Nature based or process driven: Choosing the right solution for the right reasons

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Key points

- Nature-based solutions are most effective when aligned with geomorphic river processes.
- Process-based river management improves long-term resilience and intervention outcomes.
- Hybrid approaches often provide the most sustainable balance between ecology and engineering.
- Understanding catchment-scale drivers is critical for successful river rehabilitation.

Abstract

Nature-based solutions (NbS) are increasingly used to manage erosion, improve flood resilience and rehabilitate river systems. Unlike conventional hard engineering, NbS seek to work with natural geomorphic and ecological processes to improve long-term resilience. Approaches such as riparian revegetation, large wood placement, vegetated buffers and bioengineering can stabilise banks, improve habitat and reduce sediment loss while also delivering broader environmental and social benefits. However, the successful application of NbS depends on understanding the geomorphic processes driving river behaviour. This paper discusses the role of process-based river management in guiding the appropriate use of NbS and highlights the importance of selecting interventions that align with river adjustment processes and long-term catchment resilience.

Keywords

Nature-based solutions, river management, geomorphology, erosion, resilience, rehabilitation, process-based management

Introduction

Nature-based solutions (NbS) are becoming increasingly prominent in river management, particularly in response to erosion, flood risk and climate adaptation challenges. The IUCN Global Standard for NbS defines them as actions that protect, sustainably manage or restore ecosystems to address societal challenges while providing benefits to both people and the environment. In waterway management, NbS seek to restore natural function and resilience within modified river systems while recognising the influence of historical and ongoing human disturbance.

Common NbS approaches include riparian revegetation, stock exclusion, floodplain reconnection, instream large wood placement and bioengineering techniques. These interventions aim to improve river condition while delivering co-benefits such as improved water quality, biodiversity, shading, carbon sequestration and flood resilience. NbS may be implemented independently or alongside targeted engineering support in hybrid systems.

Despite their increasing popularity, NbS are not universally appropriate and should not be treated as default alternatives to hard engineering. Their success depends on understanding why erosion or instability is occurring, whether intervention is required and how the river is likely to adjust in the future. Without this understanding, interventions risk treating symptoms rather than the underlying drivers of change.

Principles of nature-based river management

NbS align closely with established principles of sustainable river management, working with vegetation and natural river processes, addressing the causes of instability rather than its symptoms, building resilience to future disturbance, and intervening only where the risk justifies it.

Vegetation is fundamental to long-term bank stability, flood resilience, habitat quality and water quality. Vegetation-based approaches are therefore central to most stream rehabilitation projects, including those supported by structural works.

Equally important is recognising that rivers are dynamic systems and erosion is a natural process. Channel movement and sediment transport are essential components of river adjustment rather than problems that must always be prevented. Effective management therefore requires understanding river behaviour at both the reach and catchment scale.

NbS are most effective when they address the causes of instability rather than local symptoms alone. Bank erosion is often linked to broader drivers such as altered hydrology, vegetation loss, stock access or floodplain disconnection. Restoring ecological and geomorphic processes can therefore provide more sustainable long-term outcomes.

NbS also support resilience to future floods and climate variability. By improving vegetation condition, hydraulic roughness and floodplain connectivity, these approaches can reduce erosion susceptibility and enhance recovery following major events.

Intervention should only occur where justified. In some locations, natural adjustment poses little risk and active stabilisation may create unnecessary impacts. In constrained urban environments or where significant infrastructure is threatened, hybrid approaches that combine ecological rehabilitation with targeted engineering support may provide the most appropriate solution.

Process-based river management

The successful application of NbS depends on understanding the geomorphic and hydrologic processes driving river behaviour. Rivers continually adjust in response to changes in flow regime, sediment supply, vegetation and human influence. A process-based approach recognises that erosion, sediment transport and channel migration are natural components of river evolution.

This perspective is particularly important in regulated systems. Assessments of the Hume to Yarrawonga reach of the Murray River identified that flow regulation has altered anabranch activity, sediment dynamics and channel adjustment processes. Sustained summer flows and reduced overbank flooding have accelerated incision and widening in some anabranches, while other sections of the historical channel are infilling and contracting. These findings demonstrate that interventions must align with likely future river behaviour rather than attempting to restore historical conditions that are no longer geomorphically sustainable.

Similarly, investigations undertaken through the Tasmanian ‘Scaling Nature-based Solutions for Flood Resilience’ project found that many erosion issues were linked to reduced riparian vegetation, unrestricted stock access and reduced hydraulic roughness. In these situations, localised bank protection alone would not necessarily address the broader drivers of instability.

Effective NbS therefore require an understanding of channel type, sediment dynamics, hydrology, vegetation processes and human impacts operating across multiple spatial scales.

Choosing the right solution

A central challenge in river management is determining when intervention is appropriate and what form it should take. Neither hard engineering nor NbS are universally suitable.

In some situations, erosion represents a natural adjustment process that poses limited risk to assets or values. Attempting to stabilise these areas may interrupt natural processes and transfer impacts elsewhere in the system. In other cases, intervention may be justified where infrastructure is

threatened, ecological resilience has been reduced or river adjustment has been accelerated by human activities.

Vegetation-based approaches are often highly effective where instability is linked to riparian degradation or reduced hydraulic roughness. However, vegetation alone may be insufficient in areas experiencing rapid bed degradation, channel widening or steep bank retreat. In these locations, hybrid approaches that combine revegetation with targeted structural support may provide more sustainable outcomes.

Recent management frameworks for the Hume to Yarrawonga reach have shifted away from prioritising erosion severity alone and instead focus on geomorphic process, channel trajectory and system resilience. This approach recognises that some channels require adaptation to ongoing adjustment, while others may benefit from interventions that improve resilience while maintaining adjustment capacity.

Challenges and limitations

Despite their advantages, NbS present several challenges. Unlike conventional engineering works, ecological recovery and geomorphic adjustment occur over extended timeframes and outcomes are often less predictable. Vegetation establishment may fail due to drought, flooding or prolonged inundation, while poorly designed instream structures may become unstable under high flows.

NbS also require detailed site assessment and multidisciplinary collaboration. Successful implementation depends on understanding local geomorphology, hydrology, soils, vegetation and ecological processes. Monitoring and adaptive management are therefore essential.

Practical constraints can also limit implementation. Effective rehabilitation may require wide riparian buffers, stock exclusion and allowing rivers space to adjust, which can conflict with agricultural land use, infrastructure protection and community expectations regarding river stability.

A further limitation is the tendency to apply NbS as isolated site-scale treatments without addressing broader catchment-scale drivers such as altered hydrology or sediment supply imbalance. Without addressing these larger processes, local works are unlikely to achieve long-term success.

Conclusions

Nature-based solutions provide significant opportunities to improve river resilience, reduce erosion and enhance ecological condition. However, their successful application depends on more than selecting ecological treatments in place of hard engineering.

Effective river management requires understanding the geomorphic and hydrologic processes driving river behaviour and selecting interventions that align with long-term system trajectory. Process-based river management provides a framework for determining where intervention is appropriate, where adaptation is preferable and how NbS can contribute to long-term resilience.

In many situations, the most effective outcomes will involve hybrid approaches that combine ecological restoration with targeted engineering support. Ultimately, successful river management depends on developing adaptive, process-informed approaches that support resilient river systems rather than attempting to impose static channel conditions.

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