

## Analyzing barriers for stormwater management utilities

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### ABSTRACT

This study analyzed barriers for implementing stormwater utilities. Public budget constraints imply a need for prioritizing scarce public funds for financing water-related investment. In this sense, municipalities have ranked stormwater management services as a low priority compared to other public needs, causing them to be underfunded. The creation of stormwater utilities for securing resources should be supported through economic, technical, and legal arguments. There is a global water and sanitation access gap. Municipalities should dedicate themselves more to investigate how these gaps can be reduced, which will bring a higher benefit–cost ratio. Overruling these local governments and financing low priority interventions seems immoral. Furthermore, compulsory charges on public services that supply universal benefits are illegal.

**Key words** | drainage, stormwater management, tariff, tax, utility

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### HIGHLIGHTS

- Stormwater Management Utilities.
- Taxing water-related services.
- Analyzing the sustainability of public services.
- Cost and benefits of public services.
- Infrastructure financing.

### INTRODUCTION

Modern cities show vulnerability to extreme events demanding urban policies to deal with potential impacts, while promoting human health, economic development, and environment sustainability. Over 90% of these extreme events are water related and occur within cities' boundaries, which affect the local hydrological cycle. Floods and water-related events account for 70% of deaths and 50% of water-borne diseases (UNEP 2017).

Globally, every year, inadequate Water and Sanitation Services (WSS) cause two million deaths (280,000 of these deaths are caused by diarrhea); contribute to malnutrition;

and have infected over two billion people with parasites (although mostly are benign). Most of these health impacts occur to children under five years of age (WWDR 2003).

Urban water management requires a complex integrated system to supply water, meet potential user needs, control water pollution, provide proper treatment of wastewater, manage runoff waters (stormwater), prevent floods, and regulate sustainable use of water resources. A sound water management strategy helps increase environment natural resilience (WMO 2008; UNESCO 2009).

Local governments should invest on capacity building and improve urban water management through man-made infrastructure to cope with these increasing global challenges. However, the availability of public funds has decreased drastically. Public decision-making for water-

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doi: 10.2166/ws.2021.024

related investments should be based on planning and comprehensive information, which enables clear and effective benefit–cost decisions by each stakeholder (e.g. investors, users, and public officials). Costs are straightforward to assess. However, public officials have demonstrated difficulties in converting WSS benefits in monetary terms (OECD 2011; Ramôa *et al.* 2018).

Public officials have struggled with different methods for ranking water-related investments and efficiently complying with increasing needs and reducing funds. There is a need for improving governance in public-financing processes, which entails distributing responsibilities and actions among stakeholders in the decision-making process (Porse 2013).

The combination of climate change effects (rising sea-level and superstorms) with inadequate urban planning has made flooding an almost inevitable event. Many cities were developed in historic flooding prevalent areas. As flood risks intensify, stormwater management becomes an essential public need, empowering supporters in finding proper funds (WMO 2008; Morrison *et al.* 2018; Pervin *et al.* 2020).

In the natural water cycle, part of runoff water reaches the system rapidly, while a large part percolates into the ground, recharging the system in a slow base flow. In the urban engineered water cycle, the constructions over large areas, the compacted soils, and the waterproofed surfaces, increases water runoff and reduces percolation. In both cycles, at different speeds, runoff and base flow embrace their way downstream to the nearest ocean (Butler & Davies 2004; McGrane 2016).

In flood prone zones, depending on the size of water runoff increase, inadequate stormwater management can be a huge environmental problem. This stormwater setting is a major danger to local communities, because it does not only generate flooding hazards but alters the quality and quantity of the whole water system (OPW 2009; Morrison *et al.* 2018).

Due to smaller capital expenditure requirements, some cities have built joint stormwater-sewerage systems, where runoff water and domestic sewage share the same infrastructure, demanding runoff water treatment before final discharge. Despite the reduced capital expenditure, these systems entail larger operational expenditure because they stand for larger environmental threats, as for runoff treatment obligations or because heavy storms can overcome infrastructure capacity. This is the main reason why most

modern cities have developed dedicated stormwater systems, which use a separated infrastructure from domestic sewers, and do not need to treat most runoff water (Porse 2013; Wang *et al.* 2017).

Historically, stormwater management services have been financed through public funding from general taxes, but recent budget constraints and increasing population demands impose a severe competition over public funds. (USEPA 2008, 2009).

In this economic crisis, the preferred alternative has been attracting private investors for financing infrastructure development initiatives. However, sustainable WSS improvements demand better institutional and governance arrangements, which do not occur just by switching the operation from public to private (Pinto *et al.* 2017).

Stormwater management, as any public good, competes for financing with several other essential public needs (drinking-water, sanitation, health, education, transportation, and security) within a restrictive public funding scenario. In this scope, stormwater management services have been ranked below other priorities by local decision makers, leading them to be underfunded. For this reason, many municipalities have created utilities to secure proper funding to cover implementation and maintenance costs. In this sense, stormwater governance (narrow) would differ from water governance (broad) as the latter must compete with other demanding services (Porse 2013; Wang *et al.* 2017).

This study analyzed economic, technical, and legal barriers related to the creation of stormwater management utilities for securing public funds impairing more appealing public demands, which overrules public decision-making process. The analysis limited its scope to stormwater management provided by completely separated systems (runoff and domestic sewage using different infrastructures) and within municipalities where stormwater would not receive any further treatment prior to their final release into the environment. Although most Anglo-Saxon countries are characterized by this situation similarly to the Spanish, Lusophone and Francophone countries, including both developed or developing countries, this is not the reality in some countries, mainly the ones that are endowed with combined systems, such as Germany.

On this subject, there are two possible settings for assessing local public funding decision-making process: 1) The

creation of a stormwater management utility is a violation of local executive power to prioritize public needs according to their own criteria. In a restrictive financing setup, stormwater management should compete with other public demands and avoid trying to guarantee funds for less-efficient and low-return investments. 2) The creation of stormwater utilities is needed because decision makers have limited information. Utilities supporters assume that it is difficult to supply sound information to local authorities, which would lead them to create an inadequate prioritizing scheme. The service would not occur without securing proper funding. Thus, stormwater management is an essential service and should not compete for funding with other public needs. This paper contributes for the literature by discussing and highlighting these issues and strengthening the role of stormwater management not only considering the technical barriers which are already reasonably addressed by the literature, but also the economic and legal barriers. Indeed, better policies, institutions and regulation aligned with the rights incentives regarding stormwater services are required (Mumssen *et al.* 2018).

After this brief introduction, section two discusses the economic barriers in the stormwater services. Section three analyzes the technical barriers and section four the legal barriers. Finally, section five draws the concluding remarks.

## ECONOMIC BARRIERS

The United Nations states that adequate access to WSS is a basic human right. Countries are at distinct development stages concerning their water-related infrastructure. Developed countries are demanding compliance with stricter environmental regulations and investing in improving wastewater treatment, while most developing countries still need to make considerable investments in WSS infrastructure to reduce the 'access gap' to water, sanitation, and hygiene services (OECD 2011; UN 2015).

In any situation, it is important to guarantee an efficient decision-making process for analyzing, prioritizing, and selecting water-related investments. Given the current severe public budget constraints worldwide and the substantial costs of providing access to WSS, public policies have focused on making the most of public funding by prioritizing

investments with the highest benefit–cost ratio (BCR) (Kalman & Lund 2000; Visitacion *et al.* 2009; WHO 2012).

WSS development entails large disbursements to cover capital (Capex) and operational (Opex) expenditures. It is common sense that any sustainable public service should supply the means for recovering these investments throughout benefit–cost rationality. It should be effortless converting the incurred expenses in actual costs if all of those are accounted properly. However, a major struggle relies in estimating the benefits of WSS expanding initiatives.

Benefits assessment on treating contaminated water relates to improvements of water quality through the removal of different polluting substances, which is hard to calculate due to their inherent diffuse nature. Sequentially, the benefits of stormwater management are even less obvious and tougher to evaluate, especially in places where flooding is not a major challenge. Local governments have perceived stormwater management as supplying lower BCR than other competing public needs. The lack of information cannot be a sound reason for prioritizing stormwater investments. Improving information databases and methods on water-related services could help to define the situations in which the stormwater service could be an investment priority (OECD 2011; Wang *et al.* 2017).

There are other obstacles for evaluating benefits because they vary consistently with the actual WSS development stage of a specific country. In developing countries, there is a large 'access gap' so that supplying water and sanitation must be the main priority because these actions deliver the highest BCR. Additionally, hygiene education can also supply enormous benefits at a relatively low cost (Kalman & Lund 2000; Visitacion *et al.* 2009; WHO 2012).

Consequently, in developing countries, water-related investments are justified in terms of public health advances, while in developed countries they are justified in terms of environmental regulation compliance. Thus, the benefits of water-related interventions arise from a mix of tangible (e.g. lives saved, and diseases prevented) and intangible drivers (e.g. quality of life improvements and environmental sustainability) (OECD 2011).

The water-related investments BCR diminishes with the increase in the sophistication of interventions. In the preliminary infrastructure setup phases, wastewater treatment produces greater benefits, because it reduces residual risks associated with diffuse pollution. However, once a certain

degree of sanitation development is reached, incremental benefits tend to decrease drastically (OECD 2011).

Many studies (Kalman & Lund 2000, Visitacion *et al.* 2009; WHO 2012; Porse 2013; Wang *et al.* 2017) have proved that the overall benefits from providing access to WSS are larger than the costs. Even though most WSS investments entail positive BCR, they can also have push backs, as untreated wastewater continues to be discharged into drinking water sources. Strategic planning and sequencing WSS investments are critical to results effectiveness.

Thus, investments in providing WSS should not be analyzed untying (upstream) resource protection and (downstream) wastewater treatment. This integration maximizes benefits and avoids unnecessary costs from inadequately sequenced WSS investments (WHO 2012; Porse 2013; Wang *et al.* 2017).

In flood-prone areas, risk management processes might prioritize interventions and actions concerning the implementation costs and flood reductions. Upstream interventions are likely to yield greater BCR than downstream interventions. The highest stormwater BCR is expected from treating polluted water of joint systems, preventing negative impacts on environmental quality. Smaller stormwater BCR should be expected in interventions just for preventing flooding in a separated drainage system, which does not include water treatment before final discharge (WMO 2008; OPW 2009; UNESCO 2009; Morrison *et al.* 2018; Pervin *et al.* 2020).

A well established water governance plan should enforce efficient investment decisions, requiring policy makers to gather information on costs and benefits of each different water-related investment. However, investments that produce the highest benefits may also be the most expensive ones. That is the reason why information on benefits alone might not be enough to persuade public officials to invest in a specific water-related activity (e.g. stormwater management), which may not be the most effective use for limited public funds (Kalman & Lund 2000, Visitacion *et al.* 2009; WHO 2012).

Traditionally, costs and benefits assessments of water-related interventions are still insufficient and hidden in technical documents that, most of the times, remain invisible to local decision makers. This scenario has resulted in low political priority and sub-optimal levels of stormwater infrastructure (OECD 2011).

The strategy for setting up water-related investment priorities would require an adequate investment decision process,

such as: defining investment strategies; identifying costs associated with each strategy; evaluating the allocation of benefits among stakeholders; prioritizing investments; formulating investment schedule sequence; and improving public information on health and environmental benefits (WMO 2008; OPW 2009; UNESCO 2009; Morrison *et al.* 2018).

## TECHNICAL BARRIERS

Stormwater systems as public goods are part of the urban infrastructure and should be planned considering watershed characteristics, road system and land use, and designed to convey existing and future scenarios of land use and rainfall estimates (Butler & Davies 2004; Dhakal & Chevalier 2017).

Urban developments have occurred in places with inadequate public service provisions. In flood-prone zones, water-related problems result from inept stormwater management. On the existing urban scenario, it is costly to build drainage infrastructure with underground systems, standing for an enormous political and financial challenge (Nahrin 2018).

At first, city developments on flooding areas should not have been allowed. Flooding events are not just caused by severe storms. There are distinct types of flooding, each of them associated with diverse groups of root causes, in which improper city development plays a key role. Thus, one important flood-hazard initiative should be diverting population and developments from flood-prone areas (OPW 2009; UNESCO 2009).

The intense urbanization process incorporates artificial surfaces, which increase runoff, and decrease infiltration rates. As a result, there is an escalation of water that rapidly reaches the rivers during rainfalls. The proportion of water runoff depends on storm length and nature of land surface. The urbanization process changes the original balance in the hydrological cycle: evaporation, precipitation, infiltration, and runoff. Alterations in local microclimate may alter precipitation rates, which affects later stages (McGrane 2016).

Thus, this chaotic urban design in flooding-prone zones increases environmental risks pressuring for implementing costly flooding control measures. Stormwater management systems become necessary to substitute the natural water cycle. Runoff waters in this built environment need to be

directed using underground pipes to supply runoff discharge. If stormwater management fails, it causes flooding, damage, and health risks (Butler & Davies 2004; USGS 2016).

Stormwater systems divert rainwater to piped systems, without considering further consequences. As a result, floods might happen at some point downstream. Upgrading large infrastructure is both expensive and disruptive, requiring large-scale excavations, including the main road networks. Thus, the use of performance indicators, sustainable technologies, and green infrastructures improves the performance of stormwater systems and should be encouraged (McGrane 2016; Santos *et al.* 2019).

Joint drainage systems include a single pipeline carrying mixed wastewater and stormwater. However, wastewater and stormwater require different technical solutions depending upon individual impacts to environmental health. During the dry season, joint systems carry mostly wastewater flow. Furthermore, during the rainy season, the amount of contaminated water flow increases due to stormwater drainage. Under heavy rainfall, stormwater flow can be a hundred times higher than average wastewater flow. This mixed contaminated water can overload the infrastructure capacity (Butler & Davies 2004).

In contrast, separated systems are designed based upon climate conditions and human occupancy with two distinct pipelines flowing stormwater and wastewater separately. The separate system is extensively used worldwide, especially in regions with considerable rainfall patterns. The runoff waters are often discharged directly to the watercourse. This scenario can carry out a certain load of pollutants to the environment, even though it is lower than wastewater pollution (Tucci 2001; Butler & Davies 2004).

McGrane (2016) showed that large-scale stormwater management systems will always have limitations no matter their design capacity. It is unfeasible for any municipality to build a flooding protection system to force out large volumes of water in brief periods. Heavy storms can overkill existing systems and result in flooding.

In every severe storm, public officials are reminded of this challenge affecting flood-prone areas. In August 2017, Hurricane Harvey discharged thirty-four billion cubic meters of rainwater within two days on the densely populated city of Houston (in an area of approximately 1,733 km<sup>2</sup>). Harvey's consequences were aggravated by an

insufficient stormwater system (WMO 2008; Morrison *et al.* 2018).

In flood-prone areas, municipalities have raised the necessity for creating utilities to guarantee dedicated financing for existing and future infrastructure to divert runoff waters. However, there are technical barriers for stormwater charging because the assessment of each property contribution to stormwater management is not a simple task. That is why most stormwater utilities that are trying to make the technical approach easier use a charge scheme based upon impermeable surface ratio as proxy for private properties contribution to runoff waters.

Nevertheless, impervious surfaces ratio does not supply a good estimate of the contribution of runoff waters or properties to stormwater drainage systems, because runoff water patterns vary over space and time according to: i) diverse runoff rates may occur simultaneously in adjacent areas; ii) soil types vary over space and depth; iii) the use and land occupation varies from property to property; iv) many properties store stormwater for reuse; and v) some properties have a green infrastructure that can retain stormwater.

## LEGAL BARRIERS

Lawfully, stormwater management is a local government responsibility associated with three fundamental goals: urban flood control, water resource management, and environmental protection (NAFSMA 2006).

Typically, municipalities charge a user fee for funding public services, e.g. drinking water, and wastewater systems. Historically, stormwater management has been financed by public funds, mostly originated from general taxes. However, as discussed earlier, competition with other public needs has often resulted in the stormwater management services being under funded. Thus, stormwater utility supporters defend that municipalities should create a dedicated funding for supporting drainage services, which are perceived as low priority by public decision makers (USEPA 2008, 2009).

This lack of proper financial sustainability has triggered the creation of many stormwater utilities in different countries (e.g. USA, Canada, the UK, South Africa, and Australia), which would enable charges for securing reserved cash for stormwater management. These stormwater utilities have varied widely in size and in scope (Cincar *et al.* 1999; Roy



et al. 2008; Marsalek & Schreier 2009; Ellis & Lundy 2016; WKU 2016).

In 2016, a survey at Western Kentucky University (WKU 2016) estimated that there were 1,583 stormwater utilities across the United States, mostly designed to solely address flooding concerns without expecting any further runoff water treatment. Half of these utilities were concentrated in just five states: Minnesota (197), Florida (180), Wisconsin (126), Washington (117), and Ohio (105).

City expansions lead to more impermeable surfaces, less rainwater infiltration, and more water runoff to be managed. This would be the reason for stormwater utilities to charge property tax or service fees based on water runoff burden (impervious surface) from each property (Arnold & Gibbons 1996; NAFSMA 2006; Ellis & Lundy 2016).

In all stormwater utilities, charges are imposed on users to secure dedicated funds for economic sustainability, covering the costs of implementing and maintaining urban drainage systems. These charges are considered a necessary fair burden for communities to share the cost of required under funded public service (Arnold & Gibbons 1996; NAFSMA 2006).

In this scope, stormwater utilities funding has been operationalized in terms of property taxes or service fees. Legally, property taxes or service fees approaches will have different consequences in terms of who will pay, what procedures should be followed to implement and collect the charge, and how the funds can be employed. The creation of utilities to supply basic public needs often raises legal concerns leading to judicial disputes. Regulatory systems require that governments should give back what they have collected from general taxes (NAFSMA 2006).

This study analyzed legal barriers of stormwater utilities services for managing runoff waters using completely separated pipelines and that do not receive any further treatment prior to final release to the environment. The analysis used general law principles to supply a broad legal overview on stormwater charges validity. A customized legal analysis for a specific stormwater utility reflecting a country/state/municipality funding approach is not part of the scope of this study.

In most countries, funding public services with taxes raises a yellow flag on legal legitimacy, because a tax is an amount of money demanded compulsorily for supporting public services that can be individualized (*uti singuli*) in terms of their incurred costs and generated benefits. As discussed in the

previous section, most of the expected benefits from environmental preventive actions, such as flood control, are diffuse (*uti universi*) and cannot be individualized. The actual incurred costs of individual contribution to runoff water cannot be calculated. Plainly, as utilities cannot individualize the costs, they just find an effortless way to split them. The overall stormwater management costs are divided by a property's impervious surface ratio (simple to calculate), assuming that this is the major root cause for runoff waters leading to flooding events (NAFSMA 2006).

The fundamental attributes for ensuring user-fee or tax-scheme lawfulness are non-discriminatory, reasonable to individual costs/benefits, and voluntary. In stormwater utilities, none of these occurs. The benefits of stormwater utilities affect the environment and the society as a whole (NAFSMA 2006).

In stormwater tax schemes, it is expected that tax-exempt entities (e.g. churches and government) will dispute their obligation to contribute. Usually, governmental properties (street, sidewalks, and parks) are tax exempted, despite being the largest impervious surface contributors. Additionally, there will be social demands for exempting low-income communities. These discriminatory exemptions will create a huge burden on remaining taxpayers, which will destabilize the service funding system, demanding for direct or indirect subsidization (NAFSMA 2006).

Likewise, any tax-scheme implementation requires formal legislation process, which creates an extra burden for stormwater managers. Stormwater taxes cannot be associated with property taxes because the latter are mostly based on property value, which is irrelevant for determining stormwater management costs, as it is not equitable (NACWA 2016).

Consequently, many stormwater utilities have implemented a service-fee approach to reduce the risk of litigation. In this sense, stormwater utilities must be user oriented, like water and wastewater utilities; service fees should be based on the use of stormwater management services by each individual property. (NAFSMA 2006).

The U.S. Supreme Courts ruled that taxes charges are a mandatory common burden, while fees are paid voluntarily; nonetheless both need to generate specific benefits. On several occasions, the U.S. Supreme Courts have ruled that user fees can only be charged non-compulsorily to specific benefit users and cannot be applied to stormwater services

as expected benefits are universal. In this way, legal decisions have ruled that mandatory stormwater fees are illegal, because these would be taxes in disguise (NACWA 2016).

Conclusively, a stormwater management utility implies a compulsory compensation for supplying a flood control service throughout separated drainage systems without runoff water treatment, delivering *uti universi* benefits that cannot be individualized. Furthermore, these public services cannot be measured in terms of their individual incurred costs, which are usually estimated based on an impervious surface. Moreover, it is an essential service that should be supplied irrespective of any payment in return. Lawfully, stormwater management is a public good that can only be financed through public funds that have originated from general taxes. This is already the situation in Germany, among other countries (Geyler et al. 2019).

## CONCLUSIONS

Worldwide, the low-hanging fruits are related to investments for supplying water, sanitation, and hygiene. In developed countries, most of these high-return BCR were captured in the late 19th or early 20th century when basic water and sanitation infrastructure was provided to the population. Investments in basic WSS generate larger economic, environmental, and social BCR. This is the public managers' judgment call for ranking stormwater management as low priority compared to other society needs for receiving public funds.

Thus, improving funding for urban drainage became a finance challenge, particularly because in most developing countries there is a severe access gap for more compelling water-related services.

This study analyzed economic, technical, and legal barriers for stormwater management utilities created to control floods through dedicated drainage systems that do not supply any further treatment on runoff waters. The basic assumption for creating a stormwater utility is the essential nature of the service, which imposes the need for overruling municipal authorities that give low priority for drainage investments, causing them to be underfunded. The stormwater management service is an essential service, so that society should bear the costs for operating it. Thus, as a utility, the proper dedicated financing solution will be achieved.

Stormwater management requires large infrastructure and operational investments, which should be technically, economically, and legally sustainable. Stormwater utilities are created to impose charges on property owners as a function of their impermeable surfaces to cover incurred capital and operational expenditures.

Moreover, the impervious surfaces as the root cause for flooding events and on the estimate of each individual property contribution for the overall runoff waters are only an input to the problem. Additionally, most impermeable surfaces are in public properties, which will not help funding as these are tax exempted.

The most efficient stormwater management solutions should stop moving rainwater away and try to search for better alternative uses close by. Drainage systems should reclaim stormwater for alternative use by adding vegetation and green infrastructure.

Stormwater management services supply a smaller benefit cost ratio (BCR) on public investment. Utilities activists use their political power to guarantee funds for drainage interventions that are technically, economically, and legally unsustainable through centralized systems.

Municipal authorities should be focusing on investing their scarce public funds to reduce existing water and sanitation access gap, which entail higher BCR. Overruling local governments and financing low priority interventions is immoral. Likewise, a compulsory stormwater charge for services that supply universal benefits and that should be already funded through existing general taxes is illegal. Thus, this creation of a utility for securing stormwater dedicated funds is based upon unacceptable arguments.

## DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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First received 1 November 2020; accepted in revised form 11 January 2021. Available online 22 January 2021