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An Enabling Environment for Asset Management through Public Policy: The Benefits of Standardization and Application to the Water Sector

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Abstract: Water services—including urban water supply, wastewater, and stormwater services—are essential to society and critical for protecting human health and the well-being of communities. Goal 6 of the United Nations (UN) Sustainable Development Goals (SDGs) recognizes this importance and aims to “ensure availability and sustainable management of water and sanitation for all.” Despite progress, the UN reports billions of people still lack water and sanitation services. Many governments around the world face the challenge of balancing between investment in new assets, programs, and services and providing the required funding for repair and replacement of existing water assets. This paper argues infrastructure asset management establishes a foundational framework for the system of operations, management, and importantly, governance of assets to deliver services. An enabling environment for asset management, in addition to supporting the delivery of services, also contributes to meeting public policy objectives. The research question is: How can governments utilize public policy to enable asset management and consequently achieve societal objectives. A variety of public policy instruments used to enable infrastructure asset management and support achievement of government goals and objectives, such as the UN SDGs, are outlined and analyzed. The methodology involved a survey and case studies drawn from three countries, focused on the water sector. It also presents outcomes, common elements, and the need for and benefits of standardization.

Keywords: public policy; asset management; standards; water services



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1. Introduction

The United Nations Sustainable Development Goals are often the reference framework for many countries to foster development and sustainability. Goals that are dependent on the successful management and performance of infrastructure assets such as Goal 6, *Clean Water and Sanitation*, can benefit from good asset management practices [1]. Asset management, as defined by the International Organization for Standardization (ISO), is the “coordinated activity of an organization to realize value from assets” [2]. The benefits of asset management include improved financial performance, informed decision-making, managed risk, and improved services and sustainability, among others [1,3]. The management system required to balance performance, costs, opportunities, and risks needs to be considered according to different timeframes. The sustained implementation of asset management, however, goes beyond the usage of a management system approach; it is also driven by the development, application, and coordination of public policy instruments that act as enablers for asset management, at a national and local level.

An enabling environment is a set of formal rules (i.e., laws, mandates, regulations) together with the conditions (e.g., physical conditions such as natural resources or non-physical conditions such as political, economic, and cultural conditions) that affect the achievement of objectives [4,5]. Application of certain public policy instruments can help shape this enabling environment for asset management practice as evidenced through research and case study examples (see Section 3.2). “A public policy instrument constitutes a device that is both technical and social, that organizes specific social relations between the state and those it is addressed to, according to the representations and meanings it carries. It is a particular type of institution, a technical device with the generic purpose of carrying a concrete concept of the politics/society relationship and sustained by a concept of regulation” [6]. For the purposes of understanding the enabling environment for asset management through public policy, public policy instruments are interventions typically implemented by government, which are intended to support the achievement of public policy objectives. At the highest level, public policy instruments are mandatory (e.g., constitutional or legislative), and this paper also acknowledges those that are voluntary in nature (e.g., incentive-based instruments, competence and capacity building programs, etc.) [7]. There may also be possible interdependencies, cascading impacts, and/or synergistic impacts when multiple public policy instruments are developed and applied in a coordinated or comprehensive manner.

Governments face several challenges regarding the delivery of public services, including balancing the need for new infrastructure versus the need to maintain existing infrastructure, often related to institutional infrastructure for social responsibility [8] and risk management [9]. This aspect is especially relevant for water services, considering that infrastructures behave as a system (e.g., an individual water pipe or sewer does not provide a service by itself and needs to provide a continuous service). Different life cycle stages co-exist, making it challenging to select the intervention alternative that provides the higher added value while ensuring water security. Adding to this, the water sector faces other specific transversal challenges regarding: the effects of climate dynamics; the increased need for water for agriculture and megacities (challenging water resources and ecosystems); the transition to circular economy (namely by reusing wastewater and recovering nutrients from sludge); and the use of IoT to better manage infrastructure [10,11]. Moreover, as infrastructure is mostly located underground, it has low social visibility, making it harder to communicate the need for investments. Nevertheless, water infrastructure planning and investments support other community infrastructure investments and sustainability goals, such as those related to health, transportation, and housing [12,13].

This paper contends that (i) asset management can help to materialize asset-related public policy objectives and (ii) public policy can bolster the delivery of such services that depend on assets especially relating to the water sector [14]. The authors also support strengthening the link between these aspects (public policy and asset management) through international guidance and standards, drawing on global research and case study development, as a step forward with multiple benefits for governments, asset owners/operators, and the public. Through the development of ISO 55011, *Guidance for the development and application of public policy to enable asset management*, International Organization for Standardization Technical Committee 251 Asset Management (TC251) has embarked on a project to support the adoption or improvement of asset management, develop knowledge about the range of public policy instruments able to be deployed, and identify those most able to direct these policy efforts.

The aim of this paper is to understand the links between public policy involving assets that are intended to support the delivery of public services (e.g., water services) and asset management and to better understand the need for a guidance standard on the topic. The methodology comprised a survey and three case studies in the water sector to understand how an enabling environment for asset management with associated public policy instruments may contribute to meeting public policy objectives.

2. Methods

2.1. Overview

Two main research methods were used: (i) a global survey and (ii) illustrative vignette case studies with examples in the water sector from around the world of the utilization of public policy instruments that enable asset management practices, and ultimately, achieve government service delivery objectives. The global survey was distributed to approximately 300 participants in the public sector. Contacts in the international standards community for asset management and public service organizations were approached as topic experts, and these experts were asked to source survey participants. The survey covers several industry sectors, the water sector being one of them. Illustrative vignettes as case study examples were selected to present a diverse and representative sample from different geographic regions and water sector perspectives (including municipal, wastewater, and water) [15]. The survey and case study methods are described and examined in the following subsections.

2.2. Asset Management and Public Policy Survey

A survey was administered through the ISO TC251 members to approximately 300 participants, with 110 completed surveys, giving a response rate of 33%.

The objectives of the survey were to:

1. Gather input from those who are involved with government on the challenges they face relating to the delivery of public services;
2. Determine if those who develop, administer, and/or influence the formation of public policy can benefit from guidance that may enhance their existing public policy;
3. Obtain input on what type of guidance would help promote or enable asset management, especially related to specific public policy instruments or applicable public policy documents.

The ISO 55011 Survey on Asset Management and Public Policy (referenced ISO/TC 251/N686) was launched online in November 2020, and responses were accepted through to January 2021. The survey was pilot tested by members of the international committee.

Communication and promotion of the survey was undertaken through website links, including ISO TC 251 web page articles, e-mail, and social media (LinkedIn). Presentations and workshops to the global community of policy and asset management (Canada/US, Portugal, Australia) were developed to raise the profile of the project.

Three survey categories comprised the following: respondents' profile; challenges; and significant points for guidance development. The contents of the final survey can be found in Supplementary Material.

2.3. Asset Management and Public Policy Case Studies

In addition to the survey, case study examples were sourced to highlight the development and application of public policy instruments that enabled asset management in different countries, levels of government, and/or sectors and highlight the benefits to their public policy objectives. Experts from TC251 around the world shared experiences from their jurisdictions, and connections were made with those policy-making organizations. Several of these organizations were also interviewed by members of TC251 to collect additional information on the public policy instruments that were deployed. These organizations were also invited to participate in the survey noted above. The TC251 members collected and presented a range of public policy instruments from diverse contexts (including at the geographical, cultural, political, and governmental level) and different challenges, successes, and lessons learned. Three countries represented in TC251, considered a purposeful sample given their distinctive context, location, and historical background on asset management, volunteered to describe their case. Table 1 provides a listing of the case studies relevant to the water sector that were selected and summarized for this paper. Syntheses of these case studies and major findings are provided later in this paper.

Table 1. Summary profile of case studies included for evaluation.

Case Study Profile	Canada	Japan	Portugal
Name of Government/ Government Organization	Government of Canada	Sendai City	Portuguese Republic
Level of Government	National	City	National
Sector(s) Covered	Water, Wastewater, and Waste Transportation General Government Environment National Resources and Land Management Parks and Recreation	Wastewater (including drainage)	Drinking Water, Wastewater, Stormwater

3. Results

3.1. Findings of ISO Survey on Asset Management and Public Policy

3.1.1. Respondent Profiles

A total of 110 survey responses were received, representing over 20 countries. Figure 1 provides a summary of country participants. Percentages represent the proportion of countries participating in the survey. As some of the respondents to the survey represent organizations that span multiple countries, it is difficult to precisely provide the number of countries [16].

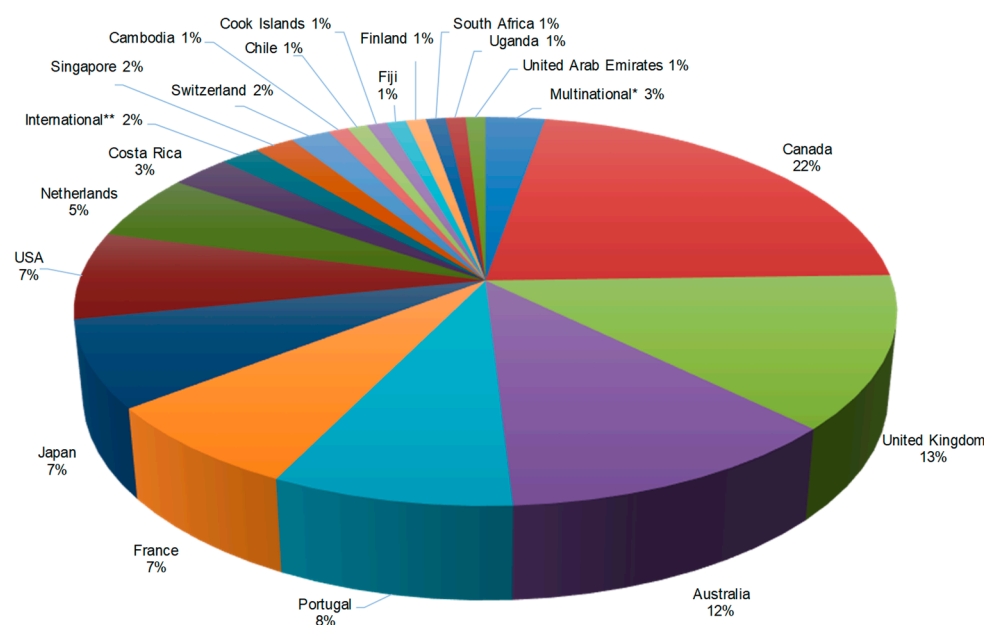


Figure 1. Summary of countries represented in survey. “Multinational **” includes two or more named countries. Additional countries affiliated with a survey respondent who self-identified as multinational in nature were not counted to avoid double counting. “International ***” includes participants who self-identified their affiliations as “international” or “global” in nature and not to any single country or number of countries.

Out of the 110 survey participants, 30% represented national governments, 25% represented local (city or town) governments, 11% represented state governments, 10% represented provincial governments, 7% represented multinational authorities, and 17% represented other types of organizations. “Other” responses included those who self-identified as representing multiple levels of government, former government officials,

government consultants or advisors, government associations, not-for-profit government advocacy organizations, or state-owned companies.

Tables 2 and 3 identify public policy roles and the government sector(s) represented, respectively.

Table 2. Roles in public policy represented.

Role in Public Policy	No. of Responses	% of Respondents
Pass Legislation	1	1%
Issue Executive Guidance	20	18%
Issue Implementing Agency Guidance	23	21%
Issue Final Regulations	10	9%
Approve Proposed Legislation or Regulations	4	4%
Submit Proposed Legislation or Regulations	20	18%
Advise on Public Policy	61	55%
Implement Public Policy	56	51%
None	12	11%
Other	19	17%

A majority of survey respondents represented roles that “advise on public policy” (55%) and “implement public policy” (51%). “Other” roles included those who: monitor public services operators; prepare guidelines; audit, lobby, advise or provide input to governments; provide research and development of public policy; inform and report to government; review effective implementation of policy by relevant agencies; implement government asset management policy; and apply asset management within a state-owned corporation.

Table 3. Government sectors represented.

Government Sectors	No. of Responses	% of Respondents
Water, Wastewater, and Waste	41	37%
Transportation	43	39%
General Government (e.g., Treasury, Administration, etc.)	24	22%
Oil and Gas	6	5%
Electrical Utility	17	15%
Industry and Manufacturing	6	5%
Health	6	5%
Education	8	7%
Agriculture	3	3%
Environment, including Flood Defense	17	15%
Natural Resources and Land Management	12	11%
Defense	9	8%
Tourism and Entertainment	6	5%
Mining	6	5%
Fishing	2	2%
Information Technology/Security	5	5%
Research and Development	11	10%
Law Enforcement	5	5%
Others(s) (please specify)	21	19%

The top government sectors represented included: transportation (39%); water, wastewater, and waste (37%); and general government (e.g., administration, treasury, etc.) (22%). “Other” sectors included: infrastructure, housing, real property, and parks and recreation.

3.1.2. Challenges

Respondents were asked to prioritize the challenges they face regarding the delivery of public services—namely, for example, while balancing the need for new infrastructure and maintaining existing infrastructure or uncertainty in future requirements and demands. Table 4 identifies the top challenges identified.

Table 4. Top challenges related to the delivery of public services.

Challenges Faced	No. of Responses	% of Respondents
Balancing the need for new infrastructure vs. the need to maintain existing infrastructure	68	62%
Obtaining sufficiently accurate and timely data to support good decision-making	65	59%
Understanding current infrastructure performance and service delivery	61	55%
Understanding the long-term mission consequences of current policy and funding choices	60	55%
Having clear infrastructure performance and service quality expectations	56	51%
Securing adequate resources (e.g., financial, non-financial, and/or competencies)	52	47%
Needing to prioritize short-term issues over long-term mission	50	45%
Meeting infrastructure performance and service quality expectations	47	43%
Including goals that address sustainable development	40	36%
Aligning current or future policies	38	35%
Demonstrating compliance of subordinate governments or non-governmental entities with the national or local government’s objectives and related goals	18	16%
Other (please specify)	13	12%
Appraising and supporting successful transition of new public policy authorities	10	9%

Responses to this question were intended to support the identification of public policy needs and areas in which asset management-related guidance may help. Other challenges included:

- Addressing the policy challenges and aligning funding in a multi-order government environment;
- Navigating digital and technology transformations;
- Changing behavior and improving culture to implement asset management;
- Managing differing public expectations;
- Persuading public officials to make sound infrastructure choices rather than popular choices;
- Incentivizing proactive long-term planning;
- Coordinating data standards;
- Continually improving organizational maturity levels;
- Increasing skill levels.

The challenges identified by the majority of the respondents (over 50%) were: balancing the focus on new or existing infrastructure, the adequacy of data acquisition to support good decisions, and the understanding of infrastructure performance and service delivery. The identified challenges are very context-specific but might be helpful to those interested in the delivery of public services, as they pinpoint the main concerns faced by those willing to implement asset management or those willing to establish, sustain, and/or improve the enabling environment for asset management.

As challenges may also be specific to and differ for a given sector in a given country, a subsequent analysis was performed on the subset of answers provided by the respondents

from the water, wastewater, and waste sector, according to the focus of this paper. The conclusion was that the selection of the overall top five concerns as presented in Table 4 were closely aligned with responses from those from the water, wastewater, and waste sector.

3.1.3. Topics to Benefit from Useful Guidance

A large majority (97%) of respondents identified benefits from additional public policy guidance or assistance related to asset management (Table 5).

Table 5. Areas government would benefit from additional public policy guidance or assistance related to asset management.

Public Policy Guidance	No. of Responses	% of Respondents
Balancing the need for new infrastructure vs. the need to maintain existing infrastructure	58	53%
Obtaining sufficiently accurate and timely data to support good decision-making	57	52%
Understanding current infrastructure performance and service delivery	55	50%
Understanding the long-term mission consequences of current policy and funding choices	54	49%
Having clear infrastructure performance and service quality expectations	53	48%
Securing adequate resources (e.g., financial, non-financial, and/or competencies)	52	47%
Needing to prioritize short-term issues over long-term mission	43	39%
Meeting infrastructure performance and service quality expectations	41	37%
Including goals that address sustainable development	36	33%
Aligning current or future policies	35	32%
Demonstrating compliance of subordinate governments or non-governmental entities with the national or local government's objectives and related goals	18	16%
Other (please specify)	17	15%
Apprising and supporting successful transition of new public policy authorities	11	10%
None of the above	3	3%

For respondents representing the water sector, the top three identified areas included: (1) balancing the need for new infrastructure vs. the need to maintain existing infrastructure; (2) securing adequate resources (e.g., financial, non-financial, and/or competencies); and (3) aligning current or future policies. "Other" areas included:

- Digital transformation;
- Governance and interaction with government and its agencies;
- Demonstrating the benefits of asset management for municipalities;
- Clear guidance on federal and state government intervention and direction into specific industries/sectors;
- Human behavioral aspects that assist in the changes needed to implement asset management for success;
- Support for longer term (multiyear) projects;
- Effective financial reporting framework for infrastructure;
- Understanding drivers for service so government can meet the real need rather than the apparent need;
- Having a scalable, flexible and consistent framework in place that is effectively enforced so performance, costs and risks can be measured and reported effectively.

Eighty-five percent (85%) of respondents reported that examples and case studies would be helpful—including elements of good practice and lessons learned about how public policy instruments have been applied to support good asset management, for example:

"Research and evidence-based examples where a scalable, flexible and consistent framework can assist in demonstrating an entity can effectively communicate with their stakeholders (and decision makers) on the performance, cost and risk trade-offs."

Survey respondents further commented on the importance of good practice case studies, acknowledging that the functions of governments and methods of formulating public policies vary from country to country, and for this reason, common guidance even if the system and organization are different can be useful, especially if the reasons behind the methods and benefits are clearly stated.

Seventy-six percent (76%) of respondents considered the main target audience for international guidance on enabling asset management through public policy would be those who “advise on public policy”. Table 6 provides a summary of responses to the target audience.

Table 6. Target audience for international guidance.

Target Audience	No. of Responses	% of Respondents
Those who:		
Advise on Public Policy	84	76%
Implement Public Policy	64	58%
Issue Implementing Agency Guidance	56	51%
Issue Executive Guidance	54	49%
Issue Final Regulations	42	38%
Submit Proposed Legislation or Regulations	42	38%
Approve Proposed Legislation or Regulations	41	37%
Pass Legislation	24	22%
Other (please specify)	8	7%

3.1.4. Public Policy Instruments and the Enabling Environment for Asset Management

Establishing and sustaining an enabling environment for asset management through public policy promotes long-term value of assets, including those in the water sector. A comprehensive public policy approach would include the development, application, coordination, or management of a variety of mandatory, incentive-based, and voluntary public policy instruments [7,17] concurrently. Table 7 contains a description of public policy instruments [17,18] and considerations on how they can be utilized to establish or sustain an enabling environment for asset management [19]. These were identified [18,19] following the research on public policy instruments in the water sector by the Portuguese Water and Waste Services Regulation Authority (ERSAR) and following the best practice international dissemination of findings undertaken by LIS-Water, the Lisbon International Center for Water.

Table 7. Public policy instruments and how they may enable asset management [17–19].

Public Policy Instrument or Grouping of Instruments	This Public Policy Instrument Can Enable Asset Management (AM) by ...
Strategic planning	... including strategic directions and setting up priorities for asset management, as a relevant component of the public policy, taking into consideration a long-term vision for the existing assets and maximizing their value, to support the policy objectives.
Legal framework	... including the requirements, enforcement mechanisms, and penalty tools in the legislation conducive to better asset management practice; ... regulating this subject, avoiding legal gaps and overlaps, and overcoming existing barriers.
Institutional framework	... including clear mandates and adequate skills (in the institutional framework in general and in the laws of the regulatory authorities) to promote the enforcement of asset management in the sector as a common practice of the service and program providers.

Table 7. Cont.

Public Policy Instrument or Grouping of Instruments	This Public Policy Instrument Can Enable Asset Management (AM) by ...
Governance models and contracts	... including clear obligations and incentives to promote the adoption of asset management, such as, for instance, good leadership, accountability mechanisms, AM implementation goals, and specification of the end of contract target value of the asset portfolio and service levels in the contracts. One of the aspects to foster is that public procurement addresses life cycle costs, performance, and risk, instead of allowing selection based only on the lowest bid or lowest investment cost.
Quality of service goals	... including in the quality of service assessment system a set of performance indicators able to assess the asset management practice and setting up realistic quality of service targets.
Tariff and tax policy	... including the medium- and long-term cost coverage of the needed investment to assure the adequate quality of service, accounting for long-term sustainability of the assets.
Financial resources	... being mobilized in a way that allows implementing the strategic plan, aligning the mechanisms for allocation of funds with the defined priorities, and introducing incentives, subsidies, grants, and requirements in this allocation that lead to effective asset management by the service and program providers.
Infrastructure construction and rehabilitation	... adopting the adequate and emerging methodologies, technologies, and practices to optimize the value of existing assets and to promote the transition between the current state of the assets and the long-term envisaged state through a balanced share between new assets (expansion) and maintenance and rehabilitation of existing assets.
Operational efficiency	... enabling and encouraging a long-term view of operational efficiency gains by making use of economies of scale (assuring the alignment with asset management strategic goals, scope, and process) and by monitoring and promoting better operational processes and practices by the service and program providers.
Training and capacity building	... identifying and addressing needs in terms of education, training of the staff, and capacity building of the service and program providers that are necessary to achieve the long-term vision regarding good asset management practices.
Research and innovation	... identifying the existing gaps and enabling and promoting problem-driven research and innovation on asset management, fostering co-production and knowledge transfer, and promoting a strong link between the knowledge and practice.
Business development	... enabling and promoting creative, healthy, and sustainable enterprises, which help in implementing new services and products to better support good practices of the service and program providers on asset management.
Data, information, and knowledge	... recognizing that sound data and information and knowledge on assets, on their condition, and on asset systems performance is critical for decision making by the service and program providers on asset management decisions; by independently verifying that information is accurate and trustworthy.
Community engagement and users protection	... reaching out and engaging the community; by enabling the creation of awareness of the assets value, including an intergenerational responsibility perspective; by ensuring that users have the opportunity to raise concerns about poor service quality due to failures on asset management practices.

Participants were asked to rate how helpful guidance would be on public policy instruments and how these instruments can be developed in a way that promotes good asset management for their government/public policy authorities. Table 8 provides a summary of responses. Out of the 15 public policy instruments surveyed, over 50% of respondents reported that guidance on 13 of them would be “very helpful” or “somewhat helpful.”

Table 8. Public policy instruments and how helpful guidance would be.

Public Policy Instrument or Grouping of Instruments	Average Rating	Not Applicable (1)	Of No Help (2)	Of Little Help (3)	Somewhat Helpful (4)	Very Helpful (5)	% Somewhat Helpful or Very Helpful
Data and Information	4.2	4%	3%	13%	31%	50%	81%
Risk Management *	4.2	2%	6%	10%	34%	48%	82%
Sustainability and Resilience *	4.1	2%	4%	13%	45%	36%	82%
Government Strategic Plans	4.0	4%	5%	14%	37%	40%	77%
Training and Capacity Building	4.0	4%	5%	17%	34%	40%	74%
Quality of Service Goals	3.9	6%	6%	15%	39%	34%	73%
Governance Models	3.9	5%	8%	18%	35%	35%	69%
Financial Instruments	3.8	5%	7%	21%	37%	29%	66%
Institutional Framework	3.6	6%	11%	21%	38%	24%	62%
Public Governance and Whole of Government	3.6	7%	10%	22%	35%	25%	61%
Research and Innovation Partnerships	3.5	6%	12%	25%	38%	18%	56%
Audits	3.5	9%	15%	18%	36%	22%	58%
Legal Framework	3.4	12%	14%	23%	30%	22%	52%
Competition Policy and Procurement	3.2	12%	17%	26%	33%	12%	45%
Tariff and Tax Policy	2.9	16%	20%	32%	24%	8%	32%

* Policy considerations.

3.2. Case Studies

To supplement the survey findings, case studies were sought to examine the public policy instruments developed and/or applied to enable good asset management practice. Examples from Canada, Japan, and Portugal provide national and local perspectives from the water, wastewater, stormwater, and waste subsectors.

3.2.1. Canada

Local governments and municipalities in Canada provide a broad range of services to communities. A typical municipality is responsible for delivery of water, wastewater, stormwater, roads, transit, and parks and recreation services. Municipalities own and are responsible for 60% of Canada's public sector infrastructure. Following Canada's "infrastructure golden age" in which the country experienced a significant build out of municipal infrastructure following World War II to support the baby boom population, there followed several decades of underinvestment in infrastructure. Triggered from the economic issues experienced during the late 1970s, the country fell from infrastructure spending as a portion of Gross Domestic Product (GDP), with a high of 5% in 1966 to a low of just over 2% around 1998. This situation resulted in a significant amount of capital maintenance items being deferred and the average age of infrastructure increasing, with infrastructure assets declining in condition and becoming more and more expensive to repair and renew. Today, municipalities are living with this legacy and infrastructure constructed during the golden age at—or past—the end of their useful life now and having not been properly maintained over a period of three decades. Problems such as climate change, population change, higher customer expectations, and the COVID-19 pandemic are further compounding this challenge.

In recent decades, the federal Government of Canada has taken steps to better understand and tackle this challenge. In 2004, the Federal Gas Tax (recently renamed to the Canada Community Building Fund) was established to direct federal funding to local infrastructure. In 2009, the Public Sector Accounting Board (Board) introduced PSAB 3150 requiring municipalities to report on what Tangible Capital Assets they owned.

Through the Investing in Canada Plan, launched in 2016, the Government of Canada committed over CAD 180 billion over 12 years for infrastructure that benefits Canadians—from public transit to trading ports, broadband networks to energy systems, community services to natural spaces. The continued spending on infrastructure is paralleled with a drive to improve asset management practices and better understand the infrastructure challenges to support effective planning and decision making—to support the extra funding being directed to the right places.

Through improved data about assets, municipalities can plan for community service needs, respond to climate change, and deliver the best, most cost-effective outcomes for their communities. Launched in 2016, the Federation of Canadian Municipalities' (FCM) Municipal Asset Management Program (MAMP) is an eight-year, CAD 110 million program funded by Infrastructure Canada that has so far invested in more than 500 municipal asset management projects, helping to build better lives for millions of Canadians. MAMP offers funding, training, and resources to help Canadian municipalities improve their asset management practices.

The Municipal Asset Management Program (MAMP) is designed to help Canadian municipalities make informed infrastructure investment decisions based on reliable data and sound asset management practices. MAMP is delivered by the Federation of Canadian Municipalities (FCM) and funded by the Government of Canada. It provides asset management training, funding, and information sharing to enable municipalities to access the data needed to plan effectively.

The main component of the Municipal Asset Management Program is the direct funding initiative that provides up to CAD 50,000 in grant funding to municipalities to further their asset management-related activities including:

- Asset management assessments;
- Development of asset management plans, policies and strategies;
- Asset-related data collection and reporting;
- Asset management training and organizational development;
- Knowledge transfer around asset management.

MAMP also offers grants to partners who provide asset management training programs (technical assistance), awareness building activities, and education on best practices with the municipal sector. The latest round of funding follows several guiding principles that stem from MAMP's objectives and govern the partner and activity selection process. For example, the Canadian Network of Asset Managers (CNAM) has been a partner organization with FCM since the outset of MAMP in 2017. CNAM has developed a number of awareness building, knowledge, and technical assistance elements to moving AM practice forward in Canada, including CNAM's *AM101* booklet—a 32-page booklet that provides municipalities with an overview of the what, why, and how of asset management for their community. A total of 5000 hard copies were printed and distributed across Canada, and digital copies are available for free download from www.cnam.ca, accessed on 24 November 2021.

Infrastructure Canada has seen success of the program, and MAMP was recapitalized in its third year, extending the program from 5 to 8 years with an additional \$60 million committed in the 2019 Federal Budget. Highlights from MAMP to date include:

- CAD 44 million worth of municipal asset management projects funded;
- 1063 municipal asset management projects funded; of 165 projects completed in its third year of the program, 84% successfully helped municipalities advance at least one level of the Asset Management Readiness Scale, and 19% of grant recipients improved in five competency areas;
- CAD 14 million worth of partner grants issued to 18 partners;
- 477 partner training events and workshops.

As of 2021, with sustained support from the Government of Canada/Infrastructure Canada, the Federation of Canadian Municipalities continues to deliver both the direct funding and partner components of the Municipal Asset Management Program.

3.2.2. Sendai, Japan

From the 1960s to the 1980s, Japan experienced a period of high economic growth and rapid infrastructure development. Following a slowdown in this growth leading up to the turn of the century, the Japanese national and local governments focused efforts on reducing government debts and using budgets more efficiently. In this same period, capital investment for infrastructure and numbers of staff members in governments were reduced. As a result, problems with infrastructure failures and deterioration have risen since the early 2000s. Significant infrastructure failures such as the Sasago Tunnel on the Chuo Expressway in Japan activated discussions of inspection, repair, and renewal of infrastructure and changed the direction of capital investment from new investment to rehabilitation and renewal, and governments developed legislation, subsidy systems, and guidelines to tackle these problems.

In the wastewater sector, the sewerage department of the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) established the subsidy system in 2009 to support extending the sewerage facility service life, developed the sewerage operation and maintenance management guideline in 2014, and amended the sewerage law in 2015. The subsidy system in 2009 was replaced by the system to support implementation of the “Sewerage Stock Management System” (SSMS) in 2016. Especially in SSMS, wastewater utilities can receive a subsidy of approximately 50% of total rehabilitation and renewal cost after inspecting facilities and developing long term renewal forecasts and rehabilitation plans. As a result, 74.6% of wastewater utilities in Japan developed renewal plans.

Sendai wastewater utility (SWU) was also at the turning point of management in the 2000s. At this time, the population growth of Sendai plateaued and halted the demand for expanding sewer networks. The city government decided to reduce the construction budget and the number of staff members. At the same time, however, SWU anticipated to increase rehabilitation demand and reduce disaster risk. Large earthquakes occur every 30 years in Sendai, and inundation risks by global warming are also increasing. The utility needed to improve its management system to explain the local context to stakeholders clearly and prioritize activities effectively and efficiently.

In 2006, SWU launched working groups to introduce Asset Management and investigated good AM practices in Australia. Based on the results, the utility decided to implement AM and established the asset management strategy office. To implement AM, the utility drafted the AM implementation strategy. It analyzed and designed solutions by conducting an interview in the utility and benchmarking in Australia. The strategy consisted of individual strategies such as “setting AM objectives”, “managing risks”, “decision making criteria”, “long-term renewal forecast”, “business process development”, “IT system development”, etc. As these efforts were implemented in parallel with the MLIT’s initiatives mentioned above, SWU had shared its experience with other governments in drafting guidelines and training courses.

Despite the damage of the Great East Japan Earthquake, while enhancing knowledge of AM effects in disaster, the utility started to operate the AM system formally in 2013. SWU reduced its average annual renewal and rehabilitation cost from JPY 18.4 billion to JPY 14.3 billion through continual AM improvement to apply new rehabilitation forecast modelling. After developing internal audit and AM training frameworks, the utility obtained the first ISO55001 certification in Japan in 2014.

The MLIT and related associations played a key role in establishing ISO55001 as a certification framework. Experts were allocated to international standardization committees TC224 and PC251 to share information. Based on their knowledge, the sewerage department of the MLIT drafted an ISO55001 application guideline and implemented the pilot certification with Sendai City, Aichi Prefecture (wastewater utility) and Swing

Corporation (private company). The guideline was revised to add practical examples in utilities in 2016 and has been utilized not only in the wastewater sector but also in private companies, including consultants and service providers for roads and water supply, etc. These initiatives ultimately triggered the establishment of the Japan Association of Asset Management (JAAM).

AM implementation in Japan initially started in the national government, and the local utility in parallel and has proceeded with continued experience and outcomes sharing with each other. The collaborative development of public policy instruments (such as the law, guidelines, and subsidy system) in Japan through official standing committee discussions between large utilities and the national government (MLIT) has enabled improvements in the sustainability of wastewater utilities. Since the launching of the ISO55000 series in 2014, private companies and academic institutions have also joined and collaborated to coordinate the AM framework through JAAM.

3.2.3. Portugal

When Portugal joined the European Union (EU) in 1986, essential water services coverage and service quality were low. A coherent public policy started to take shape in 1993, involving a major reform in the legal and institutional frameworks, governance models, and tariff and tax policies. The government's main objectives in the first years, set out in strategic plans, were to build new infrastructure to increase service coverage and improve the quality of service. In recent years, the major challenge has been to ensure service sustainability, by maximizing asset value over the long-term, through asset management practices. Training and capacity building, along with research and innovation projects, played a very important role in this path [16].

The key players and influencers in this process have been:

- The Ministry of the Environment and the Ministry of Public Works, with regard to policy development and to the allocation of European funds to water infrastructure;
- The Portuguese Water and Waste Services Regulation Authority ERSAR, who has a clear mandate and the skills to promote the enforcement of asset management, included it in its regulatory model, and is responsible for the legal and contractual regulation of the water utilities; ERSAR also promotes benchmarking between utilities, as annual results of the national assessment of the quality of service are made publicly available;
- The National Civil Engineering Laboratory LNEC and Instituto Superior Técnico IST, who implement and develop research and innovation programs and lead asset management training and capacity building initiatives for water utilities; these programs promote benchmarking as utilities diagnose their systems, exchange information with each other, and share their challenges and solution;
- The water utilities themselves, as utilities serving more than 30,000 inhabitants are required to have an infrastructure asset management system, are responsible for the assets' life cycle and to respond to the regulators quality of service system every year; the benchmarking provided by public display of their responses challenges these utilities to compare their results with similar organizations, identify their improvement opportunities, and move towards continuous improvement.

With a consistent public policy from 1993 to 2019, Portugal significantly improved public investments in the water sector, and the coverage and service quality provided by public infrastructure improved considerably across the country. For example, high quality drinking water increased from 50% to 99%; sewerage and treatment coverage, from 28% to 85%; good quality coastal bathing water, from 53% to 99%. The coordination and integration of these public policy instruments resulted in significant improvements in Portugal to UN SDGs 6 (clean water and sanitation) and 3 (public health), among others.

The major challenges today are related to the financial sustainability of the services, due to the limited power of the regulator to set the tariffs, and a rehabilitation funding

gap [20]. Development of legislation on specific requirements for an asset management system and on the verification of compliance and penalty tools is also a step to be taken.

The major lesson learned was that the successful implementation of public policies for water services depends on the joint implementation of all these elements (a government strategic plan, legal and institutional frameworks, governance models, quality of service assessment, tariff and tax policies, financial instruments, training and capacity building, and research and innovation projects) concurrently [18].

4. Discussion

Water services rely on linear physical assets usually buried underground and therefore extremely difficult to access, monitor, or maintain. Along with other system components, such as water and wastewater treatment plants, pumping stations or reservoirs, they have long service lives and also require high investments for construction. Urban water systems face several challenges today, including but not limited to the need to promote circular economy, cope with emergent pollutants, bolster alternative water sources, re-naturalize drainage solutions, and upgrade treatment technologies. Not only do water systems and existing infrastructure need to be managed for the present, but they also need to be readily adapted for future uncertainties and a changing climate to continue delivering the services required for tomorrow [10,21]. Lifecycle management of these assets is, therefore, essential in a society that intends to be sustainable and prepared for challenges to come. Success in this quest for sustainability not only is dependent on the willingness of utilities to implement asset management but also is strongly interlinked with the existence of public policies, including appropriate tools and incentives that promote asset management of water infrastructure.

Table 7 illustrates how public policy instruments can be developed and/or applied to enable asset management and promote the long-term value of assets, including those in the water sector. The experiences reported in Canada, Sendai (Japan), and Portugal demonstrate through the case studies the application of how several of these public policy instruments have been developed or implemented to enable asset management, and in turn, have bolstered achievement of the governments' public policy objectives with respect to water and wastewater services. Table 9 summarizes the public policy instruments or grouping of public policy instruments used in the three case studies to enable asset management, followed by a discussion of key themes and lessons learned.

Table 9. Case study public policy instruments.

	Canada	Japan	Portugal
Public Policy Instruments Developed or Applied	Financial Instruments Training and Capacity Building Data and Information Research and Innovation Partnerships	Legal Framework Institutional Framework Public Governance and Whole of Government Financial Instruments Training and Capacity Building Research and Innovation Partnerships	Government Strategic Plan Legal Framework Institutional Framework Governance Models Quality of Service Tariff and Tax Policy Financial Instruments Training and Capacity Building Research and Innovation Partnerships

The three case studies share a common goal, which is to improve services and the state of assets through effective infrastructure asset management, focusing on the benefits accrued through standardization. Historically all cases in the water sector demonstrated the need to start development of a coherent response to repair and renew degraded infrastructure assets through asset management within an underpinning coherent framework provided by adherence to a standardization approach. Successful implementation of public policies for water and wastewater services depended on collaboration and coordination among different levels of governments, internal and external partners—and most

importantly—success depended on the concurrent, coordinated development, and/or application of a set of public policies.

Findings of the case studies indicate that when public policy instruments are developed and applied strategically in coordination with each other, an enabling environment for asset management may be established for all service providers involved. The case studies indicated a range of voluntary public policy instruments that support asset management locally. Importantly, not all cases used mandatory approaches. Training and capability building, financial instruments, and research partnerships are voluntary mechanisms common to all case studies as instruments to support the adoption of asset management. These voluntary measures, including incentives, provided both individual and organizational encouragement. The deployment of various policy instruments examined in the cases indicate that regulatory instruments are a sufficient but not a necessary support mechanism for water assets. In the case of Japan, large utilities and the national government collaborate officially through participation in a standing committee to develop public policies (the law, guidelines, and subsidy systems) that enable asset management and improvements in the sustainability of wastewater utilities. Similarly, in Portugal, water infrastructure reform relied on regulatory instruments allied with voluntary approaches. In Canada, the water sector responded to voluntary policy instruments. All cases relied on a framework supported by standardization to achieve their objectives for asset management.

It is important to note that enabling environments are unique to each country and potentially unique to different geographic regions within a country as well. The resilience and sustainment of the enabling environment can be achieved through continual improvement and adaptation to evolving needs, contexts, and practices. The framework through which this enabling environment can be established and sustained can be informed by the development of voluntary international standards, such as the current work underway by ISO/TC251 in the development of ISO 55011. International standards offer a consistent and transparent framework, developed through the consensus of globally established experts [22] and leveraging of global best practice and lessons learned. Hodkiewicz cautions that, while the suite of asset management standards confers a certain respectability for the area of asset management, there is yet to be developed a set of assessments and validated instruments to test the claims of superior performance in adopting AM [23]. As indicated in the survey results, such an international guidance standard on public policy and asset management would be beneficial to governments (see Section 3.1.3). The results of the survey demonstrated the interest of the water sector in this topic, with that sector having one of the highest sector-based participation rates (Table 3).

5. Conclusions

Given that infrastructure asset management establishes a foundational framework for operations and management of services, such as water services, it is important that governments promote an enabling environment for asset management through enacting appropriate public policy instruments.

In strengthening this link between public policy and asset management, public policies can be developed and applied in a way that bolsters the delivery of such services that depend on assets through asset management. Relevant public policy instruments, when applied simultaneously, jointly enable infrastructure asset management and support the achievement of government goals and objectives—ultimately materializing globally significant public policy objectives such as the sustainable development goals.

The outcomes of an international survey and of the experience in three case studies in the water sector enabled the identification of common elements applied in these countries and demonstrated the need for standardization to support a coherent approach to asset management. Regarding the survey, the results presented in this paper mainly concern water services, even though the methodology was applied to water and to other services, as it is relevant for a water professional to have an overall view of the results for other sectors.

The work undertaken focuses on asset management, which is a global development to marshal resources and effort to provide a systematic perspective of physical assets.

Advancing the global exchange of knowledge in this area and developing international guidance and standards on the topic as a future piece of work can be a valuable resource in the effective pursuit of sustainable and equitable services for the public.

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