Hydr Pulse

Milestone MS3.1

Local Knowledge and Practices Report

Hydropulse Consortium

July 2026

Funded by
the European Union

Date of Delivery: 07/20226

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Document Information

This report is the Milestone Report 1.3 of the Horizon Europe project HydroPulse - Hydropower for Participatory Upscaling of Local Solutions and Ecosystem-based strategies, Grant Agreement No. 101268715.

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Please cite this report as:

Philippe COPINSCHI *et al.* (2026). Local Knowledge and Practices Report. Milestone Report 1.3 of the HydroPulse project funded under the European Union's Horizon Europe research and innovation programme, GA No: 101268715

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HydroPulse — MS3.1

Local Knowledge and Practices Report

Work Package 3, Task 3.1

Review of local knowledge and practices

1. Introduction

HydroPulse is a Horizon Europe project bringing together 15 partners across 8 countries to support the sustainable, socially responsive development of hydropower, through five case studies: Switzerland (Alpiq), Romania (UniBuc), Spain (Cuerva and EMASAGRA), and Madeira, Portugal (ARDITI).

Hydropower is often assessed primarily as an energy-production technology. HydroPulse starts from a different premise: hydropower schemes are coupled socio-ecological-technological systems. Alongside electricity generation, dams and reservoirs shape river flow regimes, sediment transport, water temperature and biodiversity, while also intersecting with irrigation, drinking water supply, flood protection, tourism and the everyday lives of local communities. Understanding hydropower well therefore means understanding both its environmental footprint and its social context together, not as separate concerns.

This matters at a European scale, too: recent assessments show that a large majority of Europe's surface water bodies do not yet reach good ecological status, underlining that river ecosystems affected by infrastructure such as hydropower remain under real, ongoing pressure. Against this backdrop, Work Package 3, Task 3.1 set out to review existing knowledge and practices related to the environmental and societal impacts of hydropower at each of HydroPulse's case study locations. This document presents an initial summary of this review, focusing on two thematic areas: environmental practices and knowledge, and societal practices and knowledge.

This is an early-stage overview rather than an exhaustive literature review: the objective at this point is to gather the key information available within each case study team, in a manageable timeframe, and grounded in the specific realities of each site rather than in the European hydropower literature as a whole. The review will continue over the coming months and will be developed further to inform the project's first Societal Readiness Report (D3.1, due M6).

2. Approach and Methodology

The review was coordinated by HEAS and UniBuc, with support from the project's other social sciences and humanities (SSH) partners, and carried out locally by the Case Study Leads at four of the five case study sites.

This initial review primarily captures documented environmental and societal knowledge and practices, drawn from published and grey-literature sources. Direct local and experiential knowledge held by residents, operators and other stakeholders will be collected and integrated through the project's forthcoming stakeholder mapping (Task 3.2) and interviews and co-mapping activities (Task 4.1).

The review was deliberately grounded in the specific context of each site, rather than in a broad, standardised search across the European hydropower literature as a whole. Such a broad search would have risked producing an academic-style review, disconnected from the day-to-day realities of each case study. Each Case Study Lead was therefore asked to identify sources directly relevant to their own location. These could be sources already known to their team, or readily accessible locally, including grey literature such as impact assessments, monitoring reports or local authority documents. The resulting information was then organised around two accessible thematic areas: environmental and societal practices and knowledge.

To ensure a consistent approach across all case studies, a standardised extraction template was developed and circulated to the Case Study Leads. For each source, teams recorded the type of document, its main environmental and societal content, and any knowledge or practice gaps identified. Sources were included if they were directly relevant to the case study site and readily accessible to the Case Study Lead, with no fixed cut-off on publication date; as a result, some of the material reviewed dates back as far as 2010–2011. The depth of the evidence base also varies considerably across case studies, both in the number and type of sources reviewed: 27 references for Romania, nine for Madeira, five for Cuerva, and nine for Switzerland. The literature review for the Spanish case study led by EMASAGRA could not be completed in time for this report and has therefore not been included in the comparative analysis presented in Section 4; it will be added once received, with the comparison across all five case studies revisited for the project's first Societal Readiness Report (D3.1, due M6). Some apparent differences between case studies may thus reflect differences in source availability and review depth as much as differences in the underlying reality on the ground.

In line with the exploratory nature of this stage, no formal assessment of source quality or credibility was requested from Case Study Leads at this point; this analytical step will be carried out subsequently by the SSH partners, as part of the synthesis feeding into D3.1.

3. Case Study Syntheses

3.1 Switzerland — Alpiq (Gougra, Valais)

System profile: The Gougra scheme (Forces Motrices de la Gougra, FMG) produces around 650 GWh annually, split between winter production from the Moiry reservoir (76.5 hm^3) and run-of-river generation from Mottec in summer, with roughly 30 GWh of pumping from Mottec and Tourtemagne to Moiry for winter storage. Inflows (258 hm^3 total) originate from the Zinal, Turtmann and Moiry glaciers, arriving mainly at Mottec (~50%). The scheme is therefore strongly dependent on glacier-fed runoff, making it particularly exposed to changes in glacial melt patterns and long-term hydrological shifts. These impacts are already visible within the system: the pumping capacity at Mottec, designed for the hydrological conditions of the 1960s, has become increasingly constrained by rising glacial runoff, resulting in growing spill volumes and reduced opportunities to transfer water to seasonal storage. The ongoing dam heightening and pumping capacity upgrade project illustrates the need to modernise legacy hydropower infrastructure to adapt to evolving climatic and hydrological conditions.

Literature findings: Historically designed for electricity generation, the Gougra system has progressively acquired multiple functions: ecological flow releases, artificial floods for river restoration, flood mitigation, artificial snow production, irrigation, drinking water and recreational value. The reviewed literature (nine sources: five academic and technical publications, two cantonal or administrative documents, and two press articles) consistently frames the FMG system as a multifunctional water–infrastructure system rather than solely an energy-production asset. Research from the UNIL–Alpiq multifunctionality programme (2022–2025, with a second phase in preparation aiming for regional regulation on multi-use of water) identifies around 40 distinct uses of alpine hydropower infrastructure.

On glacier evolution, the Moiry, Turtmann and Zinal catchments that feed the Gougra system are projected to reach "peak water" within the next decade, after which glacier contributions to river flow are expected to decline.

Governance is described as a patchwork of cantonal decisions, concession requirements and negotiated arrangements between FMG, public authorities, environmental NGOs (WWF, Pro Natura) and fishing associations. Environmental measures such as river rehabilitation, ecological flows, and renaturation are governed by clear legal provisions and implemented through decisions of the competent cantonal authorities. In contrast, the allocation of water for competing uses, including artificial snow production, irrigation, and drinking water supply, relies to a greater extent on negotiated arrangements among stakeholders. Stakeholder perceptions of reservoir multifunctionality, future concession renewals, and competing priorities for water use emerge as central themes in the literature.

Identified gaps include the absence of an integrated framework for managing multiple reservoir functions, limited understanding of trade-offs between competing uses, fragmented governance arrangements, and uneven coordination between energy, environmental and concession policies. Additional uncertainty concerns the long-term ecological effectiveness of environmental-flow and artificial-flood measures, and how future climate/glacier change will affect water allocation.

3.2 Romania — Golești, Argeș Basin (UniBuc)

System profile: Golești is the terminal reservoir in an 11-impoundment cascade along the Argeș valley (11 reservoirs, 16 hydropower units basin-wide), commissioned in 1983 and located 7.3 km below the Pitești dam. It has a maximum operational storage of 78.5 million m³, a surface area of 646 ha, and a flood-attenuation volume of 23.5 million m³. The plant (8 MW, two Kaplan turbines, 90 m³/s discharge) operates in a demand-driven mode that can generate discharge steps of ~35 m³/s — a hydropeaking pattern linked to downstream riverbed incision through sediment retention, with a retention basin proposed as a mitigation measure. The reservoir also supplies supplementary drinking and industrial water to Bucharest and the ARPECHIM Pitești plant, and irrigates around 10,000 ha via the Cârligătura–Teiu system.

Literature findings: The literature reviewed for this case study (27 references: 17 scientific publications, 3 administrative/management reports, 7 grey-literature/media sources) is dominated by eutrophication, water quality, hydrodynamics, reservoir operation and biodiversity (particularly avifauna). It documents the reservoir's persistent eutrophic status, wastewater inputs, seasonal stratification, sediment accumulation and hydropeaking impacts, with several studies proposing management responses (sediment flushing, modified operational regimes, downstream retention) that remain untested in practice. Biodiversity research documents the reservoir's high conservation value within the Natura 2000 site ROSPA0062 (with 199 recorded bird species) including evidence of climate-related shifts in avifauna dynamics over the long term. Fish-fauna studies additionally identify habitat alteration, fish stocking and species introductions as drivers of community change over roughly 30 years.

Beyond its conservation value, ROSPA0062 (2,260 ha across six reservoirs, 91.2% open water) is also valued for the ecosystem services its bird communities provide (pest control, rodent regulation, recreation, education), while also generating a documented disservice, as large winter waterfowl flocks damage agricultural crops.

Societal evidence is comparatively sparse: most references describe the reservoir's socio-economic functions (hydropower, flood protection, water supply, irrigation, recreation, conservation) rather than documenting local knowledge, stakeholder perceptions or community practices as such. What societal content exists points to recreational fishing, environmental awareness activities linked to a biodiversity-conservation project, informal waste clean-up efforts, and institutional coordination under the Water Framework Directive and Natura 2000 frameworks, including formal public consultation involving ABA Argeș–Vedea, local authorities, Hidroelectrica, NGOs and fishing associations.

Gaps identified: no systematic study of stakeholder perceptions, local ecological knowledge or governance arrangements; proposed environmental interventions are largely modelled rather than field-tested; social-science evidence relies mainly on management plans and media rather than empirical research; and recurring waste accumulation, though visibly documented, remains unstudied from a behavioural or governance perspective.

3.3 Spain — Cuerva, La Vega Plant (Monachil, Granada)

System profile: La Vega is a small run-of-river plant near Sierra Nevada National Park: 2.4 MW nominal power, 189 m net head, a nominal design flow of 1.5 m^3/s (with a measured operating range of 0.2–1.5 m^3/s), ~4 GWh annual production, Pelton turbine, operated by E-Distribución, principally serving irrigation and human consumption. Several operational constraints have also been identified that are not fully captured in the literature: very limited electrical/operational monitoring data, no reservoir (hence little flow-regulation capacity), no real-time ecological monitoring tools, and a structural mismatch between generation timing and local demand peaks.

Literature findings: The five reviewed sources (two peer-reviewed publications, two official basin planning documents, one project website; no dedicated media source identified) consistently highlight the interaction between hydropower, water scarcity, climate change and ecosystem conservation in this semi-arid Mediterranean setting. Environmental knowledge centres on altered flow regimes, ecological-flow requirements, biodiversity conservation and connectivity, and the impacts of water abstraction — with climate change repeatedly identified as the main driver of increasing drought frequency and declining availability. Official planning sources note that many water bodies in the Guadalquivir basin do not currently achieve good ecological status.

Societally, water is shared among hydropower operators, agriculture, biodiversity requirements, tourism and local communities, generating the documented conflict over water use in the Monachil valley between agriculture, tourism and conservation. Stakeholder participation, inter-institutional cooperation and public involvement in basin planning are repeatedly identified as necessary conditions for sustainable management and social acceptance; digital tools are also flagged as a potential lever to improve water and energy management, though not yet deployed at this site.

Gaps identified: lack of standardised methods for assessing ecological impacts, limited understanding of long-term/cumulative effects of run-of-river hydropower, insufficient post-construction ecological monitoring, poor integration of hydrological, ecological, energy and socio-economic data (consistent with the plant's limited monitoring capacity noted above), inadequate assessment of stakeholder perceptions, and limited operational flexibility during droughts.

3.4 Portugal — Madeira (ARDITI)

System profile: Madeira's hydropower fleet spans 3.2–10.8 MW of installed capacity, representing 15–30% of the island's total energy production, combining reservoir and run-of-river plants (e.g. Serra de Água, Janela). The historic levadas water-channel network irrigates and feeds hydropower stations alike, alongside numerous weirs across the island whose full extent is still being mapped.

Literature findings: The nine reviewed sources (seven scientific publications, one management plan, one non-technical planning document; no dedicated media source identified) focus on the impacts of hydraulic infrastructure on river ecosystems (reduced flows, ecological connectivity, fish migration barriers) and on ecological-flow maintenance. Weirs and other hydraulic structures are shown to be related with the distribution of critically endangered European eel (*Anguilla anguilla*, the island's only native freshwater fish) potentially constraining their upstream movement, through four possible distinct pathways of impact: diverting the species from natural movement routes, restricting access to critical habitat, diminishing habitat availability/quality, and causing retention or mortality. Macroinvertebrates, which show high endemism on the island, are also sensitive to water-quality-driven community shifts, though no defined biotic index yet exists to track this systematically. Separately, the literature documents flash-flood and landslide risk exacerbated by river-channelling works — a broader hazard-context finding, not specific to hydropower, but relevant to reservoir/weir operation on the island.

Societally, the levadas emerge as a particularly important socio-cultural element — not just water-transfer infrastructure but a component of Madeira's cultural heritage and tourism identity/brand. Other societal aspects include the social and institutional conditions (dynamic tariffs, demand-response, targeted investment incentives) needed for Madeira's transition toward a 100% renewable energy share, and an ongoing public consultation for the 2028–2033 hydrographic region management plan, which has already identified the main local challenges and priorities for water management.

Gaps identified: absence of trend analyses quantifying the energy sector's impact on water bodies, limited characterisation of weirs and other hydraulic barriers with respect to ecological connectivity, and limited assessment of ecological connectivity more broadly.

3.5 Spain — EMASAGRA

The literature review for this case study could not be completed in time for this first version of the report. This section will be completed and the comparative analysis in Section 4 revisited once the literature review is received.

4. Preliminary Cross-Case Observations

The following are first, exploratory observations drawn from the four case studies reviewed so far. They are not a consolidated analysis: a fuller assessment, including a review of how reliable and representative each source is, will follow in the project's first Societal Readiness Report (D3.1).

Across all four sites, the review points to one shared reality: hydropower rarely operates in isolation. In every case, the water managed by a hydropower plant is also needed for something else. It is this overlap of uses that shapes most of the environmental and social issues identified. What differs from place to place is which other uses are involved. In Golești (Romania), hydropower shares its reservoir with drinking water supply for Bucharest, industrial water reserves and irrigation for 10,000 hectares of farmland. In the Cuerva case (Spain), the tension plays out mainly between agriculture, tourism and nature conservation in the Monachil valley. In Madeira, the historic levada water channels serve irrigation, public water supply and hydropower generation all at once, while also carrying deep cultural and touristic significance. And in the Swiss case, the Gougra hydropower scheme has gradually taken on roles well beyond electricity production (including ecological flow releases, artificial floods to help restore the river, and flood protection) to the point where researchers now describe it as a "water-infrastructure system" serving multiple purposes rather than a single-purpose power plant.

Encouragingly, all four case studies are anchored in a recognised, formal system for managing water at the level of the river basin or region, whether this is a Water Framework Directive river-basin management plan (as in Romania, Spain and in Madeira), or, in Switzerland, a combination of cantonal decisions, hydropower concessions and a growing body of research into how multiple uses of water can be formally reconciled. This is a useful common thread for HydroPulse, since it means there is, in principle, a recognised institutional door to knock on at every site. That said, how far hydropower-specific issues are actually built into these plans seems to vary: it appears most developed in Romania and Spain, and least formalised (though most actively being worked on) in Switzerland, where environmental requirements such as ecological flows, river restoration and renaturation are governed by federal and cantonal legislation and implemented through decisions of the competent authorities. At the same time, negotiated arrangements between the operator, local authorities and water users play an important role in addressing competing water uses, such as irrigation, drinking water supply and artificial snow production, alongside broader challenges of coordinating energy policy, environmental policy and concession requirements.

A related and equally consistent finding is that changes to the natural flow of rivers (i.e. how much water flows, when, and how this affects the wider ecosystem) emerge as the single most common environmental concern across all four case studies, even though the underlying cause differs considerably from site to site. In Golești, the main driver is the reservoir’s tendency to become eutrophic (an excess of nutrients that degrades water quality) combined with "hydropeaking" (the sudden start-stop pattern of turbine operation, which has been linked to erosion of the riverbed downstream). In Cuerva, the driving pressure is water scarcity linked to drought. In the Swiss case, it is the long-term retreat of glaciers reshaping how much water is available and when. In Madeira, flood and landslide risk is a further, related concern, although it should be noted that this particular risk is documented as a broader hazard for the island rather than one caused specifically by hydropower.

Climate change surfaces in every case study, but in three visibly different guises, which is worth stating plainly since it illustrates how the same global pressure can look very different on the ground. In Switzerland, it takes the form of shrinking glaciers and a shift towards more rain-dependent, less predictable river flows in the coming decades. In Spain, it takes the form of longer and more frequent droughts. In Madeira, it takes the form of a heightened risk of flash floods and landslides following intense rainfall. Romania's material, by contrast, says little about climate change as a distinct hazard, except for its impact on bird populations. Its interaction with eutrophication and water quality is notably absent from the reviewed literature. This may reflect what is genuinely most relevant locally, or simply what the available literature happened to cover.

On biodiversity, the picture is noticeably richer for two of the four case studies — Romania and Madeira — than for the other two, though this likely says more about what was locally accessible to each team during this first, time-limited review than about where biodiversity pressures actually are. In Romania, the reservoir hosts one of the region's most significant bird populations (nearly 200 recorded species) with some evidence that changing climate conditions are already affecting bird numbers and behaviour over time, and separate research pointing to habitat change, fish-stocking practices and the introduction of new species as drivers of change in the fish community. Interestingly, the same birds that make the site valuable for conservation also cause a genuine, if minor, downside for farmers: large winter flocks are reported to damage crops, a reminder that environmental value and local cost can coexist at the same site. In Madeira, the case for biodiversity concern is built around the island's only native freshwater fish, the critically endangered European eel, which weirs and similar structures may obstruct, cutting it off from parts of its habitat and, in some cases, causing direct harm. The island's small water-dwelling invertebrates, many found nowhere else in the world or restricted to the Macaronesia region, also appear sensitive to water-quality changes, although no standard method yet exists locally to track this systematically.

A gap that stands out precisely because it repeats itself in every single case study is the near-total absence of any structured study of what local people actually think about hydropower, water management or the trade-offs being made in their area. This is a genuine gap in the underlying knowledge, not simply something the reviewed sources chose not to report. This first review was not exhaustive, and did not yet include an assessment of how reliable, recent or representative each source is; that credibility assessment is planned as part of the synthesis for D3.1 (due M6). It therefore remains possible that additional relevant studies, or undocumented local knowledge, exist beyond what has been captured here. In Romania, Spain and Madeira, formal public consultation processes are documented as part of river-basin or hydrographic planning. In Switzerland, stakeholder involvement occurs through both formal regulatory processes and negotiated arrangements between the operator, cantonal authorities, environmental organisations and fishing associations. In neither case does this amount to a systematic understanding of local perceptions, concerns or acceptance. As the review of the Romanian case put it, most of what is available describes what the reservoir does (for energy, water supply, flood protection) rather than what local people know or think about it. Given that HydroPulse's work on mapping local stakeholders and building lasting engagement is being launched in parallel to this review, this shared gap is arguably the single most useful finding to emerge so far: it confirms that this later work will be filling a real and current gap in knowledge, not duplicating something that already exists.

Finally, a more practical observation worth carrying forward: several of the proposed solutions identified across the case studies, such as a retention basin to soften hydropeaking in Romania and detention basins to reduce flash-flood risk in Madeira, exist only on paper or as recommendations, not as something that has actually been tried and evaluated on the ground. Separately, some tools remain missing altogether rather than merely untested: Madeira, for instance, currently has no defined index to track how its endemic macroinvertebrate communities respond to changing water quality. This pattern, tested in theory but not yet in practice, alongside a few genuine tool gaps, appears often enough across the four sites that it may be worth flagging as a general characteristic of the current evidence base, rather than a shortcoming specific to any one location.

5. Next Steps

This document represents an early snapshot of local knowledge and practices related to hydropower across HydroPulse's case studies, and several strands of work will continue in the coming months. Beyond simply completing the picture, the SSH partners will carry out a more thorough assessment of the sources gathered so far, looking, in particular, at how reliable, recent and locally relevant each one is. This is something that was deliberately left aside at this early stage to keep the workload manageable for the Case Study Leads. This deeper analysis will feed directly into the project's first Societal Readiness Report (D3.1), due at Month 6. Building on this same synthesis, D3.1 will also examine, for each case study, whether and how non-institutional or directly affected actors (such as residents, water users, fishers and local associations) are represented in the sources reviewed, drawing on the stakeholder identification work carried out under Task 3.2.

The gaps identified throughout this review (most notably, the near-absence of any structured understanding of local stakeholder perceptions across all sites) will also directly inform the project’s upcoming work under Task 3.2 and Task 4.1, which will map local stakeholders, initiate Communities of Practice, and carry out interviews and co-mapping activities at each case study location.

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