Transformative adaptation of rivers in an urban context: An ecological infrastructure and socio-ecological toolkit

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CONTENTS

LIST OF ABBREVIATIONS

IAP	Invasive Alien Plant
IDP	Integrated Development Plan
KZN	KwaZulu-Natal
LIRA2030	Leading Integrated Research for Agenda 2030

1 Introduction

Ecological infrastructure is often viewed as nature's equivalent of built infrastructure, that can "support, sustain, or in some cases substitute built infrastructure"(Cumming et al., 2017). Essentially, ecological infrastructure is the naturally functioning ecosystems, such as catchments and rivers, that deliver services to society, such as freshwater and soil formation. It is recognised that ecological infrastructure plays a crucial role in socio-economic development and that there is a growing need to ensure its maintenance, management and restoration (SANBI, 2014; Cumming et al., 2017).

This document entitled, Transformative adaptation of rivers in an urban context: An ecological infrastructure and socio-ecological toolkit, is based on transformative climate adaptation principles, catchment and localised interventions that might be applicable to address challenges commonly faced in river systems in KwaZulu Natal (KZN), South Africa. The toolkit is composed of various soft grey ecological infrastructure and socio-ecological interventions options that can be implemented in different socio-ecological contexts in and around river systems.

In the context of this toolkit, the soft grey ecological infrastructure (also referred to as engineering interventions in this toolkit) consist of both grey infrastructure (i.e. human-engineered hard structures, such as gabions) and light-touch grey infrastructure (i.e. ecologically-friendly engineering solutions, such as wetland construction and brush packing). It is important that grey infrastructure interventions are not dismissed based on the perception that they may not be ecologically-friendly, as in certain cases they may be the most suitable option and, in fact, have ecological benefits. For the purpose of this toolkit, all of the ecological infrastructure proposed is referred to as light-touch grey interventions. Socio-ecological interventions are those that aim to address environmental issues by enacting changes in societal thinking and behaviour.

Each ecological infrastructure (light-touch grey) and socio-ecological intervention option proposed in this toolkit is accompanied by a specifications sheet which provides an overview of the relevant information that will support the planning, designing, financing and implementation of such interventions.

2 Structure and approach to the development of the toolkit

The toolkit consists of three main parts. The first two unpack high-level contextual considerations, as well as the socio-ecological principles of transformative climate adaptation.

The third part considers an in-depth suite of light-touch grey engineering and socio-ecological interventions that can be implemented at a localised scale and to address catchment issues.

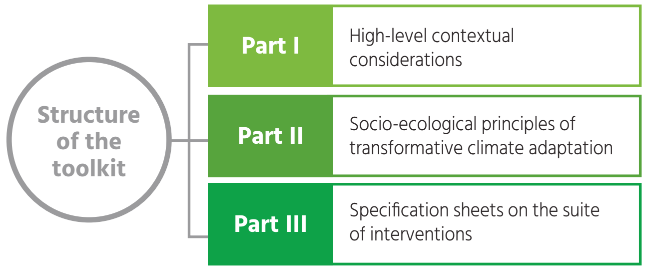


Figure 1: Structure of the toolkit

Part I requires that the toolkit user considers the context of the river and the issues and concerns they would like to address in the riverine environment, both at the local level, and in relation to the broader catchment. These include elements such as the socio-economic characteristics of the catchment, the physical and ecological characteristics of the river and streams, the stakeholders in the catchments, the beneficiaries and users of the river, and the land use in the catchment. Urban rivers are part of highly interconnected hydrological and socio-ecological systems and can therefore not be viewed in isolation or separated from their surrounding landscapes, catchment or socio-economic context.

Part II unpacks and considers the socio-ecological and transformative elements of the toolkit. These elements are the scaffolding - the philosophical ethos - which underpin transformative interventions in river systems. These elements are based on the six principles (Figure 2) that were developed during the LIRA 2030 project 'Transforming southern African cities in a changing climate' (Pasquini, forthcoming). A seventh principle, namely, 'Sustainability' was added to the list of transformative adaptation principles. This is designed to be a lens through which to view and then apply the river management interventions (projects, programmes, and specific interventions).

1. FUNDAMENTAL CHANGES IN THINKING AND DOING
2. INCLUSIVE
3. CHALLENGES POWER ASYMMETRIES
4. MUST BE DEMONSTRABLE IN PRACTICE
5. RESPONSIVE AND FLEXIBLE
6. HOLISTIC, COMPLEX SYSTEMS THINKING
7. SUSTAINABILITY

Figure 2: Seven principles that characterize transformative climate adaptation. The first six were developed during the LIRA2030 project, and the seventh was added during the course of this project.

Part III presents a suite of ecological infrastructure and socio-ecological intervention options (i.e. the toolkit). This section presents relevant information on selected interventions that can be implemented on a localised and catchment-wide scale.

To inform the selection of ecological infrastructure and socio-ecological intervention options, a review of international best practice on how to address issues commonly faced in urban environments was undertaken. From this review more than a hundred ecological, and light-touch grey infrastructure interventions were identified. In parallel, risks and impacts to the health of riverine systems specific to the KZN context were distilled from the eThekwini Municipality Integrated Development Report (IDP, 2017), and in consultation with experts and municipal authorities.

The IDP identifies eleven main risks and impacts:

- Invasive Alien Plants (IAPs),
- Sediment control,
- Catchment degradation,
- Urban stormwater management,
- Flood risk management,
- River bank erosion and stabilisation,
- Poor water quality,
- Solid waste management,
- Negative biodiversity impacts, and
- Sand mining.

All identified ecological and light-touch grey infrastructure interventions from the global review were compiled into a database and the relevant ones aggregated according to the above eleven risks and impacts prevalent in KZN. Some of these were generic and addressed multiple issues, whilst others exclusively addressed a single issue. The database can be accessed in Addendum A. It further contains information on the drivers of degradation and provides options for high-level catchment ecological infrastructure interventions that can be considered.

The eleven risks and impacts prevalent in KZN were used as a basis to refine the list of more than a hundred potential interventions down to 13 interventions, which address all the risks identified in the municipal IDP. Further consultation with eThekwini municipal officials helped to refine the list to nine interventions, which have become the focus of the toolkit and for which detailed specification sheets have been developed. The nine ecological infrastructure interventions tackled in the toolkit are:

1. Rip rap and sloping
2. Brush packing
3. Invasive Alien Plant (IAP) control and rehabilitation
4. Wetlands
5. Debris walls
6. Sloping and revegetation
7. Gabion retaining walls and weirs
8. Trash booms
9. Concrete gabion groynes

In addition to identifying the light-touch grey interventions, supportive ***socio-ecological interventions*** that could assist with addressing catchment degradation and management issues were identified. These were considered critical to providing a supporting socio-ecological narrative and learning and capacity building basis to support the more "engineered" interventions. Additionally, these additional aspects are intended to provide longer term sustainability and engagement around problem identification and solving, and ultimately building political and civil society support for transformative riverine management. A wide variety of socio-ecological interventions are possible as part of a river management programme. These include, but are not limited to: Pocket parks, footpaths, 'kick-abouts' (flat) community use areas, river stewardship programmes, capacity for catchment development, citizen science tools, leadership seminars and training in ecological infrastructure. From these, six socio-ecological interventions were selected, and a specification sheet developed for each. The selected interventions are:

- Leadership seminars for ecological infrastructure,
- EnviroChamps,
- Training courses in Ecological Infrastructure,
- Citizen Science tools,
- Learning and engagement platforms,
- Pocket Parks,
- Tree-preneurs,

The building of a house analogy

Consider that one is planning to build a home. The context of where the home is to be built is important; the needs of the new residents; the local conditions (slopes/aspect/soil/foundation conditions etc.); available budget and building resources; suburb; architectural/building style; etc.

Part I and II of the toolkit. Based on these contextual considerations, the potential owner may begin to assemble a scrap book of important design considerations, styles, palettes, finishes etc. which would be appropriate to meet the needs and available resources. This allows for an exploration and consideration of options, budgets, builder/owner, contractors, and specialists that may need to be consulted/contracted etc., and that would be appropriate, given the context, resources, needs and constraints.

Part III of the toolkit. Out of this refinement of ideas will emerge a clearer picture of the house to be built and how to go about this construction – the specific details and building plans/appointment of builder/contractors/specialists to be consulted etc.

Similarly, with this toolkit, a suite of open but "leading" questions are posed, to guide a process of considering the catchment and socio-economic context, identification of key issues that need to be addressed and then what might be done to address these needs. Similarly, which other specialists may need to be consulted in the process of addressing the issues identified.

The choice and applicability of which interventions to apply may be likened to this analogy. Interventions may be practically and economically feasible from a palette of possible interventions.

3 How to use the toolkit

3.1 PART I: Understanding the catchment contextualisation

Before any intervention can be selected, or project planned, or any programme conceived, a broad understanding of the catchment is most useful. This is relevant for ecological reasons (such as ecological characteristics, connectivity and hydrological drivers of a system), and also to understand the socio-economic context of the area. This assessment is necessary to assist and guide the decision-making process on intervention design, planning, and implementation.

There are three parts to this assessment (Figure 3 below):

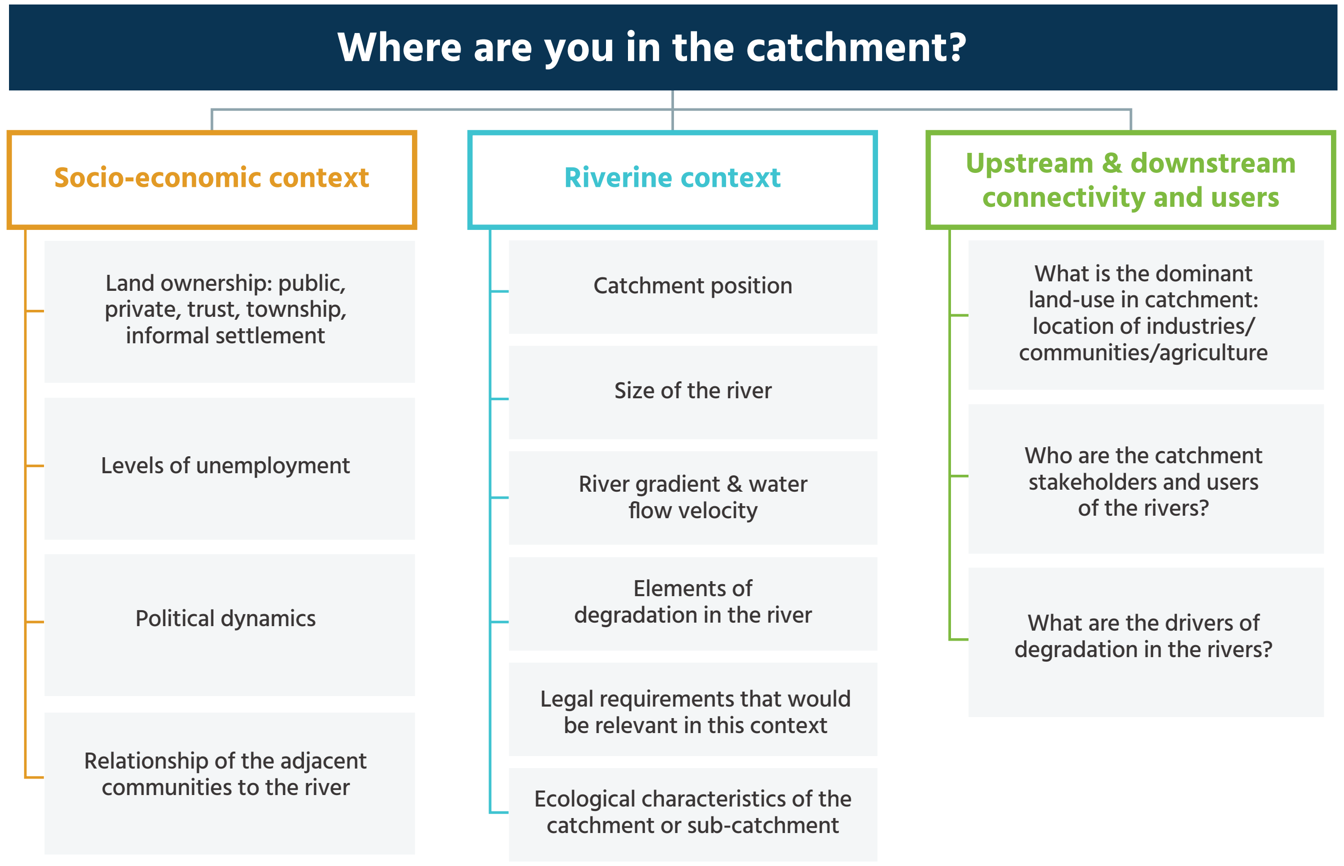


Figure 3. Important considerations as a first step to intervention implementation.

1) Evaluating the socio-economic context

To understand the legal implications of any river intervention, one of the most important considerations is **who owns the land?** Whether it is private land, municipal land, or Trust Land (in the context of South Africa, this refers to land owned by the Ingonyma Trust Board), ownership is likely to influence the suitability and effectiveness of an intervention. A further understanding and evaluation of the **socio-economic context of land ownership** is required to understand which forms of socio-ecological interventions will be suited in a particular area. As an example, river work done by co-operatives (e.g. in the Sihlanzimvelo model) or Eco-Champs/EnviroChamps (e.g. in the Aller River Rehabilitation Project model) might be best suited in township or informal settlement areas on municipal land, where such models may strengthen livelihoods; while a more formal arrangement (e.g. Green Corridors model) might be better suited where municipal land is located in a high income area. For this reason, it is also important to evaluate the **levels of unemployment and stakeholders** in the area where interventions will likely be deployed.

Political dynamics should be considered when planning and implementing interventions, as these can potentially support or weaken the impact of a planned ecological infrastructure intervention. Relevant political structures, such as ward councillors, need to be included when work in a shared resource, such as river, is to be undertaken. On a similar note, one needs to be aware of the dynamics within, and the **relationship of, the surrounding communities** with the river. This will support the decision-making process about which intervention, especially from the socio-ecological perspective, is most suited for implementation.

2) Evaluating the riverine context

This section refers to the geographical setting of the river. Important to note here is the section in which the **catchment the river/site is positioned** – whether it is in the upper, middle or lower catchment. This influences the amount and severity of impacts received from upstream activities, and whether the intervention planned will be able to fully address these. The physical elements of a river, such as its **size, gradient and water flow/velocity**, are important to consider when planning not only engineering interventions but also socio-ecological interventions. For example, it might not be possible for low-resourced cooperatives to work in fast flowing rivers with steep banks as they might not have access to the equipment which would allow them to do so. The **elements of degradation in the river also** need to be considered as these may have bearing on catchment-wide and systemic impacts – many of which might be challenging to address with a single intervention and may need a more holistic approach (Figure 3).

There may be legal requirements relevant to river interventions, especially in the case of engineering interventions. Section 21 (water use) of the National Water Act (Act 36 of 1998), as well as the Environmental Impact Assessment regulations of the National Environmental Act (Act 107 of 1998) generally control the requirements for licensing of activities/water uses and hence implementation of interventions in South Africa. Dependent upon the activities associated with, and potential impacts of the intervention, these may trigger a wider suite of regulations which need to be adhered to. It is the responsibility of the implementer of the interventions to consult relevant environmental authorities or consultants to ensure legal compliance.

It is important to consider the broader **ecological characteristics of the catchment** or sub-catchment, as this would influence the nature of restoration work that would happen. If, for example, tree-planting is considered as an intervention to combat bare areas surrounding rivers and create employment opportunities, it needs to be considered first whether the context is appropriate to plant trees. Tree-planting in an ecosystem previously characterized as a coastal grassland might not be suitable.

3) Evaluating the upstream and downstream connectivity and beneficiaries of the river

Rivers are highly dynamic and interconnected ecosystems, and as such are not only a shared resource, but a shared risk as well. They are often where the impacts in the catchment culminate and are most evident. Additionally, upstream users transfer risk to downstream users. For example, a hardened, developed catchment causes extensive downstream flooding. Therefore, it is imperative to ask **what the dominant land use in the catchment is** and identify the impacts of land uses, such as industries, communities, and agriculture, on the river. Mapping the location of land uses and the **catchment stakeholders and users of the rivers** can be a useful exercise to assist in identifying **the drivers of degradation in rivers**. Understanding the relevant stakeholders and users is an important part of the assessment and decision-making process, especially when applying many of the socio-ecological interventions, such as co-engaged learning platforms and the use of citizen science for river monitoring.

Catchment Contextualisation

Some typical leading questions to consider:

1. What is the size of the river?
2. What is the gradient of the river?
3. What is the water flow velocity?
4. What is the position in the catchment?
5. What is the land use?
6. What is the land ownership?
7. What is the socio-economic context?
8. What are the activities in the riparian zone? (agriculture, grazing etc.)

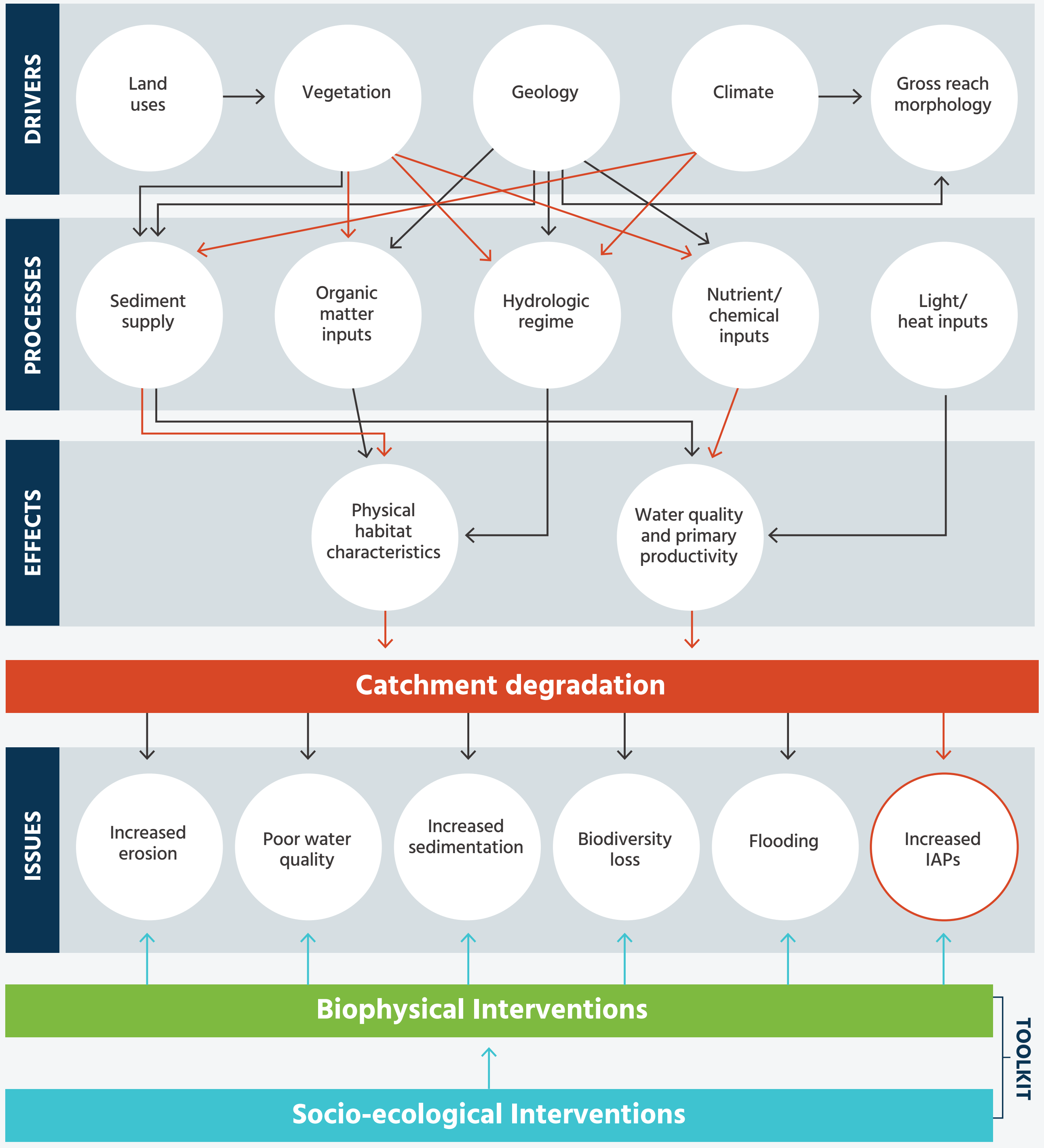


Figure 4. The complexity and connectivity of drivers of catchment processes and degradation issues

[1] The red arrows highlight an example of some of the drivers and interactions for a specific catchment degradation issue (IAPs).

3.2 PART II: Understanding the socio-ecological contextualisation

Transformative adaptation in urban river systems cannot be achieved without understanding and significant investment in the social dimensions of a catchment. Outlined below is a series of guiding considerations, under eight main themes, which underpins the planning of both engineering and socio-ecological interventions.

The LIRA2030 project interrogated the principles of transformative climate adaptation in river management. The findings of the study were distilled into six principles. The project team added another principle 'Sustainability' as a seventh principle. These seven prinicples formed the basis for developing eight themes against which to assess potential ecological infrastructure and socio-ecological intervention options. The eight themes presented below were developed following an assessment of how the transformative adaptation principles were applied to a number of river management projects that were being implemented in Durban. Figure 5 illustrates the eight themes which emerged in the real-life application of the seven transformative adaptation principles.

These themes were further examined and a number of pertinent considerations developed under each (Figure 5). These considerations are intended to inform implementers about the key engagements and approaches to follow when planning interventions in a river system in order to ensure that the six LIRA principles for transformative adaptation are addressed.

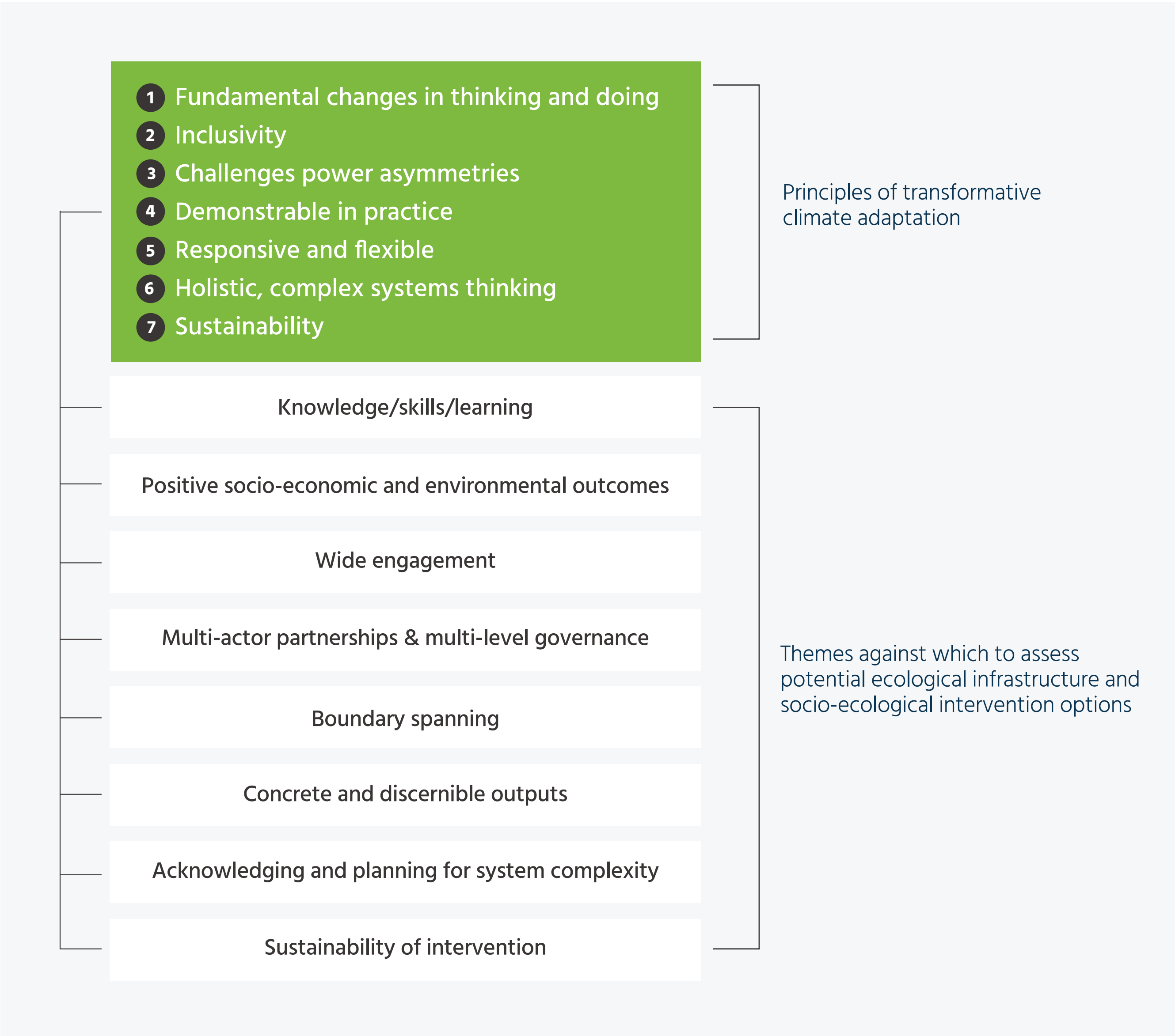


Figure 5. An illustration of the seven principles of transformative climate adaptation in river management, and the emerging themes when applying these to real river management programmes.

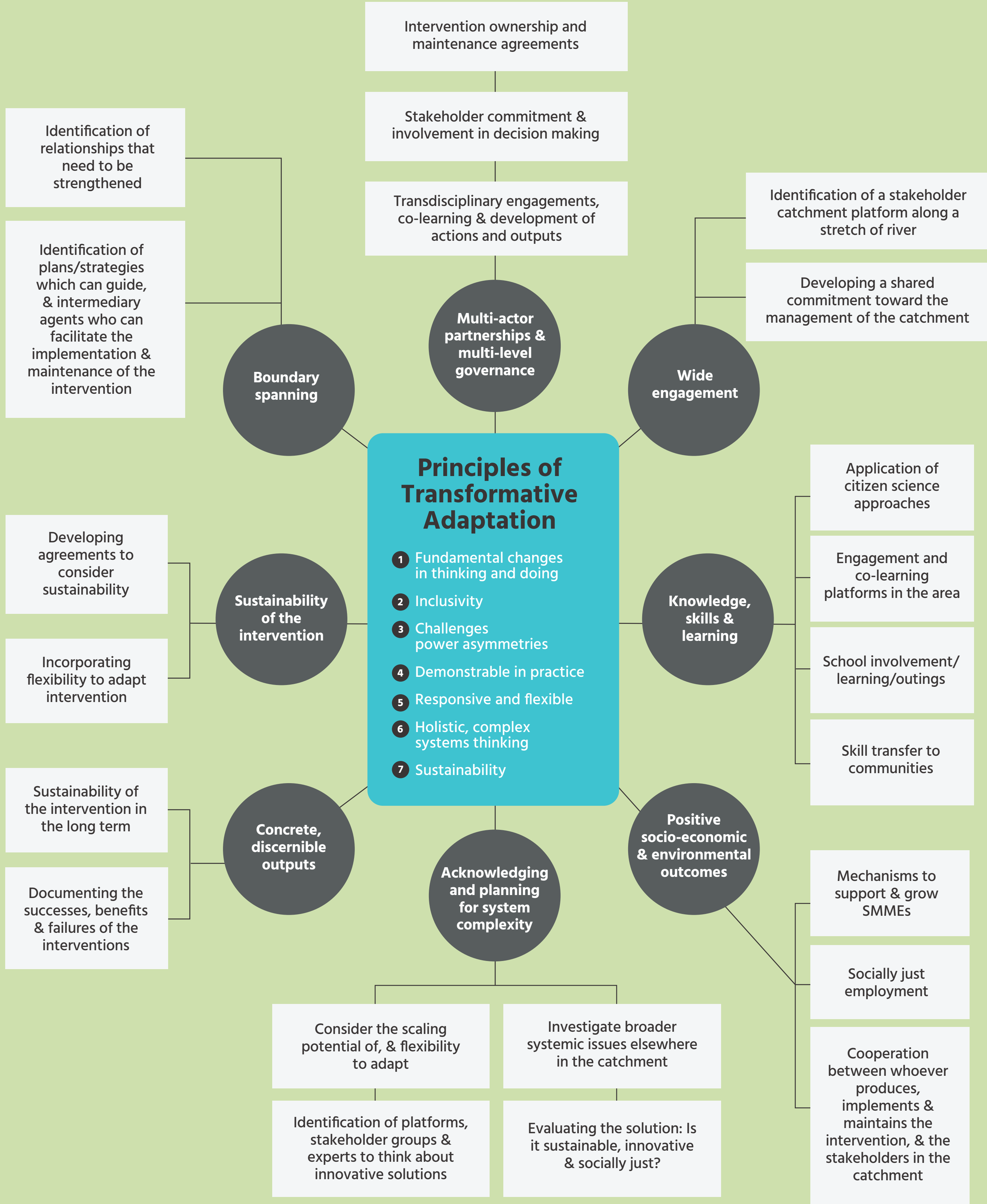


Figure 6. Key of ideal engagements and approaches when planning interventions in a river system, to ensure that the six LIRA principles for transformative adaptation are addressed, along with sustainability.

3.3 PART III: Intervention specification sheets

Once the catchment and socio-ecological contexts have been determined, the decision-makers and stakeholders can proceed with determining the appropriate ecological infrastructure and socio-ecological interventions. The interventions are presented to enable the decision-maker to assess, evaluate, and choose the most suitable interventions to address the problems identified in the catchment.

The interventions proposed have been divided into two classes: **1)** local-scale ecological and light-touch grey infrastructure interventions, and **2)** socio-ecological interventions. The ecological and light-touch grey infrastructure interventions are engineering solutions which address specific local-scale issues. The socio-ecological interventions, however, are not necessarily associated only with a specific geographic area, but are rather implemented as widely as possible, and as may be required by the communities and in the catchment. These interventions are typically more human-focused and require wider engagement and considerable planning in order to be executed effectively.

The following steps are recommended in using this toolkit.

Figure 7: Recommended steps when using this toolkit

The mock specification sheet on the right guides the reader on the various elements that are detailed in the specification sheets for each local-scale ecological and light-touch grey infrastructure proposed in this toolkit.

Local-scale ecological and light-touch grey infrastructure intervention	
THE KEY ISSUES ADDRESSED BY INTERVENTION	
DESCRIPTION	
Here a short description of the intervention is given.	
KEY AND ANCILLARY ISSUES	**INTERVENTION SUMMARY**
The following were identified as key issues to riverine environments in KZN: • Invasive Alien Plants • Sediment Control • Catchment Degradation • Urban Stormwater Management • Flood Risk Management • River Bank Erosion and Stabilisation • Water Quality • Solid Waste Management • Negative Biodiversity Impacts • Sand Mining The intervention is scored in its ability to address these issues, and the results are presented in a radar chart. The categories are defined as follows: • **High:** The intervention fully addresses the issue and would commonly be used to attend to this particular problem. • **Medium:** The intervention partially addresses the issue and would sometimes be used to attend to this particular problem. • **Low:** The intervention marginally addresses the issue but would not frequently be used to attend to this particular problem. • **Not Met:** The intervention does not address the issue at all.	The intervention summary provides the following information in a table: ▶ Capital cost • Low: Typical cost < R200 000. • Medium: Typical cost < R1 000 000. • High: Typical cost > R1 000 000. ▶ Maintenance cost • Low: Cost per annum < R15 000. • Medium: Cost per annum < R30 000. • High: Cost per annum > R30 000 ▶ Design complexity • Low: Intervention requires minimal specialised design work. • Medium: Intervention requires some degree of specialised design work. • High: Intervention requires a high degree of specialised design work ▶ Implementation complexity • Low: Intervention requires minimal specialised construction work and can be implemented predominantly by unskilled labour. • Medium: Intervention requires some degree of specialised construction work and requires some skilled labour for implementation. • High: Intervention requires a high degree of specialised construction work and requires a high level of skilled labour for implementation. ▶ Socio-economic benefits • Low: Intervention has minimal socio-economic benefits. • Medium: Intervention has some socio-economic benefits. • High: Intervention has numerous socio-economic benefits. ▶ Resilience to climate change • Low: Intervention has minimal resilience to climate change. • Medium: Intervention has some resilience to climate change. • High: Intervention has high resilience to climate change.
ILLUSTRATION OF INTERVENTION	
A suitably illustrated photographic example and a scaled illustration of what the intervention looks like is included here.	
CAPITAL AND MAINTENANCE COSTS	The capital cost estimate was compiled based on a typical size for the particular intervention. In most cases, actual rates (2020) for carrying out similar work using labour intensive methods were utilised as the basis for the cost estimate. If alternative methods of construction are employed such as the use of plant instead of labour, the costs could differ significantly from what is presented. The costs presented should be utilised as a guideline only and more accurate costs will need to be determined before implementation of a particular intervention. The assumed maintenance cost was determined per annum as a % of the capital cost.
MATERIALS REQUIRED	Provides a description of the materials required to implement the intervention.
APPROACH	Provides a high-level overview of the approach prior to intervention installation.
METHOD STATEMENT	Provides a basic outline of the activities required to carry out the intervention.
MAINTENANCE REQUIREMENT	Lists the maintenance requirements of the intervention.
CONSTRAINTS	Lists any constraints associated with the intervention.
POTENTIAL RISKS	Lists any potential risks to the intervention.
ADDITIONAL & SOCIO-ECONOMIC BENEFITS	Highlights additional physical and socio-economic benefits of the intervention.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	Emphasises whether and which professionally qualified person might potentially have to be consulted in the implementation of this intervention.

Table 1. Elements included in the local-scale ecological and light-touch grey infrastructure specification sheets and the approach used.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Rip rap and sloping

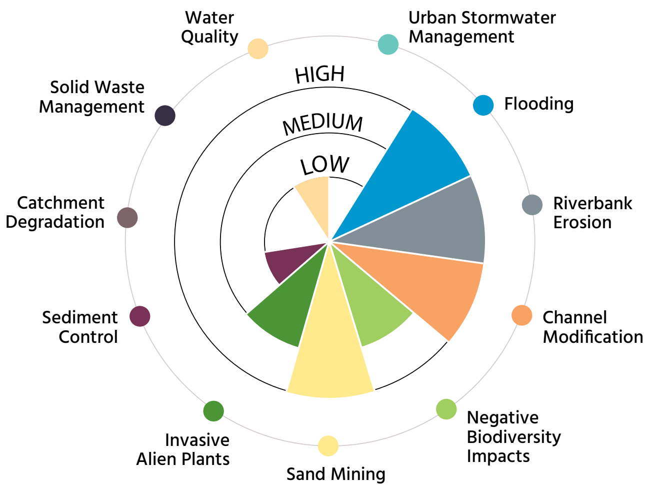
KEY ISSUES ADDRESSED

Flooding, riverbank erosion, channel modification, and sand mining

DESCRIPTION

High energy water flows can cause severe erosion, undercutting and possible collapse of unprotected riverbanks. Rip rap (packed rocks) protect the toe of a bank from being eroded and undercut. The area above the toe is sloped back and usually revegetated with indigenous vegetation such as trees, sedges and groundcover. Erosion control blankets and logs are used to assist with the initial establishment of vegetation. Once the vegetation has established on the banks above the rip rap, it helps provide support to the soil and protects it from erosion.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost	●		
Maintenance Cost	●		
Design Complexity		●	
Implementation Complexity	●		
Socio-Economic Benefits			●
Resilience to Climate Change		●	

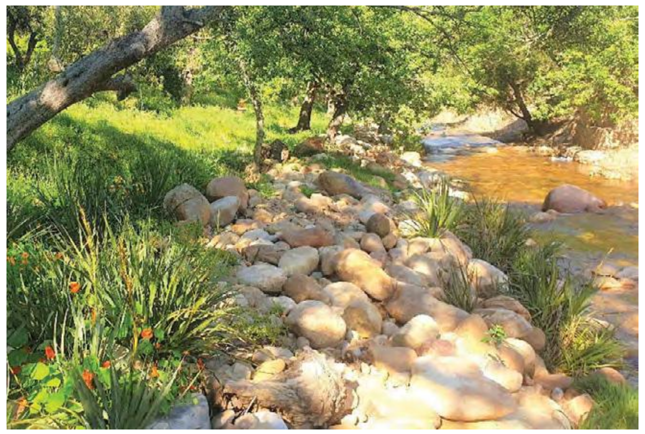


Figure 8: A photo of rip rap and revegetated sloped banks

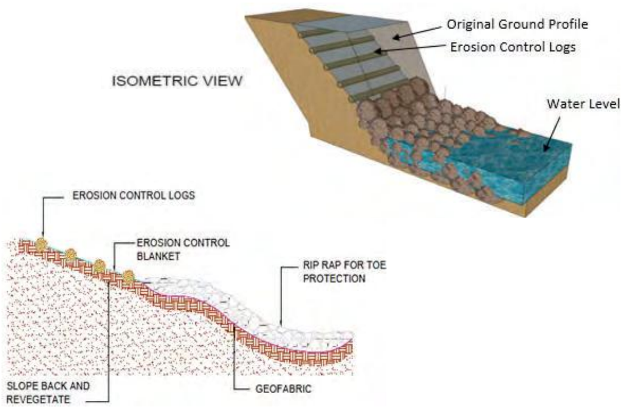


Figure 9: Diagrams showing how rip rap and sloping is typically set out

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

CAPITAL AND MAINTENANCE COSTS

- Estimated capital cost: R175 000 per $200m^2$

  The estimated costs of the intervention were based on an intervention area of $200m^2$ (20m long x 10m wide) with the following assumptions:
  - An average rock size of approximately 300mm diameter, with $1m^3$ of rock being able to cover an area of $3m^2$. It was assumed that the rip rap would be installed over the lower half of the intervention area i.e. $100m^2$ and that geofabric would be installed underneath the rip rap.
  - Revegetation would be required over the upper half of the intervention area i.e. $100m^2$.
  - Erosion control blankets placed over the revegetated area.
  - Erosion control logs placed at 1m intervals along the entire length of the revegetated area.
  - Half the bank would need to be excavated and the other half backfilled and compacted.
  - Labour intensive rates from 2019 were used and a 10% escalation factor applied.
- Estimated maintenance cost: R 9 000 per annum over $200m^2$

  The maintenance costs were estimated by assuming the following for the $200m^2$: Each year 10% of the total cost for the erosion control blankets, erosion control logs revegetation, alien clearing, non-friable and insoluble rock and geofabric would be required; and 5% of the total cost for backfilling and compaction would be required to maintain the intervention.

MATERIALS REQUIRED

- Non-friable and insoluble rock to pack onto the toe of the bank.
- Geofabric for protecting all rock-soil interfaces.
- Indigenous vegetation to revegetate the area above the rip rap.
- Erosion control blankets to protect the soil while vegetation establishes.
- Erosion control logs to reduce runoff velocities down the banks and to assist with the establishment of the vegetation.

APPROACH

- Identify areas where the banks of the watercourse are eroding and/or are highly susceptible to erosion due to high energy flows.
- Survey the environment and decide if the intervention is applicable.
- Determine the desired outcome(s) of the intervention.
- Run the hydrology and hydraulics for the site.
- Design the intervention for the required site conditions and to address the desired outcome(s).

METHOD STATEMENT

The exact method of installation may vary, depending on the particular situation but will generally include the following activities:

- Remove and stockpile topsoil.
- Slope and shape the site to a suitable gradient at which the vegetation will be able to establish.
- Install geofabric as per supplier's instructions.
- Pack rocks over geofabric, with smaller rocks placed in between larger ones to improve interlocking.
- Spread topsoil over the sloped area above the rip rap and revegetate with suitable indigenous riparian vegetation.
- Erosion control blankets / logs to be installed as per the supplier's instructions and placed over the revegetated area to assist with vegetation establishment.

MAINTENANCE REQUIREMENTS

- Monitor the site to ensure that the intervention is performing its function and addressing the desired outcome(s).
- Ensure that the rocks have not shifted or been washed away.
- Maintenance of indigenous vegetation and removal of alien vegetation.

CONSTRAINTS

- The intervention usually requires gentle gradients for implementation.
- It typically requires large open areas alongside rivers which are not as readily available in built up areas.

POTENTIAL RISKS

- During flood events, the rocks may shift and damage the environment around them.
- If the rocks shift during flood events, they may cause blockages within the watercourse. This may affect the flow within the river channel which could cause further erosion of the river banks.

ADDITIONAL AND SOCIO-ECONOMIC BENEFITS

- Can be implemented predominantly by unskilled labour – provides temporary employment for local community.
- Provides an opportunity to educate local communities on the importance of river rehabilitation and the negative effects of alien vegetation.
- The intervention looks more natural than other alternative hard engineering interventions.
- Cattle can still access the watercourse, while the rip rap protects the toe of the bank from being trampled and causing further erosion problems.

PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT

- An engineer with experience in environmental structures/interventions.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Brush packing

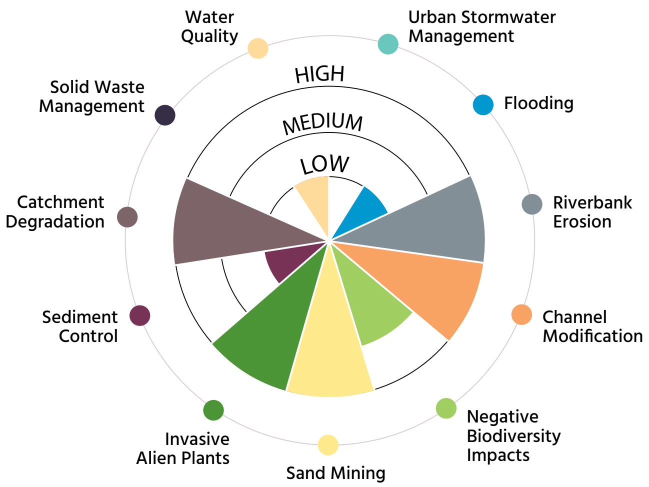
KEY ISSUES ADDRESSED

key issues addressed: riverbank erosion, channel modification, impacts of sand mining, invasive alien plants and catchment degradation

DESCRIPTION

Soil that is exposed and does not have any protection against harsh environmental elements is extremely vulnerable to erosion. Brush packing is an intervention that consists of covering the soil with felled branches and/or trees to help protect and stabilise exposed areas, while giving vegetation a chance to establish and provide future support to the soil. Generally, the area to be brush packed is sloped back to a suitable gradient with branches laid horizontally or vertically over the area (depending on the design) and often secured in place. This intervention is usually utilised in low energy flow environments and can assist with the restoration of indigenous vegetation. It can also assist with reducing soil erosion through the interception of sediment flow and the lowering of surface flow velocities.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost	●		
Maintenance Cost	●		
Design Complexity	●		
Implementation Complexity	●		
Socio-Economic Benefits			●
Resilience to Climate Change	●		

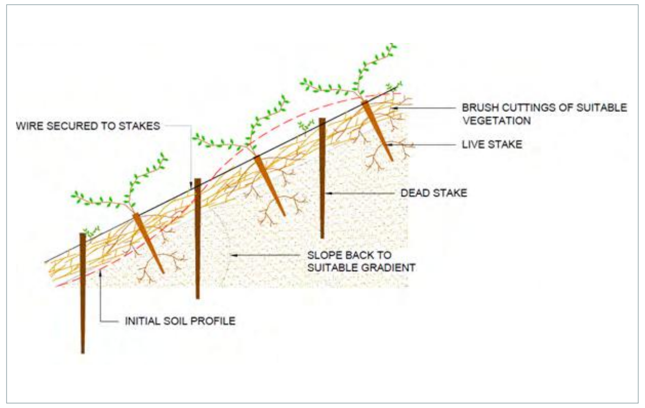


Figure 10: A diagram showing how brush packing is typically set out

Figure 11: A photo of brush packing being used to protect soil from further erosion

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

CAPITAL AND MAINTENANCE COSTS	▶ Estimated capital cost: R160 000 per 200m² The estimated costs of the intervention were based on an intervention area of 200m² (20m long x 10m wide) with the following assumptions: • Revegetation required over the entire intervention area i.e. 200m². • Erosion control blankets placed over entire intervention area. • Sourcing and placing brush over the entire intervention area. • 200m of wire installed along the entire width of the intervention at 1m intervals. • 200 stakes installed at 1m spacings. • Half the bank would need to be excavated and the other half backfilled and compacted. • Labour intensive rates from 2019 were used and a 10% escalation factor applied. ▶ Estimated maintenance cost: R 7 000 per annum over 200m² The maintenance costs were estimated by assuming the following for the 200m²: Each year 10% of the total cost for the erosion control blankets, revegetation, alien clearing, wooden stakes, binding wire and brush sourcing and packing would be required; and 5% of the total cost for backfilling and compaction would be required to maintain the intervention.
MATERIALS REQUIRED	▶ Indigenous vegetation to revegetate the site. ▶ Erosion control blankets to protect the exposed soil while the vegetation establishes. ▶ Brush to protect the exposed soil while the vegetation establishes and reduce runoff velocities down the banks. ▶ Binding wire and wooden stakes to secure the brush.
APPROACH	▶ Identify areas that have exposed soil and where brush packing can potentially be applied to help provide protection to the soil and promote the re-growth of vegetation. ▶ Survey the environment and decide if the intervention is applicable. ▶ Determine the desired outcome(s) of the intervention. ▶ Run the hydrology and hydraulics for the site. ▶ Design the intervention for the required site conditions and to address the desired outcome(s).
METHOD STATEMENT	The exact method of installation may vary, depending on the particular situation but will generally include the following activities: ▶ Remove and stockpile topsoil. ▶ Slope and shape the site to a suitable gradient at which the vegetation will be able to establish and the brush pack will be secure. ▶ Spread stockpiled topsoil over the sloped area and revegetate with indigenous vegetation. ▶ Erosion control blankets to be installed as per the supplier's instructions and placed over the revegetated area to assist with vegetation establishment. ▶ The brush is to be packed on top and tied down with wire, secured to stakes. The type of vegetation utilised for the brush is essential as the use of certain tree species may lead to future problems, such as alien vegetation growth. Live stakes can also be used which will take root and provide improved soil stability.
MAINTENANCE REQUIREMENTS	▶ Monitor the site to ensure that the intervention is performing its function and addressing the desired outcome(s). ▶ Monitor the site for damage. If the brush pack is damaged before the vegetation has had a chance to establish, it should be repaired. ▶ Remove any alien vegetation that establishes on site. ▶ If indigenous vegetation fails to establish, confirm that appropriate vegetation has been used and then re-vegetate the area.
CONSTRAINTS	▶ Brush packing is typically implemented on gentle gradients. ▶ It generally cannot be used in high energy environments, as high velocity water flow can potentially wash the structure away. ▶ It generally requires large open areas for sloping back which may not be available in typical urban settings.

Brush packing

POTENTIAL RISKS	▶ Floods damaging and/or removing the brush from the intervention before the vegetation has had time to establish will leave the soil exposed and highly susceptible to erosion. ▶ Brush packed areas are vulnerable to fire damage which may leave the soil exposed. ▶ Alien vegetation growth on the site.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Can be implemented by unskilled labour - provides temporary employment for the local community. ▶ Provides an opportunity to educate local communities on the importance of river rehabilitation and the negative effects of alien vegetation. ▶ Certain alien vegetation types can be cleared and then used in the implementation of the intervention.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ An engineer with experience in environmental interventions.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Invasive alien plant control and rehabilitation

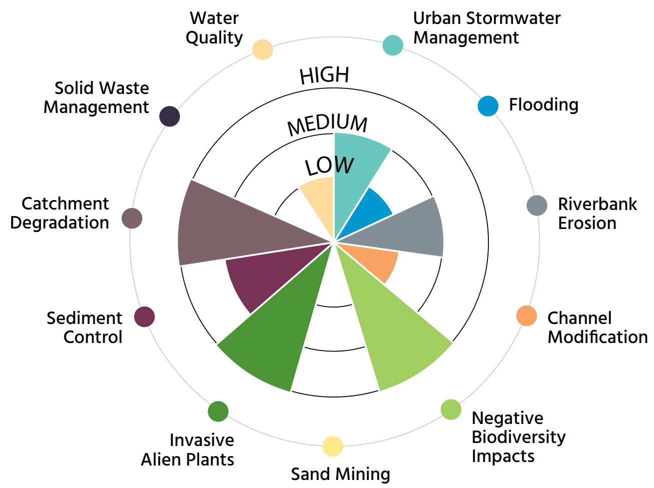
KEY ISSUES ADDRESSED

Catchment degradation, invasive alien plants and negative biodiversity impacts

DESCRIPTION

Alien invasive plants consume large quantities of water and negatively impact the health, stream bank stability and integrity of river ecosystems. As such, they pose a threat to the ecological functioning of riparian ecosystems and compromise habitat integrity for indigenous animals and plants, and exacerbate many natural and climate-related risks. If uncontrolled, alien invasive plants dominate the landscape and negatively impact biodiversity, water yields and livelihood opportunities from catchment areas. The removal of alien invasive plants can be carried out utilising mechanical, chemical or biological methods. Once the plants have been removed, the site should be rehabilitated and regularly maintained to ensure the successful establishment of indigenous plants which will in turn provide soil stabilisation and prevent erosion. The planting of a variety of species of indigenous plants in the cleared areas will enhance biodiversity and can lead to the strengthening of habitat integrity.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost		●	
Maintenance Cost			●
Design Complexity	●		
Implementation Complexity	●		
Socio-Economic Benefits			●
Resilience to Climate Change	●		

Figure 12 and 13 showing community members clearing alien invasive vegetation as part of the Working for Water Programme
Source: Working for Water **Accessed From:** https://www.rainharvest.co.za/2010/03/working-for-water-programme-is-working/
https://www.ru.ac.za/environmentalsustainability/resources/local/workingforwater/

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

Invasive alien plant control and rehabilitation

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R385 000 per hectare The capital cost of implementing an alien clearing plan includes the following items: • Training of teams on alien plant identification and various control methods and best practice guidelines in implementing these methods e.g. correct herbicide application and disposal. • Training of teams on indigenous plant identification and correct harvesting methods and transplanting of indigenous plants. • The supply of personal protective equipment (PPE), such as gloves, masks etc., and tools required for manual and chemical removal of alien plants. ▶ Maintenance cost: R30 000 per hectare per annum The maintenance cost associated with the implementation of this intervention includes the following: • The monitoring of cleared and rehabilitated sites and the removal of any alien vegetation that has re-established following initial removal. • The planting of indigenous species in areas that have failed to establish following the initial rehabilitation of the sites. • Maintenance costs for the first maintenance follow-up are quite high due to the large quantity of re-emergence of alien vegetation following the initial clearing. Follow-up visits in subsequent years will cost less.
MATERIALS REQUIRED	▶ Hand tools such as saws, pangas and shears for the manual removal of alien plants. ▶ Herbicides for the removal of alien plants using chemical means. ▶ Indigenous vegetation to be replanted in cleared areas as a means of rehabilitation. Once indigenous plants have fully established, they function as a biological control against the growth of alien invasive plants.
APPROACH	▶ Alien invasive plants may be identified and mapped out at a desktop level using available imagery and key focus areas selected and prioritised. Factors for prioritisation include (1) clearing the upper catchment and areas with lowest infestations first; (2) level of risk/threat to water supply; and (3) threat to biodiversity and alien plants growing in areas prone to veldfires (therefore creating a fire risk/hazard). Ground truthing is recommended. ▶ In the focal areas, alien plant species and densities to be determined and appropriate control strategies formulated. ▶ Alien invasive plant clearing plan and rehabilitation strategy planned and established.
METHOD STATEMENT	Removal of alien invasive plants follows a phased approach: Phase 1 – Initial Control ▶ Removal or treatment of alien invasive plants via mechanical, chemical or biological means. Clearing methods used and chemical selection would need to be advised by an ecologist. ▶ Revegetation (optional) of the cleared area using indigenous plant species. Plants species used for rehabilitation to be approved by an ecologist. Phase 2 – Follow-Up Control ▶ Follow-up treatment and control is essential. ▶ Ideally four follow up operations should be planned during the spring and summer months for the first two years after the initial clearing. This may be reduced thereafter, depending on the extent of the reoccurrence of the alien vegetation. ▶ Foliar application of herbicide should be applied to any emerging coppice. Phase 3 – Maintenance Control ▶ Alien invasive plants to be controlled through annual monitoring, maintenance and establishment of suitable indigenous plant species.
MAINTENANCE REQUIREMENTS	▶ Rehabilitation area to be monitored and any reoccurring alien vegetation to be removed using appropriate methods and replanting in areas where indigenous plants have not established. ▶ Early mechanical removal of juvenile alien plants is generally much easier and more cost effective than expensive herbicide treatment.

CONSTRAINTS	▶ The initial treatment of aliens and then re-establishment of indigenous plant species is more challenging on steeper slopes. ▶ Sourcing appropriate indigenous species to replant for rehabilitation. ▶ With chemical methods of control of alien plants, persons spraying herbicides will require adequate training in herbicide application as well as PPE. ▶ In areas of existing indigenous riparian vegetation amongst the alien vegetation, broadcast herbicide spraying may damage non target vegetation. Targeted application is required in these areas which takes much longer to implement therefore increasing the cost of labour.
POTENTIAL RISKS	▶ Flood damage/erosion to the exposed/cleared areas, especially before the indigenous vegetation has had time to fully establish. ▶ Inadequate follow-up and re-establishment of the alien vegetation if the recommended maintenance procedures are not followed. ▶ Accidental overspray of herbicides onto indigenous or useful vegetation, negatively affecting the broader habitat and biodiversity. ▶ Translocation of systemic herbicides through the soil which negatively affects the useful riparian vegetation located near the alien plants. ▶ Poor establishment (timing/geographical location/suitability etc.) of biocontrol agents.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Some aspects of alien clearing and revegetation can be implemented by unskilled labour which provides temporary employment for the local community during the initial clean-up. Regular maintenance creates additional job opportunities. Other aspects will require trained/semi-skilled persons such as herbicide applicators. This can be used as an opportunity to upskill/train community members which can lead to future employment in forestry plantations. ▶ Provides an opportunity to educate local communities on the negative effects of alien vegetation on biodiversity and the benefits of enhanced biodiversity. ▶ Certain alien vegetation types can be cleared and re-purposed for other uses e.g. branches can be used for brush packing and the manufacture of ecologs / erosion control blankets. Timber can be extracted for furniture, construction material and fuel. ▶ Community members can be trained and employed as Eco-rangers/EnviroChamps who can identify and map out areas which are infested with alien plants as well as monitor and maintain areas that have been cleared and rehabilitated. This information can be uploaded onto a database where it can be used to develop alien plant clearing plans for future implementation. ▶ Improved supply of ecosystem goods and services to locally dependent communities from areas cleared of alien plants (grazing, water, firewood, traditional herbs, plants/building materials, recreational and eco-tourism opportunities, etc.).
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Ecologist – to train the team and community members about alien and indigenous plant identification, selection of appropriate indigenous plants for revegetation and selection of appropriate chemicals/ herbicides to be used. ▶ Experienced person trained in herbicide applications and management – to train community members on correct application of herbicides and storage and disposal.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Rehabilitated and constructed wetlands

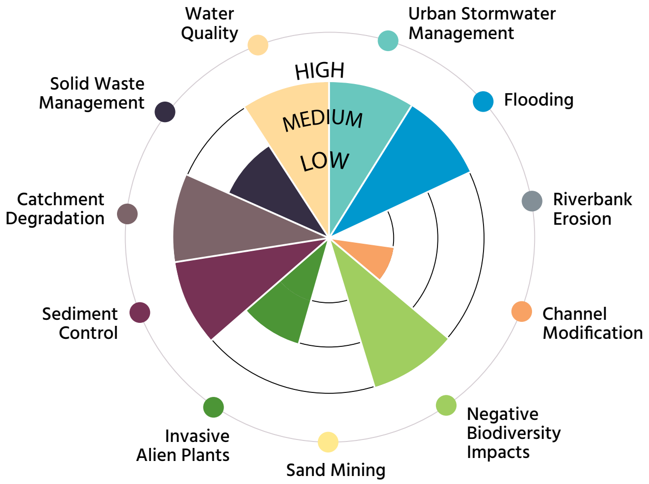
KEY ISSUES ADDRESSED

Catchment degradation, sediment control, negative biodiversity impacts, water quality, urban stormwater management, and flooding

DESCRIPTION

Constructed wetlands are artificial wetlands that have been engineered to mimic the processes found within naturally occurring wetlands, whilst rehabilitated wetlands restore functionality to improve existing impacted wetlands. Both can be designed to help enhance water quality, improve biodiversity, improve flood attenuation, and assist the recharge of groundwater. They can also be used as a means of carbon storage, as an erosion control measure, as a means of trapping litter in the right landscape setting and to assist with providing a slow release of water during low flow seasons. They also provide numerous resources that are used in a variety of commercial products e.g. incema grass for woven sleeping mats, reeds for building and in providing food for livestock etc.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost			●
Maintenance Cost			●
Design Complexity			●
Implementation Complexity		●	
Socio-Economic Benefits			●
Resilience to Climate Change			●

Figure 14 and 15 showing examples of wetlands

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R450 000 (Per hectare). The capital cost of constructing a wetland or implementing a wetland rehabilitation plan includes the following items: • Excavation for concrete structures. • Earthworks for backfilling and compacting around structures, reshaping wetland areas and construction of earthen diversion structures. • Steel reinforcing and concrete work. • The capital cost has been calculated assuming that the work is undertaken by a bulk earthworks contractor using mechanical plant. ▶ Maintenance cost: R40 000 per annum. The maintenance cost associated with the implementation of this intervention includes the following: • The replanting of indigenous wetland species in areas that have failed to establish following the initial wetland rehabilitation. • The removal of any alien invasive plants that establish in the wetland area. • The clearing of solid waste that has been retained by the wetland vegetation after significant storm events. • Assessment of the functioning of the structure and inspection of the concrete structures for cracks or flood damage on an annual basis. • Repairs to / replacement of a structure required as a result of damage from a flood event will be over and above the annual maintenance cost stated above.
MATERIALS REQUIRED	▶ Indigenous wetland vegetation to be planted in reshaped areas to aid vegetation establishment and prevent erosion. Restoring or providing the correct wetland hydrology however, often allows for the natural re-establishment of wetland plants. ▶ Concrete and steel reinforcing – for concrete weirs or drop inlet towers which function as diversion and/or control structures. ▶ Earthen material – for diversion structures which assist in restoring and/or improving diffuse flows across the wetland. Earthen material may be taken from excavation for concrete structures or any excess material resulting from reshaping earthworks.
APPROACH	▶ Existing wetlands that have been impacted by human activities may be identified and mapped out at a desktop level using available imagery and existing wetland coverages. ▶ Survey site to establish wetland levels, flow paths for correct placement of diversion structures, cut to fill areas for reshaping and layout of designed constructed wetland or areas for rehabilitation (if an existing wetland). ▶ Design concrete weirs using the following methodology: • Survey channel dimensions. • Determine catchment hydrology. • Determine peak flows for design return period. • Determine depth of overflow. • Determine dimensions of weir using hydraulic weir calculations (e.g. Manning's or Chezy). ▶ Constructed wetland or wetland rehabilitation strategy planned and established.
METHOD STATEMENT	▶ Undertake construction in the low flow season. ▶ Divert the flow around the construction site by means of a diversion channel to allow construction of concrete structures in the river channel and reshaping activities in wetland area. ▶ Remove all alien invasive plants in footprint area of the wetland. ▶ Remove and stockpile topsoil. ▶ Slope and shape the site to design levels. Reshaping of the wetland area to be completed prior to the construction of any diversion structure to ensure that all diverted flows will be safely received within the wetland area. ▶ Construct earthen diversion structures to design specifications and orientations. ▶ Construct concrete diversion/control structures as follows: • Excavate down to firm impermeable founding material. Poor founding material to be removed and replaced with gravel or other suitable material. Backfill material around concrete structures to be compacted in 150mm layers to optimum moisture content. • Formwork/shuttering to be erected to correct dimensions of concrete structure. • Steel reinforcing to be positioned according to design specifications. • Concrete to be mixed and cast in accordance with construction standards and specifications. • Upon completion of construction work, water to be rediverted into the wetland area and the temporary diversion channel rehabilitated.

Rehabilitated and constructed wetlands

MAINTENANCE REQUIREMENTS	▶ Establishment of wetland vegetation to be monitored. Wetland vegetation to be maintained by defoliation which can include slashing or burning vegetation. ▶ Wetland functioning to be monitored and adaptive management employed to improve functioning if required. ▶ Emerging alien invasive plants to be removed. ▶ Solid waste retained by wetland vegetation to be routinely removed after significant storm events. ▶ Concrete should be inspected for cracks or flood damage on an annual basis. Repairs to be carried out to damaged structures as required. ▶ Earthen diversion structures that have not fully revegetated to be monitored for erosion. Eroded areas to be backfilled and recompacted.
CONSTRAINTS	▶ Generally requires large open areas to implement which may not be readily available in urban environments. ▶ Ideally should be implemented during the dry season under low flow conditions for ease of construction.
POTENTIAL RISKS	▶ Flood damage/erosion to the exposed/cleared areas, especially before the indigenous wetland vegetation has had time to fully establish. ▶ Inadequate follow-up and re-establishment of the alien vegetation if the recommended maintenance procedures are not followed. ▶ Flood damage to the concrete structures during major floods.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Reshaping and revegetation of wetland areas and clearing of alien invasive plants can be implemented predominantly by unskilled labour – provides temporary employment for the local community. ▶ Construction of concrete structures provides temporary employment as well as upskilling of community members in construction skills such as concrete work and steel fixing. The upskilling of community members in the process can unlock further employment opportunities ▶ Provides an opportunity to educate local and broader communities about the importance of conserving wetlands. ▶ Community members can be trained and employed as Eco-rangers/EnviroChamps who can monitor and maintain areas within the rehabilitated wetland and monitor water quality as a means of assessing wetland functioning. ▶ Rehabilitated wetlands have a positive impact on water quality, enhance biodiversity, reduce solid waste in rivers and improve aesthetics. ▶ Provide educational and local eco-tourism opportunities e.g. birding, frogging etc. which stimulates the local economy.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Ecologist – to determine wetland layout, inform rehabilitation strategy to restore wetland processes and select and approve wetland vegetation for rehabilitation. ▶ Environmental/civil engineer – for design of earthen diversion structures, reshaping earthworks, concrete structures and issuing of construction specifications. ▶ Engineer/contractor – for supervision of labourers during implementation.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Debris walls

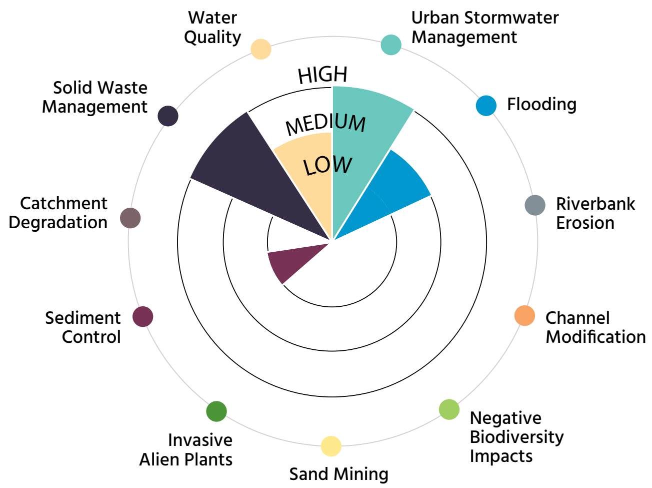
KEY ISSUES ADDRESSED

Solid waste management and urban stormwater management

DESCRIPTION

Solid waste and debris accumulation in rivers are one of the main causes of blocked and/or damaged culverts. This is a direct result of poor catchment management upstream such as indiscriminate dumping of waste and unstable or collapsed riverbanks. Blocked/damaged culverts result in poor stormwater management and increase the risk of flooding. Debris walls are concrete pillars constructed within a river channel upstream from a stormwater culvert/bridge. The purpose of the debris wall is to trap debris and solid waste before it enters the culvert, further reducing debris blockages and lowering the risk of debris blockages damaging the culvert. The debris walls can also potentially improve flow hydraulics through the culvert itself.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost		●	
Maintenance Cost	●		
Design Complexity			●
Implementation Complexity			●
Socio-Economic Benefits		●	
Resilience to Climate Change			●

Figure 16 and 17 showing examples of debris walls that have been constructed upstream of culverts/bridges

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

Debris walls

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R100 000 per debris wall. The number of debris walls is determined by the number of centre walls in the multi-cell culvert. The capital cost of implementing debris walls includes the following items: • Excavation for the debris walls. • Earthworks which entails backfilling and compacting beneath and around the structure. • Steel reinforcing and concrete work. ▶ Maintenance cost: R6 000 per annum The maintenance cost associated with the implementation of this intervention includes the following: • Clearing of solid waste and debris that has been retained by the debris walls after storm events. • Repairs to / replacement of a structure required as a result of damage from a flood event will be over and above the annual maintenance cost stated above.
MATERIALS REQUIRED	▶ Concrete and steel reinforcement.
APPROACH	▶ Locations of culverts may be obtained from municipal records. At a desktop level, imagery may be used to identify culverts that are in sections of river where large amounts of solid waste have accumulated. Field inspection of the culverts to be undertaken to confirm extent of blockages. ▶ Survey channel dimensions in field. ▶ Determine catchment hydrology and peak flows. ▶ Design and size debris walls according to hydrological and hydraulic calculations.
METHOD STATEMENT	▶ Undertake construction in the low flow season. ▶ Divert the flow around the construction site by means of a diversion channel to allow construction in the river channel. ▶ Clear culverts of all existing debris and solid waste and dispose appropriately off site. ▶ Remove and stockpile topsoil. ▶ Excavate down to firm impermeable founding material. Poor founding material to be removed and replaced with gravel or other suitable material. Backfill material around debris walls and upstream of the culvert to be compacted in 150mm layers to optimum moisture content. ▶ Formwork/shuttering to be erected to correct dimensions of debris walls. ▶ Steel reinforcing to be positioned according to design specifications. ▶ Concrete to be mixed and cast in accordance with construction standards and specifications. ▶ Upon completion of construction work, water to be redirected into the river channel and temporary diversion channel rehabilitated.
MAINTENANCE REQUIREMENTS	▶ Concrete should be inspected for cracks or flood damage on an annual basis. ▶ Repairs to be carried out to the structure as required. ▶ Solid waste / debris that has collected behind the structure should be routinely removed and disposed of after storm events.
CONSTRAINTS	▶ Ideally should be implemented during the dry season under low flow conditions for ease of construction. ▶ "Grey" infrastructure - not as aesthetically pleasing as other "green" interventions.
POTENTIAL RISKS	▶ Flood damage to the debris walls during major floods. ▶ Potential risks to persons cleaning the debris walls such as disease or infection resulting from polluted water.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Construction of debris walls provides temporary employment as well as upskilling of community members in construction skills such as concrete work and steel fixing. The upskilling of community members in the process can unlock further employment opportunities. ▶ The routine maintenance of clearing the debris from the walls can be implemented as a community clean-up initiative to create employment for the community and educate the community on the link between improper solid waste management and flood risks and poor water quality. ▶ An effective stormwater management tool for reducing culvert blockages as well as for improving the flow characteristics through the culvert itself. ▶ Cost savings as a result of the decrease in the frequency of damage to stormwater culverts.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental/civil engineer – for design of debris walls and issuing of construction specifications. ▶ Engineer/contractor – for supervision of labourers during implementation.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Sloping and revegetation

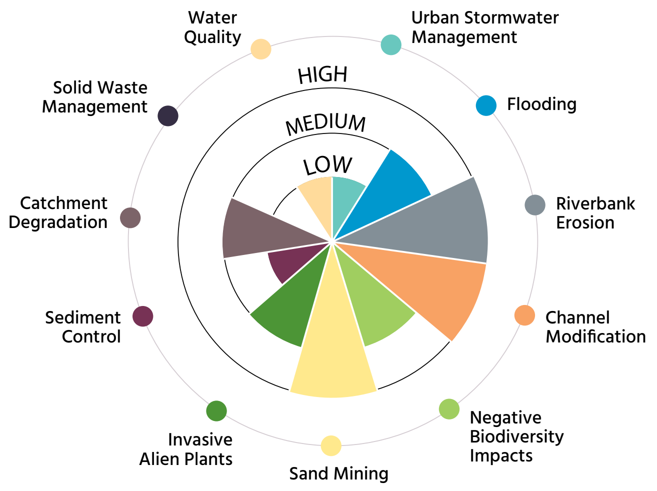
KEY ISSUES ADDRESSED

Riverbank erosion, channel modification, and impacts of sand mining

DESCRIPTION

Soil that is exposed and does not have any protection against harsh environmental elements is extremely vulnerable to erosion. By revegetating exposed areas, the roots of plants and the covering they assist in protecting soil from erosion. However, for vegetation to establish, the slope needs to be at a suitable gradient. Sloping and revegetation is usually utilised to address riverbank erosion problems. Steep eroded banks are usually reshaped and sloped back to a suitable gradient. The sloped area is then revegetated with indigenous vegetation. Erosion control blankets / logs are used to help promote the initial establishment of vegetation.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost	●		
Maintenance Cost	●		
Design Complexity	●		
Implementation Complexity	●		
Socio-Economic Benefits			●
Resilience to Climate Change	●		

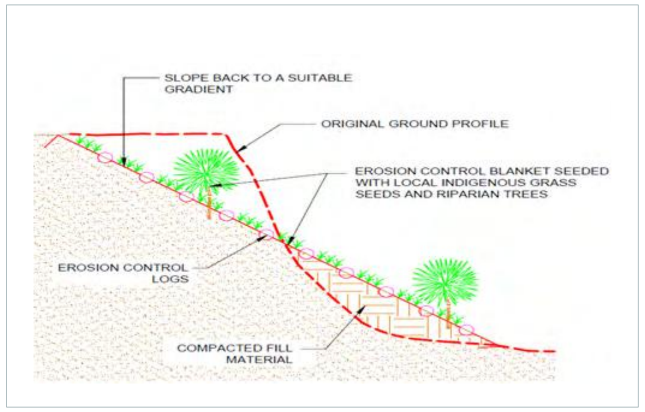


Figure 18: A diagram showing how sloping and revegetation is typically set out

Figure 19: A photo showing the initial sloping and revegetation phase
Figure 20: A photo showing an erosion control log and blanket

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

Sloping and revegetation

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R140 000 per 200m² The estimated costs of the intervention were based on an intervention area of 200m² (20m long x 10m wide) with the following assumptions: • Revegetation required over entire intervention area i.e. 200m². • Erosion control blankets placed over the intervention area. • Erosion control logs placed at 1m intervals along the entire length of intervention area. • Half the bank would need to be excavated and the other half backfilled and compacted. • Labour intensive rates from 2019 were used and a 10% escalation factor applied. ▶ Estimated maintenance cost: R 5 000 per annum over 200m² The maintenance costs were estimated by assuming the following for the 200m²: Each year 10% of the total cost for the erosion control blankets, erosion control logs revegetation, and alien clearing would be required; and 5% of the total cost for backfilling and compaction would be required to maintain the intervention.
MATERIALS REQUIRED	▶ Indigenous vegetation to revegetate the banks. ▶ Erosion control blankets to protect the exposed soil while the vegetation establishes. ▶ Erosion control logs to help reduce runoff velocities down the banks and provide the vegetation with a chance to establish.
APPROACH	▶ Identify areas where there are steep and/or exposed slopes. ▶ Survey the environment and decide if the intervention is applicable. ▶ Determine the desired outcome(s) of the intervention. ▶ Run the hydrology and hydraulics for the site. ▶ Design the intervention for the required site conditions and to address the desired outcome(s).
METHOD STATEMENT	The exact method of installation may vary, depending on the particular situation but will generally include the following activities: ▶ Remove and stockpile topsoil. ▶ Slope and shape the site to a suitable gradient at which the vegetation will be able to establish. ▶ Spread topsoil over the sloped area and revegetate with suitable indigenous vegetation. ▶ Erosion control blankets / logs to be installed as per the supplier's instructions and placed over the revegetated area to assist with vegetation establishment.
MAINTENANCE REQUIREMENTS	▶ Monitor the site to ensure that the intervention is performing its function and addressing the desired outcome(s). ▶ Check for exposed areas and revegetate as required. ▶ Maintenance of indigenous vegetation and removal of alien vegetation.
CONSTRAINTS	▶ Typically needs to be implemented on gentle gradients. ▶ Intervention generally requires large open areas alongside rivers which are not as readily available in built up areas.
POTENTIAL RISKS	▶ Flood damage to the exposed banks before the vegetation has had time to establish. ▶ Fire can burn erosion control measures and vegetation, leaving the soil exposed and susceptible to erosion.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Can be implemented by unskilled labour - provides temporary employment for local community. ▶ Provides an opportunity to educate local communities on the importance of river rehabilitation and the negative effects of alien vegetation. ▶ The intervention looks more natural than other hard engineering interventions.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ An engineer with experience in environmental interventions.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Gabion retaining wall and weirs

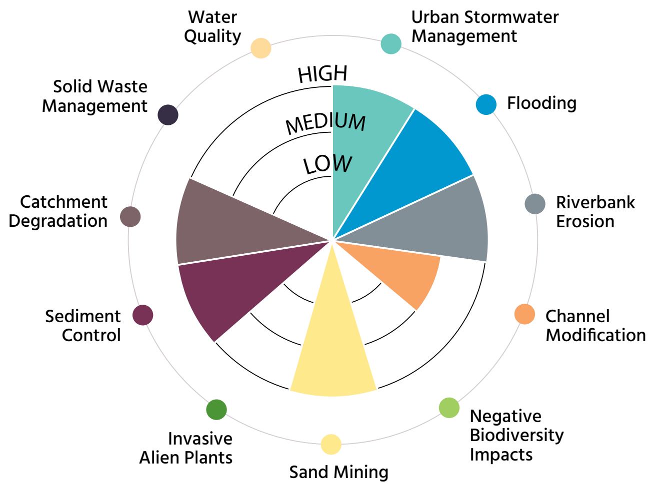
KEY ISSUES ADDRESSED

Urban stormwater management, flooding, riverbank erosion, impacts of sand mining, sediment control, and catchment degradation

DESCRIPTION

Riverbank erosion is a natural process that occurs in rivers due to the dynamic nature of the river system. However, poor land use practices such as unregulated sand mining and increased river flows resulting from poor stormwater management upstream leads to excessive bank erosion which results in bank failure. Gabion retaining walls are used to protect riverbanks from erosion by stabilising soil and breaking the energy of the water. Geofabric is installed between all earth-gabion interfaces to limit the amount of sediment moving though the gabion structure. This ensures that sediment is retained behind the structure and prevented from entering the watercourse. Gabion weirs may be installed within river channels and are used to flatten the effective gradient of the channel and raise the water level to reduce the erosive capacity of the water upstream. Gabion weirs also encourage sediment deposition, which reduces the erosion potential of the riverbanks.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost		●	
Maintenance Cost	●		
Design Complexity			●
Implementation Complexity		●	
Socio-Economic Benefits			●
Resilience to Climate Change	●		

Figure 21 showing installation of gabion baskets

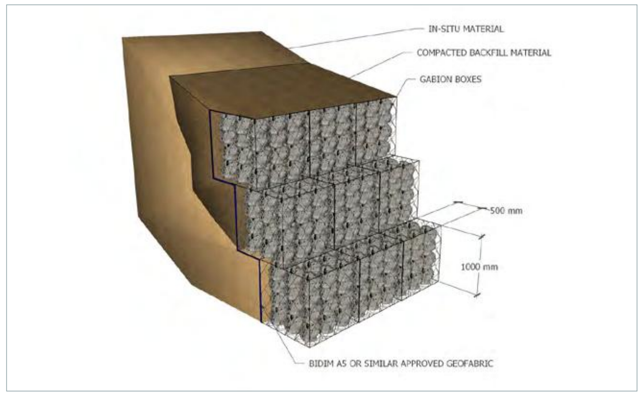


Figure 22 showing typical riverbank design of gabion bank protection

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

Gabion retaining wall and weirs

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R230 000 (Intervention volume of 30m³) The capital cost of implementing gabion retaining walls or weirs includes the following items: • Excavation for the gabion structure. • Earthworks which entails backfilling and compacting beneath and around the structure. • Installation of geotextile fabric between all interfaces between gabions and soil. • Installation of gabions. • Revegetation of the soil around the structure that was disturbed due to construction. ▶ Maintenance cost: R10 000 per annum The maintenance costs were estimated by assuming the following for the 30m³: • Each year 10% of the total cost for the revegetation around the structure would be required; and 5% of the total cost for backfilling and compaction, replacement of damaged geotextile fabric and gabions would be required to maintain the intervention.
MATERIALS REQUIRED	▶ Gabion baskets (Galfan PVC coated wire mesh). ▶ Gabion rock. ▶ Geotextile fabric (needle-punched non-woven) e.g. BidimTM A4. ▶ Indigenous vegetation to be replanted in disturbed areas as a means of rehabilitation.
APPROACH	▶ Unstable and eroded riverbanks may be identified and mapped out using good quality imagery (<5cm). If suitable imagery is unavailable, sites are to be visually inspected and surveyed in-field. ▶ Catchment hydrology to be determined including peak and base flows. ▶ Water to be tested for corrosiveness – if water is corrosive, gabion baskets to be PVC coated. ▶ Soil to be tested for dispersiveness – if soils are dispersive, gabions will be inappropriate, and an impermeable stabilisation structure will be required. ▶ In channels with high flows and eroded riverbanks, gabion retaining walls to be used to stabilise riverbanks. Size of retaining wall to be determined using surveyed dimensions of the eroded riverbank. ▶ In channels with low flows and/or channels with steep gradients (high head), a series of gabion weirs is to be used to flatten the overall gradient of the channel and reduce the energy and erosion potential of the channel. Weirs to be designed using the following methodology: • Survey channel dimensions. • Determine catchment hydrology. • Determine peak flows for design return period. • Determine depth of overflow. • Determine dimensions of weir using hydraulic weir calculations (e.g. Manning's or Chezy).
METHOD STATEMENT	▶ Excavate by hand for gabion foundations and stockpile for use as backfill behind gabion walls. ▶ Carry out surface preparation (final levelling and trimming) for bedding of gabions. ▶ Position layer of geotextile fabric at interface between gabions and soil. ▶ Position first layer of gabions and install shuttering on front (and side faces, if required) to ensure a neat finish. ▶ Tightly pack gabion with gabion rock and then tie gabion lid closed. ▶ Carry out final trimming of geotextile fabric as well as levelling and finishing around gabion installation as required.
MAINTENANCE REQUIREMENTS	▶ Gabions require routine monitoring to confirm if they are still intact. If rocks within gabion are no longer tightly packed, the gabion should be repacked and additional rocks added. ▶ Geotextile fabric must also be inspected to confirm that it has not shifted or been damaged. Geotextile to be replaced if there is evidence of damage. ▶ Solid waste that has accumulated behind and on the gabion must be routinely removed. ▶ Monitoring of the gabion structure for damaged or vandalised gabion baskets. Damaged gabions to be replaced. ▶ Monitoring of the gabion structure after any flood event to assess structural integrity. Repairs to / replacement of a structure required resulting from flood damage will be over and above the annual maintenance cost stated above. ▶ Monitoring of the establishment of vegetation around the structure.

CONSTRAINTS	▶ Ideally should be implemented during the dry season under low flow conditions for ease of construction. ▶ If the soil is dispersive, a gabion structure will be unsuitable and an impermeable structure such as a concrete retaining wall or weir will have to be considered. ▶ "Grey" infrastructure - not as aesthetically pleasing as other "green" interventions.
POTENTIAL RISKS	▶ Flood damage to the gabions during flood events. ▶ Erosion of the backfill material around the gabions can occur if the material has not been sufficiently compacted.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Installation of gabions provides temporary employment. The upskilling of community members in the process can unlock further employment opportunities. ▶ Effective in controlling sediment migration and can therefore provide a significant contribution to the reduction of catchment degradation. ▶ Can be used to stabilise and rehabilitate areas where sand mining has taken place. ▶ Effective interventions in managing urban stormwater and managing / reducing flood risks.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental/civil engineer – for stormwater, sediment control, bank stabilisation and sand mining rehabilitation design options. ▶ Engineer/contractor – for supervision of labourers during implementation.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Trash booms

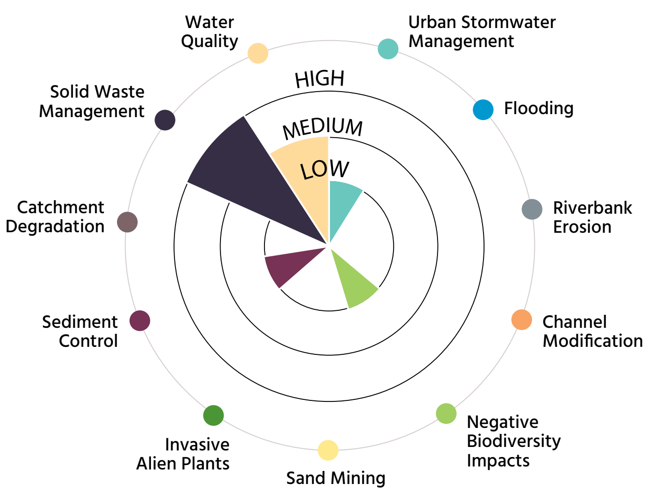
KEY ISSUES ADDRESSED

Solid waste management

DESCRIPTION

Solid waste in rivers negatively impacts biodiversity and is one of the main causes of water pollution / poor water quality. This is a direct result of poor land use upstream and limited infrastructure and waste services to disincentivise the indiscriminate dumping of waste in river systems. Trash booms are installed diagonally across waterways to catch and direct floating material (debris or solid waste) towards the banks, thus preventing this material from travelling further downstream. Floating debris can then be easily removed from the watercourse.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost	●		
Maintenance Cost	●		
Design Complexity	●		
Implementation Complexity	●		
Socio-Economic Benefits		●	
Resilience to Climate Change	●		

Figure 23 and 24 showing examples of trash booms

Source: GEI WORKS
Accessed From: https://www.erosionpollution.com/litter_pollution.html

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

CAPITAL AND MAINTENANCE COSTS	▶ Typical capital cost of intervention: R3 000 (10m wide river channel) There are a range of different trash booms that are available e.g. HDPE trash booms, galvanised steel trash booms, infilled PVC lay flat booms and inflatable PVC trash booms. The trash boom costed for in the above capital cost is the infilled PVC lay flat trash boom, which is the cheapest option. The capital cost of installing a trash boom includes the following items: • 100mm ø PVC lay flat hose to function as trash boom. • Concrete anchor blocks to be cast into the side banks. • 10mm nylon ski-rope and expansion screws with closed hook anchor bolts for anchoring of boom to concrete anchor blocks. • Training of teams on installation and maintenance of trash booms. ▶ Maintenance cost: R8 000 per annum The maintenance cost associated with the implementation of this intervention includes the following: • Clearing of solid waste and debris that have been retained by the trash boom after significant storm events. • Inspection of the trash boom after significant storm events for damage. If the trash boom is damaged, it is to be repaired or reinstalled.
MATERIALS REQUIRED	▶ 100mm ø PVC lay flat hose to function as trash boom. ▶ Recycled 2l cooldrink bottles to fill hose. ▶ 10mm nylon ski-rope and expansion screws with closed hook anchor bolts for anchoring of boom. ▶ Concrete to be casted as anchor blocks.
APPROACH	▶ At a desktop level, imagery may be used to identify sections of river where large amounts of solid waste have accumulated. ▶ Survey channel dimensions in-field. ▶ Determine catchment hydrology and peak flows. ▶ Educate community members about solid waste management and encourage recycling of waste. Encourage community members to collect recycled materials for the infilling of the trash boom. ▶ Trash boom to be installed across the river and secured to the riverbanks using ski-rope and anchors such as expansion screws with closed hook anchor bolts.
METHOD STATEMENT	▶ Collect discarded plastic bottles. ▶ Use plastic bottles to fill lay flat hose to capacity. ▶ Prior to commencement of installation, clear all solid waste out of the channel. ▶ Excavate on both side banks for concrete anchor blocks. Poor founding material to be removed and replaced with gravel or other suitable material. Backfill material around anchor blocks to be compacted in 150mm layers to optimum moisture content. ▶ Anchor filled hose to anchor block on one bank using ski-rope. Ski-rope to be anchored to concrete anchor blocks using expansion screws with closed hook anchor bolts. ▶ Straighten filled hose across the width of the channel and anchor to the anchor block on the other bank. ▶ Undertake installation in the low flow season for safer working conditions or make use of a raft/boat to convey trash boom across the river.
MAINTENANCE REQUIREMENTS	▶ Solid waste must be removed on a regular basis to prevent the boom from overfilling and creating an obstruction in the river channel. ▶ The boom should be inspected on a regular basis for flood damage and replaced if required.
CONSTRAINTS	▶ Not suitable for installation on sections of river that are prone to major flooding and high flows. However, the boom can be designed to "break" on one side during higher flows and can then be easily repaired/reinstalled after the high flows have subsided.
POTENTIAL RISKS	▶ Flood damage during moderate to major floods – although damage can be easily repaired.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Can be implemented predominantly by unskilled labour – provides temporary employment for local community as well as upskilling. ▶ The removal of debris from the trash boom can create ongoing employment opportunities for the local community. ▶ Provides an opportunity to educate local communities about solid waste management and the importance and benefits of recycling and keeping rivers clean. ▶ Provides an opportunity to establish a recycling initiative in local communities which reduces solid waste in rivers and improves aesthetics and water quality.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental/civil engineer – for the design of the trash boom and anchorage. ▶ Experienced person trained in community engagement/outreach programmes – to educate community members about recycling and the installation of trash booms.

LOCAL-SCALE ECOLOGICAL AND LIGHT-TOUCH GREY INFRASTRUCTURE INTERVENTION

Groynes

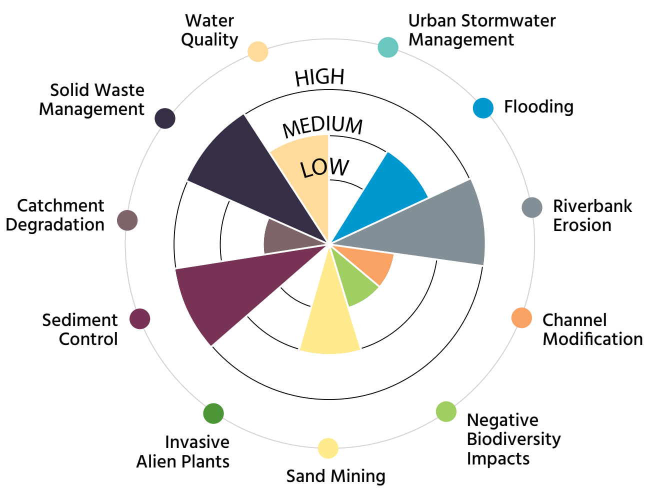
KEY ISSUES ADDRESSED

Riverbank erosion, sediment control, and solid waste management

DESCRIPTION

Riverbank erosion is a natural process that occurs in rivers due to the dynamic nature of the river system. However, poor land use practices such as unregulated sand mining and increased river flows resulting from poor stormwater management upstream leads to excessive bank erosion which results in bank failure. Another major threat to rivers is solid waste, which negatively impacts biodiversity and is one of the main causes of water pollution and poor water quality. This is a direct result of poor land use upstream and limited infrastructure to disincentivise indiscriminate dumping of waste. Groynes are structures that protrude from a bank into a river. The purpose of a groyne is to direct high energy flows away from the bank to protect it from erosion, as well as enhancing energy flow to promote the scouring of accumulated sediment and sludge in streams that are heavily polluted by raw sewage. Groynes also influence the hydraulics of a river such that the back-water behind the groyne forms an hydraulic eddy which lowers the flow and energy of the water and encourages sediment and solid waste deposition. Groynes used in rivers are predominantly constructed using reinforced concrete but can also be constructed using gabions. Rock-protected soil berms may be used on flood plains and in lower energy systems.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost		●	
Maintenance Cost		●	
Design Complexity			●
Implementation Complexity			●
Socio-Economic Benefits		●	
Resilience to Climate Change		●	

Figure 25 showing oblique aerial view of groynes as riverbank protection

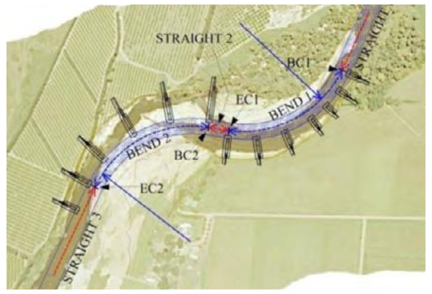


Figure 26 showing typical layout of groynes in relation to river geometry

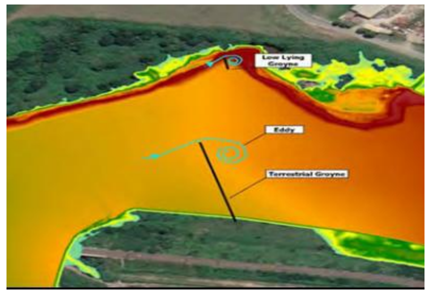


Figure 27 showing hydraulic model of river after groyne construction.

Note: Legislative authorisation may impact on several activities in this intervention and therefore consultation with the relevant government/authorising authorities is critical. Additionally, these authorisations typically take several months to gain approvals and consideration of context is critical in informing whether interventions are appropriate or not, as is stakeholder engagement (see section 3 of the preamble to these spec sheets).

CAPITAL AND MAINTENANCE COSTS

- Typical capital cost of intervention: R315 000 (For 40m^3 of gabions)

  The capital cost of implementing gabion groynes includes the following items:
  - Excavation for the gabion structure.
  - Earthworks which entails backfilling and compacting beneath and around the structure.
  - Installation of geotextile fabric between all interfaces between gabions and soil.
  - Installation of gabions.
  - Revegetation of the soil around the structure that was disturbed due to construction.
  - Construction of an equivalent sized groyne from reinforced concrete would cost R580 000.
- Maintenance cost: R15 000 (For 40m^3) per annum

  The maintenance costs were estimated by assuming the following:
  - Each year 10% of the total cost for the revegetation around the structure would be required; and 5% of the total cost for backfilling and compaction, replacement of damaged geotextile fabric and gabions would be required to maintain the intervention.
  - Clearing of solid waste and debris that has been retained behind the groyne after significant storm events.

MATERIALS REQUIRED

For gabion groynes, the following materials would be required:
- Gabion baskets (Galfan PVC coated wire mesh).
- Gabion rock.
- Geotextile fabric (needle-punched non-woven) e.g. BidimTM A4.

For concrete groynes, the following materials would be required:
- Concrete and steel reinforcement.

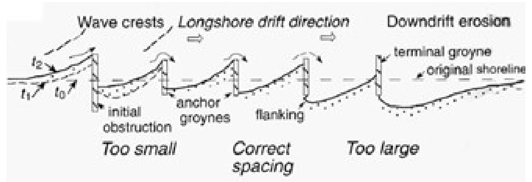
For rock-protected earthen groynes, the following materials would be required:
- Suitable semi-permeable earthen material.
- Geotextile fabric (needle-punched non-woven) e.g. BidimTM A4.
- Ø 150mm – 250mm rocks to be packed on top of the groyne for protection.
- Indigenous vegetation to be replanted in disturbed areas as a means of rehabilitation – this applies to all three types of groynes.

APPROACH

- Unstable and eroded riverbanks as well as channel dimensions and geometry may be identified and mapped out using good quality imagery (<5cm). If suitable imagery is unavailable, sites are to be visually inspected and surveyed in-field.
- Catchment hydrology to be determined including peak and base flows.
- Water to be tested for corrosiveness – if water is corrosive, gabion baskets to be PVC coated.
- Soil to be tested for dispersiveness – if soils are dispersive, gabions will be inappropriate, and a concrete groyne will be required.
- Groynes to be designed using the following methodology:
  - Determine catchment hydrology.
  - Determine peak flows for design return period.
  - Use surveyed channel dimensions and geometry to determine groyne positioning/layout required to achieve riverbank protection.
  - Calculate scour potential using Niell formula to determine vertical alignment of groynes.
  - Determine required spacing of groynes using protection length – See Figure 28 for example of correct groyne spacing.

Figure 28 showing examples of correct and incorrect groyne spacing

Source: https://en.wikipedia.org/wiki/File:Functioning_of_a_groyne_(diagram)_(2).jpgmorphology_fig4_273898339



Groynes

METHOD STATEMENT	The following method statement is for the implementation of gabion groynes: ▶ Divert the flow around the construction site by means of a diversion channel to allow construction in the river channel. ▶ Remove and stockpile topsoil. ▶ Excavate by hand for gabion foundations and stockpile for use as backfill behind gabion walls. ▶ Carry out surface preparation (final levelling and trimming) for bedding of gabions. ▶ Position layer of geotextile fabric at interface between gabions and soil. ▶ Position first layer of gabions and install shuttering on front (and side faces, if required) to ensure a neat finish. ▶ Tightly pack gabion with gabion rock and then tie gabion lid closed. ▶ Carry out final trimming of geotextile fabric as well as levelling and finishing around gabion installation as required.
MAINTENANCE REQUIREMENTS	▶ Gabions require routine monitoring to confirm if they are still intact. If rocks within gabion are no longer tightly packed, the gabion should be re-packed and additional rocks added. ▶ Geotextile fabric must also be inspected to confirm that it has not shifted or been damaged. Geotextile to be replaced if there is evidence of damage. ▶ Monitoring of the gabion structure for damaged or vandalised gabion baskets. Damaged gabions to be replaced. ▶ Monitoring of the groyne structure after any flood event to assess structural integrity. Repairs to / replacement of a structure required resulting from flood damage will be over and above the annual maintenance cost stated above. ▶ Monitoring of the establishment of vegetation around the structure. ▶ Solid waste/debris that has collected behind the structure should be routinely removed and disposed of after storm events.
CONSTRAINTS	▶ Ideally should be implemented during the dry season under low flow conditions for ease of construction. ▶ Gabion and concrete groynes are "grey" infrastructure - not as aesthetically pleasing as other "green" interventions such as earthen groynes. ▶ High level of design complexity due to the hydraulic modelling to be undertaken as well as determination of groyne spacing and alignment according to hydraulic and hydrological calculations.
POTENTIAL RISKS	▶ Flood damage to the groyne during major floods. ▶ Continued erosion of the riverbank if the groynes have been incorrectly designed e.g. incorrect alignment or spacing. ▶ Erosion of the backfill material around the groyne can occur if the material has not been sufficiently compacted.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Installation of groynes provides temporary employment. The upskilling of community members in the process can unlock further employment opportunities. ▶ Effective in controlling sediment migration and can therefore provide a significant contribution to the reduction of catchment degradation. ▶ Can be used to stabilise and rehabilitate areas where there is riverbank erosion and where sand mining has taken place. ▶ Effective intervention in reducing flow energy and velocities in rivers therefore reducing flood risks. ▶ Encourage the deposition of solid waste, thereby reducing the quantity of solid waste in the downstream reaches of the river.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental/civil engineer – for concrete, gabion and earthen groyne design options both in rivers and on floodplains. ▶ Engineer/contractor – for supervision of labourers during implementation. ▶ Ecologist – to consult with regards to the indigenous vegetation to be planted and the altered hydraulics in the channel and the effects on the hydrological processes.

Socio-ecological intervention

The mock specification sheet below guides the reader on the various elements that are detailed in the specification sheets for each socio-ecological infrastructure proposed in this toolkit.

Socio-ecological intervention	
THE KEY ISSUES ADDRESSED BY INTERVENTION	
DESCRIPTION	
Here a short description of the intervention is given.	
SUMMARY OF HOW WELL THE INTERVENTION ADDRESS CERTAIN ISSUES AND DESIGN PARAMETERS	
The following were identified as key dimensions of socio-ecological interventions: • Learning, education, knowledge production, awareness • Multi-actor partnerships & multilevel governance • Positive socio-economic outcomes • Include system complexity • Boundary spanning • Wide engagement • Concrete, discernible outputs • Sustainability of the outcome The intervention is scored in its success in considering these dimensions. The results are presented in a radar chart. The categories are defined as follows: • **High:** The major strength of this intervention is in addressing this dimension. • **Medium:** The intervention partially addresses this dimension. • **Low:** The intervention marginally addresses this dimension. • **Not Met:** The intervention does not address the dimension at all.	The intervention summary provides the following information in a table: ▶ The Implementation cost considers the cost to sustain the intervention over a year, and is unpacked more on the second page of the spec sheets. Costs of socio-ecological interventions are very subjective and dependent on the scope of implementation. ▶ Scope of actors involved refers to how much of a variety of different staleholders need to be involved to implement this intervention successfully. This has a cost implication. ▶ Complexity of intervention design refers to how much effort is needed to develop, refine, implement and sustain the intervention over a period of a year. ▶ The level of expertise needed to implement is a reflection of whether a professional person is required to assist in the implementation of the intervention; whether various groups of actors might have to be involved, or whether the implementation can be imlemented by any person in the project. ▶ The amount of materials required to implement the intervention can range from few to many. More information on this is given on the second page of the spec sheet.
ILLUSTRATION OF INTERVENTION	
A suitable photographic (or other) example of the intervention in action is included here.	
COSTS COMPONENTS	Specific costs are not explicitly given here. Instead an overview is given of the components of the intervention which might incur a cost.
MATERIALS REQUIRED	A summary of materials which would be needed to implement the intervention is given here.
METHODS/APPROACHES	This section provides a basic outline of the activities required to carry out the intervention.
MAINTENANCE	This section recommends the frequency at which the intervention needs to be implemented in order to ensure maximum effectiveness.
INSTITUTIONAL SUPPORT & SCALING OPPORTUNITIES	Here we recommend whether it is necessary to have institutional support in place for the intervention to work successfully. The potential to upscale the intervention or roll it out over a wider area is also discussed.
PARTNERSHIP OPPORTUNITIES	Some of these interventions are dependent on partnerships, or can play a key role in facilitating partnerships.
CONSTRAINTS AND POTENTIAL RISKS	Constraints and potential risks associated with the intervention are included in this section.

Table 2. Elements included in the socio-ecological specification sheets and the approach used.

SOCIO-ECOLOGICAL INTERVENTION

Tree-preneurs

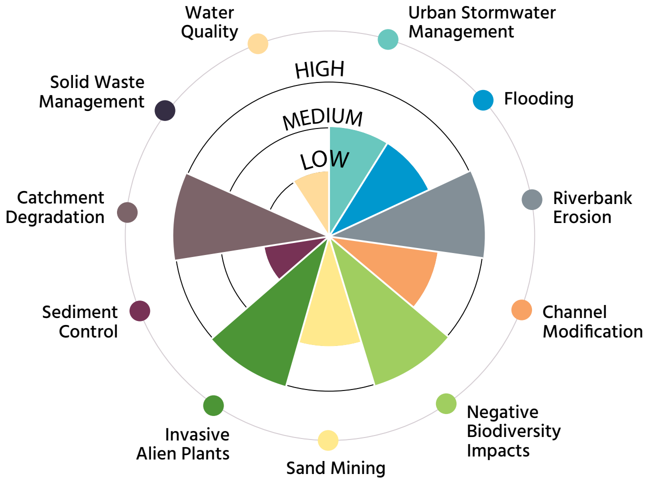
KEY ISSUES ADDRESSED

Riverbank erosion, negative biodiversity impacts, invasive alien plants and catchment degradation

DESCRIPTION

This intervention assists in educating impoverished communities on how to propagate indigenous plants to stimulate economic growth through job creation. "Tree-preneurs" provide a multitude of socio-economic benefits for communities through recycling initiatives e.g. repurposing 2l cooldrink bottles to grow the seedlings, job creation by compensating communities for seedlings grown and empowering community members to start sustainable businesses that will benefit themselves and the environment in the long term. The community members ("tree-preneurs") are supplied with seedlings. Once the seedlings have reached sufficient size, they may be exchanged for food vouchers, clothing, bicycles, educational support and other essentials. The indigenous plants/trees are then planted in areas where bank stabilisation or improved biodiversity is required. The plants can also be utilised in stormwater tree pits or for the rehabilitation of bare areas resulting from alien plant removal.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

	LOW	MED	HIGH
Capital Cost	●		
Maintenance Cost	●		
Design Complexity	●		
Implementation Complexity			●
Socio-Economic Benefits			●
Resilience to Climate Change			●

Figure 29 and 30 showing community members participating in the Tree-preneurs initiative
Source: Working for Water **Accessed From:** https://www.spier.co.za/growing-for-good/tree-preneurs
https://stellenboschnews.com/2020/09/01/tree-preneurs-still-going-strong-in-stellenbosch/

CAPITAL AND MAINTENANCE COSTS

- Typical capital cost of intervention: R65 500 (once-off starting cost for 100 tree-preneurs)

  The capital cost of implementing a tree-preneurs initiative includes the following items:
  - Training of "tree-preneurs" on the harvesting and propagation of seeds and how to nurture seeds into seedlings that are suitable to be sold or planted.
  - Education of tree-preneurs about the importance and benefits of recycling and reducing solid waste in their communities. "Tree-preneurs" to collect recyclable waste and reuse it as part of the initiative.
  - The supply of potting soil and compost to the "tree-preneurs" to assist them with growing their seedlings.
  - Compensation of "tree-preneurs" for their seedlings. In the initial phase of the initiative, "tree-preneurs" are compensated to garner support and buy-in from communities. Following training and the establishment of partnerships with nurseries and other organisations, compensation is no longer required as "tree-preneurs" are able to independently implement the initiative.
- Maintenance cost: R0 – R50 000 per annum for 100 tree-preneurs

  Maintenance costs for this intervention may vary from low to high according to model adopted for establishing and running the initiative. Any of the following models may be applied:
  - Maintenance cost – R0 (LOW COST)
    If the goal of the initiative is to empower community members to be self-sustaining "tree-prenuers" who use the tools and skills they learnt to become self-employed, there is no maintenance cost involved. The "tree-preneurs" have all the knowledge and tools they require to sustain the initiative from the initial training provided in the programme / initiative. Once the "tree-preneurs" initiative has been established, the initiative may be considered self-sustainable with no additional input required from stakeholders (the entity running/responsible for funding the program). The "tree-preneurs" are able to independently harvest and propagate seedlings and sell them to nurseries and use the proceeds to sustain the initiative and themselves.
  - Maintenance cost – R12 000 (for 100 "tree-preneurs") per annum (MEDIUM COST)
    The maintenance cost of R12 000 is based on the stakeholders of the initiative providing the "tree-preneurs" with any additional materials or support that they need to continue with the initiative in subsequent years such as additional potting soil or a larger variety of seeds etc.
  - Maintenance cost – R50 000 (for 100 "tree-preneurs") per annum (HIGH COST)
    The maintenance cost of R50 000 is based on some form of ongoing compensation of the "tree-preneurs" for their seedlings with food vouchers, clothing, school supplies etc. in the subsequent years of the initiative. This would apply in a funding model where the implementers of the initiative partners with the beneficiaries for a set term (e.g. 3 year partnership) and continues to fund the initiative for the entire term and thereafter the "tree-preneurs" carry on if they manage to become self-sustainable.

MATERIALS REQUIRED

- Seedlings.
- Seedling trays / pots.
- Hand tools for seedling maintenance e.g. hand trowels.
- Green house or nursery area to grow seedlings.
- Irrigation system to water the seedlings.

APPROACH

- Local businesses or organisations to be identified and approached to provide funding for "tree-preneurs" initiative in the communities they service.
- Impoverished communities to be identified and selected to implement "tree-preneurs" initiative.
- "Tree-preneurs" to be trained to propagate and transplant indigenous plants.
- "Tree-preneurs" to be compensated for seedlings and educated about the various uses of the seedlings such as revegetation of exposed areas and stormwater tree pits etc.

METHOD STATEMENT

- Engage with local community / stakeholders.
- Appoint and train "tree-preneurs" on how to grow and care for plants.
- Provide "tree-preneurs" with seeds and educate them about how to propagate their own seedlings.
- Educate "tree-preneurs" about the value of recycling and how to use recycled materials to grow seedlings e.g. discarded egg cartons and yoghurt containers to be used as seedling trays and discarded 2l cooldrink bottles to be used in lieu of nursery grow bags.
- Provide ongoing training and support to "tree-preneurs" during the growing process.

MAINTENANCE REQUIREMENTS

- Provide ongoing training and support to "tree-preneurs" during the growing process.
- Provision of materials during growing process such as compost and potting soil, or additional seedlings.
- Scaling of additional "tree-preneurs" in subsequent years of the programme.

CONSTRAINTS

- Capital and operational costs are largely dependent on the scale of the project and the availability of funding from stakeholders. To run the initiative successfully, stakeholders need to commit to a sustainable funding model that can sustain the project on an annual basis.

Tree-preneurs

POTENTIAL RISKS	▶ "Tree-preneurs" can face a variety of risks during the growing process period of the initiative which could affect the compensation that they receive for their seedlings. These risks include: • Lack of irrigation water due to water shortages / restrictions / drought. • Insects / pests / animals eating the plants. • Disease and infections. • Lack of temperature control and insufficient light. • Overuse of fertilisers or herbicides. • Weather damage caused by strong winds and hailstorms.
ADDITIONAL AND SOCIO-ECONOMIC BENEFITS	▶ Planting of indigenous vegetation in local communities is a "green" intervention which improves the aesthetics of the community. ▶ Provides an opportunity to educate local communities on the negative impacts of alien vegetation on biodiversity and catchment health, as well as the benefits of indigenous plant species. ▶ Provides an opportunity to educate local communities on the negative effects of solid waste and the importance and benefits of recycling. ▶ The planting of seedlings can be used to protect riverbanks from erosion and used for the rehabilitation of areas that have been negatively impacted by sand mining. ▶ "Tree-preneurs" initiatives educate and empower community members which can lead to SMME creation in the community. SMMEs can form partnerships with local nurseries to provide plants at wholesale prices and can set up their own nurseries to sell to the public. SMMEs can provide employment for locals and strengthen the local economy.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Botanist – to train community members about indigenous plant identification, propagation and selection of appropriate indigenous plants for revegetation. ▶ Partnership with Small Enterprise Development Agency (SEDA) – to train community members about SMME establishment and provide support and/or funding.

SOCIO-ECOLOGICAL INTERVENTION

Leadership seminars

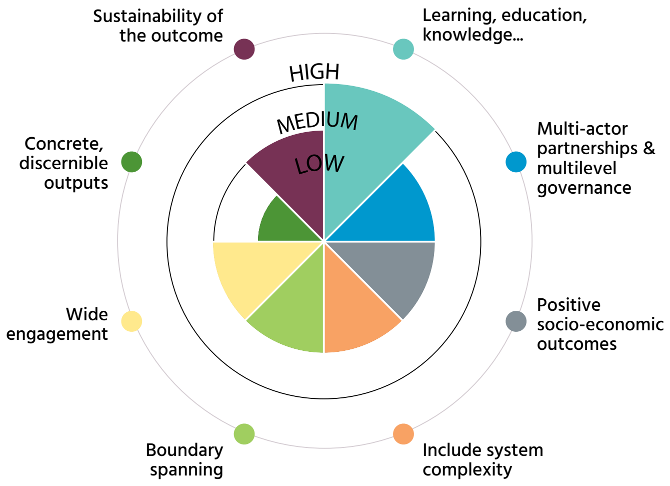
KEY ISSUES ADDRESSED

Increased understanding of ecological infrastructure and catchment management and improved catchment and ecological infrastructure management

DESCRIPTION

"Leadership Seminars" provide an opportunity for highly influential stakeholders, Councillors, Municipal Managers and Traditional Leaders to engage with and learn about ecological infrastructure and catchment management. Leadership Seminars are especially helpful to people whose work mandate requires a high level of understanding of the environment, and ecological infrastructure, such as catchment management (the natural water factories of the nation) and climate change risks and opportunities. Leadership Seminars seek to inspire and enable leaders to meet their mandated responsibilities, or Key Performance Areas, as these relate to catchment management processes.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost	●		
Scope of actors involved	●		
Complexity of design		●	
Level of expertise to implement		●	
Materials	●		

Figure 31. Amakhosi neZinduna assessing the health of a river at KwaMafunze

Figure 32. Amakhosi neZinduna in an ecological infrastructure workshop organised by WESSA and COGTA

Leadership seminars

COST COMPONENTS	▶ Leadership seminars are best done through partnerships with Ministry of Cooperative Governance and Traditional Affairs (CoGTA) or other Local Government Capacity Building initiatives. This reduces costs and optimizes the benefits. Costs to be considered include: • Venue costs, including food • Travel costs for participants • Printing of material • Experienced facilitator • Translator (if required) and support staff (at least 2) ▶ Leadership seminars can cost in the region of R2 500/person/day. This is however highly variable and dependent upon a number of factors including venue and catering costs, materials provided and trainers rates.
MATERIALS REQUIRED	▶ A venue (Ideally close to the area where the leaders work) ▶ Support materials. These could include booklets, such as: • "Key Performance areas and responsibilities within the local authorities that enable environmental projects" (This booklet outlines the Key Performance Areas of officials and political and traditional leaders as well as offering links to legislation and compliance). • "Tools and Teaching Resources for enhancing water care in catchments" (This resource outlines various tools and resources and draws on the WRC Citizen Science Tools project). • "Our Stories of Change" (This resource overviews how leaders, and other citizens, are changing their lives, and those they represent, towards more sustainable water management practices).
METHODS/ APPROACHES	Pre-Seminar ▶ Identify a community/ward to work in • Who needs to be approached? • What relationships need to be in place? • Do you first need to build trust? At the Leadership Seminar ▶ Participants have the opportunity to clarify their KPAs and their local challenges related to Ecological Infrastructure. ▶ A short field-work experience, in the local area, also adds much value to the learning and helps deepen the dialogue.
MAINTENANCE	▶ An Annual Leadership Seminar helps sustain the momentum.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▶ Collaboration with CoGTA. ▶ In the case of ward councillors – Municipal participation and support is key. ▶ In the case of Tribal Authority areas – ITB support and support from local iziNduna.
PARTNERSHIP OPPORTUNITIES	▶ Across municipal and ward boundaries. ▶ Collaboration with business and industry. ▶ Collaboration with CoGTA.
CONSTRAINTS & POTENTIAL RISKS	▶ Councillors are busy and finding time to undergo a leadership seminar can at times be challenging. A half-day seminar seems the most practical. ▶ Inappropriate Leadership Seminar facilitation can lead to disillusionment and workshop fatigue.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Suitably qualified trainer. ▶ Community facilitator – for engagement with leaders. ▶ Translator (if required).

SOCIO-ECOLOGICAL INTERVENTION

Envirochamps

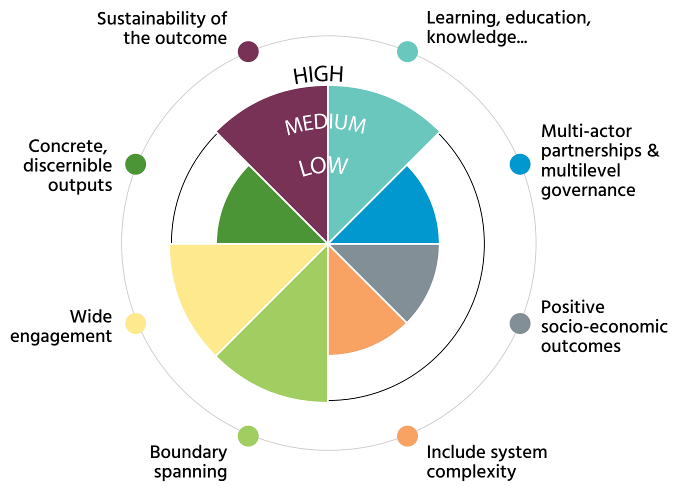
KEY ISSUES ADDRESSED

Improved water quality and catchment management, increased environmental awareness, biodiversity, job creation, socio-economic benefits

DESCRIPTION

EnviroChamps is a movement where local people, who may be unemployed, work together to address local neighbourhood issues, especially those that impact on water issues and catchment habitats. The approach is characterized by bottom-up elements. Although local solutions can be developed for local contexts, the EnviroChamps generally conduct activities such as water quality monitoring, reporting leakages, burst pipes and discharging sewers, and engaging in door-to-door initiatives to raise awareness about water and sanitation issues. To develop their capacity, EnviroChamps undertake capacity building courses, which include training about environmental issues, citizen science tools and water quality monitoring, as well as basic financial management and computer literacy courses. Other versions of this model exist. These include Eco-Champs or Enviro-monitors.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost			●
Scope of actors involved	●		
Complexity of design	●		
Level of expertise to implement		●	
Materials			●

Figure 33. EnviroChamps discuss issues with a local Mpophomeni resident (Ward, 2016)

Figure 34. EnviroChamps in Mpophomeni meet with various stakeholders to discuss issues that the EnviroChamps encounter (Ward, 2016)

Envirochamps

COST COMPONENTS	▶ Supervisor cost. ▶ Team stipends. ▶ Mobile phone. ▶ Airtime. ▶ Venue for training days. ▶ Public transport to meetings. ▶ The EnviroChamp programme costs in the region of R60 000.00/ EnviroChamp/year. This includes training and salary costs.
MATERIALS REQUIRED	▶ Personal Protective Equipment (PPE). ▶ A mobile phone, with data. ▶ Citizen Science Tools (See Citizen Science Spec Sheet). ▶ Training guides/materials.
METHODS/ APPROACHES	▶ Engagement with communities to identify and select suitable candidates for the programme. ▶ Engagement with authorities and communities to identify key environmental challenges in respective areas and tactics to address and overcome them. ▶ To record issues the Enviro-Champs often use data collection forms created using GeoODK software. GeoODK is open-source software for recording georeferenced data, including photographs, using a smartphone. ▶ Enviro-Champs may work independently, although experiences elsewhere show that the involvement of NGOs contributes towards the success of the programme.
MAINTENANCE	▶ Ongoing monitoring by EnviroChamps. ▶ Frequent training days/workshops for EnviroChamps.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▶ City and commercial support for funding. ▶ Collaboration with local and district municipalities and relevant government departments, such as Department of Water and Sanitation, and CoGTA, to address environmental issues (e.g. to fix water leaks reported by EnviroChamps). ▶ Local NGOs/conservancies interested in environmental and social issues.
PARTNERSHIP OPPORTUNITIES	▶ Municipalities, business, schools, community groups and NGOs.
CONSTRAINTS & POTENTIAL RISKS	▶ Ongoing funding support for Enviro-Champs. ▶ Unsuitable Supervisor or uninformed Leadership. Leadership needs to set a good example and instructions need to be clear. ▶ Delayed funding after promises have been made. ▶ At times Enviro-Champs have worked in a voluntary capacity or have only received a small airtime allowance. This is not sustainable in difficult economic times and even a small stipend can help the Enviro-Champ and their families a great deal.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental / citizen science educator/ facilitator for training of EnviroChamps. ▶ Community facilitator – for engagement with local communities.

SOCIO-ECOLOGICAL INTERVENTION

Training in ecological infrastructure

KEY ISSUES ADDRESSED

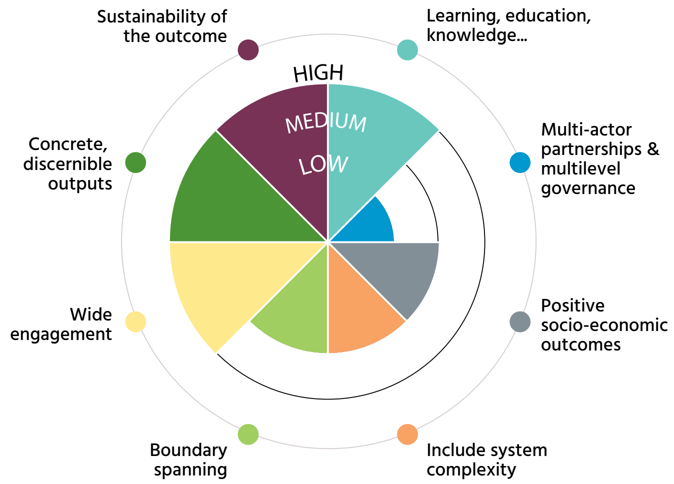
Environmental awareness and understanding of ecological infrastructure, sustainability of programmes, water quality, biodiversity, storm and flood mitigation

DESCRIPTION

A wide range of courses are available around ecological infrastructure, from in-person to online training. The greater the understanding on the topic of ecological infrastructure through this training, the greater the likelihood of the sustainability of such programmes. These courses also contribute to development of agency, appreciation, and capacity around a person's environmental context. These courses are not dependent on sophisticated technology and can be effectively conducted using WhatsApp Group Chat and other apps on mobile phones. Action learning is encouraged in support of such training programmes and, where appropriate, prior learning or indigenous knowledge practices are encouraged. Courses may be customised and adapted to local contexts. The following courses are examples:

- **Enviro-Champs: Capacity development for community mobilisation**
- **Wetlands and Wetland Management**
- **Education for Sustainable Development**
- **miniSASS, citizen science tools**

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost		●	
Scope of actors involved	●		
Complexity of design	●		
Level of expertise to implement		●	
Materials			●

Figure 35. The 5T's of Action Learning


CellPress

One Earth

Commentary

Science Must Embrace Traditional and Indigenous Knowledge to Solve Our Biodiversity Crisis

Figure 36. Mobilizing Indigenous Knowledge Practices

COST COMPONENTS	Each course is costed differently, but includes the following components: ▶ Professional time and ongoing support. ▶ Materials. ▶ Citizen science tools. A course costs in the region of R2 500/person/day. This is, however, highly variable and dependent upon a number of factors, including venue and catering costs and trainer costs.
MATERIALS REQUIRED	▶ Citizen science tools. ▶ Venues. ▶ Transport for participants and field work. ▶ Printed materials.
METHODS/ APPROACHES	These courses have a strong focus on action learning principles. The 5T's of Action Learning underpin all training programmes (see Fig.1). The principles are: ▶ Tuning in- What is the issue in this context? ▶ Talk -Discussion, mobilising of existing understanding and infrastructure knowledge. ▶ Touch (real life encounters) – Measure, engage with and understand the issue. ▶ Think- Reflect and review the issue. ▶ Take Action- Mobilising around individual and community agency. The courses are work-place-based and are thus aimed to be situated in the reality of the lives and work of the participants. This is achieved by organising the course curriculum through key questions and around key work challenges the participants are experiencing. By engaging in indigenous knowledge practices, it becomes possible to ensure that the wisdom of the past is not neglected and is used to strengthen and complement the science of the present. Participants are encouraged to share examples from their experience which strengthens the course curriculum. Many participants positively identify with the indigenous knowledge practices that are profiled and engaged with.
MAINTENANCE	▶ Once-off with follow up. ▶ Online refresher sessions, as often as needed, strengthen and reinforce the learning and applied practices.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▶ There are a wide range of support resources and materials. Key amongst these are 10 Citizen Science tools which were developed as part of a Water Research Commission project. ▶ Materials are aligned to the Sustainable Development Goals (SDGs) and bridging resources, to the SDG's have been developed in English, isiZulu, Setswana and Afrikaans. ▶ Participants who successfully complete the courses have free access to a digital library of materials (e.g. PowerPoint presentations). ▶ Courses can be rolled out over a wide geographical area and adapted for various knowledge, indigenous languages, and experience levels.
PARTNERSHIP OPPORTUNITIES	▶ There are a wide range of partnership opportunities, from facilitators, to content developers.
CONSTRAINTS & POTENTIAL RISKS	▶ All materials are shared copy-right free. Users are encouraged to use or adapt and customise the materials, freely, for non-profit educational applications. There is thus a risk that materials will be plagiarised or copy-righted by unscrupulous individuals or organisations.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Environmental / citizen science educator/ facilitator for engagement around river and water quality monitoring. ▶ Community facilitator – for engagement with potential participants.

SOCIO-ECOLOGICAL INTERVENTION

Citizen science tools

KEY ISSUES ADDRESSED

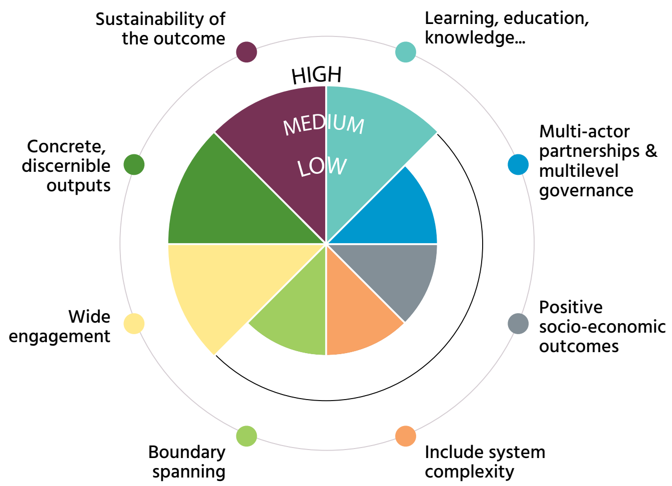
Evironmental awareness and education, water quality, biodiversity

DESCRIPTION

A variety of water resource monitoring tools have been developed for use by citizen scientists. These tools allow anyone with an interest in the management of water in their surroundings to engage in water resource monitoring and thus improve their understanding of water-related issues and problems. The action-oriented learning that takes place through the use of citizen science tools has been proven to be more effective at encouraging local action by civil society than passive awareness-raising and yields positive outcomes for both social change and water resource management. These tools include:

- miniSASS (Stream Assessment Scoring System)
- The Riparian Health Audit
- The water clarity tube
- The velocity plank
- **The wetland assessment tool**

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost		●	
Scope of actors involved	●		
Complexity of design		●	
Level of expertise to implement		●	
Materials		●	

Figure 37. The velocity plank can be used to determine flow velocity of a stream, as well as depth and discharge (The Water Wheel, 2018)

Figure 38. Learners identify aquatic invertebrates using the miniSASS tool (The Water Wheel, 2018)

Citizen science tools

COST COMPONENTS	▶ Citizen science tools are, generally, inexpensive. For some, such as miniSASS, the material is freely available online. ▶ Materials such as the clarity tube can be up to R1 400.00 and the velocity plank R600.00.
MATERIALS REQUIRED	▶ This is dependent upon the tool used and may include: • Guides/manuals. • Clarity tubes. • Velocity planks.
METHODS/ APPROACHES	▶ A collaborative approach is recommended, under guidance of a facilitator. • The WRC Citizen Science manual details the approaches (http://www.wrc.org.za/wp-content/uploads/mdocs/TT%20763%20web.pdf). • For some tools YouTube videos are available to guide users. Citizen science seems to work best when implemented through an 'action learning' approach.
MAINTENANCE	▶ Once-off training.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▶ Institutional support is not required but does assist scaling opportunities, of which there are many. ▶ Rollout to various schools and communities over a wide geographical area.
PARTNERSHIP OPPORTUNITIES	▶ Schools, business, NGOs.
CONSTRAINTS & POTENTIAL RISKS	▶ Due to limited training, data collected may sometimes be inaccurate. However, the quantity of data collected strengthens rigor.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Citizen science educator/ facilitator for engagement around river and water quality monitoring.

SOCIO-ECOLOGICAL INTERVENTION

Learning and engagement spaces

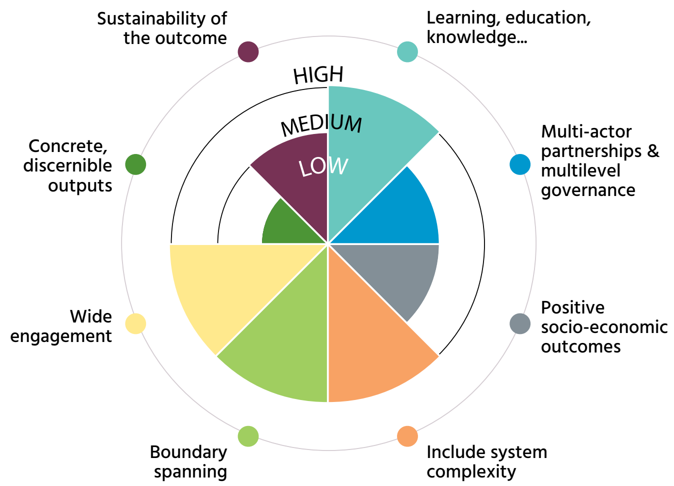
KEY ISSUES ADDRESSED

Environmental awareness and education

DESCRIPTION

Many real-world problems have become too complex to be solved by a single line of thinking, discipline or method. Many knowledge types need to be acknowledged, heard, and integrated to better understand the systemic aspects of these problems, as well as potential solutions. Transdisciplinary learning is the exploration of a relevant concept, issue or problem that integrates the perspectives of multiple disciplines in order to connect new knowledge to real life experiences. Critical reflection is a crucial part of such knowledge co-exploration and co-production, and the process of learning (and learning together) enables spaces for critical reflection. With the numerous river management networks, programmes and projects taking place across the city, such learning and engagement platforms will be crucial to coordinate efforts effectively across scales, location, and spheres.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost		●	
Scope of actors involved			●
Complexity of design	●		
Level of expertise to implement		●	
Materials	●		

Figure 39. Participants co-exploring their 'aha' moments during a learning engagement about transformative river management

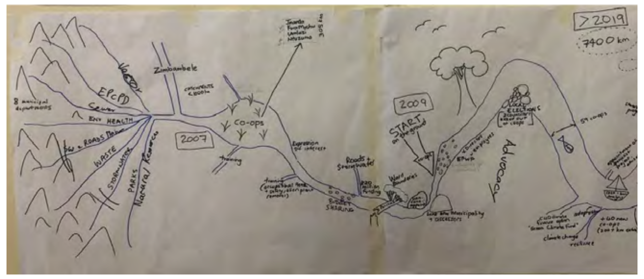


Figure 40. Participants of a learning engagement co-developed this 'River-of-Life' illustration which demonstrates the development of a river project. It is based on the contribution of various knowledge holders' perspectives

Learning and engagement spaces

COST COMPONENTS	▸ Venue. ▸ Refreshments. ▸ Coordinator. ▸ Facilitator. A workshop can cost in the region of R2 500.00/person/day. This is, however, highly variable and dependent upon a number of factors, including venue and catering costs and trainer costs.
MATERIALS REQUIRED	▸ Venue. ▸ Learning materials.
METHODS/ APPROACHES	▸ Build a network of actors and stakeholders. ▸ Initiate and institutionalize the engagement (find a house for it). ▸ Decide on a method of implementation – external facilitator or an intermediary (such as an NGO). ▸ Develop core focus areas for engagements (these engagements must be focused events). ▸ Institutionalize regular meetings.
MAINTENANCE	▸ Bi-annual to Annual.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▸ All stakeholders involved in river management – from government, to civil society, to Enviro-Champs. ▸ Careful thought must be given to how these events are structured. One platform to function across all scales and scopes will be too big, so it is probably more advisable to have numerous smaller platforms that cuts across various scales and scopes, which are coordinated by a single body/partner/institution.
PARTNERSHIP OPPORTUNITIES	▸ Many partnership opportunities. Preferably all river management stakeholders should be partners in this endeavour.
CONSTRAINTS & POTENTIAL RISKS	▸ Stakeholder fatigue and commitment dwindling over time. ▸ Not managing the safe space properly and then unintentionally creating tension or dissension in the group.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▸ Environmental / citizen science educator/ facilitator. ▸ Community facilitator – for engagement with local communities.

SOCIO-ECOLOGICAL INTERVENTION

Pocket parks

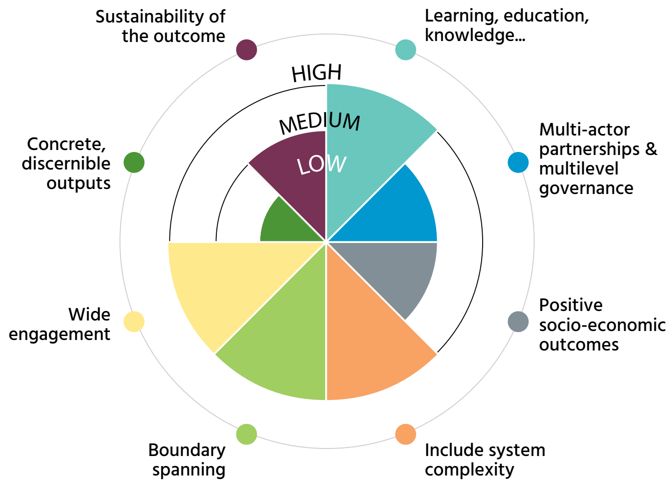
KEY ISSUES ADDRESSED

Biodiversity, recreational opportunities, linkages across the landscape, socio-economic / ecotourism opportunities, storm and flood mitigation, and aesthetic improvement

DESCRIPTION

A pocket park is a small space serving the immediate local community. It can be created in conjunction with sports and recreation areas, schools, and libraries. In highly urbanized areas, pocket parks are often the only option for creating new public spaces; but they can also be part of urban regeneration plans and improved biodiversity and ecosystem services value. In Durban, the Municipality is encouraging and supporting the establishment of such parks in and around the City. This is to support biodiversity and to provide a place for relaxation, safe play areas and small spaces for activities, events, areas to socialise, as well as form part of the urban transport network (parking, running, walking, and cycling). Pocket parks are often found along and within the open space of riverine corridors and may serve to help in stormwater and flood attenuation.

KEY AND ANCILLARY ISSUES ADDRESSED



INTERVENTION SUMMARY

DESIGN PARAMETERS	LOW	MED	HIGH
Implementing Cost			●
Scope of actors involved			●
Complexity of design			●
Level of expertise to implement		●	
Materials			●

Figure 41. Schematic drawing of a pocket park in the eThekwini Municipality

Figure 42. Open/green spaces adjacent to typical urban rivers

Pocket parks

COST COMPONENTS	▶ Designs and planning. ▶ Labour. ▶ Materials and equipment. ▶ Approx R6 million per hectare.
MATERIALS REQUIRED	▶ Labour. ▶ Alien plant clearing equipment (including herbicides where necessary). ▶ Plants for revegetation. ▶ Recreational equipment. ▶ Cycle and walking path materials. ▶ Pedestrian footbridges across river courses.
METHODS/ APPROACHES	▶ Ideally designs should be undertaken by a landscape architect/ town planner. ▶ Identification of urban open spaces/riverine corridors. ▶ Social context/ engagement with communities and needs-analysis and then tailoring of designs to meet those needs. ▶ Optimisation of open spaces to increase connectivity, community access, space utilization, biodiversity gains and ecological corridors, stormwater attenuation and flood mitigation opportunities, and recreational opportunities.
MAINTENANCE	▶ Ongoing control of alien weeds. ▶ Ongoing maintenance of open, grassed and recreational areas.
INSTITUTIONAL SUPPORT/ SCALING OPPORTUNITIES	▶ City and commercial support for design and setup costs (including landscape shaping, alien invasive plant clearing and maintenance). ▶ Local NGOs/conservancies interested in public open space/biodiversity. ▶ Biodiversity and wetland offsets – use of the banked offsets to establish these pocket parks. ▶ Engagement with local schools and communities in areas to support ongoing citizen science monitoring of open spaces and water quality/quantity (flooding levels) etc.
PARTNERSHIP OPPORTUNITIES	▶ Local community groups, charities, schools, various sporting codes (running/cycling etc.) and NGOs. ▶ Ecotourism ventures along open spaces/corridors. ▶ Uptake of plant material propagated from local tree-preneurs programmes. ▶ Changes perception of area from waste-ridden and unsafe to an area that is valued by the community.
CONSTRAINTS & POTENTIAL RISKS	▶ Often limited available space in these areas. ▶ Perceptions around the areas becoming crime corridors – pocket parks can in fact be more of a benefit in some areas than a risk – with communities now feeling these areas are safer. ▶ Flooding during storm events.
PROFESSIONAL SUPPORT REQUIRED TO IMPLEMENT	▶ Landscape architect/town planner – for layout/designs options. ▶ Environmental/ civil engineer – for stormwater and flood control/attenuation design options. ▶ Environmental / citizen science educator/ facilitator for engagement around river and water quality monitoring. ▶ Community facilitator – for engagement with local communities.

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5 ADDENDUM

Addendum A: Database of potential interventions

ISSUE	Local Interventions	Catchment Cause	Catchment Intervention	Socio-ecological Interventions
URBAN STORMWATER MANAGEMENT	• Permeable interlocking concrete paving • Green roofs / roof top gardens • Rainwater harvesting • Soakways • Interlocking concrete blocks (grass grows in-between) • Swales • Bioretention cells • Filter strips • Infiltration trenches • Sand filters • Sediment dams • Re-use • Attenuation ponds • Wetlands • Trash traps • Street cleaning • Stormwater tree pits	• Climate change • Degraded surrounding areas • Flooding	• Sustainable land use / agriculture • Re-use for agriculture • Retention ponds • Detention ponds • Constructed wetlands • Trees • Drainage corridors	• Legal requirements • Good information supply • Community education • Policing of infringements
FLOODING (WITHIN RIVER CHANNELS AND FLOOD PLAINS)	• Spatial planning • Urban river terracing • Retention areas • Room-for-rivers • Cost-benefit analyses (incorporating future flood risks) • Riverbank erosion / stabilisation techniques (such as brushing, rip rap and sloping, sloping and revegetation, groynes, retaining walls, weirs etc.) • Levees, setback levees, floodwalls	• Climate change • Land degradation • Hardened catchments	• Enhanced SWMP in urbanized areas • Develop sustainable land use management plans to promote runoff infiltrating into soil • River corridors development	• Legal regulations • Community education • Land-use management • Financial compensation • Good information supply • Flood hazard maps - zones and legistation (Flood modelling/drone work)
RIVERBANK EROSION	• Bed control techniques: • Pools and riffles • Rock and grass chutes • Drop structures • Outlet structures • Instream structures • Alignment stabilisation techniques: • Rebuild meanders • Sediment management • Installing large woody debris • Flow retarders • Groynes • Vane Dykes • Bank protection techniques: • Battering and terracing • Brushing • Organic geotextiles • Log walling, rock gabions, rock riprap • Rip rap and sloping • Geotextiles, mattresses and flexmats • Live crib walls • Sloping and revegetation • Interlocking concrete blocks (grass grows in-between) • Sand bag stabilisation	• Climate change • Land degradation • Hardened catchments • Alien veg destabilising banks	• Removal of alien vegetation and rehabilitation • Sustainable land use / agriculture • Enhanced SWMP in urbanized areas	• Legal regulations • Good information supply • Education • Financial compensation • Catchment management strategies • Policing of infringements
CHANNEL MODIFICATION	• Riverbank Erosion/stabilisation techniques (such as brushing, rip rap and sloping, sloping and revegetation etc.) • Channel linings • Artificial riffels • Levees, Setback Levees, Floodwalls • Vegetative cover and buffers/ Protection of existing vegetation along stream banks • Plant riparian trees • Check dams • Flooding Interventions	• Urbanisation	• Imitating original stream as much as possible • Spatial planning	• Legal regulations • Land-use Management • Maintenance • Community Education
BIODIVERSITY	• Riparian vegetation restoration • Creation of reed beds • Addition of gravel/woody material • Weir removal/modification • Wetland creation • Removal of AIS • Green corridos • Pollution reduction • Riverbank Erosion/stabilisation techniques (such as brushing, rip rap and sloping, sloping and revegetation) • Fish ladders • Fish cover	• AIS • Urbanisation • Land Degragation	• Spatial planning surrounding sustainable land uses that can integrate with biodiversity of the region • Restore channelized sections of river to meandering course/reconnect meanders • Self-sustaining channel design • Sustainable land use / agriculture • SWMP	• Environmental Legislation • Long term commitments to planning/design • Multi-stakeholder participation/ collaboration • Landowner Compensation • Alternative Land-use payment • Land purchase • Land swapping • Conservation covenants • Community Education

ISSUE	Local Interventions	Catchment Cause	Catchment Intervention	Socio-ecological Interventions
SAND MINING	• Floodplain rehabilitation (sediment replacement, wetlands, revegetation with riparian vegetation) • Biodiversity rehabilitation • Riverbank Erosion/stabilisation techniques (such as brushing, rip rap and sloping, sloping and revegetation, groynes, retaining walls, weirs etc.) • Replacement of sediments to over-mined sections of river • In-stream structures to promote sedimentation in overly mined areas	• Flooding • Land Degradation • Climate Change	• SWMP • Sustainable land use / agriculture	• Legal Regulations • Community education • Land owner cooperation • Sustainable policy development • Policing of infringements
INVASIVE ALIEN PLANT SPECIES	• Mechanical methods - felling, removing or burning invading alien plants. • Chemical methods - using environmentally safe herbicides. • Biological control - using species-specific insects and diseases from the alien plant's country of origin. • Riverbank Erosion/stabilisation techniques (such as brushing, rip rap and sloping, sloping and revegetation etc.) • Revegetation • Rehab		• IAP introductions • Land degradation	• Community job creation • Legislative regulations • Community Education • Socio-development • Research Institute Collaboration/ Partnership • Invasive alien clearing plans
SEDIMENTATION	• Check dams • Clearing of IAPs • Settlement ponds • Offset flows • Dredging • Warping (divert sediment laden water onto Agric land, improve soil fertility) • promote sustainable removal of sediment ("designated sand mining areas") • sediment fences	• Inappropriate land uses (ploughing and cultivation) • Alien plant infestation • Deforestation & degradation of indigenous forests • Leading to land degradation (soil erosion, damage to infrastructure, water supply shortages, loss of grazing land)	• SWMP • Sustainable land use / agriculture • Catchment erosion control • Transformed grazing regime (range management) • Adherence to burning plan (range management)	• Catchment Management Plan (CMP) • Stakeholder/ Community Empowerment • Community job creation • Community Education • Training and capacity building • Multi-stakeholder participation/ collaboration • Dam management plans • Ecosystem service funding • Establishment of Farmer Workbook monitoring system • Demonstrational projects in upper catchment

ISSUE	Local Interventions	Catchment Cause	Catchment Intervention	Socio-ecological Interventions
CATCHMENT DEGRADATION	• Riverbank Erosion/stabilisation techniques (such as brushing) • Clearing of reeds and weeds • Removal of silt blockages • River Stabilisation • Sustainable agricultural practices • Sustainable rural living • Erosion control measures • AIPs measures • SWMP	• Inappropriate water management practices • Fast growing water demand • Reduced river flow due to climate variability and change • Siltation and reed and weed infestation • Wetland degradation • Fragmented institutional responsibilities • Uncoordinated development interventions • Inequitable access to water resources	• SWMP • Sustainable land use / agriculture • Catchment erosion control	• Multi-stakeholder participation/ collaboration • Catchment Management Plan (CMP) • Trust fund for CMP • Water Charter Development • Stakeholder/ Community Empowerment • Water Audit and Database
SOLID WASTE MANAGEMENT	• Groynes • Vegetated litter traps • Trash traps_Booms • Debri walls	• Inadequate solid waste management within municipalities • Public littering and innapropriate disposal of solid waste	• Recycling • Propper disposal facilities	• Multi-stakeholder participation/ collaboration • Community job creation • Community clean-up initiatives • Regular waste collection and appropriate disposal of waste in landfills
SEDIMENTATION	• Wetlands • Open water ponds • Trash taps • Drainage corridors • Bioretention Cells • Floating wetlands • Fertilisers • Setting ponds • Biogas digestors and generators	• untreated effluent from WWTW entering watercourses • untreated industrial waste entering watercourses • Fertilizers and pesticides from agricultural sector leeching and entering watercourses causing eutrophication • Public littering and innapropriate disposal of solid waste • Flooding causing pollutants to be washed into the watercourses	• Improved waste water facilities • Separation of Grey and Black water • Re-use greywater for non-potable use (agriculture, gardens, toilets)	• Multi-stakeholder participation/ collaboration • Community Education • Catchment Management Plan (CMP) • Monitoring of industrial waste • Financial compensation • Policing of infringements • Legal regulations

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