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EXPERIMENTAL ECONOMICS-LIVING LAB LOOP IN WATER RESOURCE MANAGEMENT

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Experimental Economics-Living Lab Loop in Water Resource Management

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Abstract

Efficient and sustainable water management is imperative due to the mounting pressure on global water supplies from over-exploitation, desertification, and pollution. Integrated Water Resource Management (IWRM) strategies have demonstrated efficacy in decision support; however, a more comprehensive integration of participatory and economic methodologies is required. The objective of this research is to enhance water resource management through collaborative, stakeholder-driven innovation by integrating experimental economics with Living Labs (LLs). Living Labs offer genuine environments for collaborative creation, enabling scientists and stakeholders to resolve water-related concerns such as supply, demand, and scarcity. These environments establish a connection between controlled experimental conditions and real-world applications, offering a comprehensive understanding of policy formulation and behavioral reactions. We use the Limassol Water Futures Living Lab (LWFLL) as a case study that is dedicated to the creation of a comprehensive, intelligent decision-making framework that will enable the effective management of water resources in the presence of unpredictable climate conditions. LLs can be strengthened and improved by economic methodologies, particularly in water valuation, through integrated frameworks that account for environmental externalities and opportunity costs. Real-time input is provided by technological innovations such as smart meters, desalination technologies or soil moisture sensors, which enables dynamic pricing models to accurately depict the economic and environmental costs associated with water consumption. Experimental economics' external validity is enhanced by the integration of behavioral insights and experimental approaches into LLs, which places interventions in real-world settings.

Key words: Behavioral Microeconomics, Field Experiments, Water Resource Management; Water Supply and Demand, Analysis of Collective Decision-Making

1. Introduction

With the ever-increasing strain placed on global water resources – over-exploitation, drought, pollution (Gerten et al. 2020; Jägermeyr et al. 2017; Loucks & van Beek 2017; Navarro-Ortega et al. 2015; Vanham & Leip 2020), effective and sustainable water resource management has become more crucial than ever. Water is a public and economic good since it is essential for the support of life on Earth, as well as for the production of food, energy, and sanitation, as well as for economic activity and transportation in many cases. (UN 2014). Thus, the sustainable water resource management aims to strike a delicate balance to achieve water security in the face of conflating stresses and competing and competing demands. Over the last few decades, Integrated Water Resource Management (IWRM) approaches have proven to be one of the most effective approaches available to managers in the water sector, as such approaches bring together a broad range of knowledge and methodological approaches from various disciplines in order to provide sound decision support for practitioners and policy-makers alike (Giupponi & Sgobbi 2008; Qi & Altinakar 2011). "Integrated water resources management is based on the equitable and efficient management and sustainable use of water and recognises that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilisation" (GWP, 2020). However, despite the significant progress that current IWRM approaches have made in integrating scientific input from the physical sciences, there is still space for the more comprehensive integration of economic methods and critically participatory methods that aim to incorporate stakeholder input. (Akinsete et al. 2022; Giupponi & Sgobbi 2013).

The human factor presents the most significant obstacle in the context of water resource management. Accounting for the impact of human activity, and more importantly, the mechanisms of real-life human decision-making, is essential to inform effective, human-centric approaches to water resource management, as nature runs its course through environmental cycles such as precipitation, groundwater recharge, and surface runoff. (Adams 2021). In particular, insight into the value that society places on its water resources are necessary to design robust water management measures and appropriate economic exchange mechanisms to support the allocation of water resources and the associated costs and benefits among stakeholders (Koundouri, 2002; Koundouri, 2004; Koundouri & Dávila, 2015; Koundouri & Pashardes, 2002).

Despite the importance of carefully considering the hydrological and environmental as well as the socio-econmic parameters of water resource management through integrated sciennce-based policy and decision support tools, the uptake of such tools by policy and decision makers is limited due to the fact that such stakeholders are unlikely to use tools they are unfamiliar with and do not deem trustworthy (Adams 2021). In order to ensure that these integrated scientific approaches are effectively incorporated into the decision-making process, it is crucial to implement strategies that promote stakeholder engagement throughout the process. In other words, the co-determined inputs developed by scientists and stakeholders during periodic meetings are embedded through stakeholder participation in science-fed collaborative processes.(Adams 2021; Gupta H.V. DS Brookshire Tidwell V. Boyle D. 2011; Liu et al. 2008).

A tool to integrate stakeholders' input in the development of innovative solutions are the Living Labs. As defined by ENoLL (2024), Living Labs are open innovation ecosystems that are founded on a systematic user co-creation approach. This approach integrates research and innovation activities in communities and/or multi-stakeholder environments, positioning citizens and/or end-users at the center of the innovation process. They serve as real-life test and experimentation environments, encouraging open innovation and co-creation among the selected actors. Living Labs are both a research methodology and tool, bringing together key stakeholder including scientists, decision-makers, industry experts (e.g., water managers) and users in a co-creation and co-involved innovation processes which includes testing, experimentation, and evaluation within real-world contexts (Delina, 2020; Leminen et al., 2017; Schuurman et al., 2009). Living Labs (LLs) provide a space, where participants collaborate co-create, test, and refine solutions to complex societal challenges. Living laboratories, in contrast to conventional experimental environments, prioritize iterative processes, co-creation, and real-world complexity. Participants are not solely subjects; they are active participants in the innovation process.

Living labs are distinguished from other types of experiments that involve stakeholders, such as Natural Experiments and Randomized Controlled Trials (RCTs), by the fact that their primary objective is not to evaluate the efficacy or impact of a new program or policy. Rather, the objective is to improve the decision support tools by allowing stakeholders to engage in the process, collaborate, and co-create an enhanced version of the tool that takes the human factor into account. Despite the fact that LLs, RCTs, and natural experiments can be conducted in real-world settings, their methodologies and objectives are significantly distinct. Causal relationships are investigated in both RCTs and natural experiments. Randomized controlled trials (RCTs) are dedicated to conducting comprehensive statistical testing to determine "what works" by evaluating specific interventions under controlled conditions using a randomized design. For example, an incentive program may be tested and households may be randomly assigned to receive or not receive the incentives. On the other hand, natural experiments examine causal relationships in environments where exogenous factors (e.g., policies, disasters) induce "as-if" randomization. For example, they evaluate the impact of an intervention in one location and use a control group in a location where the intervention is not implemented.

In contrast, LLs focus is not restricted to causal analysis; it also includes systemic fit, acceptability, and usability by attempting to dynamically adapt and co-develop solutions, frequently incorporating feedback loops and diverse stakeholder perspectives. In LLs, stakeholders are carefully chosen and asked to work together to come up with, test, and improve solutions to problems facing society. For example, LLs could gather residents, local authorities, and researchers to collaborate and enhance a new decision support tool that a water management authority intends to implement in order to more effectively manage and allocate water resources. In an LL, stakeholders are carefully chosen to guarantee that they are not only "interested" in the process, but also significant in terms of the extent to which they are influencing or being influenced by the new tool. On the other hand, RCTs use random assignment of participants to eliminate selection bias and compare results, while natural experiments create control groups by considering natural events or policies being studied (*Table* 1). Click or tap here to enter text.LLs not only bridge the gap between scientists and stakeholders, but they also provide a means to elicit qualitative insights in on relevant water management issues such as supply (Hirshleifer et al. 1969), demand (Franks 2002) and scarcity (Olmstead 2010). Such areas of focus may then be further investigated utilizing experimental economic methods.

Table 1 - Key differences between Living Labs, Randomized Controlled Trials and Natural Experiments

Feature	Living Labs	RCTs	Natural Experiments
Objective	Innovation, usability testing, and co-creation	Efficacy testing and causal analysis	Leveraging outside factors for causal analysis
Control	Limited; real-world complexity	High; tightly controlled	Moderate; depends on context
Randomization	Not always used	Essential	Mimicked by external factors
Stakeholder Role	Active participants in design and testing	Subjects in a controlled experiment	Observational subjects
Adaptability	Iterative and flexible	Fixed protocol	No direct intervention
Scope of Analysis	Broad (causal, behavioral, systemic)	Narrow (causal effects)	Narrow (causal effects)

In order to offer evidence-based insights into strategic interactions between individuals and groups, as well as individual and collective decision-making, experimental economics depends on an established methodological toolkit. The method is fundamentally based on the establishment of controlled environments, which ensure that potential confounding variables are maintained between groups. By altering a particular aspect of interest, it is possible to attribute variations in participant behavior to this aspect. This approach grants causal conclusions (internal validity; (Lonati et al. (2018)). Extensive control, however, comes at the cost of reduced external validity. The gap separating controlled designs and 'real life' likely explains systematic differences between lab settings and natural environments (Galizzi & Navarro-Martinez 2018) questioning whether lab studies may truly provide quantitative conclusions (Loewenstein 1999). However, the linchpin of empirical findings is their applicability in real-life, as economics aims to inform about the best course of action. Consequently, field experiments alleviate this issue by moving investigations from the lab to more realistic contexts (Harrison & List 2004). However, the distinction between lab and field is not necessarily synonymous with a trade-off between internal and external validity (Lonati et al. 2018) experimenters applying scientific rigour and careful designs may succeed to preserve both also in field settings (Harrison & List 2004).

There are three fundamental types of trials in the context of studies that focus on the environment in general and water resources in particular. The initial category examines the potential influence of the specific behavioral characteristics of individuals on the value that society assigns to resources and the environment. Integrating the affective value of natural resources into environmental valuation models to expand their scope (López-Mosquera & Sánchez 2011; Welsch & Kühling 2009) and taking into account cognitive biases like myopic temporal discounting (Clot & Stanton 2014; Weber 2010), gain-loss discrepancies (Jang et al. 2020; Ölander & Thøgersen 2014) and suboptimal emotional forecasting (Nisbet & Zelenski 2011) are all potential ways to enhance environmental valuation models. Specifically with regard to water resources, such as the readiness to pay for the protection of water resources, as well as the role of use and non-use elements (Halkos & Matsiori 2014). Taking a look at the impact that institutions and incentives have on decisions and outcomes is the subject of the second category. Specifically, studies investigate many aspects of water market management, such as the management of water resources by markets García-Gallego et al. (2012) and the optimal characteristics of water market design (Garrido, 2007).According to Cardenas (2000), the third category investigates the social issues or externalities that are associated with public goods and resources that are taken from a common pool. This category has direct relation to the management of resources and the environment, particularly the management of shared resources. The purpose of these research is to get an understanding of the impact that individual activity has on the value of resources and the circumstances of the environment.

Scientists strive to reap the benefits of observing behaviour in the natural setting while maintaining some control over explanatory factors, which leads to more collaborative efforts with outside parties (Levitt & List 2009). LLs have the potential to facilitate this gap-bridging between lab and field. Examples of water-specific experimental economics studies supported by LLs include feedback on water use (enabled by smart meters) results that resulted in a long-term 8% reduction of volumetric water consumption among almost 50% of the households, with the effects persisting for over two years after the program's start, especially for the households receiving sub-daily smart meter information (Cominola et al. 2021). The Living Labs could address additional qualitative questions that are raised by the quantitative results of the study, such as the reasons for the remaining half of the households not showing any savings (such as the lack of engagement with the feedback or long-formed water consumption habits) and the success factors of the saving households (such as social responsibility or money savings). Consequently, the LLs offer a more comprehensive understanding of the results of the behavioral experiments through an iterative process, resulting in more robust outputs that can be used to support the establishment of suitable economic arrangements. The success of these arrangements is primarily determined by stakeholder engagement processes. (World Bank 1999).

Although the integration of economic and stakeholder engagement processes in the field of water management is still in its infancy, the co-developmental nature of these approaches facilitates a more transparent and intimate working relationship among the diverse actors in the water management sector. Furthermore, in the broader sense, facilitate a system-wide shift towards greater sustainability, social equity, and inclusive policy development within water management (Hermans et al. 2006; Hossain et al. 2019; McPhee et al. 2021; Voytenko et al. 2016).

2. ERC Water Futures Limassol Case study

The Water-Futures project[1], funded from the European Research Council (ERC), envisions the development of the next iteration of municipal drinking water systems to ensure the provision of high-quality water services in the face of challenges such as population growth, economic pressures, and climate change. The project investigates the issue: "How should the world achieve the provisioning of high-quality water services in the future while facing severe climate, economic, and population pressures, under deep uncertainty?". One of the case studies of the

[1] https://waterfutures.eu

project is based in Limassol (Limassol Water Futures Living Lab-LWFLL) and it is dedicated to the creation of a comprehensive, intelligent decision-making framework that will enable the effective management of water resources in the presence of unpredictable climate conditions. This entails the integration of cutting-edge technologies and strategies to guarantee sustainable water management in urban areas.

In December 2024, the first workshop for the Limassol Water Futures Living Lab (LWFLL) took place in the Limassol District Local Government Organization (EOAL) in Cyprus. The workshop focused on understanding the context and defining challenges in the EOAL. In the past one year, changes to the EOAL have been substantial, encompassing the establishment of new departments and divisions, the consolidation of services, the implementation of a new structure, the establishment of new tariffs, as well as licensing and building permits and the risk of financing new operations & maintaining new infrastructure. New employees are now required as the organization manages a greater number of areas and consumers within each department.

The challenges were mapped into four categories, namely, (a) the environmental, (b) the societal and policy, (c) the technical and organizational and (d) the financial challenges seeking to develop a problem statement that would entail all key challenges that EOAL is facing. Environmental challenges, including the securement of essential water supplies during climate change, the management of extreme weather events, flooding, fires, and extreme heating, and the treatment of effluent to safeguard subterranean water and the sea, leakages in the water pipes, as well as energy consumption and production are the primary obstacles encountered by EOAL. At the same time, the water quality and quantity are crucial for the survival of citizens, while the applying special pricing rates for livestock farmers and single parents are also a challenge.

Technical and organizational challenges include network leakages, hydroelectric energy generation, and the need for smart technology networks. Employee training and specialization are necessary, as well as the need for templates and data retrieval for reporting purposes. Stakeholder engagement on ESG and sustainability is also essential. Financial challenges include increased costs due to the leakages, need for imported water due to water scarcity, covering new operations with tariffs, and implementing new infrastructure projects. Fair tariff structures for all members of society are necessary, as is smart technology financing for all consumers. In conclusion, EOAL agreed that the underlying challenge that they face is the following: "*Make the organisation fully operational as soon as possible and secure the necessary funding, ensuring resilience, efficiency and human resources to serve the public and protect the environment".*

3. Discussion on the interconnection between experimental economics and living labs utilizing the LWFLL as a case study.

Effective and sustainable water resource management is imperative due to the growing pressure on global water resources, which includes over-exploitation, desertification, and pollution, as we have observed thus far. The efficacy of Integrated Water Resource Management (IWRM) approaches has been demonstrated through the integration of scientific input and economic methods. Nevertheless, it is essential to consider human factors and real-world decision-making in order to ensure the effective management of water resources. Living Labs (LLs) offer a co-creation venue for periodic stakeholder engagement, thereby bridging the gap between scientists and stakeholders. LLs facilitate the development of co-determined inputs by scientists and stakeholders during periodic meetings, which will provide qualitative insights on water management issues such as scarcity, demand, and supply. These insights can be further investigated using experimental economic methods.

Experimental economics employs controlled environments to offer evidence-based insights into the strategic interactions between individuals and groups and the decision-making processes of both individuals and groups. This method, however, may compromise external validity by failing to account for the disparity between laboratory environments and real-world scenarios. Field experiments can assist in bridging this divide by transitioning investigations from laboratory settings to more realistic environments. The study of how behavioral particularities affect society's value of resources and the environment, the understanding of how incentives and institutions affect decisions, and the resolution of group externalities and social dilemmas are three major groups of experiments related to the environment, particularly water resources. The discussion is dominated by three important questions when attempting to comprehend the shared ground between experimental economics and living labs.

a) *How can the participatory, real-world environment of living laboratories be incorporated into the controlled, hypothesis-driven nature of experimental economics?*
b) *In the design and implementation of living lab experiments, what is the significance of behavioural insights that are derived from experimental economics?*
c) *How can these two approaches be merged under one framework?*

3.1. Improving Experimental Economics using the Living Labs approach

The incorporation of living laboratories into experimental economics unites two distinct yet complementary methodologies: the former concentrates on user-driven innovation in real-world settings, while the latter prioritises controlled environments to evaluate economic behaviour and theory. Although these two frameworks operate under distinct methodological assumptions, they can complement one another by establishing robust mechanisms for comprehending human behaviour and innovation processes in real-world applications.

Economic experiments test hypotheses, investigate phenomena, and support policy-making. However, skepticism about external validity, often known as their relevance to the actual world, has hindered the acceptance of experimental economics as a scientific discipline. Some economists view experimental anomalies as evidence of flawed theories, while others argue for their applicability (Guala & Mittone 2005; Kessler & Vesterlund 2015). Living Labs are able to overcome this gap by integrating experiments into everyday life. Living labs are situated in intricate, real-world settings that involve a variety of stakeholders, including citizens, businesses, and governments. Their primary objectives are to facilitate co-creation, experimentation, and iteration. They are frequently designed to evaluate solutions to societal challenges and are highly participatory (Schuurman 2015). In this context, the complexity and unpredictability of external influences pose a challenge. The potential synergy is presented by the integration of the participatory, real-world nature of living laboratories with the experimental control of economics. This enables researchers to test economic models under real-world limitations, such as the fluctuation of the environment and the complexity of government. For instance, in the LWFLL, we see that an Integrated Water Resource Management tool should address challenges such as network leakages, installation of smart meters and investments in green energy. Using these insights, we investigate "How do different pricing mechanisms and loss-reduction incentives affect consumer and utility behavior in reducing water network leakages?" or "Does real-time water consumption feedback from smart meters influence household water usage, and how do financial incentives shape adoption rates?" using field and lab experiments. Using the Living Lab as a testbed, researchers could for example, use smart meters to examine genuine responses to water pricing, rather of investigating behavioral responses to water tariffs in an artificial context.

Laboratory-based research that rigorously regulates variables in order to identify causal relationships is the foundation of experimental economics. In this discipline, experiments are frequently incentive-compatible, meaning that participants are motivated by genuine monetary rewards to ensure that their responses are accurate, and their behaviour is realistic (Smith 2003). Researchers are able to form precise inferences in the controlled environment, but these conclusions may not always be pertinent to real-world behaviour due to external factors that are not taken into account in the laboratory. For example, a water utility planning to test different water pricing options and energy use plans would usually assign residences to different pricing structures at random. They would track how much energy and water is used and offer rewards to encourage consumers to participate. This method, however, is constrained by a lack of stakeholder engagement, a lack of real-world feasibility, and policy implementation gaps. The water utility and researchers involve stakeholders prior to, during, and following the experiment in order to improve it. The approach involves real-time feedback, policy adjustments, collaborative experimental conditions selection, surveys, and workshops. Consumers provide feedback through focus groups, while businesses and policymakers examine water pricing's impact on energy consumption. This dynamic approach makes policies more adaptable, prioritizing effective tariff structures for scaling up.

Another RCT could focus on social comparison interventions (Allcott 2011), where households receive feedback about their water use compared to their neighbors. Such interventions might be tested in conjunction with financial incentives or social recognition strategies to determine which is more effective in promoting long-term behavioral change. The use of smart meters would facilitate the collection of granular, real-time data on household water consumption, enabling researchers to assess the impact of different treatments over time (Cominola et al. 2021). This method is capable of bridging the divide between economic experiments and real-world decision-making by increasing consumer trust and the likelihood of policy adoption.

3.2. Enhancing Living labs using Experimental Economics

The second research question is intended to investigate the extent to which the insights gleaned from behavioral experiments—such as decision-making processes, incentives, and market dynamics—can be used to inform the design of experiments in living laboratories that are intended to assess new technologies or policies in real-world settings. Experimental economics offers invaluable behavioral insights, such as the understanding of bounded rationality, social preferences, and the influence of incentives, that are essential for the creation of living lab interventions. A critical component of integration is the adaptation of experimental economics' methodological tools to the real-world complexity of living laboratories. This entails the development of experiments that uphold scientific rigour while also acknowledging the participatory and iterative character of living laboratories. The utilisation of randomised controlled trials (RCTs) within living laboratories is one emerging solution (Banerjee & Duflo 2012). For example, the manner in which collective action issues are dealt with in living laboratories, particularly in water efficiency initiatives or urban planning, could be influenced by research on public goods games (Fehr & Gächter 2000).

Living Labs can be enriched by controlled economic experiments in a real-world setting. For example, LWFLL could employ economic tools, such as Randomized controlled trials (RCTs) to evaluate various tariff structures and subsidy models for vulnerable communities; choice experiments (CE) to evaluate the preferences of farmers and citizens regarding conservation incentives and water pricing; and behavioral experiments to measure the efficacy of nudges in reducing water consumption. Technological advancements, particularly the use of smart meters and Internet of Things (IoT) devices, provide new opportunities for integrating real-time feedback into water conservation experiments in living labs. These technologies can enable continuous monitoring and instant feedback, offering households real-time information on their water use relative to set benchmarks or previous usage.

Researchers can monitor consumption, economic efficiency, and public acceptability by randomly assigning residences in Limassol to various water pricing models or by exploring whether providing feedback on a daily basis, compared to weekly or monthly, leads to greater reductions in water consumption. Furthermore, time-of-use pricing models, where water rates fluctuate depending on peak demand hours, could be tested using IoT devices that monitor water consumption in real-time (Goette et al., 2019). By combining these technological innovations with the theoretical foundations of experimental economics, it becomes possible to test the efficacy of price-based and non-price-based interventions in naturalistic settings (Cominola et al., 2021).

In addition, experimental economics tools, such as an RCT, can be employed to simulate virtual water markets, where farmers, households, and industries compete for water resources according to distinct allocation regulations based on real-time availability. This RCT with a virtual water market could address questions such as "*Do scarcity-based price signals lead to reduced consumption?*", "*Does a market-based system allocate water more effectively than fixed tariffs?*", "*Do increasing block tariffs protect low-income users from excessive pricing?"* or "*Could this virtual model inform real-world tariff design and policy decisions?*". These results can be then fed into the Living Lab workshops to provide answers to qualitative questions, such as "*How do different water users perceive the fairness and effectiveness of various pricing mechanisms*?". In the LWFLL, researchers would investigate whether participants believed that pricing adjustments were equitable and whether the market-based trading system benefited or harmed specific demographics or would seek to identify factors that contribute to social resistance or acceptance that quantitative data alone is unable to capture.

3.3. A Framework for integration: The Experimental Economics-Living Lab loop

Both Living Labs and economic experiments seem to be associated with some inherent challenges, e.g., presence of confounding variables that could obscure causal relationships or lack of external validity. To address these methodological challenges, a new interdisciplinary approach has come to light, the Experimental Economics-Living Lab loop, which aims at bringing together key characteristics of these two approaches. For instance, using these two approaches, the LWFLL case study can convert water management into a data-driven, collaborative process. This integration guarantees that water policies are economically efficient and socially acceptable, while enabling stakeholders to participate in decision-making.

Initially, it is necessary to identify the primary environmental, societal, policy, technological, and financial obstacles associated with water management (e.g., pricing, network leakages, water security, or energy efficiency) by consulting with the local authority responsible for water supply and distribution. Social scientists will conduct a comprehensive stakeholder mapping to identify participants who are either impacted by or influence these challenges. This will be done using the results obtained. In parallel, economists would identify the research questions related to these challenges, such as "Will customers decrease water usage upon receiving real-time consumption data?" and determine causal processes (e.g., price elasticity, sense of fairness) using an RCT or a CE.

While laboratory experiments in economics offer high internal validity, their external validity often suffers due to artificial settings (Galizzi & Navarro-Martinez, 2019). To address these issues, researchers can adopt quasi-experimental methods, such as difference-in-differences (DiD) and propensity score matching (PSM), which allow for more rigorous control over confounding variables in non-randomized settings. For instance, aiming to study the Integrated Water Resource Management (IWRM), the LL approach could involve multiple stakeholders, including government agencies, researchers, businesses, and citizens to discuss and test the feasibility of the indicated economic and environmental assets related to water consumption, such as nature-based solutions for flood management and pollution control, using smart sensors, precision irrigation, organic fertilizers, and green infrastructure, as well the practical constraints (e.g., regulatory restrictions on tariff modifications). The results on water quality, reduced nitrate runoff, and reduced urban flood risks could be then used as attributes for the development of an RCT or another economic experiment to compare the impact of different incentive structures (e.g., financial rewards versus social recognition) on consumer behaviour and develop pricing models that will accurately capture the consumers' preferences.

DiD can be applied in water management experiments to compare consumption patterns across communities before and after a policy intervention, controlling for external factors that might otherwise distort the results. Similarly, PSM can be used to match communities or households based on key observable characteristics (e.g., socioeconomic status, baseline water consumption), thus reducing bias in the analysis (Levitt & List, 2009). The implementation of the experiment in the Living Lab allows researchers to collect both qualitative feedback (e.g., perceptions of fairness) and quantitative data (e.g., on water preferences related to water and energy use or the optimal water structures and tariffs). The advantage of this method is adaptability, as the experiment can be adjusted in real-time to ensure greater stakeholder acceptability in the event of resistance (e.g., low adoption of dynamic pricing). This approach can be iterated and scaled by transforming the results of the LLs into policy briefings for policymakers, collaborating with local governments to implement effective initiatives on a broader scale, amplifying the most effective treatments (e.g., green energy-associated pricing for water utilities) and following-up with experiments to test policy adjustments. This inquiry pertains to the potential of living labs to bridge the gap between theoretical economic experiments and practical, scalable solutions by testing economic models and behavioural theories in more complex, real-world environments where multiple variables are at play.

3.4. Obstacles and Prospects

An often-overlooked aspect of living labs is the unequal distribution of power among stakeholders, particularly in contexts involving large institutions such as governments or corporations, whose interests may not always align with those of local communities. Power asymmetries can lead to disproportionate influence by certain stakeholders, undermining the collaborative ideals of living labs (Hermans et al. 2006).

One way to address these imbalances is through the design of common-pool resource (CPR) experiments within living labs, where different governance structures can be tested to assess their impact on water management. For instance, randomized trials could assign different governance mechanisms (e.g., top-down versus bottom-up) to various communities, measuring the effectiveness of each in terms of water conservation and resource allocation (Cardenas et al., 2000). By giving equal decision-making power to traditionally marginalized groups, such as smallholder farmers or low-income households, the experiments could provide valuable insights into the role of governance in achieving sustainable water management outcomes.

The integration of experimental economics into living laboratories presents inherent challenges. One obstacle is the loss of experimental control in a real-world environment, where a multitude of confounding variables may influence behaviour. Researchers must strike a balance between the chaos of real-world environments and the desire for rigorous causal inference. Nevertheless, this presents an opportunity to enhance economic models by incorporating these intricacies. Furthermore, the significance of ethical considerations is heightened when experiments are transferred from laboratory to real-world environments. The participatory nature of living laboratories necessitates that stakeholders remain involved in the process, and transparency regarding experimental objectives is essential for preserving trust. In addition, some studies argue that the evidence is not currently sufficient to justify the effectiveness of the LLs in terms of promotion of innovation (Paskaleva & Cooper 2021), which can be surpassed by those who provide funding for LLs to demand to evaluate their performance and assess their outcomes/impacts.

4. Conclusions

Effective and sustainable water resource management is imperative due to the growing pressure on global water resources, which includes over-exploitation, desertification, and pollution. The efficacy of Integrated Water Resource Management (IWRM) approaches has been demonstrated through the integration of scientific input and economic methods. Nevertheless, it is essential to consider human factors and real-world decision-making in order to ensure the effective management of water resources. Living Labs (LLs) offer a co-creation venue for periodic stakeholder engagement, thereby bridging the divide between scientists and stakeholders. LLs facilitate the development of co-determined inputs by scientists and stakeholders during periodic meetings, which will provide qualitative insights on water management issues such as scarcity, demand, and supply. These insights can be further investigated using experimental economic methods. Experimental economics employs controlled environments to offer evidence-based insights into the strategic interactions between individuals and groups and the decision-making processes of both individuals and groups. This method, however, may compromise external validity by failing to account for the disparity between laboratory environments and real-world scenarios. Field experiments can assist in bridging this divide by transitioning investigations from laboratory settings to more genuine environments. The study of how behavioural particularities affect society's value of resources and the environment, the understanding of how incentives and institutions affect decisions, and the resolution of group externalities and social dilemmas are three major groups of experiments related to the environment, particularly water resources.

This paper explores three main questions, the application of experimental economics in living laboratories, where stakeholders actively co-create solutions, the integration of experimental economics with living labs presents a potential synergy, allowing researchers to develop field experiments or natural experiments to evaluate specific behavioral hypotheses and the ways in which living laboratories and economic experiments can be merged under one unified framework. The Experimental Economics-Living Lab Loop integrates collaborative decision-making with data-driven experiments to guarantee that policies are both economically efficient and socially viable. Living Labs are able to ensure adaptive, evidence-based decision-making by bridging the distance between theoretical experiments and real-world, scalable policies as a result of this integration, while experimental economics provide valuable insights into market dynamics, incentives, and decision-making, which are used to inform the development of Living Lab interventions. In the case of LWFLL, tariff structures, conservation incentives, and behavioral nudges related to water consumption can be tested through RCTs and Choice Experiments (CEs) allowing dynamic pricing models to accurately depict economic and environmental assets associated with water consumption.

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