Advancing Wastewater Reuse for Conservation and Climate Solutions: Policies, Practices and Lessons Learned

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Acronyms

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AWS	Alliance for Water Stewardship
CEO	Chief Executive Officer
CESPM	Comisión Estatal de Servicios Públicos de Mexicali
COP	Community of Practice
DEC	Department of Environmental Conservation
DEP	Department of Environmental Protection
DPR	direct potable reuse
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
GBF	Global Biodiversity Framework
GGA	Global Goal on Adaptation
IIT	Indian Institute of Technology
IPR	indirect potable reuse
ISO	International Organization for Standardization
ITC	Investment Tax Credit
MLD	million liters per day
NAM	Namibia
NDC	nationally determined contribution
NGO	non-governmental organization
NGWRP	New Goreangab Water Reclamation Plant
O&M	Operations and Maintenance
PFAS	per- and polyfluoroalkyl substances
PRC	Potable Reuse Commission
PUB	Public Utilities Board
SARCC	National Roundtable of Sanitation, Wastewater, and Climate Change
SDG	Sustainable Development Goal
SRTW	safe reuse of treated wastewater
SSP	Sanitation Safety Planning
TNC	The Nature Conservancy
UDLA	Universidad de Las Américas
UN	United Nations
UNICEF	United Nations Children's Fund
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WRAP	Water Reuse Action Plan
WRRF	Water Resource Recovery Facility
WRRMP	Water Reuse Risk Management Plans
ZLD	zero liquid discharge

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Executive Summary

Wastewater reuse has emerged as a cross-cutting strategy at the intersection of water security, environmental conservation, climate resilience and sustainable development. In a world facing intensifying water scarcity, ecosystem degradation, and urban pressures, wastewater—when safely treated and reused—presents a powerful, yet underutilized, resource. This report documents The Nature Conservancy's (TNC's) adaptive approach to supporting wastewater reuse across geographies, identifies critical policy barriers and enabling conditions, and offers actionable recommendations to guide future interventions and systems-level change.

The Imperative for Wastewater Reuse

Untreated or poorly treated wastewater continues to pose a severe threat to freshwater, coastal and terrestrial ecosystems worldwide. From coral reef collapse to freshwater and estuarine eutrophication, to groundwater pollution and depletion, to urban water stress, the impacts of mismanaged wastewater are profound and far-reaching. Wastewater reuse, if well regulated, addresses these challenges across urban and rural contexts alike by reducing pollution, augmenting water supplies, restoring ecological flows and supporting disaster resilience. Its benefits span sectors including agriculture, industry, housing development, environmental conservation and restoration, public health and public infrastructure.

TNC's Role and Strategy

Wastewater reuse serves not only as a sanitation or engineering solution, but as a transformative conservation strategy. Through projects in Florida, Hawai'i, Long Island, Chennai, Mexicali, and beyond, TNC has supported diverse reuse models, ranging from decentralized, nature-based systems to large-scale infrastructure retrofits. Our role has included:

- Policy convening and framework co-development (e.g., Florida Potable Reuse Commission)
- Piloting ecological reuse solutions (e.g., Las Arenitas Wetlands in Mexicali, Sembakkam Lake in Chennai)
- Corporate and community engagement (e.g., partnerships with AWS and PepsiCo, civic engagement in Chennai and Hawai'i)
- National and subnational policy dialogue and learning exchanges (e.g., U.S. EPA's WRAP, India's SRTW Framework)

TNC's comparative, systems-level perspective has connected field implementation with enabling policy conditions, while ensuring that equity, ecological integrity, and climate adaptation are central to reuse strategies.

Key Findings of This Report

This report is the product of interviews, case studies, and global policy reviews, which provided several insights:

- Wastewater reuse delivers tangible ecological, social and economic benefits when it is supported by appropriate governance and infrastructure.
- Policy remains the primary bottleneck to progress. Fragmented regulations, unclear standards and weak institutional alignment limit scaling, even when technology and financing exist.
- Public perception is still a significant barrier, especially in potable and high-contact applications. Building trust requires long-term engagement, awareness building, transparency and cultural sensitivity.
- Nature-based and decentralized reuse solutions offer cost-effective and ecologically aligned alternatives, especially for urban wetland restoration and estuarine, freshwater and coastal ecosystem protection.

- Corporate actors are willing to invest in reuse but require regulatory predictability, permitting clarity, and social license to operate.
- Jurisdictions that have prioritized fit-for-purpose standards, financial incentives and integrated planning (e.g., Singapore, Israel, Florida) have seen significant uptake of reuse systems.

Policy Barriers and Enablers

A range of policy-level barriers limits reuse, including:

- Regulatory ambiguity and jurisdictional overlap (e.g., in Long Island, project delays were caused by unclear permitting responsibilities across municipal departments).
- Lack of differentiated standards for reuse applications (e.g., in India, the absence of end-use–specific guidelines complicated planning for Sembakkam Lake's decentralized reuse system).
- Financial disincentives and the absence of enabling infrastructure finance (e.g., in Mexicali, reuse infrastructure is limited by inconsistent funding and weak market demand).
- Political risk aversion and lack of public engagement mechanisms (e.g., in Hawai'i, public and political resistance to cesspool upgrades has slowed adoption of reuse-integrated wastewater strategies).

At the same time, some policy enablers have proven critical for success:

- Clear reuse standards (e.g., Florida's Potable Reuse Framework provided regulatory clarity that unlocked utility investment).
- Integration of reuse into urban and climate planning frameworks (e.g., Singapore's NEWater program demonstrates full integration into national water planning).
- Blended finance models and regulatory incentives (e.g., Florida leveraged state-level incentives to finance reuse infrastructure).
- Multi-stakeholder policy platforms and inter-agency coordination (e.g., the SARCC platform in Ecuador convened diverse actors to shape national sanitation and reuse priorities).
- Public communication strategies that normalize reuse behavior (e.g., Singapore and Florida both employed robust public education to overcome the "ick factor").

Conclusion

This report reaffirms wastewater reuse as a critical lever in building climate-resilient, water-secure and ecologically vibrant communities. TNC's global experience underscores that when policy, science, infrastructure and community voices align, reuse systems succeed. Flavia Rocha Loures, senior policy advisor for freshwater at TNC, aptly stated, "Reuse will not scale on goodwill or intention alone. It needs policy teeth, public trust and financing mechanisms that make it viable for everyone." This is the opportunity and the responsibility facing governments, civil society and the private sector alike: to transform wastewater from a liability into a renewable resource and cornerstone of sustainable water.

TNC's Strategic Recommendations

To advance wastewater reuse as a viable and scalable conservation solution, we offer the following recommendations:

Strategic Recommendation	Description	Examples
Advance fit-for-purpose standards.	Establish risk-based, end-use-specific treatment standards aligned with application types like irrigation, potable use or industrial reuse.	• California Title 22 • Israel's crop-specific effluent standards • LA County's wildfire reuse permitting
Embed reuse in national and subnational planning frameworks.	Integrate reuse into long-term water, sanitation, urban development, and climate resilience planning.	• Singapore's NEWater planning • India's SRTW framework • Las Arenitas (Mexico) integration
Catalyze blended financing.	Mobilize capital using blended finance models, including public-private partnerships and ESG-aligned investment.	• Florida co-financing model • Corporate interest from Diageo, PepsiCo
Mainstream nature-based solutions.	Institutionalize decentralized and wetland-based reuse systems within formal water and sanitation frameworks.	• Sembakkam Lake and Pallikaranai Marsh in Chennai (India) using constructed wetlands
Strengthen multi-stakeholder platforms.	Facilitate inter-agency and cross-sector coordination through formalized dialogue platforms.	• Florida Potable Reuse Commission • Ecuador's SARCC platform
Invest in monitoring and data transparency.	Develop real-time, transparent monitoring systems to enhance trust and support regulatory compliance.	• Florida's Department of Environmental Protection's Reuse Inventory Database • Orange County, California's Groundwater Replenishment System monitoring protocol
Drive public communication and social normalization.	Create sustained campaigns to normalize reuse and address public perception challenges.	• Singapore's reuse branding strategy • Chennai's Sembakkam Lake community outreach
Integrate reuse into global climate and biodiversity agendas	Align reuse with global frameworks like SDGs and the Kunming-Montreal GBF.	• Contributions to SDGs 6, 11, 13, 14 • Alignment with Kunming-Montreal GBF pollution targets

About This Report

Policies, Practices and Lessons Learned: Advancing Wastewater Reuse for Conservation and Climate Resilience is a strategic knowledge product authored by Dr. Nupur Bapuly, a policy analyst with TNC India and a 2024–2025 TNC Coda Fellow. The report examines wastewater reuse as a conservation-aligned strategy that contributes to climate adaptation, biodiversity goals and sustainable water security.

Grounded in TNC's global practice, the report features detailed case studies from India, the United States, Mexico, and Ecuador, where TNC has supported decentralized reuse systems, nature-based treatment infrastructure, municipal-scale transitions and policy dialogues. These case studies illustrate how wastewater reuse can restore ecosystems, enhance water resilience and generate co-benefits for communities and cities.

The report is enriched by contributions and perspectives from several TNC experts and corporate partners (as identified in Appendix 2), who offer insights into the regulatory, financial and operational barriers corporations face in scaling wastewater reuse.

To broaden the policy and institutional lens, the report also draws upon global and regional frameworks such as:

- World Bank reports (2020, 2022) on resource recovery and wastewater reuse in small towns
- European Union Regulation 2020/741 on agricultural reuse standards
- World Health Organization (WHO) guidelines on health-based targets for safe reuse
- UN Water's 2017 Wastewater Report on circular economy and sustainability integration

In addition, we present examples from Singapore, Namibia, Israel, India and Pakistan to illustrate diverse legislative models, standards for potable and non-potable reuse, and challenges in regulatory coherence. These references were not part of TNC's direct implementation portfolio but serve to contextualize regional practices, institutional innovations, and enabling conditions globally.

Through policy analysis, field case documentation, expert interviews and systems thinking, this report aims to inform conservation strategy, influence regulatory design and strengthen the case for wastewater reuse as a nature-positive, climate-resilient water solution. It serves as both an internal reflection tool for TNC teams and an external engagement asset for governments, utilities, researchers and the private sector.

SECTION 1

Introduction

Overview of Sustainable Wastewater Management and Wastewater Reuse

Healthy ecosystems, whether they are freshwater, marine, or terrestrial, are fundamental to biodiversity, climate resilience and human well-being. Rivers, lakes, wetlands, aquifers, mangroves, coral reefs and estuaries all play vital roles in maintaining ecological balance and supporting livelihoods. Yet, across these diverse landscapes, untreated or poorly treated wastewater remains a pervasive and escalating threat. Excess nutrients, pathogens and chemical contaminants present in wastewater can degrade water quality, impair ecosystem functions and pose serious public health risks.

PURPOSE

This report positions wastewater reuse as a **climate-smart conservation strategy**, drawing on The Nature Conservancy's on-groundwork. It examines how policy, science and practice can align to scale impact and includes a fit-for-purpose policy checklist to guide effective, equitable and scalable reuse interventions.

The impacts of wastewater pollution are significant in coastal ecosystems,[1] where nutrient loading contributes to eutrophication, algal blooms and the collapse of coral reef and seagrass habitats.[2] However, the consequences extend far beyond the coast. Poorly managed wastewater discharge can cause freshwater ecosystems to experience severe water quality reduction,[3] reduced environmental flows, loss of aquatic biodiversity and sedimentation.[4] Freshwater ecosystems often experience these impacts long before wastewater contaminants reach the coast. Wastewater discharge also indirectly affects terrestrial ecosystems, as growing freshwater pollution and demand for water lead to overextraction of groundwater, consequently decreasing terrestrial species' food and water sources, degrading soil health, and weakening climate resilience for aquatic ecosystems and in upland and agricultural zones. All of these impacts affect communities across the catchment and the coast, especially the most vulnerable communities who directly depend upon those resources for their livelihoods and water and food security.

Sustainable wastewater management, especially through the safe and strategic reuse of treated effluent, offers a transformative solution. It allows for pollution reduction, resource recovery, environmental conservation and restoration, reduced carbon footprint and greater resilience to climate-induced water stress for people and nature. Applications such as aquifer recharge, liquid and nutrient reuse in agriculture, urban green space irrigation and environmental flow augmentation illustrate how wastewater reuse delivers multiple ecosystem benefits across both rural and urban settings.

These solutions are not only technical or operational, they are also fundamentally aligned with global sustainability and equity goals. Wastewater reuse contributes directly to the United Nations' Sustainable Development Goals (SDGs), Kunming-Montreal Global Biodiversity Framework (GBF) goals and Global Goals on Adaptation (GGAs), including:

- SDG 6.1 (universal and equitable access to safe and affordable drinking water)
- SDG 6.3 (improve water quality and increase recycling)
- SDG 6.4 (increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater)
- SDG 6.6 (protect and restore water-related ecosystems)

Lisianski Algal Bloom on Bleached Coral © John Burns_Flickr_Public Domain Mark 1.0

- SDG 11 (sustainable cities and communities)
- SDG 13 (climate adaptation and resilience)
- SDG 14.1 (reduce marine pollution)
- SDG 15 (protect terrestrial/aquatic ecosystems and halt biodiversity loss)
- GBF T7 (pollution reduction)
- GBF T11 (ecosystem services)
- GBF T12 (urban planning)
- GGA targets on water scarcity, food systems resilience, and nature, among others.

In recognition of these linkages, conservation organizations, including TNC, identify wastewater reuse as a biodiversity conservation strategy, as well as a climate mitigation and adaptation strategy. Wastewater reuse supports the health of freshwater and coastal blue carbon ecosystems, aids in the recovery of degraded watersheds, replenishes groundwater supplies and aligns with broader climate and biodiversity objectives, as mentioned above.

Importance of Sustainable Wastewater Management for Healthy Ecosystems

Sustainable wastewater management refers to the treatment, reuse and safe disposal of wastewater to reduce environmental harm and promote long-term water security. This approach is increasingly recognized as essential for preserving water quantity and quality, supporting climate resilience and protecting ecosystems, across urban and rural zones and in inland and coastal regions. As population growth, rapid urbanization and climate change intensify stresses on these systems, integrating wastewater reuse into broader water and coastal conservation strategies has become not just viable but necessary.

Conservation organizations are advocating for wastewater reuse as part of circular water management systems to conserve freshwater and coastal systems, reduce pollution loads and restore

Restored wetlands on a farm in Queen Anne's County, Md. Will Parson, Chesapeake Bay Program © Flickr_CC BY-NC 2.0

ecological function. Reused water, when appropriately treated, becomes a valuable resource that is capable of offsetting demand for freshwater in agriculture, industry and even urban green infrastructure.

Wastewater reuse directly aligns with TNC's global 2030 Goals by reducing nutrient and other wastewater pollution, supporting climate resilience and enhancing water quality in aquatic habitats.[5] Lowering contaminant loads through improved reuse practices strengthens the health of aquatic ecosystems, protects biodiversity and enhances the adaptive capacity of communities that depend on coastal and freshwater resources. It also plays a pivotal role in ensuring equitable access to safe water, particularly in underserved or vulnerable regions that are disproportionately impacted by poor sanitation and climate-induced water stress. Wastewater reuse fulfills TNC's broader mission to create a future where both people and nature thrive, by reinforcing the need for integrated approaches that provide multiple benefits, including conserving and restoring ecological integrity while improving human well-being and economic stability through sustainable water supplies.

Purpose of This Report

As aquatic ecosystems face increasing threats from wastewater pollution, there is growing recognition that we need sustainable, science-backed and well-regulated interventions. Conservation organizations like TNC are stepping into this space not only as implementers of on-the-ground solutions, but also as key actors in shaping the broader legislative, institutional and financing landscapes around wastewater reuse. This report documents TNC's adaptive approach to wastewater reuse within our conservation strategy and offers a critical analysis of the enabling and constraining policy environments in which these interventions unfold.

Through evaluation of ongoing and past projects, survey insights, policy analysis and interviews across TNC's global network, this report examines how wastewater reuse contributes to biodiversity conservation, climate adaptation, water security and public health. It also aims to surface the institutional gaps, regulatory hurdles, enabling conditions and sociocultural dynamics that continue to influence the uptake and scalability of reuse interventions. Ultimately, this report seeks to strengthen learning for TNC staff and partner organizations and inform cross-sector collaboration by making visible the linkages between field-tested solutions and broader systems change.

Objective 1: Documenting and Analyzing TNC's Initiatives Related to Wastewater Reuse

The first objective of this report is to document and analyze TNC's work on wastewater reuse across different geographies and program areas. TNC has been involved in a diverse set of initiatives, from restoring environmental flows using treated wastewater in Mexico's Colorado River Delta, to exploring decentralized reuse in India's Sembakkam Lake wetlands, to influencing state-level reuse strategies in Florida and Hawai'i. These interventions vary in scope but share a common emphasis on ecological restoration, fit-for-purpose treatment technologies and integrated water planning.

Objective 2: Understanding the Policy Landscape and TNC's Role in Policy Development

A second objective is to analyze the policy landscape surrounding wastewater reuse and assess TNC's role within it. While we do not engage in direct policy advocacy in many contexts, we play a catalytic role in shaping enabling conditions through partnership building, co-development of technical frameworks and contributions to regulatory dialogue. These include offering input in consultations, supporting pilot-based learning for regulatory reform, and facilitating coordination among utilities, regulators and civil society actors.

Understanding the legal, regulatory, financial and institutional contexts of wastewater reuse is essential for ensuring the long-term viability and scaling potential of such interventions. In Israel and Singapore, where national mandates and health-based reuse standards have driven uptake, success has hinged on a strong science–policy interface. By contrast, in decentralized systems like the United States, fragmented governance and unclear incentives remain key barriers. TNC's comparative and evidence-informed perspective allows us to offer contextualized recommendations grounded in global practice.

In this regard, this report not only provides a stocktake of TNC's field experience, but also acts as a strategic tool to guide future engagement with public and private actors. It highlights how wastewater reuse, when viewed through a systems lens, can support not only conservation goals but also urban resilience, public health, water stewardship, and equity objectives. In doing so, this report contributes to reframing wastewater as a climate and conservation opportunity that is pivotal to achieving both ecological and human well-being outcomes.

Findings

We conducted a survey to identify a portfolio of diverse, often context-specific, wastewater reuse initiatives across TNC. These included ecological reuse in river basins (Mexico's Colorado River Delta), constructed wetlands in urban peripheries (India's Sembakkam Lake), decentralized reuse systems in coral-sensitive regions (Hawai'i), public–private infrastructure transitions (Long Island and Florida), and treated water for agriculture or landscaping in select U.S. states. Most of these initiatives are embedded in broader water conservation strategies, often combining ecological goals with co-benefits such as pollution reduction, climate resilience, protection of public health and urban greening.

Key Insights on Project Impetus, Goals and Progress

Project impetus: Many reuse initiatives emerged from pressing local needs such as septic failures, aquifer depletion or reef degradation. Others were catalyzed by funding opportunities under resilience or sanitation schemes, often through partnerships with utilities, research institutions or donor organizations.

Goals: Most projects were framed around dual objectives: improving water availability (for agriculture, ecosystems or urban use), and reducing nutrient loads and untreated effluent discharge into sensitive environments.

Progress: Projects that demonstrated stronger outcomes typically featured fit-for-purpose reuse planning (e.g., tertiary treatment for irrigation or groundwater recharge), strong alignment with local or regional policy frameworks, and continued stakeholder engagement, particularly in monitoring and adaptive management. A recurring theme across successful cases was adaptive design, the ability to respond to shifting policy landscapes, community needs or technological constraints. In addition, project champions cited the importance of early-stage co-development with regulators and the presence of enabling institutional anchors, such as city water boards or municipal wastewater departments.

Pure Water Oceanside Project © City of Oceanside

SECTION 2

Wastewater Reuse: Purpose, Benefits and Challenges

This chapter explores the diverse benefits of wastewater reuse, such as augmenting water supply, supporting agriculture and industry, conserving freshwater and coastal ecosystems, and enabling disaster resilience. It also identifies key challenges associated with implementation, including regulatory fragmentation as witnessed in Sembakkam Lake (discussed in the report),[6] financing, technological constraints and public acceptance. Drawing on global case studies and real-world lessons from TNC programs, this chapter highlights both the transformative potential and operational complexities of scaling wastewater reuse.

Purposes and Benefits of Wastewater Reuse

Wastewater reuse is increasingly recognized as a critical resource in the face of mounting water stress, climate variability and ecosystem degradation. Building on the global frameworks and conservation imperatives outlined earlier, this section shifts focus from why reuse matters to how it is being practically applied across sectors. From agriculture to emergency services, wastewater reuse supports a range of end uses that deliver tangible environmental, economic and social benefits when supported by appropriate governance and infrastructure.

Primary Uses of Treated Wastewater

Treated wastewater is used in a variety of sectors, including agriculture, landscape irrigation, industrial operations, aquifer recharge, environmental flows and increasingly, portable applications such as container-based units for military operations or remote housing. Its use is also expanding in the domain of emergency response and disaster relief, most notably for wildfire suppression.

In India, reuse is primarily seen in non-potable applications such as industrial cooling, thermal power plant operations and urban landscaping, backed by national programs like AMRUT and the Safe Reuse of Treated Water (SRTW) framework.[7]

In Israel, over 85% of treated effluent is reused, mostly for agriculture, enabled by centralized governance and sector-specific water quality standards.[8]

Singapore's NEWater program provides highly purified reused water for industrial and air-conditioning cooling purposes,[9] but it also plays a crucial role in Singapore's water sustainability through indirect potable use. During dry periods, NEWater is introduced into Singapore's raw water reservoirs, where it blends with rainwater and undergoes further naturalization and conventional water treatment before being supplied as tap water to consumers. This practice, known as indirect potable use, ensures that NEWater meets stringent safety and quality standards before entering the drinking water supply.[10]

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Namibia's Windhoek facility remains the world's longest-standing example of direct potable reuse (DPR), operating since 1968.[11] Recent initiatives also highlight the growing importance of reuse in emergency services. The enabling environment that allowed this success includes these features:

- **Strong water governance and institutional support:** Namibia has established effective water governance structures, with agencies like NamWater leading implementation and management of DPR projects.
- **Adequate regulation and guidelines:** The country developed its own water reuse guidelines, drawing from international standards (WHO and U.S. EPA), which provided a regulatory framework for safe potable reuse, even before these became national standards.
- **Financing and international partnerships:** Significant investment, such as funding from the German bank KfW, has supported the expansion and modernization of DPR infrastructure.
- **Social acceptance and public engagement:** Namibia's long history with water reuse (since 1968) has fostered public acceptance and trust in the safety and necessity of potable reuse, which is crucial for project sustainability.
- **Response to water scarcity:** Persistent drought and extreme water scarcity have driven innovation and urgency, making potable reuse a necessity rather than an option.
- **Technical capacity and experience:** Namibia operates the world's oldest and one of the largest DPR plants, demonstrating technical expertise and operational know-how.

In Maui, Hawai'i, and in Los Angeles County, California, recycled water is formally integrated into wildfire suppression protocols to relieve pressure on potable systems and improve disaster resilience.[12]

Key Benefits of Wastewater Reuse

These benefits are not theoretical; countries and cities around the world are demonstrating how wastewater reuse directly addresses local environmental, social and water management challenges. The examples below illustrate how reuse contributes to ecological protection, water security, economic efficiency and climate resilience when backed by fit-for-purpose standards and supportive governance.

Environmental Protection and Ecosystem Restoration

By reducing the discharge of untreated or partially treated effluent, wastewater reuse mitigates nutrient pollution, supports aquatic life and restores ecological flows. For example, in Mexicali, Mexico, TNC's Turning Waste into Water initiative channels approximately 1,000 liters per second of treated effluent from the Las Arenitas wastewater treatment plant into the Hardy and Colorado Rivers.[13] The wastewater undergoes several treatment stages to remove nutrients before it is reused. After solids are settled out, the water passes through aerated and facultative lagoons where bacteria break down organic matter and nutrients. The final treatment occurs in constructed wetlands, where plants and microorganisms naturally remove the remaining nitrogen and phosphorus through uptake and microbial processes. This multi-stage system ensures that nutrients are effectively removed, protecting downstream ecosystems from pollution. This intervention has revived wetland habitats in the delta, enhanced biodiversity, and created one of the few consistent sources of freshwater flow into the estuary.

Marine Conservation and Coastal Ecosystem Health

Wastewater reuse plays a crucial role in safeguarding marine biodiversity by reducing direct pollutant loads into coastal environments. Coastal ecosystems like coral reefs and mangroves are highly vulnerable to nutrient loading from untreated wastewater.[14] In Florida, the Leah Schad Memorial Ocean Outfall Program[15] mandates the reuse of 60% of baseline wastewater flow by 2025 to reduce ocean discharge and protect coral reef systems.[16] Hawai'i has implemented decentralized reuse systems and buffer zones near high-discharge coastal areas to protect coral reef health and reduce nearshore contamination, demonstrating how reuse supports marine conservation goals[17].

Water Security and Climate Resilience

Reused water provides a reliable, drought-resistant source that reduces dependence on overexploited aquifers and surface water. According to UNESCO, water reuse is a key global strategy in climate adaptation.[18] In Singapore, the NEWater initiative recycles high-grade treated wastewater for industrial and indirect potable use, meeting up to 40% of the country's total water demand. This reuse strategy has significantly enhanced national water security and buffered the city-state against climate-related water stress[19]. Similarly, Israel has achieved over 85% reuse of treated effluent, primarily for agriculture, through sector-specific water quality standards and centralized governance under the Israel Water Authority. Singapore and Israel exemplify how long-term planning, and public education can mainstream reuse into national water security frameworks[20].

Economic Efficiency and Resource Recovery

Wastewater reuse enables cost recovery for utilities, reduces the need for energy-intensive solutions like desalination and long-distance water transfers and unlocks new revenue streams through water sales, biogas recovery, or biosolid reuse.[21] In India, several state-level policies mandate reuse targets, creating opportunities for utilities to generate secondary income streams from treated effluent.[22] In Long Island, New York, TNC supported a municipal initiative where two wastewater treatment facilities switched from using potable water to tertiary-treated effluent for internal operations like equipment cooling and cleaning. This transition replaced more than 600,000 gallons of potable water daily, saving over $5 million and recovering investment within two years.[23]

Agricultural and Industrial Productivity

Treated wastewater offers a nutrient-rich water source ideal for peri-urban agriculture and a reliable supply for non-contact industrial uses. The European Union's Regulation 2020/741 standardizes agricultural reuse by classifying treated water into quality tiers tailored to specific crop and irrigation methods, providing legal certainty for farmers.[24] In India, multiple state-level urban reuse policies support effluent reuse for industrial cooling and thermal power operations, particularly under the AMRUT and SRTW frameworks.[25]

Challenges in Implementation

Despite increasing momentum around wastewater reuse, implementation continues to be constrained by a wide range of systemic, technical, financial and social barriers. These challenges manifest differently across regions and reuse types, but several recurring themes emerged from global case studies and reports. This section highlights critical impediments to scaling wastewater reuse.

Regulatory and Governance Barriers

Inconsistent and fragmented regulations are among the most cited barriers. Reuse policies often fall across multiple sectors: water, sanitation, health and agriculture, leading to disciplinary silos. For instance, India's SRTW national framework[26] is a set of guidelines that outlines strategic pathways for wastewater reuse, but several states lack end-use–specific discharge standards and cross-sectoral enforcement mechanisms.[27] Another example is in Pakistan, where widespread wastewater reuse in agriculture poses public health risks, as there are no mandatory effluent monitoring protocols nor enforcement mechanisms for reuse licensing.[28]

Financial and Economic Constraints

The high capital and operational costs associated with building and maintaining reuse infrastructure, especially advanced treatment systems for potable or industrial applications, inhibit widespread adoption. Even where treatment facilities exist, the lack of clear tariff structures and poor cost-recovery mechanisms make operations financially unsustainable.[29] For example, Namibia has successfully implemented direct potable reuse for decades, yet replication remains limited due to the high cost of treatment and the need for specialized monitoring and staffing.[30]

Chili with wastewater © SuSanA Secretariat_Flickr_CC

Solid-liquid separation and diffusion of water through hydrophobic membranes in the front unit. © SuSanA Secretariat_Flickr_CC

Technical and Infrastructure Limitations

Technological mismatch is common. Large, centralized treatment plants are often located far from reuse end points such as agricultural fields or industrial zones, making distribution economically unviable without pipeline retrofits or decentralization. In addition, reuse systems often suffer from operational disruptions due to under-maintained infrastructure and a lack of skilled technicians. In sub-Saharan Africa and South Asia, limited technical capacity and poor operations and management (O&M) frameworks impede the consistent functioning of wastewater reuse systems.[31]

Public Perception and Cultural Resistance

The "ick factor," visceral resistance to the idea of using treated wastewater, continues to be a significant challenge. Even when the safety of treated is assured through scientific protocols, public opposition can stall or halt projects. Singapore overcame this through intensive public education campaigns, but many countries lack such systemic efforts.[32] In parts of India and Latin America, informal reuse is common but often carries negative social associations, which affects political will and investment.

Monitoring and Quality Control Deficiencies

Reliable monitoring systems are essential for safe reuse, especially in applications involving food production or potable uses. However, in many countries, testing infrastructure is underfunded and poorly maintained. Even in jurisdictions with relatively strong institutional capacity, monitoring systems often struggle to keep pace with the growing diversity of contaminants, which range from pharmaceuticals and microplastics to per- and polyfluoroalkyl substances (PFAS). PFAS, often termed "forever chemicals," pose particular challenges due to their persistence, the health risks they pose, and the limitations of conventional treatment technologies. Ongoing efforts in countries like the United States to develop enforceable standards for PFAS in drinking water reflect both the complexity and urgency of regulating emerging contaminants. The World Health Organization has similarly emphasized that the absence of comprehensive trace contaminant monitoring, particularly for compounds like endocrine-disrupting chemicals and antimicrobial-resistant pathogens, limits the safe implementation of reuse and hinders public confidence. These gaps in detection, regulation and institutional capacity present serious barriers to scaling safe and resilient wastewater reuse systems, especially in high-contact or food-related applications.[33]

Weak Integration of Marine Ecosystem Protection in Reuse Policy

Despite growing evidence of wastewater's ecological harm to estuarine and marine ecosystems, the policy integration of reuse as a conservation strategy remains limited. Most reuse frameworks emphasize urban or agricultural end uses, overlooking critical coastal outcomes. Reports by UN-Water[34] and the Reef Resilience Network[35] indicate that in many regions, including parts of Asia and the United States, wastewater reuse is not yet recognized as a core intervention in

Purification tanks of old wastewater treatment plant © Pok Rie_Pexels

marine conservation or coastal climate resilience planning. This disconnect undermines cross-sectoral synergies, particularly in areas with coastal urban populations and coral reef systems.

Although reuse can contribute to drought and disaster resilience, most systems are not designed for rapid deployment during emergencies. In Florida and Maui, reuse was successfully deployed in wildfire response,[36] but only in jurisdictions where emergency coordination protocols and decentralized storage were available. Elsewhere, poor coordination between disaster management and water departments has limited the scalability of reuse for emergency preparedness. These challenges, spanning regulatory fragmentation, infrastructural constraints, financial limitations, and social resistance, underscore the complex landscape in which reuse must operate. However, they are not insurmountable. The following chapters examine how select jurisdictions have begun to resolve these barriers through policy innovation, regulatory reform and institutional collaboration, offering insights for replication and scaling.

SECTION 3

Case Studies from The Nature Conservancy

This section presents case studies from TNC's global work on wastewater reuse. These initiatives reveal both the opportunities and complexities of implementing decentralized, nature-based and industrial-scale reuse solutions, with insights into ecological, operational, legal, regulatory and collaborative dimensions of wastewater reuse.

Advancing Potable Reuse and Resilience Planning in Florida[37]

Florida stands at the forefront of water reuse innovation in the United States, driven by escalating freshwater demand, nutrient pollution and climate-induced risks such as sea-level rise and wildfires. With a long history of using reclaimed water for non-potable purposes, the state has taken bold steps toward integrating potable reuse into its water security and resilience strategies. This case study explores how Florida developed a statewide potable reuse framework through multi-stakeholder collaboration, how TNC contributed to aligning policy and ecological priorities, and what lessons this experience offers for scaling reuse as a climate-smart and conservation-compatible solution.

Background

By 2035, Florida is projected to need an additional 1.1 billion gallons of fresh water per day due to population growth and climate-driven stresses.[38] The state is already a leader in reuse: its reclaimed water, having met at least secondary treatment standards, is widely used in agriculture, landscaping and other non-potable applications.[39]

Purple pipes for water reuse © Lance Cheung / USDA

Our Approach

In 2020, Florida's Potable Reuse Commission released a consensus-based Framework for Potable Reuse,[40] which was based on 18 publicly noticed stakeholder workshops involving regulators, utilities, environmental and public health professionals, including TNC.[41] The Framework outlines structured pathways for indirect and direct potable reuse, risk management and public engagement.

TNC's Engagement

TNC supported regulatory alignment, helping integrate ecological priorities and technical rigor into the Framework. Through our engagement with the Florida Department of Environmental Protection and various regional water management districts, TNC contributed to ensuring system safety, environmental protections and permitting clarity.[42]

Challenges

Key challenges included fragmented agency responsibilities, public skepticism toward potable reuse, and limited financial mechanisms. The 2020 Clean Waterways Act addressed some of these barriers by legally defining reclaimed water as a viable source for potable use, but operationalizing this required clearer administrative rules and permitting coordination.[43]

Lessons Learned

- Multi-barrier treatment and real-time monitoring are essential for managing contaminants, especially PFAS and other emerging pollutants.[44]
- Stakeholder consensus can build lasting regulatory and public support.[45]
- Linking reuse with climate resilience, such as fire suppression and drought response, increases relevance and policy traction.

Outcome

Florida is now considered a national leader in potable reuse.

- The DEP is updating administrative codes to implement direct and indirect reuse more effectively, using the 2020 Framework as reference.[46]
- Marion County's program integrates reclaimed water into emergency suppression zones, helping secure infrastructure funding.[47]
- The Framework's success is shared nationally via the U.S. EPA's Water Reuse Action Plan (WRAP), offering lessons on permitting, design, and inter-agency coordination.[48]

Wastewater Reuse for Delta Restoration: Lessons from Mexicali[49]

In one of North America's most water-stressed basins, the Colorado River Delta, wastewater reuse has become a lifeline, not just for communities, but for ecosystems that have long been deprived of freshwater. What was once one of the planet's most productive estuarine ecosystems has been reduced to slivers of dry channels due to upstream diversions, drought and rising demand. Against this backdrop, TNC, alongside partners like the Raise the River Alliance, is leading efforts to bring life back to the Delta using treated wastewater as a reliable source of environmental flow.

Background

The Colorado River Delta in Mexico once thrived as a biologically rich mosaic of riparian forests, wetlands, and estuarine habitats. However, over the past century, upstream diversions, agricultural expansion, and extended drought have left the river dry and the estuary too saline to support native life.

Our Approach

In 2019, a binational agreement between the U.S. and Mexico, Minute 323, created a framework for restoring the Delta by combining public and private investment. A major strategy under this framework

Arenitas treatment wetlands © Carlos Garcia/TNC involved redirecting treated effluent from the Las Arenitas Wastewater Treatment Plant into the Hardy and Colorado Rivers. This reclaimed water is now one of the only consistent freshwater sources for the estuary.

TNC, working with the Raise the River Alliance, played a critical role in securing and implementing this solution. In collaboration with local utility CESPM, TNC and partners expanded the plant's treatment capacity and negotiated the allocation of 10,700 acre-feet of treated water annually for environmental use, enough to cover over 11,000 football fields with one foot of water.

TNC's Engagement

TNC entered with a clear goal: restore in-stream flows to the Delta by turning waste into a reliable ecological resource. It brought scientific expertise, monitoring frameworks and system design support, helping lead the design and analysis of water deliveries in 2021 and 2022 to ensure ecological benefits were maximized. These water pulses were calibrated to emulate natural flow regimes, aiding in seed dispersal, nutrient movement and habitat revitalization.

Raise the River also developed a demonstration site in Guadalupe Victoria, irrigating two hectares of agricultural land with treated effluent, proving the potential for safe and productive reuse of wastewater in farming. A broader reuse roadmap was subsequently developed, highlighting reuse options in agriculture, aquifer recharge and urban landscaping.

Challenges

- Infrastructure limitations at wastewater facilities initially constrained the volume and quality of water available for reuse.
- Variable water quality affected the acceptability of reuse for agricultural and ecological applications.
- Limited market demand for reclaimed water required heavy investment in demonstration and outreach.
- Sustaining flows year after year depends on ongoing financial and policy support under binational agreements like Minute 323.

Lessons Learned

- Partnerships and incentives are crucial: negotiated trade-offs (like funding treatment upgrades in exchange for water allocations) can unlock ecological flows.
- Nature responds quickly: even modest water deliveries have had measurable impact on wetland recovery and estuarine revitalization.
- Agricultural engagement matters: piloting crop switching with less water-intensive yet profitable crops shows the potential for reallocation of water from farming to ecosystems.
- Reuse is scalable: lessons from Mexicali are now informing TNC's work in other basins, including Tijuana, Tecate and the Mayan Forest.[50]

Outcomes

- 10,700 acre-feet/year of treated water is now secured for environmental restoration in the Delta.
- Over 30,000 acres of riparian and estuarine habitat are being revived with regular flow deliveries.
- Treated wastewater is used in agriculture, demonstrating viable circular economy models.
- The project is being explored for blue carbon and water credit investments, aligning ecological restoration with climate finance mechanisms.
- It serves as a global model for arid region reuse, balancing water security, agriculture and biodiversity.

© John Turner

Advancing Non-Potable Reuse in Long Island, New York

In a region not typically seen as water-stressed, Long Island, New York offers a compelling example of why wastewater reuse matters beyond arid zones. Here, TNC and partners have advanced decentralized, non-potable reuse by demonstrating how treated effluent can reduce operating costs, relieve stress on potable systems and serve as a climate adaptation strategy, even in water-abundant settings. By aligning with local governments and regulatory agencies, pilot projects in Nassau and Suffolk Counties provide a replicable model for integrating reuse into municipal operations and landscapes.

Background

Long Island's water supply depends almost entirely on underground aquifers, which are increasingly threatened by over-extraction, saltwater intrusion and nutrient pollution. Despite receiving sufficient rainfall, the island's growing population and aging infrastructure have intensified interest in alternative water management strategies. Recognizing this, TNC began promoting non-potable reuse as a viable way to increase system resilience while offering tangible cost savings for local governments.

Our Approach

Practical, cost-effective pilots were developed that could demonstrate immediate operational and financial benefits. In Nassau County, TNC partnered with the U.S. EPA, New York State Department of Environmental Conservation and private utility operators to retrofit two major wastewater treatment plants. These facilities now reuse tertiary-treated effluent for internal processes such as equipment cooling and plant maintenance, replacing more than 600,000 gallons of potable water per day.

In Suffolk County, a separate demonstration in the Town of Riverhead targeted landscape irrigation. Treated wastewater from the Riverhead Water

Resource Recovery Facility was redirected to irrigate the nearby Indian Island County Golf Course, a seasonal but high-consumption water user. The project overcame multiple barriers, including complex permitting, inconsistent seasonal demand and changes in municipal leadership before becoming operational in 2016.

TNC's Engagement

TNC's entry was strategic: to de-risk reuse by embedding it within existing facilities and permitting frameworks. Rather than proposing large-scale infrastructure from the outset, TNC chose to pilot reuse within plant boundaries, minimizing capital outlay and avoiding contentious regulatory hurdles. Once operational, these efforts provided concrete data on cost savings and performance, helping local governments make the case to scale up.

Challenges

- Permitting delays slowed the golf course project despite broad stakeholder support.
- Seasonal demand constraints limited year-round feasibility for landscape reuse.
- Leadership turnover in local government impacted project continuity.
- High capital costs for off-site distribution infrastructure remain a major barrier for broader replication.
- Lack of incentives for reuse in water-rich areas has created a policy vacuum.

Lessons Learned

- Start small, scale smart: Beginning within treatment plants reduces risk and builds confidence.
- Cost savings matter: Demonstrating $5 million in savings and full cost recovery in under two years helped shift perception from "nice-to-have" to "economic common sense."
- Even in temperate climates, seasonal reuse, if targeted well, can still deliver substantial environmental and economic benefits.
- Inter-agency collaboration is critical, especially between local utilities, regulators and conservation organizations.

Outcomes

- Over 600,000 gallons/day of potable water replaced by reused water at municipal facilities.
- More than $5 million in operational savings achieved across Nassau County's plants.
- Seasonal reuse system operational in the Town of Riverhead, irrigating public green space and reducing nutrient discharge.
- Regional reuse potential mapped across Long Island for golf courses, parks and municipal campuses.
- Model scaled into policy dialogues, highlighting how non-potable reuse can contribute to both water management and fiscal sustainability, even outside traditional drought contexts.

Lake Sembakkam © TNC India

Decentralized Wastewater Reuse for Urban Lake Restoration in Chennai, India[51]

As Indian cities grapple with rising urban water stress and disappearing wetlands, Sembakkam Lake in Chennai offers a replicable model of how decentralized wastewater reuse can drive ecological restoration. Through a collaboration between TNC India, Care Earth Trust and IIT Madras, this initiative integrates decentralized treatment with nature-based infrastructure to restore a vital urban lake while advancing broader goals of biodiversity, flood mitigation and water security.

Background

Sembakkam Lake, part of a once-connected network of wetlands in Chennai, had seen severe degradation due to rapid urbanization, untreated sewage inflow and encroachment. The lake, like many others in India's fast-growing cities, suffered from reduced water quality, declining biodiversity and diminished flood retention capacity. Amid rising concern about urban climate resilience and ecosystem health, TNC India identified an opportunity to apply decentralized and nature-based wastewater reuse to rejuvenate this critical ecosystem.

Our Approach

At the core of the intervention was the installation of a Decentralized Wastewater Treatment (DWWT) system, designed to intercept and treat 5–7 million liters per day of domestic sewage before it entered the lake. This treated water was then passed through constructed wetlands and vegetated buffer zones, enabling further polishing and oxygenation while restoring the lake's natural filtering functions. The reuse system not only improved water quality but also enhanced habitat conditions, contributing to broader lake restoration.

This integrated design was supported by scientific research from IIT Madras, local ecological insights from Care Earth Trust and strategic planning by TNC to ensure that the intervention aligned with city-wide resilience goals. The project now operates as a living demonstration under the Chennai Smart Cities Mission, showing how decentralized reuse and urban ecological restoration can work hand-in-hand.

TNC's Engagement

TNC India entered at a crucial moment, when traditional infrastructure approaches had failed to curb pollution and policy interest in nature-based solutions was growing. Recognizing the need for a scalable model, TNC convened scientific partners, urban planners and local NGOs to co-design a pilot that would not only restore Sembakkam Lake but serve as a template for integrating reuse into urban wetland systems across Indian cities.

TNC played a catalytic role in shaping the project's design, implementation strategy and monitoring framework, helping institutionalize the link between decentralized treatment and urban ecological benefits.

Challenges

- Delayed municipal handover of the project created ambiguity in ownership and slowed long-term O&M planning.
- Fragmented institutional roles and jurisdictional overlaps led to coordination delays, particularly for land-use zoning and buffer zone protection.
- Encroachment in surrounding areas complicated ecosystem restoration and reduced available space for wetland buffers.
- Sludge management remained a weak point, as municipal systems were not equipped to handle waste from decentralized units.

Lessons Learned

- Nature-based reuse systems are viable for urban lakes and offer multi-functional benefits, including water quality, biodiversity, flood control and public space enhancement.
- Science–civil society partnerships are crucial to designing and sustaining these systems where municipal leadership may fluctuate.
- Policy-level gaps persist: current wetland and land-use regulations do not explicitly accommodate treated wastewater or DWWTs in urban planning frameworks.
- Alignment with national missions, such as the SRTW Framework and Smart Cities Mission, provides credibility, but implementation still hinges on local governance support.

Outcomes

- Treated water from the DWWT system is improving oxygen levels and nutrient balance in the lake, reversing years of ecological degradation.
- Bird species diversity has increased significantly, signaling early ecological recovery.
- The lake now supports groundwater recharge and seasonal flood mitigation, serving a functional role in Chennai's urban hydrology.
- The model is influencing ongoing urban water management conversations in Tamil Nadu and has the potential to be adapted in other Indian cities facing similar challenges.

Ka'upulehu West Hawaii © Bryce Groark

Hawai'i: Coral Reef Recovery through Wastewater Management[52]

In Hawai'i, the health of coral reefs and coastal ecosystems is inextricably linked to the state's outdated wastewater infrastructure, which includes over 83,000 cesspools that leak untreated effluent into groundwater and nearshore marine environments. TNC Hawai'i has positioned itself, in collaboration with local partners, at the forefront of efforts to address this chronic pollution source. By combining spatial research, community engagement and policy advocacy, TNC is advancing wastewater solutions that simultaneously safeguard marine biodiversity and promote climate resilience.

Background

Hawai'i's natural beauty masks an urgent environmental challenge: the proliferation of cesspools and on-site disposal systems across the islands. These outdated sanitation systems discharge untreated wastewater directly into the ground, contaminating groundwater, degrading nearshore water quality and accelerating the decline of coral reef ecosystems. The impact is particularly severe in coastal communities, where nutrient and pathogen pollution threaten both ecological and public health.

Our Approach

TNC Hawai'i has focused on research, spatial analysis and policy support to tackle this issue at scale. In collaboration with local universities, community organizations and conservation NGOs, TNC launched a statewide research initiative that integrates:[53]

- Groundwater contamination mapping
- Cesspool prioritization frameworks
- Policy analysis to support wastewater reform and reuse strategies.

This body of work directly informed the implementation of Hawai'i State Act 125, which mandates the upgrade, conversion or closure of all cesspools by 2050. TNC's policy support included identifying high-risk sites, helping prioritize infrastructure investments, and recommending nature-compatible interventions.

In addition, TNC has been actively supporting the integration of water reuse into Hawai'i's state-level planning frameworks, particularly in water-stressed and ecologically sensitive regions. This led to the passage of Hawai'i House Bill 1806, which authorized streamlined permitting for new reuse technologies, further enabling climate-resilient sanitation systems.

TNC's Engagement

TNC's entry into the wastewater space in Hawai'i was driven by ecological urgency. Coral reef health in many areas was in decline, and existing state efforts lacked the spatial tools to prioritize cesspool conversion effectively. TNC filled this gap by conducting watershed-scale and island-wide assessments, bringing data-driven clarity to decision-making. Our work helped shift the narrative from piecemeal cesspool upgrades to a systemic approach that ties wastewater reform to reef conservation and community well-being.

Challenges

- Dispersed pollution sources made it difficult to attribute reef degradation directly to cesspool discharge without robust data and monitoring.
- Community-level opposition occasionally arose, particularly where cesspool conversion was perceived as costly or was poorly understood.
- Infrastructure planning delays, especially in rural or underserved communities, slowed on-the-ground implementation.
- Fragmented permitting processes made it difficult for newer reuse technologies to scale until HB1806 was passed.

Lessons Learned

- Cross-sector collaboration is key: partnering with academic, community, and government stakeholders brought legitimacy and local insight to the science.
- Policy timing matters: TNC's technical work aligned well with emerging political will to address cesspools, helping translate research into reform.
- Reuse potential should not be overlooked, even in regions perceived as water-abundant. Island ecosystems face supply risks that merit diversification.
- Coral reef conservation can serve as a unifying goal, linking wastewater management with broader public support and environmental objectives.

Outcomes

- Support for Act 125 implementation through research and prioritization tools.
- New reuse strategies authorized under HB1806, catalyzing alternative sanitation solutions.
- Integrated spatial datasets and planning tools now guide state infrastructure investments.
- Increased recognition of how wastewater reform contributes to coral reef protection, water security, and climate adaptation.

Limpiopungo, Cotopaxi © Antonio Rosero/TNC Photo Contest 2019

Shaping Wastewater Policy through Multi-Sector Partnerships in Ecuador[54]

In Ecuador, where over one-third of municipalities lack access to wastewater treatment infrastructure, untreated sewage poses a serious threat to rivers, coral reefs and public health. Recognizing the intersecting risks to ecosystems, climate resilience, and human well-being, TNC, in partnership with UNICEF, Universidad de Las Américas (UDLA), and other national stakeholders, launched a bold initiative to fill a critical policy vacuum. Their effort culminated in the formation of a National Roundtable of Sanitation, Wastewater and Climate Change (SARCC),[55] marking a pivotal step in aligning sanitation policy with environmental and child health outcomes.

Background

Ecuador has long struggled with wastewater management challenges, especially in its coastal and riverine municipalities. As of 2021, 38% of municipalities lacked wastewater treatment systems, and untreated sewage continued to flow into rivers and marine ecosystems. These discharges degrade coral reefs and coastal habitats, while also posing serious threats to drinking water quality, facilitating disease outbreaks, and damaging public infrastructure, especially in vulnerable low-income communities.

At the same time, climate variability, marked by erratic rainfall, flooding and drought, was placing additional stress on outdated sanitation systems. The country lacked a coordinated national policy linking sanitation with climate resilience, environmental conservation and public health. Against this backdrop, TNC and its partners initiated a multi-sector collaboration to close policy and governance gaps.

Our Approach

Between 2020 and 2021, TNC, UNICEF, UDLA and other organizations helped establish SARCC. This platform served as a convening space for government agencies, civil society, academia and international organizations to collaborate on systemic solutions to Ecuador's wastewater crisis.

SARCC facilitated a series of multi-stakeholder workshops that gathered input from across sectors, leading to the co-development of a 60-point policy recommendation document. The strategy included actionable guidance across three domains:

- Climate-resilient sanitation infrastructure
- Public financing mechanisms
- Integration of wastewater management with child and community health priorities.

TNC also supported spatial analysis and policy mapping, aligning wastewater reform efforts with conservation priorities, including reef protection and river health.

TNC's Engagement

TNC's involvement began with an assessment of how wastewater pollution was undermining both conservation and development goals. Noting a fragmented governance landscape and a lack of institutional coordination, TNC worked closely with UNICEF and UDLA to launch SARCC as a policy innovation platform. We brought a unique ecological lens to the initiative, helping ensure that the environmental and biodiversity impacts of poor wastewater management were not overlooked.

Challenges

- Policy fragmentation across sectors led to delays in harmonizing regulatory frameworks.
- Lack of data and standardized indicators made it difficult to assess the full ecological cost of untreated wastewater.
- Limited municipal capacity and financing remained persistent barriers, especially in rural areas.
- Political transitions created uncertainty in the adoption and continuity of proposed reforms.

Lessons Learned

- National-level coordination platforms like SARCC can break down institutional silos and elevate sanitation as a cross-cutting issue.
- Embedding conservation goals within health and infrastructure agendas strengthens public and political support.
- Policy momentum builds from evidence: the 60-point recommendation document gained legitimacy by grounding proposals in real-world risk assessments.[56]
- Climate framing helped position wastewater as a resilience issue, not just an infrastructure challenge.

Outcomes

- The 60-point policy roadmap was submitted to Ecuador's Ministry of Environment and Water and is now informing national legislative and budget planning.[57]
- The SARCC model is being considered for replication in other Latin American countries where sanitation, climate and conservation priorities overlap.
- Water quality, reef protection and child health are now formally recognized as interconnected policy concerns.
- TNC has helped position wastewater reuse and nature-based solutions as viable components of Ecuador's emerging climate adaptation strategy.

Conclusion

While the benefits of wastewater reuse are compelling, from water security to ecosystem restoration to climate resilience, the path to scaling these solutions is riddled with complex policy, technical and social challenges. Case studies from across TNC's global programs emphasize that decentralized and nature-based approaches, combined with collaborative governance and enabling policy platforms, hold significant promise. Scaling reuse will require sustained investment, institutional innovation and an inclusive policy framework that supports both public and private actors.

SECTION 4

Legislative Framework and Enabling Policy Conditions

As wastewater reuse becomes increasingly vital to address global water scarcity and climate resilience, legislative and policy frameworks play a pivotal role in determining whether reuse systems can scale safely, equitably and efficiently. Across North America and globally, reuse practices are gaining traction, but their widespread adoption remains contingent on legal clarity, regulatory enforcement and institutional coordination within and across jurisdictions.

This chapter critically examines the legal and regulatory ecosystem governing wastewater reuse at three interconnected levels: global guidelines, national legislative frameworks and local/subnational regulatory instruments. Drawing upon global best practices, TNC's field experiences, and in-depth interviews with technical experts, utility representatives, and policy advisors, this section captures the laws and institutional nuances that shape implementation.

"We found that it's not always the absence of policy that's the problem—it's often the ambiguity in how existing policies are interpreted or enforced that creates roadblocks," observed Flavia Rocha Loures, senior policy advisor for freshwater at TNC. "Especially in federal systems like the U.S. or Canada, subnational decision-making power can either catalyze or stall innovation in water reuse."

First, we review key international guidelines that inform national strategies and regulatory design. Next, we analyze how selected national governments, from the United States to Israel to Singapore, have approached wastewater reuse through legislative instruments. Finally, we turn to subnational and municipal jurisdictions, where legal mandates are tested and operationalized in real-world contexts. This legal scan aims to provide a straightforward understanding of both enabling conditions and barriers to scaling wastewater reuse in diverse governance settings.

Overview of Applicable Legislative Frameworks

Global Frameworks on Wastewater Reuse

Global guidelines offer critical scaffolding for countries that are seeking to legislate and implement wastewater reuse, particularly in the absence of prior frameworks. While they are not legally binding, these guidelines shape how nations and municipalities approach risk, public health and quality assurance.

1. World Health Organization 2006 Guidelines

The WHO document *"Guidelines for the Safe Use of Wastewater, Excreta and Greywater"*[58] continues to serve as a global reference point for countries formulating legislative and regulatory frameworks for wastewater reuse. Volume 1, which focuses on policy and regulatory aspects, outlines a comprehensive multi-barrier approach aimed at safeguarding public health across the reuse chain. This includes components such as wastewater treatment standards, exposure control measures, farmer and consumer education, and monitoring protocols. Crucially, the guidelines emphasize the use of health-based targets: quantitative or semi-quantitative goals that are adaptable based on local risk assessments and capacity.

Rather than prescribing rigid treatment technologies, the WHO approach encourages context-specific risk management, allowing regulators to design frameworks suited to their environmental, social and institutional conditions. It introduces the Sanitation Safety Planning framework, which has since been used globally to inform national reuse standards, particularly in agricultural and landscape irrigation. Many countries, including Jordan, Ghana, and India, have drawn from these principles to legislate wastewater reuse policies that are protective, flexible and implementable within resource-constrained contexts.

As a non-binding yet authoritative document, the WHO guidelines have often acted as a precursor to national legislation, providing legitimacy and structure for countries to operationalize reuse while meeting broader public health and environmental protection goals.

2. United Nations World Water Development Report, 2017
Complementing this, the UN report ***"Wastewater: The Untapped Resource"***[59] has been instrumental in shaping national and regional approaches to wastewater reuse by reframing wastewater as a strategic resource rather than a waste product. It emphasizes integrating reuse into national development plans, urban water strategies, and climate adaptation frameworks, positioning reuse as essential to achieving the UN's SDG 6.3, which aims to reduce untreated wastewater and increase safe reuse globally.

The report calls on governments to incorporate reuse into multi-sectoral planning, invest in infrastructure that enables resource recovery, and establish governance mechanisms that support integrated water management. Its influence is visible in countries that have started embedding reuse into climate policies, urban sanitation missions and nationally determined contributions under the Paris Agreement.

Several countries, including Singapore, Israel, Namibia, India, and Peru, have drawn on this framing to incorporate wastewater reuse into their urban planning, agricultural water policies and water security strategies. While the legislative specifics vary, the report's core message—***to treat wastewater as an asset***—has resonated widely, catalyzing shifts toward circular economy approaches in water policy.

3. World Bank Reports, 2020 and 2022
The World Bank's 2020 and 2022 wastewater reports emphasize the need to shift from compliance-oriented wastewater management toward a resource recovery paradigm.[60] These reports advocate for integrating reuse not only as an environmental or health intervention but as an economic and infrastructure strategy, particularly in small towns and rapidly urbanizing areas.

The 2020 report, ***"From Waste to Resource,"*** argues for embedding reuse into river basin planning, utility operations and national investment frameworks. It highlights the economic inefficiencies of neglecting reuse and urges governments to adopt circular approaches that include treated wastewater as part of long-term water resource planning.

Building on this, the 2022 guide, ***"Wastewater Treatment and Reuse: A Guide for Small Towns,"*** introduces practical tools and decision-making frameworks for decentralized systems, urging policymakers to support Water Resource Recovery Facilities (WRRFs), multi-functional treatment hubs that produce clean water, energy and biosolids. It encourages integrating reuse into financial planning, asset management and performance-based budgeting for utilities.

Though they are not legally binding, these reports have influenced the design of policy instruments, especially in Latin America, sub-Saharan Africa, and South Asia, where governments are increasingly exploring reuse-inclusive investment models. The

World Bank's framing is also resonating with the private sector, especially companies in water-intensive industries seeking regulatory clarity and investment security. As Naabia Ofosu-Amaah[61] from TNC's Corporate Engagement Team noted, "These global narratives are resonating with corporate actors too, especially those with water-intensive value chains seeking regulatory clarity and investment security."

Regional Legislative Frameworks

4. European Union-Regulation 2020/741

The European Union's **Regulation 2020/741**[62] on minimum requirements for water reuse is one of the first legally binding regional frameworks to set uniform standards for treated wastewater reuse, particularly in agriculture. While it was developed for EU member states, it serves as a replicable legal model for countries seeking to regulate reuse with clarity, consistency and public health safeguards.

The regulation introduces a tiered classification system (A–D) for treated wastewater quality, based on intended use and exposure risk. It mandates the preparation of Water Reuse Risk Management Plans (WRRMPs), which must include hazard identification, mitigation measures, monitoring protocols and stakeholder roles. These plans draw on principles from both WHO's multi-barrier approach and ISO risk management standards, integrating public health protection with environmental and operational considerations.

Although it is specific to the EU region, the regulation is already influencing non-EU countries exploring agricultural reuse, especially those developing national guidelines or permitting frameworks. Its clear performance thresholds, emphasis on risk-based planning and legally enforceable structure make it a template for national legislation, particularly in middle- and high-income contexts where centralized treatment and monitoring systems are feasible.

Other Regional Frameworks

Wastewater reuse is governed through diverse legal approaches that vary widely across jurisdictions. Rather than focusing solely on country-level descriptions, this section organizes legislative and regulatory practices by the type of policy lever used. These include:

- Mandates or discharge restrictions
- Enabling frameworks without direct reuse regulation
- Classification-based reuse governance
- Potable reuse legislation

Examples from select countries illustrate how these approaches are applied in practice.

1. Mandates and Discharge Restrictions

In some contexts, legal requirements either prohibit effluent discharge or create indirect pressure to reuse through sector-specific mandates. These rules do not always promote reuse explicitly, but they make it a practical necessity.

- In Canada, water regulation is decentralized, falling under provincial jurisdiction. National laws such as the **Fisheries Act and Canadian Environmental Protection Act** regulate effluent discharges but do not address reuse directly. As Mike Nemeth, senior director of government and industry relations from Nutrien, explained, "While Alberta's environmental permitting supports Zero Liquid Discharge (ZLD) for high-discharge industries, most provinces lack standardized reuse regulations." Municipal bylaws further restrict application. For instance, Calgary prohibits greywater reuse for toilet flushing, despite technical feasibility and infrastructure readiness.
- India's state-level rules increasingly encourage reuse through ZLD mandates in industrial sectors, reinforced by the 2023 SRTW Framework,[63] which calls for municipal reuse targets and end-use-based planning.
- Pakistan, by contrast, lacks enforceable reuse legislation, even though informal agricultural reuse is widespread. While the 2022 National Hazardous Waste Management Policy references reuse, it offers no operational rules or enforcement.

2. National Enabling Frameworks (Without Direct Reuse Mandates)

Some countries lack specific reuse laws but enable reuse through existing environmental or water quality legislation. Implementation typically occurs at the state or municipal level through permits or local agreements.

- In the United States, reuse is not governed by a single national law.[64] Instead, the **Clean Water Act** (1972) and **Safe Drinking Water Act** (1974) provide enabling conditions. The EPA's 2023 update to the Water Reuse Action Plan (WRAP) promotes voluntary coordination across agencies, with nearly 40 actions proposed.[65] However, as TNC's Flavia Rocha Loures notes,[66] "In the U.S., national strategy is important, but without state-level mandates, its implementation is fragmented and uneven."
- Mexico's Ley de Aguas Nacionales (1992) permits wastewater reuse, but in practice, the policy design and enforcement are delegated to local authorities. This decentralization has created a patchwork approach, where success depends heavily on local leadership and collaboration.

A compelling example is the Las Arenitas project in Mexicali, which operates through municipal licensing and stakeholder-driven governance. As Edgar Carrera from TNC Mexico puts it,[67] "It's really about relationships and trust; we negotiate governance frameworks because national rules don't spell it out." The project also underscores a broader lesson: enabling reuse at scale requires more than regulatory permission. "It's not just about laws, it's about alignment," Carrera adds. "Legal, institutional and financial systems must converge for reuse to work at scale."

3. Classification-Based Reuse Governance

Other frameworks regulate reuse by defining treatment categories or end-use classifications, often grounded in WHO or ISO principles. These approaches enable fit-for-purpose reuse by matching effluent quality with intended application.

- India's **SRTW Framework** (2023) draws from the Environment Protection Act (1986) and Water Act (1974) to recommend clear reuse categories, targets and permitting models. Although it is non-binding, it reflects an emerging trend toward context-based regulation.
- Israel offers one of the most structured legal systems for wastewater reuse, anchored in the **1959 Water Law**,[68] which centralizes all water resource governance under the Israel Water Authority. While the original law does not focus exclusively on reuse, it grants the state full ownership and control over all water sources, allowing for comprehensive regulation of wastewater collection, treatment, allocation and reuse. Importantly, subsequent regulations and national reuse guidelines developed under this law provide specific provisions for reuse quality standards, effluent discharge limits, monitoring protocols and permitted uses, particularly for agricultural irrigation. These standards incorporate crop type, soil condition and public health considerations, and are enforced through a centralized permitting and quality monitoring system. According to the WRAP Action 11.1 Delegation Report (2022), Israel's legal infrastructure includes dedicated reuse rules that are applied consistently at the national level, contributing to its reuse rate of nearly 90%, one of the highest in the world.[69]

4. Potable Reuse Legislation

Countries pursuing indirect or direct potable reuse require advanced monitoring systems and legal clarity around safety, liability and public confidence.

- Singapore's **Public Utilities Board (PUB)** has established one of the most advanced legal and institutional frameworks for potable water reuse through its flagship **NEWater initiative**.[70] Although Singapore does not have a standalone "reuse law," PUB's enabling legislation, particularly the Public Utilities Act and supporting regulations, grants the authority wide powers over water sourcing, quality standards and infrastructure planning, allowing it to fully integrate reuse into the national water supply system.

  Under this framework, NEWater supplies high-grade reclaimed water for both non-potable industrial use and indirect potable reuse (IPR), in which treated effluent is added to reservoirs before undergoing further purification. Safety is ensured through continuous water quality monitoring, real-time data systems and adherence to stringent water quality benchmarks, including WHO and USEPA guidelines. As highlighted in the 2023 NEWater Policy Brief, the reuse strategy is not managed in isolation but is fully embedded in national water planning, forming a core component of Singapore's Four National Taps strategy, which includes local catchment water, imported water, desalination and NEWater. This integrated governance model has allowed Singapore to normalize potable reuse socially and politically, while legally safeguarding it through PUB's centralized oversight and risk management mandates.

- Namibia's **Windhoek Goreangab Reclamation Plant (NGWRP),**[71] in operation since the 1960s, is the longest continuously operating direct potable reuse (DPR) facility in the world. Its regulatory structure is distinctive in that it relies primarily on city-level technical and legal controls, rather than national reuse legislation. Oversight is exercised by the Windhoek Municipality, which is responsible for setting and enforcing operational, quality, and safety protocols, including those related to microbial and chemical risk thresholds.

  According to the 2024 NGWRP Operations Manual, the plant operates under a multi-barrier safety system, with monitoring protocols co-developed by the city's water department, health authorities and plant operators. These controls include source water selection, advanced treatment (including ultrafiltration, reverse osmosis and ozonation), real-time quality monitoring and an emergency shutdown protocol in case of contamination. Public health surveillance is also mandated at the municipal level, with inputs from the Namibian Ministry of Health.

- While Namibia lacks a national DPR framework, the Windhoek model has effectively filled that gap by institutionalizing local-level governance, plant-level standard operating procedures and regular auditing by independent laboratories. This system demonstrates that municipal autonomy, when coupled with strong technical and public health capacity, can provide a stable and safe basis for DPR operations.

While national and regional frameworks such as those in the European Union, Israel, India, Singapore and the United States provide essential legal scaffolding and directional policy intent, their implementation is often mediated by subnational systems. This is especially evident in countries like the United States, where water governance is highly decentralized and states play a leading role in determining how reuse policies are adopted, regulated and enforced. Within this landscape, the variation across states such as Florida, Hawai'i and New York offers important insights into how subnational legal instruments can either accelerate or constrain reuse innovation. Interviewees across TNC's working geographies noted that while federal alignment (e.g., through the U.S. EPA's WRAP) is valuable, it is the clarity, consistency and credibility of state-level regulation that determines actual uptake. The following section explores how subnational jurisdictions translate national ambition into operational norms, and how TNC has engaged with these layers to influence on-the-ground outcomes.

Local/Subnational Legal and Regulatory Instruments

Subnational and municipal legal and regulatory frameworks are often where reuse becomes real, translating national ambition into infrastructure, operations and accountability. This level is also where policy diversity and innovation flourish, especially in federal systems like the United States.

In the United States, several states have emerged as leaders in reuse policy innovation:

- California's **Title 22**, first introduced in the 1970s and regularly updated (most recently in 2023),[72] is considered one of the most comprehensive reuse codes globally. It lays out detailed treatment and monitoring criteria for dozens of specific end-uses, including irrigation, industrial cooling, toilet flushing and groundwater recharge, along with requirements for operator certification, pathogen control and public notification. In addition, it clearly defines treatment requirements for each permitted use, including unrestricted landscape irrigation, industrial processes, groundwater recharge and even indirect potable reuse.[73] In 2023, the state also adopted regulations for direct potable reuse (effective from October 2024), marking a significant advancement in reuse governance. A 2020 report by the World Bank clearly highlighted that California's regulatory regime has played a foundational role in scaling municipal reuse and attracting public–private partnerships in the water sector.[74]

- Florida's **Chapter 373 (Reuse Law)** and the **Leah Schad Memorial Ocean Outfall Program** (2008) exemplify how legal mandates can drive implementation.[75] These regulations require utilities to reuse at least 60% of baseline flows, limiting ocean discharge. As noted by TNC's Garrett Wallace, "Florida is taking the steps to recycle its finite water supply and reducing impacts to the natural system." The 2024 update expanded eligibility to include potable reuse and industrial applications, while also establishing dedicated state-level funding mechanisms to support infrastructure upgrades and compliance.
- Other U.S. jurisdictions have also demonstrated innovation. Hawai'i's **HB2743** (2023)[76] formalizes planning for reuse as part of the state's cesspool conversion strategy. In California, Los Angeles County has legalized tertiary-treated recycled water use for wildfire suppression under **Title 22** criteria, with operational protocols issued in 2021. These protocols authorize the use of tertiary-treated recycled water for both structural and non-structural firefighting, confirming that such water meets drinking-water–quality standards and poses negligible health risks to firefighters. Title 22 further recommends a county-wide blanket approval for emergency use, underscoring how fit-for-purpose reuse applications can directly enhance climate resilience through safe and regulated non-potable use.[77] In New York, Long Island's **2023 Infrastructure Plan**[78] encourages reuse for golf course irrigation and municipal landscaping, managed through the state Department of Environmental Conservation-permitted frameworks.
- The U.S. EPA's 2023 WRAP update further enhances this enabling environment at the federal level. While it is not binding, it promotes harmonized risk-based frameworks, technical standards for potable reuse and guidance on integrating reuse into water utility business models.[79] This alignment between federal vision and state implementation has been critical to building momentum across jurisdictions like Texas, Arizona and Georgia.

"Florida's reuse law is not just good policy; it is common sense that will help Florida meet future water demands"

— Garrett Wallace, Government Relations Director, TNC Florida

These examples show how granular policy instruments, treatment standards, end-use permits and discharge caps can foster accountability, make reuse technologies mainstream and reduce environmental burdens. They also highlight how legally defined targets, when paired with technical specificity and funding, offer replicable models for other jurisdictions.

"TNC's power lies in our ability to convene. We translate between sectors- science, business, local government, and help them design reuse interventions that actually stick."

— Naabia Ofosu-Amaah

TNC's Role in Water Reuse Initiatives

While global, national and subnational frameworks provide the legal scaffolding for wastewater reuse, their practical uptake often depends on intermediary actors that can translate policy into action. TNC, through its multi-country engagements, plays a catalytic role in bridging regulatory intent with ecological outcomes. Rather than functioning as a direct infrastructure operator, TNC acts as a facilitator of partnerships, policy convener and science-backed advocate for nature-based and context-sensitive reuse solutions. Across its global footprint, TNC has influenced how treated wastewater is integrated into watershed strategies, city resilience planning, corporate stewardship and ecosystem restoration.

U.S. Initiatives: Institutional Collaboration and Infrastructure Innovation

In the United States, TNC has played a pivotal role in shaping wastewater reuse practices across multiple jurisdictions through policy engagement, infrastructure innovation and facilitation of inter-agency coordination. Our involvement spans state-level frameworks, municipal-scale transitions, and national planning initiatives.

In Florida, TNC served as a member of the Florida Potable Reuse Commission, contributing to the development of a consensus-based framework for potable reuse. According to Garrett Wallace, our involvement was instrumental in ensuring that environmental flows were incorporated into the design of the reuse expansion. Beyond regulatory engagement, TNC also supported public outreach initiatives to help address the "ick factor" associated with potable reuse, using real-time public polling and direct community engagement to build greater comfort and trust in the reuse systems being proposed.

In Long Island, New York, TNC helped identify and address inefficiencies in potable water use at privately managed, municipally-owned sewage treatment plants. As noted by Carl LoBue, New York oceans & fisheries director, some plants were consuming over a million gallons of drinking water daily for routine activities like machinery cleaning. After a change in ownership and the discovery of this inefficiency, the issue came to the attention of TNC when the new owner communicated with a technical community advisory board for Nassau County's sewage treatment plants. TNC advocated for upgrades, the private operators made the investment, and the intervention led to the transition toward tertiary-treated effluent for internal reuse, delivering both environmental and financial gains. Use of potable water for plant operations was eliminated, resulting in operational savings of over US$5 million. This sparked interest from county officials seeking to replicate the model across other public spaces, including golf course irrigation.

In Los Angeles County, California, TNC supported the integration of recycled water into emergency wildfire suppression protocols, making it one of the first U.S. jurisdictions to authorize the use of Title 22-compliant water for this purpose. This innovation emerged from collaborative planning between utilities, fire departments and environmental regulators.

At the national level, TNC contributed to the U.S. EPA's WRAP, particularly through Action 11.1, which focused on international learning exchanges. TNC facilitated dialogues between U.S. states and Israeli agencies, helping inform U.S. approaches to reuse allocation, permitting pathways and public health safeguards, drawing on Israel's globally recognized experience in wastewater reuse governance.

Mexico: Reuse for River Restoration and Urban Planning

In Mexico, TNC has positioned wastewater reuse as a critical strategy for sustaining environmental flows and restoring degraded riverine ecosystems, particularly in the severely water-stressed Colorado River Delta. The Las Arenitas project in Mexicali exemplifies this integration of technical design and ecological restoration. Treated wastewater from a municipal facility is redirected to support wetland regeneration and biodiversity conservation, illustrating how sanitation and environmental goals can be aligned in practice.

According to Edgar Carrera, the Colorado River Delta coordinator of TNC Mexico, the intervention addresses a stark hydrological reality: there is virtually no natural freshwater left for the estuary. In this context, treated wastewater has become an

Arenitas Wetlands © Edgar Carrera/TNC

ecological lifeline for the Hardy and Colorado Rivers, enabling minimum flows and habitat restoration in areas long deprived of water. To institutionalize and scale this approach, TNC also helped design the Mexicali Sustainable Reuse Plan, which identifies reuse pathways across irrigation, aquifer recharge and urban green space applications.

Strong community partnerships have been crucial to the project's success. As Carrera emphasized, the project gained traction only after securing the active involvement of irrigation districts, utility operators and local civil society groups, actors who collectively influence water use in the Delta. This collaborative foundation has positioned the initiative for long-term acceptance and operational continuity.

Building on this momentum, TNC is now working to replicate the model in other locations across the Colorado River Delta and the broader Mayan Forest corridor, where similar ecological and hydrological challenges present both the need and opportunity for wastewater reuse as a restoration strategy.

India: Nature-Based Reuse for Urban Lakes and Wetlands

In India, TNC has advanced a decentralized, nature-based approach to wastewater reuse, particularly in urban contexts where space, infrastructure and social acceptance pose constraints to conventional solutions. Our work focuses on low-footprint treatment systems that simultaneously deliver water quality improvements, support wetland conservation and respond to community priorities.

One of the most prominent examples is the Sembakkam Lake restoration initiative in Chennai, where 5–7 million liters of untreated domestic sewage per day was flowing directly into the lake. As explained by Kishore Kumar Kabirdasan,[80] environmental engineer at TNC, it was not possible to build a centralized sewage treatment plant here due to land limitations and a lack of community buy-in. In response, TNC and our partners proposed a constructed wetland-based polishing system, specifically tailored to local hydrological and ecological conditions.

This solution was preceded by multi-seasonal water quality monitoring, which informed the system's design and allowed for a holistic understanding of treatment goals. Beyond improving effluent quality, the intervention was designed to restore the lake's ecological health, enhance groundwater recharge and revive the lake's value as a community asset.

However, the initiative also revealed gaps in regulatory recognition. As Kishore noted, there is currently no formal policy framework that explicitly classifies wetlands as legitimate sewage treatment systems, even though, in practice, such systems have proven highly effective. The absence of clear institutional backing for decentralized, nature-based reuse remains a policy blind spot that limits wider adoption.

Building on the Sembakkam model, TNC is supporting similar efforts at Pallikaranai Marsh, a large urban wetland in Chennai's southern corridor. Here, unregulated sewage inflows are undermining ecosystem function, and constructed treatment wetlands are being explored as an ecologically appropriate and financially viable alternative to traditional centralized systems.

Corporate Engagement and Global Platforms

Beyond our collaborations with public agencies, TNC has played a pivotal role in advancing corporate engagement on wastewater reuse, particularly through our participation in multi-stakeholder platforms such as the CEO Water Mandate, the Alliance for Water Stewardship, and the Nature for Water Facility. These platforms have enabled companies to translate high-level sustainability targets into on-ground reuse interventions aligned with local hydrological contexts.

As highlighted by Naabia Ofosu-Amaah, senior corporate engagement advisor for Water & Resilience at TNC, our value as an organization lies in our ability to "translate between sectors," linking science, policy and business to co-design reuse solutions that are technically viable and socially embedded. This ability to convene diverse stakeholders has been central to helping companies like AWS, Google and PepsiCo explore wastewater reuse not just as a sustainability measure but as a strategic imperative for operational resilience.

However, efforts to scale corporate reuse have often hit regulatory bottlenecks. One of the corporate partners echoed a commonly felt challenge: local permitting constraints remain among the most significant obstacles, making it difficult for businesses to invest in or implement reuse systems, even for non-potable applications such as data center cooling. Without reform in permitting frameworks,[81] many well-intentioned reuse pilots remain isolated or financially unviable.

To address these challenges, TNC has been actively shaping the policy conversation through engagement with the U.S. EPA's WRAP and global initiatives like the UN CEO Water Mandate. These efforts aim to create an enabling policy environment by promoting regulatory clarity, standardized metrics and cross-sector collaboration. TNC also advocates for blended finance models and integrated planning approaches that support both public and private actors in adopting reuse practices at scale.

In practice, companies such as Dow Chemicals have begun experimenting with constructed wetlands for effluent polishing and supporting community reuse initiatives. These examples demonstrate that when policy, infrastructure and public trust align, industrial actors can become powerful contributors to local water security and ecosystem resilience.

SECTION 5

Why Policy Still Lags Behind Practice and Recommendations

As explored in the previous chapter, a growing body of global and national frameworks, alongside regional innovations and case studies from TNC and beyond, has begun to elevate the role of wastewater reuse in addressing water security, ecological restoration and climate resilience. From urban lake rejuvenation in Chennai to industrial reuse in New York, the technical viability and ecosystem relevance of treated wastewater are no longer in question. However, the real bottleneck lies not in engineering but in governance. One corporate partner observed that even with the treatment infrastructure in place—plants, pipes and capacity—the absence of strong policy signals can result in underutilized systems and missed opportunities for scaling reuse.

Across countries and contexts, policy frameworks continue to lag behind practice. Scaling reuse is not just a matter of repairing infrastructure—it requires transforming the underlying systems of governance, trust and institutional coordination that shape how decisions are made. Even where enabling regulations exist on paper, implementation is often hindered by outdated standards, institutional turfing, regulatory ambiguity or poor social acceptance. These challenges are rarely rooted in a single source. Instead, they reflect a complex interplay of legal, institutional, political and perceptual barriers, which vary widely across geographies, governance levels and types of reuse systems (centralized or decentralized, potable or non-potable, ecological or industrial).

This chapter unpacks these barriers in six thematic clusters:

1. Regulatory and legal bottlenecks
2. Institutional fragmentation and governance gaps
3. Infrastructure gaps and data uncertainty: the twin bottlenecks
4. Political economy constraints
5. Perception, acceptability and social license to operate
6. Financing and cost-recovery challenges

While these challenges are significant, they are not insurmountable. This chapter also distills key lessons learned from diverse geographies, drawing from field interviews, institutional experiences and real-world transitions. For instance, successful interventions often feature strong inter-agency coordination, proactive community engagement and flexible regulatory interpretation that supports innovation.

The chapter concludes with a set of targeted policy recommendations to address these barriers. These include developing fit-for-purpose reuse regulations, enabling cross-sector governance platforms, expanding blended finance models, and creating national and corporate strategies for building public trust. Special emphasis is placed on recognizing ecological reuse and decentralized systems, which are often overlooked in conventional infrastructure planning but offer scalable, context-sensitive solutions in rapidly urbanizing and climate-vulnerable regions.

Ultimately, addressing policy barriers is not just about removing obstacles; it is about actively shaping an enabling environment where wastewater reuse is not treated as an exception but as an integral part of sustainable water and environmental management.

1. Regulatory and Legal Bottlenecks

Despite growing interest in wastewater reuse across various sectors, many countries still operate within incomplete or outdated regulatory frameworks. These frameworks often fail to recognize the diversity of reuse applications—from irrigation to ecological restoration—and tend to prioritize centralized, engineering-heavy solutions over decentralized or nature-based alternatives. The result is a patchwork of regulations that are either too rigid, too narrow in scope, or altogether absent, creating legal ambiguity and administrative inertia.[82]

One of the most persistent gaps is the lack of fit-for-purpose standards for different types of reuse. Many jurisdictions have potable reuse guidelines but no clarity on standards for non-potable applications such as industrial cooling, wetland support or urban landscaping. This was particularly echoed by Mike Nemeth of Nutrien while sharing insights on one of his projects, who said, "We asked for guidelines for internal reuse in boilers, but the agency had none; so, they treated it like discharge." This leads to both over-regulation, where projects are held to unnecessarily strict potable standards, and under-regulation, where no guidelines exist at all.

Further, blanket water quality thresholds for all reuse types raise compliance costs and limit innovation.[83] According to one corporate partner, vendors in countries like Vietnam and Bangladesh are ready to adopt reuse practices but lack clarity on appropriate treatment standards. In some cases, they are held to potable water benchmarks, an approach considered neither efficient nor sustainable for non-potable uses. California's Title 22 and Israel's differentiated reuse standards offer replicable models.[84]

For instance, California's Title 22 Water Recycling Criteria provides a globally recognized model for fit-for-purpose regulation, defining distinct treatment and monitoring standards for various reuse types such as irrigation, industrial cooling and groundwater recharge. Each category is aligned with the degree of human or environmental exposure, ensuring that safety requirements are proportionate to risk. The framework's risk-based approach enables utilities to maintain health protection while lowering compliance costs and fostering innovation. Similarly, Israel's national reuse framework, established under the 1959 Water Law, differentiates effluent quality standards by crop type, soil condition and exposure pathway. Centralized oversight by the Israel Water Authority ensures uniform monitoring and enforcement, contributing to reuse rates approaching 90%. Both models demonstrate how end-use-based standards can replace rigid, one-size-fits-all thresholds, making wastewater reuse safer, more affordable and scalable.

"Most of the time, it's not about whether the government allows reuse, it's about whether the regulations are clear, predictable and enforceable. That's what determines if utilities and companies will invest."

— Flavia Rocha Loures

However, many regions still lack clarity on application-based norms. In the Indian context, wetlands are not officially recognized as treatment systems under any national regulatory framework. Yet, on the ground, they are increasingly used as low-footprint, decentralized polishing systems. TNC's Kishore Kumar Kabirdasan pointed out, "There's no policy that says wetlands can be sewage treatment plants. But in practice, they work." He emphasized the need for regulatory recognition of nature-based systems to legitimize and scale what is already happening informally on the ground.

In Pakistan, the lack of fit-for-purpose reuse standards, especially for agricultural and industrial end-uses, renders formal reuse risky or impractical. The 2022 National Hazardous Waste Management Policy references reuse in principle but does not differentiate it from general discharge. Enforcement remains weak, and most reuse is informal, driven by farmers' necessity rather than policy guidance.[85]

Similarly, in the United States, fragmented standards at the state level create hurdles. While California and Florida have pioneered state-level reuse frameworks, other states operate under loosely defined or outdated guidelines, often drawing from federal clean water statutes that weren't designed with reuse in mind. Another area of concern that emerged was the fragmented permitting systems and public health risk perceptions that could potentially delay reuse projects. Carl LoBue[86] of TNC New York described how bureaucratic inertia and fluctuating local leadership in Suffolk County delayed a golf course reuse scheme for over a decade: "Everyone supported the idea, but no one had clear authority to greenlight it. Between health departments, zoning and utilities, it was a maze." Additional regulatory barriers that came to the fore include:

- Lack of standardized risk assessment protocols for potable reuse (except in California, Arizona and Texas)
- Inconsistent interpretation of reuse quality standards across jurisdictions
- Limited reuse integration into urban development codes and building permits

These challenges are echoed in the 2022 World Bank report, which found that "regulatory uncertainty, more than technical limitation, is the most common reason reuse projects fail to scale."[87]

"It's not that the law forbids reuse. It just doesn't tell you how to do it, or who's responsible. That uncertainty is why many projects stay pilot-scale."

— Edgar Carrera

Another layer of complexity is the absence of explicit guidelines for ecological reuse, such as using treated wastewater for wetland regeneration or river restoration. In Mexicali, Mexico, TNC worked with local authorities to support the use of treated effluent from a municipal plant to restore critical riverine ecosystems. TNC's Edgar Carrera shared that there were no existing legal instruments to support ecological reuse, making the work reliant on creative interpretation of environmental laws and close engagement with local stakeholders.

Corporate partners face similar challenges. One of the stakeholders pointed out that in many jurisdictions, regulatory provisions do not yet allow the use of recycled water in data center cooling towers, even when utilities are ready to supply it. In some cases, companies have had to initiate regulatory change themselves to enable such applications. Similarly, Nutrien's Mike Nemeth highlighted that "reuse projects are approved faster when tied to discharge permits, not reuse potential. That's backward." Nutrien's internal reuse systems are limited by unclear discharge thresholds and inconsistent reuse credit mechanisms across Canadian provinces. TNC's engagement with partners like PepsiCo and Google also underscores these issues. Despite ambitious water stewardship targets, their ability to invest in decentralized reuse hinges on regulatory predictability. As TNC's Naabia Ofosu-Amaah noted: "The question corporations ask isn't just 'can we reuse water?' It's: 'Will regulators approve it, monitor it, and credit us for doing it?'" These examples underscore a common theme: regulatory innovation has not kept pace with practical innovation. While technologies and pilot projects have matured, legal and institutional frameworks remain misaligned. Without updates to accommodate decentralized systems, ecological reuse and private-sector reuse interests, progress will remain patchy and project-dependent.

2. Institutional Fragmentation and Governance Gaps

Wastewater reuse often falls through the cracks of institutional mandates. In most countries, no single agency is responsible for the full wastewater value chain, from treatment and reuse to environmental regulation and public health. This siloed governance model results in poor coordination, overlapping jurisdictions and diluted accountability, particularly in decentralized or peri-urban contexts.

A common issue is the separation of water supply, sanitation and environment departments, with each holding partial authority but none empowered or resourced to drive reuse adoption. In India, for instance, urban local bodies may oversee sewerage infrastructure, while state pollution control boards govern effluent discharge standards and wetlands fall under forest departments, creating a coordination bottleneck that stifles innovation.

> *"Scaling reuse is not just about technology. It's about aligning incentives, filling institutional gaps and creating systems that people actually trust."*
>
> **— Flavia Rocha Loures**

This was echoed by TNC's Kishore Kumar Kabirdasan, who noted that "the institutional turf between water utilities, pollution control boards and wetland authorities makes it extremely difficult to develop integrated reuse models, especially those based on nature-based systems." He stressed that decentralized systems, such as treatment wetlands, need joint stewardship and flexible mandates, neither of which exists in current institutional arrangements.

The governance challenge is not unique to the global South. In the United States, TNC's engagements revealed that even in relatively advanced states, fragmentation between public utilities, environmental regulators and emergency response teams can delay or derail promising reuse applications.

For instance, the integration of recycled water into firefighting protocols in Los Angeles County required months of inter-agency dialogue even though the technology and regulatory clearances were in place. This underscores the need for institutions like TNC to play convening roles. Similarly, in Canada, policy ambiguity across provinces complicates internal reuse decisions. One corporate partner emphasized that navigating regulatory landscapes often takes more effort than designing the reuse systems themselves. They stressed the urgency of having quicker state-level regulatory responses while co-developing frameworks with public agencies.

Mexico provides a contrasting example of adaptive governance. TNC and local stakeholders helped forge a coalition of municipal agencies, irrigation districts and community groups in Mexicali. As TNC's Edgar Carrera explained, "We had to create our own reuse governance model, one that aligned with river health and local priorities. It wasn't mandated by federal law, but it worked because everyone had skin in the game."

Another emerging concern is the absence of monitoring and compliance structures for reuse systems, especially those operating outside conventional treatment plants. Without clear accountability protocols on who tracks reuse quality, volumes or destinations, governance becomes reactive rather than anticipatory. This is especially critical for corporate reuse applications, where reputational risks and community trust hinge on consistent oversight.

In all these contexts, the lack of integrated governance platforms remains a central barrier. While national missions or global frameworks might emphasize wastewater circularity, implementation hinges on local institutions' ability to collaborate, negotiate mandates and co-invest in infrastructure and communication. Absent this coordination, reuse policies, however well-designed, will struggle to translate into action.

3. Infrastructure Gaps and Data Uncertainty: The Twin Bottlenecks

Across geographies, two interlinked issues continue to hamper the scale-up of wastewater reuse: the failure to bridge treated water to end-use points and the absence of credible, standardized monitoring frameworks. These barriers exist at the interface of engineering, governance and trust, and manifest differently across urban, industrial and ecological contexts. In Long Island, for instance, Carl LoBue pointed to the disconnect between treatment and utilization. An external interviewee also echoed this challenge from an industry perspective and said that although they have reduced freshwater intake across facilities, infrastructure gaps make it hard to reuse treated water consistently. As a result, they often depend on local utilities to cross the finish line.

In addition, many legacy sanitation systems are ill-equipped to handle rising groundwater, extreme precipitation and sea-level rise.[88] In Florida's Miami-Dade County, over 13,000 septic systems are projected to be compromised by 2040.[89] Combined Sewer Overflows across New York and Chicago regularly discharge untreated effluent during storms, exacerbated by outdated infrastructure and climate inaction.[90] Yet few jurisdictions have aligned reuse strategies with climate risk assessments or integrated them into long-term planning.

"You have treated water flowing out to sea, while lawns, golf courses and plants still use drinking water. The disconnect is not technical, it's administrative and spatial."

— Carl Lobue

Even when regulatory frameworks exist, their effective implementation is often stalled by missing delivery mechanisms, poor inter-agency coordination and a lack of reuse-specific spatial planning. In Chennai, TNC's Sembakkam pilot illustrates an alternative. Rather than waiting for centralized networks to materialize, the project introduced constructed wetlands tailored to urban constraints, offering a decentralized and ecologically aligned reuse model. As Kishore Kumar Kabirdasan noted, "We didn't just design a system, we designed around what the city couldn't build."

In many regions, water remains underpriced, making reuse financially unattractive.[91] Even when reuse offers long-term savings, the upfront costs of distribution infrastructure, treatment retrofits and permitting dissuade utilities and industries. In the EU, slow farmer uptake of reuse was directly linked to the absence of targeted subsidies.[92]

These infrastructural gaps are compounded by a lack of validated data and monitoring protocols, which hinders public confidence and slows regulatory approvals. Flavia Rocha Loures emphasized this dilemma: "There are utilities treating water to reuse standards, but no one's using it because there's no third-party validation or accessible performance data."

For corporate actors, this results in high perceived risk and low incentive to integrate treated water into operations. Some have resorted to internal shadow pricing of water to justify investment, but without permitting clarity, enforceable standards, and trusted performance data, progress remains fragmented. One corporate partner stated plainly: "The water might be clean, but without standards and data, we can't sell that to our compliance teams."

Until these twin bottlenecks—infrastructure disconnect and monitoring uncertainty—are addressed through better planning integration, policy alignment and data transparency, wastewater reuse will struggle to transition from isolated success stories to widespread practice.

4. Political Economy Constraints

Even where legal frameworks and institutional capacities for wastewater reuse exist, political economy dynamics often determine whether, how and for whom reuse becomes a reality. These constraints are shaped by power asymmetries,[93] risk perceptions, rent-seeking incentives and deeply embedded public sector hierarchies that favor large-scale, centralized infrastructure over decentralized or nature-based alternatives.

In many geographies, water reuse remains a politically invisible issue. It is rarely featured in election manifestos, development grants or political debates unless it is tied to acute drought or water crisis narratives. As one TNC India team member noted, "wastewater isn't a vote-winner," which makes it harder to align reuse goals with political timelines or attract sustained funding. This misalignment is particularly problematic for decentralized reuse models, which are often more socially inclusive but less politically rewarding compared with visible, capital-intensive infrastructure.

Another dimension of political resistance stems from the complex interlinkages between water allocation, pricing and elite capture. In regions where water access is already contested, integrating wastewater reuse can provoke backlash from vested interests. For example, in parts of India, proposals to reuse treated wastewater for industry or agriculture faced pushback from both groundwater user groups and irrigation departments due to fears of shifting control over water flows. Kishore Kumar Kabirdasan reflected that "bureaucratic silos are not just institutional; they're political. Every department sees water as their turf."

In the United States, the perception challenges associated with potable reuse have required deliberate political and public trust-building exercises, often spanning years. Garrett Wallace explained that success depended not only on scientific legitimacy but on building comfort and trust through stakeholder engagement, polling and framing reuse as a resilience measure tied to environmental benefits.

The limited fiscal autonomy of municipalities further exacerbates political economy barriers. In Mexico, Edgar Carrera highlighted how municipal officials were often eager to invest in reuse infrastructure but lacked discretionary funds or had to navigate opaque budget processes that deprioritized water reuse relative to sanitation or flood control. These bottlenecks reinforced the need for multi-level governance coalitions that could leverage state, federal and donor capital in coordinated ways.

Finally, reuse decisions often intersect with broader political ideologies about privatization, decentralization, and environmental governance. Where political leadership is aligned with ecological priorities, reuse gains traction, as seen in the Las Arenitas project in Mexicali. In other cases, especially in federal systems with fragmented mandates, political disinterest or institutional inertia can stall even well-structured projects.

Overall, political economy barriers underscore the need to embed reuse strategies within broader narratives of water security, urban resilience and climate adaptation, framing them not as technical fixes but as politically salient interventions that deliver public goods, create jobs and support local self-reliance.

5. Perception, Acceptability and Social License to Operate

Even where regulatory frameworks and technical solutions are in place, public perception can act as a significant barrier to wastewater reuse. The so-called "ick factor," often rooted in psychological discomfort with using treated sewage, continues to limit the political and social feasibility of projects, particularly those involving potable reuse.
In Florida, for example, TNC supported campaigns to build trust and awareness among water users. As Garrett Wallace noted in the context of Florida's experience: "You don't win this in legislation. You win it through months of community meetings, neighborhood tours and real-time conversations about where their water comes from." His reflection highlights the reality that successful reuse adoption hinges as much on proactive, place-based engagement as it does on regulatory clarity.
Sometimes, policymakers understand the rationale for reuse but fear public pushback. One official remarked: "We know it's the right thing to do. But try telling your constituents they're drinking treated wastewater and see how far you get." Florida's progress was made possible only after years of coordinated, multi-stakeholder engagement.[94]
In India, iterative community sessions were the first step in successfully changing public perception around Sembakkam Lake. Kishore Kumar Kabirdasan recounted, "The same people who feared disease from the lake [from pollution] now bring school kids to watch migratory birds. That's the shift." Nature-based reuse systems, such as constructed wetlands, are often locally accepted but lack formal policy recognition. Kabirdasan explained that although communities around Sembakkam Lake supported wetland-based polishing systems, policy gaps persist because such approaches are not yet institutionally validated as legitimate reuse pathways.

> *"The science isn't enough, you need to build emotional trust."*
>
> **— Garrett Wallace**

Even corporate actors recognize the importance of social license. One of the leading corporate partners noted, "Reuse isn't just technical, it's reputational. We need communities to see us as water stewards, not just water users." Several other corporate partners shared that while they are willing to invest in reuse infrastructure, unclear permitting frameworks and disproportionate risk burdens discourage long-term commitments. Unpredictable regulatory environments remain a critical barrier to scaling private sector engagement.

Across geographies, these experiences underscore that technical success does not guarantee social acceptability. This is why EU law now mandates the public disclosure of compliance data to build acceptance.[95] Thus, long-term investments in public education, community engagement and transparency are essential for scaling reuse interventions, especially where safety and stigma intersect.

6. Financing and Cost-Recovery Challenges

Despite growing consensus on the environmental and economic benefits of wastewater reuse, financing mechanisms remain a significant hurdle, particularly for decentralized, nature-based or small-scale systems that do not fit traditional infrastructure funding models. The lack of dedicated public finance pipelines, fragmented cost-sharing responsibilities and limited uptake of innovative finance tools contribute to the persistence of underfunded reuse projects across regions.

Several experts noted that while capital costs for decentralized systems may be lower, the absence of operational subsidies or tariff-linked recovery frameworks discourages municipalities from adopting them. Interviewees across Mexico and India emphasized that smaller towns and peri-urban areas lack access to concessional funding for retrofitting existing systems with reuse capabilities. Moreover,

> *"We tend to talk about the policy problem as if it's singular, but in reality, every actor sees a different bottleneck, and no one sees the whole system."*
>
> **— Naabia Ofosu-Amaah**

the creditworthiness of local utilities continues to be a key constraint for accessing blended finance or performance-based grants. Mike Nemeth of Nutrien noted that "If you're only looking at the cost per cubic meter, reuse loses. But if you factor in ESG, regulatory risk, and long-term security, it wins. We need regulators to start accounting for that."

An anonymous company shared that reuse planning often competes with other capital priorities unless governments provide clear incentives: "We have internal targets, but we need matching policy tools: tax benefits, offset recognition or fast-track permitting." TNC's Carl LoBue emphasized how economic framing helped unlock reuse in Long Island: "When the county saw they could save $5 million through internal reuse, the whole conversation changed." In addition, one of the corporate partners noted that while supply chain partners are interested in investing in water reuse, persistent uncertainty around regulatory approvals, tariff incentives and credit mechanisms dampens motivation and follow-through.

Further, the cost of establishing monitoring, evaluation, and compliance systems, often mandated by national guidelines, is rarely built into municipal project budgets. As a result, utilities struggle to sustain compliance beyond pilot phases.

In contexts like the Colorado River Delta and South India, where ecological and community co-benefits are often the strongest rationale for reuse, the absence of ecosystem service valuation tools hampers the ability to attract philanthropic or climate-linked finance. The monetization of such co-benefits remains nascent, despite growing interest in results-based payments and nature performance bonds. A nature performance bond is a debt instrument in which a borrower's repayment terms (such as interest or principal) are reduced if agreed, measurable nature or biodiversity outcomes are achieved, aligning financial incentives with environmental performance.[96] These bonds are designed to link the cost of debt directly to success in protecting or restoring natural capital.

The cumulative effect is a financing gap that disproportionately affects low-income communities and non-urban systems, where reuse could deliver high-impact outcomes. Addressing this challenge requires not only earmarked budget lines and concessional funding but also regulatory mandates that incentivize life-cycle cost accounting and inter-departmental savings transfers.

Lessons Learned and Country-Specific Innovations

The landscape of wastewater reuse is rich with experimentation, but also uneven in uptake and success. Several cross-cutting lessons emerged across countries and case studies, underscoring the importance of adaptive governance, regulatory clarity, institutional capacity and community-centered planning.

1. **A clear and enforceable policy framework is a foundational enabler,** not merely a technical requirement. Countries like Singapore, Israel and Namibia demonstrate how robust guidelines, whether through quality standards, reuse classifications or discharge permits, can reduce institutional hesitation and support infrastructure investments. In Singapore, for instance, reuse is not framed as a last-resort measure, but as a core part of the water supply strategy, integrated into public narratives and backed by pricing incentives.

2. **Successful models embed reuse within broader water and ecological goals** rather than pursuing it as a stand-alone technical fix. In Mexico, the Las Arenitas project reflects this integration; treated wastewater sustains wetland regeneration

> *"Reuse will not scale on goodwill or intention alone. It needs policy teeth, public trust and financing mechanisms that make it viable for everyone."*
>
> **— Naabia Ofosu-Amaah**

and environmental flows in the Hardy and Colorado Rivers. TNC's Edgar Carrera emphasized that ecological lifelines are increasingly dependent on reuse, and that stakeholder alignment, including irrigation districts and utilities, is crucial for scale and acceptance.

3. **Decentralized and nature-based systems need to be incorporated into policy** rather than operating in policy grey zones. In India, for example, wetland-based polishing systems like the one designed for Sembakkam Lake highlight the potential of low-footprint reuse aligned with conservation. However, as TNC India's Kishore Kumar Kabirdasan observed, these systems lack regulatory recognition. Despite delivering multiple co-benefits, including groundwater recharge, ecosystem health and social acceptance, nature-based reuse remains outside most formal sanitation planning frameworks.

4. **Public perception and social license can make or break a reuse initiative.** In Florida, efforts to expand potable reuse were shaped as much by science as by public sentiment. TNC played an active role in commissioning polling and engaging communities to reduce psychological resistance, often referred to as the "ick factor," around recycled water. As Garrett Wallace of TNC Florida noted, community trust was key to gaining policy traction.

5. **Institutional coordination across sectors is often more important** than infrastructure funding. Interviewees from Hawai'i, Long Island and Los Angeles consistently pointed out that fragmentation between utilities, regulators and local governments delayed implementation, even when technical solutions were available. Cross-agency alignment, whether through task forces, reuse commissions or public–private dialogues, proved essential for lasting adoption.

Recommendations to Overcome Policy Barriers

Despite growing recognition of wastewater reuse as a strategic water management solution, its uptake remains constrained by fragmented policy regimes, unclear mandates, and limited public acceptance. Drawing on case studies, practitioner interviews, and global benchmarks, this section outlines targeted recommendations to address existing policy barriers and create an enabling environment for scale.

1. Strengthen regulatory clarity and fit-forpPurposesStandards

Across geographies, a fundamental constraint to scaling wastewater reuse is the absence of clear and differentiated regulatory standards. As one TNC corporate partner observed, "Policy doesn't have to be perfect, but it has to be predictable. That's what allows innovation to move." In many jurisdictions, policies either apply uniform water quality thresholds regardless of end use or lack enforceable guidelines altogether. This not only creates uncertainty for utilities and industries but also limits the viability of cost-effective and decentralized solutions. To enable broader uptake, governments must prioritize the development of tiered, risk-based standards aligned with specific reuse applications, such as irrigation, industrial processes, aquifer recharge or ecological flow augmentation.

Such clarity is especially critical for decentralized and nature-based systems, which often operate in regulatory grey zones. As TNC's Kishore Kumar Kabirdasan pointed out, despite the demonstrated efficacy of initiatives like the Sembakkam Lake restoration, enabling policies have yet to formally recognize these approaches. Without regulatory backing, these models remain on the periphery of mainstream planning, even where they deliver strong performance outcomes.

> *"Scaling reuse is not just about technology. It's about aligning incentives, filling institutional gaps and creating systems that people actually trust."*
>
> **— Flavia Rocha Loures**

Well-established frameworks offer a roadmap. The U.S. EPA's WRAP (2023) provides states with adaptable models for implementing fit-for-purpose standards. The **EU Regulation 2020/741** also provides graded quality standards for agricultural reuse based on crop sensitivity and irrigation method. California's **Title 22** remains a leading benchmark for multi-tiered regulations, while states like Arizona, Texas, Florida and Hawai'i are evolving their own risk-based protocols suited to local conditions. As TNC's Mike Nemeth emphasized, "clear standards save time, money and credibility."

This gap between policy intent and operational clarity also emerged in stakeholder consultations. When legal frameworks advocate for reuse without specifying permissible thresholds or quality parameters, the liability is often transferred to end users, undermining confidence and stalling implementation. One interviewee observed that in such cases, "the infrastructure exists, but the absence of regulatory assurance deters uptake."

Strengthening regulatory clarity is not simply a compliance issue; it is an enabler of innovation, investment and scale. By establishing purpose-driven standards and recognizing the full spectrum of reuse approaches, especially decentralized and nature-based systems, policymakers can create the legal certainty necessary to drive sustainable, climate-resilient water management.

2. Integrate reuse into urban and watershed planning

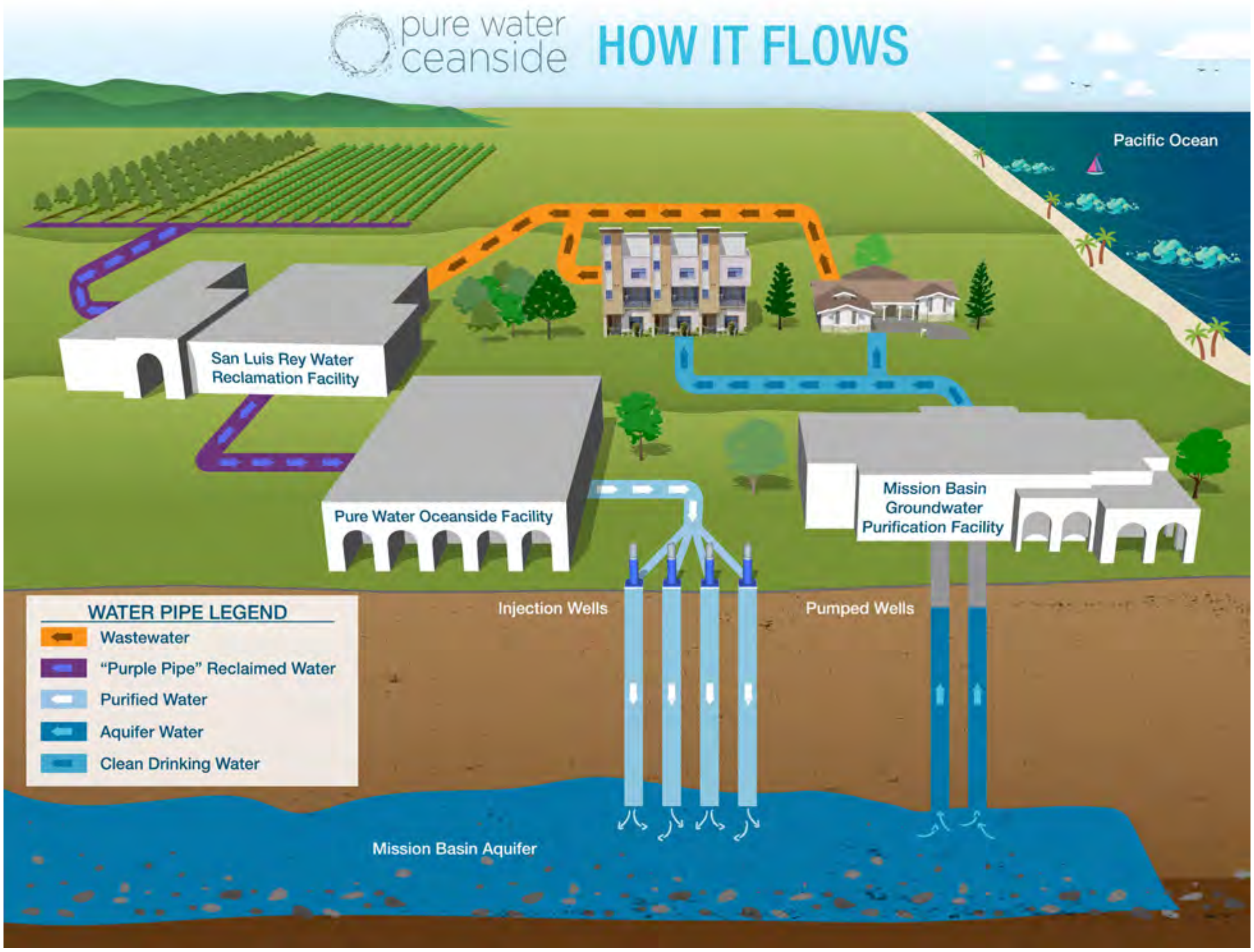
To be effective, wastewater reuse must move beyond the boundaries of individual treatment plants and become embedded within broader frameworks for urban development, water resource management and climate resilience. When reuse is planned in isolation, it risks remaining a peripheral intervention. Instead, its potential is unlocked when it is integrated into city-wide infrastructure strategies, watershed restoration programs and long-term resource planning.

Singapore exemplifies this systems-level thinking. The Public Utilities Board's NEWater strategy is not a stand-alone initiative; it is woven into the city's land-use planning, industrial zoning, demand forecasting and resilience modeling.[97] Reuse is positioned as central to Singapore's water security, supported by public communication and regulatory alignment. Similarly, Israel's national agricultural planning incorporates reclaimed water as a core input, with over 85% of treated wastewater reused, enabled by robust policy frameworks and incentives that make reuse both viable and scalable.

India is making gradual shifts in this direction. The SRTW Framework (2023) encourages states to integrate reuse into sanitation planning, river basin strategies and state water budgets. As TNC's Kishore Kumar Kabirdasan explained, "It's not binding, but it helps departments think beyond the sewage treatment plant. It's pushing reuse into planning conversations." This shift in perspective is crucial, especially for aligning financial, spatial and institutional planning around reuse.

In Mexicali, Mexico, the Las Arenitas project illustrates how aligning reuse infrastructure with a watershed-scale ecological restoration plan can foster long-term cooperation between agencies and communities. Rather than treating reuse as a secondary utility function, the project positioned it as a tool for environmental regeneration, helping to build institutional buy-in across sectors.

Across the United States, states like California have begun embedding reuse into regional drought contingency plans and basin-scale water supply strategies, recognizing its role in climate adaptation and water reliability.



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Integrating reuse into urban and watershed planning is not just about better infrastructure; it's about ensuring that reuse becomes a structural part of how cities and regions think about water, resilience and sustainable growth. When aligned with spatial, ecological and fiscal planning, reuse transforms from a niche intervention to a foundational pillar of water security.

3. Foster inter-agency coordination and mandate alignment

One of the most persistent challenges to advancing wastewater reuse is the fragmentation of institutional roles and siloing of responsibilities for water supply, sanitation, environment and urban development. This often results in overlapping mandates, misaligned priorities and bottlenecks in decision-making. To overcome this problem, we recommend establishing dedicated reuse commissions, investing in regulatory training and assigning clear roles to improve permitting efficiency and cross-agency collaboration. Florida's **Potable Reuse Commission** demonstrates this model,[98] bringing utilities, engineers and regulators together to co-develop guidance that now influences statewide policy. In Namibia, strong centralized oversight has sustained one of the world's longest-running potable reuse systems, showing how capacity and institutional stability matter as much as technology.

© Florida Potable Reuse Commission

> *"Permitting isn't just about rules, it's about relationships."*
>
> **— Carl Lobue**

We've seen the power of these approaches in action. The U.S. EPA's WRAP, to which TNC contributed, demonstrates how structured collaboration among agencies can spur meaningful progress at the state level. Similarly, in Florida, the Potable Reuse Commission served as a collective forum for utilities, regulators, NGOs and technical experts to co-design fit-for-purpose guidelines. As one of TNC's corporate partners aptly put it, "Policy shouldn't be written in isolation. If you want infrastructure to deliver, get the implementers into the drafting room."

This principle extends beyond inter-governmental alignment. Multi-stakeholder platforms—where governments, industries, utilities and civil society engage as equal partners—lay the groundwork for practical, grounded policy that aligns with real-world implementation. They create the institutional muscle to transform reuse from an aspirational concept into operational reality.

From these experiences, five enabling policy conditions emerge as essential:

- Mandates and incentives that make reuse expectations explicit and actionable.
- Integrated planning that embeds reuse into long-term water, sanitation and climate strategies.
- Tiered, risk-based water quality standards that instill regulatory clarity and build user confidence.
- Public engagement frameworks that reshape perception and build social acceptance.
- Institutional platforms that support continuous dialogue and collaboration across sectors.

In a climate-stressed world, the role of policy is evolving. It's no longer just about enforcing compliance; it's about shaping pathways for transformation. Building circular water futures will require policy environments that are inclusive, adaptive and co-created, where regulation meets innovation, and where mandates are matched with mechanisms for shared ownership.

4. Build social license and community ownership

Scaling wastewater reuse is not solely a matter of engineering; it is deeply shaped by perception, trust and public engagement. Among the most significant barriers, particularly for high-contact or potable applications, is the psychological discomfort. Technical solutions alone are insufficient. Building social license requires sustained efforts in transparency, inclusive engagement and cultural reframing.

Public acceptance grows when communities are treated not merely as end users, but as informed partners in design, oversight and stewardship. In Florida, TNC supported public polling to understand community concerns around potable reuse, which then shaped targeted outreach efforts. In Mexico's Las Arenitas project, early involvement of local irrigation boards and NGOs ensured that community voices influenced project design, reinforcing both local legitimacy and long-term viability.

The importance of trust cannot be overstated. Singapore's success with reuse is not simply a function of advanced treatment technologies, but the result of decades of public education, participatory outreach and a national narrative that reframed reused water as a symbol of resilience and innovation. As one interviewee noted, "Reuse should not be framed as a last resort. It must be positioned as a smart, resilient choice."

TNC's experience reinforces this principle. In Chennai, school engagement and community awareness efforts around lake restoration helped shift local narratives and normalize reuse. In Long Island, New York, transparent dialogue around utility savings and ecological co-benefits helped turn skeptics into advocates. As one of our corporate partners shared, "The science doesn't sell reuse. The story does."

This approach has found traction elsewhere. Singapore's NEWater visitor center played a pivotal

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role in transforming perceptions by making reuse visible and tangible. In San Diego, participatory campaigns and accessible water quality data helped secure public support for potable reuse. In India, outreach under the national government's **Namami Gange Program** has repositioned decentralized reuse as a meaningful intervention for both river health and local livelihoods.[99]

Ultimately, building social license is not a communications add-on; it is a core pillar of successful implementation. Policy frameworks must embed community engagement throughout the life-cycle of reuse initiatives, from project scoping to operations. When communities are empowered with information, involved in decision-making, and witness real-world benefits, reuse becomes not just acceptable but a source of shared pride and resilience.

5. Unlock finance for decentralized and industrial reuse

High up-front costs and uncertain returns continue to deter both municipal and industrial actors. Blended finance models, viability gap funding and performance-linked grants can lower investment risks. Targeted incentives, such as tax rebates or expedited permitting, for industries adopting reuse technologies (e.g., constructed wetlands, ZLD systems) can enhance adoption. In Long Island, TNC's collaboration with Veolia and county authorities demonstrated how public–private partnerships can yield both ecological and economic dividends, saving over $5 million annually by replacing potable water with treated effluent in municipal operations.

Even with regulation and planning alignment, reuse will not scale without viable financing mechanisms. Blended finance models, long-term municipal bonds and performance-based funding can help unlock capital.[100] In Brazil, the PRODES program reimburses municipalities based on verified performance of wastewater treatment, incentivizing long-term O&M. Durban, South Africa, pioneered an industrial reuse public-private partnership that offset public costs through commercial offtake agreements.[101] In India, urban reuse is increasingly supported under AMRUT 2.0, though tariff reforms are still needed for financial sustainability.[102]

Fire supression © Ozzie Stern/unsplash

> *"Wastewater reuse is not the future, it's the present. Policy just hasn't caught up yet."*
>
> **— Flavia Rocha Loures**

6. Position reuse within climate adaptation and resilience strategies

Wastewater reuse should be integrated into national and subnational climate adaptation frameworks. Its co-benefits for groundwater recharge, drought resilience and wetland restoration position it as a critical lever for meeting water-related climate goals. Jurisdictions such as Los Angeles County in California have pioneered the use of recycled water in wildfire suppression, aligning reuse practices with disaster preparedness and environmental protection[103].

7. Foster policy experimentation and pilot-friendly environments

Finally, governments must create regulatory spaces that permit experimentation and learning. This includes streamlined permitting for pilot projects, adaptive standards based on real-time data and flexible financing windows. Innovation-friendly environments enable agencies to deploy context-specific solutions, especially in regions with variable hydrology or infrastructure limitations. In addition, transparent monitoring systems, adaptive governance and citizen oversight increase accountability and trust.[104] Israel and Singapore provide real-time public access to water quality data, reinforcing safety and credibility. In the United States, potable reuse projects must meet strict regulatory monitoring under the Safe Drinking Water Act. In Chennai, community participation in monitoring treated wastewater used for lake restoration has fostered local ownership and better operational performance. Embedding feedback loops also allows for iterative improvements to standards and operations.

The barriers to wastewater reuse outlined in this chapter are real, but they are not insurmountable. When countries have prioritized clarity, coordination and communication, reuse has scaled. By transitioning from reactive to proactive policy, wastewater reuse can become not only technically feasible but politically, socially and economically viable.

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SECTION 6

Conclusions and the Way Forward

Wastewater reuse has the potential to move from the periphery of water management to the center of global sustainability efforts. It offers a powerful solution to some of the most pressing ecological, climate and water security challenges of our time. Whether it is reducing nutrient pollution in coral reefs, securing water for drought-stricken agriculture or enhancing resilience in rapidly urbanizing landscapes, wastewater reuse is no longer a fringe intervention, it is an essential tool in the conservation and climate adaptation arsenal.

Wastewater reuse is not merely a technical fix; it is a systems-level opportunity to reimagine how water is managed, valued and governed. Across Florida, Long Island, Chennai, Hawai'i, Mexicali and other geographies, TNC has demonstrated how reuse can be integrated into ecological restoration, disaster preparedness, wetland regeneration and corporate water stewardship. These initiatives show that with the right policy signals, institutional collaboration and community trust, reuse systems can be equitable, cost-effective and scalable.

At the policy level, TNC's work highlights that enabling conditions, not just infrastructure, are the real accelerators of change. Clear regulatory standards, fit-for-purpose guidelines, financial incentives and inclusive stakeholder platforms are essential mechanisms for embedding reuse in mainstream planning. This alignment is especially crucial as governments and corporations strive to meet ambitious water, climate and biodiversity targets under the UN's SDGs and the Kunming-Montreal Global Biodiversity Framework.

To further cultivate this enabling environment, conservation organizations can serve as conveners to co-create policy frameworks, expand partnerships to include utilities and private sector champions, and amplify community narratives that normalize and celebrate reuse. In addition, they can invest in decentralized and nature-based solutions to provide sustainable wastewater infrastructure and promote environmental equity.

Scaling successful reuse initiatives is not only possible, it is imperative. With intensifying climate pressures and widening inequities in water access, the reuse of treated wastewater offers a rare convergence of environmental necessity, economic logic and social equity. This is an opportunity to bridge science and policy, while working across sectors to ensure that wastewater is no longer treated as waste, but as a resource.

Key Recommendations for Scaling Wastewater Reuse

To institutionalize wastewater reuse as a pillar of conservation and resilience, TNC and our partners should prioritize policies that

1. **Advance fit-for-purpose standards:** Develop tiered, risk-based water quality guidelines for different reuse applications, and support their codification in local and national regulations.
2. **Embed reuse in planning frameworks:** Integrate reuse into water, climate, urban development and disaster preparedness plans to ensure long-term policy coherence and infrastructure alignment.

3. **Catalyze blended financing models:** Unlock capital through green bonds, resilience funds and public–private partnerships, especially for decentralized and nature-based reuse systems.
4. **Mainstream nature-based reuse solutions:** Promote constructed wetlands, buffer zones and other ecological infrastructure as formal components of wastewater treatment and reuse strategies.
5. **Strengthen policy engagement platforms:** Establish and maintain multi-stakeholder bodies that bring together utilities, regulators, communities and corporate entities to shape adaptive reuse policies.
6. **Invest in monitoring and data transparency:** Support the development of standardized monitoring frameworks and public dashboards to build trust and enable performance-based management.
7. **Drive public communication and social normalization:** Launch inclusive storytelling and education campaigns that reframe reuse as safe, resilient and aspirational—especially in high-contact applications.
8. **Position reuse within climate and biodiversity agendas:** Ensure that wastewater reuse is recognized in global and national frameworks as a key strategy for climate resilience, biodiversity protection and blue economy development.

As TNC's Flavia Rocha Loures aptly stated, "Reuse will not scale on goodwill or intention alone. It needs policy teeth, public trust and financing mechanisms that make it viable for everyone." This is the path forward-to transform wastewater from a missed opportunity into a cornerstone of resilient, inclusive water futures.

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55 SARCC functions as a multi-stakeholder coordination platform rather than a formal statutory body. It was convened as an ad hoc initiative, jointly led by TNC, UNICEF and UDLA, with support from relevant government entities. While not established through legislation, it was

designed to inform national policy and build institutional alignment across sectors. Its influence is evident in how the 60-point recommendations have been taken up by Ecuador's Ministry of Environment and Water. We have retained this framing in the report to reflect its catalytic and policy-shaping role, even though it does not hold formal regulatory authority.no

56 For more details, see https://tnc.box.com/s/fttgm80gw0bsk27uurl6bbdji9sgxvr6

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65 The EPA's 2023 update to the Water Reuse Action Plan (WRAP) promotes voluntary, policy-level coordination across federal agencies, utilities, research institutions and the private sector. Although WRAP is non-regulatory, it outlines nearly 40 actionable items that influence how water reuse is prioritized, financed and governed. These include developing risk frameworks, updating reuse-related guidance and promoting public-private partnerships. In that sense, WRAP functions as a national water reuse policy roadmap—providing structure, vision and shared goals for implementation, even though it lacks the force of law. However, the core tension remains:

WRAP sets federal policy direction, but execution depends on state-level regulatory adoption or utility-led initiatives. U.S. Environmental Protection Agency. 2020. National Water Reuse Action Plan: Collaborative Implementation (Version 1) (EPA 820-R-20-001). https://www.epa.gov/waterreuse/national-water-reuse-action-plan-collaborative-implementation-version-1

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APPENDIX 1

Survey Methodology

To comprehensively understand the landscape of wastewater reuse across TNC's programs, we undertook a structured research and outreach process. This included a qualitative survey with a series of in-depth interviews conducted across internal teams and external corporate partners. These interviews were conducted via the interview platform Riverside.fm, which enabled both audio recording and real-time transcription.

The survey instrument, designed for both TNC members and corporate partners, aimed to capture not only the geographic spread and thematic trends across reuse initiatives, but also the drivers, enabling conditions, institutional roles and barriers in project implementation.

This mixed-methods approach allowed for both qualitative insights and comparative analysis of institutional strategies, technical innovations and stakeholder dynamics. We paid particular attention to project origins, goals, enabling conditions, implementation challenges and outcomes, which enabled us to identify replicable practices and scalable models. Where relevant, the analysis also explores how TNC's reuse projects intersect with corporate supply chains, nature-positive infrastructure strategies and blended finance pathways.

The survey instrument included questions on

- Type and scale of wastewater reuse projects
- Primary end-use applications (e.g., agriculture, aquifer recharge, industrial)
- Regional and national policy and governance contexts
- Perceived environmental and social benefits
- Challenges related to implementation, technology and compliance
- Level of stakeholder involvement and monitoring practices

The survey also captured whether projects had received formal governmental recognition or were embedded in local/state/national planning processes. Respondents were encouraged to flag case studies that merited deeper exploration in follow-up interviews.

Overview of Internal Survey

The internal survey was designed and circulated among members of the following relevant TNC communities of practice (CoPs): Aquatic Wastewater Pollution, Freshwater, North America Cities Network, Urban Water and WASH Network. The survey was designed to collate an inventory of wastewater reuse initiatives and understand the alignment of these projects with TNC's broader 2030 Goals, particularly water security, climate resilience and ecosystem restoration.

Methodology for Conducting Interviews

Once the survey was closed, we evaluated the responses and identified potential individuals for more in-depth interviews on the basis of the relevance and maturity of their water reuse projects. Next, we conducted virtual, in-depth semi-structured interviews with TNC staff from the following project geographies: Florida, Hawai'i, Long Island, Mexico (Tijuana and Mexico City Water Fund) and India (Sembakkam Lake wetlands). The interview protocol followed a structured template organized into thematic blocks: project goals and outcomes, enabling policies, partnerships, monitoring systems, community engagement and future perspectives.

In addition, we interviewed corporate partners involved in water stewardship. A dedicated questionnaire explored how reuse fits into their sustainability strategy, the role of legal and regulatory frameworks, corporate innovation in reuse and opportunities for NGO-industry partnerships. This two-pronged strategy, engaging internal staff and external partners, enabled a cross-sectional view of the reuse ecosystem from both implementation and policy engagement perspectives.

Fit-for-Purpose Reuse Policy Checklist and Two-Tier Structure

This checklist synthesizes global best practices, TNC's on-the-ground experiences, and lessons from corporate and government stakeholders to guide the development of robust, fit-for-purpose wastewater reuse policies. It integrates key frameworks including WHO Guidelines, EU Regulation 2020/741, World Bank WRRF model, Singapore's PUB, California's Title 22, and country-level examples from India, Israel, Mexico and the United States.

Comprehensive Fit-for-Purpose Wastewater Reuse Policy Checklist

1. **Clear End-Use Categorization**
    a. Defines reuse categories (e.g., irrigation, cooling, potable, ecological)
    b. Differentiates contact vs. non-contact uses
    c. Specifies sectoral quality norms (e.g., agriculture, industrial, firefighting)

2. **Tiered, Risk-Based Water Quality Standards**
    a. Implements risk-based, multi-tier standards (e.g., EU A–D)
    b. Specifies residual contaminant limits (e.g., PFAS, antibiotics)
    c. Aligns with WHO multi-barrier approach

3. **Permitting and Regulatory Clarity**
    a. Defines responsible agencies and timelines for reuse permitting
    b. Clarifies post-treatment water ownership rights
    c. Includes guidance on regulatory enforcement

4. **Monitoring, Auditing and Data Transparency**
    a. Mandates real-time or third-party water quality monitoring
    b. Publishes open-access reuse performance data
    c. Audits treatment and delivery systems periodically

5. **Financial and Institutional Incentives**
    a. Provides tariff structures, credits or subsidies for reuse
    b. Enables blended finance and ESG-linked reuse investments
    c. Supports full cost recovery for O&M

6. **Integration with Planning Frameworks**
    a. Links reuse to sanitation, urban resilience and climate planning
    b. Aligns reuse targets with river restoration or basin goals
    c. Integrates reuse into long-term infrastructure development

7. **Enabling Decentralized and Nature-Based Systems**
    a. Formally recognizes wetlands and small-scale systems as treatment infrastructure
    b. Provides siting and integration guidance for decentralized reuse
    c. Includes provisions in zoning and building codes

8. **Public Engagement and Social License**
    a. Funds communication strategies to overcome perception barriers
    b. Mandates stakeholder co-design for visible reuse projects
    c. Tracks public acceptance as part of Monitoring, Evaluation, and Learning (MEL)

9. **Institutional Coordination and Accountability**
    a. Appoints a lead agency for inter-departmental coordination
    b. Defines implementation mandates across sectors (health, urban, water, sanitation)
    c. Regularly reviews and updates reuse policy frameworks

10. Legal Recognition and Enforcement

a. Codifies reuse standards and mandates in law
b. Aligns with existing health, environmental and urban laws
c. Enforces compliance through inspections, penalties and incentives

11. Circular Economy and Resource Recovery

a. Promotes reuse as part of nutrient/energy/water recovery
b. Supports biosolids and biogas valorization
c. Aligns with circular city or industry policy

12. Climate Risk and Resilience

a. Includes screening for climate hazards in reuse planning
b. Enables emergency reuse (e.g., fire suppression)
c. Supports adaptation pathways and climate co-benefits

13. Equity, Gender and Inclusion

a. Prioritizes reuse access in underserved communities
b. Ensures gender-sensitive planning and monitoring
c. Builds in inclusive governance models

14. Risk Management and Health Safeguards

a. Develops Water Reuse Safety Plans (WRSPs)
b. Implements hygiene and exposure risk protocols
c. Includes contingency plans for contamination events

15. Monitoring, Evaluation, and Learning

a. Links reuse outcomes to SDG 6.3, GBF T7, T11 targets
b. Measures ecological, social, and water quality benefits
c. Integrates MEL into policy cycles and infrastructure design

Two-Tier Structure for Reuse Policy Implementation

This structure distinguishes between minimum viable policy components (Tier 1) and advanced, best-practice elements (Tier 2) to help governments and partners phase in reforms and align with global standards.

Tier 1: Minimum Compliance–Foundational Enablers

- Clearly defined reuse categories and sectoral applications
- Basic water quality thresholds (non-potable)
- Single agency permitting process with timeline
- Basic public awareness campaign and stakeholder consultation
- Inclusion of reuse in water and sanitation planning documents
- Defined institutional responsibilities and O&M mandates
- Pilot-scale reuse with quality monitoring

Tier 2: Best Practice–Climate and SDG-Aligned

- Risk-based, tiered quality standards aligned with WHO and EU norms
- Mandated third-party monitoring and real-time data platforms
- Incentives for decentralized, nature-based and circular solutions
- Integrated reuse within climate adaptation, disaster resilience and biodiversity policies
- Gender-responsive and equity-focused design and MEL
- Water Reuse Safety Plans and multi-barrier health protocols
- Reuse credits, subsidies and ESG-linked finance options
- Recognition of reuse within legal mandates (environment, building, health, industry)

APPENDIX 2

List of Respondents

The report is enriched by contributions from the following TNC experts and corporate leaders. Two of the interviewees preferred to remain anonymous.

Name	Affiliation	Role
Amy Zimmer-Faust	The Nature Conservancy, California	Plastics Strategy Lead
Carl LoBue	The Nature Conservancy, New York	New York Oceans & Fisheries Director
Claire Hirashiki	The Nature Conservancy, California	Data Scientist, Wastewater Pollution
Edgar Carrera	The Nature Conservancy, Mexico	Colorado River Delta Coordinator
Flavia Rocha Loures	The Nature Conservancy	Senior Policy Advisor, Freshwater, Policy and Public Funding
Garrett Wallace	The Nature Conservancy, Florida	Southern Division Government Relations Director
Jos Hill	The Nature Conservancy, Pacific Division	Program Director, Wastewater Pollution
Kassie Morton	The Nature Conservancy, Pacific Division	Project Director, Wastewater Pollution
Kishore Kumar Kabirdasan	The Nature Conservancy, India	Assistant Project Manager, Urban Conservation
Michael Matosich	The Nature Conservancy	Corporate Engagement Advisor, Water & Resilience
Michael Nemeth	Nutrien	Senior Manager, Agriculture & Environmental Sustainability
Naabia Ofosu-Amaah	The Nature Conservancy	Senior Corporate Engagement Advisor, Water & Resilience

APPENDIX 3

Survey Instrument—The Nature Conservancy Wastewater Pollution Community of Practice

Background

- Can you briefly describe your role and experience in wastewater pollution and reuse, and how long have you been involved in such projects?
    a. Which TNC 2030 Goals does your project fall under?
- What are the primary applications of reclaimed water in your region (e.g., agricultural irrigation, industrial use, environmental restoration), and have there been any innovative uses that have proven effective?
- How does wastewater reuse contribute to your region's overall water management strategy?

Challenges

- What were/are the main challenges you are facing/encountered in implementing wastewater reuse in your region? (Ask about local climate, technical and logistical issues if not addressed)

Benefits

- What, in your opinion, are the most significant environmental or economic benefits of wastewater reuse that you've observed?
- Can you provide an example of a successful wastewater reuse initiative and its impact and how do you measure its environmental, social, and economic impacts?

Policy and Governance

- What level of support do you receive from local and national governments for wastewater reuse initiatives?
- How effective are current wastewater reuse policies in your region? Do they support wastewater reuse effectively, and if not, what changes would you suggest?
- Have you worked on any policy frameworks that facilitated wastewater reuse? What were the key challenges in policy implementation?
    a. For colleagues/partners working in the U.S.: In the context of the U.S., do you see a need to adjust permitting processes to streamline approvals while maintaining environmental compliance?

Partnerships

- Have you collaborated with any partners/organizations on your project? If yes, please describe your experience and which partners were most effective in achieving the project's objectives.
- Are there examples of public-private partnerships that have been successful in advancing wastewater reuse?
    a. What incentives or barriers exist for private sector investment in wastewater reuse?

Community and Stakeholder Engagement

- What role do local communities or stakeholders play in the success or failure of wastewater reuse projects?
- Can you share any experience where stakeholder engagement significantly influenced the outcome of a wastewater reuse project?

Technological Aspects

- What technologies have been used in the water reuse projects you've worked on? Which ones have turned out to be effective?
- What specific contaminants (e.g., heavy metals, pharmaceuticals, microplastics, PFAs) are most challenging to remove in your projects, and what treatment methods are used to address them?
- How scalable are these technologies for larger regions or countries?

Monitoring *(ask these questions based on interviewee's expertise)*

- How is the quality of reclaimed water monitored, depending on its intended use (e.g., industrial cooling, landscape irrigation, potable reuse)?
- What parameters do you monitor to ensure compliance with local and international water reuse standards, and how frequently are they assessed?
- What real-time monitoring technologies are used to track the quality of reclaimed water, and how are data from these technologies utilized in operational decision-making?

Future Perspectives

- How do you see the role of wastewater reuse evolving in the coming years, particularly in the face of climate change and water scarcity?
- What critical areas need attention to scale up wastewater reuse, and what future trends or innovations in wastewater reuse do you anticipate will emerge?
- What best practices or lessons learned can you share about wastewater reuse that could benefit other regions?

APPENDIX 4

Survey Instrument—Corporate Partners

Background

- Could you please introduce yourself and provide a brief overview of your professional background?
- How did your journey in the field of wastewater reuse begin? We'd love to learn what motivates you to work in this area, and how your perspective of water reuse has evolved over time.

Company's Objectives on Wastewater Reuse

- Could you provide an overview of how wastewater reuse fits within the company's broader sustainability strategy and describe the company's overarching goals related to wastewater reuse?

Key Initiatives and Programs

- What specific initiatives or programs has the company implemented to advance wastewater reuse?

Role and Contributions

- What role have you played in the company's wastewater reuse initiatives?
- Could you share examples of notable projects, milestones or contributions from your experience?

Challenges and Barriers

- What do you see as the primary challenges in developing or implementing stronger wastewater reuse policies that are supportive of initiatives like yours?
- How have regulatory, technological, societal, or any other barriers impacted the company's efforts, and what strategies have been used to overcome them?
- Is there any documentation reflecting these challenges, strategies or lessons learned that you could share with us?

Opportunities for Growth and Innovation

- What opportunities do you see for expanding wastewater reuse practices within the industry or the company?
- Are there emerging technologies, trends or potential collaborations that you believe will drive future advancements?

Partnerships

- Have any external partnerships been critical to development of your reuse initiative or program, and if so, could you tell us about these partnerships?
- Do you see opportunities for partnership with NGOs?


The Nature Conservancy