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The Social Return Potential of Micro Hydropower in Water Networks Based on Demonstrator Examples

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Abstract: Micro hydropower (MHP) provides a viable renewable energy solution from which individuals, organisations and communities can also derive social value and benefits. Desk studies and literature reviews show limited studies that (a) quantify the social impact of MHPs in water networks and (b), establish evaluation methods for such analysis. To date, most studies relating to MHP projects have focused on physical and technological parameters, as well as cost and environmental factors that influence their design, installation, operation, and maintenance. Less attention has been given to the intangible social, political, and institutional considerations, which are also important for the acceptability and adoption of renewables such as MHPs, and for their performative longevity. This study addresses these gaps. The social return on investment (SROI) method was used as the basis to quantify the cost and social returns of three MHP demonstrators in a public and private water supply, and irrigation network in Europe. The value inputs and outputs from each case were analysed and a SROI range of between 2.6 and 5.8 euros for each one euro invested was determined. The findings were further evaluated using sensitivity tests. This work serves as a useful first step to establishing a SROI benchmark range for MHP schemes in water networks, extrapolatable for other renewable energy interventions. They also highlight the opportunities and challenges of quantifying and forecasting the social returns of MHPs to guide future work.

Keywords: hydropower; social return on investment; water distribution network; irrigation network; river flow

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1. Introduction

Hydropower refers to energy derived from the flow of water [1]. The derived mechanical energy is in turn used to produce electricity [2]. There is no internationally accepted definition for small hydropower (MHP), but here, the term is used for energy less than 100 kW [3]. Sub-sets of this are pico hydropower (PHP) which includes rated energy of less than 5 kW and micro hydropower (MHP) generates energy between 5 and 100 kW. MHP technology has applications in both open channels e.g., river, or in pipes [4,5].

MHPs in certain scenarios and contexts offer a practical, technical, and economically viable means to deliver accessible and affordable renewable energy [6]. Benefits for deployment start with offsetting the energy consumption that is required to operate water services, estimated to be 4% of global energy consumption [7]. It also works to reduce water pressure in the system, which in turn reduces leakages in the water network [8]. MHP studies have predominantly focused on energy recovery potential and the underlying cost-benefit argument [9,10]. Previous researchers [7,11–14] found that MHPs in water and irrigation networks generate enough electricity to be economically viable. Garcia et al., and Fabiani et al. [11,14] also demonstrated the carbon off-set benefits. Other studies, e.g., [15,16] investigated the energy generating potential to inform the design of MHPs in water networks and found that success criteria to include the right physical conditions (i.e., head and flow), the right technology, the necessary technical skills to construct, operate and maintain this type of installation, and the right finance and market conditions [17]. The technical feasibility and reliability of the MHP systems, their cost and social impact, e.g., [18]. A similar analysis to demonstrate technical viability was undertaken for the demonstrators in this study [19] in addition to exploring the acceptance and acceptability [18,20], the economic viability, the policy, social, or institutional acceptability and impact [20], and the technical potential and their benefits as social infrastructure, or social enterprises [21].

The social, institutional, economic, and political factors have increasingly been shown to be important indicators in an assessment of a MHP scheme's performance before and after its installation [15]. Thus, new investment assessment pathways such as the Environmental, Social and Governance (ESG) investment pathways now include non-technical considerations in the viability of renewable schemes such as MHP [20,22]. MHPs also align with existing financial structures for lending [23] and they can be financed through existing EU green finance frameworks and taxonomy (EU Taxonomy Climate Delegated Act 2020; Regulation (EU) 2020/852). In many cases, investments in MHPs are typically undertaken by municipalities or local authorities, small or medium-sized enterprise (SME), and organisations such as manufacturing, agricultural or household entities. Scope for financing may be limited in these cases. Although MHPs fall within the taxonomy criteria, they currently do not meet green finance thresholds. As such, entities planning to adopt these renewable technologies often rely on opportunities for cost-offsets and rebates (e.g., feed-in-tariffs) rather than wholesale financing or borrowing [24]. This further emphasises the need for a broader base of tangible and non-tangible value metrics for the assessment and evaluation of renewable schemes such as MHPs.

Background and Research Gap

Energy contributes to economic development, social progress, and human welfare [25]. Access to clean and affordable energy is universally recognised, including in the sustainable development goals, to help reduce energy poverty, contribute to health, job creation, economic empowerment, income generation, and other equity objectives [26–28]. Renewable technologies such as MHPs serve as social infrastructure, in a similar manner to providing necessary infrastructure in society, e.g., health services, schools, or roads [29]. It can also support social enterprises used to secure livelihoods and small profit-making businesses [16]. MHPs can help overcome the global gap in energy access which exists for many poor communities and rural areas who continue to have limited or no access to this form of clean energy sources [30]. Energy costs disproportionally affect the poor and perpetuate the gap between groups of society, as well as between and within countries. However, the current capacities and exploitation of MHP still differ across EU member states [3]. Although the use of renewable energy sources has increased in recent times, its financial efficacy among other factors limits the extent to which they can significantly replace unsustainable energy sources such as fossil fuels [31].

Technology acceptance defines the behavior towards energy technologies and acceptability is the attitude which drives the uptake of new technologies ([32], p. 526). It is increasingly apparent that improving the acceptance and acceptability levels of renewable technologies need to consider non-financial indicators such as social value in addition to the economic and environmental benefit. However, this requires a two-pronged approach. This was synthesised by Zaunbrecher et al. [33] who on one hand argued the need for ecologically and socially accepted energy supply scenarios, and on the other, advocated a methodological bridge and a multi-faceted evaluation approach to address acceptance and acceptability. The first was addressed for instance by Kastner and Matthies [34] who identified that external and internal factors interact to determine investment in renewables. These external factors include perceived financial costs and benefits, reliability of the system or technology, environmental benefits and social support and values. A study by the authors of [20] found similar push and pull factors for the acceptability of MHPs, affirming that beyond technical and ecological factors, the market, institutional and policy context, cost and financial benefits, social support and collaborative services combine to influence the adoption of MHP technology. The outcome was a socio-technical conceptual framework for the adoption of MHPs.

Secondly, methods already exist to evaluate the financial feasibility of renewable technologies. The cost-benefit analysis (CBA) or return on investment (ROI) approaches are the most widely accepted. Others include the cost of energy method (COE), the lifecycle costing method (LCC), and the levelised costs of energy method (LCOE) [35]. These techniques are underpinned by the net present value calculation of the discounted cash flows generated from the project over the life of the project. They do not account for other potential sources of value such as climate impact mitigation and adaptation, improving sustainability and reducing carbon footprints, protecting resources and ecosystems, and notably deriving social value. Signposting the quantifiable social impact of renewables is particularly important where technical acumen is low, and financial capacity is weak, e.g., in rural communities, social enterprise and other projects driven by public good, e.g., [36]. This has driven the call for evaluation methods that include the intangible as well as tangible, economic, and social indicators.

Watson and Whitley [37] stated that the SROI is the most developed method for this combined approach. They compared SROI with other social impact methods, e.g., the social enterprise balanced scorecard (BSC), the ongoing assessment of social impacts (OASIS), and social accounting and auditing (SAA). They found that SROI is the only tool that satisfies Weinstein and Bradburd's [38] four tests: (a) measuring outcomes rather than tracking outputs (i.e., the number of end users), (b) the ability to compare the value of different types of benefits, (c) the consideration of counterfactual evidence (other factors) in impact creation, and (d) usefulness of effective and coherent funding decisions. SROI accounts for investments and enables a consideration of multi-stakeholder value streams as well as the time scales of the impact. Most approaches measure in their "native" units, but SROI can more closely relate to direct program goals [39]. Therefore, an SROI analysis was applied in this project as it has the potential to improve the evaluation and, thus, the social performance of interventions in line with organisational expectations [40].

SROI has already been utilised in multiple sectors in the US, EU, and UK. However, desk studies and a search of the literature only found studies by Mitsumori et al. [41–44], which used SROI to specifically quantify the social impact of MHPs for cases in Japan. Therefore, there remains a global gap in scaling up the use of SROIs in MHP projects. Further, despite the extensive academic studies on the technical, environmental, and financial viability of MHPs, there also remains a gap in studies that evidence the social value and impact of MHPs especially in demonstrator projects or projects where financial gain is not the key driver.

The aim of this study is to address these research gaps by (a) investigating and quantifying the social impact of MHP demonstrator projects, and (b) investigating whether SROIs provide a viable means to quantifying social value in MHP projects. Case studies in Europe are used to compare the cost and social investment returns of three MHP demonstrators—public and private water supply, and irrigation in Europe. Although the study is limited to demonstrator projects, the findings:

- Extend the theoretical and practical knowledge on quantifying the social impact of MHPs as the first step towards establishing a benchmark social return range for MHPs in water networks;
- Demonstrate a viable methodology for evaluating the tangible as well as the intangible benefits of MHPs. If successful, the resulting SROI ratio will simplify the indicative social value that can be derived in the immediate periods of a MHP installation represented;
- Contribute a simplified approach with which the acceptance and the acceptability of MHPs can be promoted. A SROI range, rather than a fixed value can support decision making, on the balance that some value will increase, while others will decrease over time;

- Enumerate the opportunities and challenges of quantifying and forecasting the potential social returns which can be scaled up to similar MHP installations.

2. Materials and Methods

The choice of evaluation approach was based on what to measure, how to measure, by whom and for what? (Figure 1). Measuring social impact serves to determine whether an investment is delivering social results and to what extent the results are significant. Institutions and organisations that have this information available to them are in a better position to address resource efficiency through implementing adaptation measures to ensure desirable outcomes [45].

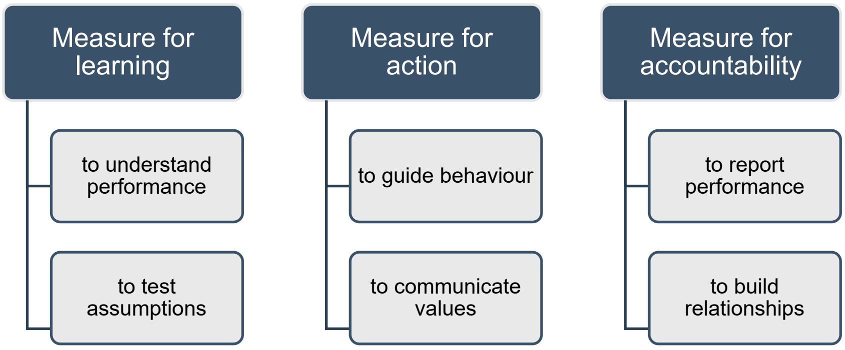

Figure 1. Purposes of Measurement [46].

The SROI method was applied using an evaluative case study approach. SROI combines methods such as the Cost Benefit Analysis (CBA), Opportunity Cost Analysis, and Impact Assessment methods (Table 1) to achieve a singular, holistic outcome. It attempts to address the limitations in conventional social quantification approaches by 'adding 'social' benefits while arriving at ROI' [47]. It ascribes monetary value to both tangible and intangible social, environmental, and financial outcomes.

SROI served two purposes in this study: (a) to evaluate and measure the social impact of MHPs in water networks; and consequently (b) determine the ease and efficacy of SROI to estimate the social impact of future MHP schemes from the early design stages. The SROI analysis was conducted in the following stages *after* [48–50]:

1. Define the scope/field of analysis and identify key stakeholders: Clear SROI analysis boundaries help to define the involved stakeholder groups and their role;
2. Map potential impact and outcomes with stakeholder involvement: This task was necessary to demonstrate the links between inputs, outputs, and outcomes. This activity was undertaken with the stakeholders;
3. Gather evidence of the outcomes and assign a value (or proxy value): As predicted by the authors of [51], this stage was protracted due to the complexity of sourcing data to determine if outcomes had occurred prior to assigning a monetary value. Information was not always readily available, was in different languages, or in disparate, unsignposted documentary sources and databases. Data from the Eurostat databases (e.g., [52]) and the European Emission Allowances (EUA)-EEX website were used to validate the data found online or provided by stakeholders;
4. Calculate the impact and eliminate redundant/deadweight effects. This calculation goes through four steps to reduce the risk of overestimation [50,53]: the Deadweight estimation represents the outcomes that would have occurred if the activity had not taken place. The relationship between deadweight and outcome is reverse, as a decrease in outcomes is due to an increase in deadweight. The Displacement estimation, also known as the substitution effect, represents the negative and unforeseen elements overlapping positive elements that already existed. The Attribution estimation based on the proportion of the outcome is associated with other organisations. The Depreciation estimation represents the reduction in the impact across time, i.e., drop-off;

5. SROI ratio calculation: This step involves adding up all the benefits, subtracting any negatives, and comparing the result against the initial investment. The sensitivity of the ratio was then evaluated.

Table 1. Research design (after: [54]).

Stages	Aim	Method
Knowledge, methods, and stakeholders	Background on social value and impact, measurement methods and financial proxies	Literature review
	Identification of pilot sites	Sampling
	Identification of stakeholders	Survey, Mapping
Data Collection	Definition of the change areas and social impact	Stakeholder consultation, Survey, Interviews
	Quantification of inputs	Determining the financial and non-financial investments
	Quantification of benefits	Stakeholder consultation, Survey, Interviews
Data Analysis	Cost analysis and determination of non-monetised inputs and redundancies (Deadweight)	Monetary and non-monetary cost attribution and analysis
	Quantification of the change and benefits per annum	Application of proxies to results
SROI analysis	SROI ratios	Application of SROI formula (adapted from Social Value UK)

2.1. Sampling

Purposive sampling of demonstrator projects was based on three selection criteria: (a) sector/organisation; (b) geographical location; and (c) size/scale:

- Sector/organisations: Representing domestic, public and irrigation water sectors. The public site in France was implemented and managed by a water company. The purpose of the site was to generate energy within the network and to provide public mobile phone charging points. The driver was to increase the water companies' visibility and image and raise awareness of their use of sustainable renewable energy production using MHPs. The agricultural site in Spain produced energy for irrigation especially during the summer months. The domestic site in the UK generated energy for personal use as well as to provide power to up to 120 houses in the rural area.
- Geographic location: The sites were sited in Andalucía, Spain; Normandy, France; and Wiltshire, UK.
- Size: The sample represents small, medium, and large-scale installations and applications. The different sizes and scales provided the opportunity to study the technical, economic, and social returns—the latter being the focus of this report.

The represented sample does not cover all possible MHP sites, contexts, or scenarios in EU regions. However, the approach is consistent with an in-depth pilot study methodological approach with which the social impact of MHPs can be evaluated and the limitations for potential replicability identified. The sites are summarised in Table 2.

French demonstration plant: The French demonstrator was implemented in two places. The first MHP installation was located at a node within a water distribution network. There were no additional land or building requirements. This was a 7-kW system with an initial estimation of generating 51 MWh per annum, operating at up to 20 h per day. However, it operated for 14 h per day resulting in approximately 80 kWh per day. It accounted for less than 1% of the energy demand for production for the water utility. However, similar to all the cases in this study, it served as a demonstrator for how PATs in MHPs can work in such systems. Maintenance of the system was not expected during the first 3–5 years and would be dependent on the durability of the equipment, e.g., pumps. According to one of the company's directors: "This plant is an innovation target, communication target, green target (although no green points). It is more about communication and certification ISO 14001—environmental impact. It contributes to compliance with environmental regulations, greater marketability, better use of resources, higher quality goods and services, increased levels of safety, improved image, and increased profits. We are a public company—so we must be seen to be innovating to create a better place for the future". The second system was installed at a node near a bus stop to provide mobile phone charging capacity for the public. This is a smaller 1 kW PHP system to serve 2–4 5 V charging points for mobile phones and other small devices. At the time, the population of the town was 13,175 people. Approximately, 1151 students attend the only high school in the area and use the bus stop every day. Therefore, this demonstrator showcased the technology and provide a useful and free social service.

Table 2. Demonstrator sites in this study.

Geographical Location	**France**		**Spain**	**UK**
	Water Network	**Public Charging Points**		
Municipal level	Yes	No. Community level	No	No
Organisation/sector	Public water treatment	Water network/energy supply/local services	Private farm	Private owner
MHP scheme age	New	New	New	15 years
Turbine type	PAT	Specialised turbine, not PAT	PAT	Kaplan turbine
Head (m)	10 m	1–2 m	10.1 m	2.5 m
Flow (L/s)	94.4 L/s	4.17 L/s	14.1 L/s	330 L/s (min. river flow)
Power (kW)	7 kW	1 kW	4 kW	55 kW
Evaluation period	0–5 years	0–5 years	0–5 years	0–12 years
Associated water processes, e.g., cleaning, irrigation	Inlet to water treatment plant	None except for monitoring	Irrigation	Fishing, natural river flow
Productive end-uses, e.g., lighting, pumping	Self-consumption for pumping system	Mobile phone charging; sending data for network monitoring	Irrigation	Electricity for self and grid consumption
MHP output consumption	Direct	Indirect	Direct	Direct and indirect
Previous/other renewable energy schemes	No	No	No	Ground source heat pumps
Other purposes, e.g., Awareness and promotion	Yes	Yes	Yes	Yes. Including knowledge, awareness, and training
Costs (installation + materials)	EUR 43,453	EUR 21,940	EUR 30,000	EUR 32,976

Spanish demonstration plant: The Spanish demonstrator was implemented in a pressurised irrigation network in Andalusia. When installed, it produced energy for the entire irrigation season, supplying irrigation and fertilisation for about 300 hectares of farmland. The plant consisted of a hybrid solution of two back-up solar panels of 600 W, a 4 kW PAT, and a set of four batteries. The solar panels are used to maintain charge in the batteries during winter when no irrigation flow is occurring. The pico-hydro plant completely replaced the previously used 7 kilo-volt-amperes (kVA) diesel generator; about 2000 L of diesel consumption per annum is avoided. In addition, more than 9 tCO_2 and EUR 2400 were saved during the 2019 irrigation season [18]. Significant environmental, social, and economic benefits were thus achieved, eliminating greenhouse gas emissions and all the direct and indirect diesel generator costs. This is in addition to branding, marketing, and productivity value for the farm because of the renewable energy system.

UK demonstration plant: The UK project was a private MHP run-of-river system. It consisted of a hybrid solution of ground source heat pump (2011) and a 55 kW Kaplan turbine. This system was comparatively expensive compared to the more recent cases primarily due to the long process since its commissioning in 2007, and external costs associated with statutory compliance assessments required for such schemes, e.g., environmental impact studies, fish and wildlife impact studies, consultancy fees, etc. The system generates approximately 750 kWh per day of which 85% is fed into the grid, serving 80–120 houses in the immediate rural area. It offsets 1.74 years of the emissions attributable to the system and the building.

2.2. Data Collection and Analysis

The stakeholders were broadly categorised as policymakers and facilitators, e.g., government and non-government agencies; finance providers, e.g., grant awarding, and aid agencies; owners and managers, e.g., utilities and municipalities; knowledge and technical support providers and end-users. The data collection included structured and informal interviews, e.g., during site-visits held with the owners/managers and knowledge/technical support providers for the project. The lead implementer(s) for each demonstration site also undertook the mapping exercise and completed a self-reporting survey/checklist used to capture their direct and indirect inputs/costs, outputs, and benefits of the MHP intervention. They were asked to map the inputs, outputs, and benefits against the different user and stakeholder groups. In addition, they mapped and provided the numerical attribution to the perceived benefit, the duration, and the impact of the change. Interviews were also held with the stakeholders to further clarify the perceived socio-economic benefits of the MHP installations and to validate the information provided in the surveys.

Where direct costs were not available, a cost/financial proxy was utilised to achieve comparative values in and across the cases. The assumptions made in the economic model, related to the time taken, the outcomes, and monetary value on those outcomes, crucially impacts the results [48]. In these cases, the proxy values were determined from company records, a literature review, as well as a range of national and European statistics and value databases. Proxy data were not available for all demonstration sites, or for all the instances of analysis. Therefore, EU-wide or country specific data were used as proxy of proxies where no specific case study proxies were found (e.g., [55]).

Although the demonstration sites were in different sectors and of different scales, it was essential that the measures used were comparable. Therefore, the value of the MHP interventions was calculated against the following criteria for each site:

- The average levelised cost of electricity of MHPs (e.g., [56]) consisting of installed capital cost, i.e., cost of materials, equipment expertise and labour as provided by the installer; economic life; capacity factor; operation and maintenance costs and the cost of capital;
- Cost, e.g., including where relevant, associated costs, e.g., land value on which the installation is situated, or cost/rent per square meter. Provided by the owner and validated against market benchmarks and official figures, e.g., UK Land Value Estimates for Policy Appraisal [57];
- Productivity costs—cost of disruption during installation, commissioning and servicing, cost incurred for staff training, management, and administration loss of income from designated land, e.g., less land for agricultural land, new or loss of jobs and associated salaries, etc. Estimated annual wage figures including associated contributions were provided by the owners and validated against national wage benchmarks (e.g., Eurostat Wages and Labour costs [58]).
- Valuation of in-kind contributions, e.g., existing equipment, publicity, and dissemination events, e.g., the EU Energy Day held at the Spanish demonstration plant during June/July 2019.

Estimating Financial and Social Return on Investment

The financial cost-benefit or ROI calculations were as follows [11,12]. Actual cost of PAT-based MHP devices were used. Cost could also be estimated as shown in [20]. The financial feasibility that underpinned the SROI was conducted using Equations (1)–(3):

$$\text{Net present value NPV} = -\text{TC} + \sum\nolimits_{t=1}^{L} \frac{\text{TSt}}{(1+\text{r})\text{t}} \quad (1)$$

$$\text{Payback (years)} = \frac{\text{installed cost (EUR)} - \text{ Rebate or incentives (EUR)}}{\text{TSt}(\frac{\text{EUR}}{\text{yr}})} \quad (2)$$

$$\text{Levelised cost of energy (EUR/kWh)} = \frac{\text{TC (EUR)} + \text{O\&M}\left(\frac{\text{EUR}}{\text{yr}}\right)}{\text{TSt}(\frac{\text{EUR}}{\text{yr}})} \quad (3)$$

where:

TC = Total cost

TSt = Annual energy savings (EUR/yr) = Annual energy output × Price (EUR/kWh) − Ep − O&M

Annual energy output = (unit cost of electricity kWh × 24 × 365) × Price (EUR/kWh)

L = Number of periods (years).

r = discount rate @ 3 and 5%

O&M (EUR/yr) = 2% of Total installation cost = TC × 0.02

Ep = depreciation = 1% of Total installation cost = TC × 0.01

The SROI measures the monetary value of social benefits relative to the cost to achieve the benefits. For example, a SROI ratio of 2:1 refers to the estimated social value of EUR 2 for every EUR 1 invested. The SROI formula is as follows:

$$\sum_{k=1}^{n}\left(\begin{array}{c}\text{Quantified}\\ \text{outcome} \times \text{Financial}\\ \text{proxy}\end{array}\right) \times \frac{1}{1-\text{DeadW}} \times \frac{1}{1-\text{Attr}} \times \frac{1}{1-\text{Displ}} \times \frac{1}{1-\text{Depr}} \times \frac{1}{(1+\text{i})^{\text{k}}} \quad (4)$$

where:

n = the number of years

i = the discount rate.

DeadW = Deadweight estimation; Attr = The Attribution estimation; Displ = The Displacement estimation and Depr = The Depreciation estimation are all previously defined.

As the cases were for demonstrator projects, the SROI ratio [44] was assessed for the initial period of 5 years:

$$\text{SROI} = \frac{\text{Net present value of social gain/outcomes}}{\text{Net present value of inputs (Investments)}} \quad (5)$$

$$\text{Net present value (NPV)} = \text{FV (Total present value } - \text{Investment)} \times \frac{1}{(1+\text{r})^{\text{t}}} \quad (6)$$

where:

t = the number of years

r = the discount rate at 3%, 7% and 10%.

FV = Future value based on discount rate and number of years

3. Results

The findings of the SROI analyses for each demonstrator project are presented in this section. The maximum duration for SROI analysis was five years (as recommended in the value map [48]) and the impact was discounted at 3%, 7%, and 10% (see Table 3 for comparison of discount rates). The discount rate was based on the Weighted Average Cost of Capital which represents the discount rate for calculating the Net Present Value (NPV).

This rate typically considers inflation, risk-free rate, and risk premium. The following sections present the findings for each demonstrator case.

Irrigation demonstrator in Spain: The results of the social impact evaluation of the Spanish demonstration case showed the net quantifiable investment was EUR 48,369, with direct financial investment from funder as circa EUR 30,000. The remainder were indirect costs attributed to staffing and costs associated with communication and dissemination and for enhancing the reputation and influence, e.g., CSR accruable from the deployment of such as innovation in this context. The discounted impact generated during 2019, the first year of the installation was approximately EUR 88,756. The age of the project and the lack of data and reliable proxies made some significant impacts unquantifiable. Challenges included quantifying the long-term impact of policy and community and other incremental change that would have occurred including through the significant awareness and engagement activities associated with the project. Based on a 3% discount rate (see Table 3), the investment is projected to generate value of approximately EUR 280,620 after five years, a NPV of EUR 232,251, and an SROI ratio of 5.8:1. Therefore, under similar scenarios, up to 6 euros of value could be created for every 1 euro invested in an MHP plant for irrigated agricultural land.

Table 3. Estimating SROI for the Spanish demonstrator. Cost impact estimates, quantity times, financial proxy, less deadweight, displacement, and attribution. All values to nearest Euros.

Stakeholders	Description	Outcomes. What Was Gained. How Changes Are Described	Proxy	Cost Impact
Farm owner/manager	Land cost/value	Reclaimed land from old diesel system for powering irrigation.	Value of the land per m^2.	1440
	Innovation	Renewable energy innovation to replace unsustainable energy source. Time/effort saved in undertaking tasks, improved productivity.	Man hours. Increased productivity.	21,600
	Reputation and influence	Brand gain from onsite renewable energy source. Free publicity and marketing. Increased reputational value for the farm.	Cumulative cost of promotion, marketing, and branding.	31,500
	Operational	Renewable energy gain.	Levelised cost of generated electricity.	1004
	Renewable energy	Decommissioning or limited use of diesel. Litres of diesel replaced per annum. Cleaner air. Decommissioning or limited use of diesel pump. Annual maintenance costs.	Cost savings from purchasing diesel. Annual cost savings of maintenance.	7450
		Energy offset from MHPs per annum, e.g., Surplus energy for security systems and lighting.	Cost of energy EUR per kWh.	1486
		Decommissioning diesel, tonne per CO_2 saved.	Commodities cost of CO_2.	221
		Environmental risk of spillage eliminated.	Cost of diesel spillage treatment products. Cost of fines.	14
	Human resources/capital and productivity	2 × staff training. Improved technical knowledge and expertise in MHP.	Cost savings of external consultants per annum.	150
		Improved efficiencies. Minimised disruption.	Offset training and consultancy costs. Offset planning and logistics costs.	1800
		Reduced risk of fire. Removing the diesel engine risks.	Cost savings per potential fire incidence. Cost savings for fire response or emergency services.	7251
			Cost per crop or production time lost to fire. Labour cost for reducing fire risks.	7439

Table 3. *Cont.*

Stakeholders	Description	Outcomes. What Was Gained. How Changes Are Described	Proxy	Cost Impact
Research grant providers and agencies	EU Funder	Demonstration efficacy of MHPs for the agricultural sector, knowledge, and capitalisation of technology.	Unquantified.	0
Change agents (local authorities, individuals, lay engineers)	Project academics and partners	Research knowledge and expertise. Dissemination and impact activities across Spain and the EU AA. Free articles in newspapers and media coverage.	Media impact value, i.e., cost invested versus engagement/impressions on outlets.	2500
Academic/research organisations	University and industry partners	Value of knowledge of system performance. Considering that water demand fluctuates throughout the year. Flow and pressure are variable. Value of knowledge and economics of MHPs. Value of knowledge gained from pilot plant. Value of knowledge gained from impact on irrigation and fertilisation activities. Value of knowledge of system performance.	Man hours.	4900
Community	Local irrigation organisations and community	Increased practical knowledge and awareness of MHPs. Access to local demonstration site.	Unquantified.	0.00
	Individuals/general public	Sustainably sourced food products. Reduced environmental impact of farming and irrigation.	Unquantified.	0.00
Govt authorities and agencies	Regional energy and hydraulic agencies. Local authorities	Improved awareness. Evidence to support decision making. Evidence to support guidelines, policy.	Unquantified.	0.00
Total input/investment	48,369		Total (discounted @ 3%).	88,756
			Total after 5 years (discounted @ 3%).	33,162
			Net Present Value (PV minus the investment).	232,251
			Social Return value per 1 EUR invested.	5.8

Public water utility in France: The results of the social impact evaluation of the French demonstration case showed the total quantifiable investment of EUR 28,103. The quantifiable direct cost of the MHP was approximately EUR 18,553. The remaining costs were attributed to staffing, costs associated with communication and dissemination, and for enhancing the reputation value of the innovation. A significant proportion of this cost was underwritten by the company. The discounted impact generated during 2019/20, the first year of the installation amounted to approximately EUR 44,601. However, it is worth noting that this value was grossly underestimated due to underwritten costs, the age of the project and lack of data and reliable proxies. These included quantifying the impact of the innovation on productivity and financial turnover, as well as the significant long-term impact of on the sector and policy, as well as other incremental change that would have occurred due to the significant publicity, dissemination, and engagement activities related to the project. The maximum duration for SROI analysis was five years and the initial impact was calculated at 3% (Table 4). Based on this discount rate, the investment generated an estimated value of EUR 280,620 after five years, an NPV of EUR 73,004 which produced a SROI ratio of 2.60:1. Therefore, under similar scenario, up to 3 euros of value could be created for every 1 euro invested in an MHP plant for water utilities.

Table 4. Estimating SROI for the French demonstrator. Cost impact estimates, quantity times, financial proxy, less deadweight, displacement, and attribution. All values to nearest Euros.

Stakeholders	Description	Outcomes. What Was Gained. How Changes Are Described	Proxy	Cost Impact
Owner/manager	Innovation	Immediate benefit of information activities within organisation.	Future benefit and time saved in energy issues.	2400
	Knowledge and awareness	Comparative knowledge before and after the pilot plant.	Knowledge increase from practical experience rather than paying for training or consultants.	*unquantified*
	Reputation and influence	Wider reputational influence with customers.	Company estimated organisational value derived from promotion and events including per delegate. This includes CSR and policy compliance (cost of non-compliance) value and other metrics.	65,772
	Power output from MHP to offset power use at the plant	Renewable energy gain.	Energy output per kw per annum.	3066
	Cost input for energy	Cost per kWh of energy.	Cost of energy per kWh saved per annum.	3373
	Environmental impact, CO_2 savings	CO_2 savings per kwh per annum.	Commodities cost of CO_2.	82
	ISO 14001, and other green certification	Benefit from green and other forms of certification.	Percentage financial benefit against annual turnover: Approx. EUR 5000 per million turnovers.	*Unquantified*
Research grant providers and agencies	EU funder	Demonstration efficacy of MHPs for the agricultural sector, knowledge, and capitalisation of technology.	*Unquantified*.	0
End users/Customers	Water costs for end users. Price savings for customers	Indirect savings per customer.	Approx. EUR 0.01 per year per customer.	4700
General public		Raising awareness in public places, e.g., bus stops of sustainability practices to serviced water customers in the region.	*Unquantified*.	0
Academic/research/ professional organisations	University and industry partners	Value of knowledge of system performance. Considering that water demand fluctuates throughout the year. Flow and pressure are variable. Value of knowledge and economics of MHPs. Value of knowledge gained from pilot plant. Value of knowledge gained from impact on irrigation and fertilisation activities. Value of knowledge of system performance.	*Unquantified*. Man hours. Delegates numbers at promotion and dissemination events.	0
Policy makers and facilitators	Environmental, energy and water policy makers and regulators	Awareness and implementation by government agencies and municipalities.	*Unquantified*.	
Total input/investment	71,793		Total (discounted @ 3%).	79,392
			Total after 5 years (discounted @ 3%).	9139
			Net Present Value (PV minus the investment).	117,359
			Social Return value per 1 EUR invested.	2.6

Private demonstrator in the United Kingdom: There are currently 1099 MHP schemes generating a total of 214.79 MW in the UK [59]. The majority of MHP schemes in the UK are initiated by individuals or communities [60]. As of July 2020, there are 59 schemes in the Northwest, 280 in Wales and THE West Midlands, 104 in the Southwest, and at least 215 schemes in the West Scotland and the Highlands. Based on an investigation of hydraulic head and flow characteristics in waterways in Scotland, 13,000 sites were considered as technically feasible for developing micro-hydro power, with a further 26,000 potential sites in England and Wales [61]. A 2019 example of a private scheme at a National Trust site in Wales by another EU project, Dŵr Uisce, utilised 4 kW PAT that is expected to generate about 19,000 kWh of electricity each year. The UK's Feed-in-Tariff scheme has since ceased to operate. Therefore, it is increasingly important that UK MHP schemes achieve other measures for value-for-money.

The results of the social impact evaluation of the UK demonstration case showed the total quantifiable investment of EUR 59,248 (of which EUR 32,976 is the direct MHP system cost if the MHP system cost alone was considered) (Table 5). However, this increased to EUR 301,952 if site and other compliance costs are considered (Table 6). This highlights the significant impact that the site and especially the policy context have on MHP project costs. The influence of context on the levelised cost of MHPs was also found. Other costs were attributable to staffing, primarily for repair and maintenance. The investment impact was valued at EUR 259,161 irrespective of the project cost. The maximum duration for SROI analysis was five years. The value of property and land, and the associated beneficiaries, e.g., in a community scheme is therefore a significant factor when valuing renewables, especially in the UK. Notably, there was an 11-fold increase in the value of land on which the MHP is situated. This had some impact on how properties and land were valued, to the benefit of property owners in the area. It also impacted on the SROI of this case. Without this, the SROI ratio would be estimated at 0.67:1 at the higher project cost, and 5.17:1 at the lower direct project cost. The former is a much less favourable social return for private MHP projects. However, this improved with lower site and compliance costs. The findings here are therefore conditional. Although policy factors significantly influence the viability, realisation, and cost of MHP projects in the UK, the extent to which projects such as this have directly influenced policy is not directly apparent. However, there were indirect benefits such as contributions to reductions in environmental impact, use of the facility for training, and access to the public for education and awareness.

Table 5. Estimating SROI for the UK demonstrator. Cost impact estimates, quantity times, financial proxy, less deadweight, displacement, and attribution. All values to nearest Euros.

Stakeholders	Description	Outcomes. What Was Gained. How Changes Are Described	Proxy	Cost Impact
Owner	Land	Increased value of land including designing the system to minimise impact on local ecology and for communal amenity.	Current value of land per m^2.	220,017
	Innovation	Input into policy and community committee and groups on the innovative use of renewables.	Man, hours contributed by owner.	4800
	Knowledge and awareness	Comparative knowledge before and after the plant.	Unquantified. Knowledge capacity to disseminate and train others.	0
	Resourcing. Reputation and influence	Local, renewable energy supply to at least 12 other houses in the immediate vicinity of the site.	Equivalent cost of domestic energy per kWh from grid and subsidies.	31,975
	Carbon savings and reduced environmental impact	t/CO_2. The conversion factor is 0.283 kg CO_2 saved for each kWh produced from a carbon free source.	Commodities cost of t/CO_2 for all units supplied.	2342
		Low-cost operation and maintenance cost of MHP.	Equivalent cost savings.	30

Table 5. *Cont.*

Stakeholders	Description	Outcomes. What Was Gained. How Changes Are Described	Proxy	Cost Impact
End users/Community	Knowledge and awareness	Awareness due to public access to visit the system and site.	*Unquantified.*	0
Government authorities and agencies	Improved awareness Evidence to support policy, and decision making Evidence to support practice	Improved knowledge and awareness from attending training sessions at the site.	*Unquantified.*	0
Non-Govt. Organisations	Knowledge, information sharing		*Unquantified.*	0
		1260 kw power generated. Calculated as carbon savings t/CO_2.	Commodities cost of t/CO_2.	0
Total input/ investment	301,952		Total value (Year 1) EUR.	259,161
			Estimated value (Year 5) (EUR).	207,184
			Net Present Value (PV minus the investment).	1,019,165
			Social Return value per 1 EUR invested.	4.4

Table 6. Sensitivity of the SROI results of the MHPMHP cases to discount rates.

Country	Sector	Investment Cost (EUR)	Discount Rate (%)	Total Present Value (EUR)	NPV (EUR)	SROI per Euro Invested (EUR)	SROI		
							Ave	St. Dev	Range
Spain (4 kW)	Irrigation	88,756	3 7 10	280,620 262,622 250,889	232,251 214,253 202,520	5.80 5.43 5.19	5.47	0.31	0.61
France (7 kW)	Public water utility	71,793	3 7 10	189,152 181,956 177,164	117,359 110,164 105,371	2.63 2.53 2.47	2.54	0.08	0.16
United Kingdom * (55 kW)	Private supply	301,952	3 7 10	1,321,117 1,213,919 1,144,545	1,019,165 911,967 842,593	4.38 4.02 3.79	4.06	0.30	0.59
		59,248	*3* *7* *10*	*186,590* *171,962* *162,488*	*150,471* *135,843* *126,368*	*5.17* *4.76* *4.50*	*4.81*	*0.34*	*0.67*

* Direct and indirect costs and SROI showed for comparison. The values in italics only consider the direct cost of the MHP and excludes land/property values for the basis of comparison with other cases.

Sensitivity Analyses

The outcomes from SROI are based on certain degrees of assumptions as it is not always possible to quantify every direct or indirect benefit, e.g., in terms of operation, productivity, and capitalisation. Sensitivity analyses are necessary to assess the extent to which prior assumptions influence the calculations and findings. This involved varying the different assumptions that underpinned the calculations and proposing alternative scenarios to test the extent to which this significantly altered the findings.

Discount rates: Discount rates are important in impact calculations as the impact of renewable schemes such as MHP are highly depended on the upfront investment costs. MHP installations require high capital investment but low operation and management (O&M) costs and no fuel systems [62]. Their discount rates are therefore a useful proxy of the capital cost and assessing fair value or market price for such renewables projects. Moreover, the risks associated with equities are not always present in renewable energy assets. They are also not sensitive to assumptions about their economic lifetimes which tend to be quite long. Almost all costs represent initial capital costs, the discount rate creates a sensitivity in results, and the sensitivity of the LCOE varies according to the discount rates and lifetimes [63]. Where data are available (e.g., [64]), the discount rates of micro hydropower could range from 3 to 10% (Table 6). The results of this first sensitivity test–discount rate thus provide a reasonable baseline for other comparisons.

Individual and organisational factors: The individual or organisational contributions in the form of initiative, time, and financial investment were found to play a significant role in achieving social impact for MHP projects. This test (Table 7) examined the SROIs by removing the owner input and contributions, but not the investment costs. Comparisons between the cases and the three discount rates did not compare favourably with the baseline Test 1. Consistency was found for Spain and France. The exception was the private UK MHP plant where the land value skewed the outcomes. Thus, the NPV was negative after five years. This is not surprising as negating owner contributions from SROI analysis is an unlikely and unrealistic scenario. However, it also emphasised the importance of owner contribution, financial or otherwise, for achieving social value.

Table 7. Sensitivity of the SROI results to owner/manager input.

Country	Sector	Investment Cost (EUR)	Discount Rate (%)	Total Present Value (EUR)	NPV (EUR)	SROI per Euro Invested (EUR)	SROI		
							Ave	St. Dev	Range
Spain	Irrigation	39,699	3 7 10	78,811 74,724 72,034	39,112 35,025 32,335	1.99 1.88 1.81	1.89	0.09	0.18
France	Water utility	69,393	3 7 10	54,793 50,072 47,018	−14,599 −19,320 −22,375	0.79 0.72 0.68	0.73	0.06	0.11
United Kingdom	Private	278,824	3 7 10	177,130 162,676 153,324	−101,694 −116,147 −125,500	0.64 0.58 0.55	0.59	0.05	1.00

Investment cost: Another test (Table 8) was conducted based on the investment cost being the same as that of the pilot plant circa EUR 30,000. This was crucial as the investment cost is a major factor. It is also an important element of determining returns on investment—social or financial. In this test, the investment cost was set to EUR 30,000 in all cases. The findings showed close synergy with the baseline Test 1. Again, the Spanish and French cases were consistent. The exception was when land values were not considered for the fourth case—the private UK installation. As discussed earlier, this scenario was specific to this context and does not always apply in other regions.

Table 8. Sensitivity of the SROI results to investment costs.

Country	Sector	Investment Cost (EUR)	Discount Rate (%)	Total Present Value (EUR)	NPV (EUR)	SROI per Euro Invested (EUR)	SROI		
							Ave	St. Dev	Range
Spain	Irrigation	39,670	3 7 10	280,620 262,622 250,889	232,251 214,253 202,520	5.80 5.43 5.19	5.47	0.31	0.61
France	Public water utility	36,400	3 7 10	189,152 181,956 177,164	152,752 145,556 140,764	5.20 5.00 4.87	5.02	0.17	0.33
United Kingdom *	Private	56,272	3 7 10	186,590 171,962 162,488	130,318 115,690 106,215	3.32 3.06 2.99	3.12	0.17	0.33

* Direct and indirect costs and SROI showed for comparison. The values in italics only consider the direct cost of the MHP and excludes land/property values for the basis of comparison with other cases.

Operation and productivity impact: A further sensitivity analysis (Table 9) was conducted to examine the influence of operation and productivity impact accrued as a direct result the MHP plant.

Table 9. Sensitivity of the SROI results to MHP O&P impact.

Country	Sector	Investment Cost (EUR)	Discount Rate (%)	Total Present Value (EUR)	NPV (EUR)	SROI per Euro Invested (EUR)	SROI		
							Ave	St. Dev	Range
Spain	Irrigation	39,670	3 7 10	225,042 209,265 199,007	215,372 169,595 159,337	5.67 5.28 5.02	5.32	0.33	0.65
France	Water utility	42,893	3 7 10	158,595 154,143 151,126	115,702 111,250 108,233	3.70 3.59 3.52	3.60	0.09	0.18
United Kingdom *	Private	298,809	3 7 10	1,317,067 1,210,201 1,141,040	1,018,259 911,392 842,232	4.41 4.05 3.82	4.09	0.30	0.59
			3 7 10	182,540 168,244 158,983	−116,269 −130,565 −139,826	0.61 0.56 0.53	0.57	0.04	0.16

* Direct and indirect costs and SROI showed for comparison. The values in italics only consider the direct cost of the MHP and excludes land/property values for the basis of comparison with other cases.

Table 10 summarises the findings from the sensitivity tests; showing averages, ranges, and standard deviations to enable effective comparisons.

Table 10. Comparison of sensitivity tests.

Tests	Country	Spain (4 kW)	France (7 kW)	United Kingdom * (55 kW)	
	Sector	**Irrigation**	**Water Utility**	**Private**	
Test 1: Discount rate	Average (SROI)	5.47	2.54	4.06	4.81
	St. Dev (SROI)	0.31	0.08	0.30	0.34
	Range (SROI)	0.61	0.16	0.59	0.67
Test 2 *: Owner influence	Average (SROI)	1.89	0.73	0.59	
	St. Dev (SROI)	0.09	0.06	0.05	
	Range (SROI)	0.18	0.11	1.00	
Test 3: Investment costs	Average (SROI)	5.47	5.02	3.12	
	St. Dev (SROI)	0.31	0.17	0.17	
	Range (SROI)	0.61	0.33	0.33	
Test 4: O&M, Productivity impact	Average (SROI)	5.32	3.60	4.09	0.57
	St. Dev (SROI)	0.33	0.09	0.30	0.04
	Range (SROI)	0.65	0.18	0.59	0.16

* Excluded sensitivity analysis as explained.

4. Discussion

Table 11 summarises the average range of SROI for each case accounting for the variations across the case studies, and the levels of assumptions made in the analysis. In similar scenarios, the SROI for irrigation can be up to 5:1 for irrigation, 2:1 for water utilities, and 3:1 for private systems. These figures are subject to external factors such as the context, the specifications of the system, the regulatory requirements and associated time and costs, costs of finance, and added benefits such as feed-in tariffs.

Table 11. SROI range across all sensitivity tests, excluding Test 2.

Sector	SROI (Minimum)	SROI (Maximum)	SROI (Average)
Irrigation	5.32	5.47	5.40
Water utility	2.54	3.60	2.07
Private	3.12	4.09	3.61

Two goals were defined at the onset of the study: (a) to investigate and quantify the social impact of MHP demonstrator project, and (b) to investigate whether SROIs provide a viable means to quantifying social value in MHP projects.

4.1. Assessing the Social Impact of MHP in Water Networks

The social impacts of MHP were determined as follows:

- *Expanding energy source and access:* The potential for MHP to improve access to clean energy, particularly in remote areas without grid access was affirmed. In the demonstrator projects, it was found to deliver a range of socio-economic benefits that can facilitate product and economic transactions, assist in building rural markets, increase good practice, and create jobs. The installations were also found to enhance education and skills development in existing communities and the workforce;
- *Organisational capacity and change:* All the demonstrators showed significant organisational change from unsustainable, or less sustainable practices to improved sustainability. This was more notable in the irrigation example whereby a diesel generator was entirely replaced by a renewable, non-disruptive solution [65]. Similar to other case studies (e.g., [66]), projects such as this have a positive impact on capacity on skills and capacity development especially for the owner or organisation;
- *Livelihood, productivity, and expanded uptake:* The direct job implications of the MHP installations were not significant, but there were wider job implications for suppliers, manufacturers, installers, etc. The number of direct renewable jobs in the EU was estimated at 1.2 million in 2017, with hydropower—large and small ranked as the third largest employer [67]. The demonstrators delivered job benefits for the SMEs involved in the design and installation of the MHP plants, the production of equipment, as well as maintenance jobs. The replacement or displacement of non-renewable energy sources helped to maintain or increase productivity in the form of cost savings, and improvement to processes. This productivity could be extended to the further modernisation and better practice within the sector or community. Taking irrigation as an example, the demonstrator trailblazed energy recovery potential within existing networks. Similarly, the private example, whereby many more MHPs were installed in the area as a direct result of this exemplar. This is in addition to the level of interest generated amongst sector peers; therefore, also promoting the uptake of this renewable energy source, and strengthening the cohesiveness and social capital between and among sectoral communities;
- *Reputational value:* In the global market, studies have shown that corporate reputations account for over 35% of the market capitalisation [60]. Therefore, the reputation derived from the implementation of renewables such as MHPs is a valuable commodity for organisational entities. Stakeholders repeatedly mentioned the reputation and public image value of their MHP installations. They rated this as much more important that the economic or environmental value;
- *Knowledge and awareness:* The demonstrator enhanced knowledge and skills among the project team and external stakeholders in all the cases and for academics and non-academics, especially those without prior technical competencies in MHPs. For instance, since installation, the UK site has hosted over 1500 visitors excluding those attending the annual local festival. The owners have given about 68 presentations including hosting training days for the Environment Agency staff, and talks delivered to tour groups. They have contributed to various policy committees and consultations about renewable energy schemes in general, and, specific to MHP schemes. They have also, through a Community Power Group, supported other individuals in the design and commission of other MHP schemes in the area. The impacts here were generated through the availability of data from real cases and the dissemination and training initiatives aimed at promoting the technical competence across all stakeholder groups, not just the academics involved in the project. The projects have had a significant impact in creating attitudinal and environmentally positive behaviour change. They promote pro-environmental awareness and the adoption of non-popular renewables such as MHPs;
- *Practical and policy applications and significance:* Policy change takes a long time to occur as policy decisions go through many stakeholders and processes before being

implemented. It was therefore difficult to assess the direct policy impact of the MHP demonstrators. Nevertheless, the importance of the policy environment can include influencing the cost of MHP installations as well as the resulting value. Notably in the local industry development, higher tax receipts were associated with innovation and increased productivity, occupational patterns, and skills, and localising or extending the value chain and sector/community benefits. Other stakeholders such as the owners, end users, and funders also indirectly benefitted from the schemes through marginal reductions in providers of products or services or innovation credits other attributable impact on the part of the funder.

4.2. Critiquing the Effectiveness of the SROI Approach

The second goal of the study was to investigate whether SROI was effective in quantifying the social benefits and value of MHPs, including the extent to which it increases the role of stakeholders in MHP processes [68,69]. In the context of this study, the SROI approach provided an improved method to cost–benefit analysis as it accounts for stakeholders, i.e., those affected by the activities. It also permitted the evaluation of intangible externalities and outcomes of the MHP interventions, by considering the social, economic, and environmental benefits in addition to the produced financial value [52]. Nevertheless, the following challenges and limitations were identified during the analytical stages:

- Outcomes and impact values and data were not always available due to the lack of evidence and information from the relevant stakeholders. Hence, the authors of [51] have recommended that researchers should decide the frame of analysis and the available resources to implement it early on. Although significant efforts were made to substantiate these in this study, e.g., by comparing against similar cases in similar sectors. Educated estimations are necessary where proxies are not available. These estimates nevertheless can undermine the confidence in any SROI findings. Further, there were instances of known impact which could not be credibly valued, e.g., quantifying increased awareness and knowledge from dissemination via public media outlets. Moreover, the age of some of the demonstrator cases meant that the value to the public, e.g., mobile phone charging, could only be extrapolated from initial figures. In this study, these were mitigated where possible with substantiated proxies. However, further longitudinal studies are required to collaborate the findings. It would also be highly beneficial if regional, national and EU data organisations actively collect disaggregated social impact data for renewables to enable more robust studies;
- The financial inputs of the studied cases may not be representative of a non-demonstrator installation. For instance, demonstrator plants have other associated costs, e.g., for monitoring and disseminating performance data. The funders, stakeholders and beneficiaries for demonstration projects may be skewed. In most cases, the funder is not necessarily the owner, and may not directly benefit from the intervention.
- The criticisms of SROI centre on the methods for calculating social impact. This includes the challenges of quantifying non-financial and non-quantifiable outcomes. Inevitably, different people will determine and evaluate the monetary value of social metrics in different ways. This may lead to decisions to favour investment solutions whose merit and impact can be monetised. Further, conducting SROI is feasible when information on outcomes, cost, and revenue are readily collated and available. Otherwise, it could potentially be onerous in terms of time and effort, and this was found to be the case in this study. However, the results obtained have been shown on balance to be useful for decision making.

Therefore, SROI could positively support decision making by policy makers, investors, and organisations on the possible social value and scope of performance for planned MHP interventions, especially if corroborated with findings from other tools for quantifying the wider social value and impact of technological interventions.

5. Conclusions

This study aimed to define the SROI range of demonstrator projects. It evaluated the efficacy of the SROI approach for assessing and forecasting the social impact of future MHP schemes in the immediate to short term. The SROI of the demonstrator projects were found to range from EUR 2 to 5 for everyone EUR 1 invested. These values can be used to forecast social benefit and inform decision making on the adoption of MHPs in water networks. Regarding SROIs, the outcomes will always be estimated values that should be validated using other methods of quantification and analysis. Although not without its challenges and limitations, the findings also show that SROI is a useful tool for quantifying the social impact of MHPs. Thus, this study also achieved the aim of an approach with which the acceptance and the acceptability of MHPs can be promoted.

In addition to quantifying social value, it was found that contextual factors such as the regulatory compliance can impact on investment costs, and therefore the adoption of MHPs. Further, it was found that financial incentives, e.g., feed-in-tariffs, are essential for some schemes but are not necessarily primary drivers for the uptake of MHPs for other schemes, e.g., in water utilities and for irrigation. The potentials for environmental and social impact were recognised and highly valued as important drivers by the owners in the studied cases.

Lastly, the findings demonstrated a useful SROI range as the first step to benchmarking social return on investments in MHPs, and potentially other renewable energy schemes. However, further research is needed to address the limited research in this area.

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