A new lens for visualising trade-offs and synergies in urban waterway management

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Key points

- Urban waterway decisions are often fragmented across governance, technical, and project boundaries.
- An additive RGB heuristic scores community, nature and water on the three colour channels, so yellow, cyan and magenta show where objectives overlap.
- The framework overlays existing prioritisation and decision-support tools rather than replacing them.
- Colour-based synthesis can improve cross-agency dialogue, portfolio planning, and early-stage option screening.
- The approach offers an accessible pathway to more integrated and resilient urban waterway management.

Abstract

Urban waterways are being reshaped by population growth, densification, pollution and climate-driven hydrology, and many of those changes are hard to reverse. Although a wide range of decision-support tools exists, many waterway and stormwater decisions remain constrained by governance silos and narrowly framed project scopes. This fragmentation limits managers' ability to recognise system-wide interactions, identify emerging risks, and capture opportunities for integrated outcomes. This paper introduces a visual heuristic based on additive RGB colour coding to support more coherent and strategic decision-making across urban water systems. The framework offers a simple way to visualise trade-offs and interactions that are often hidden within technical assessments. It can be overlaid onto existing prioritisation tools, triage systems, and ecological return-on-investment models, improving communicative clarity and supporting more transparent cross-agency dialogue. Early application suggests that colour-based synthesis helps practitioners and stakeholders see the broader system context, improving alignment between stormwater, biodiversity, and infrastructure planning. RGB colour coding is proposed as an accessible, integrative layer that can strengthen decision support for resilient, liveable waterways.

Keywords

Urban waterway management, stormwater, decision-support tools, visual heuristic, RGB colour coding, trade-offs, synergies, blue-green infrastructure, water sensitive urban design

Introduction

Every year we make decisions on urban waterways that we cannot undo. Channels are piped, floodplains are built out, and reaches are rehabilitated one project at a time, while densification, ageing drainage, diffuse pollution, habitat loss and heavier rainfall keep raising the stakes (Hohmann & Truffer, 2022; Sun et al., 2024; Wu et al., 2025). In many cities, these pressures are not experienced as isolated technical issues. Rather, they interact across catchments, governance boundaries, and investment cycles, producing cumulative effects that are difficult to identify through single-purpose planning tools. Decisions intended to improve one outcome, such as flood conveyance or asset protection, may inadvertently reduce ecological function, limit amenity, or shift costs and risks elsewhere in the system (Farina et al., 2024; Thorsson et al., 2025).

These conditions have increased interest in integrated urban water management, water sensitive urban design, and nature-based approaches that recognise waterways as social, ecological, and infrastructural systems rather than simply drainage corridors (Hohmann & Truffer, 2022; Koiv et al., 2025; Uribe-Aguado et al., 2022). At the same time, the practical decision environment remains fragmented. Waterway managers, drainage engineers, planners, ecologists, and asset owners often work with different objectives, datasets, and assessment frameworks. Even when sophisticated modelling or prioritisation tools are available, their outputs may not be readily interpretable across disciplines or in fast-moving project discussions (Glaas et al., 2022; Sun et al., 2024).

We do not need another model. We need a layer that sits over the models we already have and shows how competing objectives relate to one another. This paper 1) sets out why our current tools still leave a gap, and 2) describes a simple colour tool that lets us see trade-offs and synergies at a glance.

Literature review

Recent literature demonstrates significant progress in decision-support for urban stormwater and waterway management. A large body of work focuses on optimisation, simulation, and multi-criteria evaluation using tools such as SWMM, SUSTAIN, GIS-based suitability analysis, TOPSIS, fuzzy logic, and other multi-objective frameworks (Arya & Kumar, 2024; Bekiryazici & Acar, 2024; Uribe-Aguado et al., 2022; Wang et al., 2022; Wu et al., 2025). These approaches have improved the ability of practitioners to compare intervention scenarios, estimate hydrologic performance, test cost implications, and identify preferred combinations of green, blue, and grey infrastructure. In technical terms, the field is increasingly capable of representing complexity.

Alongside this technical development, the literature shows a marked shift toward multifunctionality. Rather than assessing interventions only in terms of runoff reduction or pollutant removal, many recent studies now consider multiple benefits and competing objectives, including flood mitigation, water quality improvement, urban cooling, biodiversity support, public amenity, economic efficiency, and resilience under future climate uncertainty (Farina et al., 2024; Koiv et al., 2025; Thorsson et al., 2025; Uribe-Aguado et al., 2022). This is an important evolution because urban waterways increasingly need to perform several functions at once. As a result, contemporary decision-making is no longer about selecting the most efficient solution for a single criterion, but about negotiating among overlapping and sometimes conflicting values.

However, the literature also reveals persistent limitations. Several reviews and applied studies note that governance, implementation, long-term management, and stakeholder usability are still weakly integrated within decision-support practice (Glaas et al., 2022; Hohmann & Truffer, 2022; Sun et al., 2024). Tools may be analytically robust but remain difficult to embed in routine planning, uncertain in their institutional ownership, or unclear in their communicative value for non-specialist users. This problem is especially relevant where urban water decisions cut across multiple departments, each of which may frame success differently. In these settings, the challenge is not only to generate better analysis, but also to make interactions among objectives more legible to diverse decision-makers.

A further strand of literature emphasises equity, participation, and justice in stormwater planning. Emerging work considers social vulnerability, affordability, environmental justice, and the uneven distribution of green infrastructure benefits (Herbst et al., 2023; Kamanmalek & Alamdari, 2024; Wang & Foley, 2023). This broadens the scope of decision-support beyond hydrology and engineering performance alone. Yet it also adds complexity, because the inclusion of additional criteria can make evaluation frameworks harder to interpret and communicate. The implication is that the value of integrative visual tools increases as the number of relevant decision dimensions increases.

Why do existing tools still leave a gap?

In practice, urban waterway management often proceeds through a series of bounded decisions: a capital project is scoped around flood mitigation, a rehabilitation project is framed around bank stability, a biodiversity program is designed around habitat condition, and an asset renewal program is justified through maintenance savings or risk reduction. Each of these framings can be rational within its own institutional context. The difficulty arises when cumulative interactions between them are not made explicit. A decision that appears efficient from one viewpoint may create hidden losses or missed opportunities when seen at a broader system scale (Farina et al., 2024; Hohmann & Truffer, 2022; Sun et al., 2024).

Decision-makers rarely lack data. What they lack is a shared way of seeing what that data implies for everyone else's objectives (Glaas et al., 2022; Sun et al., 2024; Thorsson et al., 2025).

This is where visual heuristics can add value. A heuristic is not a complete model of reality; it is a structured aid to judgment. In complex planning environments, heuristics can help actors quickly recognise patterns, surface assumptions, and identify where deeper analysis is required. For urban waterway management, a useful heuristic should be simple enough to support discussion, but structured enough to avoid becoming decorative rather than analytical. The proposed RGB framework is intended to meet this need by turning multiple dimensions of system performance into an immediately interpretable visual signal (Glaas et al., 2022; Wang & Foley, 2023).

How does the tool work?

The proposed framework uses additive RGB colour coding to represent relationships among key dimensions of urban waterway decision-making. At its simplest, three variables or thematic domains are assigned to the red, green, and blue channels. The precise assignment can be adapted to context, but a plausible configuration in urban waterway management would link one channel to stormwater or hydraulic performance, one to ecological or biodiversity outcomes, and one to infrastructure, service, or implementation considerations. When these dimensions are evaluated together, the resulting colour blend provides a compact visual indication of dominance, balance, overlap, or absence.

Each domain is scored from 0 (dark) to 250 (bright). Score community on red, nature on green and water on blue, and the blend does the interpretive work for us. Where one channel dominates, the colour stays close to a primary: a strong red against weak green and blue tells us a site is being justified on community grounds alone. Where two channels are strong together a secondary colour emerges, and each secondary has a plain reading:

- Yellow (red + green) — community and nature together: parks, shade, canopy, access to green space.
- Cyan (green + blue) — nature and water together: habitat, environmental flows, a healthy stream.
- Magenta (red + blue) — community and water together: flood safety, amenity, water in the city.

These are the co-benefit zones. They are where we get more than one outcome for the same dollar, and they are exactly what a single-purpose business case tends to hide. Where all three channels are strong the colour lifts toward white at the centre of Figure 1, which is the integrated outcome we are aiming for. Where all three are weak the result is dark, signalling low value, low confidence, or simply not enough information yet. Channel scores can come from quantitative measures normalised to the 0–250 range, or from workshop judgements translated onto an ordinal scale. The framework does not prescribe which; it sits over whatever assessment inputs an organisation already uses.

The tool is not a score. It is there to help us compare options, spot patterns, and have a better conversation. It can sit over existing datasets, prioritisation matrices, catchment triage systems, or ecological return-on-investment frameworks without requiring those tools to be fundamentally redesigned. In this sense, it acts as a translation layer between technical assessment and collaborative interpretation. A further advantage is that the mathematics of the framework is both collapsible and expandable: users can aggregate information upward for strategic overview, disaggregate it downward for closer inspection, and still retain a traceable relationship between the visual output and the underlying component values. This makes the approach useful not only for communication, but also for auditability and iterative decision review.

The three channels are not fixed. Different teams can define them to suit the decision in front of them. For example, a strategic portfolio view might use hydrologic risk reduction, ecological uplift, and deliverability. A corridor-scale rehabilitation program might use erosion risk, habitat value, and community amenity. A capital planning context might use service need, cost efficiency, and co-benefit potential. The method therefore supports local adaptation while retaining a common visual logic, consistent with broader calls for context-sensitive and decision-relevant urban water planning tools (Hohmann & Truffer, 2022; Koiv et al., 2025; Thorsson et al., 2025).

Earlier work by the author also points to the value of simplified visual and conceptual frameworks for making complex waterway decisions more interpretable. Browning (2019) scored hazard, value and need on the three colour channels, so that risk, opportunity and gamechanger sites emerged as secondary colours, while Browning (2021) examined confluences and synergies across water, sewage, and stormwater systems through an explicitly integrative framing. More recently, Browning (2024) explored competing objectives relating to flooding, sediment, and revegetation, again highlighting the importance of making interaction effects visible rather than treating them as isolated issues. Together, these examples suggest that decision quality can be strengthened when complex urban water relationships are rendered in forms that are easier to compare, discuss, and translate across disciplinary boundaries.

Figure 1 Additive RGB colour-coding framework developed for integrated waterway management in the Norman Creek study. Red represents community, green represents nature, and blue

represents water. Mixed colours indicate overlapping benefits between domains, with lighter composite tones signalling stronger multi-domain convergence. This visual structure makes co-benefits and trade-offs more immediately interpretable than conventional single-domain representations and is transferable to mapping and other spatial decision-support formats. Note. Author's adaptation based on Tara and Vos (2021)

Where would we use it?

Urban waterway management provides a useful setting for this approach because intervention priorities are rarely determined by one variable alone. A reach with high erosion risk may also offer strong habitat restoration potential, but present difficulties in access or asset coordination. Another site may be highly deliverable and politically attractive, yet offer only marginal ecological gains. Traditional matrices can represent these conditions numerically, but they often struggle to communicate the combined pattern at a glance. RGB visualisation offers a way to make those patterns easier to interpret across technical and managerial audiences (Glaas et al., 2022; Thorsson et al., 2025; Wang & Foley, 2023).

One practical use would be as an overlay on existing prioritisation maps or project registers. Sites could be colour-coded according to three agreed dimensions, enabling decision-makers to distinguish between locations that are single-issue priorities, dual-benefit opportunities, or genuinely integrated intervention candidates. This would be particularly useful in portfolio planning, where a program needs to balance quick wins, risk mitigation, ecosystem recovery, and cross-agency alignment rather than simply rank projects by one metric (Koiv et al., 2025; Thorsson et al., 2025; Uribe-Aguado et al., 2022).

A second use would be in interdisciplinary workshops or stakeholder engagement processes. In these settings, the challenge is often not the absence of information but the difficulty of aligning perspectives. A colour-based synthesis can help participants see why one team views a site as urgent while another views it as low value, and can provide a neutral starting point for discussing whether this reflects different objectives, different evidence, or genuinely incompatible priorities. By making divergence visible, the framework can improve the quality of deliberation (Glaas et al., 2022; Wang & Foley, 2023).

A third use would be as a communication aid for integrating waterway objectives into broader urban planning and infrastructure delivery. Stormwater, biodiversity, liveability, and asset management teams frequently use different languages of justification. The RGB heuristic offers a shared visual shorthand that can sit within reports, maps, dashboards, and option comparison tables, helping waterway considerations travel more effectively across institutional boundaries. In other words, this is as much about how we work together as it is about how we present data.

The Norman Creek catchment example in Brisbane illustrates how the proposed RGB heuristic can complement existing urban water balance methods. Figure 1 assigns community to red, nature to green, and water to blue, so that blended colours make overlap and co-benefit legible at a glance. Three primary channels anchor the figure, secondary and tertiary colours then emerge from the analysis, and a common goal is articulated in the centre to focus attention on integrated outcomes. Figure 2 shows the conventional modelling framework used in the same catchment, linked to tools such as Aquacycle, which is valuable for simulating the urban water cycle as an integrated whole but does not, on its own, make convergence, mutual benefit, or priority between management objectives immediately visible (Tara & Vos, 2021). In this way, the RGB framework acts as an interpretive layer over existing analysis, helping practitioners identify where objectives remain siloed and where integrated outcomes are emerging.

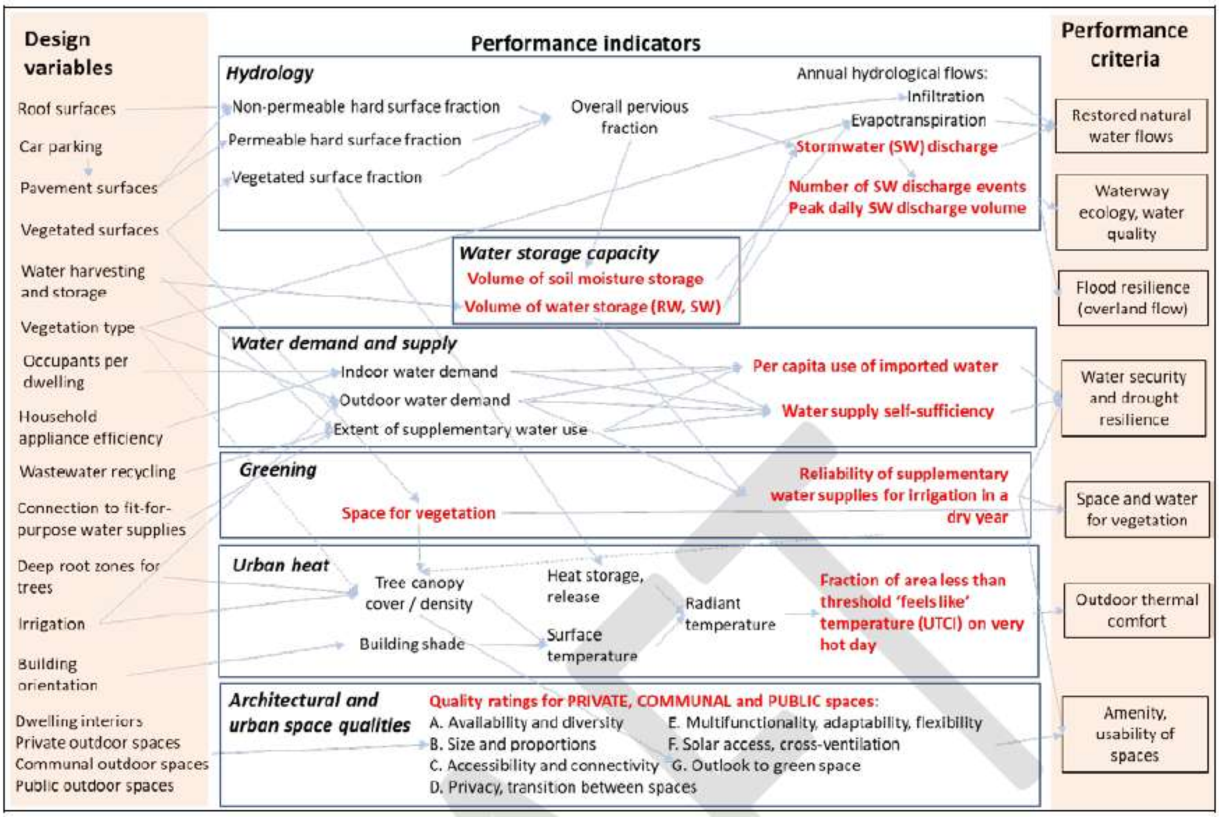

Figure 2 Existing urban water balance framework used in the Norman Creek study. The framework shows the type of modelling environment that can support integrated assessment of hydrology, demand, storage, and reuse through tools such as Aquacycle. Although such frameworks are analytically useful for representing the urban water cycle, their outputs do not readily communicate convergence or priority across community, ecological, and water-management objectives. Note. From *Greenslopes Catchment Urban Flows and Urban Heat Water Sensitive Typology Assessment*, by N. Tara and C. Vos, 2021, Brisbane City Council

Discussion

The main contribution of this paper is conceptual and practical rather than computational. It responds to a recurring problem in the literature: the existence of increasingly sophisticated decision-support tools alongside continuing difficulties in governance integration, communication, and implementation (Glaas et al., 2022; Hohmann & Truffer, 2022; Sun et al., 2024). By proposing a visual heuristic rather than another optimisation model, the paper addresses a different but important layer of the decision process. Most of our decisions do not fail for want of analysis. They fail because the analysis never travels beyond the team that produced it (Wang & Foley, 2023).

So what do we get out of RGB? It is cheap, it is quick to read, and it sits on top of the way we already plan. It encourages users to ask whether a preferred option performs narrowly or more broadly, whether apparent priorities are actually siloed, and whether missed synergies could be captured through reframing. Its structure is also analytically useful: because the component values remain mathematically traceable, the framework can be collapsed for high-level portfolio views or expanded for more detailed project interrogation without losing the logic of the original assessment. In addition, the emergence of secondary and tertiary colours under additive blending gives users a practical way to spot synergistic opportunities, including interventions that may deliver multiple benefits with relatively lean investment. It may therefore be particularly valuable in early-stage option screening, strategic portfolio management, and collaborative planning contexts where speed and shared understanding matter (Farina et al., 2024; Koiv et al., 2025; Thorsson et al., 2025).

There are also limitations. Colour synthesis inevitably simplifies, and poor parameter selection could make the visual output misleading. The framework therefore depends on transparent definition of variables, careful scaling, and an understanding that colour is an aid to interpretation rather than proof in itself. In addition, visual heuristics can help identify where tensions and opportunities exist, but they cannot resolve underlying political, financial, or institutional barriers. Their value lies in improving the visibility of those barriers, not eliminating them.

Future research should test the framework against real decision cases, compare practitioner interpretations with conventional tabular outputs, and examine whether RGB-based representation improves the consistency or transparency of prioritisation decisions. It would also be useful to explore how the method performs in participatory settings, whether different channel definitions produce stable insights, and how the approach can be linked to existing digital dashboards and spatial planning systems (Glaas et al., 2022; Thorsson et al., 2025; Wang & Foley, 2023). Such testing would move the concept from promising heuristic to validated support tool.

Viewed in this context, the RGB heuristic can be understood not as a standalone device, but as a further development in a broader line of inquiry into interpretive tools for urban waterway management. Its contribution is to make overlap and imbalance legible through additive colour logic, allowing convergence and trade-offs to be recognised at a glance. This strengthens the communicative function that earlier frameworks began to explore, while offering a flexible visual structure that can be adapted to different combinations of ecological, hydraulic, service, or community variables.

Conclusions

Urban waterway management is increasingly shaped by interacting hydrologic, ecological, infrastructural, and governance challenges (Hohmann & Truffer, 2022; Sun et al., 2024; Wu et al., 2025). While the decision-support literature has advanced substantially in technical sophistication, a practical gap remains in the communication of trade-offs and synergies across disciplines and institutions (Glaas et al., 2022; Thorsson et al., 2025). This paper has argued that a simple colour tool can help close that gap by making these patterns easier to see, compare and talk about.

By positioning RGB colour coding as an overlay rather than a replacement for existing analytical tools, the paper offers an accessible pathway for improving interpretive clarity in urban water decision-making. Its value lies in helping practitioners recognise where objectives align, where conflicts persist, and where broader system thinking is required. In doing so, the framework has the potential to strengthen more transparent, integrated, and resilient approaches to planning for liveable urban waterways (Glaas et al., 2022; Koiv et al., 2025; Wang & Foley, 2023).

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