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D5.2: Modelled Scalability of Solutions

Task 5.3: Scalability analysis of SD modelling

WP5: Roadmaps for uptake and scalability of the innovative solutions

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ABSTRACT	This report presents a system dynamic modelling analysis of scaling challenges for innovative water treatment technologies in the Mediterranean region. The analysis focuses on three distinct cases: heavy metal recovery from wastewater, removal of Contaminants of Emerging Concern (CoECs), and water reuse in agriculture. Using system dynamic modelling methodology, we identify key variables, leverage

	points, and feedback loops that influence technology adoption and market development in each case. The analysis reveals that while regulatory frameworks act as primary market drivers across all cases, the specific pathways to commercial success differ based on value creation mechanisms, infrastructure requirements, and market maturity. Through detailed mapping of system dynamics, the report provides strategic insights for technology developers and business stakeholders to optimize their commercialization approaches. The findings highlight the importance of aligning environmental benefits with economic viability while addressing case-specific technical and market development challenges.

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0.3	Update based on review	Arto Wallin, Jyri Rökman	Beneficiary
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1.0	Final Review and Formatting	Rodrigo Sedano, ITCL	Project Coordinator

Executive Summary

The successful scaling of innovative water treatment technologies requires understanding complex interactions between technological, economic, regulatory, and social factors. This deliverable applies system dynamics (SD) modeling to analyze the scalability potential of solutions developed within the iMERMAID project, focusing on three distinct cases: heavy metal recovery, removal of Contaminants of Emerging Concern (CoEC), and water reuse in agriculture.

System dynamics modelling provides a structured approach to understand how different elements within a complex system influence each other over time. The methodology helps identify critical feedback loops and leverage points where targeted interventions can most effectively drive system-wide changes. This analysis is particularly valuable for technology developers and business stakeholders as they plan commercialization strategies.

The key objectives of this analysis are to:

- Model and analyse the potential uptake pathways for iMERMAID's monitoring and remediation solutions.
- Map the complex system of factors influencing technology adoption.
- Identify critical causal relationships between key variables.
- Determine the most effective leverage points for scaling up solutions.
- Provide strategic insights for business development and commercialization.

Through collaborative workshops with subject matter experts and stakeholders, we developed detailed system maps for each case. The analysis reveals that while regulatory frameworks consistently serve as primary market drivers, successful scaling requires careful alignment of multiple factors including:

- Technical performance and reliability.
- Economic viability and value creation.
- Infrastructure integration requirements.
- Stakeholder engagement and acceptance.
- Market development timing and approach.

These findings provide a foundation for developing detailed commercialization roadmaps in subsequent project phases. The insights will help guide strategic decision-making for both technology development and market entry approaches, ultimately supporting the successful scaling of innovative water treatment solutions in the Mediterranean region.

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Acronyms

CoEC	Contaminants of Emerging Concern
CSR	Corporate Social Responsibility
EQS	Environmental quality standards
EU	European Union
ISO	International Organization for Standardization
LP	Leverage point
LP	Leverage Point
MIP	Masachussets Institute of Technology
PESTEL	Political, Economic, Social, Technological, Legal
SD	System dynamics
TRL	Technology Readiness Level

1. Introduction

1.1. The context

Wastewater treatment and pollution control in marine environments has become increasingly critical due to the growing presence of chemical contaminants across water bodies, particularly in densely populated coastal areas. The Mediterranean Sea basin is especially vulnerable to chemical pollution accumulation due to its limited water exchange with open seas and high concentration of anthropogenic activities along its coasts. Currently, there are over 100,000 distinct types of anthropogenic chemicals available in the EU market, many of which have not been thoroughly investigated for their environmental impacts. These contaminants of emerging concern (CoEC) originate from various sources including agriculture (fertilizers, pesticides, fungicides), pharmaceuticals (antibiotics, anti-inflammatory drugs, beta-blockers), personal care products (soaps, lotions, fragrances), industries (heavy metals, plasticizers, flame retardants), and combustion by-products. While some pollutants are addressed by the Water Framework Directive and its daughter directives through established environmental quality standards (EQS), many emerging contaminants lack comprehensive monitoring and treatment protocols. This creates an urgent need for innovative monitoring and remediation solutions that can effectively detect, assess and remove these chemical pollutants from water systems before they accumulate in marine environments.

1.2. System dynamic modelling

System dynamic (SD) modelling is a robust analytical method designed to understand and predict the behaviour of complex systems over time. Rooted in the principles of feedback control theory and systems thinking, SD modelling emphasizes the interdependence and feedback loops within a system's structure. It provides a holistic view of how individual elements within a system interact, evolve, and influence each other.

The core premise of SD modelling is that the structure of a system inherently determines its behaviour. This means that by thoroughly analysing the components, relationships, and feedback loops within a system, one can predict how the system will respond to various changes and interventions. SD modelling employs a variety of tools and techniques, including *causal loop diagrams* and *stock-and-flow diagrams*, to map out and visualize these complex interactions.

One of the key strengths of SD modelling is its ability to incorporate various types of data and knowledge, including quantitative data, qualitative insights, and expert opinions. This makes it particularly useful for tackling multifaceted issues where traditional linear analysis may fall short. By simulating different scenarios and observing potential outcomes, SD modelling helps identify leverage points where strategic and/or policy interventions can lead to significant and sustainable improvements.

SD modelling is not just a theoretical exercise; it is highly practical and applicable across diverse fields. It enables policymakers, managers, and researchers to test hypotheses, explore the implications of different strategies, and make informed decisions that account for the dynamic and interconnected nature of real-world systems.

In summary, system dynamic modelling offers a powerful framework for understanding and managing the complexity inherent in many contemporary challenges. Its emphasis on structure, feedback, and dynamic behaviour provides valuable insights that can guide effective decision-making and drive systemic change.

1.3. The Complexity of Innovative Solution Uptake

The uptake of innovative solutions is inherently complex, influenced by a multitude of interconnected factors spanning technological, institutional, economic, social, environmental, and legal domains. Each of these forces plays a critical role in shaping the adoption process, often in non-linear and unpredictable ways. Understanding this complexity is crucial for effectively promoting and scaling new solutions.

Technological factors are critical in determining the feasibility and scalability of innovative solutions. These include:

- the maturity and readiness of the technology (and competing technologies),
- compatibility with existing systems,
- ease of integration, and
- the availability of technical expertise.

Rapid technological advancements can drive innovation by providing new capabilities and improving efficiency. However, technological challenges such as interoperability issues, technical support, and the need for continuous updates and improvements can pose significant barriers. Understanding the technological landscape and its evolution is essential for anticipating potential hurdles and preparing for future developments.

Institutional factors encompass the policies, regulations, norms and organizational structures that can either facilitate or hinder innovation. For instance, supportive government policies and regulatory frameworks can provide the necessary environment for new technologies to flourish, while restrictive regulations can stymie progress.

Economic factors involve the financial aspects of innovation uptake, such as cost, funding availability, and market dynamics. The economic feasibility of adopting a new solution is often a decisive factor for stakeholders, influencing their willingness and ability to invest in new technologies. Market conditions, including competition and demand, also play a significant role in the economic viability of innovations.

Social factors pertain to the human elements of adoption, including public perception, cultural attitudes, and behavioural patterns. Innovations often require changes in behaviour or shifts in societal norms, which can be met with resistance or acceptance depending on how well these changes align with existing values and practices. Stakeholder engagement and community involvement are essential to address social dynamics effectively.

Environmental factors reflect the ecological impacts and sustainability considerations associated with innovative solutions. As global awareness of environmental issues grows, the ecological footprint of new technologies becomes a critical consideration. Innovations that promote sustainability and reduce environmental harm are more likely to gain support and adoption.

Legal factors involve the legislative and judicial aspects that impact the adoption of new solutions. Intellectual property rights, compliance with legal standards, and liability issues are all legal considerations that can influence the innovation process. Navigating these legalities is essential for ensuring the smooth implementation of new technologies.

By applying system dynamic modelling, we can capture and analyse the intricate web of these factors, understanding how they interact and influence each other. This holistic approach allows us to identify potential barriers and enablers of innovation uptake, providing a comprehensive view of the systemic challenges and opportunities. Ultimately, this understanding helps in designing effective strategies for promoting and scaling innovative solutions, ensuring they achieve their intended impact and sustainability.

The insights gained from SD modelling inform the development of **strategic roadmaps** for scaling up innovative solutions. These roadmaps outline the key actions, timelines, and resources needed to achieve the desired outcomes. By providing a clear and evidence-based plan, SD modelling supports decision-makers in designing effective strategies for innovation uptake.

For the purposes of the deliverable, a holistic PESTEL categorization for all use cases was created based on the stakeholder company interviews and workshops. Use case specific PESTEL summaries are presented later.

Table 1. Summary of PESTEL analysis

Category	Drivers	Barriers	Stakeholders	Key Phenomena and Trends
Political	EU Horizon programs increasing awareness	Complex authorization processes	Regulatory bodies (local, national, EU)	Increasing regulatory pressure on water quality and pollutant limits, especially in the EU. Local and national authorities setting stricter environmental standards. Influence of environmental NGOs and citizen science initiatives.
Economic	Cost reduction for customers Cost control and optimization	High initial funding requirements Low water prices reducing demand	Banks for investment Customers (utilities, industries)	High costs of current water treatment technologies (e.g., reverse osmosis). Need for funding to scale up new technologies. Economic incentives for industries to reduce pollutants due to potential cost savings.
Social	Increased social awareness Reputational risks for companies	Resistance to change Lack of social acceptability	NGOs and civil organizations Agricultural cooperatives/big farms	Growing public awareness and concern about water pollution and sustainability. Social acceptability and demand for sustainable water management solutions. Importance of stakeholder engagement, including NGOs and local communities.
Technological	Low energy consumption of new solutions Compactness and ease of installation Realtime	Need for skilled personnel Technical validity and reliability issues	Technical experts (sensor developers) Research institutions	Advances in real time monitoring and sensor technologies. Development of nonchemical pollutant removal methods. Integration of AI for optimization of water management processes.

	monitoring and optimization			
Environmental	Need to meet regulatory standards Reduce environmental impact of businesses	Low concentration of pollutants Technical challenges in scaling	Environmental monitoring bodies/agencies Municipalities	Increasing water scarcity, especially in regions like Southern Europe. Need for efficient water reuse and recycling. Focus on reducing energy consumption in water treatment processes.
Legal	Stringent regulations and standards Compliance with sustainability standards (e.g., ISO 15001, 14001) Regulatory compliance driving innovation	Lack of specific regulations for new technologies	Regulatory bodies (local, national, EU)	Compliance with EU directives on water quality and emerging pollutants. Industry-specific standards and regulations. Potential future regulations on micropollutants and microplastics.

2. The process of SD modelling

Applying System Dynamic (SD) modelling to analyse the adoption of innovative solutions involves a systematic approach to understand and map out the complex causal relationships among various factors. The primary goal is to unravel the intricate dynamics that influence the uptake and scaling of new solutions. There are a few different methods for system dynamic modelling. One well known method is so called MIT process (developed at Massachusetts Institute of Technology) that outlines modelling from start to implementation. MIT process can be divided into 6 steps (see Figure 1), however, it is an iterative and continuous cycle, as new insights often lead back to refining the problem articulation or hypothesis. This deliverable focuses particularly on describing first three steps, described in following sections.

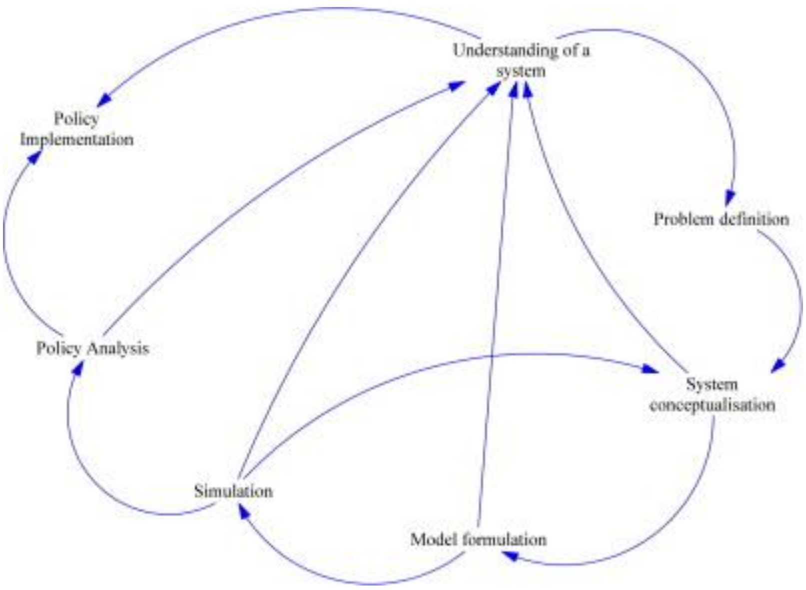

Figure 1. System dynamics modelling process (Golroudbary and Zahraee 2015).

2.1. Problem articulation

The first step, problem articulation, involves clearly defining the problem you are trying to solve. In the case of water treatment solutions, this means understanding why scaling is needed, what challenges are faced, and identifying key performance indicators (e.g., treated water volume, resource utilization). Defining boundaries for the system and specifying the dynamic behaviour of interest (such as delays or resource bottlenecks) are crucial at this stage.

2.2. System conceptualisation - dynamic hypothesis

The second step in the MIT process aims to develop a preliminary theory of how the system operates. The first task in this process is identifying the key variables that impact the system. These variables can be categorized, for example, into technological, institutional, economic, social, environmental, and legal domains. For instance, variables might include government policies, market demand, public perception, environmental regulations, and legal compliance. Each of these factors plays a unique role in shaping the system's behaviour.

Once the key variables are identified, the next task is to map out the causal relationships between them. This involves creating causal loop diagrams that illustrate how changes in one variable can influence others, either directly or through feedback loops. For example, an increase in government incentives for water treatment can boost market demand, which in turn can lead to more investments in water treatment technology, creating a reinforcing feedback loop.

SD modelling also distinguishes between reinforcing and balancing feedback loops. *Reinforcing loops* amplify changes in the system, leading to exponential growth or decline. In contrast, *balancing loops* counteract changes, promoting stability and equilibrium. Identifying these loops is crucial for understanding the system's dynamics and predicting its behaviour under different scenarios.

Initially the focus is on building focused theories about causal relations between variables (the scope of model is limited). In water treatment, it might involve hypothesizing the relationships between water inflow, treatment capacity, and resource availability. The hypothesis is usually articulated as a causal loop diagram to visualize feedback loops and how different factors influence one another.

2.3. Model formulation

This third step translates the dynamic hypothesis (sub-models) into a larger system dynamics model which aims to provide an overall view on the studied phenomenon. *Collaboration with subject matter experts* is a critical component of the SD modelling process. Experts bring valuable insights and knowledge about the specific context and variables involved. Engaging with them through workshops and discussions helps ensure that the model accurately reflects the real-world complexities and dynamics. This collaborative approach also fosters a shared understanding of the system among stakeholders, facilitating consensus and coordinated action.

After constructing the qualitative SD model, simulation model can be created. It can be used to explore various scenarios and their potential impacts on the system. These simulations help identify critical *leverage points*—variables or interventions that can significantly influence the system's behaviour. For instance, the model might reveal that increasing public awareness about the benefits of a new technology is a powerful leverage point for accelerating its adoption.

2.4. Model testing

After formulation, the model is tested for validity. This step involves checking if the model behaves as expected under a variety of scenarios. Model testing is iterative and includes both structural validation (ensuring the structure accurately represents the real-world system) and behavioural validation (comparing model outputs with observed data).

2.5. Policy design and evaluation

Once the model is validated, different strategies for scaling water treatment are tested. The purpose is to understand the impact of different interventions. The policies are evaluated based on their ability to meet objectives, such as increasing the volume of treated water while maintaining sustainable resource use.

2.6. Implementation

The final step involves translating the findings into practical actions. It means taking the insights from the model and applying them to real-world water treatment systems, either through new policies, investments, or operational adjustments.

In summary, the application of SD modelling offers a comprehensive framework for analysing the complex dynamics of innovation adoption. It helps identify critical leverage points, anticipate potential challenges, and design strategic interventions to promote and scale new solutions. Through collaboration and scenario simulation, SD modelling provides valuable insights that guide the development of effective and sustainable innovation strategies.

3. Results

The main goal is to use system dynamic modelling to build models for scalability problem, which helps to understand how businesses focusing on selling technological solutions could be scaled up by 2030. This target year is selected because currently developed solutions are at Technology Readiness Level (TRL) 5-7, which is not yet at the level of commercial scaling (most companies are currently in piloting phase). Nevertheless, it is crucial to understand factors impacting the scalability of the solutions, as these insights will influence strategic choices that companies need to make in the coming years.

From the scalability perspective, we have selected three distinct use cases that provide complementary views on scaling challenges in the wastewater treatment sector:

1. Scalability of a water treatment technology, which aims at the recovery of recyclable materials (metals) from wastewaters.
2. Scalability of water treatment technology for removing Contaminants of Emerging Concern from wastewater.
3. Scalability of water treatment technology for water reusability in agriculture.

These three cases were chosen because they:

- Represent unique and distinct business models in the water treatment sector.
- Provide complementary perspectives on scaling challenges, from material recovery to pollutant removal and water reuse.
- Have clear business representatives with strong commercialization potential and commitment.
- Together cover the main challenges in scaling up innovative water treatment solutions in the Mediterranean region.

3.1. Scalability of recyclable materials business

3.1.1. Problem definition

In this case, we focus on recovering heavy metals from wastewater, which are then sold as recycled materials. These materials compete directly with virgin metals, thus the interest lies in understanding dynamics between supply and demand of both recycled and virgin materials.

Table 2. A high level PESTEL analysis was created based on the interviews and case specific workshops.

Category	Drivers	Barriers
Political	- Regulatory pressure to circularity	- Delay in regulation
Economic	- Public funding for solution development	- Price pressure in critical raw material
Social	- Reputation / social acceptance	- Lack of incentives for circular products

Technological	- Process optimization	- Lack of selective treatment
Environmental	- Demand for circular materials	- Environmental risks in business
Legal	- Circular economy action plan	- Lack of circular economy ecosystems

3.1.2. System conceptualization

System conceptualization includes description of the key variables and key leverage points (LP) in the system. It also includes detailed description of primary dynamic structures.

Table 3. Key variables

Variable name	Explanation
Price of recycled materials Price of virgin material	Market price of virgin and recycled material added with acceptable sustainability premium.
Price difference (RM-VM)	Difference in price of recycled material vs virgin material.
Acceptable price difference	The market currently would allow certain premium, meaning that the price of recycled materials can be up to X% higher than that of virgin metals for the average buyer.
Demand of recycled material Demand of virgin material	A demand for virgin materials and recycled materials. Total demand depends on the industrial activity (what is the utilization rate of existing factories) and type of industry & industrial processes (i.e., how much target material is needed in production process).
Supply of recycled material Supply of virgin material	A supply of recycled and virgin materials, which depends on industrial capacity to produce materials and utilization rate of production capacity. The supply of virgin metals is significant factor in defining market price. If there are disruptions in the mining and supply of virgin metals, the price of recycled metals may increase due to scarcity. Conversely, an abundant supply of cheap virgin metals could pressure recycled metal prices downward.
Supply & demand gap of recycled material Supply & demand gap of virgin material	Difference between supply and demand (supply – demand). Higher the value, the more the is excess supply of material.
Installed recycling capacity	Installed capacity of the recycling technology in focus.
Recycling infra investments	Realized investment into infrastructure that can be used to harvest recyclable material from wastewaters.

Interest to invest in recycling infra	Interest of companies to invest in infrastructure that can be used to harvest recyclable material from wastewaters.
Relative attractiveness of recycled material	Aggregate variable that sums up all variables that impact on relative attractiveness of recycled material over virgin material.
Supply from competitive tech	Supply of recycled materials created with competitive technologies.
Elasticity of demand	The elasticity of demand refers to the change in demand when there is a change in another economic factor, such as price, income or substitute availability.
Industry overall need for target material	Total need of all the industrial sectors for target material (rare metal), which is either virgin or recycled.
Investments in production that utilizes target material	Companies' investments new production capacity that requires rare metals as an input in their production process, therefore increasing total demand of rare metals if new production capacity is built.
Interest to invest in new production (that utilizes target material)	Companies interest to invest in new production capacity (see above).
Economic conditions	Economic conditions are key variable in the demand of many products which use rare metals.
Interest to invest in production capacity of virgin materials	Companies interest to invest in new technology to extract virgin materials.
Installed capacity to produce virgin materials	Capacity that can be utilized to extract virgin materials from available sources. The more there is capacity to produce, the higher the supply is (if there are no agreements to cut the production).
Stock of accessible virgin materials	Available source of virgin materials (e.g., mine) that can be extracted lawfully.
Extraction of virgin materials	Process of extracting virgin materials.
Relative quality of recycled materials	The quality of the recycled heavy metals compared to virgin metals also impacts on the acceptable price difference. If the recycled metals have comparable or superior quality, buyers may be willing to pay a higher premium. Conversely, lower quality may necessitate discounts, limiting the ability to command a premium price.
Corporate Social Responsibility (CSR)	Companies aiming to enhance their CSR image may be more willing to pay a higher price for recycled metals, reinforcing the demand and price premium.
Cost of producing recycled metals:	The cost associated with extracting and processing heavy metals from wastewater plays a crucial role. Advances in technology that reduce the cost

	of recycling can improve profit margins, enabling companies to maintain competitive pricing while allowing for a premium.
Government Policies and Subsidies	Supportive government policies, such as subsidies for recycling plants, can lower the costs of recycling operations. This would make recycled materials more competitive against virgin metals, potentially increasing their maximum price and improving profitability.
Technological Advancements in Metal Recovery:	Innovations that improve the efficiency of heavy metal recovery from wastewater can lower operational costs and enhance yield. This can make recycled metals more economically viable and attractive, thereby allowing for a higher price premium. Technological advancements can also lead to improved quality, which positively impacts market acceptance.

Leverage points are strategic places within a system where small shifts can lead to significant changes in the overall behaviour and outcomes of the system. In system dynamics, these are critical variables or interactions that, when adjusted, can produce disproportionate improvements or impact on the system's performance. Identifying leverage points allows modelers to target interventions that optimize resource use, enhance system efficiency, and drive systemic changes effectively. In the context of wastewater treatment market scalability, leverage points are mainly focused on regulatory incentives. However, other types of leverage points are also possible such as, cost reductions in technology, or shifts in public demand for sustainable practices, which could significantly influence adoption and market growth.

Table 4. Key leverage points

Name of lever	Explanation
LP1: Environmental regulations	Policies that set standards for pollution control and waste management, encouraging companies to adopt recycling technologies and reduce environmental impacts.
LP2: Economic incentives to use circular materials	Financial or tax benefits provided to companies that incorporate recycled or sustainable materials, promoting circular economy practices over reliance on virgin resources.
LP3: Investment (dis)incentives in virgin material production	Government or market (dis)incentives that make it economically attractive to invest in traditional extraction of virgin metals, potentially impacting demand for recycled alternatives.
LP4: Investment incentives (in production capacity of recycled materials)	Funding or tax relief aimed at reducing the cost barriers for establishing or expanding facilities that produce recycled metals, enhancing the market for recycled resources.
LP5: Production incentives (recycled materials)	Subsidies, grants, or tax credits that lower costs for recycled metal production, increasing its competitiveness against virgin material production.

LP6: Financial (dis)incentives to boost production of virgin materials	Taxes or penalties on virgin metal production to internalize environmental costs, discouraging the use of new resource extraction.
LP7: Regulation to limit the use of target material in	Rules that cap or restrict the use of certain rare metals, particularly in non-essential applications, to manage scarcity and encourage recycling.
LP8: Rights for extracting virgin materials	Licenses or legal rights granted for virgin metal extraction, which can influence the availability and pricing of these materials, impacting the appeal of recycled options.
LP9: Campaigns to improve public awareness	Increased consumer preference for companies that prioritize sustainability can lead to greater demand for products made with recycled metals.

These causal relationships collectively influence the dynamics of setting the maximum price for recycled heavy metals. By representing these relationships in causal loop diagrams, we can visualize reinforcing and balancing feedback loops, providing insights into leverage points that can be used to enhance the competitiveness and scalability of recycled materials in the market.

3.1.3. Model formulation

Several causal relationships influence the maximum price of materials harvested from wastewater, which is the major factor defining how attractive business is. These relationships can be represented in causal loop diagrams to better understand how different factors interact to impact price dynamics. The following diagram provides a full picture of the system. Since the picture is quite crowded, in the following pages we provide separate figures from key areas of the diagram. This allows more detailed analysis.

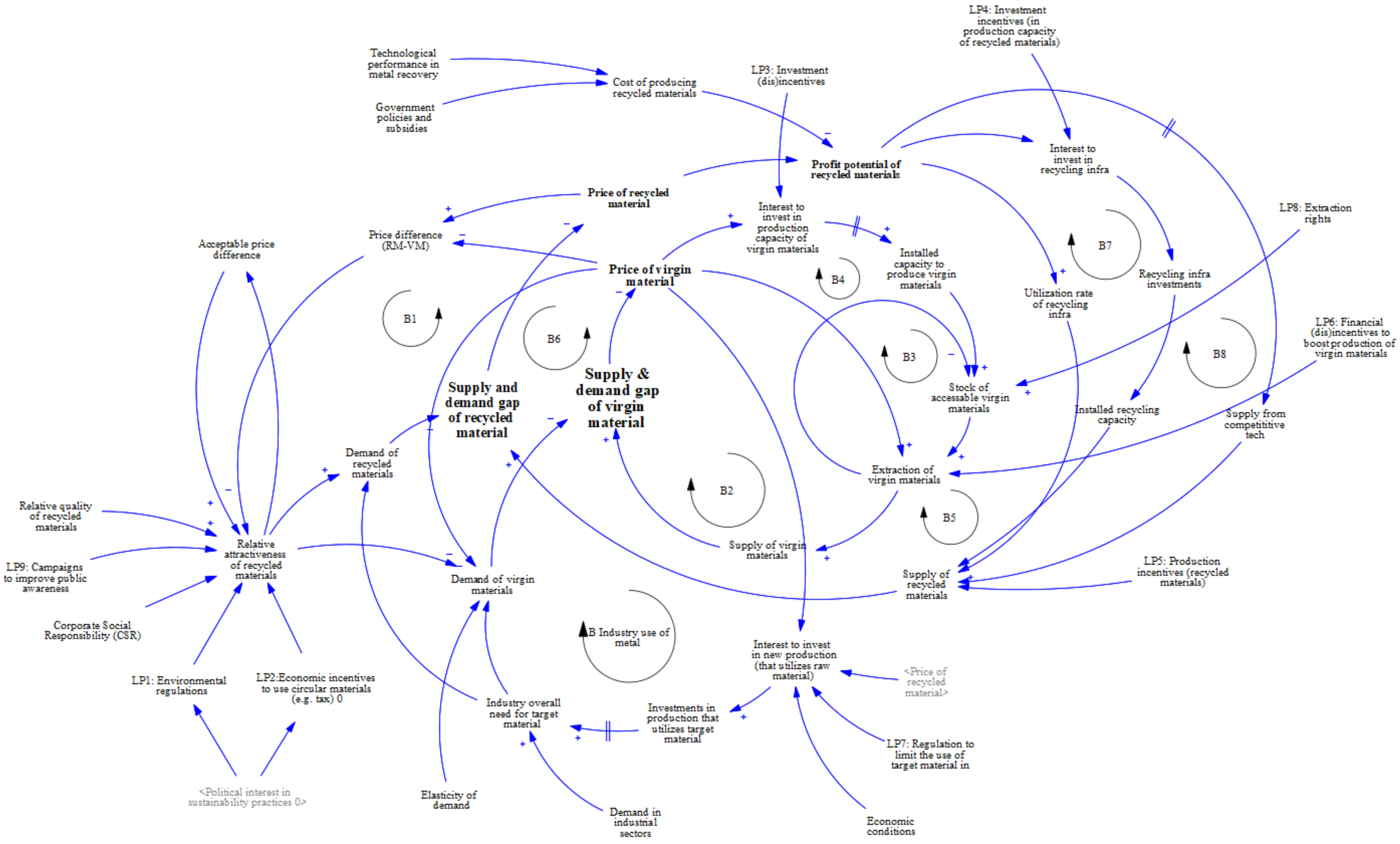

Figure 2: System Model of Scalability of recyclable materials business.

First, we analyse in detail the supply of virgin materials.

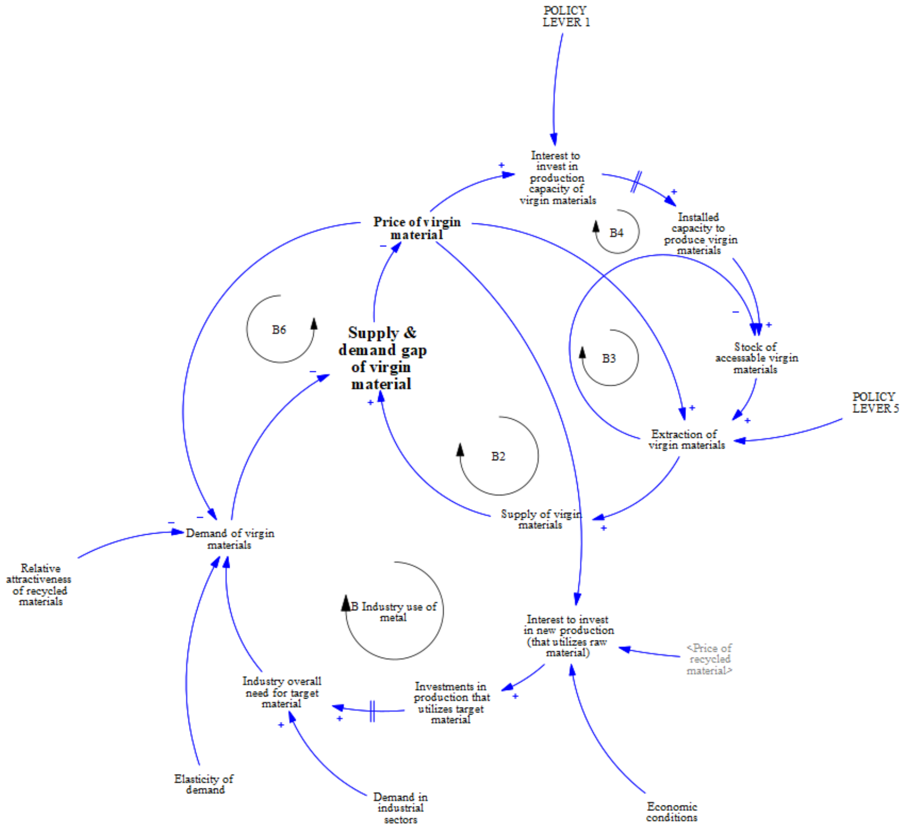

Figure 3. Causal loops related to supply and demand of virgin materials

In the first figure we have 5 feedback loops:

Table 5. Summary of Causal loops related to supply and demand of virgin materials

#	Loop	Explanation
B2	Price of virgin material → Extraction of virgin materials → Supply of virgin materials → supply & demand gap	Balancing loop where price defines how much virgin materials are extracted
B3	Extraction of.. → Stock of ..	Balancing loop: Extraction of virgin materials depletes the stock of those
B4	Price of virgin mat. → Interest to invest.. → Installed capac. → Stock of accessible.. → Extraction → Supply → Demand gap	Balancing loop: high price leads to additional investments, which leads to increased production of virgin material, which starts to lower the price.
B6	Supply & Demand gap → Price of virgin material → Demand of Virgin material	Balancing loop, where increase in price reduces demand, which reduces the price

BX	Price of virgin → Interest to invest.. → Investments in production → industry overall need → Demand for virgin materials	Balancing loop, where high price starts to limit investments new production capacity (that utilizes raw materials leading to lower demand in the long run) and affecting the price

Next figure focuses on relative attractiveness of recycled materials.

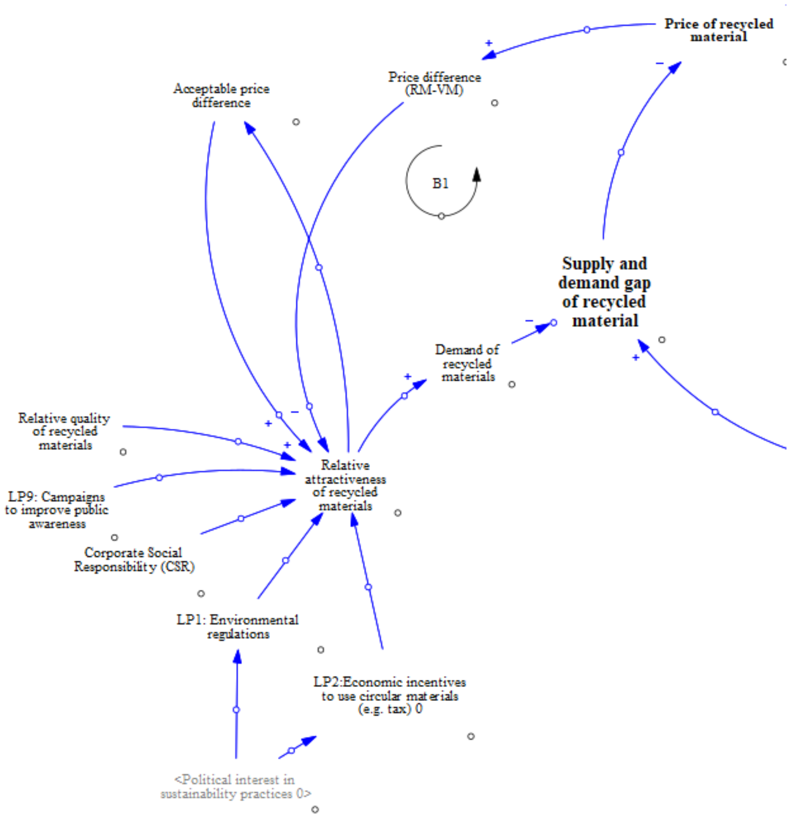

Figure 4. Variables and causal loops related to demand of recycled material

Table 6. Summary of causal loops related to demand of recycled material

#	Loop	Explanation
B1	Price of recycled mat. → Price difference → Relative attractiveness → Demand of recycled materials → Supply & Demand gap	Balancing loop: increase in price of recycled material increases price differences, which reduces attractiveness of recycled materials. Reduced attractiveness reduces demand and thus increases supply and demand gap finally reducing price

The third figure focuses on supply of recycle materials.

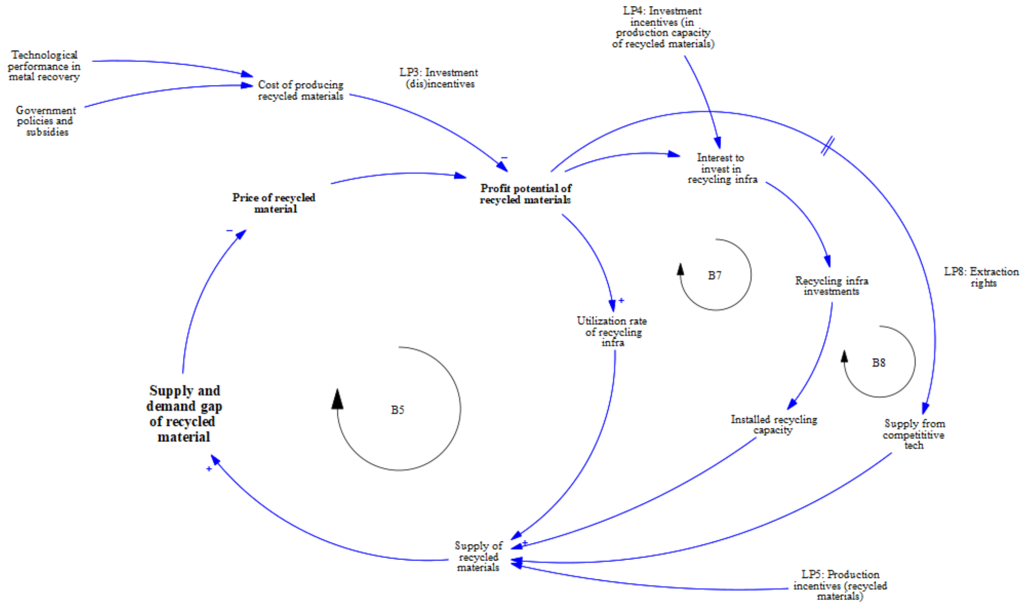

Figure 5. Causal loops related to the supply of recycled materials

Table 7. Causal loops related to the supply of recycled materials

#	Loop	Explanation
B5	Price of rec… → Profit potential → Utilization rate → Supply of rec… → Supply & demand gap	Balancing loop where the price paid for recycled material defines how actively infrastructure is utilized. Higher utilization rate means more supply and therefore wider supply & demand gap, which lowers the market price.
B8	Profit → Supply from competitive tech → supply → supply & demand gap	Similar to above, but focuses on competing solutions. Higher price attracts also competing solutions to the market which puts pressure on price.
B7	Price → profit → Interest to invest → Investment in new infra → Installed capacity → supply → supply & demand gap	Similar to above balancing loops. However, key variable in this loop is interest to invest in new recycling infra, which increases/decreases with the profitability

3.1.4. Conclusions

The system dynamic analysis of heavy metal recovery from wastewater reveals several key insights that are both specific to metal recovery and potentially applicable to other contaminants of emerging concern (CoEC).

Business Model Applicability to Other CoECs

While this analysis focused on heavy metals due to their clear market value as recyclable materials, similar market dynamics could apply to other recoverable contaminants like phosphorus from pesticides or rare elements from pharmaceuticals. However, key differences would emerge in:

- Market structure: Unlike heavy metals which have established commodity markets, many other recovered materials would require new market development.
- Value proposition: Heavy metals have clear intrinsic value, while other contaminants may derive value primarily from regulatory compliance or environmental benefits.
- Recovery economics: WeeeFiner's 4D Scavenger technology demonstrates particularly high selectivity for heavy metals, whereas recovery of other CoECs may face different technical and economic challenges.

Environmental Considerations

While our analysis emphasized economic factors as key drivers of scalability, this reflects the reality that environmental benefits alone rarely drive widespread technology adoption. However, environmental factors are deeply embedded in several ways:

- Regulatory leverage points (LP1-LP9) are fundamentally driven by environmental protection goals.
- Corporate social responsibility and sustainability demands create market pull.
- Environmental risks and impacts influence both regulation and social acceptance.
- Long-term environmental degradation affects resource availability and costs.

WeeeFiner Business Case Application

The identified leverage points offer specific strategic guidance for WeeeFiner's commercialization efforts:

- Focus on regulatory compliance markets where environmental standards create demand.
- Target applications where metal (or other material) recovery generates clear economic returns.
- Develop partnerships with industrial users facing both environmental compliance needs and material cost pressures.
- Emphasize technological advantages in selectivity and efficiency that enable profitable operation.
- Build evidence of environmental benefits to support regulatory and social acceptance.

Implications for Technical Partners

The analysis highlights several key considerations for technology developers:

- Importance of achieving cost-competitive operation at commercial scale
- Need to demonstrate both environmental and economic benefits
- Value of flexibility to address multiple contaminants as regulations evolve
- Critical role of quality and reliability in gaining market acceptance
- Opportunity to leverage regulatory trends as market drivers

This systems analysis provides a framework for understanding how technical, economic, regulatory and environmental factors interact to influence technology adoption. While economic factors often drive near-term decisions, environmental considerations shape the overall system through regulation, social pressure, and long-term resource availability. Success requires addressing both dimensions through solutions that are environmentally beneficial while being economically viable.

3.2. Scalability analysis: Removal of Contaminants of Emerging Concern from wastewaters

3.2.1. Problem definition

In this case, we focus on business cases in which wastewater treatment infrastructure is used to remove Contaminants of Emerging Concern from wastewaters. This case applies both industrial setting, where CoECs are removed from industrial plant effluent, and in municipal solid waste setting, where CoECs are removed from landfill leachates. Leachate is defined as any contaminated liquid that is generated from water percolating through a solid waste disposal site, accumulating contaminants, and moving into subsurface areas.

Primary technology in this case is Eden Tech's microfluid treatment system. However, scalability analysis applies to all technologies that are used for the same purpose.

3.2.2. System conceptualization

System conceptualization includes description of the key variables in the system.

Table 8. Key variables of Scalability analysis: Removal of Contaminants of Emerging Concern from wastewaters

Variable name	Explanation
Installed wastewater infra	Level of wastewater infrastructure installed by customers. This level changes over time depending on in/outflows.
Installation of new equipment	Inflow (installation) of new wastewater treatment infrastructure.
Obsolescence	Outdating of wastewater infra due to reaching end of lifecycle or e.g. due to regulation.
Decision to invest	The decision to invest can be defined as function of interest to invest and market price.
Competitive advantage	Relative advantage of solution created by the company in focus (e.g., Eden tech) in relation to competitors' solutions.
Ease of use After-sales support	Companies who make investment decisions consider numerous variables that define which solution is most attractive. After-sales support and ease

	of use are important factors as these companies may not have special knowledge how to use technology.
Ability to remove micropollutants (vs harvesting them)	Important features of the solution such as is it able to fully remove CoEC or is it just collecting concentrated CoEC, which needs to be further stored or treated.
Efficiency	How efficiently the solution can remove target material from wastewater.
WW quality before COC removal	Quality of wastewater that is influent for the considered water treatment solution may have impact on how well solution work and how often it needs to be maintained.
Interest to invest in WW treatment infra	There can be several factors that influencing customer organisations interest to remove target material (e.g., CoEC) from wastewaters such as *availability of funds, and targeted level of regulatory compliance (i.e. whether company chooses to obey regulations).*
Discrepancy in WW quality	Discrepancy of wastewater quality means the difference in desired quality and realized quality (measure or assumed). Realized quality will change depending on the influx of water and contaminants in it + the used WW treatment infrastructure.
Regulatory Pressure	Regulatory pressure is a major factor in defining the desired level of water quality.
Outdating of infra due to regulation	New regulations may speed up the outdating of installed wastewater infra and force companies to renew infra before the end of its lifecycle.
Market And Competitive Pressure	Corporations may choose to implement higher standards for wastewater than what is required by the effective regulations. The reasons can be, for example, aim to position company as a sustainability leader or goal to avoid risks for brand and reputation.
Customer demand & actions gap	The difference in customers demand for sustainable WW practices vs. realized actions.
Economic Incentives	If there is no absolute necessity to make the investment (regulation), then companies always analyse investments from the financial point of view.
Cost of capital	Interest rates and availability of financing for infrastructure investments.
Operational cost savings	Potential savings from reduced water usage, cost associated with storing or getting rid of contaminated water, and lower energy costs associated with advanced treatment systems.
Life-cycle cost of equipment	Life-cycle cost is a combination of initial capital expenditure (capex) and operation costs during the lifetime of the solution. It also includes required maintenance and spare parts etc.
Demand for solutions	Total demand for wastewater treatment solutions capable of performing needed water treatment task.

Supply of solutions	Supply of all competitive solutions (technologies) that can address the problem.
Supply and demand gap	Difference between supply and demand (supply – demand). Higher the value, the more the is excess supply of equipment.
Market price of solutions	Balance between supply and demand defines the market price of solutions.

Leverage points represent strategic intervention points within a system where relatively small changes can produce significant impacts on overall system behaviour. In the context of CoEC removal from wastewater, leverage points are particularly important as they help identify where targeted interventions can most effectively drive technology adoption and market growth. While regulatory incentives often serve as primary leverage points in this domain, other critical points include technological advancement that reduces treatment costs, increased public awareness of CoEC risks, and market mechanisms that encourage early adoption. Understanding these leverage points is essential for stakeholders aiming to accelerate the implementation of CoEC treatment solutions.

Table 9. Leverage Points (LP) of Scalability analysis: Removal of Contaminants of Emerging Concern from wastewaters

Name of lever	Explanation
LP: Regulatory requirements	Regulatory requirements set by politicians are likely to be the main LEVERAGE POINT for the scalability of the business.
LP: Fines and penalties for non-compliance	If non-compliance is not sanctioned, there may not be enough incentives to follow the regulation.
LP: Technological advancements	Breakthrough in performance of technologies can jumpstart the demand of solutions.
LP: Knowledge of harmfulness of micropollutants	Knowledge of harmfulness impacts both on customers' demands on implementing sustainable wastewater practices as well as politicians' interest to set regulations.
LP: Subsidies and grants	Availability of government grants, subsidies, or tax breaks for sustainable or eco-friendly infrastructure projects.

3.2.3. Model formulation

From the table and figure below, you can find causal loop diagram, which is drawn based on the data collected in group model building exercise. In the figure we can identify 4 balancing feedback loops and 1 reinforcing loop. These loops are:

Table 10. Balancing Loops in Scalability analysis: Removal of Contaminants of Emerging Concern from wastewaters

Name	Explanation
B1	Impact of price on demand. If the demand increases faster than supply, increase in market price will become a limit for new investments.
B2	Improved wastewater quality will reduce the need to do further investments.
B3	Improved wastewater treatment infrastructure will reduce the gap between what environmentally aware customers want and what is the actual level of water treatment.
B4	Improved wastewater treatment infrastructure will reduce the regulatory pressure to install new infra.
B5	More wastewater treatment technologies in place, the more there is machinery to be replaced in long-term (note long delay).

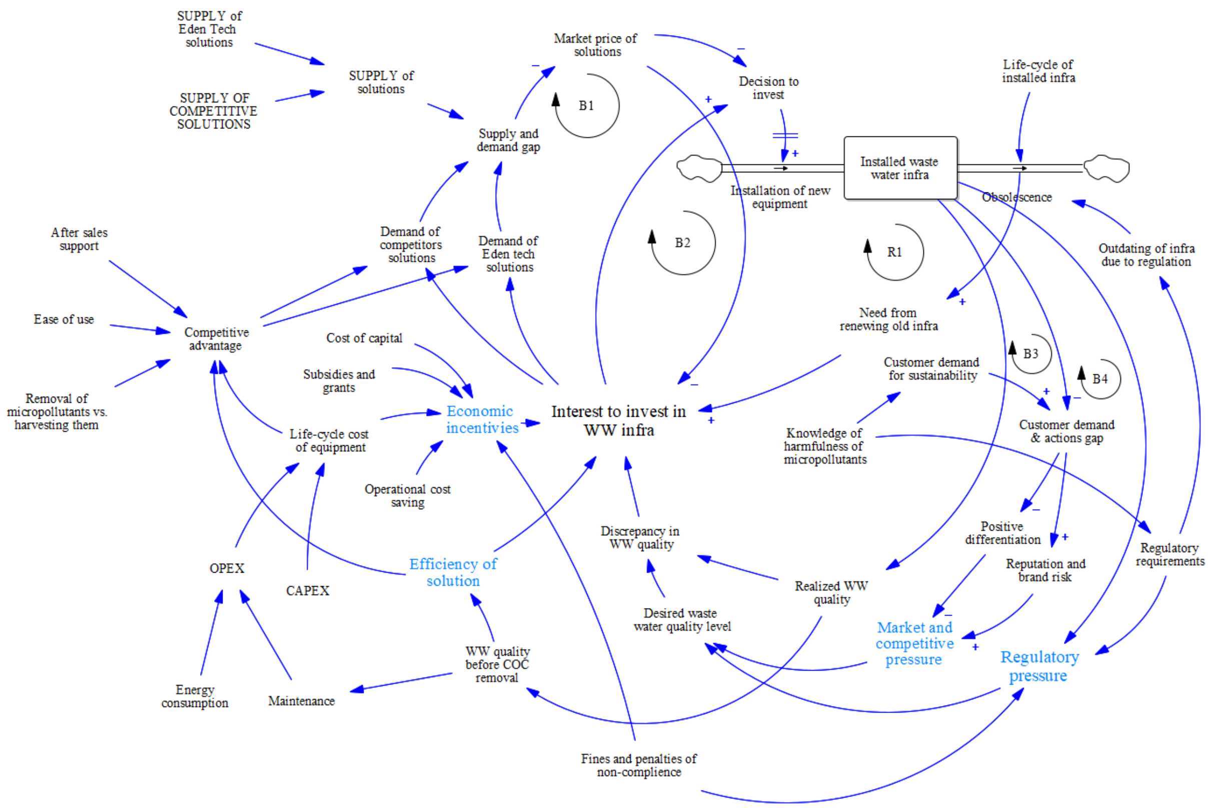

Figure 6. Complete SD model

3.2.4. Conclusions

The system dynamic analysis of Contaminants of Emerging Concern (CoEC) removal from wastewater reveals key insights about market development and technology adoption patterns.

Technology Application Beyond CoECs

While this analysis focused on CoEC removal (particularly using Eden Tech's microfluidic treatment system), the identified system dynamics have broader implications for:

- Treatment of newly identified pollutants as detection capabilities improve
- Adaptation to evolving regulatory frameworks for emerging contaminants
- Integration of treatment solutions into existing wastewater infrastructure
- Development of preventive rather than just remedial approaches

Balance of Environmental and Economic Drivers

The analysis reveals a complex interplay between environmental imperatives and economic realities:

- Environmental risks drive regulatory development and public awareness.
- Economic feasibility determines technology adoption rates.

- Cost-benefit considerations affect both private and public investment decisions.
- Social acceptance influences both regulatory development and market demand.
- Long-term environmental impacts create feedback loops affecting future regulatory requirements.

Eden Tech Business Case Application

The identified system dynamics suggest several strategic priorities for Eden Tech's commercialization efforts:

- Position technology as a proactive solution for anticipated regulatory requirements.
- Demonstrate cost-effectiveness compared to alternative treatment approaches.
- Focus on market segments where CoEC removal creates clear value (e.g., pharmaceutical industry).
- Build evidence of treatment effectiveness for multiple types of emerging contaminants.
- Develop partnerships with wastewater treatment operators to facilitate integration.

Implications for Technical Partners

The analysis provides valuable guidance for technology developers:

- Need for scalable solutions that can adapt to varying contaminant levels.
- Importance of ease of integration with existing treatment infrastructure.
- Value of real-time monitoring and control capabilities.
- Critical role of operational reliability and maintenance requirements.
- Opportunity to develop predictive capabilities for emerging contaminants.

This systems analysis highlights how the success of CoEC treatment technologies depends on the alignment of multiple factors: regulatory requirements, technical capabilities, economic feasibility, and operational practicality. While environmental protection drives the underlying need, successful market development requires solutions that can be effectively implemented within existing wastewater treatment frameworks while meeting both performance and economic criteria. The analysis suggests that regulatory development will likely continue to be the primary driver of market growth, but technology providers must ensure their solutions are both technically robust and economically viable to achieve widespread adoption.

3.3. Scalability analysis: Regenerated water in agriculture

3.3.1. Problem definition

The use case location of San Esteban in Spain focuses on pollutants originating from local agriculture. Chemicals used in agriculture are washed and carried into aquatic bodies by agricultural wastewater and runoff, which is one of the primary causes of water pollution. Examples of hazardous pollutants are pesticides, herbicides and fungicides.

The case analysis presented here is based on interviews and workshops with SOCAMEX and Iris. SOCAMEX represents the local water treatment plant operations and Iris develops the advanced treatment technologies, namely Pulsed Discharge Plasma (PDP). Other project stakeholders are also developing wastewater monitoring technologies for emerging pollutants detection.

The key problem, as presented by the stakeholders, revolves around not only wastewater quality, but also the possibility to utilize regenerated water in agriculture in the future as a mean to cope with anticipated increasing water scarcity.

A high-level PESTEL summary was created based on the interview and workshop findings to highlight some of the perceived drivers and barriers related to the problem.

Table 11. PESTEL summary of Scalability analysis: Regenerated water in agriculture

Category	Drivers	Barriers
Political	- Regulatory requirements related to water consumption, wastewater quality, and re-use	- Regulation limits re-use of water
Economic	- New funding mechanisms	- Cost of infrastructure
Social	- Awareness and education of citizens	- Reluctance for circularity (things coming from waste)
Technological	- Tech adoption in industrial sectors	- Challenges in technology integration
Environmental	- Pressure to increase water re-use	- Accumulation of contaminants over time in water cycle
Legal	- Regulatory thresholds for contaminants tightening	- Lack of knowledge of emerging contaminants concentration and effects

3.3.2. System conceptualization

Table 12. Model variables of Scalability analysis: Regenerated water in agriculture

Variable name	Explanation
Water scarcity	Water scarcity refers to the decreased availability of fresh water from natural sources.
Local agriculture	Agriculture present locally that consumes water from the same area.
Need for water	Total demand for water in agriculture.
Agriculture water intake	Intake of water for agriculture, e.g., irrigation.
Natural water sources	Locally available fresh water.
Climate change	Climate change is increasingly contributing to variance in weather, creating e.g. extreme drought or rain.
Weather	Seasonal changes in weather and long-term trends depending on climate change progress.
Consumption of sources of pollutants	Local agriculture consumes a variety of pesticides and other sources of emerging contaminants that partially end up in wastewater streams.
Wastewater quality	Wastewater quality depends on the density of pollutants and water volume.
Wastewater discharge to treatment	The part of the water from agriculture that is not "consumed", and is discharged through wastewater infra.
Water in use in agriculture	The level of water currently in processes or in use in agriculture.
Fraction of discharge	Fraction of discharge refers to the ratio of consumed and discharged wastewater.
Water consumption	Difference between water intake and discharge.
Water treatment intake	Intake of water into treatment plant from wastewater sources.
Other sources	Other than agriculture wastewater.
Traditional water treatment	Water currently being processed by traditional (1-3 level) treatment processes.
Effluent discharge	Processed wastewater discharged to natural water bodies.
Quaternary treatment	Water in processing in quaternary treatment. Refers to advanced treatment technologies that are able to treat also emerging contaminants.
Intake of regenerated water	Agricultural intake of regenerated water.
Q effluent discharge	Discharged water from quaternary treatment to natural water bodies.

Water intake from natural freshwater sources	Fraction of total water intake from natural water sources.
Demand for regenerated water	The total need for consumption of regenerated water.
Capacity gap	Difference in supply and demand of regenerated water
Commercial potential of regenerated water	Viability of business case for advanced water treatment and water supply.
Private funding for R&D	Investments of private companies in advanced water treatment technology.
Public funding for R&D	Investments of public entities in advanced water treatment technology.
Research	Level of research activities related to advanced water treatment technologies.
TRL of Quaternary treatment	Technology Readiness Level of advanced treatment.
TRL of Contaminant detection	Technology Readiness Level of pollutant detection technologies.
Knowledge of emerging pollutants	The accumulation of new knowledge of emerging pollutants
Social acceptance of regenerated water	Public opinion and acceptability of "circularity" and use of regenerated water.
Detection of contaminants	The process of detecting emerging contaminants, enabled by new technologies and research.
Capacity of solution to detect pollutants	Spectrum and accuracy of detection capabilities. Driven by the TRL of contaminant detection.
Capacity of solution to process water	Volume of water that the advanced treatment technology is able to process in certain time. Driven by the TRL of quaternary treatment.
Emerging contaminants in water cycle	Accumulation of untreated contaminants in bodies of water.
Political will for water management development	Level of political will of politicians and public authorities to allocate resources in development of water management.
Regulation	Level or strictness of water quality related regulatory requirements.
Wastewater quality requirements	Desired levels of wastewater quality.
Infrastructure for regenerated water	Development initiatives for advanced treatment and water supply infrastructure.

Implementation of regenerated water delivery	Implementation and readiness of infrastructure to supply regenerated water.
Implementation of quaternary treatment	Implementation and readiness of advanced treatment capacity.
Desired capacity for quaternary treatment	Target level volume for advanced water treatment.

3.3.3. Model formulation

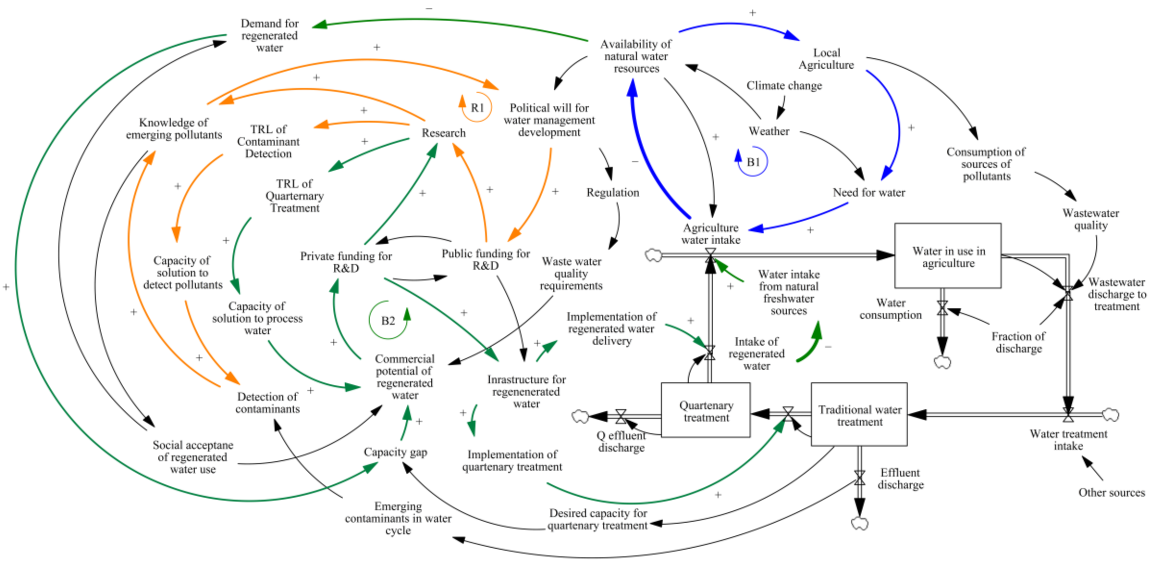

Figure 7. System Model for Scalability analysis: Regenerated water in agriculture

Table 13. Feedback Loops in Scalability analysis: Regenerated water in agriculture

#	Loop	Explanation
B1	Local agriculture → Need for water → Agriculture water intake → Natural water resources → Water scarcity → Local agriculture	Balancing loop 1: The level of local agriculture is dependent on availability of water for e.g. irrigation. Both the water intake of agriculture and changes in weather contribute to the level of local water scarcity.
B2	Water scarcity → Demand for regenerated water → Capacity gap → Commercial potential of regen. water → Private funding for R&D → Research →	Balancing loop 2: Water scarcity is a great demand driver for increasing demand for regenerated water. This creates a capacity

	TRL of Quaternary treatment → Capacity of solution to process water → ... → Infrastructure for regen. water → Implementation of regen. water delivery & quaternary treatment → Intake of regen. water → Water intake from natural fresh water sources → Natural water resources → Water scarcity	gap in water supply and demand that supports the commercial potential of developing solutions for regenerated water. Business case makes it viable for private firms to fund R&D activities for advanced, quaternary water treatment technologies. When the technology matures, it can be implemented as part of water management infrastructure that creates supply for regenerated water for agriculture. Thus, over time the decreasing dependence on water from natural freshwater sources can be expected to lower the water scarcity.
R1	Political will for water management development → Public funding for R&D → Research → TRL of contaminant detection → Capacity of solution to detect pollutants → Knowledge of emerging pollutants → Political will for water management development	Reinforcing loop 1: Political will for water management development is dependent on new knowledge creation of emerging pollutants and drives the public funding for related R&D activities. Through research, improved contaminant detection technology is expected to be created which improves detection and knowledge creation related to emerging pollutants, reinforcing the political will to act.

3.3.4. Conclusions

The system dynamic analysis of water reuse in agriculture reveals important insights about the complex interplay between water scarcity, technology adoption, and social acceptance of regenerated water solutions.

Applicability Beyond Agricultural Water Reuse

While this analysis focused on agricultural water reuse, the identified dynamics could have relevance for e.g.:

- Urban water reuse applications.
- Industrial process water recycling.
- Managed aquifer recharge systems.
- Integrated water resource management approaches.
- Other circular economy water initiatives.

Environmental and Economic Interconnections

The analysis reveals particularly strong connections between environmental pressures and economic factors:

- Water scarcity acts as both environmental pressure and economic driver.

- Climate change creates increasing urgency for water reuse solutions.
- Infrastructure costs must be balanced against water security benefits.
- Public health and environmental safety drive regulatory requirements.
- Long-term sustainability requires both environmental and economic viability.

Socamex Business Case Application

The system dynamics suggest several strategic priorities for Socamex's business development:

- Build evidence of safe and reliable water reuse to support public acceptance.
- Develop scalable solutions that can adapt to varying agricultural needs.
- Focus on regions where water scarcity creates clear economic drivers.
- Create partnerships across the water-agriculture value chain.
- Demonstrate compliance with evolving regulatory frameworks for water reuse.

Implications for Technical Partners

The analysis highlights specific considerations for technology developers:

- Need for robust treatment solutions that ensure consistent water quality.
- Importance of real-time monitoring for quality assurance.
- Value of modular solutions that can scale with demand.
- Critical role of energy efficiency in operational economics.
- Opportunity to integrate smart control systems for optimization.

This systems analysis demonstrates how water reuse success depends on creating a virtuous cycle between technical capability, economic feasibility, and social acceptance. Unlike the other cases analysed, water reuse faces a unique challenge in public perception and acceptance of "recycled" water use in agriculture. The analysis suggests that while water scarcity provides the fundamental driver, success requires building trust through demonstrated safety, reliability, and clear economic benefits. The multiple feedback loops identified show how technical performance, knowledge creation, and social acceptance must all develop in parallel to achieve successful scaling.

4. Final conclusions

The system dynamics analysis conducted across three distinct water treatment applications - heavy metal recovery, Contaminants of Emerging Concern (CoEC) removal, and agricultural water reuse - reveals both universal patterns and application-specific dynamics that shape the development and scaling of innovative water treatment technologies in the Mediterranean region. Through detailed modelling and stakeholder engagement, we identified complex interconnections between technological, economic, regulatory, and social factors that influence successful market development and technology adoption.

A key finding across all cases is the central role of regulatory frameworks in driving market development, though the specific mechanisms and timelines vary by application. While regulations create the fundamental market pull, successful scaling requires careful orchestration of multiple factors including technical performance, economic viability, infrastructure integration, and stakeholder acceptance. The analysis reveals that purely environmental benefits rarely drive widespread adoption - successful solutions must deliver multiple values aligned with both compliance requirements and economic imperatives.

The time horizons for market development differ significantly across applications, influenced by factors such as existing market structures, infrastructure requirements, and social acceptance barriers. Heavy metal recovery benefits from established material markets, enabling relatively faster scaling when technical and economic criteria are met. CoEC removal follows a medium-term development pattern largely synchronized with regulatory evolution. Water reuse faces the longest development timeline due to extensive infrastructure requirements and the need to build public acceptance for "recycled" water use.

Each application area demonstrates unique dynamics in how value is created and captured. Heavy metal recovery combines direct material value with compliance benefits, while CoEC removal primarily derives value from risk management and regulatory compliance. Water reuse creates value through resource security and sustainability benefits, but requires more extensive infrastructure development. These distinct value creation mechanisms necessitate different approaches to business development and stakeholder engagement.

A common thread across all application areas is the importance of system adaptation speed being limited by infrastructure investment cycles. This creates inertia in the system that must be considered in commercialization strategies. Additionally, public awareness and acceptance emerge as critical factors, though their importance varies by application - from relatively minor in heavy metal recovery to central in water reuse applications.

Understanding these dynamics is crucial for technology developers and business stakeholders as they develop strategies for scaling their solutions. The analysis suggests that successful commercialization requires carefully tailored approaches that account for the specific dynamics of each application area while leveraging common patterns in how water treatment markets develop and mature.

Top 5 Key Strategic Aspects for Business Development:

1. Regulatory Framework as Primary Driver

- All three application areas demonstrate that regulatory requirements act as the fundamental driver for market development

- Regulatory pressure creates both direct demand and indirect effects through corporate risk management
- Early alignment with emerging regulations provides competitive advantage
- Different regulatory mechanisms apply:
    - material recovery standards (Application area 1),
    - pollutant limits (Application area 2), and
    - water reuse criteria (Application area 3).

2. Economic Viability Through Multiple Value Streams

- Pure environmental benefits rarely justify investment; multiple value propositions are needed
- Value streams vary by case:
    - Heavy metals: Material recovery value + regulatory compliance
    - CoEC removal: Risk management + compliance + reputation
    - Water reuse: Resource security + cost savings + sustainability goals

3. Technology Integration and Scalability

Success requires seamless integration with existing infrastructure

- Scalability challenges differ across application areas:
    - Heavy metals: Selective recovery efficiency at scale
    - CoEC removal: Consistent performance across varying pollutant loads
    - Water reuse: Infrastructure requirements for distribution

4. Market Development Timeline

All application areas show goal-seeking behaviour but with different time horizons

- Heavy metals: Faster market development due to existing material markets
- CoEC removal: Medium-term development following regulatory evolution
- Water reuse: Longer-term development requiring infrastructure investment

5. Stakeholder Engagement Requirements

- Different stakeholder priorities across cases:
    - Heavy metals: Industry and recycling ecosystem
    - CoEC removal: Regulators and wastewater treatment operators
    - Water reuse: Agricultural users and public acceptance

Cross-Case Comparison:

Similarities:

- All application areas demonstrate strong regulatory dependence
- Economic viability requires multiple value streams

- Technical performance must be balanced with operational practicality
- System adaptation speed is limited by infrastructure investment cycles
- Public awareness and acceptance influence market development

Key Differences:

- Value Creation Mechanisms:
    - Application area 1 (Heavy Metals): Direct material value + compliance
    - Application area 2 (CoEC): Primarily compliance and risk management
    - Application area 3 (Water Reuse): Resource security and sustainability
- Infrastructure Requirements:
    - Application area 1: Focused treatment units
    - Application area 2: Integration with existing treatment
    - Application area 3: Extensive distribution infrastructure
- Market Readiness:
    - Application area: More mature markets and established value chains
    - Application area 2: Emerging markets driven by evolving regulations
    - Application area 3: Early-stage market requiring significant development

Disclaimer

It should be also noted that the goal of the systems modelling is **not** to include all details (referred as detail complexity). If done so, it would have made it very difficult to read diagrams. The goal of SD modelling is to analyse dynamic complexity i.e., dynamic behaviour of the system created by the feedback loops. In order to keep this analysis in focus, we have limited the number of details. Furthermore, although this deliverable report application areas separately, there is significant overlap between them. Thus, companies are likely to generate valuable insights by studying the system dynamic models from the other cases (not their own).

5. References

1. "Business Dynamics: Systems Thinking and Modeling for a Complex World" by John D. Sterman.
2. "Thinking in Systems: A Primer" by Donella H. Meadows.
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The Mediterranean Sea and its surrounding regions support a diverse variety of essential socioeconomic activities. It is one of the highly exploited water ways and the influence of anthropogenic activities on its marine habitats and ecosystems has grown significantly since the industrial revolution. Because of this, the Mediterranean Sea basin is very vulnerable to chemical contamination and build-up. To safeguard the Mediterranean Sea basin from contaminants for emerging concerns (CoEC), iMERMAID will integrate, coordinate, and synergize innovative preventive, monitoring, and remediation solutions. iMERMAID will build an evidence-based multidimensional framework that will guide policymaking and transform societal perceptions to reduce CoEC usage, emissions, and pollution. Furthermore, next generation sensor and remediation solutions will be developed within iMERMAID to monitor and remove prioritized chemicals from its source while reducing upstream pollution. iMERMAID builds an ideal interdisciplinary team by bringing together prominent SMEs, researchers, regulators, and innovation professionals who have been essential in improving the knowledge and awareness of CoEC. Beyond state-of-the-art techniques, iMERMAID will strive to strengthen regulations against CoEC, expand economic possibilities and competitiveness, improve the standard of living for EU residents, while preventing the accumulation of chemical pollution in the Mediterranean Sea basin. iMERMAID will empower the efforts to create a zero pollution, contaminant free waters by enabling the Chemical Strategy's goals to become a practical reality.

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