# How can Engineering and Environmental Economics collaborate to manage Urban Stormwater in the face of Global Change?

## Comment l'ingénierie et l'économie de l'environnement peuvent-elles collaborer pour gérer les eaux pluviales urbaines face au changement global?

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## RÉSUMÉ

Nous reconnaissons depuis longtemps que notre climat, nos villes, nos communautés et nos infrastructures évoluent, et continueront d'évoluer, entraînant une augmentation des risques liés à la gestion des eaux pluviales. Un grand nombre de solutions techniques ont été proposées, dont beaucoup se sont révélées très efficaces dans des études de cas spécifiques. Cependant, malgré les besoins et les interventions techniques, les défis liés aux eaux pluviales persistent et, dans de nombreux cas, se sont aggravés ces dernières années. Financé par le fonds interdisciplinaire du NERC, ce projet explore comment une collaboration plus étroite entre l'ingénierie et l'économie peut favoriser une science translationnelle et éclairer la pratique de la gestion des eaux pluviales. L'exploration a eu lieu lors d'un atelier réunissant environ 40 participants issus des milieux scientifiques, techniques, économiques et politiques, afin d'identifier les défis et les opportunités pour la gestion des eaux pluviales face au changement global. À partir de cette évaluation, dix questions transversales ont été identifiées, présentant un potentiel d'investigation immédiate et de résultats opérationnels. L'interdisciplinarité de Novatech offre un cadre idéal pour approfondir et partager ces idées au sein de notre communauté internationale.

## ABSTRACT

We have long recognised that our climate, cities, communities and infrastructure are changing, and will continue to change, leading to increased risks associated with stormwater management. A vast number of technical solutions have been proposed, many of which have proven highly effective in specific case studies. However, despite the need and the technical interventions, stormwater challenges persist and, in many cases, have exacerbated over recent years. Funded by the NERC interdisciplinary fund, this project explores how closer collaboration between engineering and economics can enable translational science and inform stormwater management practice. The exploration took place through workshopping around 40 attendees from scientific, engineering, economic and policy backgrounds to identify the challenges and opportunities for stormwater management in the face of global change. From this evaluation, ten cross-cutting questions have been identified which have the potential for immediate investigation and actionable results. The interdisciplinarity of Novatech provides the ideal place to further explore and share these ideas to our international community.

## KEYWORDS

Environmental Economics, Engineering, Natural Capital, Policy, Practice, Stormwater.

# 1 INTRODUCTION

## 1.1 Stormwater management: The biggest flood risk of all?

Stormwater flooding is, by some, regarded as the "biggest flood risk of all" (Bevan, 2018) and generates enormous impacts to our societies, environments and economies at a global scale.

It has long been understood that stormwater hazards are predicted to worsen in response to changing climates, increasing urbanisation and a reliance on legacy drainage infrastructure. Despite widespread recognition and significant funding streams, recent research highlights that the magnitude of future stormwater flooding has been systematically underestimated (Swain et al., 2020). Thus, current management is insufficient for addressing future risk. Even in low emissions scenarios, global cities are likely to face far greater hazards from flooding than previously recognised (Guerreiro et al., 2018).

## 1.2 Has Engineering solved the problem? Why is there a gap between possibility and practice?

Historically stormwater has been managed through extensive deployment of passive infrastructure across cities and catchments. This is well recognised, and new intervention approaches, drawing across the benefits of nature-based solutions, traditional 'hard engineered' structures and smart technologies are becoming more commonplace (Mikovits et al, 2015; Lowe et al, 2017; Webber et al 2022).

**An Engineer's perspective:** Despite the emergence of novel interventions, wide scale adoption of true best practice remains fragmented and reliant on a drive from 'champions' within practice. Why is that, with technology ready and practitioners willing, this gap in implementation remains? How can we take technology into practice and policy, to provide a step change in the way stormwater is valued, managed and mitigated?

## 1.3 Can combining Environmental Economics and Engineering bridge the gap between technology, communities and policy?

Concurrently, economic approaches to global challenges have increasingly highlighted the need to better link human and natural systems – for example 'HM Treasury's The Economics of Biodiversity: The Dasgupta Review (2011)'. Shifting weather outcomes and patterns of human development impose stress on existing infrastructure (produced capital) for dealing with stormwater. Concurrently, the depreciation of natural assets (natural capital) over the last several decades has diminished nature's capacity to mitigate the effects of these changes. The non-market benefits provided by natural assets are more challenging to quantify in units commensurable with the monetary costs of physical infrastructure. Further, economists must rely on ecologists' and engineers' estimates of the effectiveness of green and grey solutions to best inform policy decision making. One outcome from the disparity between data available on the costs and benefits of market and non-market solutions isa higher failure rate of existing, often under-maintained, infrastructure and a significant need to evaluate adaptation and investment strategies in the next decade.

**An Economists perspective:** By bridging engineering, economics, policy, hydrology and related fields, we can fulfil the mandate of The Dasgupta Review and combine disciplines to effectively deploy green and grey solutions to urban stormwater challenges imposed by global change.

## 1.4 Developing a community of practice

Recognising the potential to develop interdisciplinarity to address stormwater management, this abstract reports on the development of a community of practice to understand the opportunities of incorporating different techniques to better understand and respond to increasing growing threats. This community was established through a NERC interdisciplinary grant, hosted at the University of Exeter. Work so far has included two workshops including academics, engineers, economists, consultants and policy makers, who have developed a list of ten priority areas for future research.

# 2 MATERIALS AND METHODS

## 2.1 Workshop 1: Where is the current science for stormwater management?

The first workshop was research focused, highlighting current academic progress at the frontier of stormwater management. The half-day event included ten research presentations from academics in water engineering, hydrology, biodiversity economics, computer science, environmental science, policy, environmental economics, nature-based solutions, and environmental chemistry. Attendees joined from eight partner organizations, including universities from the UK, the US, and the Netherlands.

## 2.2 Workshop 2: How can we implement the science in practice?

The second workshop was hosted in the University of Exeter's Creative Quadrant (CQ), a space designed for interactive, hands-on processes to foster interdisciplinary problem-solving and innovation.

The workshop centred on challenges and opportunities for stormwater practice and policy. 30 attendees from 15 different organizations joined in-person and online, including experts from consulting firms, insurance agencies, and the water sector. Participants first heard and discussed their thoughts on how key findings from the engineering and economics academic perspectives ascertained during the first workshop translated to their own needs and understanding, and how the needs for research and practice could be bridged.

# 3 RESULTS AND DISCUSSION

## 3.1 Themes emerging from Workshop 1

Discussion during Workshop 1 emphasised a series of themes for future research:

1. Defining the problem: What is it, and what are the limitations of current practices.
2. What should our objectives be? Should we formulate towards risk, resilience, cost, cost-benefit or return on investment?
3. How can we addressing ambiguities of evaluating assets versus systems? How do we define these boundaries, and what does this do to our decision making?
4. How does conceptualising based on big events (resilience) versus frequent occurrences (risk) influence our decision making, and are decision makers cognisant of this influence?
5. When we address 'cost efficiency': who pays, who benefits, when does this happen, and to what extent are investments needed to be recouped for the public good?

## 3.2 Defining ten key questions for future research to develop best practice

Workshop 2 used the above themes to explore actionable research goals with practitioners, policy makers and engineering/ economic professionals. This established ten actionable research questions which should be examined to develop science towards actionable policies and standards

1. Who should pay for and who should benefit from stormwater infrastructure? How can we define the boundaries of these costs and benefits across multiple actors and systems?
2. How can we, and should we, align drivers for multiple ecosystem services, including quantification of natural capital. How does the aforementioned complexity impact this?
3. How can we incorporate spatial effects within our decision making? Focusing on the concepts

of scale, distribution, who pays and who benefits.

4. How could an offsets and credits market work? What unit of stormwater management could be traded within such a market?
5. How can we incentivise ongoing maintenance and operations? What is our best current evidence for whole life costs and maintenance.
6. How can we fill gaps in technical understanding? What is the evidence base for maintenance and monitoring over the long term? Is now the time for a global virtual stormwater observatory?
7. How do water company business models and industry regulation impact long term investment and performance? What are the most successful business models for water companies (globally).
8. How can we move from an asset focused to systems wide approach, and who/ how can manage and synthesise this into actionable technical guidance.
9. What is important to manage within a changing climate and communities? Should our goals relate to one big event thinking, or the cumulative impacts of small changes to the mean?
10. How can uncertainty be taken into account within decision making? Should we consider solutions based on a scale from 'good enough' adaptive and cumulative practice, versus 'precision decisions' where cost of action necessitates a one chance solution?

## 4 CONCLUSIONS

The opportunities afforded by a closer interdisciplinary relationship between engineering and economics could provide the basis for advancing current examples of best practice case studies towards the evaluation, incentivisation and realisation of emerging stormwater management solutions. Novatech is the ideal location to further explore how these research questions can be addressed to advance new technologies towards sustainable practice and policies.

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