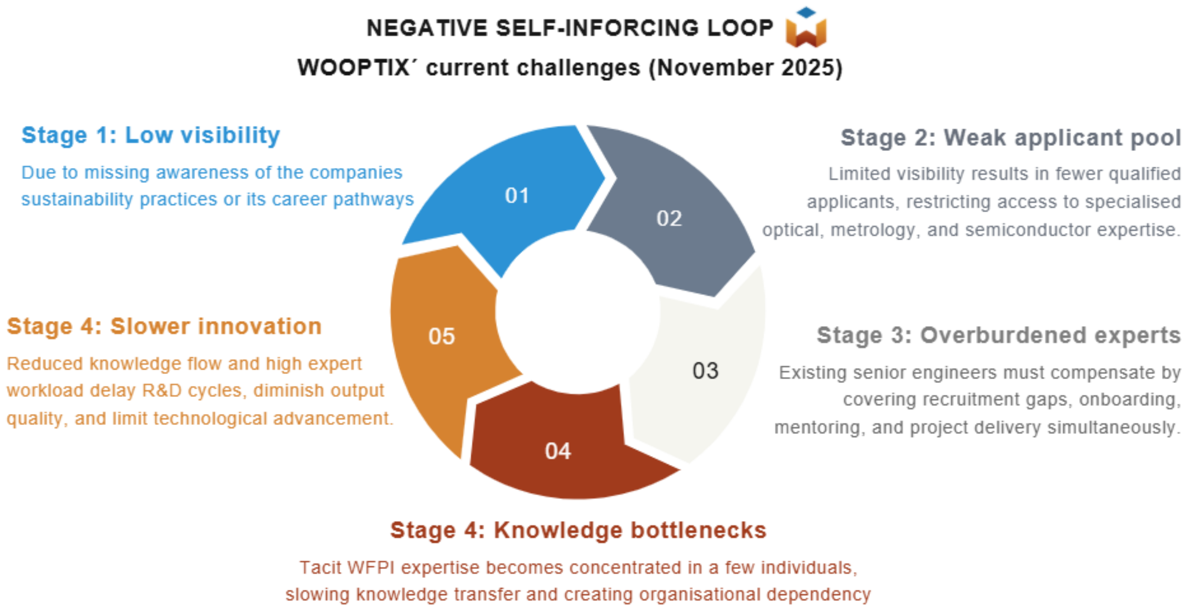

Figure 9: The Negative Reinforcing Loop at WOOPTIX (Own illustration based on expert interviews)

6.1.5 Consulting Mandate & Deliverables

The identified challenges demonstrate the need for a systemic and implementable model to enhance talent attraction, knowledge sustainability, and innovation capacity. Three targeted concepts were therefore developed by ReNova (Table 1):

Table 1: Overview of the Three Concepts (Own illustration based on WOOPTIX´ challenges)

Concept idea	Purpose and Explaination	Expected Contribution
1) People & Knowledge Website Chapter	A new digital entry point communicating micro-credentials, career pathways, corporate culture, and WFPI insights.	Strengthens visibility + talent attraction (for final theses, internships)
2) Sustainability Chapter Upgrade	A reframing of the existing webpage to highlight environmental, social, and organisational sustainability impacts accordingly to the SDGs	Enhances transparency + investor credibility
3) WOOPATHON Challenge	A recurring deep-tech challenge generating reusable knowledge artefacts and attracting high-skill talent.	Generates knowledge artefacts + attracts talent

Together, these interventions form the *WOOPTIX Circular Knowledge Loop*, a regenerative model for circulating knowledge, innovation, and talent. The concepts are introduced and discussed in Chapters 6.3 and 6.4.

6.2 Circularity Analysis

6.2.1 System Boundaries and System Map

WOOPTIX functions as a knowledge-intensive organisation in which value creation depends on the circulation rather than the accumulation of expertise. Knowledge enters the system primarily through ULL theses, internships, and PhD projects, complemented by external applicants, microcredential learners, and industry feedback (Rodríguez, personal communication, 12 November 2025). Core internal processes include R&D work, mentoring and documentation. These processes generate outputs such as prototypes, algorithms, and onboarding materials, though these currently remain dispersed and largely undocumented. As a result, knowledge circulation relies heavily on tacit transmission from senior experts (Pangallo, personal communication, 10 November 2025). The system map shows how academic input is transformed into applied expertise, refined through interactions with industry partners, and intended to be consolidated in a central Knowledge Hub. The cyclical nature of these flows highlights both the organisation's dependence on individual expertise and the potential to strengthen circularity through structured documentation and accessible knowledge repositories.

6.2.2 From System Map to Circular Knowledge Loop

The Circular Knowledge Loop represents the intended future state of WOOPTIX´s knowledge ecosystem following the implementation of the People & Knowledge webpage, the expanded Sustainability chapter, and the WOOPATHONS. Enhanced digital visibility strengthens Attraction, drawing students, professionals, and investors by showcasing clear learning pathways and WOOPTIX´s scientific and sustainability commitments. WOOPATHONS formalise Engagement by exposing participants to WFPI-related challenges and early-stage learning. These activities generate Innovation outputs that were previously tacit. Through Knowledge Return, these outputs are integrated into the Knowledge Hub, where they inform onboarding, training, future challenges, and external communication. The resulting regenerative cycle reduces knowledge bottlenecks, accelerates learning, and improves WOOPTIX´s visibility among talent, partners, and investors.

6.2.3 Application of R-Strategies to Knowledge

Although R-strategies are traditionally used for materials, they can also be applied to knowledge, which is Wooptix's most valuable resource. Currently, knowledge in the company flows in a linear way students join briefly, ideas disappear once the project ends, and expertise often remains only with individuals. By applying circular R-strategies, Wooptix can turn this into a continuous knowledge loop.

Refuse and Reduce focus on preventing knowledge loss and reducing the time and cost required to generate new insights. Through initiatives like the Woopathon and the Knowledge Hub, student solutions, reports, and prototypes remain accessible rather than disappearing after the program. This reduces future onboarding effort and shortens the time needed to develop new ideas.

Reuse and Repair help Wooptix benefit repeatedly from existing insights. Ideas created during hackathons can be built upon in later cycles, and past solutions can be revisited to address skill gaps or refine internal processes. Instead of starting from zero each time, teams can "repair" and strengthen current capabilities using shared knowledge.

Refurbish, Repurpose, and Recycle allow Wooptix to continuously upgrade and transform old ideas into new opportunities. Concepts initially created for technical challenges may later support business, organizational, or sustainability strategies. Even unsuccessful solutions still contribute valuable learning that becomes input for future innovation rounds. In this way, knowledge does not end, instead it evolves.

Overall, applying R-strategies to knowledge enables Wooptix to build a circular knowledge ecosystem where ideas, skills, and insights stay within the organisation, grow over time, and create compounding strategic value.

6.2.4 Sensitivity and Trade-Off Analysis

The success of Wooptix's knowledge-based initiatives depends on several external and internal factors. Participation levels, for example, are a major sensitivity point: high engagement from universities and professionals generates diverse ideas and a larger talent pool, while lower engagement reduces overall impact. Similarly, the quality of the challenges Wooptix defines plays a crucial role. Well-framed, relevant problems inspire high-value solutions, while poorly defined topics limit the outputs.

Another important sensitivity variable is internal resource availability. The effectiveness of the program increases significantly when Wooptix mentors are actively involved, since expert guidance helps participants produce realistic and usable solutions. Incentives such as certificates, visibility, or internship opportunities also affect engagement levels; stronger incentives usually increase participation and effort.

Trade-offs are also present. Open innovation generates fresh ideas and visibility, but requires careful handling of confidentiality, meaning Wooptix must choose challenge topics that are safe and non-sensitive. The program also demands short-term staff effort, but this investment leads to long-term benefits such as reduced hiring costs, stronger employer branding, and more innovation. There is also a balance between speed and depth: faster hackathon cycles create momentum, while longer cycles produce more refined solutions.

6.3 Innovation analysis/Problem solving concept 1: Improvement of the WOOPTIX website

A clear and coherent digital communication strategy is essential for Wooptix, particularly in a context where deep-tech companies depend on transparency, talent attraction and strategic partnerships to accelerate innovation cycles. The current website provides valuable information about the company's technological capabilities and projects, yet it does not fully reflect the organisation's growing concern on knowledge creation, talent development, and sustainability. Therefore, this concept proposes a structured redesign of the Wooptix website aimed at strengthening stakeholder communication, improving user navigation, increasing visibility of the company's purpose and values, and supporting long-term organisational goals in circularity, innovation and talent acquisition.

6.3.1 Creation of the "People & Knowledge" Section

The first proposed improvement is the introduction of a new website section titled "People & Knowledge", replacing the traditional "Careers" tab. The rationale behind this shift is to expand the scope from a purely recruitment-focused page to a holistic platform that highlights Wooptix's role as a generator of knowledge, an incubator of talent, and a connector within the research and innovation community. This new section would unify all opportunities related to human development and learning within the company, including PhD mentoring programmes, trainee and internship programmes, job vacancies, micro-credentials, short training modules, and a dedicated subsection introducing the "Woopathon", the company's customised hackathon concept designed to attract multidisciplinary talent, stimulate creative problem-solving, and generate novel ideas for optical innovation.

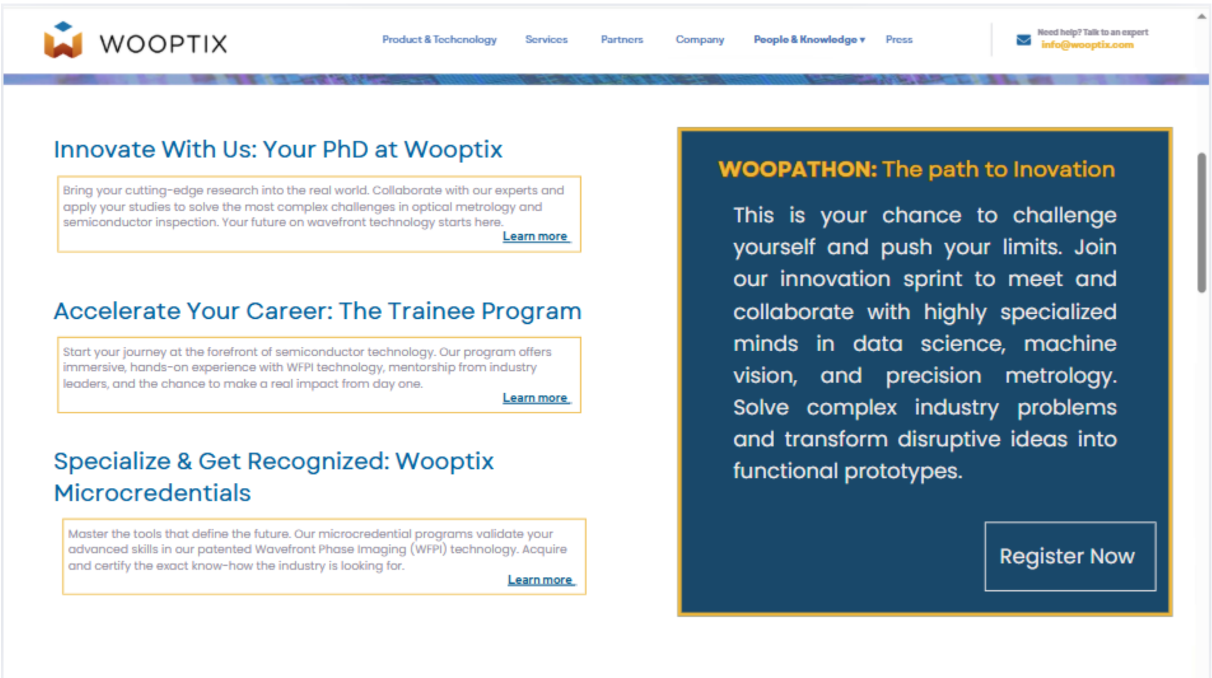

Figure 10: Simulation of the redesigned "People & Knowledge" webpage for Wooptix

(Created by the author)

By integrating all these elements, "People & Knowledge" communicates a strong value proposition: Wooptix is not only a high-tech company but also an ecosystem that invests in people, scientific exploration, and collaborative innovation. For potential applicants and partners, this enhances transparency, strengthens employer branding, and showcases career development pathways, key factors in attracting talent in a competitive deep-tech market.

6.3.2 Enhancement of the Sustainability Section

The second strategic improvement focuses on strengthening the previous Sustainability section of the Wooptix website. While the previously version highlights how the company's technologies contribute to global challenges, it still lacks a structured, transparent, and comprehensive explanation of Wooptix's own sustainability commitments and the measurable impact it creates. Enhancing this section would allow visitors, both technical and non-technical, to clearly understand how the company's innovations translate into societal and environmental benefits.

To address this gap, the redesigned Sustainability section should articulate how Wooptix's products and technological advancements directly support more efficient and responsible industry practices, but also how internal practices contribute to that too. This includes enabling improved resource efficiency, advancing precision manufacturing, and reducing waste in semiconductor inspection processes. Positioning these contributions within a clearer narrative will help connect the company's technology-driven mission with concrete sustainability outcomes. The new section should also explicitly map Wooptix's alignment with the Sustainable Development Goals (SDGs) to which it already contributes. The company's activities and innovation efforts intersect with several key SDGs:

- **SDG 4 (Quality Education):** through mentorship programs, microcredential initiatives, and active collaboration with academic institutions.
- **SDG 8 (Decent Work and Economic Growth):** by creating high-value employment opportunities in the deep-tech sector and fostering talent development
- **SDG 9 (Industry, Innovation and Infrastructure):** through the development of advanced optical metrology technologies that drive industrial innovation.
- **SDG 17 (Partnerships for the Goals):** by cultivating partnerships with universities, research centres, and industrial stakeholders to accelerate technological progress.

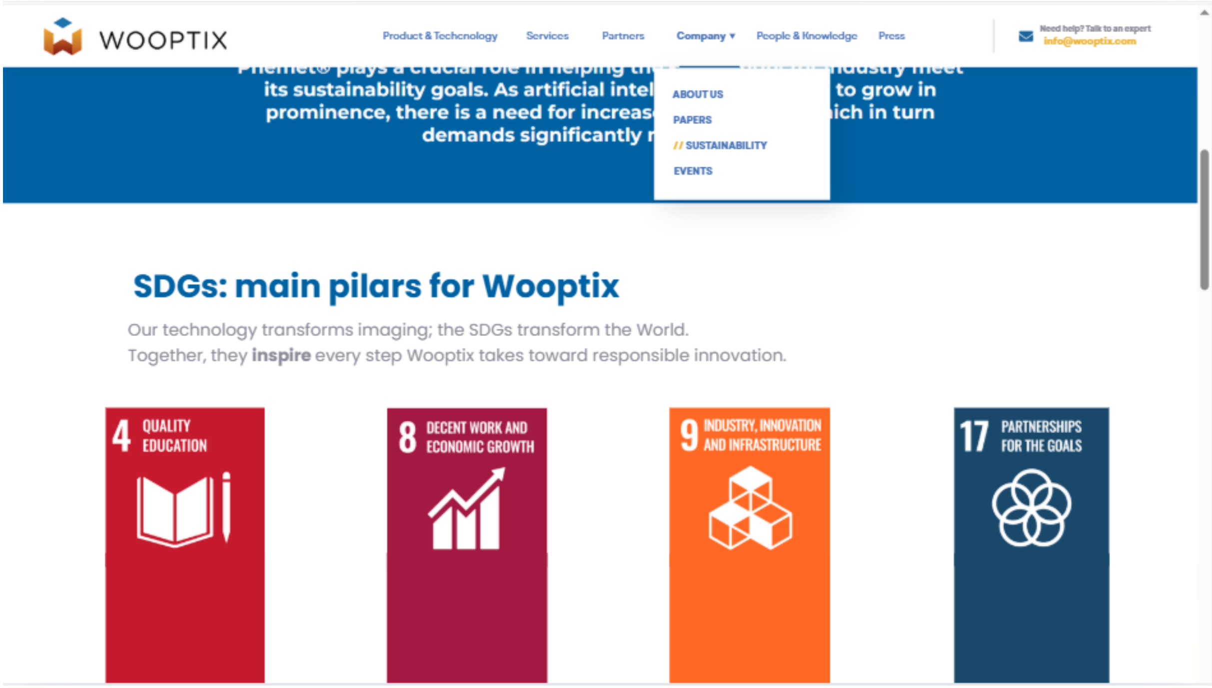

Figure 11: Simulation of the redesigned "Sustainability" webpage for Wooptix

(Created by the author)

Improving this section positions Wooptix as a transparent and responsible organisation that recognises the importance of aligning high-tech innovation with global sustainability priorities. This is particularly relevant as investors, partners and clients increasingly evaluate technology companies not only on performance, but also on environmental and social impact.

6.4 Innovation analysis/Problem solving concept 2: WOOPATHON Circular Knowledge Innovation Program

6.4.1 Purpose

The Woopathon Framework is designed as a continuous, circular system of innovation and talent development that links Wooptix with universities through recurring cycles of challenge-based learning, mentoring, idea refinement, and knowledge reintegration. Its structure reflects established innovation research: open innovation theory emphasizes the strategic value of moving knowledge across organizational boundaries (Chesbrough, 2003), while organizational knowledge creation theory argues that firms remain competitive when they continually generate, share, and internalize new knowledge (Nonaka, 1994).

By embedding these principles into a repeating challenge cycle, the Woopathon Framework transforms universities into ongoing sources of talent, research insights, and experimental problem-solving, ensuring Wooptix has a constant inflow of ideas and people who understand its technologies.

The need for such a system is reinforced by global evidence of a severe semiconductor talent shortage, projected to require over a million additional skilled workers by 2030 (Deloitte, 2024; SIA, 2023). Research consistently shows that structured university–industry collaboration is one of the most effective pathways for building advanced skills, transferring knowledge, and accelerating innovation (Perkmann et al., 2013; Ankrah & AL-Tabbaa, 2015). Additionally, universities today are key contributors to the UN Sustainable Development Goals (SDGs) through education, research, and multi-stakeholder partnerships (Chankseliani, 2021; UNESCO IESALC, 2023). By leveraging universities as open portals of further development, the Woopathon Framework creates a regenerative ecosystem—one that not only mitigates the talent gap but also embeds sustainability and long-term learning into Wooptix's innovation strategy.

1. **Address the Talent Shortage** - The Woopathon attracts, trains, and prepares future specialists before hiring, creating a long-term pipeline of capable talent.

    - Semiconductor companies worldwide face a persistent global shortage of skilled professionals who understand optical metrology, wafer inspection, and deep-tech systems. Wooptix's own interview highlighted that the company's most critical bottleneck is not technology, but the availability of "minds" people with the right combination of expertise and curiosity. By involving students early through the Woopathon, Wooptix can expose participants to WFPI technology, data acquisition methods, metrology workflows, and semiconductor challenges before they seek full-time positions. This proactive development significantly reduces the time and cost required to onboard new employees because participants already have foundational understanding and motivation built through hands-on challenges.

2. **Support Continuous Knowledge Circulation** - Woopathon ensures that new ideas, perspectives, and insights continually re-enter Wooptix, preventing knowledge stagnation and strengthening long-term innovation capacity.

    - In fast-moving sectors like semiconductor metrology, knowledge becomes obsolete rapidly if it is not continuously renewed. The Woopathon allows Wooptix to regularly access external creativity from students, researchers, and professors, who approach challenges using emerging theoretical frameworks, new computational methods, or innovative conceptual angles. Every cycle produces solution drafts, prototypes, reflections, and documentation that are reintegrated into Wooptix's internal knowledge system. The cyclical nature of the program ensures that Wooptix is never dependent on a single generation of ideas but instead continuously feeds on evolving academic insights and youthful experimentation.

3. **Advance Sustainable Innovation** - The Woopathon embeds environmental and social sustainability into scientific development, ensuring Wooptix's growth aligns with SDG principles and responsible innovation.

    - Many challenges can be themed around environmental issues such as reducing semiconductor waste, improving energy efficiency, or developing metrology methods for microplastic detection. Universities, which naturally emphasize ethical and sustainable science, serve as intellectual catalysts for these topics. This ensures that participants approach technical problems not only from a performance perspective but also from a systemic environmental one. As a result, the Woopathon does not only produce new ideas for optical metrology, it produces responsible, future-oriented ways of thinking that contribute to Wooptix's long-term social and environmental impact.

6.4.2 Woopathon Challenge Flow

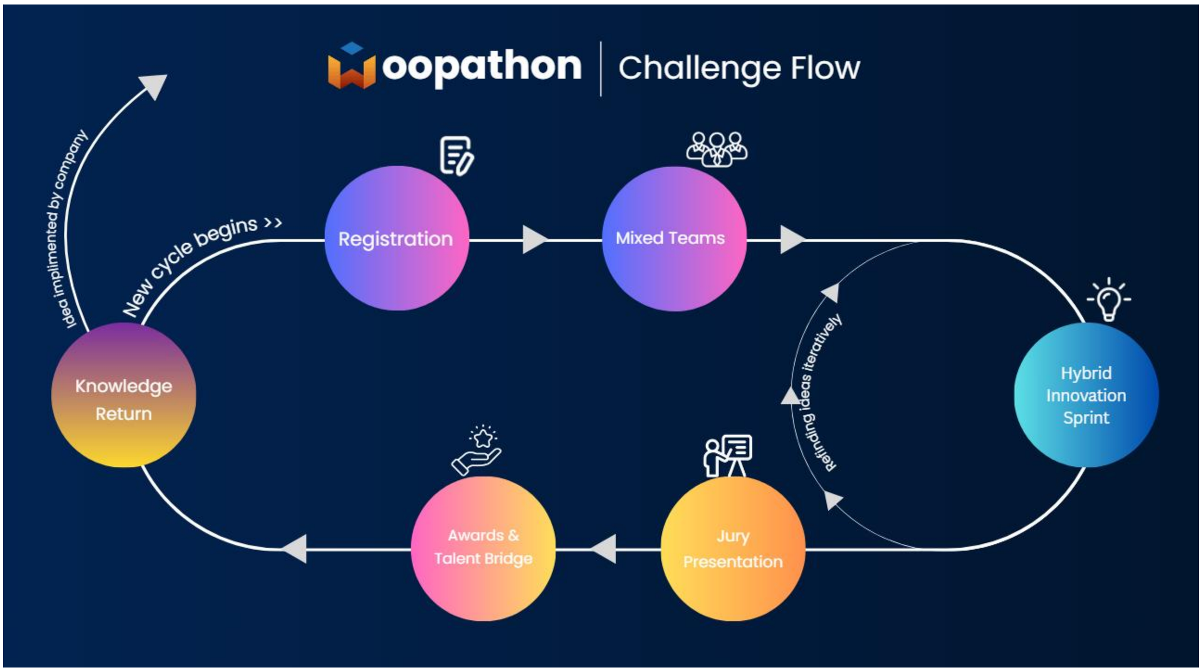

Figure 12: Woopathon Challenge Flow

The Challenge Flow serves as the operational engine of the Woopathon Framework. It outlines how participants move from initial entry into the program to becoming contributors to Wooptix's knowledge ecosystem. It also describes how knowledge circulates continuously between universities and Wooptix, forming a closed-loop innovation cycle that grows stronger with each iteration.

6.4.2.1 Registration (Opening the System)

Registration begins through Wooptix's university partners and website, enabling simultaneous reach to students, alumni, and professionals. This mirrors the concept of academic engagement, where universities act as ongoing partners that channel knowledge and talent toward industry (Perkmann et al., 2013). By positioning itself as a learning-oriented collaborator, Wooptix follows recommended best practices for firms integrating into innovation ecosystems (Ankrah & AL-Tabbaa, 2015; Kozirog et al., 2022).

6.4.2.2 Mixed Teams (Interdisciplinary Collaboration)

Teams are intentionally mixed by combining students, alumni, and professionals. Students bring creativity, alumni understand workflows, and professionals contribute industry insights. Research demonstrates that diverse expertise improves complex problem-solving and innovation outcomes (Riesener et al., 2019). This also aligns with Nonaka's idea that shared and overlapping perspectives encourage richer knowledge creation (Nonaka, 1994).

6.4.2.3 Hybrid Innovation Sprint (Moving Beyond One-Off Hackathons)

The Hybrid Innovation Sprint forms the core operational phase of the Woopathon Framework. It combines the focused creativity of a sprint with the structure of challenge-based learning and the continuity required for deep-tech environments.

Structure

1. **Preparatory Briefing**
   Participants receive challenge outlines, WFPI-related context, and relevant technical materials. This supports a shared baseline of understanding.

2. **Mentor Assignment**
   Each team is paired with a Wooptix mentor who provides technical guidance and iterative feedback, consistent with the role of mentoring in university–industry collaboration (Perkmann et al., 2013).

3. **Intensive Sprint**
   Teams engage in concentrated ideation, data interpretation, conceptual design, and prototype development. This format adapts the creative intensity of hackathons while addressing documented weaknesses of traditional hackathons such as limited depth and follow-through (Briscoe & Mulligan, 2014; Uffreduzzi, 2016).

4. **Post-Sprint Refinement**
   Teams adjust and strengthen their work following feedback. Iterative refinement aligns with innovative ecosystem models that view iteration as essential to producing technically viable solutions (Riesener et al., 2019).

Characteristics

- **Hybrid Delivery (Online/On-Site)**
  Ensures accessibility for students, alumni, and professionals while allowing synchronous collaboration (Kamalaldin et al., 2022).

- **Interdisciplinary Teamwork**
  Teams integrate optical, data-science, engineering, and innovation expertise,

reflecting research showing that complex technical challenges benefit from cross-functional collaboration (Riesener et al., 2019).

- **Structured Deliverables**
  Outputs include conceptual models, prototype sketches, data insights, and sustainability considerations.

6.4.2.4 Jury Presentation (Evaluation and Sense-Making)

In this stage, teams present their outputs to a panel of Wooptix engineers and academic experts. Jury evaluation serves as a sense-making mechanism: it filters ideas, validates technical and scientific rigor, and identifies concepts with strategic relevance.

This mirrors the role of evaluative interfaces in innovation ecosystems, where expert review helps translate exploratory ideas into concrete innovation opportunities (Riesener et al., 2019). It also builds participants' scientific communication skills, which are crucial for effective university–industry collaboration (Ankrah & AL-Tabbaa, 2015).

6.4.2.5 Awards & Talent Bridge (From Participant to Contributor)

The Awards & Talent Bridge stage converts participant achievements into structured development pathways: internships, thesis collaborations, microcredentials, or trainee positions. Research shows that development-focused incentives (not cash prizes) strongly motivate student participation and enhance long-term engagement in university–industry innovation initiatives (Perkmann et al., 2013; Ankrah & AL-Tabbaa, 2015).

This stage also operationalizes recommendations from semiconductor workforce studies, which urge companies to collaborate with universities to build continuous talent pipelines and address global skills shortages (Deloitte, 2024; SIA, 2023).

6.4.2.6 Knowledge Return (Circular Integration of Outputs)

The Knowledge Return phase finalizes the Woopathon cycle by converting participant outputs into structured, reusable knowledge assets. This stage ensures that insights generated through the Hybrid Innovation Sprint are systematically reintegrated into Wooptix and shared with academic partners, supporting the circularity of the Woopathon Framework.

Documentation

- Consolidation into the Wooptix Knowledge Hub
  All outputs (reports, prototypes, notes, assessments) are stored in a structured repository, consistent with Nonaka's (1994) model of explicit knowledge capture.

- Codified Learning
  Insights from each cycle inform future internal R&D directions and contribute to organizational memory, reflecting open innovation principles of purposeful knowledge absorption (Chesbrough, 2003).

Academic Integration

- Curriculum and Research Input
  Universities incorporate relevant materials into coursework, seminars, or new research questions, supporting their role as active actors in innovation ecosystems (Etzkowitz, 2003; Nistor et al., 2022).

- Preparation for Future Cycles
  Returned knowledge guides the design of upcoming Woopathon challenges, ensuring progressive development across iterations.

Ecosystem Effect

- Cumulative Knowledge Growth
  Each cycle strengthens the next, forming a self-reinforcing loop of learning and innovation, an effect described in research on sustainable innovation ecosystems (Riesener et al., 2019).

6.4.3 Partnerships (Universities as Open Portal for Continuous Development)

The Woopathon Framework positions universities as central partners in Wooptix's circular knowledge ecosystem. Rather than serving only as recruitment channels, universities operate as development hubs, knowledge gateways, and innovation nodes that continuously generate and transfer capabilities into Wooptix. This aligns with research emphasizing the increasing role of universities in modern innovation ecosystems (Perkmann et al., 2013; Etzkowitz, 2003).

- **Universities as Knowledge Gateways**
    - Provide access to emerging research and experimental methods in optics, photonics, and data science, enriching Wooptix's technical base.
    - Contribute scientific rigor and analytical reasoning essential for deep-tech innovation (Nonaka, 1994).
- **ULL as the Central Development Hub**
    - Serves as Wooptix's primary academic anchor through existing micro-credentials, faculty expertise, and longstanding collaboration.
    - Offers a continuous talent pipeline in physics, engineering, and related disciplines, supporting stable workforce development.
- **National and International Universities as Expansion Nodes**
    - Universities in Spain, Europe, and partner institutions abroad contribute diverse academic strengths and innovation cultures.
    - Multi-university collaboration supports scalable challenge-based learning and broader access to interdisciplinary talent (Kamalaldin et al., 2022; Nistor et al., 2022).
- **Universities as Sustainability Accelerators**
    - Higher education institutions integrate SDG principles into teaching and research, enabling Wooptix to embed sustainability into its technological development.
    - Collaboration supports SDG 4 (Quality Education) and SDG 9 (Industry, Innovation & Infrastructure).
- **Long-Term Talent and Knowledge Portals**
    - Internships, thesis collaborations, and microcredentials create predictable, structured pathways for talent entry and knowledge continuity (Ankrah & AL-Tabbaa, 2015).
    - Academic partners reintegrate Woopathon insights into curricula, reinforcing learning between cycles.

6.4.3.1 Additional Strategic Partner Option: National Yang Ming Chiao Tung University (NYCU)

National Yang Ming Chiao Tung University (NYCU)in Taiwan may serve as an additional high-value partner due to its internationally recognized expertise in semiconductor engineering, photonics, and applied physics. Research consistently identifies NYCU (formerly NCTU) as one of Taiwan's top institutions in electrical engineering, optoelectronics, and semiconductor research, with strong publication outputs and global research impact in these fields (Huang et al., 2019; Kao & Lee, 2021). Its location within the Hsinchu Science Park, one of the world's leading semiconductor ecosystems which provides proximity to advanced suppliers, researchers, and industry clusters, including TSMC, UMC, and major photonics firms (Mathews & Cho, 2000). A collaboration with NYCU could therefore support deeper research development without the IP risks associated with short-term hackathon formats, while also strengthening Wooptix's SDG-aligned goals in education, innovation, and sustainable talent development (UNESCO IESALC, 2023).

6.4.4 Feasibility Assessment

A comprehensive feasibility assessment was conducted to evaluate the practicality, resource requirements, and long-term viability of implementing the Woopathon Framework. The assessment follows six widely used dimensions in innovation and organizational feasibility studies: technical, organizational, financial, human resource, ecosystem, and long-term sustainability feasibility, reflecting standard frameworks applied in innovation management and technology adoption research (Tornatzky & Fleischer, 1990; OECD, 2018).

Feasibility Dimension	**Assessment Summary**	**Supporting Evidence**
Technical Feasibility	Feasible	• Wooptix already has WFPI datasets, optical tools, and technical expertise needed to design challenges. • Mentor-based supervision already exists through internships and thesis collaborations. (Perkmann et al., 2013; Riesener et al., 2019)
Organizational Feasibility	Feasible	• Existing cooperation with ULL through micro-credentials, studentships, and knowledge exchange.

		• Company culture is academically rooted and supports knowledge circulation. (Nonaka, 1994)
Financial Feasibility	Highly Feasible	• Hybrid events reduce operational cost. • Rewards are development-based (internships, certifications), not cash-intensive. • Addresses talent shortage and reduces hiring/onboarding costs. (Ankrah & AL-Tabbaa, 2015; Deloitte, 2024; SIA, 2023)
Human Resource Feasibility	Feasible with distributed roles	• Mentoring can be rotated across engineering teams. • University faculty can co-supervise. • Workload manageable due to cyclical planning. (Nistor et al., 2022)
Ecosystem Feasibility	Strongly feasible	• Aligns with university SDG missions (SDG 4 & 9). • Fits Triple Helix innovation models: university–industry–government cooperation. • Expandable through networks such as NYCU. *(Etzkowitz, 2003; UNESCO IESALC, 2023)*
Long-Term Sustainability	Sustainably feasible	• Knowledge Return stage ensures cumulative learning. • Knowledge Hub maintains continuity across cycles. • Scalable from pilot (ULL) to international partners. *(Nonaka, 1994; Riesener et al., 2019)*

Table 2: Woopathon feasibility assessment:

In conclusion, the feasibility assessment shows that the Woopathon is highly practical and easy to implement, requiring very little additional time, resources, or financial investment. Because it builds on Wooptix's existing partnerships and internal expertise, the framework can be launched quickly and scaled gradually, offering a high-impact but low-resource solution for talent development and continuous innovation.

6.5 Corporate Consulting Application

6.5.1 Problem & Need Identification

As consultants, we began by analysing Wooptix's strategic landscape, operations, and growth challenges. Through interviews, observations, and secondary research, we identified three key needs:

1. Visibility Gap

Wooptix operates in a highly specialised deep-tech domain but lacks global visibility compared to competitors like ASML or Onto Innovation. This limits both brand reach and investor attractiveness.

2. Talent Shortage in Deep-Tech Skills

Finding engineers who can design, build, and operate advanced metrology systems is increasingly difficult. Tenerife's geographic isolation further reduces the available talent pool.

3. Non-Circular Knowledge Flow

Knowledge exchange is mostly internal and project-based; there is no structured system for external learning, co-creation, or idea retention.
This weakens innovation speed and reduces long-term sustainability of expertise.

6.5.2 Market Research & Benchmarking

To understand best practices, we analysed how leading deep-tech and semiconductor companies approach talent development, innovation, and ecosystem engagement.

Global Benchmarks (Industry Leaders)

ASML, Challenge-Based Recruitment Programs

ASML runs yearly innovation challenges, internships, and university co-creation labs. These programs attract thousands of applicants globally and strengthen their talent funnel.

Intel, Global Innovation Competitions

Intel uses open innovation challenges to source ideas from students, researchers, and startups.
Outcome: increased visibility, strong partnerships, and diverse talent pipelines.

Nvidia, Research Collaborations & University Programs

Nvidia invests heavily in university alliances and hackathons, enabling new ideas in AI hardware and software ecosystems.

Key Insights From Market Research :

1. Top companies use challenge-based open innovation
2. They build long-term partnerships with universities
3. They create systems that allow knowledge to circulate continuously
4. Talent attraction is tightly linked to innovation programs
5. Visibility increases when companies open their doors to the global community

6.5.3 Proposed Consulting Intervention: Woopathon (Circular Innovation Program)

Based on the above findings, we propose the Woopathon- a continuous, circular knowledge and innovation platform built for Wooptix.

The Woopathon integrates:

1. Talent Attraction

Students, PhDs, alumni, and professionals join mixed teams to solve Wooptix challenges.

2. Open Innovation in a Deep-Tech Context

Participants co-create solutions that Wooptix can apply in its operations, engineering, and strategy.

3. Circular Knowledge Flow

Outputs are uploaded to the Wooptix Knowledge Hub for reuse, learning, and continuous improvement.

4. Visibility Enhancement

Partner universities, online platforms, and Wooptix's website amplify the program globally.

As consultants, we position Woopathon as a strategic system rather than a standalone event.

6.5.4 Expected Impact for Wooptix

1. Stronger Global Visibility

More online presence, partnerships, and exposure similar to industry leaders.

2. Sustainable Talent Pipeline

Continuous access to student talent, early-career researchers, and external professionals.

3. Innovation Input

Fresh external solutions for technical, organizational, and sustainability challenges.

4. Knowledge Sustainability

No loss of ideas, everything is documented, reused, and improved internally.

The program creates long-term competitive advantage in a deep-tech market.

5.5 Risk Assessment & Mitigation

Risk 1: Low Participation

Mitigation:
Partner with multiple universities, advertise on social media, and offer prizes/internships.

Risk 2: Overlap With Company Resources

Mitigation:
Create small internal mentor teams rather than large-scale internal commitments.

Risk 3: Knowledge Leakage

Mitigation:
Participants sign NDAs; sensitive challenges are framed carefully.

6.5.5 KPIs & Measurement

To evaluate success, we suggest tracking:

- Number of participants per cycle
- Diversity of skills (students, professionals, PhDs)
- Global reach (countries/universities represented)
- Ideas generated vs adopted by Wooptix
- Talent conversion (internships, hires)
- Website traffic on Woopathon section
- Brand mentions and online engagement

6.6 Conclusion and Teamwork Reflection

The successful development of the Wooptix Circular Knowledge Loop was strongly enabled by the structured collaboration and effectiveness of Team D (ReNova Consulting). The team operated with a clear division of responsibilities aligned with individual strengths, ensuring accountability while fostering complementary collaboration. This structure supported efficient task execution across research, design, and strategic formulation phases.

Weekly coordination meetings followed an agile sprint logic, enabling continuous progress monitoring, feedback exchange, and rapid adaptation to new insights and academic supervision. This iterative approach ensured that conceptual ideas were consistently tested for feasibility and strategic relevance. Constructive conflict management further strengthened team performance. Differing viewpoints were addressed through structured dialogue, leading to higher analytical quality and stronger conceptual integration.

The team's interdisciplinary background in innovation management, sustainability, engineering, and organizational studies proved to be a major asset.

Systematic documentation supported project quality and continuity. Research findings, theoretical frameworks, design iterations, and strategic decisions were consistently shared across the team. This ensured transparency, avoided duplication of work, and facilitated smooth integration of individual contributions into a unified consulting proposal. Overall, the team's internal working model reflected the same principles embedded in the Wooptix Circular Knowledge Loop itself—knowledge sharing, continuous learning, and iterative improvement.

The Wooptix Circular Knowledge Loop represents a strategic transformation of how a geographically isolated deep-tech company can compete within the highly complex and fast-moving semiconductor industry. Wooptix's core challenges—talent scarcity, fragmented knowledge, and limited global visibility—were identified as interlinked elements of a self-reinforcing negative cycle. If left unresolved, this cycle would continue to constrain innovation, weaken organizational learning, and undermine long-term competitiveness. The Circular Knowledge Loop was therefore designed as a regenerative system capable of continuously producing and reintegrating knowledge, talent, and innovation.

At its core, the system redefines knowledge as a circulating strategic resource rather than a static internal asset. By integrating the People & Knowledge Website Chapter with the Woopathon Circular Knowledge Challenge, Wooptix moves from a traditional recruitment and R&D approach toward an open, ecosystem-based innovation model. The redesigned website becomes a dynamic interface between the company and the global knowledge economy, reinforcing Wooptix's positioning as a knowledge authority in Wavefront Phase Imaging rather than solely a technology provider.

The Woopathon acts as the operational engine of the Circular Knowledge Loop. Unlike conventional one-off hackathons, it is structured as a recurring innovation mechanism. Each cycle generates not only technical outputs but also documented learning artifacts that are reintegrated into Wooptix's Knowledge Hub. These outputs are reused across onboarding, internal training, marketing, and R&D activities, ensuring that innovation value is continuously captured, refined, and disseminated.

From a circularity perspective, the model adapts circular economy R-strategies to the management of intangible assets. Recruitment is reconfigured as long-term engagement, learning outputs are reused across organizational functions, onboarding costs are reduced through pre-training and micro-credentials, and tacit expert knowledge is recovered through structured documentation and mentoring.

Strategically, the Circular Knowledge Loop addresses Wooptix's three core challenges in an integrated manner. Global visibility is strengthened through continuous outward knowledge of communication. Talent scarcity is mitigated by transforming recruitment into a long-term learning pipeline. Knowledge fragmentation is reduced through systematic documentation and structured knowledge reuse.

From a consulting perspective, the solution is conceptually robust and operationally feasible. The pilot Woopathon requires limited financial and organizational resources, while the website redesign builds on existing digital assets. As such, the Circular Knowledge Loop constitutes a low-risk, high-leverage strategic intervention. At the organizational level, the model aligns management, engineers, HR, and academic partners around a shared knowledge infrastructure, strengthening coherence and reducing internal friction.

Academically, the project contributes to circular innovation research by demonstrating how circular economy principles can be applied to human capital and knowledge systems in a deep-tech context. While successful implementation depends on sustained managerial commitment, mentor participation, and intellectual property governance, these challenges are manageable through phased deployment and strong governance.

In conclusion, the Wooptix Circular Knowledge Loop provides a structural solution to a structural problem. By intentionally designing knowledge regeneration, Wooptix transitions from a technology-centered firm to a knowledge-driven, learning-centered organization capable of achieving long-term sustainable competitiveness.

7. Teidagua

7.1 Company Background

7.1.1. Overview

Teidagua is a public water management company that is in charge of the complete water cycle in the municipalities of La Laguna and Tacoronte, on the island of Tenerife. Its activities mainly focus on supplying drinking water, collecting and treating wastewater, desalination, and the reuse of reclaimed water, trying to ensure continuity of the service and the environmental protection at the same time. The company operates several important infrastructures all around the region, including pumping stations, desalination systems, distribution networks, and some wastewater treatment plants as well. One of the most important facilities is the Punta del Hidalgo Wastewater Treatment Plant (WWTP), which our team visited during the Biofactory Project.

Teidagua puts a strong priority on safety, innovation, sustainability, and also on improving their processes. This was quite clear during the on-site briefing, where the staff members explained the main safety rules and guided us through the main operational areas of the WWTP. The Punta del Hidalgo plant uses advanced technologies like the MBR (membrane bioreactor) treatment, and the tertiary treatment and desalination line, and everything is monitored with a SCADA system that helps keep control of all operations. Thanks to this, the plant produces a high-quality effluent, which is later processed to obtain reclaimed water that is used for agricultural irrigation in nearby places such as Bajamar and Punta del Hidalgo.

In the past few years, Teidagua has been strengthening its commitment to circular economy principles, resource efficiency, and environmental responsibility. Right now, the company is collaborating in the Biofactory Project, which wants to transform the wastewater treatment plant from a normal or conventional facility into a kind of resource-producing center capable of generating renewable energy, reducing waste, and integrating the water, waste, and energy cycles together. This initiative fits well with the European sustainability goals and places Teidagua as an important factor in local innovation and in the environmental transition of the region.

7.1.2. Current Situation and Challenges

The Punta del Hidalgo WWTP is currently managing the treatment of the municipal wastewater using a sequence of modern processes that are quite controlled. The incoming water first goes through the inlet works and the pretreatment area, where the coarse and fine screens remove solids in order to protect the systems that come after. Then the flow moves into the two equalization tanks, which try to regulate the hydraulic variations before reaching the biological process. The main core of the plant is the MBR biological reactor, where the bacteria degrade the organic matter. There are several advanced sensors — like the dissolved oxygen probe, the redox sensor, the suspended solids probe, and also the level sensor — that help to keep the process conditions stable and reasonably efficient. After the biological treatment, the membranes do an ultrafiltration that produces a very high-quality effluent. This water later goes through tertiary treatment, reverse osmosis, and chlorination, obtaining Category A regenerated water that is used for irrigation in the surroundings. In parallel with the water line, the sludge line thickens and dewaters the sludge, which is finally transported outside the plant as a controlled waste.

Even if the plant works well overall, there are several limitations that describe the current situation. Right now, the Punta del Hidalgo WWTP does not include anaerobic digestion, which means that the sludge must be handled externally, creating more costs and a kind of dependency on external waste treatment systems. The absence of biogas production also prevents the facility from using its own waste to generate some energy for itself. Besides this, European regulations about sustainability and circular economy are becoming more demanding, so wastewater plants are expected to recover more resources, reduce waste generation, and move toward a certain level of energy self-sufficiency. All this creates both an opportunity and also a challenge for Teidagua to modernize the plant into a more complete biofactory.

Another important challenge is related to space availability and the land classification around the WWTP. Adding a new anaerobic digester needs a careful analysis of the possible areas inside the plant. Two potential areas, called Zone A and Zone B, have their own physical, environmental, legal, and social considerations. Zone A is closer to the sludge outlet and would probably cause less social impact because it is far from residential houses, but the land there is rural agricultural land with coastal and intensive agricultural protection, which makes the permits and the environmental authorizations much more complicated. On the other hand, Zone B is located on consolidated urban land with existing infrastructure, so the permitting process is simpler and seems more feasible. However, it is farther from the sludge outlet and a bit closer to nearby houses, which means odor management and safety need to be considered more carefully. Understanding the benefits and the constraints of each area is essential to guarantee the technical and legal viability of installing the digester.

Apart from the land-use and technical issues, the project also has economic and regulatory challenges. Installing an anaerobic digester requires checking the capital and operational costs, estimating the energy that could be produced from the sludge or from co-digestion with agricultural residues, and confirming if the project can reach a favorable energy balance. The plant must also comply with ATEX safety standards, odor control rules, environmental impact studies, and the wastewater reuse regulations required by the Canary Islands Water Authority and the EU Regulation 2020/741. Finding funding through regional, national, or European programs for green transition becomes an important part of making the project possible.

7.1.3. Business Model & SWOT Analysis

The Biofactory model at Punta del Hidalgo shifts Teidagua from traditional wastewater management to an integrated, circular-economy approach. The purpose of the Biofactory is to embody both environmental commitment and economic efficiency by transforming waste streams into valuable outputs;

1.Clean, high-quality reclaimed water for local agriculture
2.Renewable energy (biogas) that offsets electricity consumption
3.Nutrient-rich biofertilizer and soil products supporting regional farming
4.Reduced sludge disposal needs, lowering operational and environmental burdens

This model demonstrates how a wastewater treatment plant can become a resource-producing hub, creating measurable environmental, social, and economic benefits for the community. The Biofactory concept aligns with EU sustainability goals, enhances resilience, supports innovation, and reinforces Teidagua's role as a leader in sustainable water management in Tenerife.

Before: Traditional wastewater treatment (costs and waste)

Figure 13: Traditional wastewater treatment (costs and waste)

After: Biofactory (turning wastewater into water, energy, and nutrients)

Figure 14: Biofactory (turning wastewater into water, energy, and nutrients)

SWOT Analysis:

The SWOT analysis provides a structured overview of the internal and external factors This strategic assessment supports decision-making by identifying the strengths weaknesses opportunities and threats.

Strengths

-**Creating Value from Waste:**The Biofactory concept repositions wastewater and sludge not as waste streams but as valuable resources. Through nutrient recovery, biogas production, and high-quality reclaimed water, the plant becomes a generator of economic and environmental value.

-**Local Collaboration:**Strong relationships with local agricultural producers particularly banana farmers enable the effective use of reclaimed water and biofertilizers. These collaborations reinforce community acceptance and ensure resource recovery loops remain local.

Weaknesses

-**Energy Dependency:**The existing WWTP relies heavily on purchased electricity, increasing operational costs and making the facility vulnerable to energy price fluctuations. Limited onsite energy generation constrains progress toward circularity.

-**Quality and Monitoring Requirements:**Advanced treatment demands continuous monitoring, high technical expertise, and frequent maintenance. Ensuring consistent compliance with EU standards for reclaimed water quality adds complexity

Opportunities

-**Replicable Model for Other Regions:**Transforming the Punta del Hidalgo WWTP into a fully functional Biofactory creates a demonstrative model for other islands or municipalities. This positions Teidagua as a benchmark in circular water management within the Canary Islands and beyond.

-**Increased Connections:**The project opens avenues for deeper cooperation with agricultural cooperatives, renewable-energy suppliers, research institutions, and environmental agencies. These collaborations can lead to funding opportunities and technological innovation.

Threats

-**Market & Climate Risk:**Climate variability and water scarcity may affect both influent flow and demand for reclaimed water. In addition, changes in agricultural markets could impact acceptance and value of recovered products such as biofertilizer.

-**Financial Threats:**High capital investment, operational costs, and regulatory compliance requirements pose financial risks. Economic viability depends on securing funding, optimizing energy generation, and reducing external sludge-management expense

7.2 The Biofactory Concept

7.2.1 Biofactory Definition

The “Biofactory” represents a circular economy approach to wastewater treatment that enhances water quality while optimizing the use of materials and energy. It focuses on recovering valuable resources, fostering collaboration among stakeholders, and reducing both environmental emissions and operational costs. This approach offers a potential response to the global challenge of achieving integrated water and sanitation management. (XX).

Life Cycle Sustainability Assessment (LCSA) is increasingly recognized as a strategic tool for advancing the “Biofactory” concept in sanitation. Current research highlights Integrated Resource Recovery (RR) Systems as the leading focus, underscoring the importance of life cycle–based methodologies for diverse wastewater treatment plant (WWTP) designs. To enable global adoption of the Biofactory, LCSA frameworks must be developed with goals and scopes aligned to circular economy principles. A critical step in this process is the integration of Social Life Cycle Assessment (SLCA), ensuring that social dimensions are incorporated alongside environmental and economic ones.

The functional unit of LCSA should reflect the Biofactory's objectives, accounting for internal and feedback loops, avoided products, and co-product allocation within system boundaries. These boundaries must extend beyond technical and environmental systems to include economic and social aspects, capturing flows relevant to circular economy practices across processes and stakeholders. Addressing challenges in data quality and availability is essential, particularly in low-income regions where limited research and datasets hinder comprehensive impact assessments. Innovative approaches to organizing life cycle inventories are therefore required to harmonize environmental, economic, and social dimensions.

Interpretation of LCSA results should be supported by decision-making models that weigh the relative importance of impact indicators and incorporate stakeholder perspectives. This enables the identification of technologies most suitable for Biofactory development in varied socio-economic contexts. By integrating SLCA into LCSA through such models, socio-economic and socio-environmental variables can be systematically included. Ultimately, establishing a robust LCSA framework is vital for advancing cleaner wastewater treatment systems. The Biofactory can recover resources, improve material efficiency, and reduce WWTP impacts worldwide offering practical solutions to the global water quality crisis.

7.2.2 Biofactory for Tenerife

The application of the Biofactory concept in Tenerife presents a unique opportunity to address pressing challenges in water management, resource recovery, and sustainability. As part of the Canary Islands, Tenerife faces significant constraints related to water scarcity, high dependence on desalination, and seasonal fluctuations in demand driven by tourism. These conditions make the island an ideal case study for demonstrating how wastewater treatment plants (WWTPs) can be transformed into Biofactories that not only treat wastewater but also recover valuable resources, generate energy, and support circular economy practices.

Integrating Life Cycle Sustainability Assessment (LCSA) ensures that environmental, economic, and social impacts are considered, while Social Life Cycle Assessment (SLCA) captures stakeholder perspectives. This approach supports cleaner wastewater systems, enhances coastal water quality crucial for tourism, and strengthens resilience in a circular economy framework. Strong governance and alignment with EU policy would enable Tenerife's Biofactories to become benchmarks for sustainable water management in island contexts.

7.2.3 Existing Examples

A compelling example of the Biofactory concept in practice can be found in Granada, Spain, where the public water utility Teidagua has successfully converted traditional wastewater treatment plants into resource recovery facilities. These Biofactories: Biofactoría Sur and Biofactoría Vados, demonstrate how circular economy principles can be applied to sanitation infrastructure to reduce waste, recover valuable materials, and generate renewable energy.

Teidagua processed nearly 25 million kilograms of waste, with over 23.6 million kilograms transformed into compost in 2023. This significantly reduced landfill use and promoted nutrient recycling. Only a small portion of the waste was classified as hazardous, showing the effectiveness of their treatment and separation processes. The Biofactories also reuse treated water for agriculture and industry, convert sludge into fertilizer, and recover fats and sands for secondary applications. These innovations support a shift from energy consumption to energy production, with biogas used to generate electricity through cogeneration systems.

Teidagua's approach reflects the principles of Life Cycle Sustainability Assessment (LCSA), integrating environmental, economic, and social factors into decision-making. Their commitment to research, process optimization, and stakeholder engagement further strengthens the model's relevance. This example illustrates how Biofactories can be successfully implemented at scale, offering a practical and replicable solution for regions aiming to improve wastewater management and resource efficiency. Especially in areas like Tenerife, where water scarcity and tourism pressures demand sustainable infrastructure. (XX)

7.3 Biofactory Lab Proposal

7.3.1 Technical Diagnosis of the WWTP

The Punta del Hidalgo Wastewater Treatment Plant (WWTP) is already a high-efficiency facility regarding water treatment. The plant uses advanced Membrane

Bioreactor (MBR) technology and reverse osmosis to purify wastewater. This process successfully produces high-quality regenerated water for agricultural irrigation, meeting EU standards and closing the local water cycle. However, the management of solids (sludge) remains a critical inefficiency.

Currently, sludge is thickened, dewatered, and transported off-site for disposal. This linear process is expensive and wastes the organic energy potential within the sludge. Additionally, the facility is a net energy consumer, purchasing approximately 245,430 kWh from the electrical grid annually. This reliance on external energy increases both the carbon footprint and operational costs.

The technical diagnosis highlights two primary constraints for upgrading the facility:

1. Limited Space: The plant has very little land available for expansion. This necessitates a design that is vertical and compact to fit within the existing boundaries.
2. Complex Feedstock: The bioplant intends to process local banana plant waste. While rich in energy, this material is fibrous and difficult to break down (digest) without specialized pretreatment.

To address these issues, the facility must transition from a linear disposal model to a circular biofactory model. Implementing on-site anaerobic digestion will transform sewage sludge and organic waste into resources, generating renewable energy to reduce grid consumption and producing stabilized bio-fertilizer.

7.3.2 Conceptual Design of the Digester

To address the identified spatial and feedstock constraints while maximizing resource recovery, a co-digestion system with Thermal Hydrolysis Process (THP) pretreatment is proposed. The design basis utilizes a 20-year projection horizon, assuming a compound annual growth rate (CAGR) of 1.5% in influent flow to account for the planned expansion of the municipal sewer network. This results in a design hydraulic load of approximately 54 m^3/day, comprising thickened sewage sludge and a slurried co-substrate mix of banana plant waste and fordux.

7.3.2.1 Technology Selection: Thermal Hydrolysis and CSTR

A Continuous Stirred Tank Reactor (CSTR) was selected for its robustness in handling high-solid content slurry. However, given the high lignocellulosic content of the banana waste and the spatial constraints of the site, a standard mesophilic CSTR was not implementable due to the large space requirement and long hydraulic retention times (HRT > 25 days) required for effective fiber degradation. Consequently, the design integrates an upstream THP unit. By subjecting the feedstock to high temperature (160–170°C) and pressure, the THP unit solubilizes complex organic matter and disrupts cell walls. This pretreatment enhances the biodegradability of the feedstock, increasing biogas yield by an estimated 20–30% and, crucially, reducing the required HRT to approximately 17 days.

7.3.2.2 Sizing and Dimensions

The reduced HRT enables a significant reduction in the required digester volume compared to conventional systems. Based on the projected 20-year loading rate, a reactor volume of 950 m^3 is required. To comply with the site's footprint limitations, a vertical cylindrical geometry was adopted. The proposed digester features a diameter of 9 meters and a height of 16 meters, resulting in a ground footprint of approximately 127 m^2 (including service buffers). This compact, vertical profile allows the unit to be sited within the limited extension area adjacent to the plant.

7.3.2.3 Process Integration and Energy Recovery

The system is designed for a co-digestion ratio of 1:1 by volatile solids (VS) between sludge and agricultural residues, optimizing the Carbon-to-Nitrogen (C:N) ratio for process stability. The produced biogas undergoes desulfurization before being utilized in a 50 kWe Combined Heat and Power (CHP) engine. Thermal energy recovered from the CHP unit is recirculated to heat the THP process and the digester, ensuring thermal self-sufficiency. This configuration is projected to generate approximately 1,157,780 kWh/year, exceeding the plant's current energy deficit and effectively transforming the facility into a net energy producer.

7.3.2.4 Layout Strategy

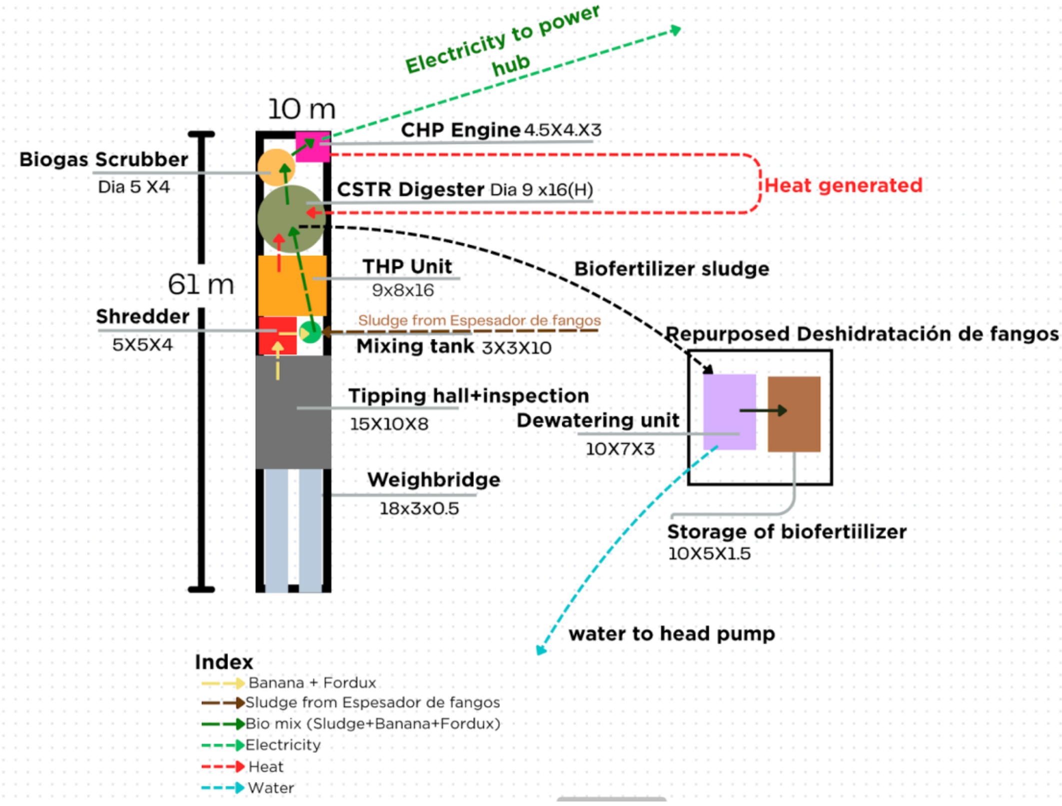

Figure 15: Conceptual Layout and Process Flow of the Proposed Biofactory (Own Illustrations)

A split-site repurposing strategy is adopted to minimize civil works and environmental impact. The new "Digestion Core" (THP, CSTR, and CHP) and the "External Waste Reception" facility will be constructed in the extension zone, occupying a total footprint of roughly 610 m². The existing sludge dewatering building will be repurposed to house the new digestate dewatering equipment, utilizing existing infrastructure to further reduce the project's physical footprint.

7.3.3 Location of the Digester

After analysing the different parts of the WWTP and the possible free spaces around it, we finally focused on the two areas that Teidagua itself had already pointed out before: Zone A and Zone B. Both zones have their own advantages and disadvantages, but when we compare them more carefully, the conditions of Zone B make it the most reasonable and, actually, the most realistic option for installing the anaerobic digester. Even if at first it might look a bit less ideal because of the distance to the sludge outlet, the whole context shows that it works better for the long-term project.

Zone A is closer to the sludge line, and that could make the operations slightly simpler, but the real problem is the land classification. This area is inside rural land with several protection categories, especially the intensive agricultural protection and the coastal protection. These classifications mean that the administrative process becomes really slow, really expensive, and full of environmental requirements that could even make the project not possible. So even if the space in Zone A is bigger and a bit more isolated from the nearest houses, the legal situation makes it too risky and not practical for the timeline of a project like this.

On the other hand, Zone B is located on consolidated urban land, and this changes almost everything. Because the land is already urban, the permits and licences are simpler and don’t need the heavy environmental impact studies that Zone A would require. Also, the area already has some basic infrastructures like electricity access, vials and a more prepared surface, so installation becomes faster and cheaper. It is true that Zone B is somewhat closer to residential houses, but not really closer than the current Teidagua installations that already operate there. With proper odor control and safety measures, the social impact should stay very low, almost the same as now.

Even if Zone B has a smaller available area and needs a solution for the transport of the sludge—due to being a bit farther from the outlet—these issues are technical challenges that can be solved with normal engineering measures. Compared to the legal and environmental obstacles of Zone A, these challenges are much lighter and more predictable. Because of all these reasons, and also because Teidagua itself indicated this zone as a feasible place in the future development, Zone B is considered the correct and most viable location for the digester installation.

7.3.4 Economic and Financial Analysis

Link to the Analysis Sheet

This section evaluates the financial feasibility of implementing a small-scale anaerobic co-digestion system with combined heat and power (CHP) at the Punta del Hidalgo WWTP. The objective is to quantify the energy generation potential, estimate the associated capital and operational costs, and determine whether the proposed biofactory concept can provide measurable economic benefits for Teidagua in the medium to long term.

The analysis is based on operational data provided by Teidagua, combined with widely accepted European benchmarks for sludge digestion, biogas yield, and small-CHP performance. A structured financial model was developed to translate technical assumptions into quantifiable energy output and cost–benefit indicators. The approach ensures methodological transparency and consistency with engineering standards used in European wastewater-to-energy applications.

To begin, sludge availability and biodegradable potential were estimated from the provided dewatered sludge quantity of approximately 186 kg of dry solids per day. Applying a volatile-solids-to-dry-solids ratio of 0.7 and a conservative 50 percent volatile solids destruction rate, the plant has sufficient organic loading to support stable anaerobic digestion. Based on standard literature values for municipal sludge, the specific biogas yield was assumed to be 0.6 m^3 per kilogram of volatile solids destroyed, resulting in an estimated daily biogas production of roughly 300 m^3. This biogas volume equates to an energy content of approximately six kilowatt-hours per cubic metre, in line with the typical methane composition of municipal digester gas.

To reach the client's target of approximately 245,000 kWh of annual electricity production, the model requires installation of a 28 kWe CHP unit. This sizing reflects the combined biogas availability and the electrical efficiency of 35 percent observed in comparable small-scale European installations. Thermal efficiency of the CHP unit was set at 50 percent, which provides additional thermal energy that, while not monetised in the baseline case, represents a meaningful opportunity for long-term heat recovery or process integration.

Under these assumptions, the system is expected to generate approximately 672 kWh of electricity per day and around 960 kWh per day of recoverable thermal energy. The annual electrical output of 245,280 kWh translates directly into avoided electricity purchases for Teidagua, based on the plant's internal tariff of 0.15 €/kWh. This produces annual savings of €36,792, forming the foundation of the project's economic justification.

The capital expenditure associated with the proposed system is estimated at €268,473. This includes the digester structure and mixing equipment, the packaged CHP engine, ancillary components such as pumps, piping and gas handling units, and an allowance for engineering design, permitting, and contingency. This cost estimates reflect recognised European sources including IEA Bioenergy, NREL and IRENA datasets for small-scale anaerobic digestion and CHP systems. Operating costs amount to approximately €19,545 per year and include routine CHP engine maintenance, general upkeep of the digester and supporting infrastructure, and an estimated one hour per day of operator time for inspection, logging and minor adjustments.

When annual operational costs are deducted from the electricity savings, the resulting net annual benefit is approximately €17,247. This yields a simple payback period of around sixteen years. While this payback period reflects the baseline scenario based solely on avoided electricity costs, additional value streams can significantly enhance financial performance. In particular, the inclusion of external organic waste streams (banana wastes or fordux residues) could generate tipping-fee revenues, while the reduction or elimination of sludge-disposal costs which is currently priced at €120 per tonne at 15 percent dryness would provide meaningful additional annual savings. Incorporating these elements would shorten the payback period into the eight-to-ten-year range, which is more competitive with European small-digester benchmarks and strengthens the business case under a circular-economy framework.

From a strategic perspective, the economic performance must be interpreted alongside non-financial benefits. The project enhances Teidagua’s energy resilience, reduces exposure to electricity price fluctuations, and supports compliance with evolving EU decarbonisation and resource-recovery regulations. Additionally, the project creates a replicable model for other wastewater facilities within the Canary Islands, reinforcing the company’s innovation leadership in sustainable water management. While the financial returns alone may not justify the investment under a traditional payback evaluation, the combination of economic, regulatory and environmental co-benefits positions the biofactory concept as a strategically sound initiative for long-term value creation.

7.3.5 Innovation and Management Strategy

Long-term organizational success depends on the development of core competencies and the corresponding capabilities required to support them. When effectively cultivated, these elements allow a company to position itself strategically within areas where it can perform optimally and pursue its chosen business objectives.

Information and communication technologies (ICT), as cross-cutting enablers, are central to driving innovation and growth across industries (Münchner XX). As software increasingly becomes integral to both company operations and products, ICT is expected to play an even greater role (Sarrazin & Sikes XX).

From a social-structural perspective, innovation and communication are understood as processes shaped through interactions between organizations and their stakeholders. These communicative exchanges construct meaning and shared realities, which are essential foundations for the emergence of new ideas and innovations. The strategic project communication is shown in Figure XX.

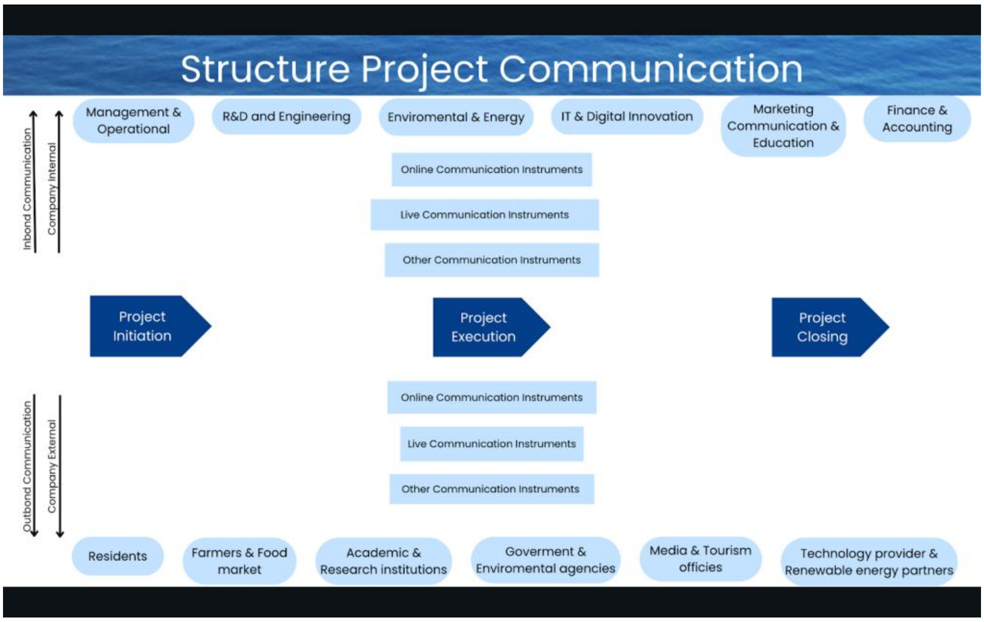

Figure 16: Structure Project Communication (Own Illustration)

At the top level are the internal stakeholders, represented by the departments within the organization. Communication with these stakeholders can be structured through three main instruments:

- Online communication tools such as internal platforms (e.g., SharePoint or Microsoft Teams) that facilitate document sharing, virtual coordination meetings, and dashboards for project tracking.
- Live communication formats including interdepartmental workshops on circular economy practices and staff training sessions at wastewater treatment plants (WWTPs).
- Other communication channels such as internal digital magazines and employee storytelling videos, which help foster engagement and organizational culture.

At the bottom level are the external stakeholders, who also interact through three communication instruments:

- Online communication tools including the Teidagua website and social media campaigns, which provide information and promote transparency.
- Live communication formats such as workshops and educational tours, which build awareness and strengthen community involvement.
- Other communication channels including press articles, demonstration events, and explainer videos, which disseminate knowledge and highlight project outcomes.

In the middle lies the project process, which connects internal and external stakeholders through three phases:

- Project initiation: This stage focuses on planning and stakeholder engagement. It involves identifying key actors, defining objectives, and ensuring that both internal departments and external partners are aligned with the project's vision.
- Project execution: The emphasis here is on implementation and monitoring. Activities include carrying out planned interventions, applying communication instruments, and tracking progress through measurable indicators to ensure objectives are met.
- Project closing: This final stage centers on evaluation and expansion. It requires assessing outcomes against initial goals, gathering stakeholder

feedback, and identifying opportunities to scale or replicate successful practices in new contexts.

The concept of innovation can be understood through three key dimensions: originality, which refers to initiatives that generate new value; a holistic perspective, which recognizes that innovation may occur across any aspect of the business system; and customer outcomes, which highlight the value created for both the customer and the organization. The Innovation Radar provides a clear visual representation of a firm's innovation strategy by assessing twelve distinct vectors. This profile serves as a tool to improve alignment of innovation efforts across different functions and organizational levels (Chen & XX). Fig XX presents the innovation radar profile, highlighting dimensions that organizations can prioritize when pursuing innovation.

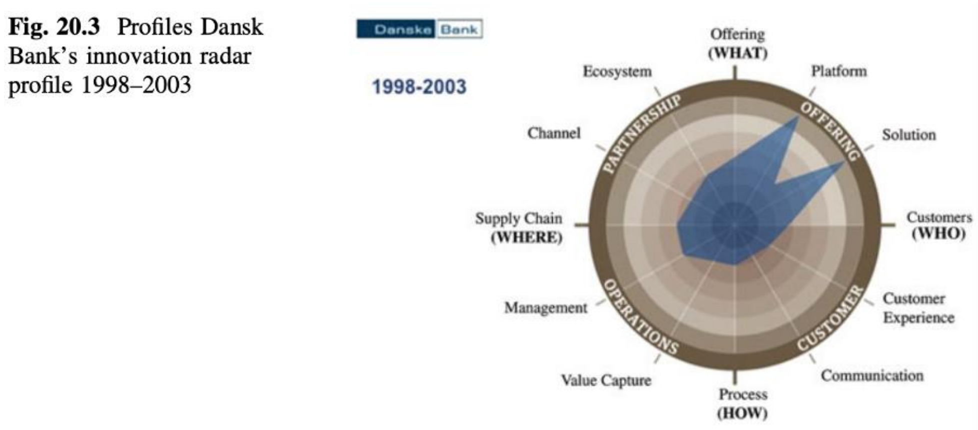

Figure 17: The Innovation Radar Profile

The proposed Biofactory model introduces a comprehensive circular economy strategy that redefines Teidagua's wastewater treatment operations by shifting from a disposal-oriented system to a resource-generating one. This approach combines product and service innovation by transforming wastewater into valuable outputs such as biogas, reclaimed water for agriculture and landscaping, and compost, while also creating opportunities for educational activities and eco-tourism. Operationally, the Biofactory integrates advanced process technologies including anaerobic digestion, water reuse systems, and optimized sludge treatment supported by smart monitoring tools that improve energy efficiency, reduce emissions, and move the plant toward energy self-sufficiency. It is success relies on establishing an interconnected ecosystem of partners, such as farmers, municipalities, universities, and local industries, who can supply organic waste streams and benefit from the recovered resources, thereby forming a cooperative circular framework. At the stakeholder level, the Biofactory delivers social innovation by engaging farmers, municipal services, environmentally conscious residents, and tourists, fostering public trust in water reuse through campaigns, educational programs, and participation incentives. Together, these elements position the Biofactory as a strategic initiative that simultaneously enhances operational performance, strengthens community collaboration, and supports Tenerife's broader transition toward a circular and sustainable water economy.

7.4 Conclusion

The analysis of the Punta del Hidalgo Wastewater Treatment Plant (WWTP) and the broader operational strategy of Teidagua demonstrates that the transition from a **conventional wastewater treatment model to a circular, resource-oriented Biofactory** is both technically feasible and strategically advantageous. Through a comprehensive assessment encompassing organizational context, technological processes, spatial constraints, economic modelling, and innovation strategy, this project shows how the Biofactory concept can effectively address current limitations while aligning the company with emerging environmental, regulatory, and societal expectations.

Teidagua's **existing infrastructure** already reflects a strong foundation for circularity, particularly through advanced MBR treatment, tertiary processes, and high-quality reclaimed water production. However, persistent **challenges** most notably external sludge management, energy dependency, and the absence of resource-recovery infrastructure limit the plant's capacity to meet the evolving demands of EU sustainability frameworks.

The **proposed** compact digester design, adapted to the spatial constraints of the site and strategically located in **Zone B**, offers a realistic pathway to integrate energy generation, nutrient recovery, and waste valorisation within the existing facility.

The economic and financial assessment further strengthens the project's viability. Although the baseline payback period is moderate, the integration of co-substrates, the reduction of sludge disposal costs, and the potential for tipping-fee revenues significantly enhance long-term financial performance. When combined with non-monetary benefits energy resilience, improved environmental stewardship, and regulatory alignment the Biofactory presents a compelling strategic investment. Moreover, the adoption of a Life Cycle Sustainability Assessment (LCSA) framework ensures that environmental, social, and economic dimensions are considered holistically, promoting decision-making that extends beyond short-term operational metrics.

Equally important is the project's emphasis on **innovation management** and **stakeholder communication**. Effective implementation requires not only technological upgrades but also coordinated engagement across internal departments, external partners, local communities, and regional institutions. The proposed communication and innovation strategy underscores how Teidagua can position itself as a facilitator of regional circularity, building trust, transparency, and community participation. By fostering collaboration with farmers, research centers, municipalities, and the private sector, Teidagua can reinforce the Biofactory as a shared ecosystem rather than an isolated technological installation.

Ultimately, **transforming** the Punta del Hidalgo WWTP into a Biofactory is more than an engineering upgrade it is a systemic shift toward a regenerative, circular water-energy-nutrient model that strengthens Tenerife's resilience to water scarcity, climate pressures, and economic volatility. The project serves as a replicable blueprint for other island and coastal regions seeking to modernize their water infrastructure under sustainability criteria. Through its commitment to innovation, resource efficiency, and social responsibility, Teidagua is well positioned to become a regional leader in the transition toward sustainable and integrated water management.

7.5 Assumptions used in the Financial Model

- Average dewatered sludge: 186.3 kg DS/day (Teidagua data)
- VS/DS ratio: 0.70 (Metcalf & Eddy, 2013)
- VS destruction: 50% (Metcalf & Eddy, 2013; DTU Biogas Handbook)
- Specific biogas yield: 0.6 m³/kg VS destroyed (DTU; EPA AD guidelines)
- Biogas energy content: 6 kWh/m³ (EBA, 2022)
- CHP electrical efficiency: 35% (EBA, 2022)
- CHP thermal efficiency: 50% (EBA, 2022)
- Electricity tariff: 0.15 €/kWh (Teidagua)
- Digester CAPEX: 600–1,000 €/m³ (IEA Bioenergy Task 37)

- CHP CAPEX: 1,500–2,500 €/kWe (IRENA, 2016)
- O&M cost: 2–3% of CAPEX (IEA/Wastewater benchmarks)
- Labour: 1 hr/day (EPA AgSTAR; small AD norms)

8. Loro parque

8.1 Company Profile

Loro Parque in Puerto de la Cruz, Tenerife Island is one of the most popular zoological institutions in Europe and a leading tourist attraction site in the Canary Islands. It was founded in 1972 as a small parrot sanctuary and has since grown to be a 13.5-hectare park that is home to a very diverse variety of species, including birds, aquatic life, terrestrial mammals, and reptiles. In a year the park attracts more than a million visitors and is reputed to be a blend of animal care, research, and education to people as well as entertainment (Loro Parque, 2022).

Through its operating programs, Loro Parque is also well-supported by Loro Parque Fundación, an internationally renowned conservation foundation, whose main activities revolve around the conservation of biodiversity, habitat recovery, and the protection of endangered species and, in particular, parrots. It is based on this foundation that the park donates money to conservation initiatives and works with researchers, universities, and NGOs across the world (Loro Parque, 2022) (Loro Parque Fundacion, 2024) (Parque, 2022).

In general, the brand positioning of the park is based on animal welfare, environmental conservation, scientific literacy, and tourism driven by sustainability.

8.2 Current Sustainability Practices

According to the visit to the park and the data given by employees, Loro Parque puts great emphasis on the environmentally responsible activities and long-term ecological responsibility. The major sustainability practices witnessed include:

Resources Efficiency: Water Management: Water-recycling systems and filtration technologies are used in the (Loro Parque, 2025) park to reduce water consumption, especially in water habitats with high water requirements (e.g., aquariums and marine mammal pools) (Loro Parque, 2025).

Energy Optimization: Energy saving through efficient lighting systems, natural ventilation in most of the enclosures, and through use of renewable energy sources (photovoltaic panels) help in saving energy.

Waste Management: The park has proper waste-collection points all over the areas where visitors move around to encourage recycling to cut down on landfill waste. Such organic waste as plant material and animal bedding are usually reused or composted to serve internal landscaping and decrease external waste production.

Biodiversity Conservation: Loro Parque is also a member of breeding endangered species, animal welfare enrichment programs, and conservation networks. The park finances scientific studies through the Loro Parque Fundacion and has helpedin several recoveries of species.

Education and Awareness: The park incorporates the messages of sustainability in shows, exhibitions, and information boards. Tourists should be urged to make greener choices including waste sorting and natural environment respect.

Responsible and Ethical Management: The park has high animal care, veterinary support and habitat design standards, which are part of ethical zoological practices of the park. The park shares information of transparency regarding conservation projects and environmental initiatives (Loro Parque, 2025).

8.3 Identified Needs & Key Challenges of Loro Parque

Through the trip and interaction with the responsible personnel, it was apparent that Loro Parque is doing well in its sustainability internally- but must deal with visitors' behaviour and image.

Building Visitor Awareness/ Engagement: The greatest obstacle that can be seen is the fact that most visitors are unaware of the level of sustainability work being pursued by the park. Even after recycling points and information boards are introduced, a part of the guests continues to: dispose of waste in the wrong way, ignore educational messages, or do not relate their own actions to the environmental influence. This brings a continuous necessity to enhance communication tactics and make sure that sustainability is not practiced behind the scenes but also on the surface and involving to the audience (Field Observation, 2025) (Loro Parque, 2025).

Addressing Unresponsible Waste Disposal: A particular behavioural issue that has been identified by the staff is incorrect about sorting of the waste. It still has several visitors: dispose of general waste in the recycling bin, litter roads, or disregard signs on waste management. The problem worsens the working load of the operations and goes against the aim of the park, which is to provide a clean environment that is environmentally responsible. Closing the Gap between Visitor Perception and Sustainability Practice. Even though Loro Parque has extensive environmental-friendly initiatives, most of the tourists could see the park more as a fun facility instead of a conservation establishment. This incompatibility may decrease the efficiency of educational programs and restrain the ability of the park to contribute to long-term sustainable behaviour. Loro Parque is one of the robust examples of zoological management based on sustainability, and conservation, waste reduction, energy efficiency, and education costs in this park is enormous. Nevertheless, it still faces the problem of encouraging the guests to engage in green activities, especially in the areas of waste management and environmental consciousness. To enhance the relationship between internal sustainability management and the behaviour of the visitors, communication, visibility, and engagement practices may be improved (Field Observation, 2025) (Loro Parque, 2025).

8.4 Improvement Potentials

Although Loro Parque is characterized by the great level of environmental responsibility fulfilment and is well-known due to its successes in the sphere of the conservation, the analysis of the existing visitor experience and communication strategies shows that there are some obvious ways to develop them further. These areas of improvement are not related to the quality of the sustainability work of the park per se, which is already developed, but the way this work is relayed, comprehended, and encountered by the visitors. Low Profile of Sustainability in its operations: One of the key areas of improvement can be considered the visibility of the ecological practices in the park. A few of the environmental projects of Loro Parque, like resource-efficient systems or conservation partnerships, are mostly an internal activity that cannot be easily seen by visitors. Since the sustainability attempts are not part of the normal visitor experience, the sustainability story is not necessarily well realized or comprehended (Field Observation, 2025) (Loro Parque, 2025).

More Interactive and Engaging Formats of Learning: The existing educational resources at the park are primarily based on the inactive or textual information sources, which are not necessarily in correspondence with modern visitor demands. The current audiences, particularly the families and school groups, tend to react heavily to interactive and playful formats enabling them to be actively engaged in the learning process. Consequently, the possibilities of going further with the conventional signage and incorporating formats that promote interaction are substantial. Loro Parque does offer educational resources as PowerPoint presentations, explanatory videos as well as short, animated videos, but these are rather passive. The information is delivered to the visitors, but they do not take part in the learning process. The current digital experience does not offer any ability to engage guests in real time and lets them explore, experiment, and practice sustainability knowledge. It is the hands-on, playful and immersive learning that usually appeals more to modern visitors, particularly families, children and school groups. In the absence of these interactive components, the education material will turn to a backdrop of the visit instead of a part of the visit that is unforgettable and behaviour-altering. This disconnection decreases the capacity of Loro Parque to develop emotionally, sustained sustainability experiences which resonate with the visitors even after their park visits (Field Observation, 2025) (Loro Parque, 2025).

8.5 Proposed Sustainability Solutions

Based on the potential of improvement defined in the previous section the project team IslaCycle came up with the Loro Verde Sustainability Experience, an idea to increase visitor interest, enhance environmental education and make the sustainability workings of the park more noticeable. The suggested actions do not involve changes in animal care, infrastructure or even core operations.

- Loro Verde Smart Card System

Loro Verde Smart Card is an electronic guide during the visit and enables the guest to be actively involved in sustainability-related activities. On visiting the stations, they scan the card, then access multilingual content, earn points, and get feedback. The main idea of the system is to establish a premeditated, interactive learning experience, which will be a part of the park experience.

- Loro Verde Gaming Hub: Interactive Learning Stations.

The sustainability issues are proposed in the form of interactive and fun activities in a chain of small, five modular learning game stations within the park. Every station has a certain theme, i.e., waste separation, water protection, energy use, or species conservation, and turns learning into an exciting and unforgettable event. These stations are aimed at attracting a visual appearance, child-friendly, and accessible to foreigners. Visitors can scan their Loro Verde Smart Card at the stations to earn points.

- Sustainability Knowledge Corner

The proposed Knowledge Corner is an imagined small but convenient learning area with the setup of digital screens and informational short, topic-based modules. The space has an audio guide in English, German and Spanish so as to serve the international audience of the park. The topics of interest to visitors can be chosen and listened to at will, giving the visitor a flexible self-directed learning process. The Knowledge Corner offers a simplified introduction to main sustainability themes without the need to spend many hours reading and having prior knowledge due to the concise explanations and clarity in visuals.

- Environmentally Responsible Action Reward System.

To motivate the visitors, they can earn points of engaging in sustainability activities, quizzing or making conscientious decisions regarding the environment. Ensuring that small rewards like discounts or symbolic reward or even digital badges can be traded as points. This mechanism encourages positive reinforcement and transforms sustainability into a fun task that is particularly interesting to younger target audiences.

- Smart Direct Sorting Recycling Bins.

An in-depth solution to facilitate correct separation of waste is to introduce smart recycling bins that will have a scanners module to give an intuitive solution to the problem. Visitors are guided immediately by looking through the scan of the smart card to show which bin is to be used. This will decrease the uncertainty, enhance the accuracy of sorting, and establish a more exciting disposal system that is in line with the environmental goals of the park.

- Limited-impact, Modular Implementation.

Each of the suggested elements is purely planned to undergo minor structural changes and minimal impact on the environment. The idea is based on the use of modular kiosks, miniature digital units, and lightweight installations. This guarantees easy integration with the existing park infrastructure, elimination of disruption, and resonance with the philosophy of the park, Loro Parque, of reducing ecological footprint.

8.6 Visitor Behaviour & Waste Prevention

Visitor behaviour plays a crucial role in the overall environmental performance of Loro Parque. Despite the park's advanced internal sustainability practices, observations and staff feedback indicate that visitor actions continue to generate avoidable waste streams and contamination of recyclables (Field Observation, 2025). Throughout the park, numerous waste-collection points and recycling containers are available to support correct waste separation, while organic materials such as plant residues and animal bedding are composted and reused in internal landscaping, aligning with circular economy principles (Loro Parque, 2025). However, these systems can only operate at full effectiveness if guests actively participate. In practice, staff report recurring issues such as residual waste being placed in recycling bins, littering along pathways, and low engagement with educational signage on waste and conservation topics (Field Observation, 2025).

At the same time, Loro Parque has implemented several measures that provide a strong foundation for more ambitious visitor-facing waste prevention. The park pursues a "plastic-reduction" strategy in its gastronomy and retail areas, progressively phasing out single-use plastics and replacing them with reusable or compostable alternatives (Loro Parque, 2025). Partnerships with local suppliers and the emphasis on kilometre-zero products further reduce packaging waste and transport emissions, while composting of organic waste closes material loops within the park's own agricultural production. Nevertheless, many of these efforts remain largely invisible to the average visitor, who may primarily perceive Loro Parque as an entertainment venue rather than an advanced circularity laboratory.

From a circular economy perspective, the main challenge therefore lies less in the absence of technical solutions and more in the behavioural gap between internal sustainability management and guest practices. Increasing the visibility of waste prevention measures, strengthening on-site communication, and integrating interactive elements into the visitor journey could help align visitor behaviour more closely with the park's ambitions. In doing so, Loro Parque could not only reduce waste volumes and improve recycling quality but also leverage its high visitor numbers to promote more sustainable consumption patterns beyond the park itself (Field Observation, 2025; Loro Parque, 2025).

8.7 Energy Efficiency & Renewables

Energy efficiency and renewable energy integration form a central part of Loro Parque's long-term sustainability strategy. The park operates several high-capacity renewable systems that significantly reduce its reliance on conventional energy sources and support the Canary Islands' decarbonisation goals. A key component of this system is its photovoltaic infrastructure, which generates a large share of the electricity used in the park's operations. According to the organisation, these renewable installations allow Loro Parque to meet much of its own demand and contribute surplus energy to the regional grid, thereby strengthening local energy resilience and reducing carbon intensity (Loro Parque, 2025). These efforts are complemented by ISO 14001, ISO 9001, EMAS and Biosphere certifications, which ensure that energy management is embedded within formalised environmental governance structures and independently verified on a regular basis.

In addition to electricity generation, Loro Parque operates an integrated water–energy system through its private desalination plant. The facility produces around 600,000 litres of drinking water per day and enables the park to remain largely self-sufficient in a region experiencing increasing water scarcity (Loro Parque, 2025). By combining desalination, efficient filtration and strict quality control, the park reduces stress on municipal water supplies and closes internal water loops in alignment with circular economy principles. Across its enclosures, show areas and visitor pathways, Loro Parque applies energy-efficient lighting, optimised pumping technologies and natural ventilation concepts to minimise energy consumption wherever possible. These measures collectively demonstrate a strategic approach that prioritises both demand reduction and low-carbon supply.

Despite this strong technical foundation, opportunities for further progress remain. Many visitors are unaware of the extent of the park's renewable energy production or the sophisticated systems operating behind the scenes. As with its waste-management activities, much of the park's energy efficiency work remains invisible to the average guest, limiting its potential as an educational and branding asset. Increasing the visibility of these achievements for example, through digital dashboards, interactive displays or integrated storytelling could strengthen visitor understanding of how the park manages its environmental footprint. From an operational perspective, additional optimisation potential may exist in expanding real-time monitoring of energy-intensive areas, piloting demand-management tools or integrating performance indicators more systematically into daily routines. Enhancing communication while deepening monitoring practices would therefore support Loro Parque's long-term sustainability objectives, improve operational efficiency and further reinforce its position as a leading conservation-driven institution (Field Observation, 2025; Loro Parque, 2025).

8.8 Smart Communication & Digital Engagement

The gamification of waste-management practices at Loro Parque introduces an interactive and engaging communication strategy aimed at positively influencing visitor behaviour. Rather than relying on traditional direct messaging, this approach uses playful, indirect interaction to motivate responsible actions while fostering a sense of participation in the park's sustainability efforts. By integrating entertainment with learning visitors, especially younger generations become active contributors to environmental stewardship during their visit. The system is centred around a smart waste-sorting bin equipped with a digital screen and three color-coded containers, each designated for a specific type of waste. When visitors place the correct item in the correct bin, the screen activates and displays a multiple-choice question related to animals, environmental protection, or conservation facts shared during Loro Parque shows. This transforms waste disposal into a learning moment: visitors who answer correctly earn points, and a short digital animation appears, showing their chosen parrot being rewarded. If the answer is incorrect, fewer points are awarded, and the animation encourages the visitor to "try again next time," maintaining a positive reinforcement loop. A second type of smart bin, placed throughout the park, allows visitors to scan their digital card after disposing of waste correctly to accumulate additional points. These points can later be connected to rewards, achievements, or digital badges, strengthening long-term engagement.

The purpose of this system is twofold:
To increase attentiveness and knowledge retention. Since the quiz questions are based on information presented during shows, visitors become more attentive and engaged in order to succeed in the game and earn higher rewards.
To reinforce sustainable behaviour. By linking proper waste sorting with immediate, enjoyable feedback, the system builds positive habits through an action-reward mechanism without making the experience feel forced or instructional.
Overall, the gamification strategy enhances the bond between Loro Parque and its visitors by transforming routine actions into meaningful interactions. It encourages environmentally responsible behavior, strengthens educational impact, and creates memorable experiences that align with the park's mission of conservation and sustainability.

The integration of QR codes throughout Loro Parque serves as an accessible and flexible tool for enhancing digital communication and enriching the visitor learning experience. By linking physical exhibits with instant digital content, QR technology encourages active exploration, allowing visitors to deepen their understanding of animals, conservation efforts, and environmental initiatives at their own pace. QR codes are strategically positioned near animal enclosures, educational panels, and conservation zones. When scanned, each code redirects visitors to concise digital materials such as videos, research insights, interactive infographics, or behind-the-scenes content produced by Loro Parque Fundación. This transforms static displays into dynamic educational gateways, giving visitors the option to engage more deeply with topics that interest them, and strengthening the park's mission of raising environmental awareness. One of the key advantages of QR technology is its adaptability. Content linked to each code can be updated regularly to reflect ongoing research, new conservation programs, seasonal events, or newly born animals. This ensures that the visitor experience remains fresh and encourages repeat visits. For example, during breeding periods, QR codes near specific aviaries can provide real-time updates, care routines, or interviews with the zoological staff, offering an immersive learning experience. Additionally, QR codes play a role in reinforcing sustainability messaging within the park. Codes placed near recycling stations, botanical areas, or water-saving systems lead to short explanations about Loro Parque's environmental practices. This transparent communication increases trust and showcases the park's commitment to responsible resource management. To further connect digital engagement with visitor participation, QR codes can also be integrated into gamified activities and point-earning systems. By scanning designated QR checkpoints, visitors can unlock extra points, join thematic challenges, or participate in eco-friendly missions. This creates a seamless link between physical exploration and digital interaction, making learning both enjoyable and impactful. The QR-based system enhances smart communication by combining simplicity, accessibility, and interactive depth. It transforms the visitor's journey from passive observation to active discovery, supporting the park's educational objectives while strengthening its role as a leader in conservation-focused digital engagement.

8.9 Impact Assessment

Environmental Impact

The proposed digital engagement strategies for smart waste-management gamification, QR-based educational content, and interactive communication tools are expected to generate positive impacts across environmental, social, and economic dimensions. The following section summarizes the projected outcomes within each pillar of sustainability while remaining aligned with Loro Parque's conservation mission.

The gamified smart bins are projected to significantly improve recycling accuracy by motivating visitors to sort waste correctly through rewards and interactive feedback. Better waste sorting reduces contamination of recyclable materials, lowers disposal costs, and supports the park's long-term environmental objectives.
The QR system further strengthens environmental impact by increasing visitor awareness about conservation, animal welfare, and sustainability practices. By giving real-time access to educational content, visitors gain a deeper understanding of responsible behavior within the park, contributing to a cleaner and more sustainable environment.

Social Impact

These actions enhance the visitor experience by making learning interactive, accessible, and engaging for all age groups. Gamification encourages participation, especially among families and children, turning sustainability into a positive and memorable activity.
QR codes provide easy access to multilingual information, promoting inclusivity for international visitors and those with accessibility needs. By communicating scientific knowledge in a modern and interactive format, the park strengthens its educational role and reinforces its social commitment to environmental awareness also strengthens public image as an educational and socially responsible institution.

Economic Impact
It also has long-term economic benefits. Enhanced visitor engagement often leads to longer stays, higher satisfaction, and increased spending on food, experiences, and merchandise.
Operational costs may also decrease due to more efficient waste management and reduced need for physical signage updates, as digital QR content is easier and cheaper to maintain.
Additionally, the gamification system can support loyalty programs, special rewards, or themed merchandise, offering potential new revenue opportunities.

8.10 Challenges & Opportunities

The implementation of **Loro Verde**, the new interactive sustainability hub, presents several operational, organisational and strategic challenges for Loro Parque, but also creates substantial opportunities for strengthening environmental education, circular behaviour and visitor engagement.

Challenges:

1. Technological integration and maintenance
Loro Verde relies on digital infrastructure, including smart cards, scanners and reward kiosks. These systems require regular updates, maintenance and technical support, particularly given the humid climatic conditions of the park and the high intensity

of daily visitor usage. Ensuring long-term reliability and avoiding system downtime will be essential for maintaining user satisfaction and operational efficiency.

2. Initial investment and infrastructure cost

The development of interactive stations, game modules, digital displays and the integrated points system involve a significant initial financial outlay. While long-term benefits are expected in terms of visitor satisfaction and improved environmental behaviour, the initial costs represent a relevant implementation barrier that must be strategically planned.

3. Cross-department coordination

The concept requires collaboration across several internal departments—education, IT, visitor services, maintenance, marketing and retail. Consistent communication and operational alignment across these units are necessary to ensure seamless functioning of the digital system, effective visitor guidance and coherent messaging.

4. Ensuring consistent visitor engagement

Although the design of Loro Verde is highly interactive, some visitors may prefer traditional attractions or may not have sufficient time to participate fully. Clear communication, visible signage and active involvement of staff will be critical to encourage participation and maximise educational impact.

5. Space management and visitor flow

A high concentration of visitors, particularly families with children, may lead to crowding in the hub area. Ineffective visitor flow could reduce both the quality of the experience and the effectiveness of the educational content. Careful spatial planning and real-time monitoring of visitor density will therefore be necessary.

Opportunities:

1. Higher visitor engagement through gamification

Loro Verde increases motivation and learning effectiveness by transforming sustainability into an interactive sequence of:

Play → Learn → Earn Points → Receive a Reward.

Gamification enhances attention, memory retention and emotional involvement across all age groups, strengthening the park's educational impact.

2. Strengthening Loro Parque's sustainability brand

The initiative reinforces the park's existing conservation identity by showcasing sustainability in a modern, interactive and visitor-centred format. This contributes to stronger brand positioning and enhances Loro Parque's reputation as a forward-thinking environmental institution.

3. Data collection for improved environmental strategies

Smart-card based interactions allow the park to gather valuable data on visitor behaviour, such as:
– the most visited themes and stations,
– frequency of recycling actions,
– participation in eco-behaviour tasks.
This supports continuous improvement and strategic decision-making in environmental education.

4. Additional commercial opportunities

The reward system can encourage visitors to engage with sustainable products, shops or branded experiences, creating positive associations between sustainability and visitor satisfaction, while generating additional economic value.

5. Opportunities for partnerships

The hub enables collaboration with universities, NGOs and technology developers interested in environmental education, gamification or behavioural research, opening new avenues for innovation and joint projects.

8.11 Conclusion & Outlook

Loro Verde represents a significant step toward transforming sustainability education at Loro Parque into a highly engaging, interactive and memorable experience. By translating complex topics such as recycling, renewable energy, biodiversity and circular thinking into simple game-based activities, the initiative enhances visitors' environmental awareness while promoting responsible behaviour inside the park.

The concept contributes to:
– improved understanding of environmental challenges,
– reduced waste and harmful visitor behaviour,

– stronger engagement with conservation topics,
– enhanced sustainability branding for Loro Parque,
– and data-driven continuous improvement.

Looking ahead, Loro Verde offers considerable potential for further development, including the integration of additional themed games, stronger connectivity with the official Loro Parque mobile app, and the introduction of school partnerships for curriculum-linked activities. Future expansion could also incorporate AR-based content, enabling immersive learning experiences that deepen visitor connection to conservation values.

In conclusion, Loro Verde supports Loro Parque's mission by making sustainability accessible, engaging and emotionally meaningful—ultimately helping visitors connect more deeply with environmental responsibility and long-term conservation.

9. Final Discussion and Recommendations

Chapter 9 is designed to translate the cross-case insights into a consolidated strategic direction for Tenerife. It is divided into two subsections that build logically upon one another. Subsection 9.2 introduces the analytical framework used to assess the circular initiatives on the island, focusing on the environmental, social, and economic dimensions of circularity. This enables a holistic understanding of shared challenges, opportunities, and synergies across the different case studies. Subsection 9.3 then develops a set of joint recommendations derived from these findings. These recommendations propose how Tenerife can advance from isolated circular projects toward a coordinated, system-level transition, emphasising integrated resource management, the role of tourism in driving behavioural change and local value creation, the strengthening of knowledge and innovation ecosystems, and improved governance and measurement structures. Together, these two subsections connect the empirical results with actionable strategic outcomes, forming the concluding bridge between the analysis and Tenerife's long-term circular transition pathway.

9.1 Key Insights Across All 6 Case Studies

HOTEL TIGAIGA

Hotel Tiagaiga demonstrates that long-term, certification-driven sustainability (EMAS and ISO 14001), when embedded into daily operations, can create a strong foundation for circularity; however, the document clearly reveals a *strategic imbalance* between high technical environmental performance (especially in energy management and waste circularity) and comparatively weaker performance in water efficiency, employee mobility, and sustainability communication—meaning that the hotel's greatest future sustainability gains will come not from initiating sustainability for the first time, but from *optimising resource-intensive areas and transforming already-existing practices into visible, communicated, and socially integrated circular systems*.

BALTEN

Balten's core strategic strength lies in its ability to convert renewable energy surplus into system-wide sustainability gains through economically viable electricity-storage solutions, where battery storage clearly emerges as the most financially favorable option (positive NPV, highest practical IRR for daily use), while long-term technologies such as green hydrogen and A-CAES position the utility for future energy resilience. The document shows that, supported by strong institutional partnerships and extensive public subsidies, BALTEN is not only addressing Tenerife's critical water–energy nexus, but is actively transforming energy surplus management into a foundation for lower emissions, reduced grid dependency, and long-term infrastructure stability.

TAGUA

Tagua is a Spanish company specializing in water cycle management, focusing on customized and sustainable solutions. The company faces significant challenges, particularly in the Canary Islands, where water scarcity and tourism pressure are critical concerns. Tagua aims to promote sustainability and circular economy through innovative and collaborative approaches.

Awareness and education are crucial for promoting sustainable water use. Tagua emphasizes transparent communication and public participation to increase acceptance of reclaimed water and promote sustainable practices. This includes implementing evidence-based communication strategies and collaborating with universities and industries.

The company also invests in technical solutions to enhance the efficiency of water treatment processes. This includes energy recovery and biochar production, which can contribute to environmental and economic sustainability. Collaboration with other companies and institutions is essential for developing innovative and sustainable practices.

Tagua recognizes that sustainable water management is a complex challenge requiring collaboration among all stakeholders. The company works with governments, universities, and communities to promote awareness and implement sustainable solutions. Education and public participation are fundamental to the success of these initiatives.

In summary, Tagua is committed to promoting sustainability and circular economy in water management. The company believes that collaboration, awareness, and innovation are key to addressing water scarcity challenges and promoting a more sustainable future. Tagua continues to work towards these goals, focusing on education, collaboration, and innovation.

WOOPTIX

WOOPTIX is a European deep-tech company specializing in Wavefront Phase Imaging (WFPI), a cutting-edge optical metrology technique used for nanoscale semiconductor inspection. The company collaborates with leading industry partners, including ASML and Intel, to drive innovation in the semiconductor sector.

With a team of around 80 specialists, 25% of whom hold PhDs, WOOPTIX is dedicated to pushing the boundaries of optical metrology. The company has developed a unique concept called WOOPATHON, a customized hackathon designed to attract top talent and stimulate creative problem-solving.

WOOPATHON combines the energy of a hackathon with a challenge-based learning approach, aiming to bring together multidisciplinary teams to tackle real-world problems. This initiative reflects WOOPTIX's commitment to innovation, talent acquisition, and knowledge sharing.

WOOPTIX is also focused on enhancing its digital communication and knowledge management. The company is developing a new website and a dedicated "People & Knowledge" section to showcase its expertise and facilitate collaboration.

Partnerships with universities, including the University of La Laguna (ULL), play a key role in talent development and innovation.

By aligning its efforts with the United Nations' Sustainable Development Goals (SDGs), WOOPTIX aims to contribute to a more sustainable future while driving technological advancements in the semiconductor industry. The company's commitment to innovation, talent, and sustainability positions it as a leader in the field of optical metrology.

TEIDAGUA

The Biofactory project at the Punta del Hidalgo Wastewater Treatment Plant (WWTP) in Tenerife, Canary Islands, is a pioneering initiative to transform the facility into a resource-producing hub. Operated by Teidagua, the project aims to generate renewable energy, reduce waste, and promote circular economy principles. The project aligns with the European Union's sustainability goals and Teidagua's commitment to environmental stewardship.

The project involves implementing a small-scale anaerobic co-digestion system with combined heat and power (CHP) to produce energy. The system will be installed in Zone B, a consolidated urban land area, which simplifies permits and leverages existing infrastructure. The Biofactory will produce high-quality reclaimed water for agriculture, biogas, and nutrient-rich biofertilizer, reducing sludge disposal needs and enhancing energy resilience.

The project's economic analysis shows a moderate payback period, but the integration of co-substrates and reduced sludge disposal costs enhance its financial performance. The Biofactory will also contribute to improved environmental stewardship, energy resilience, and regulatory compliance, demonstrating Teidagua's commitment to sustainability and circular economy principles.

The Punta del Hidalgo WWTP is an ideal location for the Biofactory project, given its strategic importance in treating wastewater for agricultural use. The facility's existing infrastructure and location facilitate the implementation of the project, which is expected to serve as a model for future sustainable wastewater management initiatives.

The Biofactory project showcases Teidagua's innovative approach to wastewater management, emphasizing resource recovery and environmental sustainability. By transforming the Punta del Hidalgo WWTP into a Biofactory, Teidagua is taking a significant step towards reducing its environmental footprint and promoting a more circular and sustainable approach to water management.

LORO PARQUE

Loro Parque, a prominent zoo and aquarium in Tenerife, Spain, has implemented innovative strategies to promote sustainability and environmental education among its visitors. The park aims to educate and engage visitors, especially younger generations, in environmental stewardship and sustainability practices, while also enhancing the overall park experience.

One of the key initiatives is a smart waste-sorting bin system that gamifies waste disposal, teaching visitors about environmental conservation and rewarding correct behaviour. Visitors can participate in a gamified experience, earning virtual coins and redeeming them for prizes, while learning about proper waste separation and disposal practices. This interactive approach has led to a significant increase in waste sorting accuracy among visitors.

Loro Parque has also introduced interactive learning stations, such as the Loro Verde Gaming Hub, that engage visitors in sustainability topics like waste separation, water protection, and energy use. Additionally, the park features a Sustainability Knowledge Corner with digital screens and audio guides in multiple languages, offering flexible self-directed learning opportunities for visitors.

The park has also implemented an Environmentally Responsible Action Reward System, which incentivizes visitors to participate in sustainability activities and make eco-friendly choices. Visitors can collect stamps and redeem rewards, promoting a sense of accomplishment and encouraging repeat participation in sustainability efforts.

By incorporating these innovative initiatives, Loro Parque has created a unique and engaging experience for its visitors, promoting environmental awareness and sustainability practices while enhancing the overall park experience. The park's efforts demonstrate its commitment to environmental stewardship and education, setting an example for other zoos and aquariums to follow.

9.2 Impact Assessment (3 Dimensions of Circularity)

HOTEL TIGAIGA

Hotel Tigaiga's proposed solutions have a positive impact on the environment. The Smart Gardening solution reduces water consumption, minimizes waste, and promotes biodiversity. Sustainable Employee Mobility decreases carbon emissions and reduces parking pressure. Smart Communication encourages resource-efficient guest behavior, reducing waste. These solutions contribute to a more sustainable environment.

The solutions also have a significant social impact. Smart Gardening enhances employee skills and improves guest experience. Sustainable Employee Mobility improves employee cost savings and reduces stress. Smart Communication fosters staff pride and enhances guest engagement. These solutions improve the overall well-being of employees and guests.

In terms of economic impact, the solutions reduce operational costs and increase efficiency. Smart Gardening reduces costs, while Sustainable Employee Mobility reduces transportation costs and increases productivity. Smart Communication attracts eco-conscious guests, increasing revenue. These solutions contribute to the hotel's financial sustainability.

Overall, Hotel Tigaiga's proposed solutions generate mutually reinforcing environmental, social, and economic benefits, strengthening the hotel's sustainability and circularity performance. By implementing these solutions, the hotel can reduce its environmental footprint, improve the well-being of employees and guests, and increase its revenue.

BALTEN

BALTEN's solutions have a positive environmental impact. Battery storage maximizes renewable energy use, reducing emissions. Green hydrogen eliminates fossil-fuel dependency in transport and industry. Advanced Compressed Air Energy Storage (A-CAES) preserves soil and water resources through low-emission mechanical storage. These solutions contribute to a more sustainable environment.

The solutions also have a significant social impact. They support local farmers and the agricultural community by ensuring a reliable water supply. Additionally, they promote sustainable practices and reduce pollution, improving the overall well-being of the community.

In terms of economic impact, the solutions reduce operational costs and increase efficiency. Battery storage offers the most favorable economics, with a positive Net Present Value (NPV) and Internal Rate of Return (IRR). Green hydrogen and A-CAES also generate revenue through fuel sales and low emissions. These solutions contribute to BALTEN's financial sustainability.

Overall, BALTEN's proposed solutions generate mutually reinforcing environmental, social, and economic benefits, strengthening the organization's sustainability and circularity performance. By implementing these solutions, BALTEN can reduce its environmental footprint, improve the well-being of the community, and increase its revenue.

TAGUA

TAGUA's solutions have a positive environmental impact. The implementation of circular sludge management in treatment plants reduces energy consumption and promotes resource recovery. Energy recovery, biochar production, and composting or co-composting are some of the technical processes used. Anaerobic digestion also reduces energy consumption by 14% and significantly reduces operating costs.

The solutions also have a significant social impact. Public education, school programs, community outreach, and participatory communication improve awareness and acceptance of desalinated and reclaimed water. Open-plant days, collaboration with educational institutions, and transparent labeling of reclaimed-water irrigation demonstrate Tagua's commitment to responsible environmental, social, and governance policies.

In terms of economic impact, the solutions reduce operational costs and increase efficiency. The use of biogas obtained from sludge covers part of the energy required by the sewage treatment plant. Tagua's internationalization efforts and participation in programs like ICEX Next also contribute to the company's financial sustainability.

Overall, Tagua's proposed solutions generate mutually reinforcing environmental, social, and economic benefits, strengthening the company's sustainability and circularity performance. By implementing these solutions, Tagua can reduce its environmental footprint, improve the well-being of the community, and increase its revenue.

WOOPTIX

WOOPTIX's solutions have a positive environmental impact. The WOOPATHON Challenge promotes sustainable innovation and reduces waste by generating reusable knowledge artefacts. The Sustainability Chapter Upgrade highlights environmental, social, and organisational sustainability impacts, enhancing transparency and investor credibility. These solutions contribute to a more sustainable environment.

The solutions also have a significant social impact. The WOOPATHON Challenge attracts high-skill talent and promotes interdisciplinary teamwork, enhancing skills and knowledge sharing. The People & Knowledge Website Chapter communicates micro-credentials, career pathways, and corporate culture, strengthening visibility and talent attraction. These solutions improve the overall well-being of participants and the community.

In terms of economic impact, the solutions reduce operational costs and increase efficiency. The WOOPATHON Challenge generates knowledge artefacts and attracts talent, reducing hiring costs and increasing innovation. The Sustainability Chapter Upgrade enhances investor credibility, contributing to Wooptix's financial sustainability. These solutions contribute to Wooptix's long-term competitiveness.

Overall, Wooptix's proposed solutions generate mutually reinforcing environmental, social, and economic benefits, strengthening the organization's sustainability and circularity performance. By implementing these solutions, Wooptix can reduce its environmental footprint, improve the well-being of participants and the community, and increase its revenue.

TEIDAGUA

The Biofactory concept has a positive environmental impact. It enhances water quality, optimizes material and energy use, and reduces emissions and operational costs. The compact digester design integrates energy generation, nutrient recovery, and waste valorisation, reducing the plant's environmental footprint. The use of Life Cycle

Sustainability Assessment (LCSA) ensures environmental, social, and economic dimensions are considered holistically.

The Biofactory concept also has a significant social impact. It promotes stakeholder engagement, improves public perception, and supports local economic development. The project's emphasis on innovation management and stakeholder communication ensures effective implementation and benefits for the community. The Biofactory model transforms wastewater treatment operations, creating a resource-generating system that benefits both the environment and society.

In terms of economic impact, the Biofactory concept reduces operational costs and increases efficiency. The integration of co-substrates, reduction of sludge disposal costs, and potential for tipping-fee revenues enhance long-term financial performance. The Biofactory presents a compelling strategic investment, with benefits including energy resilience, improved environmental stewardship, and regulatory alignment.

Overall, Teidagua's Biofactory concept generates mutually reinforcing environmental, social, and economic benefits, strengthening the company's sustainability and circularity performance. By implementing this concept, Teidagua can reduce its environmental footprint, improve the well-being of the community, and increase its revenue, contributing to a more sustainable future.

LORO PARQUE

LORO PARQUE's proposed solutions have a positive environmental impact. The gamified smart bins are projected to significantly improve recycling accuracy, reducing contamination of recyclable materials, lowering disposal costs, and supporting the park's long-term environmental objectives. The QR system increases visitor awareness about conservation, animal welfare, and sustainability practices, contributing to a cleaner and more sustainable environment.

The solutions also have a significant social impact. Gamification encourages participation, especially among families and children, turning sustainability into a positive and memorable activity. QR codes provide easy access to multilingual information, promoting inclusivity for international visitors and those with accessibility needs. This strengthens Loro Parque's educational role and reinforces its social commitment to environmental awareness.

In terms of economic impact, the solutions reduce operational costs and increase efficiency. Enhanced visitor engagement leads to longer stays, higher satisfaction, and increased spending on food, experiences, and merchandise. Operational costs decrease due to more efficient waste management and reduced need for physical signage updates.

Overall, Loro Parque's proposed solutions generate mutually reinforcing environmental, social, and economic benefits, strengthening the park's sustainability and circularity performance. By implementing these solutions, Loro Parque can reduce its environmental footprint, improve the well-being of visitors, and increase revenue, contributing to a more sustainable future.

9.3 Joint Recommendations for Tenerife

The cross-case analysis of Hotel Tigaiga, Balten, Tagua, Wooptix, Teidagua and Loro Parque shows that Tenerife already hosts a rich portfolio of circular economy initiatives – from advanced water and energy infrastructures to deep-tech innovation platforms and behaviour-change projects in tourism. At the same time, the island continues to face structural vulnerabilities: water scarcity, dependence on desalination and imports, high exposure to tourism fluctuations, and significant pressure on ecosystems. The central task is therefore not to “invent” circularity from scratch, but to connect, scale and govern these existing efforts so that they jointly support Tenerife’s long-term environmental, social and economic resilience.

The following joint recommendations translate the six case studies into an island-level agenda. They are structured along three dimensions of circularity (environmental, social, economic) and aligned with the circular economy principles and 10R hierarchy presented in the theoretical framework. Rather than isolated flagship projects, we propose an integrated transformation pathway that links water and energy systems, tourism, knowledge and innovation, and governance.

9.3.1 Build an Integrated Water–Energy Circularity Strategy

Across Balten, Tagua and Teidagua, Tenerife already operates critical elements of a circular water–energy system: large-scale irrigation reservoirs, desalination and distribution infrastructures, integrated water-cycle management, and a Biofactory concept that turns wastewater into energy, reclaimed water and biofertiliser. Yet these initiatives are still largely managed as separate projects rather than as a single, strategically coordinated island system. The first joint recommendation is therefore to establish an integrated Water–Energy Circularity Strategy for Tenerife, anchored institutionally in the Cabildo and co-governed with the main utilities and municipalities.

Environmentally, the strategy should prioritise closing water loops at multiple scales. At the utility level, Teidagua's Biofactory model at Punta del Hidalgo demonstrates how high-quality reclaimed water, biogas and biofertiliser can be produced from wastewater while reducing sludge disposal and emissions. At the distribution level, Balten's reservoirs and pumping systems are already central to supplying more than 90% of irrigation water, and the company is exploring storage technologies to stabilise renewable electricity generation. At the end-user level, Tagua's projects reveal how reclaimed water can substitute freshwater in agriculture, tourism and municipal services – provided social acceptance is actively managed. Coordinating these levels in a single planning framework would allow Tenerife to optimise where water is reused, where desalination remains unavoidable, and where energy-intensive processes can be offset with local renewables.

Economically, such a strategy should bundle investment cases into a coherent "pipeline" that can attract EU and national funding for storage, Biofactories and water reuse. Balten's business cases for storage solutions, Teidagua's LCSA-based Biofactory design and the proposed greywater pilot at Hotel Tigaiga already provide financially robust templates. Instead of each organisation negotiating subsidies or loans independently, Tenerife could position a portfolio of interlinked projects as a single regional programme that lowers financing costs, reduces duplicated feasibility studies and accelerates approval processes.

Socially, the integrated strategy must explicitly address perception and trust. Tagua's analysis shows that resistance to desalinated and reclaimed water is driven less by technical quality and more by cultural, psychological and emotional factors. We recommend that the Cabildo, Tagua and Teidagua jointly design an island-wide communication and participation campaign around "Circular Water for Tenerife". This should combine transparent data (quality indicators, risk assessments), storytelling (local farmers benefitting from reclaimed water, hotels reducing potable water use) and participatory processes (public workshops, school programmes) to normalise water reuse as a responsible and modern practice rather than a “second-class” solution.

Practically, an Integrated Water–Energy Circularity Strategy could be operationalised through a permanent Water–Energy Nexus Taskforce with representatives from Balten, Tagua, Teidagua, key municipalities, the tourism board and academic experts. The taskforce would coordinate scenario planning, prioritise investment corridors (for example, linking Biofactories, agricultural zones and tourism clusters), and ensure that environmental, economic and social criteria – as captured in LCSA/SLCA – are used consistently for decision-making.

9.3.2 Use Tourism as a Platform for Circular Behaviour and Local Value Creation

Tourism is both Tenerife’s main risk and its main lever. The case studies of Hotel Tigaiga and Loro Parque show that individual actors are already experimenting with ambitious circular practices: advanced environmental management systems, smart irrigation and greywater concepts at hotel level, and gamified waste-sorting and sustainability education for over a million visitors at park level. However, these innovations remain fragmented and largely invisible as a coherent island narrative. The second recommendation is to deliberately use tourism as the primary platform for circular behaviour change and local value creation.

At environmental level, Tenerife should expand the pilots of high-tier circular strategies (Refuse, Rethink, Reduce, Reuse) across the tourism value chain, moving beyond a narrow focus on recycling. Building on Tigaiga’s proposed greywater reuse and smart gardening project, a “Circular Hotel Corridor” could be established in Puerto de la Cruz, where selected hotels implement greywater recycling, sensor-based irrigation, renewable energy integration and food waste prevention in collaboration with local utilities and suppliers. Similarly, Loro Parque’s Loro Verde and smart bin concepts could serve as prototypes for interactive waste and water-saving systems in airports, shopping centres and other high-traffic areas, making sustainable behaviour an integral part of the tourist journey rather than a one-off attraction.

Economically, a joint circular tourism strategy should strengthen local value loops. This includes supporting local farmers and producers through procurement policies (for example, hotels favouring local, organic products and using Biofactory compost), developing eco-certified experiences (hiking, cultural tours, "behind-the-scenes" visits to circular infrastructures) and encouraging tourism operators to engage in long-term supplier relationships that reduce imported inputs. The 10R framework and sustainable business model archetypes discussed in the theoretical chapter provide useful templates for designing such models (for instance, "maximise material productivity" or "create value from waste").

Socially, tourism can be turned from a source of pressure into a vehicle for citizen and visitor engagement. Loro Parque's experience highlights both the challenge – visitors often see the park primarily as entertainment and ignore educational messages – and the opportunity: gamification and interactive formats substantially increase learning and pro-environmental behaviour. We recommend that Tenerife develops a "Circular Tenerife Experience Charter" that sets minimum standards for visitor-facing sustainability communication (clarity, visibility, interactivity) and offers a voluntary quality label for hotels, parks and tour operators that meet these criteria. The label should be co-designed with local communities and include commitments to fair working conditions, cultural authenticity and support for local businesses, thereby aligning environmental and social dimensions.

9.3.3 Develop a Circular Knowledge and Innovation Ecosystem

The Wooptix case demonstrates that, in addition to physical resource flows, knowledge itself can be managed as a circular resource. The proposed Circular Knowledge Loop and Woopathon framework show how a company in a geographically peripheral location can use challenge-based learning, university partnerships and digital communication to attract talent, generate innovation and retain organisational learning. This logic is directly transferable to Tenerife as a whole: the island needs a circular innovation ecosystem that continuously generates, tests and disseminates solutions for water, energy, tourism and biodiversity.

We therefore recommend the creation of a "Tenerife Circular Innovation Lab" as an island-wide platform that connects universities (such as ULL), vocational schools, companies (Balten, Tagua, Wooptix, Teidagua, Loro Parque, hotels), start-ups and public institutions. The lab would organise recurring challenge cycles similar to Woopathon, but with a broader focus on territorial challenges: for example, "closing the water loop in tourism", "decarbonising irrigation" or "gamifying circular behaviour in public spaces". Student and professional teams would work on real company and municipal problems, supported by mentors from industry and academia, while all outputs are stored in a shared digital knowledge hub accessible to partners.

Environmentally, such a lab would accelerate the diffusion of best practices and technologies, preventing each organisation from “reinventing the wheel” in isolation. Economic benefits would arise from talent retention, entrepreneurial activity and reduced innovation costs; Wooptix’s experience shows that challenge-based programmes generate pipelines of ideas and candidates that can be systematically evaluated and re-used. Socially, the lab would strengthen ties between young professionals, local communities and companies, making circular economy a visible career path and fostering a culture of co-creation instead of top-down policy making.

9.3.4 Strengthen Governance, Finance and Measurement for a Systemic Circular Transition

Finally, the case studies reveal that many of Tenerife’s circular initiatives are technically sound but constrained by fragmented governance, siloed budgets and limited shared measurement. Balten’s storage projects depend on national and EU grants; Teidagua’s Biofactory requires complex permitting and cross-departmental coordination; Tagua’s reused-water projects are hindered by social acceptance; and tourism actors lack a joint framework for communicating circular performance. To move from project-based progress to a systemic transition, Tenerife needs more robust enabling structures.

First, at governance level, the island should institutionalise cross-sector circularity coordination. This could take the form of a “Tenerife Circular Economy Council” chaired by the Cabildo and including representatives from water and energy utilities, tourism, deep-tech and industry, municipalities, civil society and academia. The council would not replace existing authorities but serve as a strategic platform to align sectoral plans with the Circular Economy Action Plan, resolve trade-offs, and prioritise projects with the highest combined environmental, social and economic impact. The Water–Energy Nexus Taskforce and Circular Tourism Cluster proposed above could operate as thematic working groups under this council.

Second, on finance, Tenerife should shift from ad-hoc project funding to programme-based investment logic. Using the LCSA and business-case work already conducted for the Biofactory, storage technologies and hotel water-saving measures, the island can create standardised templates that reduce transaction costs for future proposals and make it easier to bundle multiple projects into single financing applications (for example, for structural funds or green bonds). These templates should explicitly integrate environmental indicators (emissions, water savings, waste reduction), social indicators (jobs, health, community acceptance) and economic metrics (NPV, payback period), reflecting the three dimensions of circularity discussed in Chapter 9.2.

Third, measurement and transparency must be improved to sustain trust and learning. Several cases already work with formal management systems and certifications (EMAS, ISO, Biosphere) or advanced monitoring (LCSA, visitor behaviour analytics, digital dashboards). Building on these, we recommend that Tenerife develops an island-wide “Circularity Dashboard” that aggregates key indicators from participating organisations and sectors. This dashboard should be publicly accessible and used both for accountability (tracking progress towards island-level targets) and for learning (identifying high-performing practices that can be replicated). It would also provide a factual basis for the communication campaigns needed to strengthen public acceptance of water reuse, renewable energy projects and tourism measures.

Finally, governance and measurement structures must remain sensitive to social equity. Circular economy interventions can inadvertently shift burdens (for example, higher tariffs or disruptive construction) onto vulnerable groups if not carefully designed. The use of SLCA in the Biofactory case demonstrates how stakeholder perspectives can be integrated into decision-making. We recommend that similar participatory methods be mainstreamed in other sectors, ensuring that local residents, workers and small businesses are involved in shaping circular policies and benefit from the value created.

Finally, governance and measurement structures must remain sensitive to social equity. Circular economy interventions can inadvertently shift burdens (for example, higher tariffs or disruptive construction) onto vulnerable groups if not carefully designed. The use of SLCA in the Biofactory case demonstrates how stakeholder perspectives can be integrated into decision-making. We recommend that similar participatory methods be mainstreamed in other sectors, ensuring that local residents, workers and small businesses are involved in shaping circular policies and benefit from the value created.

9.3.5 Synthesis and Outlook

Taken together, these joint recommendations outline a coherent pathway for Tenerife's circular transition. The integrated Water–Energy Circularity Strategy addresses the island's physical resource constraints; the circular tourism agenda leverages its main economic engine as a driver of behavioural change and local value creation; the Circular Innovation Lab turns knowledge and talent into regenerative resources; and strengthened governance, finance and measurement frameworks provide the enabling conditions for scale

The six case studies demonstrate that Tenerife already possesses the technical expertise, entrepreneurial capacity and institutional partnerships required to realise this vision. What is now needed is a deliberate effort to connect these "islands of excellence" into a coordinated system that aligns with the principles of the circular economy and the three dimensions of circularity: environmental regeneration, social inclusion and economic resilience. If the recommendations outlined here are implemented in a staged but determined manner, Tenerife can move from being a vulnerable tourism-dependent island to a recognised European showcase of circular transformation – not only safeguarding its own future but also offering a replicable model for other island regions facing similar challenges.

10. References

10.1 Sources Subsection 1

10.2 Sources Subsection 2

Bansal, N., & Kanwar, S. S. (2013). Peroxidase(s) in environment protection. *The Scientific World Journal, 2013*(1), 714639. https://doi.org/10.1155/2013/714639

Boulding, K. E. (1966). The economics of the coming spaceship Earth. In *Environmental quality in a growing economy* (pp. 3–14).

Circle Economy. (2024). *The Circularity Gap Report 2024*. Circle Economy Foundation.

Cradle to Cradle Products Innovation Institute. (2021). *Cradle to Cradle Certified® Product Standard: Version 4.0*. C2CPII.

Dimitrov, D. (2010). *The paradox of sustainability definitions*. https://researchcommons.waikato.ac.nz/entities/publication/786951b3-5dd6-4816-b829-af72531544e8

Ellen MacArthur Foundation. (2013). *Towards the circular economy: Vol. 1. Economic and business rationale for an accelerated transition*. Ellen MacArthur Foundation.

Ellen MacArthur Foundation. (2017). *A new textiles economy: Redesigning fashion's future*. Ellen MacArthur Foundation.

Ellen MacArthur Foundation. (n.d.). *Ellen MacArthur on the basics of the circular economy*. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

European Parliament. (n.d.). *Circular economy: Definition, importance and benefits*. https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

Fullerton, J. (2015). *Regenerative capitalism: How universal principles and patterns will shape our new economy*. Capital Institute.

Heinberg, R., & Lerch, D. (Eds.). (2010). *The post carbon reader: Managing the 21st century's sustainability crises*. Post Carbon Institute. https://www.postcarbon.org/publications/post-carbon-reader/

Kirchherr, J., Reike, L., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221–232.

McDonough, W., & Braungart, M. (2002). *Cradle to cradle: Remaking the way we make things*. North Point Press.

Moore, J. E., Mascarenhas, A., Bain, J., & Straus, S. E. (2017). Developing a comprehensive definition of sustainability. *Implementation Science, 12*(1), 110. https://doi.org/10.1186/s13012-017-0637-1

Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. Johns Hopkins University Press.

Polman, P., & Winston, A. (2021). *Net positive: How courageous companies thrive by giving more than they take*. Harvard Business Review Press.

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). *Circular economy: Measuring innovation in product chains*. PBL Netherlands Environmental Assessment Agency.

Purvis, B., Mao, Y., & Robinson, D. (2018). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science, 14*(3), 681–695. https://doi.org/10.1007/s11625-018-0627-5

Reed, B. (2007). The shift from sustainability to regeneration. *Building Research & Information, 35*(6), 674–680.

Sánchez-Teba, E. M., Benítez-Márquez, M. D., Bermúdez-González, G., & Del Mar Luna-Pereira, M. (2021). Mapping the knowledge of CSR and sustainability. *Sustainability, 13*(18), 10106. https://doi.org/10.3390/su131810106

United Nations Environment Programme. (2015). *Global waste management outlook*. UNEP & International Solid Waste Association.

World Business Council for Sustainable Development. (2000). *Eco-efficiency: Creating more value with less impact*. WBCSD.

World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.

10.3 Sources Subsection 3

Albino Silva, J., Pereira, L., Andraz, J., & Nunes, R. (2023). *Global report 2023: Results of tourism sector companies*. Monitur. https://monitur.ualg.pt/wp-content/uploads/2024/02/Companies-Report-2023-EN.pdf

Cabildo de Tenerife. (2024). *Declaración de emergencia hídrica de la isla de Tenerife*. Cabildo de Tenerife. https://www.tenerife.es/declaracion-de-emergencia-hidrica-de-la-isla-de-tenerife

Domótica 24h. (2025). *Programadores de riego wifi: Los mejores del 2025*. Domótica 24h. https://domotica24h.com/control-jardin-wifi-3g-4g/control-riego-wifi-3g-4g

Glišić, S., & Stamenković, P. (2025). Perception of small and medium-sized hotel managers on the economic feasibility of procuring local agricultural products. *Ekonomika Poljoprivrede, 72*(1), 289–313. https://doi.org/10.59267/ekoPolj2501289G

Gössling, S., Scott, D., & Hall, C. M. (2015). Tourism and water: Interactions, impacts, and challenges. *Tourism Management, 46*, 158–171.

Garrido-Sánchez, M. E., López-Guzmán, T., & Cañizares, S. M. S. (2022). Sustainability practices in small and family-run hotels: A Canary Islands case study. *Sustainability, 14*(11), 6502.

Hotel Tigaiga. (2023). *Estrategia de sostenibilidad*. Hotel Tigaiga. https://tigaiga.com/wp-content/uploads/2023/09/2023-Tigaiga-ODS_es.pdf

Hotel Tigaiga. (2023). *Gestión ambiental en establecimientos alojativos: Marzo 2023*. Hotel Tigaiga. https://tigaiga.com/wp-content/uploads/2023/09/2023-Memoria-de-sostenibilidad_es.pdf

Hotel Tigaiga. (2024). *Magazin Hotel Tigaiga*. https://tigaiga.com/wp-content/uploads/2024/11/Magazin_Hotel_Tigaiga_2024_low.pdf

Hotel Tigaiga. (2025). *Declaración ambiental simplificada: Periodo 1 enero – 31 diciembre 2024*. Hotel Tigaiga. https://tigaiga.com/wp-content/uploads/2025/09/Declaracion-Ambiental-2025-simple-1.pdf

Hotel Tigaiga. (2025). *Hotel Tigaiga information*. Hotel Tigaiga. https://tigaiga.com/en/hotel-tigaiga-services/

Hotel Tigaiga. (2025). *Nachhaltigkeit – Hotel Tigaiga*. Hotel Tigaiga. https://tigaiga.com/de/nachhaltigkeit/

Hydraloop. (2022). *A good building is one that reuses water on-site*. Hydraloop. https://www.hydraloop.com/newsandevents/a-good-building-is-one-that-reuses-water-on-site/

Jones, P., Hillier, D., & Comfort, D. (2016). Sustainability in the global hotel industry. *International Journal of Contemporary Hospitality Management, 28*(1), 36–67.

Martínez-García, E., & Raya, J. (2020). Environmental commitment and guest satisfaction in Mediterranean hotels. *Tourism Management, 77*, 103–130.

Mentor Water Experts. (2025). *Hotel greywater recycling systems*. Mentor Water Experts. https://mentorwater.com/greywater-reuse-in-hotels/

Ortega, E., & Díaz-Pérez, F. (2022). Mobility patterns of hospitality workers in island destinations. *Journal of Transport Geography, 98*, 103–120.

Peattie, K., & Peattie, S. (2009). Social marketing: A pathway to sustainable behaviour change. *Journal of Business Research, 62*(2), 260–268.

Pérez-Martín, M., & Hernández-Cordero, A. (2023). Water scarcity and efficiency challenges in island territories: Evidence from the Canary Islands. *Water Resources Management, 37*(2), 569–585.

Rhode Island Public Transit Authority. (2023, October 26). *Omni Providence Hotel first hotel group to join RIPTA's Wave to Work commuter benefits program*.

https://www.ripta.com/omni-providence-hotel-first-hotel-group-to-join-riptas-wave-to-work-commuter-benefits-program/

Solar Impulse Foundation. (2023). *Recycling greywater in hospitality*. Solar Impulse Foundation. https://solarimpulse.com/solutions-explorer/implementation-stories/recycling-greywater-in-hospitality

Souza, E. (2025). Closing the water loop with greywater recycling in the bathroom. *ArchDaily*. https://www.archdaily.com/1033783/closing-the-water-loop-with-greywater-recycling-in-the-bathroom

Talg, I. (2025, November 10–12). *Interview by Team A*.

Talg, I., & Talg, E. (2022). *Grundsätze und Politik des Hotels Tigaiga*. Hotel Tigaiga. https://tigaiga.com/wp-content/uploads/2023/10/A-Politica-2022DEUTSCH-1.pdf

TORO. (2025). *Sensores y controles remotos*. TORO. https://www.toro.com/es-ES/professional-contractor/irrigation-sensors-remotes

10.4 Sources Subsection 4

Arcadis. (2025). *Decarbonize: Solve tomorrow, today*. https://www.arcadis.com/en/insights/decarbonization

Bocken, N., Short, S., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production, 65*, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

Brunner, M., Gundolf, K., & Guieu, G. (2025). From a conventional to a sustainable business model: A review on transformation actions and indicators. *Cleaner Logistics and Supply Chain, 16*. https://www.sciencedirect.com/science/article/pii/S2772390925000575

BusinessModelCanvas.guru. (2025). *Sustainable business model canvas*. https://businessmodelcanvas.guru/en/sustainable-business-model-canvas/

Cardeal, G., Höse, K., Ribeiro, I., & Götze, U. (2020). Sustainable business models: Canvas for sustainability, evaluation method, and their application to additive manufacturing in aircraft maintenance. *Sustainability, 21*(12). https://doi.org/10.3390/su12219130

Idrica. (n.d.). *Billing cycle: BALTEN*. https://www.idrica.com/projects/billing-cycle-balten/

Karuppiah, K., Sankaranarayanan, B., & Ali, S. (2023). A systematic review of sustainable business models: Opportunities, challenges, and future research directions. https://doi.org/10.1016/j.dajour.2023.100272

Kiel, T. (2025). *Sustainable business models: 8 strategies with impact & 4 real-life examples*. Plant Values. https://plant-values.de/en/sustainable-business-models-8-strategies-and-4-practical-examples/

La Moncloa – Government of Spain. (2025, February 21). *Aids for renewable hydrogen clusters*. https://www.lamoncloa.gob.es/lang/en/gobierno/news/paginas/2025/20250221-aids-renewable-hydrogen-clusters.aspx

LinkedIn. (n.d.). *Balsas de Tenerife (BALTEN)*. https://es.linkedin.com/company/balsastenerife

Mercom India. (n.d.). *Highview Power: 2 GWh energy storage projects in Spain*. https://www.mercomindia.com/highview-power-2gwh-energy-storage-projects-in-spain

Mercom India. (n.d.). *Spain expands grants for energy storage projects to €840 million*. https://www.mercomindia.com/spain-expands-grants-for-energy-storage-projects-to-e840-million

Modo Energy. (2025). *Spain BESS buildout outlook*. https://modoenergy.com/research/en/spain-bess-buildout-outlook-september-2025

Next Kraftwerke. (n.d.). *Renewable energy on islands*. https://www.next-kraftwerke.com/energy-blog/renewable-energy-island

Nerurkar, O. (2017). A framework of sustainable business models. *Indian Journal of Economics and Development, 5*. https://www.researchgate.net/publication/316036863_A_framework_of_sustainable_business_models

PV Magazine. (2022, December 1). *Spain provides financial support for 600 MW of utility-scale storage*. https://www.pv-magazine.com/2022/12/01/spain-provides-financial-support-for-600-mw-of-utility-scale-storage/

PV Magazine. (2024, July 31). *Spain unveils €2.3 billion support programme for hydrogen development and renewable energy sectors*. https://www.pv-magazine.com/2024/07/31/spain-unveils-e2-3-billion-support-program-for-hydrogen-development-renewable-energy-sectors/

Santamarta, J., Miklin, L., Nadal, C., Alcántara, J., Martín, J., & Pérez, N. (2023). Waste management and territorial impact in the Canary Islands. *Land, 12*(1). https://doi.org/10.3390/land12010212

Shippax. (2025). *Moeve and Grupo Armas sign deal to supply 40,000 tonnes of 2G marine biofuels in Canary Islands*. https://www.shippax.com/en/news/moeve-and-grupo-armas-trasmediterrnea-sign-landmark-deal-to-supply-40000-tonnes-of-2g-marine-biofuels-in-canary-islands.aspx

Strategic Energy. (n.d.). *Spain allocates over €840 million to 144 energy storage projects*. https://strategicenergy.eu/spain-allocates-over-e840-million-to-144-energy-storage-projects-as-the-sector-responds/

Tenerife Eco Tours. (2025). *Challenges of mass tourism in Tenerife*. https://tenerifecotours.com/en/challenges-of-mass-tourism-in-tenerife/

Tenerife Weekly. (2023, January 7). *More than €8 million to guarantee the supply of quality irrigation water*. https://tenerifeweekly.com/2023/01/07/more-than-8-million-to-guarantee-the-supply-of-quality-irrigation-water/

Tenerife Weekly. (2024, March 1). *Tenerife declares water emergency*. https://tenerifeweekly.com/2024/03/01/tenerife-declares-water-emergency/

Tenerife Weekly. (2025, February 13). *The key against drought in Tenerife is to bring irrigation water to Tegueste*. https://tenerifeweekly.com/2025/02/13/the-key-against-drought-in-tenerife-is-to-bring-irrigation-water-to-tegueste/

Tenerife Weekly. (2025, October 24). *Officials celebrate as crucial water supply sees stunning turnaround: "The situation is optimal."*

https://tenerifeweekly.com/2025/10/24/officials-celebrate-as-crucial-water-supply-sees-stunning-turnaround-the-situation-is-optimal/

Tedagua. (n.d.). *Reuse and desalination systems on the island of Tenerife*. https://www.tedagua.com/en/project/reuse-and-desalination-systems-on-the-island-of-tenerife

Xylem. (n.d.). *BALTEN: Implementation of an advanced business management system (ERP)*. https://www.xylem.com/en-bg/resources/case-studies/balten-implementation-of-an-advanced-business-management-system-erp/

Energy Storage News. (n.d.). *Spain launches €280 million grants for standalone storage, thermal, and PHES*. https://www.energy-storage.news/spain-launches-e280-million-grants-for-standalone-energy-storage-thermal-and-phes/

Energy Storage News. (n.d.). *Spain allocates funding for 92 MW generation / 186 MWh energy storage on Canary Islands*. https://www.energy-storage.news/spain-allocates-funding-for-92mw-generation-186mwh-energy-storage-on-canary-islands/

Energy Storage News. (n.d.). *Naturgy begins construction on 160 MW BESS portfolio in Spain*. https://www.energy-storage.news/naturgy-launches-construction-on-first-portion-of-ten-site-160mw-bess-portfolio-in-spain/

ESS News. (2025, August 6). *Spain mandates storage in €148.5M funding round for innovative renewables*. https://www.ess-news.com/2025/08/06/spain-mandates-storage-in-e148-5m-funding-round-for-innovative-renewables/

Clean Hydrogen Observatory. (n.d.). *Spain announces €1.2B subsidies for green hydrogen hubs*. https://observatory.clean-hydrogen.europa.eu/media/news/spain-announces-eu12bn-new-subsidies-green-hydrogen-hubs

Euronews Green. (2024, July 26). *Spain in pole position for green hydrogen race as EU approves massive state aid*. https://www.euronews.com/green/2024/07/26/spain-in-pole-position-for-green-hydrogen-race-as-eu-approves-massive-state-aid

European Commission. (2024). *EU funding for hydrogen development*. https://ec.europa.eu/commission/presscorner/detail/en/ip_24_4023

Highview Power. (n.d.). *Developing 2 GWh of liquid-air long-duration energy storage projects in Spain*. https://highviewpower.com/news_announcement/highview-power-developing-2-gwh-of-liquid-air-long-duration-energy-storage-projects-in-spain/

H2 View. (2025). *PLOCAN to build offshore green hydrogen plant in Canary Islands*. https://www.h2-view.com/story/plocan-to-build-offshore-green-hydrogen-plant-in-canary-islands-with-15000kg-annual-capacity/

ITC Canarias. (n.d.). *Instituto Tecnológico de Canarias*. https://www.itccanarias.org/web/es

Moeve Global. (n.d.). *Moeve & Armas 2G biofuels drive – maritime*. https://www.moeveglobal.com/en/press/moeve-armas-2G-biofuels-drive-maritime

World Economic Forum. (2021). *Tuvalu minister stands in sea to film COP26 speech to show climate change*. https://www.weforum.org/stories/2021/11/tuvalu-minister-stands-in-sea-to-film-cop26-speech-to-show-climate-change/

10.5 Sources Subsection 5

Athanasios Davalas. (2023). *The importance of the TAM–SAM–SOM model and how big data and AI help*. https://www.researchgate.net/profile/athanasios-davalas/publication/377992593_the_importance_of_the_tam-sam-som_model_and_how_big_data_and_ai_help/links/661d4ce843f8df018d0e3fdb/the-importance-of-the-tam-sam-som-model-and-how-big-data-and-ai-help.pdf

Carbonell-Alcocer, A., Romero-Luis, J., & Gertrudix, M. (2025). The role of communication in environmental awareness according to circular economy stakeholders. *Journal of Environmental Management, 374*, 124112. https://doi.org/10.1016/j.jenvman.2025.124112

Dolnicar, S., & Schäfer, A. I. (2009). Desalinated versus recycled water: Public perceptions and profiles of the accepters. *Journal of Environmental Management, 90*, 888–900.

Fielding, K., & Roiko, A. (2014). The role of psychology in advancing sustainable water practices. *Sustainability Science, 9*, 587–601.

Garda-López, J., Barajas-Alvarez, P., Gonzales-López, J., Loge, F., Mahlknecht, J., Senés-Guerrero, C., & Gradilla-Hernández, M. (Year unavailable). *Evaluating sludge management strategies using wastewater treatment plant simulations and life cycle assessment*. Springer. [NOTE: Publication year missing in your source]

Häusel, H.-G., & Henzler, H. (2018). *Buyer personas: Wie man seine Zielgruppen erkennt und begeistert*. Haufe-Lexware.

Leong, C. (2020). Can conformity overcome the yuck factor? Explaining public acceptance of recycled water. *Journal of Cleaner Production, 245*, Article 118668.

Minea, G., et al. (2025). The role of ESG in driving sustainable innovation in the water sector. *Water, 17*, 2259.

Qrenawi, L. I., & Rabah, F. K. J. (2021). Sludge management in water treatment plants: Literature review. *International Journal of Environment and Waste Management, 27*(1), 93–??? (Article 111909). https://doi.org/10.1504/IJEWM.2021.111909 [Note: Page range incomplete in your text; APA requires full range if available.]

Rozin, P., Haddad, B., Nemeroff, C., & Slovic, P. (2015). Psychological contamination and the "yuck factor" in water reuse attitudes. *Risk Analysis, 35*(4), 710–720.

Sachdeva, S., et al. (2016). Sacred values, culture and environmental risk perception: The case of the Ganges River. *Journal of Environmental Psychology, 45*, 19–29.

Smith, V., Watson, L., & Prado, S. (2018). Tourism perception and environmental standards: Implications for water reuse. *International Journal of Hospitality Management, 72*, 82–91.

Tagua. (2024). *About us*. https://tagua.es

Tyagi, V. K., et al. (2013). Impairment in water quality of Ganges River and consequential health risks on account of mass ritualistic bathing. *Journal of Water and Health, 11*(1), 184–195.

UNEP. (2023). *Measuring progress: Water-related ecosystems and the SDGs*. United Nations Environment Programme.

Viva Canarias Online. (2024, November 25). *Tourismus bricht alle Rekorde 2024*. https://viva-canarias.es/blog/tourismus-bricht-alle-rekorde-2025/

Wester, J., et al. (2016). The psychology of recycled water: Factors predicting disgust and willingness to use. *Water Resources Research, 52*(4), 3212–3226.

TAGUA S.L. (2024). *Integrated water cycle illustration* [Image]. TAGUA. https://tagua.es/.

10.6 Sources Subsection 6

Accenture. (2023). *Tackling the semiconductor talent crisis*. https://www.accenture.com/us-en/insights/high-tech/semi-talent-shortage

Ankrah, S., & Al-Tabbaa, O. (2015). Universities–industry collaboration: A systematic review. *Scandinavian Journal of Management, 31*(3), 387–408.

Brambilla, F. R., Radaelli, G., Pisoni, A., & Peruta, M. R. D. (2022). Hackathons as a strategy for open innovation. *Revista de Administração da UFSM*.

Briscoe, G., & Mulligan, C. (2014). *Digital innovation: The hackathon phenomenon*. Queen Mary University of London.

Chankseliani, M. (2021). Higher education and the Sustainable Development Goals. *Higher Education, 81*(6), 1091–1110.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.

Deloitte. (2024). *Global semiconductor talent shortage report*. Deloitte Insights.

D’hert, G. (2025). *Addressing the growing semiconductor talent gap*. https://www.eetimes.com/addressing-the-growing-semiconductor-talent-gap/

Etzkowitz, H. (2003). Innovation in the Triple Helix of university–industry–government relations. *Social Science Information, 42*(3), 293–337.

European Commission. (2023). *European Chips Act and semiconductor strategy*. https://digital-strategy.ec.europa.eu

Huang, C.-Y., Chen, H.-M., & Lin, K.-Y. (2019). Research performance of Taiwan's leading engineering universities: A bibliometric analysis. *Scientometrics, 120*(2), 543–568.

Kamalaldin, A., Marion, T., & von Kortzfleisch, H. (2022). *Sustainable entrepreneurship and innovation ecosystems in European universities (ENHANCERIA)*. ENHANCERIA Project.

Kao, C., & Lee, T.-S. (2021). Taiwan's optoelectronics and semiconductor R&D ecosystem: University contributions and innovation capacity. *Technological Forecasting and Social Change, 165*, 120535.

Kozirog, K., Pérez-Sanagustín, M., & Mora, H. (2022). Universities as drivers of sustainable innovation. *European University Association*.

Mathews, J. A., & Cho, D.-S. (2000). *Tiger technology: The creation of a semiconductor industry in East Asia*. Cambridge University Press.

McKinsey & Company. (2024). *How semiconductor companies can fill the expanding talent gap*. https://www.mckinsey.com/industries/semiconductors/our-insights/how-semiconductor-companies-can-fill-the-expanding-talent-gap

Nistor, R., Gligor, D., & Gherhes, V. (2022). University–industry innovation ecosystem hubs: Building bridges over uncertain waters. *Journal of Innovation and Entrepreneurship, 11*(1).

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14–37.

Nonaka, I., & Takeuchi, H. (2019). *Knowledge-creating organizations*. [Edition information needed—likely reprint; confirm if necessary]

OECD. (2018). *Oslo manual: Guidelines for collecting, reporting and using data on innovation* (4th ed.). OECD Publishing.

OECD. (2021). *Innovation ecosystems and talent mobility*. OECD Publishing.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., & others. (2013). Academic engagement and commercialisation: A review of university–industry relations. *Research Policy, 42*(2), 423–442.

Porter, M. E., & Kramer, M. R. (2011). Creating shared value. *Harvard Business Review, 89*(1–2), 62–77.

Riesener, M., Hofmann, P., & Gräßler, I. (2019). Innovation ecosystems for industrial sustainability: A framework to increase innovation productivity. *Procedia Manufacturing, 33*, 466–473.

Semiconductor Industry Association. (2023). *Chipping away: Assessing and addressing the labor market gap facing the U.S. semiconductor industry*. Semiconductor Industry Association & Oxford Economics.

Tornatzky, L. G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington Books.

Uffreduzzi, M. (2016). *Hackathon as emerging innovation practice* (Master's thesis, Politecnico di Milano).

UNESCO International Institute for Higher Education in Latin America and the Caribbean. (2023). *The contribution of higher education to the Sustainable Development Goals*. UNESCO.

WOOPTIX. (2025). *Wooptix corporate webpage and materials*. https://wooptix.com

McKinsey & Company (2022). Semiconductor value chains and strategic dependencies.

Ellen MacArthur Foundation (2020). Circular economy principles for business.

Chesbrough, H. (2020). Open innovation and value creation.

Nonaka, I., & Takeuchi, H. (2019). Knowledge-creating organizations.

OECD (2021). Innovation ecosystems and talent mobility.

European Commission (2023). European Chips Act and semiconductor strategy.

Schumpeter, J. (1934). Theory of economic development.

Porter, M. E., & Kramer, M. (2011). Creating shared values.

Geissdoerfer et al. (2017). Circular economy as a sustainability paradigm

10.7 Sources Subsection 7

Bogetoft, P. (2013). *Performance benchmarking: Measuring and managing performance*. Springer.

Bonnici, T. S., & Galea, D. (2015). *SWOT analysis*.
[Publisher not provided — add if needed]

Chen, J., & Sawhney, M. (2010). *Defining and measuring business innovation: The value oriented view of innovation*. Kellogg School of Management.

European Biogas Association. (2022). *European biogas report*. European Biogas Association.

Furness, M. (2023). *The biofactory: Implementing a life cycle sustainability assessment decision-making tool for quantifying integral sustainability benefits of the wastewater circular economy in Chile*.
[If this is a thesis, tell me and I will format it correctly]

IEA Bioenergy Task 37. (2020). *Cost of anaerobic digestion plants*. IEA.

International Renewable Energy Agency (IRENA). (2016). *Biogas for power generation: Technology brief*. IRENA.

Metcalf & Eddy. (2013). *Wastewater engineering: Treatment and resource recovery* (5th ed.). McGraw-Hill.

Münchner Kreis e.V., European Center for Information and Communication Technologies (EICT), Deutsche Telekom, & TNS Infratest (Eds.). (2009). *Prospects and opportunities of information and communication (ICT) and media: International Delphi study 2030*.

Osterwalder, A., & Pigneur, Y. (2011). *Business model generation*. Campus Verlag.

Pfeffermann, N., Minshall, T., & Mortara, L. (2013). *Strategy and communication for innovation*. Springer.

Sarrazin, H., & Sikes, J. (2013). *Competing in a digital world: Four lessons from the software industry*. McKinsey & Company.
[If this is an online article, I can add the URL]

Teidagua. (n.d.). *Depuración*. https://www.teidagua.es/depuracion

10.8 Sources Subsection 8

Loro Parque. (2022, July 22). *Our history, our legacy*. https://www.loro-parque.com/en/our-history/

Loro Parque. (2025). *Our history – Loro Parque*. https://www.loroparque.com/en/our-history/

Loro Parque. (2025, June 30). *Sustainability – Loro Parque*. https://www.loro-parque.com/en/sustainability-loro-parque/

Loro Parque. (2025). *Sustainability – Loro Parque*. https://www.loro-parque.com/en/sustainability-loro-parque/

Loro Parque Fundación. (2024, September 4). *Collaborate with the Foundation*. https://www.loroparque-fundacion.org/en/collaborate-foundation/

Loro Parque Fundación. (2024). *Loro Parque Fundación – Conservation and research*. https://www.loroparque-fundacion.org/en/

Parque, L. (2022, September 7). *Versele-Laga and Loro Parque Fundación enhance cooperation*. https://www.loroparque.com/en/versele-laga-and-loro-parque-fundacion-enhance-cooperation/

10.9 Sources Subsection 9

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling, 127*, 221–232. (Provides core frameworks for circular economy and system-level transitions.)

Bocken, N., Short, S., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production, 65*, 42–56. (Basis for sustainability-oriented business model innovations in Tenerife.)

Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. (2017). Circular economy: A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757–768. (Supports the integration of environmental, social, and economic sustainability.)

Purvis, B., Mao, Y., & Robinson, D. (2018). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science, 14(3)*, 681–695. (The theoretical foundation for the structure of Sections 9.2 and 9.3.)

Dolnicar, S., & Schäfer, A. (2009). Public perception of desalinated versus recycled water. *Journal of Environmental Management, 90(2)*, 888–900. (Reference for public acceptance challenges of reused water.)

Leong, C. (2020). Overcoming the “yuck factor”: Public acceptance of recycled water. *Journal of Cleaner Production, 245*, 118–129. (Supports communication recommendations regarding reclaimed water.)

Jones, P., Hillier, D., & Comfort, D. (2016). Sustainability in the global hotel industry. *International Journal of Contemporary Hospitality Management, 28(1)*, 36–67. (Foundation for circular tourism recommendations related to Tigaiga.)

Martínez-García, E., & Raya, J. (2020). Environmental commitment and guest satisfaction in coastal hotels. *Tourism Management, 77*, 103–130. (Justifies behavior-based sustainability interventions in hospitality.)

Chesbrough, H. (2003). *Open Innovation*. Harvard Business School Press. (Core reference for innovation ecosystem and Wooptix-related proposals.)

Ankrah, S., & Al-Tabbaa, O. (2015). Universities–industry collaboration: A systematic review. *Scandinavian Journal of Management, 31(3)*, 387–408. (Supports proposals for the Circular Innovation Lab and knowledge ecosystem.)

11. Appendices

Appendix 1: Work Contribution Table:

Contributor **(Team & Name)**	**Work Contribution**
Team A:	**Sections 1.1-1.3 + company section 3**
Niklas Hauser (527703)	Sections 1.3, 3.2 & Set-up: overall research question and structure (except for structure within company sections), Work Distribution across teams, deadlines & source handling.
María Tejera González	Sections 1.2, 3.3.1
Marta Mei Expósito Camejo	Sections 1.1, 3.3.2,
Md Emon Khan	Sections 3.0, 3.4, 3.7
Jay Thakur	Sections 3.1, 3.3
Jose Márcio Zoteli e Silva	Sections 3.3.3, 3.5, 3.6
Team B:	**Sections 2., 2.1, 2.2, 2.5 + company section 4**
Alisa Sirin Yilmaz (447458)	Section 2, 2.1, 2.1.1.1, 2.1.1.2, 2.1.1.3, 2.1.1.4
Mahan Amirian	Section 4
Vivian Okeke (542168)	Section 2.1.1.5, 2.1.1.6, 2.1.1.7, 2.1.1.8
Vinuth Kumar	Section 2.2
Alberto Cruz Martin	Section 2.2
Team C:	**Sections 2.3, 2.4, 2.5 + company section 5**
Prodip Gain	Section 2.3, 2.5
Sanjeevappa Akilesh	Section 5.1, 5.1.2, 5.1.3, 5.1.4
Estel Tepshi	Section 5.2
Godwin Akinpelumi Adeoye IPB (a66665)	Section 2.4, 2.5
Sally Hammel (411217)	Section 5.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4
Team D:	**Sections 9.1, 9.2, 9.4 + company section 6**

Monja Oberhofer (444262)	Sections: 6., 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5, (6.2.1, 6.2.2), Structure for Team D, Concept creator (Website improvement)
Letícia Sato Jaworski	6.3, 6.3.1, 6.3.2
Thitisart Thitathan	Sections: 6.4, 6.4.1, 6.4.2, 6.4.2.1 - 6.4.2.6, 6.4.3, 6.4.3.1, 6.4.4
Osamudiamen Quentin Isibor (IPB- A66662)	Sections: 6.2.1, 6.2.2, 9.1, 9.2, Sources chapter 6 and 9
Neha Shashidhara	Sections: 6.2.3 , 6.2.4 , 6.5 (All)
Team E:	**Section 9.0 + 9.3, 9.4 + company section 7**
Anita Ndregjoni	Sections;7.1.3, 7.4
Pablo Torres Suárez (alu0101329604)	Section 7.1.1., 7.1.2., 7.3.3., 9.4
Rishabh Shukla	Section 7.3.1., 7.3.2.
Satish Badiger	Section 7.3.4, 9.3
Maria Stefani Adventina (514220)	Section 7.2, 7.3.5.
Team F	**Final formatting & all front/back matter (Title Page, Structure, List of Figures & Abbreviations, Final Reference section, Appendices) + company section 8**
Lucy Azar (435026)	8.1, 8.2, 8.3, 8.4, 8.5 Font, size, spacing, formatting instructions, Final Check, List of Figures, deadline setting, Term Paper layout
Ceyda Beyaz (431974)	8.1, 8.2, 8.3, 8.4, 8.5 + Title Page, Advising the students for citation style (APA); Font, size, spacing, formatting instructions; Final Check
Houssem Eddin Gharbi (A66668)	Section: 8.8, 8.9, List of figures
Pablo Hernández Herrero	8.10, 8.11
Rushikesh Khandezod	Section: 8.6, 8.7 Citation style and format