

# COMPARATIVE ANALYSIS OF ON-SITE SANITATION GOVERNANCE

FINLAND, SWEDEN, NORWAY, AND SCOTLAND



**Decentralised  
Water  
Technologies**

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## Executive Summary

On-site (decentralised) sanitation systems are a structurally important but frequently under-governed component of wastewater management in high-income countries with dispersed rural settlement patterns. Even where centralised sewerage achieves near-universal service coverage in urban areas, a persistent rural minority relies on household- or cluster-scale systems such as septic tanks with soil infiltration, holding tanks, sand filters, and packaged treatment plants. These systems are essential for rural housing viability and local economic activity, yet they can also represent a significant source of diffuse pollution when poorly designed, inadequately maintained, or weakly supervised.

This report provides a comparative governance analysis of on-site sanitation in Finland, Sweden, Norway, and Scotland, focusing on how legal mandates, institutional responsibilities, enforcement capacity, and support mechanisms shape environmental performance and rural service equity. The comparison is designed to support Scotland's Decentralised Water Technologies by identifying governance arrangements that are potentially transferable (in whole or in part) to the Scottish regulatory and institutional landscape.

### Scale and policy relevance

In the three Nordic countries, approximately three million residents live outside centralised sewer networks—around 13% of their combined population—alongside a large stock of leisure homes (roughly half a million per country) that are also predominantly off-grid. The Finnish Environment Institute (SYKE) comparative study emphasises that wastewater from non-connected properties can materially affect local water quality and usability if not well managed, and that sanitation policies have broad socio-economic implications (including affordability and acceptability of upgrades).

In Scotland, decentralised wastewater is likewise a non-trivial rural issue. Existing analyses indicate 22,459 private water supplies serving around 185,850 people, and estimate 180,000 to 468,000 domestic septic tanks nationally—concentrated in rural and highland areas beyond the central belt. While the report's primary focus is on on-site sanitation (wastewater), the Scottish case cannot be fully understood without recognising that water and wastewater challenges often co-exist in the same off-grid geographies and governance arrangements.

### Comparative governance dimensions

The comparative framework developed in this study examines nine governance dimensions that jointly determine system performance: 1) regulatory and legal frameworks; 2) organisational arrangements; 3) compliance and enforcement mechanisms; 4) financing and economic instruments; 5) technical standards and permitted system types; 6) data, monitoring and information systems; 7) stakeholder engagement and competence; 8) environmental and equity outcomes; and 9) emerging innovations and good practices.

### Key cross-country findings

The analysis shows that Finland, Sweden, and Norway have all introduced national frameworks aimed at mitigating environmental pressures from off-grid wastewater. These frameworks set treatment requirements, clarify stakeholder roles, and underpin permitting procedures; however, the SYKE study stresses that non-compliance remains a major barrier across all three. Sweden relies more heavily on municipality-led interpretation and implementation of national guidance, whereas Finland and Norway use more explicitly binding national requirements. Across the Nordic cases, coherence at national level helps define expectations, but coherence alone does not guarantee compliance without inspection capacity, data, and owner support.

Scotland operates through a robust environmental protection regime, but the institutional centre of gravity differs: decentralised wastewater systems sit largely outside the national utility's remit and are primarily the responsibility of owners, with regulators and local authorities playing supervisory/authorising roles. This structural feature places high demands on individual capacity and willingness to maintain systems—especially where costs are high, perceived risks are low, and inspection probabilities are limited.

A central finding from the Nordic comparative evidence is that a substantial share of systems in regulated areas fail to meet requirements, and that “more than half” of on-site systems subject to treatment requirements are unlikely to comply. The report attributes this to capacity/resource constraints, knowledge and competence gaps, limited public awareness, and incomplete data. Scotland faces comparable dynamics, compounded by long-standing uncertainty about the true number, location, and condition of septic systems, which weakens targeted risk-based supervision.

Across the Nordic cases, a wide range of technologies is available, but traditional reliance on septic tanks without adequate secondary treatment remains common, and performance variation is frequently linked to construction errors and inadequate operation/maintenance. Scotland's decentralised wastewater similarly relies heavily on septic tank systems, where performance depends on correct siting, soil conditions, and regular desludging—factors that are difficult to assure through owner responsibility alone at scale.

In all four contexts, costs are largely borne by property owners. The Nordic report explicitly highlights socio-economic impacts where upgrade costs are high relative to property values, creating predictable resistance and delays. Scotland shows related equity concerns for rural communities managing essential services without consistent technical and institutional support, particularly where decentralised water and wastewater responsibilities intersect.

### **Transferable lessons for Scotland**

Despite these challenges, the comparative analysis suggests that improving environmental outcomes from on-site sanitation requires more than “better rules”. The most transferable governance lessons are:

- Make systems governable through data: comprehensive, routinely updated registration and classification of system types and risks.
- Move from reactive to risk-based supervision: inspection strategies that prioritise sensitive catchments and likely failure modes.
- Strengthen competence across the chain: clearer expectations for design/install standards, maintenance routines, and professional support.
- Pair duties with support: guidance, user-facing services, and—where appropriate—targeted financial mechanisms that reduce affordability barriers.

The overall implication is that Scotland can treat on-site sanitation not as a peripheral private matter, but as a core component of national wastewater outcomes—aligned with environmental protection, public health, and rural equity objectives in the wider decentralised technologies agenda. Taken together, the comparative evidence indicates that improving governance of on-site sanitation in Scotland will depend less on new technologies than on strengthening data visibility, supervision capacity, institutional coordination, and support for system owners.



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## Introduction

On-site sanitation refers to the wastewater service chain in dispersed settlements outside centralised sewer networks, including system selection and installation, day-to-day operation, routine maintenance, sludge management, and final disposal or discharge. In high-income countries, decentralised sanitation is often treated as a residual category—a technical substitute where network extension is “not viable”. Yet comparative evidence increasingly indicates that it is not marginal: it serves sizeable rural populations, interacts with sensitive receiving environments, and can cumulatively generate material diffuse pollution pressures when governance and maintenance are weak (Laukka et al., 2022).

This challenge is particularly visible in the Nordic region and in Scotland. In Finland, Sweden, and Norway, approximately three million residents live outside centralised sewerage, representing around 13% of their combined population, alongside extensive leisure-home stocks that are frequently located in non-sewered areas (Laukka et al., 2022). These settlement patterns make decentralised wastewater governance a persistent national policy problem rather than a temporary infrastructure gap. In Scotland, decentralised systems are likewise concentrated in rural and highland areas beyond the central belt. Contemporary assessments report 22,459 private water supplies serving about 185,850 people and estimate 180,000–468,000 domestic septic tanks across the country (Lawson et al., 2024).<sup>1</sup> While the present report focuses on sanitation governance, the Scottish evidence base shows that decentralised water and sanitation are often co-located, reinforcing the need for coherent governance arrangements and support structures across both service domains (Lawson et al., 2024).

From an environmental perspective, off-grid wastewater systems are often classified as diffuse pressures because they are numerous, spatially dispersed, and individually small—yet collectively consequential. The Nordic comparative assessment notes that wastewater from non-connected properties can substantially affect local water quality and usability if not well managed, and that sanitation governance has wide socio-economic implications, particularly where upgrade costs are high relative to property values (Laukka et al., 2022). From an implementation perspective, decentralised sanitation presents a “governability” problem: responsibilities are distributed across thousands of owners; inspection is labour-intensive; technical performance is sensitive to site conditions and behaviour; and administrative datasets are frequently incomplete. These features can produce a predictable policy outcome: strong formal rules, persistent non-compliance, and limited visibility of cumulative impacts (Laukka et al., 2022).

The Scottish context adds a distinct institutional dimension. Decentralised wastewater systems sit largely outside the operational remit of the national utility, leaving primary responsibility with owners and users, while regulatory functions are distributed across environmental regulation and local authority functions (Lawson et al., 2024). This can create uneven capacity to manage essential services, particularly in remote communities where professional services are scarce and costs of maintenance are higher. The decentralised technologies agenda—exemplified by Scotland’s Off-Grid Water programme—therefore raises a central governance question: what combination of regulatory standards, institutional responsibilities, enforcement approaches, and support mechanisms is most likely to deliver safe, equitable, and environmentally protective outcomes for rural populations (Lawson et al., 2024)?

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<sup>1</sup> Based on “modelled locations”, Scotland’s Centre of Expertise for Waters (CREW) reports that there are 168,635 locations serving 172,805 properties (Akoumianaki & Ibiyemi, 2022).

## Aim and approach of this report

This report is designed as a policy-oriented analysis to support decision-making on decentralised wastewater governance in Scotland. It aims to inform policymakers, regulators, and stakeholders—including Members of the Scottish Parliament—by identifying practical governance lessons that can strengthen environmental protection, service equity, and rural resilience in off-grid contexts. Rather than focusing on technological solutions alone, the report emphasises the institutional and regulatory conditions under which decentralised sanitation systems perform effectively in practice.

The analysis is grounded primarily in the comparative work of the Finnish Environment Institute (SYKE), which provides a detailed cross-country assessment of on-site sanitation governance in Finland, Sweden, and Norway (Laukka et al., 2022). While the SYKE report focuses specifically on on-site sanitation as a subset of decentralised wastewater systems, this distinction is explicitly taken into account in the present comparative analysis. This core evidence base is complemented by additional academic literature, policy documents, and regulatory sources, as well as ongoing research conducted within the Decentralised Water Technologies (DWT) project in Scotland (Lawson et al., 2024). Together, these sources enable a structured comparison that is both empirically grounded and policy-relevant, while also acknowledging that regulatory frameworks and practices continue to evolve.

The report adopts a comparative governance approach, focusing on how different institutional arrangements shape implementation outcomes. It examines nine interrelated governance dimensions: (1) regulatory and legal frameworks; (2) organisational arrangements; (3) compliance and enforcement; (4) financing and economic instruments; (5) technical standards and system types; (6) data, monitoring, and information systems; (7) stakeholder engagement and competence; (8) performance outcomes and environmental impacts; and (9) emerging innovations and good practices.<sup>2</sup> The report then synthesises findings in a cross-country comparative matrix and identifies policy-relevant lessons—especially those most applicable to Scotland’s decentralised technologies context.

The purpose of this structured comparison is not to rank national systems, but to identify transferable governance features—including both strengths and limitations—that can inform Scottish policy development. In this sense, the report contributes to the wider decentralised water agenda by framing on-site sanitation not as a residual or purely private matter, but as a core component of national wastewater governance, requiring coordinated institutional attention, appropriate regulatory tools, and sustained policy support.

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<sup>2</sup> These dimensions are informed by established water governance frameworks highlighting the role of legal, institutional, economic, and informational factors in shaping outcomes (Rogers & Hall, 2003; Tropp, 2007; OECD, 2015; Jiménez et al., 2020), and adapted to the specific characteristics of decentralised wastewater systems identified in recent comparative studies (Laukka et al., 2022; Lawson et al., 2024).

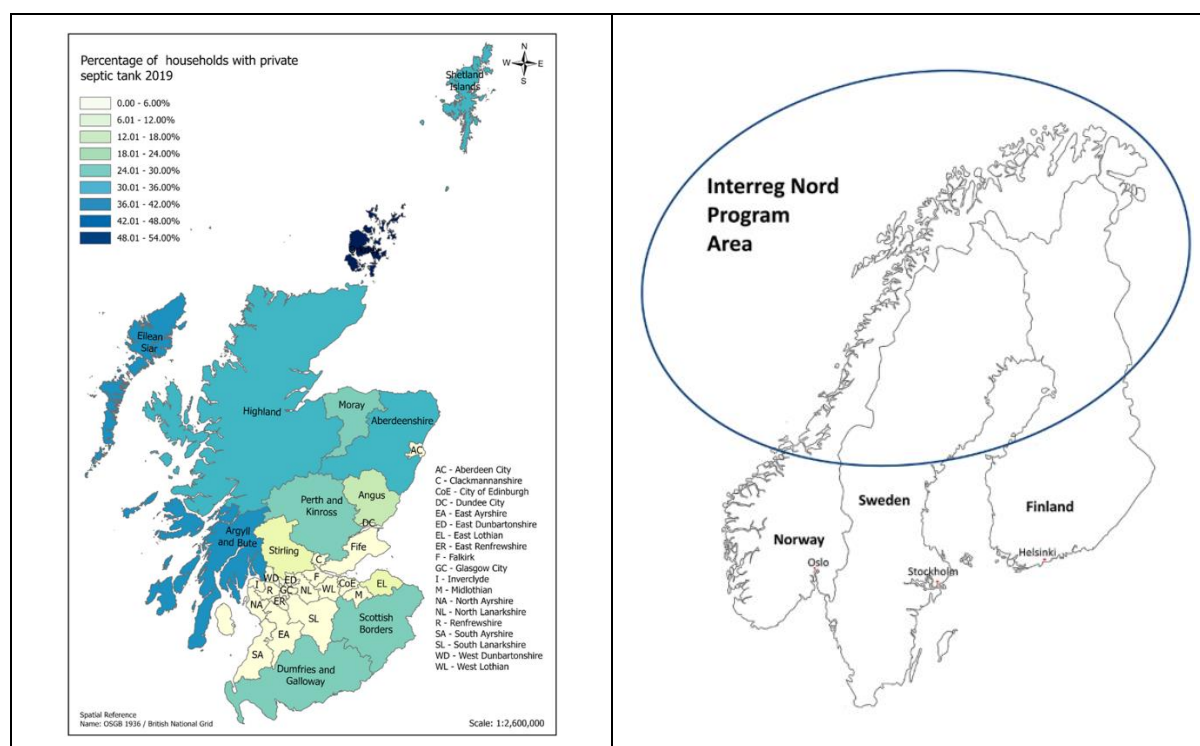


Figure 1. Maps of the research focus

## Context: On-Site Sanitation in the Four Countries

Finland, Sweden, Norway, and Scotland share a broadly comparable structural context in wastewater service provision: very high levels of connection to centralised sewer networks in urban areas, combined with persistent reliance on on-site sanitation systems in rural and low-density settlements. In all four cases, extending centralised sewerage to dispersed properties is often economically prohibitive and, in some locations, environmentally unjustifiable. As a result, on-site wastewater treatment systems form an enduring and structurally significant component of national sanitation systems rather than a transitional or marginal solution.

In the three Nordic countries, approximately three million people—around 13% of the combined population—live outside centralised sewer networks (Laukka et al., 2022). These populations are complemented by a very large number of seasonally occupied leisure dwellings, the majority of which are also unsewered. In Scotland, although overall coverage by centralised services is high, a substantial rural minority continues to depend on private sewage treatment systems, alongside private water supplies, reflecting a similar pattern of infrastructural exclusion shaped by geography, settlement history, and cost (Lawson et al., 2024).

### Finland

Finland has a population of approximately 5.5 million, of whom around 15% live in areas without access to municipal sewer networks (Laukka et al., 2022). An estimated 286,000 permanent dwellings rely on on-site sanitation systems, in addition to approximately 441,000 leisure cottages, many of which are located in environmentally sensitive areas near lakes or coastal waters. Septic tanks—often combined with soil infiltration or sand filtration—remain common, particularly in older installations, while dry or composting toilets are frequently used in seasonal dwellings. The high density of water bodies and widespread recreational use of lakes mean that diffuse pollution from on-site systems has long been a prominent policy concern in Finland.

## Sweden

Sweden's population of approximately 10.3 million includes an estimated 12% living outside sewered areas (Laukka et al., 2022). Nearly 471,000 permanent residences and around 600,000 holiday homes rely on on-site wastewater treatment. The Swedish on-site sanitation landscape is characterised by a diverse mix of technologies, including infiltration trenches, sand filter beds, septic tanks, and small package treatment plants. Many systems serve clusters of properties organised through local user associations, blurring the boundary between individual and collective decentralised solutions. As in Finland, the prevalence of coastal and freshwater environments heightens sensitivity to nutrient discharges, particularly phosphorus.

## Norway

Norway, with a population of around 5.4 million, has approximately 14–15% of residents living in unsewered areas (Laukka et al., 2022). An estimated 377,000 permanent homes and approximately 440,000 holiday cabins depend on on-site wastewater treatment. Septic tanks remain the dominant solution, especially in less sensitive inland areas, although more advanced systems are increasingly required in vulnerable catchments. Norway's challenging topography and cold climate—particularly in northern regions—introduce additional technical constraints, as freezing temperatures and seasonal variability can impair biological treatment processes if systems are poorly designed or maintained.

## Scotland

Scotland's population of roughly 5.5 million exhibits a similar urban–rural divide in wastewater service provision. While the majority of households are connected to centralised sewerage operated by Scottish Water, a non-trivial rural minority relies on private sewage treatment systems. Estimates suggest between 180,000 and 468,000 septic tanks are in operation nationwide, concentrated largely in rural and highland areas beyond the central belt (Lawson et al., 2024). Many of these systems consist of conventional septic tanks discharging to soakaways, although compact package treatment plants are increasingly used in new developments or sensitive locations. Responsibility for these systems rests primarily with individual property owners, with environmental oversight provided by the Scottish Environment Protection Agency and limited involvement from local authorities.

## Cross-cutting implications

Across all four countries, on-site sanitation systems play a critical role in sustaining rural habitation and economic activity, yet they also represent a significant source of diffuse pollution when inadequately designed, maintained, or supervised. Evidence from the Nordic countries indicates that a substantial proportion of existing systems fail to meet current treatment requirements, while in Scotland the true performance and environmental impact of many systems remain uncertain due to historical under-registration and limited monitoring (Laukka et al., 2022; Lawson et al., 2024).

Despite these challenges, all four countries operate within relatively advanced environmental governance contexts, with strong overarching commitments to water quality protection and public health. The key differences lie not in policy intent but in how on-site sanitation is framed institutionally, regulated legally, and supported in practice. These differences provide a valuable basis for comparative analysis, enabling the identification of governance arrangements that enhance compliance, equity, and environmental performance.

The sections that follow examine these governance dimensions in detail, beginning with a comparison of regulatory and legal frameworks, before moving on to institutional arrangements, enforcement mechanisms, financing structures, data systems, and stakeholder capacity.

## Regulatory and Legal Frameworks for On-Site Sanitation

All four countries examined in this report have established legal frameworks aimed at controlling pollution from wastewater systems located outside centralised sewer networks. However, the legal form, degree of prescriptiveness, and allocation of responsibility differ markedly between the Nordic countries (Finland, Sweden, Norway) and Scotland. These differences shape not only environmental outcomes but also the practical governability of on-site sanitation systems.

Across the Nordic countries, on-site sanitation is treated as an integral component of national wastewater regulation and environmental regulatory frameworks, embedded within environmental protection law and supported by explicit treatment performance requirements, although the legal force and implementation model differ between Finland, Sweden and Norway. In contrast, Scotland regulates on-site sanitation primarily through a risk-based environmental permitting system, with fewer nationally standardised performance thresholds and a stronger emphasis on siting, design, and discharge controls rather than numeric treatment outcomes. This distinction has important implications for compliance, enforcement, and equity.

### Finland: binding national performance standards

Finland operates one of the most explicit and legally binding regulatory regimes for on-site sanitation in Europe. The core legal instruments are the Environmental Protection Act (527/2014), Chapter 16, and the Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (157/2017), supplemented by the Water Act and the Land Use and Building Act and supported by related planning, building and water services legislation (Laukka et al., 2022).

The Finnish framework applies to on-site wastewater systems serving up to 100 population equivalents (PE) and establishes nationally uniform minimum treatment performance requirements. Two protection levels are defined:

- **Standard level:** minimum 80% reduction in biochemical oxygen demand (BOD), 70% phosphorus (P) removal, and 30% nitrogen (N) removal.
- **High protection level:** minimum 90% BOD, 85% P, and 40% N removal, applicable in environmentally sensitive areas such as shore zones and groundwater protection areas.

These numeric standards are legally binding and apply regardless of the specific technology chosen. New buildings have been required to comply since the mid-2000s, while older properties were granted transition periods, with limited exemptions available on social or technical grounds (e.g. advanced age of residents, minimal wastewater generation).

A distinctive feature of the Finnish approach is the inclusion of nitrogen removal requirements in national treatment standards, alongside phosphorus and organic matter reductions. These requirements apply broadly to on-site systems outside sewered areas and reflect the role of decentralised wastewater in nutrient loading pressures on receiving waters (Laukka et al., 2022; Government Decree 157/2017).

### Sweden: flexible standards through general advice

Sweden regulates on-site sanitation primarily through the Swedish Environmental Code (SFS 1998:808) and the Ordinance Concerning Environmentally Hazardous Activities and Protection of Public Health (SFS 1998:899). Detailed technical guidance is provided through General Advice (NFS 2006:7), originally issued by the Swedish Environmental Protection Agency and subsequently adopted by the Swedish Agency for Marine and Water Management (HaV/SwAM) after responsibility shifted in 2011 (Laukka et al., 2022).

These General Advice documents establish recommended treatment performance levels, typically distinguishing between:

- **Normal protection level** (approx. 90% BOD, 70% P removal), and
- **High protection level** (approx. 90% BOD, 90% P removal, with nitrogen reduction required where locally justified).

While not legally binding, the General Advice are widely used by municipalities as the basis for permit decisions. Swedish municipalities have substantial discretion to determine which protection level applies within their jurisdiction, allowing standards to be tailored to local environmental sensitivity (e.g. coastal zones, drinking water catchments).

A notable feature of the Swedish framework is that on-site sanitation may include systems serving up to 200 PE, meaning that some small collective or utility-operated systems can fall within the same regulatory category as household-scale systems. This creates a wider regulatory definition of on-site sanitation than in Finland or Norway, where the relevant thresholds are lower (Laukka et al., 2022).

The Swedish approach gives municipalities considerable discretion in translating national guidance into permit conditions. This flexibility allows local adaptation but can also contribute to variation in enforcement practice and compliance outcomes across municipalities.

#### Norway: nationally defined sensitivity classes

Norway regulates on-site sanitation through the Pollution Control Act and associated Pollution Control Regulations, which set legally binding national requirements for wastewater discharges outside sewer networks (Laukka et al., 2022).

The Norwegian framework applies to systems up to 50 PE and differentiates requirements based on environmental sensitivity, categorising areas as:

- **Less sensitive areas:** minimal requirements, often satisfied by sedimentation alone.
- **Normal areas:** minimum 70% BOD and 60% P reduction.
- **Sensitive areas:** stringent requirements, typically 90% P removal and 70–90% BOD reduction, with nitrogen removal imposed in selected catchments.

Unlike Sweden, these categories are largely predefined at the national level, though municipalities retain discretion to impose stricter conditions where justified. Installation of on-site systems generally requires both a discharge permit and a building permit, reinforcing the integration of environmental and construction controls.

Norway places particular emphasis on professional competence, requiring certified designers and installers for most systems and, in some cases, formal maintenance contracts for advanced treatment units. This regulatory design seeks to reduce failure at the installation stage and improve long-term performance (Laukka et al., 2022).

#### Scotland: risk-based environmental regulation

In Scotland, on-site sanitation is regulated under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR), administered by the Scottish Environment Protection Agency (SEPA). Rather than prescribing national numeric treatment performance standards, the Scottish framework relies on a registration and licensing system linked to environmental risk (Lawson et al., 2024).

Small domestic sewage discharges (typically serving fewer than 15 properties or <50 PE) are authorised through registration, subject to compliance with General Binding Rules, while larger or higher-risk

discharges require a bespoke licence. Regulatory attention focuses on siting, system design, and prevention of pollution, with particular emphasis on proximity to water bodies, groundwater vulnerability, and cumulative impacts.

Building standards legislation further governs system construction, including tank sizing, drainage field design, and minimum separation distances. However, once installed, ongoing responsibility for operation and maintenance rests almost entirely with property owners, and Scottish Water has no mandate over on-site systems (Lawson et al., 2024).

Recent evidence suggests that a substantial proportion of septic tanks historically remained unregistered, limiting regulatory visibility and enforcement capacity (Lawson et al., 2024). While Scotland's approach is administratively efficient and proportionate, the lack of explicit national performance benchmarks may weaken clarity for owners and complicate systematic compliance assessment.

### Comparative insights

Taken together, the four cases reveal two broad regulatory models:

1. **Performance-based national standards** (Finland, Norway; partially Sweden), where treatment outcomes are explicitly defined and legally enforceable; and
2. **Risk-based environmental permitting** (Scotland), where compliance is assessed primarily through siting, system type, and pollution prevention rather than measured treatment efficiency.

The Nordic experience demonstrates that binding standards provide clarity and legal certainty, but do not automatically ensure compliance without adequate inspection and owner support. Scotland's model offers flexibility and proportionality but risks fragmentation and uneven outcomes in the absence of robust data, monitoring, and guidance.

For the Decentralised Water Technologies project, this comparison highlights that regulatory design is not merely a technical choice but a governance decision with direct implications for equity, enforceability, and long-term environmental protection.

### Institutional and Organisational Arrangements

While regulatory frameworks define legal obligations and environmental objectives, it is institutional and organisational arrangements that determine whether on-site sanitation governance functions effectively in practice. Across Finland, Sweden, Norway, and Scotland, on-site sanitation is governed through multi-level institutional systems involving national ministries, regulatory agencies, local authorities, and private actors. However, the allocation of roles, coordination mechanisms, and levels of institutional support vary substantially, shaping implementation capacity, compliance, and equity outcomes.

A shared characteristic across all four countries is that on-site sanitation is not delivered as a public utility service in the same manner as centralised sewerage. Instead, responsibility is fragmented across environmental regulation, building control, and private ownership. The key difference lies in how far national and local institutions actively support, supervise, and integrate on-site sanitation within the wider water governance system.

### Finland: shared responsibilities with national coordination

In Finland, governance of on-site sanitation involves clear role differentiation between national, regional, and municipal authorities, supported by strong coordination mechanisms (Laukka et al., 2022).

At the national level, the Ministry of the Environment is responsible for policy development and legislation, while the Finnish Environment Institute (SYKE) plays a central role in research, technical guidance, and knowledge dissemination. SYKE has been particularly influential in translating regulatory requirements into accessible guidance for municipalities, property owners, and service providers.

At the regional level, the Centres for Economic Development, Transport and the Environment (ELY Centres) supervise and guide municipalities, handle appeals, and may grant exemptions in special cases. This intermediate tier provides technical and legal backstopping, reducing the burden on small municipalities.

Municipalities themselves hold the primary responsibility for implementation. Typically, duties are divided between:

- **municipal building control authorities**, which issue building permits and approve system design; and
- **municipal environmental authorities**, which supervise environmental compliance and manage exemptions.

Importantly, Finland deliberately separates regulatory oversight from system design, discouraging municipalities from providing technical design services in order to preserve regulatory impartiality. Property owners are responsible for operation and maintenance, often supported by private consultants and licensed waste contractors. The Finnish institutional model is characterised by strong national guidance and regional support, which partially compensates for limited municipal capacity.

### Sweden: strong municipal autonomy and enforcement responsibility

Sweden's institutional arrangement places strong responsibility at the municipal level, with local authorities responsible for permitting, supervision, and enforcement of on-site systems (Laukka et al., 2022).

National agencies, notably the Swedish Agency for Marine and Water Management (Havs och Vattenmyndigheten, HaV), provide policy direction and issue guidance, but day-to-day governance of on-site sanitation rests almost entirely with municipal environmental and health authorities. These authorities are responsible for:

- permitting new and upgraded on-site systems,
- determining applicable protection levels,
- supervising compliance, and
- enforcing corrective measures where standards are not met.

Unlike Finland, Swedish municipalities typically combine permitting and supervision within the same department. A distinctive institutional feature is the legal requirement for municipalities to adopt multi-year supervision plans for on-site sanitation, ensuring that inspection and enforcement are planned rather than purely complaint-driven.

Regional County Administrative Boards provide oversight of municipal performance and offer technical support but do not intervene routinely. This institutional design grants municipalities significant discretion but also exposes disparities in capacity and political prioritisation. Larger municipalities with

environmental expertise tend to implement systematic inspection regimes, while smaller or resource-constrained municipalities often struggle to fulfil their supervisory role.

### Norway: professionalisation and technical oversight

Norway's institutional framework combines strong municipal authority with an explicit emphasis on professional competence and technical standardisation (Laukka et al., 2022).

National policy is set by the Ministry of Climate and Environment, with technical guidance and coordination provided by the Norwegian Environment Agency. Unlike Finland, Norway has a less prominent regional tier, and responsibility is concentrated at the municipal level.

Municipalities act simultaneously as:

- pollution control authorities issuing discharge permits; and
- building authorities approving system construction.

This dual role is legally separated but often administered by the same small teams in rural municipalities. To compensate for limited administrative capacity, Norway places significant responsibility on the private sector, requiring certified professionals to design, install, and in some cases maintain on-site systems. Industry organisations such as Norsk Vann and research institutions like NIBIO play a crucial role in producing manuals, training materials, and standardised procedures.

This emphasis on professionalisation reflects a governance strategy that seeks to prevent non-compliance upstream, by reducing installation errors and ensuring adequate maintenance, rather than relying solely on inspection and sanctions.

### Scotland: fragmented institutional responsibility

In Scotland, institutional responsibility for on-site sanitation is more fragmented than in the Nordic countries, reflecting historical governance arrangements and the strong separation between centralised and decentralised services (Lawson et al., 2024).

Environmental regulation of on-site sewage discharges is the responsibility of the Scottish Environment Protection Agency (SEPA), which administers registration and licensing under the Controlled Activities Regulations. SEPA's role is primarily regulatory and risk-based, with limited routine inspection capacity for domestic systems.

Local authorities play a secondary but important role through:

- **Planning departments**, which assess development proposals and enforce sewer connection requirements<sup>3</sup>; and
- **Building Standards departments**, which approve the technical design and installation of septic tanks and drainage systems.

Once systems are installed, responsibility for operation and maintenance rests primarily with property owners. No public body provides universal ongoing operational oversight or support for on-site systems, although limited services—such as septic tank emptying—may be offered on a commercial basis by providers including Scottish Water, subject to local capacity and access constraints. Scottish Water does not have a regulatory or service obligation for private on-site systems, creating a clear institutional boundary between centralised and decentralised wastewater services.

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<sup>3</sup> In practice, however, stakeholders report challenges in verifying connection commitments at the planning stage, particularly where developers indicate future connection to sewer networks that may not materialise in implementation (Environmental Officer, private communication).

Evidence from Scotland indicates that this fragmented institutional landscape contributes to limited monitoring, weak feedback loops, and persistent inequalities between urban populations served by public utilities and rural households responsible for their own sanitation infrastructure (Lawson et al., 2024).

### Cross-country comparison and institutional implications

Across all four countries, municipalities and property owners are central actors in on-site sanitation governance. However, the degree of institutional support, coordination, and professionalisation differs markedly.

The Nordic countries demonstrate that strong municipal responsibility can be effective only when supported by national guidance, technical backstopping, and professional service ecosystems. Finland's regional support structures and Norway's competence requirements partially mitigate the challenges of governing dispersed systems. Sweden's reliance on municipal autonomy highlights both the strengths and vulnerabilities of decentralised enforcement.

Scotland's institutional model, by contrast, places comparatively greater responsibility on individual owners within a risk-based regulatory framework, with limited institutional capacity for proactive supervision or support. This arrangement reduces administrative burden but also constrains the effectiveness of governance in practice.

These institutional differences help explain observed variations in compliance, data availability, and environmental outcomes, and underscore the importance of aligning regulatory ambition with institutional capacity—an issue explored further in the following section on Compliance and Enforcement Mechanisms.

### Compliance and Enforcement Mechanisms

Across all four countries examined, a persistent challenge in on-site sanitation governance is the gap between regulatory intent and actual compliance. Although legal frameworks define treatment requirements and institutional responsibilities, evidence consistently indicates that a substantial proportion of on-site sanitation systems do not meet applicable standards (Laukka et al., 2022). This compliance gap reflects not only technical failures but also the inherent difficulty of enforcing environmental regulation across large numbers of small, privately operated systems dispersed over rural landscapes—a challenge widely recognised in the governance of decentralised environmental systems (Mazur, 2011; Reymond et al., 2020).

Compliance and enforcement mechanisms vary considerably between Finland, Sweden, Norway, and Scotland, shaped by differences in legal design, inspection regimes, institutional capacity, and the balance between punitive and supportive regulatory approaches.

#### Finland: formal obligations with limited systematic inspection

In Finland, compliance with on-site sanitation requirements is legally mandatory and clearly defined through nationally binding performance standards. In principle, municipalities possess the authority to require system upgrades, issue enforcement orders, and apply sanctions where treatment requirements are not met (Laukka et al., 2022).

In practice, however, systematic inspection of existing installations is limited. Municipal enforcement activities are often triggered by:

- applications for building permits or major renovations,

- changes in property ownership,
- complaints from neighbours, or
- observed pollution incidents.

Routine inspections of all on-site systems are uncommon due to limited municipal resources and the logistical challenges of accessing remote properties. As a result, compliance is frequently inferred indirectly from system age or type rather than verified through effluent monitoring. National estimates suggest that more than half of systems subject to treatment requirements fail to meet them, particularly older installations relying solely on septic tanks without secondary treatment (Laukka et al., 2022).

Finland's experience illustrates the limits of performance-based regulation without an accompanying inspection infrastructure, even where legal clarity is high.

### Sweden: planned supervision with uneven implementation

Sweden adopts a more explicitly structured approach to enforcement by requiring municipalities to develop multi-year supervision plans for on-site sanitation. These plans are intended to prioritise inspections based on environmental risk and system age, thereby introducing a degree of predictability and strategic focus into enforcement (Laukka et al., 2022).

Municipal environmental authorities have the power to:

- deny permits for non-compliant systems,
- issue improvement notices,
- impose deadlines for upgrades, and
- levy fines or other sanctions in cases of persistent non-compliance.

Despite this formal structure, enforcement outcomes vary substantially across municipalities. Larger or environmentally sensitive municipalities tend to conduct more frequent inspections, while smaller or resource-constrained municipalities often struggle to implement their supervision plans in full. As in Finland, direct measurement of effluent quality is rare, and compliance assessments rely heavily on system characteristics and documentation.

Studies indicate that a majority of inspected systems do not fully meet applicable protection levels, highlighting persistent compliance challenges despite Sweden's comparatively proactive regulatory design (Laukka et al., 2022).

### Norway: professionalisation as a compliance strategy

Norway's compliance strategy places relatively less emphasis on routine inspection and greater emphasis on preventive enforcement through professionalisation. Municipalities issue discharge permits and building approvals, but enforcement activities are often integrated into the permitting and installation process rather than applied retrospectively (Laukka et al., 2022).

Key compliance mechanisms include:

- mandatory use of certified professionals for system design and installation,
- requirements for maintenance contracts for certain advanced treatment systems,
- and coordination between building control and environmental authorities at the municipal level.

While municipalities retain the power to impose sanctions or require corrective action, proactive inspection of existing systems is uneven and largely complaint-driven. National surveys suggest that non-compliance remains widespread, particularly among older systems installed before current regulations were introduced (Laukka et al., 2022). However, Norway's emphasis on competence requirements seeks to reduce future non-compliance by addressing technical failures at source.

### Scotland: risk-based authorisation and reactive enforcement

In Scotland, compliance and enforcement are structured around a risk-based environmental authorisation system rather than routine inspection. Under the Controlled Activities Regulations, all private sewage discharges must be registered or licensed, and legal responsibility for compliance rests with the system owner (Lawson et al., 2024).

SEPA has the authority to:

- impose conditions on registrations and licences,
- require system upgrades where pollution occurs,
- issue enforcement notices, and
- prosecute in cases of serious or repeated non-compliance.

However, routine inspection of domestic septic systems is not standard practice. Enforcement is typically triggered by pollution incidents, complaints, development activity, or information emerging through registration processes. Historical under-registration<sup>4</sup> has further constrained enforcement capacity, as regulators cannot target systems that are not visible in official records.

As a result, compliance outcomes for septic systems are difficult to quantify, but available evidence suggests that many legacy systems would not meet contemporary environmental protection expectations. The Scottish experience highlights the limitations of a regulatory model that relies heavily on owner responsibility and post-hoc intervention in the absence of systematic monitoring (Lawson et al., 2024).

### Cross-country comparison: common constraints and divergent strategies

Across all four countries, several common patterns emerge:

- **Low inspection frequency** relative to the number of systems undermines deterrence.
- **Indirect compliance assessment** (based on system type or age) substitutes for effluent monitoring.
- **High upgrade costs** discourage voluntary compliance in the absence of enforcement.
- **Limited sanctioning** reduces the perceived risk of non-compliance.

At the same time, the countries differ in how they attempt to address these constraints. Sweden emphasises planning and systematic supervision, Finland relies on clear legal obligations, Norway prioritises professional competence, and Scotland adopts proportionality through risk-based authorisation.

The evidence suggests that no single enforcement mechanism is sufficient. Effective compliance depends on a combination of:

- system visibility through registration and data systems,

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<sup>4</sup> See note n. 3.

- risk-based inspection strategies,
- credible enforcement powers,
- enforced building and installation standards at the point of construction,
- regular maintenance and desludging, often supported by professional service providers,
- and supportive measures that enable owners to comply.

These findings underscore the importance of aligning enforcement mechanisms with institutional capacity and social realities, a theme that becomes even more salient when examining financing and economic instruments, the focus of the next section.

## Financing and Economic Instruments

Financing arrangements play a decisive role in shaping the effectiveness and equity of on-site sanitation governance. Unlike centralised sewerage systems—typically financed through public investment, user tariffs, and cross-subsidisation—on-site sanitation systems in all four countries examined are largely treated as private assets, with capital and operational costs borne primarily by individual property owners. This financing model has profound implications for compliance, system performance, and rural equity.

Across Finland, Sweden, Norway, and Scotland, regulatory frameworks impose legal obligations on owners to install, upgrade, and maintain on-site systems, yet financial support mechanisms are generally limited, fragmented, or absent. As a result, economic constraints frequently undermine the translation of regulatory ambition into real-world outcomes.

### Finland: owner responsibility with limited targeted support

In Finland, the legal responsibility for financing on-site sanitation systems rests squarely with property owners. Costs include system design, installation, upgrading to meet performance standards, routine maintenance, and periodic sludge removal. These costs can be substantial, particularly where advanced treatment systems or phosphorus-removal units are required in sensitive areas.

While Finland has occasionally deployed targeted financial instruments, such as temporary subsidies or tax deductions for system upgrades, these measures have been limited in scope and duration (Laukka et al., 2022). Municipalities do not generally provide direct financial assistance, and there is no national, permanent grant scheme dedicated to on-site sanitation upgrades.

The absence of sustained financial support has contributed to widespread delays in compliance, particularly among:

- elderly homeowners,
- owners of low-value rural properties, and
- seasonal cottage owners with limited incentive to invest in high-cost treatment systems.

Although Finland's regulatory framework allows for exemptions or extended compliance timelines on social grounds, these mechanisms address affordability indirectly rather than reducing the financial burden itself.

### Sweden: decentralised financing with uneven local instruments

Sweden follows a similar principle of owner-financed on-site sanitation, but with greater municipal variation in the use of economic instruments. Installation and upgrade costs are borne by property owners, while routine sludge removal is often organised municipally and financed through service fees.

Some Swedish municipalities have experimented with local financial instruments, including:

- low-interest municipal loans,
- coordinated procurement arrangements to reduce unit costs,
- or advisory services designed to help owners select cost-effective solutions.

However, these initiatives are not nationally coordinated and depend heavily on local political priorities and fiscal capacity (Laukka et al., 2022). As a result, access to financial support varies significantly between municipalities, reinforcing spatial inequalities.

Importantly, Sweden's reliance on municipal enforcement without consistent financial assistance has generated resistance among property owners in some areas, particularly where stricter protection levels are imposed without corresponding economic support.

### Norway: selective incentives and cost-sharing experiments

Norway's financing model likewise places primary responsibility on property owners, but it has made more selective use of targeted economic incentives, particularly in environmentally sensitive catchments. In some regions, homeowners have been eligible for:

- partial subsidies for installing enhanced phosphorus-removal systems,
- support for upgrading failing systems near vulnerable water bodies, or
- participation in coordinated upgrading schemes.

These measures are typically geographically targeted and time-limited, rather than embedded in a national financing framework (Laukka et al., 2022). Norway's emphasis on professional design and installation also increases upfront costs, although proponents argue that this reduces long-term failure and maintenance expenses.

Despite these efforts, affordability remains a barrier for many households, especially in remote areas with low property values and high construction costs.

### Scotland: minimal financial support and structural inequity

In Scotland, the financing of on-site sanitation systems is almost entirely privatised. Property owners are responsible for all costs associated with installation, registration or licensing, maintenance, desludging, and system replacement. Unlike users of centralised sewerage, on-site system owners do not benefit from tariff-based cost spreading or public investment in infrastructure.

Limited financial assistance exists in Scotland, but it is narrowly focused and insufficient to address sanitation costs directly. For example, grants are available for improving private water supplies, but there is no equivalent national grant scheme dedicated specifically to septic tank or on-site wastewater upgrades (Lawson et al., 2024). This asymmetry reinforces a governance divide between drinking water and wastewater services in rural areas.

The absence of robust financial instruments has several consequences:

- delayed upgrades of non-compliant systems,

- continued operation of ageing infrastructure,
- increased risk of pollution incidents, and
- heightened inequity between urban households connected to public sewerage and rural households responsible for private systems.

From a governance perspective, Scotland's financing model relies heavily on voluntary compliance and owner willingness to invest, despite limited economic incentives and weak enforcement.

### Comparative assessment: financing and compliance outcomes

Across all four countries, a consistent pattern emerges: high compliance costs combined with limited financial support undermine regulatory effectiveness. Even where legal obligations are clear and environmental risks are recognised, property owners frequently postpone or avoid investment due to affordability concerns.

The comparative evidence suggests several key insights:

- Regulatory stringency without financial support produces resistance and non-compliance.
- Targeted subsidies and cost-sharing arrangements can improve compliance, but only where they are predictable and well-communicated.
- Treating on-site sanitation as a purely private responsibility overlooks its collective environmental and public-health implications.

These findings point to a fundamental governance tension: on-site sanitation delivers public environmental benefits, yet is financed almost exclusively through private expenditure. Without mechanisms to reconcile this mismatch, compliance gaps are likely to persist.

### Implications for policy design

The financing experiences of Finland, Sweden, Norway, and Scotland suggest that effective on-site sanitation governance requires integrating economic instruments into regulatory and institutional frameworks. Potential options include:

- targeted grants or low-interest loans for upgrades in high-risk areas, particularly for low-income and vulnerable households,
- cost-sharing mechanisms coordinated at municipal or regional level,
- linking financial support to compliance milestones or maintenance contracts, and
- exploring service-based models that reduce individual financial burdens.

These considerations are particularly relevant for Scotland, where emerging policy agendas around equity, resilience, and decentralised water technologies provide an opportunity to reframe on-site sanitation financing as a matter of public value rather than private obligation alone.

The next section examines how technical standards and system types interact with governance and financing arrangements to shape environmental performance.

### Technical Standards and System Types

Technical standards are a central mechanism through which governance objectives for on-site sanitation are operationalised. They translate abstract environmental protection goals into concrete design requirements, performance thresholds, and operational expectations for treatment systems. Across

Finland, Sweden, Norway, and Scotland, technical standards play a dual role: they define what constitutes “adequate treatment” and shape which technologies are considered acceptable in different environmental and spatial contexts.

Despite this shared function, the four countries adopt distinct regulatory philosophies. The Nordic countries rely predominantly on performance-based standards, expressed through pollutant removal efficiencies or effluent quality thresholds, whereas Scotland emphasises design- and site-based standards, enforced through building regulations and risk-based discharge controls. These differences have significant implications for system selection, compliance monitoring, and long-term performance.

### Finland: nationally defined performance requirements

Finland applies one of the most explicit and uniform performance-based approaches to on-site sanitation among the countries studied. National legislation specifies minimum removal efficiencies for organic matter (BOD), phosphorus, and nitrogen, with two levels of requirement—standard and high—depending on environmental sensitivity (Laukka et al., 2022).

Under this framework, acceptable system types include:

- septic tanks combined with secondary treatment (e.g. sand filters or infiltration fields),
- packaged treatment plants,
- constructed wetlands (limited use),
- dry or composting toilets (mainly in seasonal dwellings).

Septic tanks without secondary treatment are widely used historically, but they are generally insufficient to meet current performance standards in regulated areas. Finland’s framework explicitly links system adequacy to treatment outcomes, not merely to system type. In principle, any technology capable of achieving the required removal efficiencies is acceptable.

However, empirical evidence indicates that actual system performance often falls short of regulatory targets, due to construction defects, poor maintenance, or inappropriate system selection. Cold winter conditions further affect biological treatment efficiency, although Finnish regulations assess compliance on an annual average basis, allowing seasonal variation (Laukka et al., 2022).

### Sweden: performance guidance with local discretion

Sweden’s technical standards for on-site sanitation are articulated through national “General Advice” rather than binding legislation. These guidelines define expected treatment levels—typically corresponding to high reductions in BOD and phosphorus, and nitrogen where locally required—but allow municipalities substantial discretion in implementation (Laukka et al., 2022).

Commonly permitted system types include:

- infiltration trenches and sand filter beds,
- septic tanks with secondary treatment,
- package treatment plants,
- holding tanks (limited use),
- alternative systems such as urine-diverting toilets in specific contexts.

Sweden’s emphasis on soil-based post-treatment systems reflects both hydrogeological suitability and long-standing practice. However, reliance on infiltration systems can pose risks in areas with shallow soils, high groundwater tables, or sensitive receiving waters.

As in Finland, a substantial proportion of systems fail to meet expected performance levels in practice. This underperformance is often attributed to ageing infrastructure, inadequate maintenance, and weak follow-up rather than inherent technological limitations (Laukka et al., 2022).

#### Norway: differentiated standards by environmental sensitivity

Norway employs a tiered technical standard system, explicitly linked to environmental sensitivity classifications. Treatment requirements range from minimal sedimentation in less sensitive areas to advanced nutrient removal in sensitive catchments, particularly those affecting drinking water sources (Laukka et al., 2022).

Permitted technologies include:

- septic tanks (acceptable only in low-sensitivity areas),
- soil infiltration systems,
- phosphorus-removal units,
- compact package treatment plants,
- advanced biological or chemical treatment systems in sensitive zones.

A distinctive feature of the Norwegian approach is the strong emphasis on professional design, installation, and in some cases maintenance, particularly for package plants. This requirement aims to reduce technical failure rates and improve long-term system performance.

Nonetheless, even in Norway, field evidence suggests that many systems do not consistently achieve their theoretical performance, underscoring the limits of technical standards in the absence of systematic monitoring and enforcement.

#### Scotland: design- and risk-based technical regulation

Scotland differs markedly from the Nordic countries in its approach to technical standards. Rather than specifying pollutant removal efficiencies, Scottish regulation focuses on:

- system design and construction standards,
- siting and separation distances,
- hydraulic loading and soil infiltration capacity,
- protection of water bodies through risk-based controls.

Technical requirements are enforced primarily through:

- Building (Scotland) Regulations and associated technical handbooks, and
- the Water Environment (Controlled Activities) Regulations (CAR), administered by SEPA.

Acceptable systems include:

- septic tanks with soakaway drainage,
- small package treatment plants,
- limited alternative systems (e.g. reed beds) subject to site suitability.

Environmental protection is achieved indirectly by requiring appropriate dispersion of effluent and prohibiting direct discharges where pollution risk is high. While this approach offers flexibility and reduces administrative burden, it also limits the ability to assess performance quantitatively and makes

compliance assessment more dependent on professional judgement and complaint-based investigation (Lawson et al., 2024).

### Comparative assessment: technology, standards, and outcomes

Across all four countries, septic tanks—often without advanced treatment—remain the most widespread system type, despite widespread recognition of their limited treatment efficiency. More advanced systems are available and permitted, but uptake is constrained by cost, awareness, and enforcement.

Several comparative insights emerge:

1. Performance-based standards provide clarity but require monitoring capacity: Finland and Norway clearly articulate what constitutes acceptable treatment, but weak monitoring undermines compliance.
2. Design-based standards reduce regulatory burden but obscure environmental performance: Scotland's approach prioritises feasibility and proportionality but lacks systematic evidence on actual pollutant reduction.
3. Technology alone does not guarantee outcomes: Across all cases, underperformance is often driven by poor installation, inadequate maintenance, and lack of user engagement rather than inappropriate technology choice.
4. Climate and geography matter: Cold temperatures, variable soils, and dispersed settlement patterns shape system viability and long-term effectiveness, reinforcing the need for context-sensitive standards.

### Implications for governance

The comparative evidence suggests that technical standards are most effective when embedded within supportive governance systems that include:

- professional competence requirements,
- routine inspection or maintenance obligations,
- accessible guidance for system owners,
- and alignment between technical expectations and financial capacity.

For Scotland, Nordic experience highlights the potential value of complementing design-based regulation with clearer performance expectations—at least in high-risk areas—while maintaining proportionality and flexibility. Conversely, Nordic countries may learn from Scotland's risk-based approach to tailoring technical requirements to local conditions.

The next section examines how data, monitoring, and information systems shape the capacity of authorities to implement and enforce these technical standards in practice.

## Data, Monitoring, and Information Systems

### Introduction: visibility as a precondition for governance

Reliable data and monitoring systems are foundational to effective governance of on-site sanitation. Without accurate information on the number, location, type, and condition of systems, regulators lack the ability to assess environmental risk, target enforcement, evaluate policy effectiveness, or plan investments. Across Finland, Sweden, Norway, and Scotland, deficiencies in data availability and

monitoring capacity consistently emerge as a core constraint, undermining even well-designed regulatory and institutional frameworks.

A central challenge common to all four countries is that on-site sanitation systems are small, privately operated, and spatially dispersed, making them inherently difficult to inventory and monitor. Consequently, governance systems often rely on partial registries, indirect indicators of compliance, or complaint-driven information flows.

#### **Finland: fragmented records and limited performance data**

In Finland, data on on-site sanitation systems are distributed across multiple administrative systems, including municipal building permit records, environmental permits, and waste management databases. While municipalities possess information on newly installed or upgraded systems, comprehensive national or regional registries of existing systems do not exist (Laukka et al., 2022) – with recent research indicating that this fragmentation persists (Nissilä, 2025).

Monitoring of system performance is largely indirect. Authorities typically infer compliance based on:

- system type and age,
- documentation submitted during permitting,
- or reports from waste hauliers during sludge removal.

Routine effluent sampling of domestic on-site systems is rare, due to both cost and logistical constraints. As a result, estimates of non-compliance rely on targeted studies and inspections rather than systematic monitoring. The Finnish case demonstrates how even detailed performance-based regulation can be undermined when data systems are insufficient to verify outcomes.

#### **Sweden: inspection planning without comprehensive inventories**

Sweden has taken steps to strengthen data visibility through its requirement that municipalities develop multi-year supervision plans for on-site sanitation. These plans necessitate that municipalities identify and prioritise systems for inspection, often based on age, location, or perceived environmental risk (Laukka et al., 2022).

Despite this, Sweden lacks a unified national database of on-site systems. Municipal records vary in quality and completeness, reflecting differences in historical permitting practices and administrative capacity. Performance monitoring similarly relies on visual inspections and documentation review, with direct effluent sampling used sparingly and primarily in problem cases.

While Sweden's planning requirements improve strategic oversight at the local level, the absence of standardised national data limits cross-municipal learning and comprehensive assessment of cumulative environmental impacts.

#### **Norway: system documentation and professional reporting**

Norway's data and monitoring approach is shaped by its emphasis on professional competence. Permitting processes require detailed technical documentation, and in some cases system owners must submit maintenance or service reports for advanced treatment units (Laukka et al., 2022).

Municipalities maintain records of permitted systems, but as in Finland and Sweden, legacy installations predating modern regulations are often poorly documented. Monitoring focuses on verifying that systems have been installed and maintained according to approved designs, rather than on routine measurement of effluent quality.

Although Norway benefits from relatively high-quality technical documentation for newer systems, overall data completeness remains uneven, particularly in remote municipalities with limited administrative resources.

### Scotland: registration-driven visibility with limited performance monitoring

Scotland's data infrastructure for on-site sanitation has improved in recent years through the expansion of mandatory registration of private sewage discharges under the Controlled Activities Regulations. This process has increased visibility of system locations and types, addressing a long-standing gap in regulatory oversight (Lawson et al., 2024).

However, registration data primarily capture existence and authorisation status, rather than operational performance. Routine monitoring of effluent quality from domestic septic systems is not standard practice. Enforcement and further investigation are typically triggered by:

- pollution complaints,
- development applications,
- or information arising during registration reviews.

As a result, Scotland faces a similar challenge to the Nordic countries: improved system visibility has not yet translated into systematic knowledge of environmental performance. Lawson et al. (2024) note that the true cumulative impact of septic systems on Scottish water bodies remains poorly quantified.

### Cross-country comparison: common data deficits

Across all four countries, several common patterns are evident:

- **Incomplete system inventories**, particularly for older installations.
- **Minimal routine performance monitoring**, with effluent sampling used only in exceptional cases.
- **Reliance on proxy indicators** (system age, type, location) rather than measured outcomes.
- **Fragmented data ownership**, spread across multiple authorities and administrative systems.

These limitations constrain the ability of regulators to implement risk-based regulation, evaluate policy effectiveness, and prioritise investment. They also hinder transparency and accountability, as neither policymakers nor the public can easily assess whether on-site sanitation systems are meeting environmental protection objectives.

### Implications for governance and policy

The comparative evidence indicates that strengthening data and monitoring systems is a prerequisite for improving on-site sanitation governance. Key implications include:

- **Registration is necessary but not sufficient**: knowing where systems exist is a critical first step, but governance requires additional information on condition and performance.
- **Risk-based monitoring offers a pragmatic pathway**: targeted inspections and sampling in high-risk areas can improve outcomes without imposing excessive administrative burdens.
- **Integration of data systems matters**: linking building permits, environmental registrations, and maintenance records could substantially improve oversight.
- **Digital tools and standardised reporting** hold promise for reducing monitoring costs and improving data quality.

For Scotland, the ongoing development of registration systems provides a foundation upon which more strategic, data-informed governance could be built, drawing on Nordic experience while remaining proportionate to institutional capacity.

The next section turns to stakeholder engagement and capacity, examining how awareness, professional competence, and user support shape the effectiveness of on-site sanitation governance.

## Stakeholders, Institutional Arrangements, and Capacity

Governance of on-site sanitation involves a complex constellation of actors operating across multiple administrative levels, including national ministries, environmental regulators, local authorities, private service providers, research institutions, civil society organisations, and—critically—property owners themselves. Across Finland, Sweden, Norway, and Scotland, on-site sanitation is governed through decentralised institutional arrangements in which primary responsibility for system operation rests with private owners, while regulatory oversight is exercised largely at the municipal or local level.

While these institutional architectures are relatively well defined in formal terms, comparative evidence shows that governance effectiveness depends not only on *who is responsible*, but also on *whether those actors possess the capacity, knowledge, resources, and incentives* to fulfil their roles in practice (Rogers & Hall, 2003; OECD, 2015). This section therefore integrates two dimensions of governance:

- (1) institutional roles and responsibilities,
- (2) and stakeholder engagement and operational capacity.

### Institutional roles and responsibilities by country

#### Finland

At the national level, the Ministry of the Environment establishes the legislative framework governing on-site sanitation, while the Finnish Environment Institute (SYKE) supports implementation through research, guidance, and national coordination initiatives. Regional Centres for Economic Development, Transport and the Environment (ELY Centres) provide supervisory oversight and guidance to municipalities and may adjudicate appeals or grant exceptions in specific cases.

At the local level, Finnish municipalities divide responsibilities between:

- **building control authorities**, which issue construction permits for new or replacement on-site systems, and
- **municipal environmental authorities**, which supervise environmental compliance and may grant exemptions or require system upgrades.

Property owners are legally designated as system operators and bear responsibility for compliance, maintenance, and upgrading where required. The private sector plays a significant role in system design, installation, and maintenance, although formal certification of designers and installers is recommended rather than mandatory. Sludge removal is typically organised through licensed waste hauliers operating under municipal waste management schemes.

#### Sweden

In Sweden, the Swedish Agency for Marine and Water Management provides national guidance and supports knowledge exchange, while County Administrative Boards oversee and support municipal implementation. However, municipalities are the central operational actors, exercising both permitting and supervisory authority over on-site sanitation systems.

Municipal environmental health departments:

- approve new installations and upgrades,
- set locally applicable treatment requirements based on national guidance,
- conduct inspections and enforcement,
- and are legally required to develop rolling supervision plans for on-site systems.

Property owners remain responsible for system operation and maintenance, typically arranging desludging services through municipally coordinated waste services. Private consultants and contractors are widely used, though not formally certified at the national level. Sweden also features a range of user cooperatives and small collective systems, which function similarly to utilities while remaining classified as on-site systems.

## Norway

Norway's governance model places strong emphasis on professional competence. National policy is set by the Ministry of Climate and Environment, with technical guidance issued by the Norwegian Environment Agency. Implementation is primarily municipal.

Municipalities issue:

- discharge permits under pollution control legislation, and
- building permits under planning and construction law.

Property owners are responsible for compliance but are generally required to engage accredited professionals for system design and installation. In many cases, municipalities also require maintenance contracts for advanced treatment systems. Sludge removal services are municipally organised but privately delivered, and service providers often function as informal monitoring agents by reporting observed deficiencies.

The Norwegian model is notable for its close collaboration between government agencies, research institutions (such as NIBIO), and sectoral organisations (notably Norsk Vann), which collectively produce extensive guidance materials and training resources.

## Scotland

In Scotland, governance of on-site sanitation is more fragmented institutionally. The Scottish Environment Protection Agency (SEPA) is the primary regulator of private sewage discharges under the Controlled Activities Regulations, maintaining the public register of systems and enforcing environmental compliance.

Local authorities play a more limited role, primarily through:

- **planning control**, determining whether connection to the public sewer is required or whether a private system is permissible, and
- **building standards**, ensuring that new systems meet technical design requirements.

Unlike the Nordic countries, Scotland's national water utility (Scottish Water) has no responsibility for on-site systems.<sup>5</sup> Property owners are fully responsible for registration, operation, maintenance, and compliance. The private sector provides (with limited supplementary services offered by Scottish Water

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<sup>5</sup> However, stakeholder evidence suggests that coordination between planning authorities and Scottish Water can present practical challenges, particularly in relation to verifying whether proposed connections to the public sewer network are ultimately realised in practice (Environmental Officer, private communication). See note n. 3.

on a commercial basis) installation, desludging, and maintenance services, but there is no dedicated national certification scheme specific to on-site sanitation professionals.

### Stakeholder engagement and capacity constraints

Across all four countries, comparative evidence highlights persistent capacity gaps that limit the effectiveness of formal institutional arrangements.

#### Property owners

Assigning operational responsibility to private owners assumes levels of technical knowledge and risk awareness that are frequently absent, particularly for older systems. Owners may be unaware of legal requirements, system limitations, or environmental impacts, leading to inconsistent maintenance and delayed upgrades. These challenges are especially pronounced in rural areas and among ageing populations.

#### Municipal and regulatory capacity

Local authorities are central to governance but often operate under severe resource constraints. Limited staffing, large rural territories, and competing priorities reduce inspection frequency and shift enforcement toward complaint-driven approaches. Even where inspection planning is mandated, as in Sweden, implementation remains uneven.

#### Professional competence

The competence of service providers varies considerably. Norway's mandatory professional requirements reduce installation errors and improve reliability, while Finland, Sweden, and Scotland rely more heavily on market dynamics and voluntary standards. In the absence of formal accreditation, system performance depends heavily on individual contractor quality.

#### Knowledge intermediaries

Civil society organisations, research institutes, and sectoral associations play a crucial role in translating regulation into practice. Finland's national guidance programme, Sweden's sectoral platforms, and Norway's collaborative manuals illustrate the value of sustained engagement infrastructures. Scotland has historically lacked equivalent intermediary capacity, though recent research-policy initiatives suggest growing momentum (Hendry & Akoumianaki, 2016).

### Comparative synthesis

The integrated analysis reveals that formal responsibility alone does not guarantee effective governance. Across the four countries:

- Property-owner responsibility requires structured support to avoid inequitable outcomes.
- Municipal capacity is a recurring bottleneck, regardless of regulatory stringency.
- Professionalisation of the service sector significantly improves system performance.
- Knowledge intermediaries are critical for building trust, competence, and compliance.

For Scotland, Nordic experience suggests that strengthening advisory services, professional pathways, and engagement mechanisms could substantially improve outcomes without fundamentally restructuring the regulatory framework. Scotland would benefit from developing similar intermediary capacity as in the Nordic examples, designed to minimize transitional costs and maximize efficiency in different conditions.

The next section examines compliance and enforcement outcomes, assessing how these institutional and capacity dynamics translate into actual environmental performance and regulatory effectiveness.

## Performance Outcomes and Environmental Impact

This section reviews available evidence on how on-site sanitation systems perform in practice across Finland, Sweden, Norway, and Scotland, focusing on compliance with regulatory expectations, impacts on water quality, and distributional implications (See Table 1 and Figure 2). While data availability varies significantly between countries, a consistent pattern emerges: on-site sanitation remains a major contributor to diffuse pollution, and governance systems struggle to translate formal standards into sustained environmental performance.

### Finland

In Finland, despite a nationally binding regulatory framework with defined pollutant removal targets, empirical evidence indicates substantial underperformance of on-site systems. According to national assessments summarised by Laukka et al. (2022), more than half of systems subject to treatment requirements fail to meet stipulated standards for organic matter, phosphorus, or nitrogen removal.

Environmental impacts are particularly pronounced in areas with dense concentrations of unsewered properties near lakes, groundwater aquifers, and coastal waters. On-site systems have been shown to contribute disproportionately to nutrient loads compared with sewer-connected households, undermining national objectives for eutrophication control. Seasonal use of leisure cottages further complicates performance, as intermittent loading and limited maintenance increase the likelihood of system malfunction.

Although Finland has invested heavily in guidance and awareness campaigns, the environmental benefits of regulatory reform have been slower to materialise than anticipated, largely due to incomplete upgrades and uneven enforcement.

### Sweden

Sweden exhibits a similar pattern of persistent non-compliance despite long-standing regulatory oversight. Studies cited by Laukka et al. (2022; Envall et al., 2023) estimate that approximately 50–70% of existing on-site systems do not achieve the performance levels recommended under national guidance, particularly with respect to phosphorus removal.

The environmental consequences are most evident in nutrient-sensitive catchments, including inland lakes and the Baltic Sea basin, where septic effluent contributes to eutrophication pressures. While Sweden's requirement for municipal inspection planning has improved visibility of system failures, actual remediation has been constrained by limited municipal resources and the high costs of system replacement for property owners.

Sweden's flexible, locally determined protection levels have enabled stricter controls in sensitive areas, but have also resulted in uneven outcomes across municipalities, with environmental performance strongly dependent on local enforcement capacity.

### Norway

In Norway, performance outcomes for on-site sanitation systems are highly variable and closely linked to local regulatory classification. Laukka et al. (2022) report non-compliance rates ranging from 50% to as high as 90% in some surveys, particularly for older septic systems located in areas subject to upgraded treatment requirements (see also Tiwari et al., 2025).

Environmental impacts are significant in fjords, lakes, and drinking water catchments, where nutrient and pathogen discharges from on-site systems pose risks to both ecosystems and public health. Cold climatic conditions exacerbate performance challenges, as freezing temperatures and reduced biological activity impair treatment efficiency in soil-based systems during winter months.

Norway's stronger emphasis on professional design and installation has improved the performance of newer systems, but legacy installations continue to dominate the overall environmental footprint of on-site sanitation.

### Scotland

In Scotland, evidence on performance outcomes is more limited and fragmented than in the Nordic countries. While registration under the Controlled Activities Regulations has improved regulatory visibility, there is no systematic national dataset on the operational condition or pollutant removal efficiency of domestic septic tanks.

Lawson et al. (2024) highlight that many Scottish on-site systems are legacy installations that would be unlikely to meet contemporary treatment expectations if assessed against Nordic-style performance criteria. Reported pollution incidents, combined with the historical under-registration of systems, suggest that environmental risks remain significant, particularly in rural and highland areas.

The environmental impacts of on-site sanitation in Scotland are compounded by reliance on private responsibility for operation and maintenance, limited inspection frequency, and weak incentives for proactive upgrades. As a result, performance outcomes depend heavily on individual owner behaviour rather than systematic governance.

### Cross-cutting observations

Across all four countries, several common patterns emerge:

- High non-compliance rates persist despite formal regulation.
- On-site systems contribute disproportionately to nutrient and pathogen pollution relative to their share of the population served.
- Environmental impacts are most acute in sensitive catchments, yet enforcement capacity is often weakest in remote rural areas.
- Performance outcomes are shaped less by technical standards alone than by inspection intensity, owner awareness, and financial capacity.

These findings underscore the need to treat on-site sanitation not as a marginal issue, but as a structurally important component of national water quality management strategies.

### Emerging Innovations and Good Practices

The preceding sections reveal a common set of implementation challenges across all four countries, including persistent non-compliance, limited monitoring capacity, affordability constraints, and uneven professional and user capacity. This section identifies governance, technical, and organisational innovations that have emerged in Finland, Sweden, Norway, and Scotland to address persistent challenges in on-site sanitation. Rather than focusing on novel technologies alone, the analysis emphasises institutional and governance practices that have demonstrated potential to improve compliance, environmental performance, and equity. These practices are particularly relevant for Scotland's Decentralised Water Technologies agenda, where improving outcomes depends as much on governance reform as on technical change.

## Finland

Finland has been a pioneer in developing service-oriented and advisory approaches to on-site sanitation governance. One of the most frequently cited good practices is the national on-site sanitation guidance programme coordinated by the Finnish Environment Institute (SYKE) and regional partners between 2011 and 2019. As documented by Laukka et al. (2022), this initiative mobilised environmental NGOs and regional actors to provide free, neutral, property-level advice to homeowners.

Rather than relying solely on enforcement, advisors visited households, assessed existing systems, explained legal requirements, and discussed technically and financially appropriate upgrade options. This approach improved awareness, reduced resistance to regulation, and helped property owners make informed decisions. While it did not eliminate non-compliance, it significantly strengthened the social legitimacy of on-site sanitation regulation.

Finland has also piloted alternative sanitation technologies—including composting toilets for leisure cottages, compact biofilters, and nature-based treatment systems—combined with systematic evaluation of their performance in cold climates. Importantly, underperforming solutions (such as willow evapotranspiration beds in northern regions) were openly reassessed and, where necessary, discouraged, illustrating a commitment to adaptive, evidence-based policy learning.

## Sweden

In Sweden, a notable governance innovation is the institutionalisation of mandatory municipal inspection planning. The requirement that each municipality adopt a rolling three-year supervision plan for on-site sanitation has increased the visibility of non-compliant systems and embedded inspection within routine municipal work (Laukka et al., 2022).

Although implementation capacity remains uneven, this planning requirement represents a shift from reactive enforcement toward systematic, risk-informed oversight. Some municipalities have further enhanced this approach by prioritising inspections in nutrient-sensitive catchments and coupling enforcement notices with technical guidance.

Sweden has also developed strong knowledge-exchange platforms, notably sector-wide guidance networks linking regulators, researchers, and technology suppliers. These platforms disseminate lessons from pilot projects, share inspection practices, and support continuous professional development for municipal staff (VA-guiden, 2024). While not eliminating governance disparities, such networks help reduce fragmentation and improve consistency across municipalities.

## Norway

Norway's most distinctive innovation lies in the professionalisation of on-site sanitation design, installation, and maintenance. National regulations require that systems be planned and constructed by qualified professionals, and many municipalities further require maintenance contracts for advanced treatment units. This competence-based approach aims to prevent failure at source by ensuring that systems are appropriately designed for site conditions and correctly installed.

Laukka et al. (2022) highlight the role of collaborative institutions—particularly national water and bioeconomy organisations—in producing comprehensive technical manuals and governance guidance for both regulators and practitioners (Norsk Vann, 2020). These materials standardise expectations across municipalities and reduce reliance on individual discretion.

In addition, some Norwegian municipalities have experimented with targeted financial incentives in sensitive catchments, offering partial subsidies or low-interest loans to support upgrades where

environmental benefits are greatest. Although not universal, these place-based instruments demonstrate how economic tools can complement regulatory controls.

### Scotland

In Scotland, innovation has been driven primarily through regulatory integration and risk-based approaches, rather than through prescriptive performance standards. The requirement to register all private sewage discharges under the Controlled Activities Regulations has laid the foundation for improved visibility of on-site sanitation systems, a critical precondition for effective governance (Lawson et al., 2024).

Scotland has also integrated on-site sanitation governance into building standards and planning controls, ensuring that new systems meet minimum siting and design requirements at the point of construction. This upstream intervention reduces the risk of future failure and shifts regulatory attention from remediation to prevention.

More recently, initiatives under the Decentralised Water Technologies programme and related research have begun to reframe on-site sanitation as part of a broader agenda encompassing rural equity, climate resilience, and human rights (Lawson & Amezaga, 2026). Lawson et al. (2024) note that Scotland's emerging policy discourse—particularly around the human right to water and sanitation and net-zero commitments—creates space for more proactive, service-oriented models of decentralised water management. This shift is also reflected in recent Scottish Parliament research and policy discussions on water resilience and equitable service provision (SPICe, 2025a; 2025b; 2025c)

Public awareness campaigns, such as guidance on septic tank maintenance and pollution prevention, represent further steps toward normalising on-site sanitation as a shared environmental responsibility rather than a purely private matter. Emerging initiatives such as the Rural Water Agenda provide accessible information and support for private water and wastewater users, helping to raise awareness and improve user practices (Rural Water Scotland, 2026). However, these initiatives remain relatively modest compared with Nordic advisory programmes.

### Cross-cutting lessons and relevance for Scotland

Across the four countries, several transferable lessons emerge:

- **Advisory and service-based approaches** (Finland) can complement regulation by improving owner understanding and acceptance.
- **Systematic inspection planning** (Sweden) enhances regulatory visibility and accountability, even where resources are constrained.
- **Professional competence requirements** (Norway) improve technical performance and reduce long-term failure risks.
- **Integrated, risk-based regulation** (Scotland) provides flexibility but requires stronger feedback loops to translate visibility into improved outcomes.

Taken together, these practices suggest that effective governance of on-site sanitation depends less on any single innovation than on bundling regulatory clarity, professional capacity, owner support, and data-driven oversight. For Scotland, Nordic experience points toward the value of expanding beyond registration toward advisory services, targeted inspections, and enhanced technical support—without abandoning the flexibility that characterises its current regulatory model.

## Conclusion: policy recommendation for Scotland

Based on the comparative analysis of governance arrangements in Finland, Sweden, Norway, and Scotland, several practical policy priorities emerge for improving the governance and environmental performance of on-site sanitation systems in Scotland.

### **1. Improve national inventories of on-site systems**

Establish more comprehensive and regularly updated records of septic tanks and other decentralised wastewater systems. Improved data visibility would enable regulators and local authorities to identify high-risk areas, target interventions, and support catchment-level environmental management.

### **2. Expand risk-based supervision strategies**

Strengthen targeted inspection and monitoring programmes in environmentally sensitive catchments and areas with high densities of on-site systems. Risk-based supervision can improve regulatory effectiveness without requiring universal inspection coverage.

### **3. Strengthen technical competence across the service chain**

Enhance expectations for professional design, installation, and maintenance of on-site systems. This could include clearer technical guidance, training programmes for installers and maintenance providers, and stronger professional standards for system design.

### **4. Improve guidance and support for property owners**

Develop accessible, user-focused advisory services to help property owners understand maintenance requirements, identify potential failures, and access professional support. Improved guidance can reduce non-compliance caused by lack of awareness or technical knowledge.

### **5. Address affordability and rural equity concerns**

Consider targeted financial support mechanisms for system upgrades or replacements where environmental risks are high and household resources are limited. Financial incentives can complement regulatory requirements and reduce resistance to necessary improvements.

### **6. Strengthen coordination across governance actors**

Improve coordination between environmental regulators, local authorities, and national policy institutions involved in decentralised wastewater management. More integrated governance arrangements can reduce fragmentation and support consistent regulatory outcomes. This should include ensuring that decentralised sanitation is fully integrated into national wastewater management strategies, rather than treated as a peripheral or residual service.

### **7. Develop intermediary service ecosystems for on-site sanitation**

Support the development of a structured network of intermediary actors—including certified designers, installers, maintenance providers, desludging services, and independent advisory organisations—to assist property owners in meeting regulatory requirements. Comparative evidence from Nordic countries suggests that effective governance of on-site systems depends not only on formal regulation, but also on the availability of competent professional and advisory services that translate regulatory requirements into practice. Strengthening these intermediary systems would reduce the burden on individual households while improving compliance and environmental performance.

### Message to Parliamentarians

Scotland's environmental ambitions, including commitments to protect water quality and support sustainable rural communities, depend not only on large-scale infrastructure but also on the effective governance of decentralised systems. Hundreds of thousands of households across Scotland rely on on-site wastewater treatment systems such as septic tanks. These systems are essential for rural housing and economic activity, yet their performance remains difficult to oversee due to incomplete data, fragmented institutional responsibilities, and limited inspection capacity.

The comparative evidence from Finland, Sweden, and Norway shows that these challenges are not unique to Scotland. However, it also demonstrates that governance improvements—particularly in data visibility, risk-based supervision, and support for system owners—can significantly strengthen environmental outcomes without requiring large-scale infrastructure investment.

For Scotland, the issue is not primarily technological but institutional. Improving oversight of decentralised wastewater systems would help protect rivers, lochs, and coastal waters while supporting rural households who depend on these systems. Addressing this governance gap aligns directly with Scotland's broader environmental objectives and its commitment to sustainable water management. Strengthening technical competence across the design, installation, and maintenance chain—and supporting the development of intermediary service networks that can assist property owners—will also be essential for ensuring consistent environmental outcomes.

Members of the Scottish Parliament have an important role to play in strengthening this area of policy. Parliamentary attention can help ensure that decentralised sanitation is recognised as a core component of Scotland's water infrastructure, deserving of the same strategic consideration as centralised systems. This may involve supporting improved system inventories, encouraging more coordinated governance arrangements, and ensuring that rural communities receive the guidance and support needed to maintain essential sanitation services.

Taking action in this area would contribute to protecting Scotland's water environment, strengthening rural resilience, and ensuring that environmental standards are applied fairly and effectively across both urban and rural contexts. Recognising and governing decentralised sanitation as a core component of Scotland's water infrastructure will help close an important policy gap and ensure that environmental protection standards are applied consistently across both urban and rural Scotland.

Table 1. Comparative Governance Matrix

Governance dimension	Finland	Sweden	Norway	Scotland
<b>1) Regulatory &amp; legal frameworks</b>	<ul style="list-style-type: none"> <li>National framework sets obligations for small systems</li> <li>Strong “public interest” framing (protect lakes/coastal waters; diffuse impacts).</li> </ul>	<ul style="list-style-type: none"> <li>National environmental framework + municipalised permitting logic; standards commonly implemented through local decisions</li> <li>Emphasis on tailoring requirements to sensitivity (local protection levels).</li> </ul>	<ul style="list-style-type: none"> <li>Binding national requirements for small discharges under Pollution Control Regulations; &lt;50 PE focus.</li> <li>Sensitivity zoning enables stricter local rules where WFD objectives not met.</li> </ul>	<ul style="list-style-type: none"> <li>Governed under CAR: authorisation via registration and licensing tied to environmental risk rather than national numeric effluent benchmarks.</li> <li>Domestic discharges: registration required for small septic tanks (&lt;15 PE); simple licence if serving &gt;9 domestic properties.</li> </ul>
<b>2) Institutions &amp; role allocation</b>	<ul style="list-style-type: none"> <li>Multi-level governance: national guidance + municipal implementation; owners/operators carry day-to-day responsibility.</li> </ul>	<ul style="list-style-type: none"> <li>Local authorities are the practical “engine room” (permits, follow-up), with national framework enabling discretion.</li> </ul>	<ul style="list-style-type: none"> <li>Municipalities supervise legislation and issue permits; local regulation can replace baseline requirements with stricter ones.</li> </ul>	<ul style="list-style-type: none"> <li>Scottish Water has no responsibility; responsibility sits with users/owners; regulation split across SEPA + local authorities.</li> </ul>
<b>3) Compliance &amp; enforcement</b>	<ul style="list-style-type: none"> <li>Compliance hinges on municipal capacity + owner behaviour.</li> </ul>	<ul style="list-style-type: none"> <li>Compliance model relies heavily on municipal follow-through; unevenness emerges from variable local capacity.</li> </ul>	<ul style="list-style-type: none"> <li>Permit requirement for new/expanded systems; municipalities can impose special conditions/prohibitions in specific areas.</li> </ul>	<ul style="list-style-type: none"> <li>Enforcement is structurally risk-based: authorisation conditions + pollution prevention; visibility depends on registration.</li> <li>Known governance challenge: maintenance failures are common drivers of risk.</li> </ul>
<b>4) Financing &amp; economic instruments</b>	<ul style="list-style-type: none"> <li>Owner-financed installations/upgrades dominate; equity stress arises where upgrade costs are high vs. property value.</li> </ul>	<ul style="list-style-type: none"> <li>Predominantly private financing; municipal variation in how costs/requirements fall on households.</li> </ul>	<ul style="list-style-type: none"> <li>Primarily owner-financed, with scope for targeted measures in sensitive areas.</li> </ul>	<ul style="list-style-type: none"> <li>Users bear routine costs; example: Scottish Water desludging service (priced per visit type).</li> <li>Structural issue: rurality increases service access costs (contractors, travel).</li> </ul>
<b>5) Technical standards &amp; system types</b>	<ul style="list-style-type: none"> <li>Technology choice must meet regulatory expectations; performance sensitive to site/operation.</li> </ul>	<ul style="list-style-type: none"> <li>Wide mix of systems; permitting often ties system choice to local sensitivity.</li> </ul>	<ul style="list-style-type: none"> <li>Explicit national removal requirements by sensitivity class</li> <li>Design must allow representative sampling/measurement in relevant cases.</li> </ul>	<ul style="list-style-type: none"> <li>Typical domestic model: septic tank + soakaway; effectiveness strongly depends on maintenance + design adequacy.</li> <li>Scotland regulates mainly through siting/design conditions within CAR authorisations rather than numeric effluent targets.</li> </ul>
<b>6) Data, monitoring &amp; information systems</b>	<ul style="list-style-type: none"> <li>Persistent issue: incomplete inventories/records + limited measured performance data.</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring constrained by incomplete inventories; inspection capacity often determines what is known.</li> </ul>	<ul style="list-style-type: none"> <li>Regulation anticipates documentation/measurement capacity (sampling/flow measurability for some units).</li> </ul>	<ul style="list-style-type: none"> <li>Registration creates baseline visibility but does not automatically create performance monitoring; historic evidence of weak maintenance visibility.</li> </ul>
<b>7) Stakeholder engagement &amp; capability</b>	<ul style="list-style-type: none"> <li>Governance requires owner understanding + competent installers; capacity gaps are a recurring bottleneck.</li> </ul>	<ul style="list-style-type: none"> <li>Heavy reliance on municipal interpretation means guidance/training ecosystems matter; capacity varies.</li> </ul>	<ul style="list-style-type: none"> <li>Strong professionalisation logic: “expert” design/build/operate expectations embedded in law for some discharges.</li> </ul>	<ul style="list-style-type: none"> <li>Scotland’s decentralised agenda links to rights, net-zero, and community empowerment framing;</li> </ul>
<b>8) Performance outcomes &amp; environmental impacts</b>	<ul style="list-style-type: none"> <li>Diffuse cumulative impacts on local water quality are a core policy concern; performance depends on upkeep and site conditions.</li> </ul>	<ul style="list-style-type: none"> <li>Environmental sensitivity (coastal/freshwater) makes nutrient/bacteria pressures salient; outcomes vary with local enforcement.</li> </ul>	<ul style="list-style-type: none"> <li>Risks include odour, bathing water reduction, hygienic issues; municipalities can intervene via conditions/prohibitions.</li> </ul>	<ul style="list-style-type: none"> <li>Public health risk pathway emphasised: malfunction often tied to design flaws + lack of desludging; septic risks correlate with waterborne disease pathways.</li> </ul>
<b>9) Emerging innovations &amp; good practices</b>	<ul style="list-style-type: none"> <li>Value of coordinated guidance/tooling to support local implementation (capacity-building as “innovation”).</li> </ul>	<ul style="list-style-type: none"> <li>Practice innovation often shows up as risk-based local tailoring + inspection planning cultures.</li> </ul>	<ul style="list-style-type: none"> <li>Local regulations can tighten standards where WFD objectives are not met—built-in adaptive mechanism.</li> </ul>	<ul style="list-style-type: none"> <li>Scotland’s “good practice” pathway is regulatory integration + registration-led visibility, and reframing decentralised systems within broader policy agendas (net-zero/rights/just transition).</li> </ul>

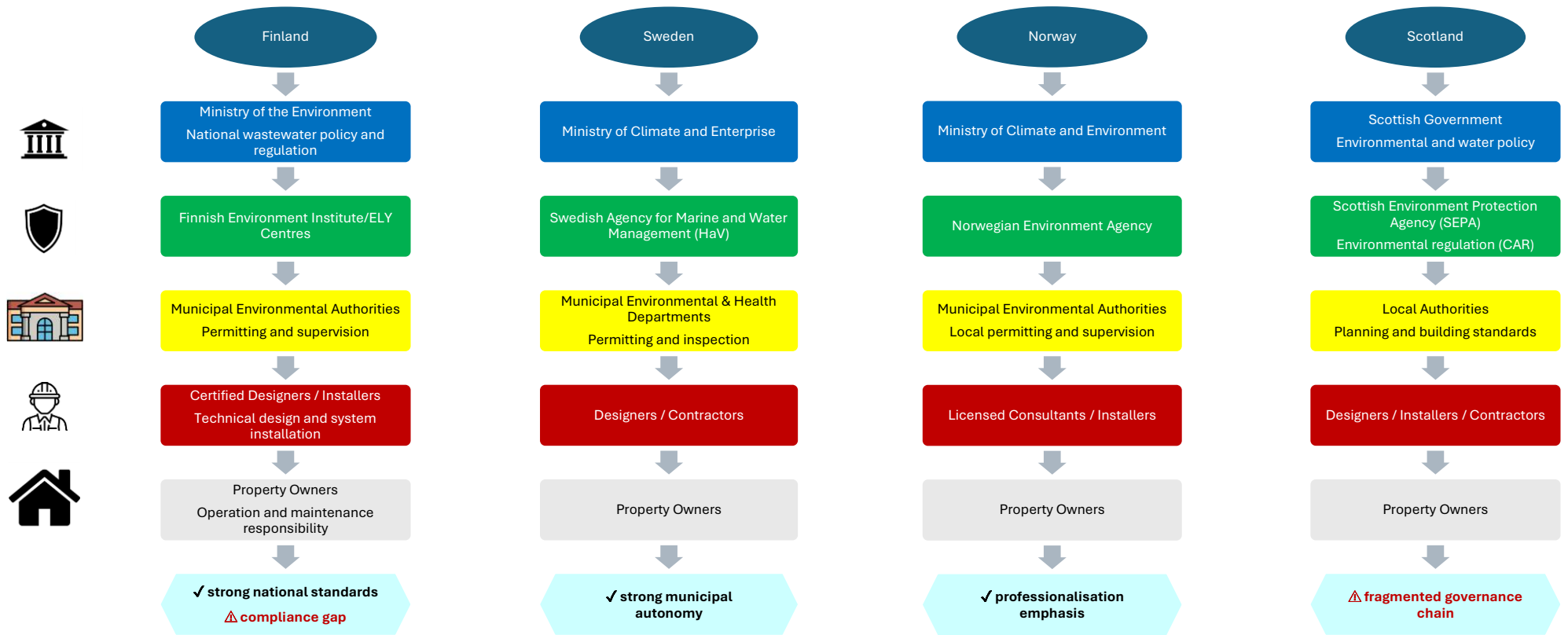


Figure 2. Institutional governance of on-site sanitation systems across Finland, Sweden, Norway and Scotland.

All four countries combine national regulatory frameworks with local implementation and private ownership of systems. However, governance authority is more strongly municipal in the Nordic countries, whereas Scotland relies on a combination of environmental regulation (SEPA), planning and building authorities, and owner responsibility. These structural differences influence inspection practices, data availability, and compliance outcomes.

- National policy / legislation
- Environmental regulator
- Local government
- Professional service providers
- Property owners

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