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Reframing Nature-based Solution Valuation through Complexity and Life-Cycle Planning: Evidence from Rain-Garden Performance in Auckland

Ira, S.J.T.[1], Simcock, R.[2], and Jayawardena, I.[1]

1. University of Auckland, New Zealand
2. Bioeconomy Sciences Research Institute, New Zealand

INTRODUCTION & AIM

Urban stormwater Nature-based Solutions (NbS) deliver hydrological, ecological, cultural and wellbeing benefits. However, their implementation remains constrained by:

- Short-term cost efficiency logics
- Conventional cost–benefit analysis (CBA)
- Fragmented governance and life-cycle planning
- Under-recognition of plural and non-market values

In stormwater planning, this results in decisions driven primarily by hydraulic performance and capital cost — rather than full benefit realisation.

Research Aim

To develop and test a Decision Support Framework (DSF) that:

- Integrates measurable and non-measurable benefits
- Embeds valuation within enabling governance conditions
- Applies complexity-aware decision-making (Cynefin)
- Incorporates life-cycle cost and total economic valuation

The DSF is demonstrated through a case study of five rain garden typologies in Auckland.

METHOD

Stage 1 – Conceptual Foundation

Systemic barriers, identified through interviews, were mapped across the NbS life cycle of **Design**, **Consenting**, **Construction**, **Vesting**, and **Maintenance**. Four enabling conditions were identified:

1. Strategic vision & prioritisation
2. Institutional governance & integration
3. Valuation, finance & resource allocation
4. Technical design & implementation

Stage 2 – Embedding Valuation

The More Than Water (MTW) framework was used to assess 19 benefit categories and 12 cost categories across environmental, social, cultural and economic domains. Benefits were classified by:

- Tangibility (tangible ↔ intangible)
- Evidence type (direct ↔ indirect)

Stage 3 – Complexity-Aware Assessment

MTW outputs were mapped onto the Cynefin decision domains:

1. Simple → monetisation appropriate
2. Complicated → semi-quantitative modelling
3. Complex → qualitative & deliberative assessment
4. Chaotic → rapid sense-making contexts

This alignment ensures valuation method matches decision context.

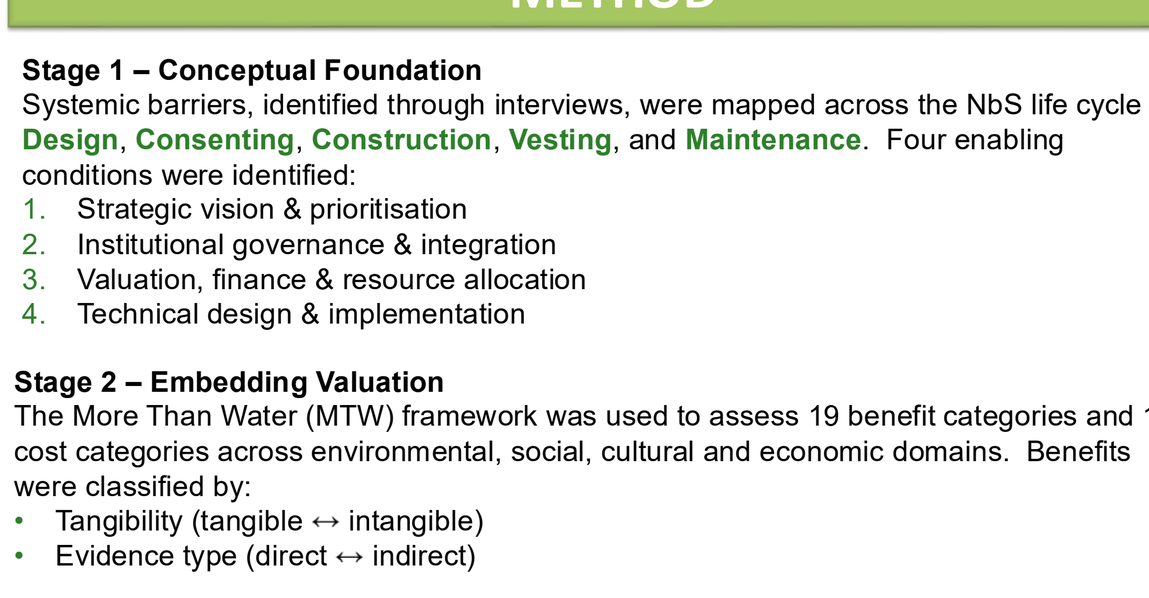

Figure 1. *The DSF, demonstrating the integration of enabling conditions and decision complexity to support plural, life-cycle economic valuation of NbS.*

Stage 4 – Empirical Demonstration

Five Auckland rain garden typologies were analysed against the DSF. For each typology a MTW multi-benefit assessment (workshop + expert elicitation) and Life Cycle Cost (LCC) model (50-year horizon; 4% discount rate; sensitivity testing) were run.

RESULTS & DISCUSSION

1. Decision Context

Rain gardens sit within the Complex domain due to multiple interacting water and non-water benefit pathways, uncertainty and incomplete monetisation data. This justifies plural valuation rather than exclusive CBA.

2. Multi-Benefit Performance

MTW plural valuation results demonstrate typology strongly influences benefit realisation:

- Typology 1: medium hydrology; low non-water co-benefits
- Typologies 2–3: improved ecological & resilience benefits
- Typologies 4–5: strongest overall performance

Key drivers of benefit uplift:

- Media depth
- Vegetation complexity
- Surface area
- Integration with trees & riparian margins
- Hydraulic performance was broadly comparable —
- but ecological, wellbeing, and resilience benefits varied substantially.

3. Life-Cycle Cost Findings

LCC analysis revealed:

- Typology 1 = highest cost (~$150/m²/year)
- Typologies 2–3 = moderate cost ($50–80/m²/year)
- Typology 5 = lowest cost (~$45/m²/year)

Larger, integrated systems achieved economies of scale.

4. Value Proposition of the DSF

The DSF demonstrates that:

- Design typology influences plural benefit realisation
- Larger, integrated systems deliver broader benefits at lower life cycle costs
- Governance and consenting processes currently favour sub-optimal Typology 1 configurations
- Valuation method must align with complexity context
- Without systemic enabling conditions, optimal typologies will not be selected.

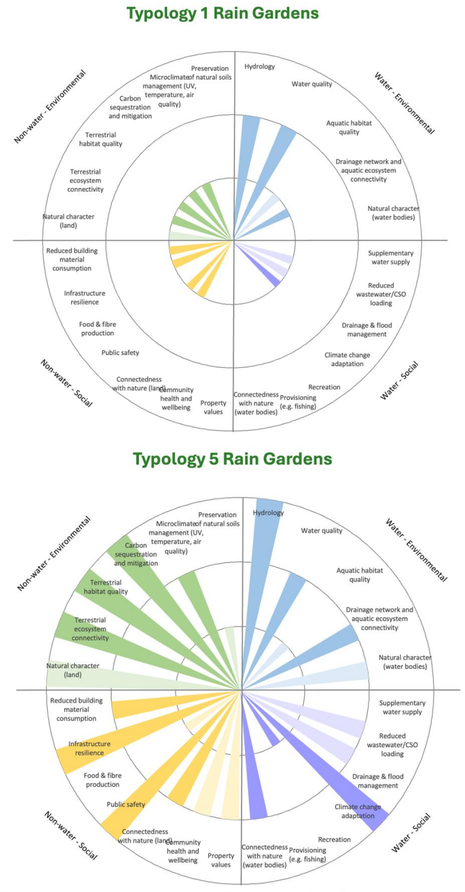

Figure 2. *MTW benefit assessment results. The length of the sector represents the level of benefit and the intensity of colour represents certainty*

CONCLUSION

These findings confirm that conventional cost–benefit analysis under-represents plural NbS value, particularly in complex decision contexts. In complex stormwater decisions, plural valuation and life cycle planning are necessary to reveal broader benefits and long-term cost efficiencies. By aligning valuation methods with decision complexity, the proposed DSF strengthens decision legitimacy, ensuring that infrastructure choices are transparent, context-appropriate, and reflective of diverse stakeholder values. While demonstrated through rain garden typologies, the framework offers a transferable approach for embedding multi-benefit recognition, governance integration, and long-term resilience across wider urban infrastructure planning.

FUTURE WORK / REFERENCES

Future work will expand application of the DSF across additional NbS typologies and governance contexts, integrating participatory MTW+ processes and semi-quantitative optimisation tools to enable comparative scenario testing and international benchmarking.

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