

Supplementary Note 1 | Multi-Level Perspective (MLP) Analysis of decisive Factors Influencing past and present Stormwater Management. This table categorizes and details the decisive factors identified through a MLP analysis, which explores the dynamics of stormwater management transition in Swedish cities from the 1960s to 2024. The table is structured into three main sections corresponding to different levels of the MLP framework: Landscape, Niche, and Regime. A more conceptual visual representation of this table is depicted in Figure 2.

MLP	DESIGNED QUESTION	IDENTIFIED FACTOR	DESCRIPTION
Landscape	The questions were designed to identify the macro pressures of urbanization, sustainability, climate change, major flooding/drought events, <i>etc.</i> , to understand their impact on stormwater transition over the past decades. The questions relating to the landscape level aimed to highlight factors relating to both long-standing trends and the current macro challenges that stormwater management are facing.	1. Lasting wellbeing 2. Biodiversity and ecosystem conservation 3. Public awareness, preference, beliefs, and trust 4. Cultural and behavioural shifts	Overarching societal aspiration for long-term quality of life, ecological integrity, and resilience informing stormwater management objectives. Incorporating nature-based solutions (NbS) to preserve habitats, provide ecosystem services, and align stormwater management with broader ecological values. Collective public opinion and level of societal momentum, influencing how stormwater management strategies (<i>e.g.</i>, decentralized) are received, endorsed, or contested in society. Gradual changes in norms (<i>e.g.</i>, sustainability), values, and habits (<i>e.g.</i>, rainwater harvesting) that embed stormwater management into everyday routines and support its long-term uptake.
Regime	Questions at this level focused on understanding past and present governance and management of the stormwater systems, particularly the organizational structures, key actors, mainstream approaches, and the overarching policies and laws that govern these systems. The objective was to dissect the array of internal and external factors that contribute to the inertia or stability of these systems, as well as to assess how governance of mainstream stormwater management either resist or adapt to change.	5. Inter-organizational interaction and coordination 6. Network and partners 7. Polycentric approach 8. Stormwater collaboration group 9. Outsourcing 10. Knowledge sharing 11. Collaborative willingness, readiness and preparedness 12. Organizational governance structure 13. Commitment and accountability 14. Management of conflicts of interests 15. Efficient decision-making process 16. Comprehensive legislation 17. Policy feedback and evaluation mechanisms 18. Policy interpretation and implementation 19. Financing of training and skill development 20. Financing of operations and maintenance 21. Monitoring and assessment 22. Proactive strategic planning 23. Management of uncertainties and risks 24. Long-term operations and maintenance	Strength communication, cooperation, and coordination among various departments and organizations involved in stormwater management, reducing fragmentation and fostering a more integrated and holistic approach to stormwater management. Network, relationships, alliances, and partnerships among diverse stakeholders (<i>e.g.</i>, utilities, agencies, NGOs, private sector, <i>etc.</i>) to support collaborative partnership. Governance structures with multiple, semi-autonomous decision-making centres operating at various levels and scales. A dedicated and cross-disciplinary team (<i>e.g.</i>, municipal water engineers, urban planners, landscape architects, strategists and finance officers) tasked with coordinating stormwater planning, implementation and evaluation across departments and external partners. Engagement of external experts, consultants, or service providers to supplement internal capacities and introduce specialized knowledge. Institutional arrangements (<i>e.g.</i>, mentorship programs) for effective transfer of information, expertise, and lessons learned, strengthening organizational capacity. Organizational ethos that values openness, cooperation, and the capacity to work synergistically with external partners. A clear internal framework delineates decision-making hierarchies, responsibilities, and procedures to ensure transparency and efficiency. The degree to which actors (<i>e.g.</i>, leaders, employees) uphold agreed-upon objectives and remain responsible for achieving stormwater management goals, fostering trust and reliability. Procedures to identify, negotiate, and resolve competing priorities, ensuring divergent stakeholder interests do not impede stormwater management progress. Well-structured, evidence-based, and deliberative protocols that enhance the quality and responsiveness of stormwater management interventions. Robust legal frameworks and regulatory instruments formalizing standards, responsibilities, and compliance requirements for stormwater management. Structured processes for reassessing and updating policies, ensuring continued relevance and alignment with evolving conditions. Translation of legislative and policy directives into actionable measures, integrated into daily routines and responsive to political pressures. Allocating dedicated funds to build human-resource capacity through education and training for effective stormwater management. Securing reliable, ongoing funds for system operation, upkeep and upgrades to sustain long-term performance. Continuous documentation, evaluation, and data collection on stormwater management performance, enabling evidence-based improvements. Proactive frameworks identifying future challenges, opportunities, and uncertainties, ensuring stormwater management resilience and preparedness. Approaches to consider, or better, to handle future variability (<i>e.g.</i>, climate change, pandemic, and (geo) political instability), enabling flexible scenario planning and risk mitigation in stormwater management. Sustained procedures and responsibilities guiding stormwater systems lifecycle management, ensuring durability and resilience.

Niche	The questions explored the past and present technological innovations, including both decentralized measures (NbS) such as bioretention ponds, and computational technologies such as models and smart monitoring systems. Questions also related to the efficacy of various pilot projects, noting successful implementations as well as the lessons learned from trial and error in these projects. In addition, the role of individual and collaborative efforts in driving the transition was explored.	25. Recreational value	Integration of stormwater management spatial contexts that offer recreational opportunities, improving public well-being.
		26. Aesthetic enhancement	Designing stormwater management interventions with visual and cultural appeal, enriching urban landscapes while fostering public appreciation and cultural relevance.
		27. Community well-being improvement	Strengthening social cohesion, local identity, and sense of belonging by aligning stormwater management with community needs, values, and everyday experiences.
		28. Stormwater quantity control	Encompasses retention, detention, harvest and other hydrologic processes that reduce or delay runoff volumes and peak flows, thereby mitigating flooding and erosion and easing pressure on downstream systems.
		29. Stormwater quality treatment	Implementing treatment and filtration measures to remove pollutants and protect receiving water bodies.
		30. Efficient use of urban public spaces	Incorporating stormwater management into municipal lands (e.g., parks) to achieve sustainability goals and offer recreational and community benefits.
		31. Effective solutions on privately owned land	Encouraging stormwater management on private properties, extending the benefits and values beyond public areas.
		32. Standardization of practice	Establishing clear guidelines, standards, and evaluation criteria to ensure consistency, traceability, and reliability in designing and implementing stormwater systems.
		33. Complex stormwater system integration	Strategically combining grey, green-blue infrastructures (or NbS) into a cohesive, multifunctional network and systems.
		34. System flexibility	The inherent ability of the stormwater systems to adjust to evolving environmental conditions, operational demands, and urban development pressures.
		35. Stormwater strategists - specialist & generalist	Availability of both niche experts and broadly skilled professionals supporting strategic decision making in stormwater management.
		36. Pilot policy initiatives	Small-scale, trial-based regulatory or planning experiments testing innovative approaches, informing broader reforms if successful.
		37. Financing of technical investments	Providing funding for new infrastructure, modelling tools and innovative technologies to improve stormwater management strategies and systems.
		38. Active participation and engagement	Mechanisms (e.g., community-based monitoring) for meaningful citizen involvement in decision-making and stewardship.
		39. Innovations and experimental projects	Trial-based initiatives testing novel technologies or NbS configurations, generating lessons for potential mainstream adoption.
		40. Use of advanced software, tool and material	Employing AI, IoT, advanced modelling, and eco-friendly materials to enhance stormwater management system performance and resilience.

Supplementary Note 2 | Semi-Structured Interview Guide Based on the Multi-Level Perspective (MLP). This file presents the full set of semi-structured interview questions used in Phase 1 (Fig. 1a: Step 3&4), structured according to the MLP framework from 1960 to 2024. Grey text indicates clarifying prompts or guiding narratives used when interviewees require further explanation. Bullet points indicate potential follow-up questions used to deepen or structure the discussion. The interview was originally written and conducted in Swedish and has been translated for the purpose of this supplementary note.

Date for interview :	
Name of the organization and department you work / have worked:	
Job title and role:	
Professional year :	
Mainly area of responsibility :	
REGIME QUESTIONS (1960-2024)	
STORMWATER MANAGEMENT SYSTEMS	During your career and to your knowledge - which system and techniques in stormwater management have been most prevalent? <i>Are these techniques still widely used today?</i> <i>If so, why do they remain dominant? (e.g., effectiveness? ease of use? resistance to change?)</i>
GOVERNANCE & MANAGEMENT	Who within your organization has been primarily responsible for stormwater management? We're interested in understanding how collaboration around stormwater management is approached in your organization. (Collaboration is often a key factor in effectively managing stormwater within urban environments, involving various departments, organizations, and stakeholders.) <i>How does cross-departmental collaboration work look like?</i> <i>Who are the key partners ?</i>
POLICY OR LEGISLATION	Have any specific policies or pieces of legislation significantly impacted the development of stormwater management? <i>If yes, which one/ones, and why were they important?</i>

MAIN ACTORS	Who would you say has been especially influential in shaping the direction of stormwater management in the city while you've been here? • <i>Does this influence primarily come from political, departmental, or external private actors?</i> • <i>Has this influence looked the same over the years?</i>
OTHER ACTORS	Have there been occasions when you outsourced stormwater management? If external private actors have influenced stormwater management decisions, who are they? • <i>private organizations?</i> • <i>company ?</i> • <i>the public ?</i> • <i>private people ?</i>
IMPACT AND INFLUENCES FROM SOCIETY	Do you believe the general society / public is concerned with how stormwater is managed? Why or why not?
FINANCIAL RESOURCES	How would you describe the financial conditions within your organization for achieving goals in stormwater management? (e.g., Budget allocation and prioritization; Funding Sources; Financial challenges; Future financial planning.) • <i>Can you talk about the budget and funding available for stormwater management projects here?</i> • <i>Do you feel it's been adequate for meeting your goals?</i>
LANDSCAPE QUESTIONS (1960-2024)	
MACRO IMPACT AND INFLUENCES	How have broader strategic considerations/agendas been integrated into your organization's approach to stormwater management? (e.g., climate change, sustainability, resilience, and biodiversity etc.)

	• <i>If yes, in what way ?</i> (e.g., Influence the decision-making process in stormwater management? Mindset? operational agenda? Etc.)
GRADUAL CHANGE / IMPACT - SOCIAL	How are social values such as recreation, amenity, integrated into stormwater management? (Consideration of place identity/sense of place, activities, and aesthetics, etc., name more?)
GRADUAL CHANGE / IMPACT - OTHER	In addition to climate change, stormwater management is affected by a variety of other trends and agendas. How do you feel about that? (Urban densification? environmental justice? public health?)
IMMEDIATE CHANGE / IMPACT	Have you experienced natural and unpredictable events such as flooding, cloudburst, system fail that led to a (immediate) change in stormwater practice and policies ? • <i>If yes, what event and which year?</i> • <i>If so, how did this affect the organization and how you worked?</i> • <i>If yes, change in policies and guidelines?</i> • <i>Has there been an opportunity for financial support in the event of sudden events?</i>
NICHE QUESTIONS (1960-2024)	
TECHNOLOGY & INNOVATION	How have technological innovations (e.g., monitoring, sensors, simulations, decision-support tools, AI) impacted stormwater management? • <i>How do you think of AI used in your work?</i>
OPEN STORMWATER MANAGEMENT (NATURE BASED SOLUTIONS)	When did your organization begin to adopt or see an increase in the use of open or natural based solutions for managing stormwater? • <i>If yes, Which year? Which place? What prompted this shift?</i>
PILOTS & EXPERIMENTATION	Could you highlight any key projects that have significantly influenced the evolution of stormwater management practices? Either successful or unsuccessful ones. (Impactful outcomes, Lesson learnt, Strategy or policy shift, Collaboration and partnership, etc.?)

	How important would you say experimentation and testbeds are to the development of stormwater management? • <i>Why? When? Where in the cityscape?</i> • <i>Has the development come from practice (via "trial and error ") or has the development been driven by research?</i> • <i>What examples can be given in that case and when?</i>
FINANCIAL RESOURCES FOR PILOTS & EXPERIMENTATION	Can you discuss the availability of funding and resources dedicated to exploring new and innovative approaches in stormwater management? How has this impacted the ability to pilot experimental projects?
COOPERATION & KNOWLEDGE TRANSFER	How do knowledge and experience sharing in stormwater management work within your department, with other departments, or with external entities? • <i>Do you feel that there are/were good opportunities for knowledge and experience transfer between different city departments</i> • <i>Has the administration had time to keep up with developments?</i> • <i>Which collaboration works well? Why?</i> • <i>Is/was there a specific system or approach within the department and organization for knowledge transfer between employees?</i> • <i>If yes, which ones?</i> • <i>If yes, when were these/this introduced?</i> • <i>If yes, have they been formalized in any way (in strategies, internal policies , etc.)? Has internal knowledge ever been formalized?</i>
INDIVIDUAL COMPETENCE	To what extent do you feel that a single individual's competence and drive have been significant for the development within stormwater management? (Can you share how the expertise, leadership, and enthusiasm of any individual within our organization have significantly influenced our approach to stormwater management? We're interested in specific examples where such contributions have led to meaningful changes, innovations, or breakthroughs in our practices.)

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- *If yes, leadership and vision?*
 - *Positive influence on others / team members / partners?*
 - *Or Influence on Policies and Practices?*
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