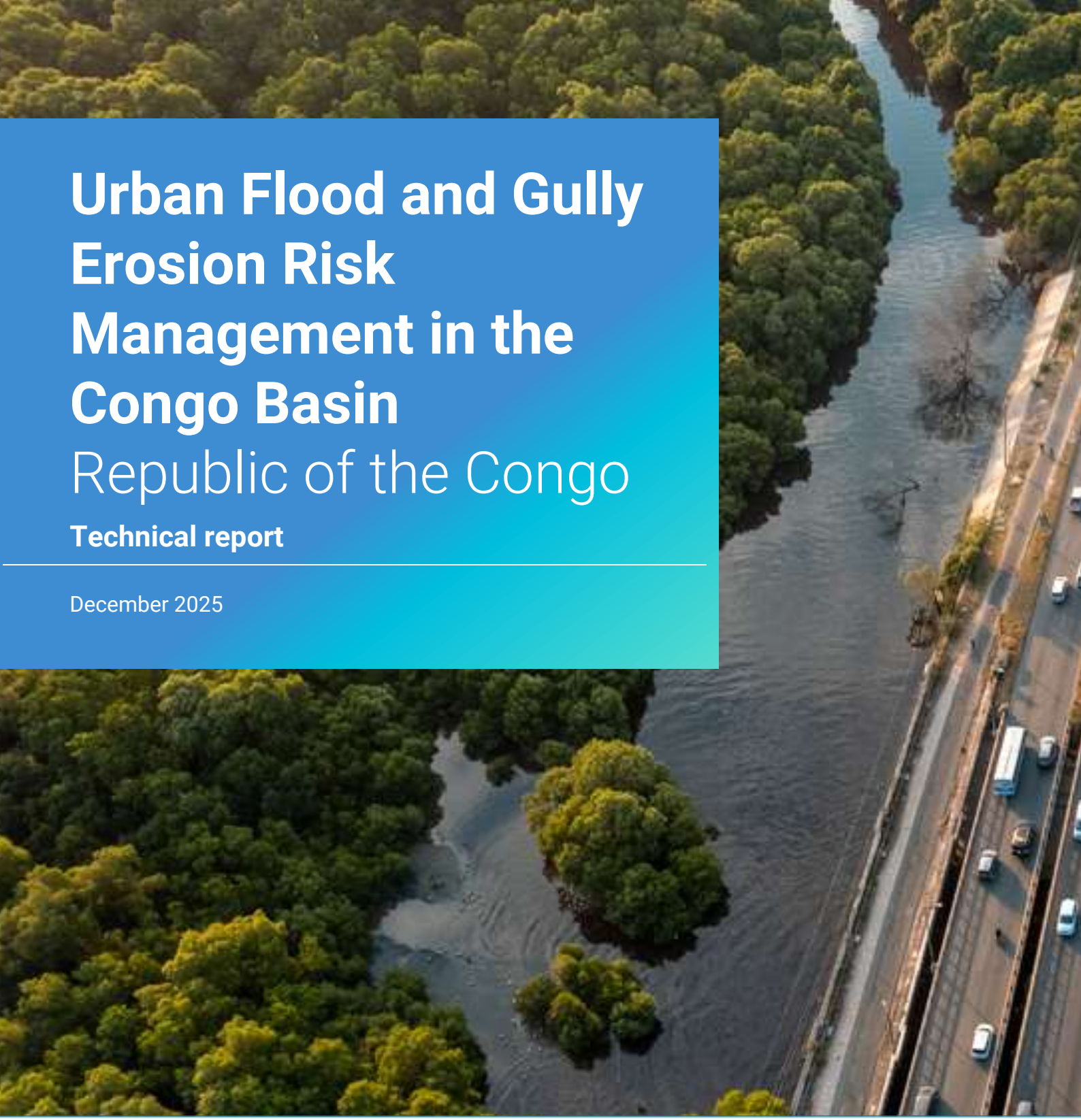
Urban Flood and Gully Erosion Risk Management in the Congo Basin

Republic of the Congo

Technical report

December 2025



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Sector	Nature-based Solutions
Region	Congo Basin country: Republic of the Congo
Keywords	Climate Change Adaptation, Climate Risk Assessment, Sustainable Urban Planning, Capacity building
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Acknowledgements:

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ABBREVIATIONS

Acronym	Definitions
AFD	Agence Française de Développement (French Development Agency)
ARAP	Abbreviated Resettlement Action Plan
BCR	Benefit–Cost Ratio
BoQ	Bill of Quantities
CAPEX	Capital Expenditure
CCAO	Climate Change Africa Opportunities
CGDC	Comité de Gestion et de Développement Communautaire (Community Development Committee)
COTECH	Comité Technique (Technical Committee)
CSR	Corporate Social Responsibility
DGGT	Délégation Générale aux Grands Travaux (General Delegation for Major Works)
DRC	Democratic Republic of Congo
DRR	Disaster Risk Reduction
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EWS	Early Warning System
GCA	Global Center on Adaptation
GIS	Geographic Information System
M&E	Monitoring and Evaluation
Mairie	Municipality / City Hall (French term)
MoU	Memorandum of Understanding
NAP	National Adaptation Plan
NbS	Nature-based Solutions
NbSWLM	Nature-based Soil, Water and Land Management
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
OCA	OCA Global
OPEX	Operating Expenditure
PACT	Plan d'Action Climat / Plan d'Action Climat Territorial (Brazzaville climate strategy)
PIU	Project Implementation Unit
PLU	Plan Local d'Urbanisme (Local land-use plan / urban master plan)
PPE	Personal Protective Equipment
Q&A	Questions and Answers
RAP	Resettlement Action Plan
RoC	Republic of the Congo
RPF	Resettlement Policy Framework

Acronym	Definitions
SEP	Stakeholder Engagement Plan
SfN	Solutions fondées sur la nature (French: Nature-based Solutions)
SIP	Strategic Investment Plan
SMEs	Small and Medium-sized Enterprises
SNACC	National Climate Change Adaptation Strategy
SURP	Strengthening Urban Resilience Project
TA	Technical Assistance
ToR	Terms of Reference
WB	The World Bank

1. INTRODUCTION

1.1 Background Context

The Republic of the Congo (RoC) is experiencing a rapid urbanisation process—especially in Brazzaville and Pointe-Noire—occurring in parallel with increasing exposure to climate-related hazards. Intense and prolonged rainfall episodes frequently overwhelm drainage systems, accelerate ravine formation and gully expansion on unstable slopes, and increase fluvial flooding along low-lying corridors. In coastal Pointe-Noire, shoreline dynamics and coastal erosion add an additional layer of risk to settlements and livelihoods.

To support a more resilient urban development pathway, the World Bank and the Global Center on Adaptation (GCA) commissioned the regional project **"Urban Flood and Gully Erosion Risk Management in the Congo Basin"**, implemented by a consortium led by OCA Global (with GlobalCAD, Meteosim, ResALLience and Climate Change Africa Opportunities – CCAO). The project promotes the identification, prioritisation and implementation of **Nature-based Soil, Water and Land Management (NbSWLM)** practices that:

- **Strengthen urban climate resilience**, by reducing flood and/or gully-erosion risks; and
- **Enable implementation of locally adapted and priority NbS**, through capacity development of local governments and communities.

In **RoC**, the technical assistance focused on **Brazzaville and Pointe-Noire** and produced:

- **A national inventory of NbSWLM practices**, documenting **11 RoC cases** across urban and peri-urban settings and multiple NbS "families" (including ravine/gully stabilisation, urban agriculture/soil improvement, reforestation, and coastal/mangrove restoration).
- **A Compendium of pre-feasibility assessments** for three priority investment sites: two nearby gully affected sites in Brazzaville (Tsième catchment, Mfilou-Ngambio and Mfilou-Itsali) and one linear green-corridor / river renaturalisation case in Pointe-Noire (Tchikobo–Songolo corridor).
- **Two multi-day national missions in October and November 2025**, combining validation workshops, technical trainings, and hands-on community demonstrations (including bamboo check-dams, vetiver planting, mulching and sack-gabion trials) to consolidate implementable design and O&M lessons.

Together, these outputs show that NbSWLM can represent a credible and complementary pillar for **flood, ravine and gully-erosion risk management** in RoC's priority urban areas—provided interventions are well targeted, technically coherent at catchment/reach scale, socially owned, and supported by clear O&M arrangements and safeguards.

1.2 Purpose of this document

This **Summary Report for Decision-Makers** distils the core lessons from RoC's NbSWLM inventory, the three-site pre-feasibility compendium, and the October/November 2025 workshops and community trainings. It is written for:

- **National decision-makers** (ministries and agencies in charge of urban development, environment, water, agriculture, and disaster risk reduction).
- **Municipal and local authorities** in Brazzaville and Pointe-Noire, including technical services responsible for drainage, public works and land-use planning.
- **Development partners, NGOs and practitioners** supporting climate-resilient infrastructure, urban upgrading, and community-based risk management.

This document can be used to:

1. **Frame the problem** – understand how pluvial flooding, gully erosion and landslides interact with land use and poverty in RoC's urban areas.
2. **Follow a practical decision pathway** – from rapid site screening to pre-feasibility and shortlisting of NbSWLM options.

3. **Understand what to expect from pre-feasibility studies –** summarising the key elements that a "good enough" pre-feasibility (including those in the RoC Compendium) should contain before investments move to detailed design.
4. **Draw on RoC-specific lessons** – what has worked technically, economically, socially and institutionally in the case studies.
5. **Organise implementation** – who should do what, when and with which minimal monitoring indicators.

1.3 Objective and Scope

The main objective of this document is to equip decision-makers with **clear criteria and a step-by-step process** for addressing hazard-prone urban and peri-urban areas using NbSWLM practices, drawing directly on:

- The **RoC NbSWLM Inventory** (11 documented cases across Brazzaville and Pointe-Noire, including coastal/mangrove restoration and urban ravine/erosion management).
- The **Compendium of pre-feasibility assessments**, focused on three priority investment sites selected through evidence-based screening and then developed into early-stage investment profiles.
- Feedback and operational lessons from the **October 2025 inventory validation workshop** and the **November 2025 pre-feasibility validation + community demonstrations**, which refined design assumptions and highlighted enabling conditions (notably: hybrid grey–green interfaces, theft-resilience, O&M assignment, and health/sanitation safeguards around water-retaining features).

This brief is **not a substitute** for the underlying technical reports. Instead, it consolidates and generalises their most decision-relevant content for replication and scale-up across RoC's urban areas.

Scope covered in this summary

- **Hazards:** primarily pluvial/fluvial flooding, ravine and gully erosion, unstable/erodible slopes; with additional attention to **coastal dynamics** in Pointe-Noire where relevant.
- **Geographic focus:** urban and peri-urban priority areas in **Brazzaville** (notably the Tsième catchment in Mfilou: Ngambio and Itsali) and Pointe-Noire (notably the Tchikobo–Songolo river corridor / greenway).

2. WHEN IS NBSWLM FIT-FOR-PURPOSE?

2.1 Climate and hazard context

RoC's main urban risk hotspots—**Brazzaville** and **Pointe-Noire**—face a convergence of **high-intensity rainfall**, rapid land-use change, and constrained urban service delivery. Recent analyses within the project indicate that mean precipitation is highly variable, and that **future conditions are likely to be more erratic**, with **more intense extreme rainfall events** that amplify flood peaks, erosion and slope instability.

Figure 1. Gully erosion in the Itatolo area, in 9th district of Brazzaville

Across both cities, impacts are consistently **amplified by unplanned urbanisation**, inadequate or undersized drainage, informal settlements in exposed areas, and catchment degradation (including vegetation loss on slopes). The inventory explicitly notes that major flood events in Brazzaville and Pointe-Noire have been exacerbated by these urban development pressures, while deforestation on steep slopes increases susceptibility to **gully erosion** and **localized instabilities**; Pointe-Noire's low-lying coastal setting adds **coastal flooding and erosion** exposure.

Pluvial (urban) flooding and drainage overload

In dense neighbourhoods, intense rainfall rapidly converts to surface runoff where infiltration capacity is low and drainage networks are discontinuous or poorly maintained. The pre-feasibility work for Pointe-Noire's **Tchikobo–Songolo corridor** describes a **highly urbanised corridor** where **fluvial flooding is intensified by pluvial inflows**, and where riverbanks and channels require restoration due to degradation and encroachment.

Ravines, gully erosion and slope instability (Brazzaville)

In Brazzaville, the priority investment sites in the **Tsième catchment (Mfilou)** illustrate typical urban ravine dynamics: concentrated runoff from surrounding slopes feeds active gullies, with **headcut migration** and lateral slope instability that threaten houses and critical infrastructure. The Compendium notes severe gully erosion and active headcut advance near the **PN20 road**, where partial runoff collection exists but does not intercept all flows—leaving uncaptured runoff to continue eroding gully heads and destabilising slopes.

Floodplain / coastal–fluvial exposure (Pointe-Noire)

Pointe-Noire combines riverine constraints with coastal exposure. The Compendium's susceptibility screening classifies the coastal area adjacent to the green corridor site as **high susceptibility to coastal floods**, with widespread risk affecting settlements and assets nearby the corridor and port-influenced coastal–fluvial zone. In any case, the green corridor is at a sufficient distance from the coastline to be considered a safer area.

2.2 Nature-based Solutions as a core and complementary pathway

Nature-based Solutions—here framed as **Nature-based Soil, Water and Land Management (NbSWLM)**—reduce risk by restoring the functions that conventional grey-only systems often fail to provide in rapidly transforming catchments: reducing and **slowing runoff, stabilising soils and banks, trapping sediment, and restoring conveyance and overflow space**.

In RoC, the Inventory shows that many effective cases are **hybrid by design**, combining vegetation-based measures with selective civil works (for example, runoff-drain channels, engineered elements at erosion hotspots, and hybrid coastal protection combined with ecological restoration). This reflects local conditions: high rainfall intensity, strong urban constraints, and the need for immediate protection at geomorphological "hotspots."

Figure 2. Urban agriculture practice gardening in Talangai's neighbourhood, in the city of Brazzaville

Both workshops reinforced a consistent technical principle: **bank and slope restoration must be paired with adequate runoff routing**, and in RoC this frequently implies **grey–green hybridisation** (e.g., collectors and energy dissipation elements combined with vegetative anchoring), rather than vegetation alone.

Accordingly, NbSWLM in this report is treated as:

- A **core intervention pathway** in upstream and peri-urban slope/ravine contexts where modular bioengineering and soil-water management can measurably reduce runoff and sediment before they enter dense neighbourhoods; and
- A **complementary pathway** in dense urban fabrics and constrained river corridors, where NbSWLM increases system redundancy and protects/extends the performance of drainage, river training and selected structural protections.

2.3 When NbSWLM is fit-for-purpose

The RoC pre-feasibility assessments and workshops show that NbSWLM practices are most effective in RoC when they are:

- Rooted in catchment and reach-scale logic (treat causes, not symptoms). The three-site portfolio reflects a preference for upstream and mid-catchment sediment trapping and stabilisation in Brazzaville ravines, coupled with corridor-scale fluvial restoration in Pointe-Noire, rather than isolated point fixes.
- Modular, technically simple, and locally replicable. Stakeholders highlighted low-cost practices that can be rapidly deployed and scaled through community trainings: bamboo check-dams, vetiver/grass belts, short vegetated stabilisation modules/terraces, selective reinforcement of legacy gabions with vegetative anchoring, composting/soil improvement linked to urban agriculture, and household/street runoff capture (soak pits/cisterns).
- Sequenced to improve survival and performance. Field demonstrations indicated higher survival and sediment capture when check-dams are installed first and vetiver belts are placed immediately downstream, and when works are timed to allow stabilisation before major rains. Thus, implementing larger scale repair and restoration interventions during the dry seasons.
- Designed with explicit O&M and safeguards from day one. Workshops repeatedly flagged that infiltration/retention features must be screened (e.g., avoid locations with clogged drains and dumping risk), with clear cleaning regimens to prevent vector and waste issues; and that simple monitoring routines (survival checks, inspections after storms) need named responsible groups (quartier leadership, women/youth reps) and minimal financing lines.

However, RoC experience also shows where hybrid (NbS + grey) or predominantly grey works are prerequisites:

- Vertical scarps, heavily scoured banks, and active geomorphological hotspots where vegetation alone cannot reshape or stabilise the reach. The recommended approach is targeted engineered protections (e.g., gabion cascades / short revetments) combined with riparian revegetation, rather than attempting full bio-only reshaping.
- Critical infrastructure interfaces (e.g., the PN20 road exposure at Mfilou) where immediate stability and energy dissipation measures are necessary, alongside upstream runoff interception and slope restoration. The Compendium illustrates that partial collectors alone are insufficient if uncaptured flows continue to attack gully heads and side slopes.
- Constrained urban river corridors with high exposure and encroachment, where corridor-wide function recovery (bank restoration, floodplain rehabilitation, green corridors) must be paired with selective control structures and flow-velocity management.

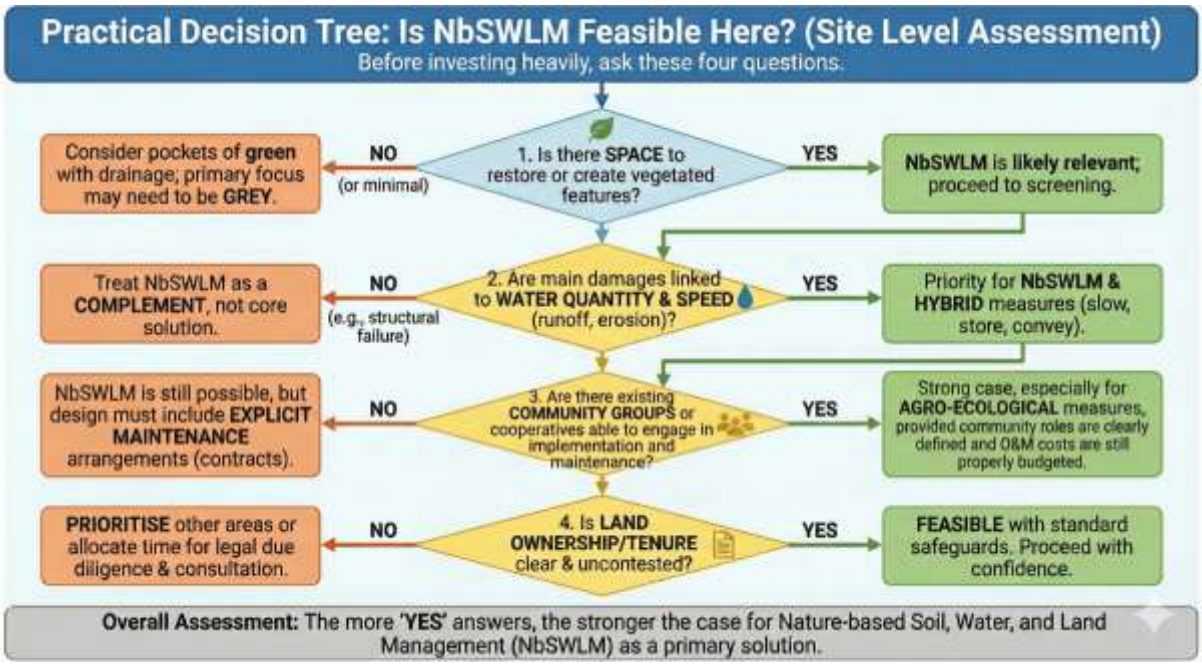
2.4 A practical decision tree – Is NbSWLM likely to work here?

Before investing heavily in studies, decision-makers can use a simple set of questions at the neighbourhood or site level:

1. Is there space to restore or create vegetated features?
    - YES → NbSWLM is likely relevant; proceed to screening.
    - NO, or minimal → consider whether pockets of green infrastructure can be combined with drainage improvements; primary focus may need to be grey.
2. Are the main damages linked to water quantity and speed (runoff, erosion) rather than structural failure of major infrastructure?
    - YES → Priority for NbSWLM and hybrid measures that slow, store and safely convey water.
    - NO → If main issue is, for example, a failing dam, bridge or major drainage trunk, treat NbSWLM as a complement, not the core solution.
3. Are there existing community groups or cooperatives able to engage in implementation and maintenance?
    - YES → Strong case for NbSWLM, especially agro-ecological measures, provided community roles are clearly defined, and O&M costs are still properly budgeted (e.g. stipends, tools, and support from municipal crews or local SMEs).
    - NO → NbSWLM is still possible, but design must include explicit maintenance arrangements (contracts, public works schemes, service providers).

4. Is land ownership/tenure broadly clear and uncontested?
    - YES → NbSWLM is feasible with standard safeguards.
    - NO → Prioritise areas where tenure is clearer or allocate time for conflict-sensitive consultation and legal due diligence before committing to permanent measures.

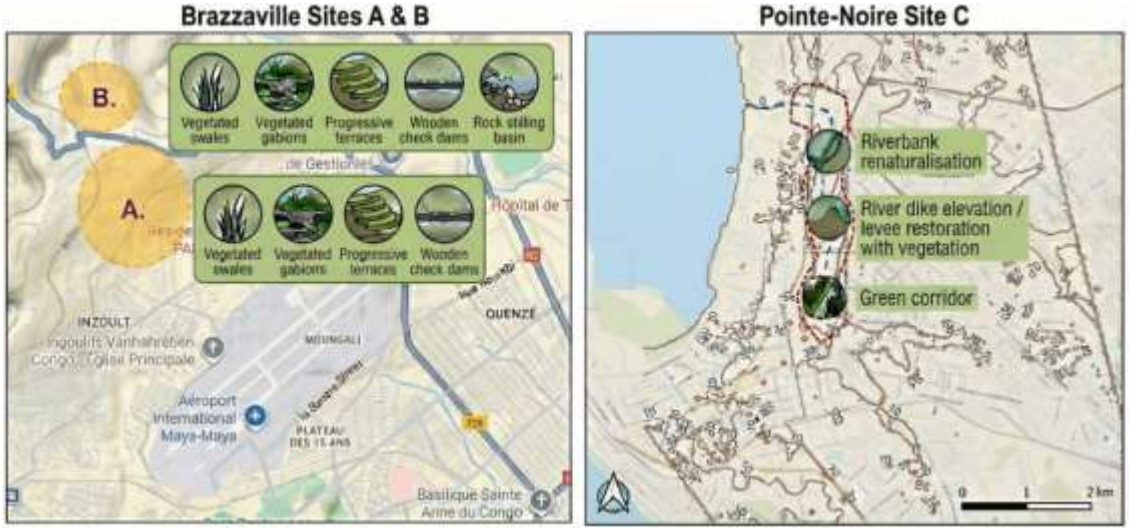
Figure 3. NbSWLM Feasibility Decision Tree



3. SNAPSHOT OF THE PROPOSED NBSWLM MEASURES

To support rapid briefing and preparation of investment operations, this section provides a short "project sheet" for each of the three NbSWLM packages assessed in detail in the Republic of the Congo: (i) two gully-erosion hotspots in Brazzaville's Tsième catchment (Sites A and B), and (ii) a linear river green corridor in central Pointe-Noire (Site C). Each sheet summarises the location and risk context, the core NbSWLM measures, an indicative implementation timeline, and a cost/performance snapshot based on the unit-cost and BCR ranges in the RoC Compendium (to be scaled and refined during detailed design and procurement).

Figure 4. Schematic Map (not to scale for illustrative purpose only) of RoC Target Sites and Proposed NbSWLM Measures



3.1 Site A: Twin riverine junction gully stabilisation (Mfilou–Ngambio, Brazzaville)

Location and risk context

- Area: Twin riverine junction in the Tsième catchment (Mfilou district), Ngambio neighbourhood, near, south ofthe PN20 road and the *Ecole Primaire d'Itsali*.
- Main issues: At the opposite north side of the PN20 road, two adjacent erosion gullies ("Eastern" and "Western") concentrating stormwater from surrounding urban slopes; despite existing constructed channels, both headcut and downstream erosion continue.
- Target scale: Gully heads, side slopes, and the immediate road–drainage interfaces that control inflows from the upper urban micro-catchment.

Figure 5. Location of Site A (left), view of the Eastern gully near PN20 (centre) and view Western gully with vegetation along slopes (right).

NbSWLM solution (pre-feasibility)

- Runoff interception / upper-slope measures
  - Vegetated infiltration swales (bioswale-type) to slow and infiltrate stormwater before it concentrates into gullies.
  - Progressive vegetated terraces with vetiver on suitable slopes to reduce runoff velocities and trap sediment.
- Gully / drainage-line measures
  - Vegetated gabions (including short cascades where required) to stabilise active erosion sections and protect toes and banks.
  - Wooden/bamboo check dams in the valley floor to trap sediment and progressively reduce bed incision.

Indicative implementation timeline

- Preparation and feasibility / preliminary design: ~9–15 months (topographic cross-sections, drainage diagnostics, land/tenure checks, safeguards screening, and community engagement).
- Roll-out of works: ~1–2 dry seasons to deploy priority modules (swales → slope measures → gully modules), with adaptive sequencing based on early performance.
- Maturation of benefits: protective effects increase over ~2–4 years as vegetation establishes; routine O&M remains essential thereafter.

Costs and performance

- CAPEX: Pre-feasibility unit costs indicate (i) infiltration swales at USD 6,990–22,295 per 100 m, (ii) vegetated gabions at USD 12,110–30,095 per 100 m, and (iii) vetiver progressive terraces at USD 5,820–17,485 per ha; wooden check dams are USD 3,533.5–9,920 per 100 m.

- OPEX: Annual O&M is labour-dominated and estimated at USD 1,575–7,350 per 100 m/year (swales), USD 1,271.5–5,276.5 per 100 m/year (gabions), USD 1,340–7,870 per ha/year (vetiver terraces), and USD 1,240–6,950 per 100 m/year (check dams).
- Economic performance: BCR ranges are wide (reflecting uncertainty and strong dependence on exposure and delivered costs): 0.28–5.97 (swales), 0.30–2.63 (vegetated gabions), 0.33–5.94 (vetiver terraces), and 0.21–1.33 (wooden check dams).

3.2 Site B: Head cut–road valley area stabilisation (Mfilou–Itsali, Brazzaville)

Location and risk context

- Area: Head cut–road valley area in the Tsième catchment (Mfilou–Itsali), on the opposite side of the PN20 road from Site A, within the same Mfilou district context.
- Main issues: Multiple active gully headcuts and steep slopes driving rapid incision and localised instability; runoff conveyed by damaged/failed drainage structures aggravates erosion at discharge points, increasing threat to nearby homes, paths and local infrastructure.
- Target scale: The three gully headcuts (priority hotspots) and the immediate slope sections where runoff is generated and concentrated.

Figure 6. Location of Site B (left), view of abandoned houses in the Ngambio neighbourhood in very close proximity to the gully (centre) with sandbags and sandbags in cascade created by the community (right).

NbSWLM solution (pre-feasibility)

- Runoff interception / hillslope measures
  - Vegetated infiltration swales and complementary slope measures to reduce peak runoff entering the headcuts (implemented where space and permeability allow).
  - Progressive vegetated terraces with vetiver on slopes that can sustain vegetation establishment and access for maintenance.
- Headcut stabilisation and energy dissipation (hybrid hotspot response)
  - Vegetated gabions (short cascades / reinforced modules) where vertical scarping or active scour is present.
  - Rock stilling basins at gully head/discharge points to dissipate concentrated energy and stop headcut migration (priority "anchor" work at the most destructive outlets).
- Downstream sediment control
  - Wooden/bamboo check dams as staged sediment traps, conditional on upstream runoff control to reduce blowouts.

Indicative implementation timeline

- Preparation and feasibility / preliminary design: ~9–15 months (headcut geometry surveys, outlet/discharge diagnostics, access/logistics plan, safeguards screening and community engagement).

- **Roll-out of works:** ~1–2 rainy seasons, with a recommended sequencing that prioritises **energy dissipation at headcuts** first (stilling basins / short engineered modules), then slope measures and downstream check dams.
- **Maturation of benefits:** 2–4 years for combined stabilisation + vegetation establishment; sustained O&M is a make-or-break condition.

Costs and performance

- **CAPEX:** Same core unit ranges as Site A apply for swales, gabions, terraces and check dams (see above). In addition, rock stilling basins are estimated at USD 12,980–52,936 per 450 m³ (as a standardized unit for the assumed basin set).
- **OPEX:** For stilling basins, annual O&M is estimated at USD 580–3,290 per 450 m³/year (inspection, minor resetting, repairs and basic monitoring).
- **Economic performance:** BCR ranges for the shared practices are the same as the Tsième catchment package (wide uncertainty bands). Rock stilling basins show a comparatively high BCR range (2.21–20.36 in the current pre-feasibility framing), reflecting strong avoided-damage potential where exposure is high—while still requiring cautious interpretation and site-specific design verification.

3.3 Site C: Linear green corridor and river restoration package (Tchikobo–Songolo final sections, Pointe-Noire)

Location and risk context

- **Area:** Urban greenway along the final Tchikobo and Songolo river sections in Pointe-Noire, focusing on a **~3.4 km** corridor in Mulumba district affected by settlement encroachment.
- **Main issues:** Flood hazard and constrained river/floodplain space, compounded by encroachment and degraded riparian functions; risk reduction depends on recovering storage, stabilising banks, and managing land-use pressure along the corridor.
- **Target scale:** Priority segments of the river corridor where flood exposure, bank erosion and settlement pressure overlap; workshop participants recommended considering an at-least **25 m buffer zone** along the watercourse as part of a credible corridor concept (with implications for land processes and cost). Still, the pre-feasibility study suggests to apply the floodplain restoration approach to the 20-year return period flood footprint in order to create longer term adequate habitation conditions along the corridor and guarantee the full ecosystem and hazard resilience potential of this fluvial restoration approach.

Figure 7. Location of Site C (left), view of the and floodplain occupation for residential (centre) and industrial uses (right) along the Songolo river course

NbSWLM solution (pre-feasibility)

- River corridor measures (core package)
    - **Riverbank renaturalization** (bio-engineered stabilisation, riparian restoration and regrading where relevant) to reduce erosion and restore ecological function.

- Setback / restoration of potentially existing levees and river dike elevation with vegetation where needed to improve conveyance and safety while retaining a "green" stabilisation approach.

- Urban retrofit / demonstration corridor (optional complementary element)
  - Green corridor along Avenue Jacques Opangault (pervious/vegetated strip concept) presented as an illustrative urban greening/resilience approach, to be justified mainly through broader urban-upgrading co-benefits, that could be replicated along many of the central boulevards and broad streets across the city center..

Figure 8. Simplified representation of Av. Jacques Opangault's appearance after implementing the proposed green corridor

Indicative implementation timeline

- Preparation and feasibility / preliminary design: ~12–24 months, reflecting the need for corridor definition, land-use clarification, safeguards planning and negotiated agreements (especially if buffer clearance or resettlement-related processes are triggered).
- Roll-out of works: ~2–3 dry seasons, recommended as a phased approach (pilot segment(s) first, then scale along priority reaches).
- Maturation of benefits: 3–5 years for full corridor function (riparian establishment + behavioural/land-use stabilisation), with continuous O&M and enforcement.

Costs and performance

- CAPEX: Riverbank renaturalization is USD 13,260–33,670 per ha; river dike elevation with vegetation is USD 5,326–8,011 per 100 m; and the Avenue Jacques Opangault green corridor is USD 9,450–15,960 per 100 m (defined as a standardized strip set per 100 m of street).
- OPEX: Annual O&M is estimated at USD 800–1,740 per ha/year (renaturalization), USD 345–733 per 100 m/year (dike elevation with vegetation), and USD 805–1,220 per 100 m/year (avenue corridor).
- Economic performance: BCR ranges are 0.32–2.74 (riverbank renaturalization), 0.78–2.17 (dike elevation with vegetation), and 0.37–0.81 (Avenue Jacques Opangault corridor). The compendium explicitly notes that the avenue corridor is conservatively framed and is best defended as an *urban service and resilience measure* embedded in wider upgrading objectives rather than as a narrowly monetised "carbon-style" investment.

4. LESSONS FROM THE ROC PROJECT

4.1 Technical lessons

- **Runoff routing first: "source control" is the foundation of durable ravine/gully protection**

  Across Brazzaville's ravine systems, stakeholders consistently converged on one principle: **uncontrolled household and street discharges initiate and re-activate gullies**, so vegetation and slope treatments must be paired with basic runoff routing (collectors, safe overflow paths, soak pits/cisterns where relevant) to avoid re-scouring and headcut relapse. The RoC Compendium mirrors this by framing proposed measures (swales, check-dams, gabions, terraces) as **only viable within an integrated drainage system**, including upstream runoff management and parcel-level infiltration solutions.

Figure 9. Vegetated gabions in Ngamakosso, Brazzaville

- **Integrated, reach-scale continuity outperforms isolated "spot fixes"**

  Practitioners highlighted that treating only the visibly eroding point often leads to **outflanking and headcut migration**; interventions must be designed as **contiguous packages** along slopes/channels and explicitly account for upstream contributors. This logic is reflected in the three-site portfolio selection and in the Compendium's practice-by-site framing for Mfilou (Sites A and B), where multiple linked measures are combined to control inflows, stabilise headcuts and manage sediment.

- **Low-cost, modular bioengineering is well-suited to RoC's urban/peri-urban ravines—if "governed"**

  The November 2025 community demonstrations validated several **rapidly deployable, low-tech measures** (notably bamboo check-dams and short vegetated stabilisation modules), which **trapped sediment effectively** in small tributaries and were considered replicable by local groups. However, participants stressed that these measures must be "governed" (rules and a guardian group) to prevent premature removal or misuse—an explicitly technical sustainability condition in informal settings.

- **Short, dense vegetative modules outperform long continuous terraces in informal urban settings**

  A practical design rule emerging from field stations is that **short vegetated segments (~8–12 m) with dense planting** are easier to install, monitor and protect (including against theft), and facilitate staged repairs after storms. This is particularly relevant for Brazzaville's ravines where access and security constraints make large continuous works difficult to maintain.

- **Sequencing matters: sediment trapping and energy dissipation first, then vegetation consolidation**

  Field observations led to simple but critical sequencing guidance: **vetiver belts placed immediately downstream of check-dams** showed higher survival and improved sediment capture. More broadly, where geomorphology includes vertical scarping or heavily scoured hotspots, participants recommended **anchoring with targeted engineered protections first** (gabion cascades/short revetments/stilling features), followed by riparian revegetation—rather than attempting full reshaping by vegetation alone.

- **Hybrid designs are often essential—and poor "grey-only" execution can fail quickly**

  The October workshop reinforced a consistent RoC-specific lesson: **gabions and structural works fail when foundations, drainage and energy dissipation are inadequate**, as observed in Ngamakosso where gabions were displaced and undermined. The Compendium therefore stresses the need for **hydraulic/hydrologic sizing, geotechnical checks, proper installation protocols, and corrosion-resistant materials**, and frames vegetated gabions as effective only when integrated with runoff control.

- Urban infiltration/retention features are valuable, but require site screening and explicit O&M commitments

  Stakeholders cautioned that infiltration/retention measures (e.g., swales) should not be installed where drains are clogged or where no cleaning regime exists, due to stagnant water and dumping risks; they recommended **simple percolation tests** and **community cleaning rotas** as pre-conditions. The Compendium similarly notes that swales require careful assessment of slope, soil permeability and groundwater conditions to avoid waterlogging or erosion within the feature.

- Maturity times and seasonality must be planned: establish before peak rains

  RoC field experience during the November demonstrations underscored that major rains can quickly create new preferential flow paths if works and vegetation have not stabilised—supporting the operational lesson that **larger restoration works should be implemented in dry periods**, allowing soils and plantings to consolidate before intense rainfall. This has practical implications for scheduling, procurement and early monitoring milestones.

- Maintenance norms and "who-does-what" are technical requirements, not administrative add-ons

  Both workshops converged on the need for a clear **O&M matrix (responsible entity × task × frequency)** and simple monitoring routines (survival checks, fixed photo-points, storm-damage logs with action thresholds). The November workshop further recommended embedding O&M roles and basic financing lines into pilot ToRs to avoid "build-and-leave" outcomes, and rehearsed practical routines (monthly survival checks, cleaning after storms, defined repair roles).

- **Anticipate potential project degradation contexts**. Clear examples at the Chateu d´Eau and the large Ngamakosso gully restoration projects showed the importance of considering both pre-existing use and mobility by the surrounding residents of the targeted areas, in order to anticipate potential impacts upon project commissioning, and implement the required mitigation measures, and future maintenance needs for guaranteeing the long-term durability of projects implemented. Furthermore, new erosive practices that may be developed by the neighbors during their use of the restored area should be monitored and timely addressed. Budget adequately for this impact mitigation measures and subsequent maintenance needs.

4.2 Economic lessons

- Many NbSWLM measures are economically attractive when they reduce frequent, "every-year" losses

  In RoC, the pre-feasibility cost–benefit work indicates that several modular measures can deliver strong value for money where they reduce recurrent, smaller-scale damages (household losses, pathway and road degradation, sediment clogging, repeated small repairs). This is reflected in the wide but often favourable BCR ranges for **infiltration swales**, **vetiver terraces**, and—where exposure is high—**rock stilling basins** used to arrest headcut retreat. The workshops reinforced that these measures also deliver practical co-benefits (improved neighbourhood safety/access, reduced nuisance flooding, and local livelihood co-benefits when vegetation products are usable), which can materially improve the economic case beyond the strictly monetised avoided damages.

Figure 10. Planting of stabilizing vegetation at Ngamakosso Water Tower, Brazzaville

- High CAPEX items are driven by engineered materials, machinery and logistics—NbSWLM helps "right-size" them

  RoC's experience points to a common cost driver: wherever interventions require **industrial gabions, heavy stone, concrete, excavation equipment, or complex access on steep ravine walls**, CAPEX increases rapidly. The RoC Compendium's unit costs reflect this contrast: structurally intensive components (e.g., **vegetated gabions**, **stilling basins**) have higher investment ranges than purely vegetative slope measures. The practical implication is strategic: use NbSWLM upstream and along "non-critical" reaches to **reduce runoff and**

sediment, thereby limiting the length and intensity of engineered works needed at hotspots (e.g., near PN20 and active headcuts in Mfilou). This can contain the overall CAPEX envelope while improving robustness.

- Maintenance is inexpensive relative to CAPEX, but only if it is organised and funded as a recurrent line

  As in comparable settings, RoC's OPEX requirements are labour-intensive rather than capital-intensive (cleaning swales, desilting check-dams, replacing failed plants, minor repairs after storms). The Compendium's annual O&M ranges are meaningful but generally small compared to capital costs when spread across municipal/community delivery mechanisms. The workshops were explicit that when O&M is not budgeted and assigned, measures fail quickly—particularly in urban ravines where dumping, clogging and storm damage are common. Embedding NbSWLM O&M into routine municipal lines, neighbourhood arrangements (CGDC/quartier mechanisms), or small-service contracts was repeatedly highlighted as an economic necessity, not just a governance preference.

- "Good-enough" economic screening is sufficient at pre-feasibility—focus on ranges, sensitivity, and exposure

  The RoC Compendium uses unit cost ranges and BCR intervals to support early prioritisation rather than claiming false precision. This approach is appropriate for early decision-making in RoC because results are highly sensitive to:

  - Delivered costs (access constraints, material prices, workmanship quality);
  - Exposure and asset density (avoided damages rise sharply where gullies threaten roads/housing); and
  - Performance assumptions (especially for vegetative establishment and maintenance). Practically, decision-makers can use these ranges to classify measures into: (i) robustly beneficial, (ii) potentially beneficial but design-sensitive, and (iii) low-value unless bundled with broader upgrading co-benefits. The Pointe-Noire corridor illustrates this: some elements show moderate BCRs, while the Avenue Jacques Opangault green corridor has a lower BCR under conservative monetisation and is best justified as part of wider urban upgrading and liveability objectives (benefits not fully captured in narrow CBA).

- Bundling measures and co-financing logic matters more than optimising single components

  A recurring RoC lesson is that the best economics often come from bundled packages (runoff control + headcut anchoring + sediment trapping + maintenance) rather than single measures assessed in isolation—because packages reduce failure risk and protect each component's benefits. Workshops also pointed to the opportunity to combine NbSWLM budgets with related municipal and donor envelopes (solid waste management to reduce drain clogging; road maintenance at PN20 interfaces; urban greening programmes), improving overall financing feasibility and cost-effectiveness.

- Public finance visibility and recurrent O&M funding determine economic viability at scale

  RoC workshop discussions highlighted that even when NbSWLM is cost-effective on paper, benefits erode quickly if routine O&M is not financed as a recurrent budget line. Integrating NbSWLM into municipal and sectoral budgets—covering both CAPEX and OPEX—was framed as essential to protect economic returns. Participants also noted that bundling NbSWLM financing with adjacent expenditure streams (solid waste management to reduce drain clogging; road maintenance at PN20 interfaces; urban greening programmes) can improve affordability and reduce lifecycle costs.

Indicative cost bands for the RoC NbSWLM packages

The RoC NbSWLM Compendium provides screening-level, order-of-magnitude economic estimates for the practices embedded in the three proposed packages (Sites A–C). Table 1 summarises indicative annual cost bands (annualised CAPEX over an assumed project lifetime plus annual OPEX), annual benefit bands where monetised, and the resulting BCR ranges (benefit–cost ratio). A BCR above 1.0 indicates that estimated monetised benefits exceed costs; values below 1.0 may still be justified where important co-benefits are not captured in the simplified CBA (e.g., public health and safety, urban liveability, biodiversity, equity and social gains).

Table 1. Indicative cost bands for the RoC NbSWLM packages

NbSWLM package / site	Measure type	Unit	Indicative annual cost band	Indicative annual benefit band	Approx. BCR (range)*
Sites A & B (Brazzaville – Tsième catchment, Mfilou)	Vegetated infiltration swales	100 m	2,480–10,239	2,880–14,805	0.28–5.97
	Vegetated gabions	100 m	2,839.5–9,176.5	2,709–7,455	0.30–2.63
	Progressive vegetated terraces with vetiver	ha	2,094–10,137	3,370–12,437	0.33–5.94
	Wooden check dams	100 m	1,698–8,235	1,720–2,260	0.21–1.33
Site B (Brazzaville – Tsième catchment, Mfilou)	Rock stilling basin	450 m³	2,261–10,149	22,385–66,392	2.21–20.36
Site C (Pointe-Noire – Tchikobo–Songolo corridor)	Riverbank renaturalisation	ha	2,517–6,100	1,980–6,884	0.32–2.74
	River dike elevation / levee restoration with vegetation	100 m	1,031–1,765	1,380–2,240	0.78–2.17
	Green corridor (Av. Jacques Opangault)	100 m	1,420–2,258	832–1,154	0.37–0.81

*Colour code for BCR (based on upper value of the range): dark green ≥ 3.0; medium green 2.0–2.99; light green 1.0–1.99. All measures with upper BCR < 1.0 would be shown without green shading.

These ranges suggest that the **Brazzaville ravine/gully package (Sites A–B)** can deliver **low-to-moderate annual unit costs with potentially strong economic performance**, particularly for **infiltration swales** and **vetiver-based slope measures** where exposure is high and maintenance is reliable. **Rock stilling basins** show the highest BCR ranges in the screening analysis, reflecting the high avoided-damage potential of arresting active headcuts at critical hotspots—although results are highly sensitive to delivered costs and correct siting/design. By contrast, the **Pointe-Noire corridor measures (Site C)** show **moderate cost bands and mixed BCR ranges**: **riverbank renaturalisation** and **vegetated levee/dike elements** can be economically justified in priority reaches, while the **Avenue Jacques Opangault green corridor** is below 1.0 under conservative monetisation and is best positioned as part of broader urban upgrading and liveability objectives with significant non-monetised co-benefits.

4.3 Governance lessons

- **Clear institutional leads and a practical coordination "spine" are prerequisites for delivery**

  In RoC, NbSWLM sits at the intersection of **urban services/drainage, public works, environment, land-use planning, agriculture and disaster risk management**. Workshop discussions repeatedly stressed that implementation stalls when roles are diffuse—especially across municipalities, arrondissement services and national technical directorates. A recurring recommendation was to designate, for each investment package, **one accountable technical lead** (municipal engineering/service technique or a dedicated PIU where applicable) supported by a **light coordination mechanism** that brings together land, environment, urban planning, community leadership structures and relevant line ministries.

- Neighbourhood governance and community stewardship are not "soft" add-ons; they are risk controls

  RoC's ravine/gully contexts are often embedded in informal settlement patterns where dumping, uncontrolled connections and ad-hoc works are common. Participants emphasised that NbSWLM assets (swales, check-dams, planted modules) require **local stewardship structures** to prevent removal, misuse or rapid degradation. The workshop highlighted the need to formalise neighbourhood-level stewardship (e.g., through CGDC/quartier mechanisms or equivalent local committees) with a **clear mandate for basic rules** (no waste dumping in swales, protected planting strips, controlled discharge points) and a **named monitoring routine**.

- Approvals and safeguards must be built in early—especially where "space-making" is required

  Several RoC interventions raise predictable safeguards issues: works near waterways and the **riparian buffer/servitude**, restrictions on extraction or occupation, and in Pointe-Noire's corridor (Site C) the potential need to **reclaim flood space** that may be occupied—implying tenure clarification and, in some cases, resettlement-related processes. Workshops stressed that environmental/social screening, land/tenure checks and community consultations should be treated as **design inputs** (to refine alignments, phasing, and compensation/mitigation options), not as a final administrative step that can derail an otherwise mature technical proposal.

- A "who does what, when" O&M matrix is the core governance deliverable for NbSWLM

  Participants repeatedly linked performance to the existence of an explicit **O&M responsibility matrix** (actor × task × frequency × budget source). This is particularly critical in RoC's urban ravines where storm damage and clogging are frequent and where small failures can quickly cascade into major erosion. A practical governance lesson from the community demonstrations is that **maintenance can be routinised** (monthly survival checks; post-storm inspections; scheduled desilting) only if responsibilities are assigned to named municipal units and/or contracted local groups with minimal financing.

- Avoid "build-and-leave": contracts and supervision must embed quality and aftercare

  RoC workshop feedback drew on observed failures of purely structural works where installation quality was poor (foundations, drainage, sizing), resulting in displaced or undermined gabions. Governance implications are concrete: procurement packages should include **minimum technical standards**, independent quality checks, and (where feasible) **defects liability / aftercare clauses** that cover early rainy-season performance and repairs.

- Enforcement and behaviour change are part of the solution set (especially for drainage and waste)

  In RoC's urban catchments, technical performance is undermined by systematic drivers: uncontrolled household connections, illegal occupation of corridors, and waste dumping in drainage lines. Workshops indicated that NbSWLM implementation should be paired with **basic enforcement and behaviour-change measures** (signage, community agreements, targeted policing of dumping hotspots, and simple incentives), otherwise O&M costs rise and performance drops.

4.4 Social lessons

- Community incentives are central to ownership and long-term care

  In RoC's urban ravine and corridor contexts, workshop discussions confirmed that communities engage most actively when NbSWLM is linked to **tangible, near-term benefits**: reduced flooding and erosion affecting homes and access paths, safer crossings, improved neighbourhood cleanliness and liveability, and (where relevant) usable vegetation products (e.g., vetiver/bamboo for household uses) under clear local rules. The practical lesson is to design packages with explicit **benefit pathways** for residents (risk reduction + co-benefits) and to agree **local use/benefit arrangements** upfront to strengthen incentives for routine maintenance.

Figure 11. Pisciculture pond in Ngamakosso, Brazzaville

- Inclusion of women and youth increases both fairness and effectiveness

  The October and November workshops emphasised that women and youth are already central to day-to-day management of neighbourhood spaces (water, waste, household drainage practices, informal maintenance), yet are often under-represented in formal decision channels. Involving women's groups and youth associations in **nurseries, planting teams, routine inspections, and awareness/enforcement activities** was highlighted as a practical way to improve both equity and performance—particularly for measures that require frequent light maintenance (swales cleaning, survival checks, rapid repairs after storms).

- Behaviour change and local rules are part of the "social design" of NbSWLM

  A RoC-specific social constraint discussed repeatedly is that technical features fail quickly if they become dumping points or are undermined by uncontrolled household discharges. Participants noted that social acceptance and effectiveness increase when projects include a basic "social package": community agreements on dumping and discharge points, simple signage, school/neighbourhood sensitisation, and a named local steward group to reinforce norms.

- Unintended effects must be anticipated and mitigated early

  RoC workshop inputs highlighted several predictable risk areas that require early mitigation:

  - **Tenure and access tensions** where corridor restoration implies buffer enforcement or space-making (particularly relevant for Pointe-Noire's river corridor), potentially affecting livelihoods and settlement patterns.
  - **Unequal distribution of benefits and burdens**, including who provides unpaid labour for maintenance and who gains from improved safety/access or vegetation products.
  - **Public health risks** if swales/retention features clog and hold stagnant water or accumulate waste; this requires explicit maintenance rules and rapid-response cleaning after storms. These risks can be managed if they are treated as part of design.

5. IMPLEMENTATION PLAYBOOK

5.1 Who does what, and when?

To move from analysis to implementation, the three NbSWLM packages identified in Brazzaville and Pointe-Noire require a sequence of concrete actions by clearly mandated institutions. Table 2 summarises, for each package, the key steps, the lead agency, main supporting actors and an indicative timeframe, if a financing instrument (e.g. a World Bank–supported project or national programme) is available.

Table 2. Implementation steps, responsibilities and timing for the three NbSWLM packages

NbSWLM package	Key step	Lead institution(s)	Key supporting actors	Indicative timing*
Site A – Brazzaville (Mfilou–Ngambio twin ravine junction)	1. Endorse the integrated ravine stabilisation package as a priority risk-reduction investment and integrate it into an urban resilience / watershed operation.	Mairie (Brazzaville/arrondissement) + Prefecture and Ministère de l'Environnement, du Développement durable et du Bassin du Congo	**COTECH**, DGGT/Grands Travaux, municipal technical services, CGDC/quartier committees, NGOs/CBOs	0–3 months
	2. Prepare and procure a combined feasibility + preliminary design study (runoff routing at PN20/collector interface, slope classes/cross-sections, percolation checks where swales are proposed, constructability/access, initial safeguards scoping).	Municipal technical services / PIU (if applicable)	**COTECH** (ToR validation), DGGT/Grands Travaux, universities/experts, NGOs/CBOs, CGDC reps	3–9 months
	3. Negotiate and formalise community agreements and O&M arrangements (anti-dumping rules, discharge control, roles, incentives/use-rights for vegetation products, reporting lines).	Prefecture + Mairie	**COTECH**, CGDC/quartier chiefs, women/youth reps, NGOs/CBOs	6–12 months (overlapping)
	4. Procure and implement works contracts (e.g., infiltration swales near road/collector, gabion cascade/energy dissipation at headcuts where required, regrading + vegetated terraces, wooden check-dams on valley floors), including community mobilisation and training.	Mairie / PIU	**COTECH** (technical spot-checks), DGGT/Grands Travaux (hybrid/grey interfaces), contractors/SMEs, CGDC brigades	12–24 months
	5. Put in place routine O&M and simple monitoring (monthly survival checks, post-storm inspections, desilting/repairs, photo-points, incident logs) and embed responsibilities and recurrent costs in municipal operating arrangements.	Mairie + CGDC	**COTECH** (periodic review), NGOs/CBOs, local SMEs	Starts by month 12; ongoing
Site B – Brazzaville (Mfilou–Itsali ravine head / road-valley area)	1. Endorse the ravine-head stabilisation package (hybrid where scarping/active scour exists) as a priority investment linked to protection of road and nearby assets.	Mairie + Prefecture and Ministère de l'Environnement, du Développement durable et du Bassin du Congo	**COTECH**, DGGT/Grands Travaux, municipal technical services, CGDC, NGOs/CBOs	0–3 months
	2. Prepare and procure a combined feasibility + preliminary design study (headcut hydraulics and energy dissipation sizing, safe relocation/control of runoff discharge points, slope stability checks, constructability/access, safeguards scoping).	Municipal technical services / PIU	**COTECH** (ToR validation), specialised engineers, DGGT/Grands Travaux, CGDC reps	3–9 months
	3. Formalise community governance measures required for performance (protection of structures/plantings, rules	Prefecture + Mairie	**COTECH**, CGDC/quartier chiefs, women/youth reps, NGOs/CBOs	6–12 months (overlapping)

	on discharge and dumping, definition of maintenance brigades and incentives).			
	4. Procure and implement works (e.g., stilling/energy dissipation feature at critical discharge point, regrading/terracing with vegetated gabions where required, speed-control/flow-spreading features along drainage paths, vegetation consolidation), with staged commissioning.	Mairie / PIU	**COTECH** (technical spot-checks), DGGT/Grands Travaux, contractors/SMEs, CGDC brigades	12–24 months
	5. Establish O&M and monitoring routines (post-storm repair triggers; % survival at 3/6/12 months; cleaning schedules; incident logging) and keep quarterly one-pagers for decision-makers to support scale-up.	Mairie + CGDC	**COTECH** (review), NGOs/CBOs	Starts by month 12; ongoing
Site C – Pointe-Noire (Tchikobo–Songolo fluvial green corridor + associated urban green elements)	1. Endorse the fluvial green corridor as a priority flood-risk reduction and urban liveability investment and integrate it into an urban resilience / flood management operation with phased delivery by reaches.	Municipality of Pointe-Noire + Prefecture of Pointe-Noire and Ministère de l'Environnement, du Développement durable et du Bassin du Congo	**COTECH**, Loandjili Town Hall (where relevant), DGGT/Grands Travaux, planning/land services, CGDC/neighbourhood committees, NGOs/CBOs	0–6 months
	2. Define the corridor recovery zone and safeguards pathway (apply/assess the 25 m or 20-year RP buffer or floodplain-based delineation; conduct affected-assets screening; estimate rough acquisition/compensation implications; prepare safeguards ToR and budget).	Prefecture + Municipality / PIU (safeguards)	**COTECH**, land administration/cadastre, planning/urbanism services, CGDC/community reps, NGOs/CBOs	6–12 months
	3. Land acquisition / corridor clearance decision process (if triggered): conduct census and socio-economic survey of PAPs; asset inventory; set eligibility cut-off date; valuation; compensation and livelihood restoration measures; establish/activate GRM; prepare RAP/ARAP as required before works in affected segments.	Municipality / PIU (social safeguards) + Prefecture	**COTECH**, land administration/cadastre, planning/urbanism services, CGDC/community reps, NGOs/CBOs	9–18 months (iterative; segment-specific)
	4. Procure feasibility + preliminary design by priority segments (hydraulics/cross-sections; levee setback/elevation options; riverbank renaturalisation typologies; public-space interfaces; O&M concept and enforcement approach).	Municipality technical services / PIU	**COTECH** (technical endorsement), DGGT/Grands Travaux, specialised designers, CGDC reps	9–18 months
	5. Procure and implement works by segments (pilot reach → scale): floodplain liberation where required, riverbank bioengineering/renaturalisation, levee works, planting, and corridor management measures.	Municipality / PIU	**COTECH** (spot checks), DGGT/Grands Travaux, contractors, CGDC brigades	18–48 months
	6. Operationalise corridor stewardship: O&M contracts/brigades, anti-dumping and buffer enforcement routines, monitoring dashboard (incidents, survival, maintenance events), and institutional handover arrangements.	Municipality + CGDC/neighbourhood committees	**COTECH** (periodic review), Prefecture, NGOs/CBOs, local SMEs	From start of works; ongoing

*Indicative timing refers to elapsed time from the moment each package is politically endorsed and linked to a financing instrument; actual durations will depend on project cycles and funding availability.

5.2 Commissioning, operation and learning

As soon as NbSWLM works move from construction to use, the focus shifts from "what to build" to **how to keep it working**. Operation, maintenance and learning are therefore decisive: they determine whether **Brazzaville's ravine packages (Sites A and B)** and the **Pointe-Noire fluvial green corridor (Site C)** remain functional, are understood and respected by users, and continue to deliver risk-reduction and co-benefits over time. In RoC, workshop discussions made clear that this phase is not only technical O&M: it also depends on **community agreements** (anti-dumping rules, discharge control, use-rights for vegetation products, protection against removal/theft) and a practical **M&E starter kit** that helps local actors detect problems early (e.g., blocked swales, damaged check-dams, renewed headcut retreat) and adjust routines accordingly.

The table below brings these elements together for RoC, summarising what needs to happen after commissioning, who should do it, and illustrating how such arrangements can work in practice.

Table 3. Key actions, responsibilities and examples in Phase 4 (commissioning, O&M, community agreements and M&E)

Functional area / step	Key actions	Lead & supporting actors	Illustrative examples
1. Commissioning and handover	• Verify that works (including vegetative components) meet design standards and basic performance criteria (e.g., correct outlet protection, stable foundations, functioning energy dissipation, adequate planting density and survival). • Finalise "as-built" drawings and **one-page O&M notes** for municipal teams and CGDC. • Formal handover from contractors/PIU to long-term asset owner (Mairie/commune / Municipality of Pointe-Noire), including O&M responsibilities and M&E indicators.	**Lead:** Mairie/commune (Brazzaville sites) or Municipality of Pointe-Noire (Site C) / PIU (if applicable). **Support:** **COTECH** (technical acceptance), DGGT/Grands Travaux (where hybrid/structural elements), supervision engineer, CGDC reps.	In the RoC workshops, participants highlighted that **vegetation is often not included in final acceptance**. They recommended specifying acceptance criteria such as **minimum survival rates after the first rains** and requiring contractors to provide simple "as-built" sketches and O&M notes usable by municipal staff and CGDC—not only engineering dossiers.
2. Operation and maintenance (O&M)	• Translate generic O&M guidance into concrete routines: tasks, frequency and tools (e.g., swale cleaning/desilting; check-dam inspection and minor repairs; replanting gaps; pruning; spot repairs on gabion interfaces; clearing illegal discharges). • Allocate responsibilities between municipal services, local SMEs, and CGDC/community brigades. • Secure recurrent O&M budgets and—where relevant—simple performance-based micro-contracts for maintenance teams.	**Lead:** Mairie/commune (Sites A–B) or Municipality of Pointe-Noire (Site C). **Support:** **COTECH** (periodic review), DGGT/Grands Travaux (structural interfaces), CGDC/quartier committees, local SMEs, NGOs/CBOs.	RoC field demonstrations and workshop discussions stressed that swales and small structures lose function quickly if clogged by sediment/waste. Participants proposed **post-storm cleaning triggers** and short monthly checks by CGDC brigades, supported by small municipal contracts (tools, transport, minor materials).
3. Community agreements and benefit-sharing	• Formalise community roles in O&M (what is voluntary vs paid) and associated benefits (e.g., controlled use of vetiver/bamboo biomass; safer access routes; improved local amenities). • Clarify rules on dumping, discharge connections, cultivation/harvesting near NbSWLM structures, and acceptable uses of restored areas. • Establish accessible dispute resolution and periodic review (e.g.,	**Lead:** Prefecture + Mairie/commune (Sites A–B); Prefecture + Municipality of Pointe-Noire (Site C). **Support:** **COTECH**, CGDC/quartier authorities, women and youth associations, NGOs/CBOs (facilitation), land/planning services (Site C).	Workshop participants noted that without clear local rules, measures are undermined by **dumping and uncontrolled household discharges**, and small structures can be removed or damaged. They recommended written quartier-level agreements defining **prohibited behaviours**, **maintenance days**, and **use-rights** for

	quarterly/annual review at quartier/corridor level).		planted materials to strengthen ownership.
4. Monitoring, evaluation and learning	• Apply an M&E starter kit: a small set of practical indicators (e.g., survival rate of plantings; sediment height behind check-dams; evidence of renewed headcut retreat; frequency/depth of nuisance flooding; number of clogged swales; reported damage incidents; user satisfaction) • Identify potential unexpected impacts associated to erosive pratices of surrounding residents, such as mobility paths. Address any impacts timely in order to avoid the development of new uncontrolled erosion features within the restored area. This may endanger the stability of the investments made. • Assign responsibilities for regular observation and simple reporting formats (checklists, photo-points, short monthly/quarterly notes). • Use results to adjust O&M routines, prioritise additional interventions and inform scale-up.	Lead: Municipal technical services (Brazzaville and Pointe-Noire). Support: COTECH (learning/scale-up platform), CGDC monitors, NGOs/CBOs, universities/technical partners; PIU during project life.	The RoC workshops emphasised simple, field-based monitoring: fixed photo points, quick checklists after major storms, and a short incident log to decide when to (i) intensify cleaning, (ii) repair damaged modules, or (iii) extend works upstream. Participants indicated these approaches are feasible if tools and responsibilities are clearly assigned.

6. CAPACITY, FINANCING AND NEXT STEPS

6.1 Capacity requirements

To implement NbSWLM at scale in Brazzaville and Pointe-Noire, RoC institutions will need strengthened capacity in at least five areas:

1. Technical design and supervision (incl. hybrid grey–green interfaces)

   Civil engineers, urban drainage technicians, agronomists and soil/bioengineering specialists able to translate concepts into buildable packages (alignments/densities, routing first, grey–green junction details), with clear acceptance criteria for vegetative components.

2. Social facilitation and safeguards (incl. resettlement readiness for Site C)

   Staff able to run participatory planning, negotiate local rules (anti-dumping, discharge control, use-rights), manage grievances, and design/sequence safeguards instruments—especially where corridor effectiveness requires floodplain liberation and therefore formal land acquisition / compensation processes.

3. Local implementation management and contracting

   Municipal/communal teams capable of supervising contractors and community brigades, using practical tools (BoQ, phasing, spot checks) and ensuring that O&M obligations are embedded in contracts and handover arrangements.

4. Monitoring and learning systems

   People and routines to track a small number of indicators (survival %, photo-points, storm-damage logs, maintenance actions with thresholds) and feed results back into design and maintenance planning.

5. Financial planning and lifecycle costing

   Capacity to estimate unit costs, compare options quickly, and prepare finance-ready proposals that include **recurrent O&M** (micro-contracts, brigade budgets, tool replacement, nurseries), not only CAPEX.

Training preferences and constraints identified in the October workshop suggest that capacity-building should be **applied and field-based** (3–5 days, practical clinics and templates), and designed to work around common barriers (funding, limited internet access, operational workloads).

6.2 Capacity loop and peer-to-peer learning

A pragmatic capacity loop is recommended for RoC:

1. Pilot → document → share

   Use **Ngambio–Itsali (Sites A–B)** and priority segments of **Tchikobo–Songolo (Site C)** as learning sites, documenting designs, costs, O&M arrangements, safeguards lessons, and performance after major rains.

2. Peer exchanges and seasonal reviews

   Convene short **seasonal technical reviews** (pre- and post-rainy season) led through COTECH/municipal technical services with CGDC participation to review monitoring notes, identify failure modes (clogging, headcut reactivation, vandalism/theft), and adjust routines.

3. Maintain "living" technical templates

   Update and circulate concise design sheets and checklists (do/don't rules, standard sections, O&M matrices, monitoring starter kit) so knowledge is not lost through staff turnover and remains usable by municipal teams and community brigades.

6.3 Financing options

The RoC Compendium and workshops support a diversified financing strategy that matches instrument type to risk profile and scale:

- Domestic public resources (CAPEX + OPEX)

  Municipal budgets for drainage, public works and neighbourhood services should explicitly include NbSWLM O&M (routine desilting, pruning/replanting, rapid repairs), supported by simple O&M plans and response protocols.

- International finance and blended operations

  NbSWLM can be packaged into urban resilience and flood/erosion risk operations (including hybrid investments) and complemented by adaptation windows and donor grants.

- Community contributions (structured and fair)

  Contributions are most viable through clearly agreed arrangements (labour rotations, local maintenance committees, small community funds) with transparent benefit-sharing and grievance channels. During the November practical workshop, community leaders demanded technical means to be facilitated by the administration in order to support the community member in adopting a pro-active attitude with regard to the preservation of their surrounding environment, including restored project areas.

- Private sector and CSR for maintenance and stewardship

  The November workshop explicitly recommended leveraging **CSR**—particularly for **post-installation maintenance**—where companies depend on functioning access roads, reduced flooding, or stable watersheds.

- Micro-grants / revolving funds for tools and nurseries

  The inventory proposes small, practical financing mechanisms (microgrants, revolving funds) to keep maintenance teams equipped and nurseries supplied, linking disbursements to active maintenance performance.

Each intervention package should match its **risk profile and scale** with appropriate funding instruments: small grants and municipal funds for localised measures; larger loans or blended finance for major corridor or basin-scale programmes.

6.4 Next steps and responsibilities for RoC

For RoC, the NbSWLM Inventory and the Compendium of pre-feasibility assessments already identify three priority NbSWLM packages: (i) Site A – Ngambio twin ravine junction (Brazzaville/Tsième catchment), (ii) Site B – Itsali ravine head and road–valley area (Brazzaville/Tsième catchment), and (iii) Site C – Tchikobo–Songolo fluvial green corridor (Pointe-Noire). The next steps are therefore to confirm and refine these priority zones and packages, embed them in concrete investment operations, and organise implementation and long-term operation—including the potential need for land acquisition / corridor clearance processes in Pointe-Noire if a functional corridor requires space recovery.

The table below summarises the key actions, lead agency, main supporting actors and an indicative timeframe:

- **Short term:** within the first 12 months after endorsement.
- **Medium term:** roughly years 1–3.
- **Long term:** beyond year 3, once pilots are underway.

Table 4. Priority next steps for implementing NbSWLM in RoC

Key action (RoC)	Lead agency	Key supporting actors	Indicative timing
1. Confirm/refine priority zones and NbSWLM packages identified in the Inventory and Compendium (Sites A–B in Brazzaville/Tsième catchment; Site C in Pointe-Noire) and formally endorse them as part of the urban risk-reduction and climate-resilience agenda.	Prefecture + Mairie/Commune (Brazzaville) and Prefecture + Municipality of Pointe-Noire	**COTECH**, DGGT/Grands Travaux, municipal technical services, CGDC/quartier committees	Short term (0–12 months)
2. Integrate the three NbSWLM packages into concrete investment pipelines (e.g. urban resilience, flood/erosion risk management, watershed programmes) and agree on financing instruments and implementation arrangements (PIU, budget lines, supervision arrangements).	Municipalities (Brazzaville and Pointe-Noire) + Prefectures	**COTECH**, DGGT/Grands Travaux, development partners, municipal finance units	Short term (0–12 months)
3. Upgrade and complete feasibility and design preparation for the three packages, building on pre-feasibility: detailed technical options, surveys/cross-sections, runoff/drainage diagnostics, hydrological/hydraulic checks, economic screening and safeguards scoping (including corridor safeguards pathway for Site C).	Municipal technical services / PIU (if applicable)	**COTECH** (technical validation), DGGT/Grands Travaux, specialised designers/engineers, universities/experts, CGDC reps	Short term → Medium term (6–24 months)
4. For Site C: implement the land acquisition / corridor clearance decision process (if triggered)—PAP census and socio-economic survey, asset inventory, eligibility cut-off date, valuation, compensation and livelihood restoration measures, GRM, and RAP/ARAP preparation—before works in affected segments.	Municipality of Pointe-Noire / PIU (social safeguards) + Prefecture	**COTECH**, planning/land services, land administration/cadastre, CGDC/community reps, NGOs/CBOs	Short term → Medium term (9–24 months; segment-specific)
5. Formalise local implementation and maintenance arrangements, including community agreements and O&M contracts (who maintains what, tools, incentives, anti-	Prefectures + Municipalities	**COTECH**, CGDC/quartier committees, women/youth	Short term → Medium term (6–24 months)

dumping/discharge rules) for Sites A–B and corridor stewardship for Site C, consistent with Sections 4–5.		associations, NGOs/CBOs, local SMEs	
6. Launch a first wave of implementation contracts for the three packages (works + supervision + community facilitation), ensuring Phase-4 arrangements (commissioning criteria incl. vegetation, O&M and M&E starter kit) are embedded in ToRs, BoQs and budgets.	Municipalities / PIU	COTECH (go/no-go and spot checks), DGGT/Grands Travaux, contractors/SMEs, NGOs/CBOs, CGDC brigades	Medium term (Years 1–3)
7. Operationalise Phase-4 systems: put in place routine O&M and the M&E starter kit (indicators, data collection, periodic review) and use results to adjust practices and plan scaling-up to additional ravines/corridors/river reaches.	Municipal technical services + CGDC (day-to-day)	COTECH (learning platform), Prefectures, DGGT/Grands Travaux (structural interfaces), NGOs/CBOs, universities/experts	Long term (Beyond Year 3; starts in Year 1)

ANNEXES

1. Annex I: Methodology for NbSWLM decision-making

Structured decision pathway

The approach tested in RoC follows a simple but robust sequence of steps that can be replicated in other cities and communes. It starts from a broad picture of where problems are most acute and progressively narrows down to a set of concrete NbSWLM packages that are realistic to implement, finance and maintain—drawing on the RoC NbSWLM inventory, the pre-feasibility compendium, and the October/November 2025 validation and training workshops.

Stage 1 – Rapid site screening

The process begins with a rapid scan of the territory. Existing information is brought together—past event records, satellite imagery, basic topography, drainage patterns, and knowledge from municipal staff and communities—to identify where floods, slope instabilities and gully/ravine erosion are most frequent and where exposure is highest.

Key steps

- Compile what is already known. Gather available studies, maps, photos, and event histories, and complement them with rapid field reconnaissance and local observations.
- Identify "hotspots" and candidate zones. Highlight upper contributing areas, ravine heads, urban drainage corridors, and floodplains where hazard intensity and exposure overlap.
- Apply a fragility and feasibility lens. For each candidate zone, consider access, security, institutional presence, social tensions, and the likelihood that community-based O&M can be sustained; set aside areas where NbSWLM is unrealistic in the short term without prior enabling actions.
- Produce a focused short list. The output is a manageable list of priority zones where risk is significant and where there is at least a reasonable chance of organising and sustaining NbSWLM interventions.

Stage 2 – Practice selection

Once priority zones are identified, attention shifts to what can realistically be done on the ground. The national NbSWLM inventory serves as a practical menu of options. For each zone, teams identify dominant hazard processes and context constraints and then shortlist practice "families" that are likely to work (e.g., ravine headcut stabilisation modules, slope terracing with vegetation, urban swales, riparian restoration, floodplain management).

Key steps

- Match hazard types with practice families. Align measures with dominant processes: concentrated urban runoff and ravine incision; hillslope rilling/gully formation; riverbank instability and floodplain encroachment.
- Use the inventory as a menu, not a recipe. Select technically appropriate practices, then adapt to local slope classes, soils, space constraints, land uses, and maintenance reality.
- Filter by practicality and co-benefits. Prioritise options that are modular, labour-based and compatible with local incentives (e.g., safer access, reduced nuisance flooding, controlled use of planted biomass where appropriate).
- Bundle measures into coherent packages. Build integrated packages rather than isolated interventions (e.g., "ravine package" = runoff routing + headcut anchoring + slope stabilisation + sediment control + O&M arrangements).

Stage 3 – Concept-level pre-feasibility

Stage 3 asks a simple question: *are the shortlisted packages viable in this specific place?* Teams ground-truth assumptions through field walks and stakeholder discussions, check space and constructability, identify land/tenure constraints, sketch indicative layouts, estimate cost bands, and assess how implementation and

maintenance would be organised. This is the stage where "technical feasibility" and "institutional/social feasibility" are tested together.

Key steps

- Ground-truth concepts on site. Verify runoff pathways, identify critical discharge points, check for utilities/constraints, and validate where measures can physically be placed.
- Check social and land conditions early. Engage land users, quartier leadership/CGDC, and local authorities to understand tenure, likely disputes, vulnerability considerations, and realistic maintenance arrangements. Where land rights are unclear, teams should document risks and define the safeguards pathway (including compensation processes if needed).
- Shape the technical concept and cost bands. Use sketches and rule-of-thumb parameters; apply unit cost ranges to estimate CAPEX/OPEX bands and identify cost drivers (materials, access, specialised works).
- Classify the depth of analysis needed. Flag where a standard pre-feasibility is sufficient (low-risk modular works) versus where a detailed pre-feasibility is required (e.g., constrained river corridors, floodplain liberation, segments with potential resettlement).

Stage 4 – Validation and shortlisting

The final stage is collective judgement and ownership. Draft pre-feasibility findings are reviewed in workshops with municipalities/prefectures, technical agencies, DGGT/Grands Travaux, COTECH, NGOs and community representatives. Participants validate the problem framing, refine measures, confirm governance arrangements, and shortlist packages for investment.

Key steps

- Present options transparently. Share maps, concepts and cost bands in accessible language; invite feedback on feasibility, sequencing, and likely unintended effects.
- Refine designs and resolve concerns. Adjust species, alignments, phasing, and hybrid interfaces based on local capacity and constraints.
- Agree roles and coordination. Confirm who leads, who supports, and where technical validation occurs (notably through COTECH), including who carries O&M responsibility and how enforcement/community rules will be applied.
- Select a shortlist for investment. Endorse the packages with the best balance of risk reduction, cost-effectiveness, institutional fit, safeguards feasibility and social acceptability.
- Anticipate degradation contexts. Document how residents currently use the targeted areas (dumping, access routes, informal drainage connections, extraction) and integrate mitigation (design tweaks, rules, enforcement, budgeted maintenance) into the investment plan.

Minimum Decision Dataset

To avoid paralysis by analysis, RoC experience suggests a minimum dataset that should be available before approving NbSWLM investments for detailed design and financing:

1. Hazard processes and pathways
    - Type and frequency of past events (flash floods, ravine headcut retreat, debris flows, bank collapses, nuisance flooding).
    - Upstream drivers (runoff concentration from streets/collectors, loss of vegetation cover, encroachment, extraction).
    - Downstream receptors (settlements, roads, schools, markets, critical utilities).
2. Terrain, soils and hydrologic response proxies
    - Slope classes (e.g., <5%, 5–15%, >15%) and local relief.
    - Dominant soils and implications for infiltration and stability (including simple percolation tests where swales/infiltration are proposed).

- Runoff concentration paths, micro-catchment boundaries, known flow depths/velocities during storms.

3. Tenure, access and safety
   - Land ownership/use patterns (public land, communal land, private parcels, informal occupations).
   - Known disputes, contested areas, or zones under special restrictions.
   - Safety constraints (unstable scarps, deep channels, hazardous extraction points, access limitations for works and O&M).
4. Services, infrastructure and sensitive assets
   - Roads, culverts, drainage lines, bridges, electricity/water infrastructure and their vulnerability points.
   - Social infrastructure (schools, health centres, markets).
   - Cultural/ecological assets (wetlands, key habitats, culturally significant sites).
5. Community and institutional capacity
   - Presence and strength of CGDC/quartier committees, cooperatives, youth/women's groups.
   - Prior experience with public works, tree planting, ravine maintenance, waste management.
   - Municipal staff and partners available for supervision, facilitation and monitoring.
6. Preliminary economic and financing information (at least qualitative)
   - Relative cost and availability of key inputs (stone, gabions, bamboo/timber, seedlings, transport).
   - Candidate financing sources (municipal budgets, national/sector programmes, donor funds, CSR, structured community contributions).
   - A preliminary view on O&M financing feasibility (who pays, how often, through what contracting mechanism).

2. Pre-feasibility ASSESSMENT types

Standard vs Detailed pre-feasibility assessment

The RoC experience (Inventory, Compendium and the October/November 2025 workshops) suggests two practical levels of pre-feasibility. Most **modular ravine and urban NbSWLM measures** in Brazzaville can be advanced through a **Standard pre-feasibility**, while **corridor-scale river/floodplain works** in Pointe-Noire—especially where safeguards and land acquisition may be triggered—typically require a **Detailed pre-feasibility** before moving to full feasibility and detailed design.

Table 5. Levels of pre-feasibility assessments

Aspect	Standard pre-feasibility	Detailed pre-feasibility[1]
Typical use	Low-tech, modular NbSWLM measures with limited structural risk and rapid constructability (e.g., infiltration swales, vetiver terraces, short vegetated stabilisation modules, small wooden/bamboo check-dams, street-level green elements).	More complex/capital-intensive works, or those whose failure would have serious consequences (e.g., vegetated gabion cascades and stilling structures at critical headcuts, high-energy discharge points; river corridor restoration tied to dike/levee works; floodplain recovery requiring corridor clearance).

[1] For many financing institutions, this level of analysis is essentially equivalent to a feasibility study, and in this report, it is understood as the last analytical step before launching detailed design and procurement.

Aspect	Standard pre-feasibility	Detailed pre-feasibility[1]
Key content	Site description; hazard/risk statement (runoff pathways, headcut drivers, dumping/discharge context); NbSWLM concept and indicative layout; simple design rules (sections, slopes, spacing/species); indicative CAPEX/OPEX bands; qualitative risk/co-benefit assessment; basic O&M concept and community rules; governance roles and coordination (incl. COTECH review points).	All Standard elements plus: topographic inputs; at least simplified hydrological/hydraulic checks (design storms, discharge points, energy dissipation); geotechnical notes where relevant; refined cost estimates and BoQ; simplified economic appraisal and sensitivity; phased implementation and financing options; safeguards screening with explicit land/tenure pathway (including RAP/ARAP readiness where triggered).
Effort level	Several weeks; primarily existing data + targeted field checks and stakeholder interviews.	Several months; specialist inputs and additional data collection/surveys and (where needed) simplified modelling.
When to escalate	Escalate to Detailed when any of the following apply: (i) interaction with critical infrastructure (major road, bridge, trunk drainage, utilities); (ii) high population exposure and rapid-onset failure risk; (iii) high capital cost / heavy materials; or (iv) strong dependence on hydraulic behaviour not yet understood (critical outfalls/headcuts).	N/A – upper tier before full feasibility and detailed design.

In Brazzaville-type ravine contexts, many slope/terracing and small drainage-line measures can be handled through **Standard pre-feasibility**, while large headcut-control structures at high-energy discharge points and the **Pointe-Noire fluvial green corridor** (with potential land acquisition/safeguards complexity) usually warrant a **Detailed** level.

Quality criteria for pre-feasibility work

The RoC case studies captured in the Compendium and validated in workshops point to common quality criteria that any NbSWLM pre-feasibility should meet. A good pre-feasibility should:

1. **Explain the risk clearly** — how runoff is generated and concentrated (streets/collectors/parcel discharges), how erosion initiates and propagates (headcuts, ravine widening), and what assets are exposed.
2. **Specify measures with enough technical detail to guide design** — basic dimensions/sections, slopes, spacing, species/planting densities, and where hybrid (grey–green) interfaces sit.
3. **Address O&M explicitly** — who does what, how often, with which tools and incentives; include anti-dumping and discharge-control routines where relevant.
4. **Provide CAPEX/OPEX bands and major cost drivers** — even if appraisal-grade CBA is not possible; identify drivers such as access, materials, and heavy works.
5. **Flag institutional and governance conditions** — required approvals, role allocation, and clear points for COTECH technical validation and municipal sign-off.
6. **Identify inclusion and livelihood opportunities and potential negative impacts** — especially for women and youth; and explicitly screen for risks such as corridor clearance, tenure conflict, health risks from clogged swales, or inequitable labour burdens.
7. **Set out a simple monitoring plan (3–6 indicators)** — performance and maintenance indicators (survival %, clogging frequency, sediment accumulation behind check-dams, evidence of renewed headcut retreat, reported damage incidents) with clear reporting responsibility.