Case Study: From Grey to Green – Financing Nature-Based Solutions in Public Enterprise

Relevant disciplines: in Public Enterprise Economics, Infrastructure Finance, or Environmental Economics

Level: Postgraduate

Time allotment: Introduction + 60-90 minutes session

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1. Introduction

In January 2015, the Cantareira reservoir system — the principal source of drinking water for 9 million residents of Greater São Paulo — fell below 5 per cent of its operating capacity. The drought that triggered this crisis was exceptional, yet its roots were systemic: decades of deforestation in the surrounding watersheds had eroded the natural sponge that once moderated rainfall into river flows. SABESP, the state water utility responsible for the metropolitan area's supply, faced a stark choice: invest billions in additional reservoir capacity and pumping infrastructure, or restore the native Atlantic Forest vegetation across hundreds of thousands of upstream hectares.

This dilemma — between expanding engineered "grey" infrastructure and investing in nature-based alternatives — is not unique to Brazil. From Chennai to Amman, from Helsinki to Nairobi, public enterprises charged with delivering essential services increasingly confront the same question: how should a state-owned enterprise evaluate, finance, and govern investments that generate environmental and social returns alongside — or even instead of — traditional financial returns?

A landmark systematic review of 37 international studies, synthesising evidence from water utilities, state forestry companies, and municipal corporations across five continents, reveals both the mounting momentum behind nature-based solutions (NbS) and the profound institutional, financial, and informational barriers that stand in the way of their large-scale adoption. This case uses that evidence base to place students inside the decision-making environment of three contrasting public enterprises, asking them to grapple with the economics of ecosystem services, the financing of long-horizon investments, and the governance of hybrid commercial-public missions.

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> "If immediate investments are made into nature-based solutions, the rate of species loss projected by 2100 could be reduced from 37 per cent to 25 per cent — a difference measured in the irreversible."
>
> *— Isbell et al. (2022), as synthesised in the systematic review*

1.1. Learning Objectives

Upon completion of this case study, you will be able to:

1. **Construct a rigorous economic argument** for why markets systematically under-supply nature-based infrastructure
2. **Evaluate long-horizon infrastructure investments under uncertainty**, using decision-tree or real-options frameworks to compare grey and nature-based alternatives and to identify the threshold conditions under which each option dominates.
3. **Explore an integrated policy package** — spanning legal/regulatory frameworks, blended finance instruments, and measurement, reporting and verification (MRV) standards — that addresses institutional inertia and mobilises capital for nature-based solutions, while anticipating political economy constraints.

2. Background

2.1. What Are Nature-Based Solutions?

Nature-based solutions are interventions that work with, rather than against, natural processes to deliver infrastructure services. They encompass reforestation and afforestation, constructed and restored wetlands, blue-green urban drainage, agroforestry systems, coastal mangrove restoration, and prescribed fire management for fire-dependent habitats. When designed with appropriate native species diversity, NbS can deliver a portfolio of ecosystem services simultaneously:

Table 1. Taxonomy of Ecosystem Services Delivered by NbS

Service Category	Examples Documented in the Review
Regulating	Flood attenuation, drought mitigation, carbon sequestration, water purification, storm protection
Provisioning	Clean drinking water, timber (sustainable yield), food crops, bioenergy feedstock
Supporting	Nutrient cycling, soil formation, pollination, nitrogen fixation, hydrological regulation
Cultural	Recreation, tourism, landscape amenity, indigenous cultural heritage, human health benefits

Critically, NbS differ from conventional infrastructure in two respects that have profound implications for their financing. First, many of their outputs — clean air, biodiversity, flood protection — are public goods or positive externalities not captured by market prices. Second, their benefit streams are long-dated, often materialising over decades rather than the 3–5-year payback horizons preferred by private capital markets. These characteristics create a structural funding gap that no private actor has an incentive to fill unilaterally, making public enterprise both a natural protagonist and, as this case explores, a frequently reluctant one.

2.2. The Evidence Base: What Public Enterprises Are Actually Doing

The systematic review identified 37 peer-reviewed studies published between 2004 and 2024. Several patterns emerge that define the landscape within which the case's protagonists operate.

Table 2. Profile of the Evidence Base

Metric	Finding
Studies published before 2016	25% of sample
Studies published 2020–2024	Majority of post-2016 output
Dominant intervention type	Forest management (46%), afforestation (10%), agroforestry (11%)

Water & wastewater interventions	27% of sample
Blue-green and coastal infrastructure	12% of sample
Geographic concentration	China (largest single country); limited coverage of Latin America, W. Europe
Q1 journal publications	70% of the final sample

The concentration on forestry and China reflects both the scale of China's National Forest Protection Programme (NFPP) — which contributed to nearly a quarter of global net forest growth between 2000 and 2017 — and a relative dearth of research on urban utilities and coastal enterprises in the Global South. For postgraduate students of economics, this skew itself raises important questions about publication bias, the transferability of findings, and the opportunity cost of under-researched NbS modalities.

3. Case: Companhia de Saneamento Básico do Estado De São Paulo (Sabesp) Water Utility, São Paulo Metropolitan Region, Brazil

3.1. Setting

SABESP is a majority state-owned water utility operating under a public service concession from the São Paulo state government. Its' mandate is to provide safe, affordable drinking water to a metropolitan population of approximately 22 million. Following the 2013–2015 drought emergency, state and federal policymakers directed SABESP to develop a long-term watershed restoration strategy as a complement to, and eventual partial substitute for, conventional reservoir expansion.

3.2. Investment Decision

SABESP's engineers have identified two competing options to secure the supply of 28 cubic metres per second currently threatened by ongoing deforestation:

Table 3. SABESP: Infrastructure Option Comparison

Parameter	Option A: Reservoir Expansion (Grey)	Option B: Watershed Restoration (NbS)
Capital cost (est.)	US$ 2.4 billion	US$ 340 million over 15 years
Construction / maturation period	7 years	10–15 years to full ecosystem function
Annual operating cost	US$ 80 million	US$ 18 million
Useful life	50 years	Perpetual if maintained
Secondary benefits	None identified	Carbon credits, flood attenuation, biodiversity, recreation
Private finance availability	Investment-grade project finance	Limited; bespoke structures required
Key risk	Cost overrun, climate-change demand volatility	Ecological performance uncertainty, long time horizon

The utility's finance director notes that SABESP is rated BBB- by international credit agencies. It can access bond markets but faces a covenant restricting leverage above 4× EBITDA. An independent environmental simulation model, developed in collaboration with federal scientists, projects that complete watershed restoration could reduce peak annual water treatment costs by 22 per cent by 2040, but the confidence interval on that estimate spans ±14 per cent due to climate uncertainty.

3.3. Financing Landscape

Peru's 2014 Compensation Mechanisms for Ecosystem Services Law — one of the policy innovations highlighted by the systematic review — created a legal framework permitting public water utilities to charge a ring-fenced tariff surcharge (the MRSE) dedicated exclusively to upstream watershed management. The MRSE tariff in Cusco and other Peruvian cities now funds NbS at scale, with an Ecosystem Services Compensation Mechanisms Incubator bridging the gap between policy design and on-the-ground implementation.

> "The incubator allowed public water utilities to see the design of watershed investments made by their counterparts, facilitating more rapid replication of successful projects."
>
> — Coxon et al. (2021), as synthesised in the systematic review

Brazil has no equivalent legislation. SABESP's legal counsel believes a dedicated ecosystem-service tariff could be introduced by state decree, but consumer advocacy groups have signalled opposition to any tariff increase. An alternative structure — an Environmental Impact Bond (EIB) — has been proposed by an investment bank, under which private investors would fund the restoration programme and be repaid by SABESP only if independently verified ecological outcomes (reduced turbidity, increased dry-season baseflow) are achieved.

3.4. Institutional Inertia and Path Dependency

Through path dependency, weak institutional capacity and inertia, decision-makers often favour traditional grey infrastructure. Decision-makers consistently overestimated the time lag between investing in NbS (mangrove restoration, urban wetland networks) and the realisation of flood protection benefits, while simultaneously underestimating the adaptation potential of ecosystems relative to engineered alternatives.

Table 4. Barriers to NbS Adoption: Frequency in the Literature

Barrier	No. of Studies (out of 37)
Poor management & ineffective governance	9
Shortage of finance and fiscal stress	8
Demand for commodities / competing land uses	7
Poor understanding of NbS benefits	6
Lack of research / monitoring data	5
Lack of actionable metrics	5
Institutional rigidity and path dependency	4

Extreme flooding events in the cities of Chennai and Kochi in India have encouraged the new resilience initiatives focusing on blue-green infrastructure (BGI) through their institutions. Yet, the Chennai Commissioner of Public Works has publicly stated that her department has no mechanism for valuing ecosystem services in its capital appraisal framework, meaning that a mangrove restoration scheme with a 40-year benefit stream would score zero in the department's standard cost-benefit template. This is not an isolated failing: the systematic review found that conflicting valuations of ecosystem services — ecological versus engineering versus economic — represent a systemic barrier across virtually all the public enterprises studied.

3.5. The Financing Gap: A Structural Problem

Across the systematic review, a common thread emerges: NbS are chronically underfinanced. The review documents an infrastructure funding gap for conventional water assets alone ranging from US$ 1,210 to US$ 1,350 per capita in high-income countries such as Finland, Canada, and Norway. For NbS, the gap is structurally more severe, for four reasons that students of public enterprise economics should carefully analyse:

- **Public goods problem:** many NbS outputs (flood protection, biodiversity, carbon sequestration) are non-excludable and non-rival, generating benefits that accrue to society broadly but cannot be monetised by the investing enterprise.
- **Long payback horizons:** investor preference for shorter payback periods structurally disadvantages NbS. Natural forest conservation may require 20–50 years to yield measurable hydrological benefits, conflicting with typical private capital time preferences.
- **Non-standard business models:** NbS do not conform to the financial templates — discounted cash flow, internal rate of return — that private capital markets use to evaluate infrastructure investments, limiting the pool of eligible investors.
- **Metric inadequacy:** without standardised, auditable metrics linking ecological inputs to financial outputs, it is impossible to price NbS risk or structure performance-linked instruments. The systematic review found this to be a barrier explicitly acknowledged in five studies.

The review identifies a menu of innovative financing instruments that have been proposed or piloted internationally. Students should evaluate each on its ability to address the specific market failures at play:

Table 5. Financing Instruments for Nature-Based Infrastructure

Instrument	Mechanism	Key Precedent
Ecosystem Service Tariff (MRSE)	Ring-fenced user tariff dedicated to upstream watershed management; mandated by law	Peru (2014 Ecosystem Services Law)
Environmental Impact Bond (EIB)	Private investors fund NbS; repayment contingent on verified ecological outcomes	Washington D.C. (stormwater); proposed for Brazil

Forest Resilience Bond	Bond backed by projected avoided costs of wildfire suppression and watershed degradation	Blue Forest Conservation, California USA
Payment for Ecosystem Services (PES)	Direct compensation to landowners/managers for delivering specified ecosystem services	RUPES Programme, Indonesia; Kenya Shamba System
Green Bond (NbS-tagged)	Standard bond with use-of-proceeds restricted to eligible NbS projects	Multiple sovereign and utility issuers globally
Blended Finance Facility	Concessional public capital absorbs first-loss risk, crowding in private capital at below-market risk levels	World Bank / GEF NbS facilities

3.6. Policy Frameworks and Their Limits

The systematic review documents 26 instances where national policy frameworks, legal instruments, or certification systems have facilitated NbS adoption by public enterprise. Three deserve particular attention for their design implications:

- **Peru's Ecosystem Services Law (2014):** By explicitly permitting the use of public funds for ecosystem service provision, Peru resolved a critical legal ambiguity that deterred many utilities from investing in NbS at all. The law also created the MRSE tariff mechanism. However, the research notes that the law represents "the bare minimum": it enables investment but does not compel it, nor does it address the measurement challenges needed to justify expenditure under public procurement rules.
- **China's National Forestry Strategy:** State-directed NbS at the scale of the NFPP requires a degree of centralised policy authority available only to sovereign governments. The programme demonstrates that large-scale NbS can deliver positive returns, but also that top-down, undifferentiated mandates without adequate community compensation, biodiversity safeguards, and monitoring frameworks can undermine long-run ecological and social outcomes.
- **Forest Certification (FSC and PEFC):** The review finds that international certification standards have had mixed effectiveness. In Lithuania, FSC's 5 per cent biodiversity set-aside minimum was found to be seven to eight times smaller than evidence-based scientific recommendations. In Finland, PEFC certification contributed to phasing out large-scale prescribed burnings critical for fire-dependent ecosystems — a finding with direct subsidy-design implications. The review concludes that national biodiversity legislation has generally been more effective than voluntary certification schemes.

4. The Case Task: Advising SABESP on Financing Watershed Restoration

Your specific assignment unfolds in two stages. In the first, you take on the role of an independent economic analyst evaluating SABESP's decision-making environment. In the second, your group is convened as an advisory panel asked to appraise the investment and design a financing policy for wider adoption.

4.1. Stage One: Diagnosing the Market Failure

Before SABESP's board can act, someone must explain *why* the market has failed to deliver this investment on its own, and *why* the utility's own management may be reluctant to act even when the economics favour restoration. This stage asks you to build that diagnostic case individually, drawing on the theoretical toolkit you bring to the course.

1. **Public Goods and Market Failure.** Construct a rigorous economic argument for why markets will systematically under-supply nature-based infrastructure relative to the social optimum. In your answer, distinguish between the different types of market failure at work (public goods, externalities, information asymmetry, time inconsistency) and explain which is the binding constraint in each case.
2. **Principal–Agent Problems in Public Enterprise.** The systematic review documents widespread institutional inertia and path dependency within public enterprises. Using principal–agent theory, explain why a state-owned utility manager might rationally prefer grey infrastructure over a higher net-present-value NbS investment. What governance interventions could a government shareholder deploy to re-align incentives?

4.1.1. Submission Requirements

Stage One is submitted as an individual essay (recommended length: 800–1,000 words, excluding references), addressing Questions 1 and 2.

4.2. Stage Two: Appraising the Investment and Designing the Policy Response

With the diagnosis in hand, your group is now asked to move from analysis to recommendation — first as investment appraisers modelling SABESP's specific decision under uncertainty, then as policy advisors designing the enabling conditions for NbS adoption at scale.

3. **Investment Appraisal Under Uncertainty.** SABESP's environmental simulation model projects a 22 per cent reduction in water treatment costs from watershed restoration, with a ±14 per cent confidence interval. (a) Sketch a decision tree or real-options framework to evaluate the watershed restoration investment versus reservoir expansion, incorporating this uncertainty. (b) At what probability of achieving the projected benefit does Option B (NbS) dominate Option A (reservoir) on a net-present-value basis, assuming a social discount rate of 5 per cent and a project life of 40 years? State your assumptions.

4. **Policy Design: From Evidence to Action.** You are advising a minister of finance in a middle-income country who wishes to accelerate NbS adoption by public utilities and municipal corporations. Drawing on the systematic review evidence, design a policy package that: (a) creates the enabling legal and regulatory framework; (b) mobilises both public and private finance; (c) establishes credible measurement, reporting, and verification (MRV) standards; and (d) addresses institutional inertia within existing public enterprises. Identify the two most significant political economy constraints your package would face and explain how you would address them.

4.2.1. Submission Requirements

Stage Two is submitted as a group presentation and/or written group report (recommended length: 1,500–2,000 words, excluding references and appendices), addressing Questions 3 and 4, and should include:

1. **Investment Recommendation:** Your group's appraisal of Option A versus Option B, with supporting numerical analysis and stated assumptions.

2. **Policy Package:** Your group's proposed policy design for accelerating NbS adoption, including how the two identified political economy constraints would be addressed.

3. **Conclusion:** A concise statement of your group's overall recommendation to the minister/board, and the key trade-offs it involves.

4.3. Supplementary Exhibit: Key Concepts and Definitions

Table 6. Glossary of Core Terms

Term	Definition
Nature-Based Solutions (NbS)	Interventions that protect, sustainably manage, or restore natural or modified ecosystems to address societal challenges while simultaneously providing human well-being and biodiversity benefits.
Ecosystem Services	Benefits that people obtain from ecosystems, classified as provisioning (e.g. clean water), regulating (e.g. flood control), cultural (e.g. recreation), and supporting (e.g. nutrient cycling).
Grey Infrastructure	Conventional engineered infrastructure (pipelines, reservoirs, concrete channels) designed to deliver a single service, typically without co-benefits.
Environmental Impact Bond (EIB)	An outcome-based finance instrument in which investor returns are contingent on verified environmental performance metrics.
MRSE Tariff	Mecanismo de Retribución por Servicios Ecosistémicos: a Peruvian ring-fenced water tariff surcharge dedicated to upstream ecosystem conservation.
Payment for Ecosystem Services (PES)	A market-based instrument in which beneficiaries of ecosystem services compensate providers (landowners, communities) for managing land in ways that sustain those services.

Path Dependency	The tendency of organisations to continue along an established trajectory of practice due to sunk costs, institutional norms, and cognitive inertia, even when superior alternatives exist.
Blended Finance	The strategic use of concessional public or philanthropic finance to mobilise additional private investment into projects with positive development or environmental outcomes.

4.4. Selected References

The following sources inform the case.

- Coxon, C. et al. (2021). Ecosystem Services Compensation Mechanisms: Water security and NbS in Peru. Nature-based Solutions and Water Security.
- Grodnik-Nagle, A. et al. (2023). Seattle Public Utilities and the transition to adaptive watershed management. Ecology and Society.
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- Masi, F. et al. (2020). Hybrid decentralised NbS for municipal wastewater: Slovenia and India. Water (Switzerland).
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- Peck, M. & Khirfan, L. (2021). Municipal water management in Amman: barriers to NbS adoption. Land Use Policy.
- Sánchez, A. & Govindarajulu, D. (2023). Blue-green infrastructure and flood resilience in Chennai and Kochi. Urban Forestry and Urban Greening.
- Seddon, N. et al. (2020). Understanding the value and limits of nature-based solutions to climate change. Philosophical Transactions of the Royal Society B.

5. Instructor's Guide & Debriefing Points

5.1. Purpose and Background:

This case is designed for a postgraduate course in Public Enterprise Economics, Infrastructure Finance, or Environmental Economics. It draws on a systematic review of 37 peer-reviewed studies examining nature-based solutions (NbS) adopted by state-owned enterprises and municipal corporations worldwide. Students are expected to have prior exposure to discounted cash flow analysis, public goods theory, and principal–agent problems.

5.2. Structuring the Session

This case is designed to run across two sessions, with independent and group work sandwiched between them:

- **Session 1 – Introduction.** The educator introduces the case: the SABESP dilemma, the systematic review evidence base, and the key theoretical concepts students will need (public goods and market failure, principal–agent theory, path dependency, blended finance). No group work takes place in this session.

- **Between Sessions 1 and 2 – Individual Essay.** Students work independently on Questions 1 and 2 and submit their essay *before* Session 2 begins. This ensures every student arrives at the group session having already engaged individually with the theoretical foundations, rather than relying on group members to carry that analysis.

- **Session 2 – Group Work.** Students convene in their assigned groups to work through Questions 3 and 4, building their investment appraisal and policy package together. The educator can circulate during this session to prompt groups whose analysis is thin, or to challenge groups whose assumptions are too generous to either option.

- **After Session 2 – Group Submission.** Groups submit their presentation and/or written report following the session, incorporating any refinements made after in-class discussion or feedback.

5.3. Debriefing Points

To encourage critical thinking and reflection, the educator may wish to raise the following points:

- **Grey vs green as a false binary?** Push students to question whether SABESP's choice is genuinely "either/or," or whether a hybrid strategy — partial reservoir expansion alongside phased watershed restoration — might dominate both pure options. What does treating this as a binary choice conceal about how public enterprises actually sequence infrastructure decisions?

- **The evidence base has a geography.** The systematic review is concentrated in China and in forestry interventions, with limited coverage of Latin America, urban utilities, and coastal enterprises in the Global South. Ask students what this means for how confidently SABESP — a Brazilian water utility — should generalise from the evidence reviewed, and what kind of local evidence-gathering might be needed before proceeding.

- **Financing instruments are not politically neutral.** The MRSE tariff, Environmental Impact Bonds, and blended finance facilities each redistribute risk and cost differently across taxpayers, ratepayers, and private investors. Encourage students to articulate, for their chosen instrument, *who bears the downside* if the projected ecological benefits do not materialise — and whether that allocation is likely to be politically sustainable.

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