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PhD thesis

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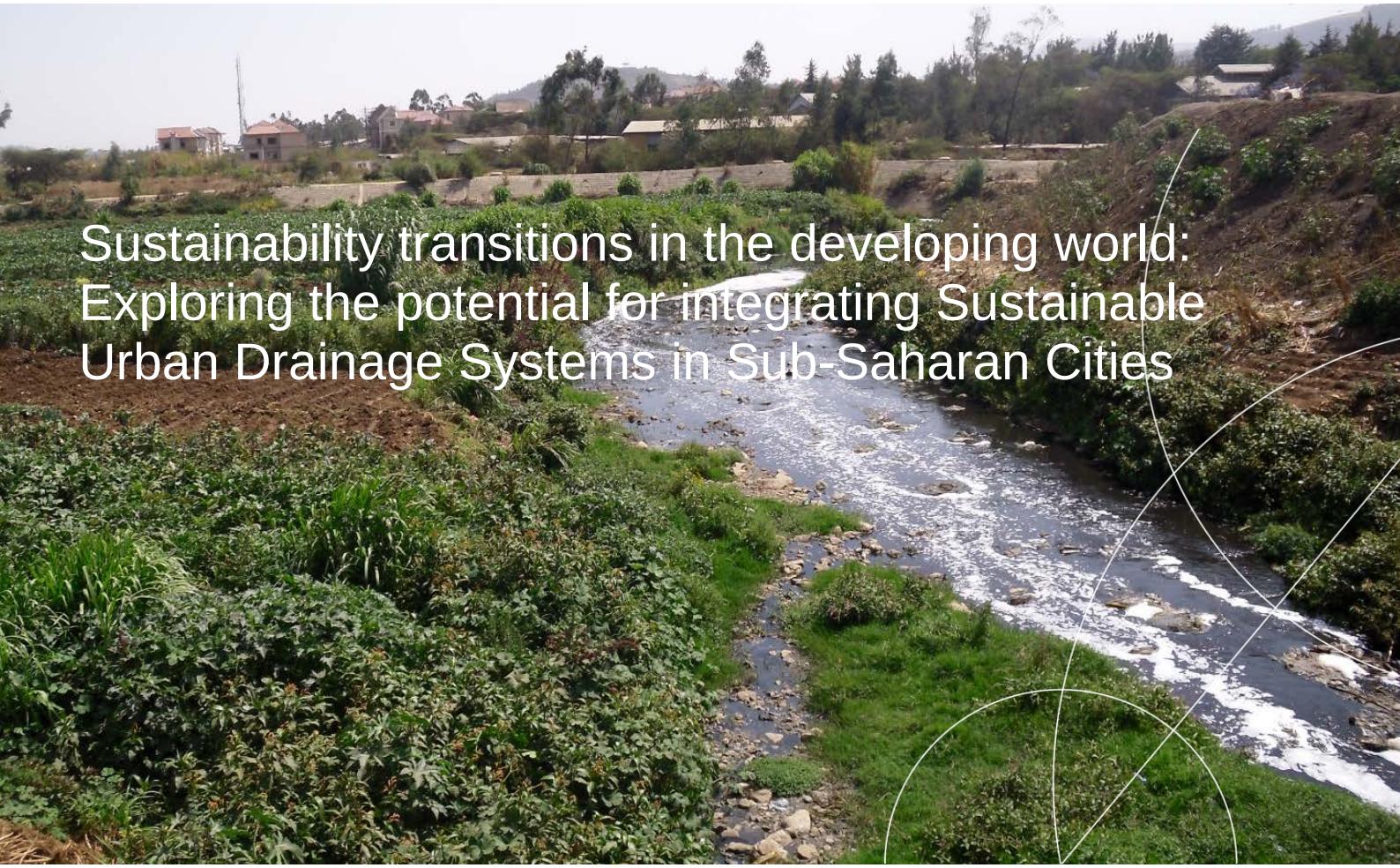

Sustainability transitions in the developing world: Exploring the potential for integrating Sustainable Urban Drainage Systems in Sub-Saharan Cities

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Abstract

With the progression of climate change, urban stormwater management infrastructure will come under pressure. There is doubt about the ability of conventional centralised stormwater management systems to adequately manage projected increases in precipitation and attention in the urban water management sector is turning towards decentralised green infrastructure-based approaches such as Sustainable Urban Drainage Systems (SUDS). This PhD thesis explores the potential for sustainability transitions towards more sustainable urban water management (SUWM) through the integration of SUDS mainly from the perspective of developing world cities, most of which currently face infrastructure deficits and, to a lesser extent, from the perspective of developed cities which are faced with ageing infrastructure and seeking infrastructure renewal options.

Three case studies and a literature review form the empirical foundation of the research which is presented as four research papers. The literature review assesses the theoretical value of using SUDS as a stormwater management option for developing world cities. The first case study explores the potential for integrating SUDS as a flood-risk management option and transitioning towards SUWM in Dar es Salaam and Copenhagen. The second case study explores the potential for socio-technical leapfrogging towards SUWM through the integration of SUDS in Addis Ababa and Dar es Salaam whilst simultaneously exploring the relevance of sustainability transitions concepts to cities in the South. The last case study looks at the ongoing engagement with SUDS in Johannesburg and how far this may signal a transformation towards SUWM.

Results indicate that the potential for integrating SUDS and moving towards SUWM differs according to context. For developing cities with infrastructure deficits like Addis Ababa and Dar es Salaam, most opportunities for socio-technical change lie in more bottom-up emergent change as urban water management regimes may not have adequate capacity. For cities like Johannesburg and Copenhagen with more adequate capacity, change towards SUWM is most likely to be a result of endogenous transformation activities of the urban water management regime. The main contribution of this thesis is in providing an engagement of sustainability transitions concepts with the analysis of urban water management sectors in the global South thus widening the geography of the empirical work in transition studies, as well as highlighting the applicability of approaches such as SUDS to Sub-Saharan cities.

Dansk Resumé

Klimaforandringernes fortsatte udvikling vil belaste infrastrukturer til bymæssige regnvandshåndtering. Der er tvivl om, hvorvidt konventionelle centraliserede regnvandshåndterings systemer vil være i stand til på tilstrækkelig vis at håndtere forventede øgninger i nedbør, og i den bymæssige vandhåndteringssektor rettes opmærksomheden mod decentraliserede grønne infrastrukturbaserede tilgange såsom bæredygtige bymæssige afløbssystemer (SUDS). Denne PhD-afhandling udforsker potentialet for bæredygtig omstilling i retning af mere bæredygtig bymæssig vandhåndtering (SUWM) gennem integration af SUDS primært fra et perspektiv vedrørende byer i udviklingslande, hvoraf mange på nuværende tidspunkt står overfor utilstrækkelig infrastruktur, og i mindre grad fra et perspektiv omkring udviklede byer med forældede infrastrukturer, der søger muligheder for fornyelse af infrastruktur.

Tre case studier og en litteratur gennemgang danner det empiriske grundlag for forskningen, der præsenteres som fire forskningsartikler. Litteraturgennemgangen vurderer de teoretiske værdier ved brug af SUDS som en regnvandshåndteringsmulighed for byer i udviklings lande. Det første case studie udforsker potentialet for at integrere SUDS som håndteringsløsning for oversvømmelsesrisiko og omstilling i retning af SUWM i Dar es Salaam og København. Det næste case studie udforsker potentialet for socio-tekniske kvantespring i retning af SUWM gennem integration af SUDS i Addis Ababa og Dar es Salaam og udforsker samtidig relevansen af koncepter for bæredygtig omstilling for byer syd for Sahara. Det sidste case studie ser på den igangværende indsats med SUDS i Johannesburg, og hvor langt dette kan varsle en omdannelse i retning af SUWM.

Resultaterne indikerer at potentialet for at integrere SUDS og en bevægelse henimod SUWM varierer afhængigt af kontekst. For udviklingsbyer med manglende infrastruktur såsom Addis Ababa og Dar es Salaam ligger flest muligheder for socio-tekniske forandring i en forandring der bygger på bottom-up tilgang da regimer indenfor bymæssig vandhåndtering muligvis ikke har tilstrækkelig kapacitet. For byer såsom Johannesburg og København med mere tilstrækkelig kapacitet vil ændringer i retning af SUWM formentlig være et resultat af endogene omstillingsaktiviteter ved det bymæssige vandhåndteringsregime. Hovedbidraget fra denne afhandling ligger i at levere en indsats indenfor koncepter for bæredygtig omstilling gennem analyser af sektorer for bymæssig vandhåndtering i de globale sydlige områder og derved udvide den geografiske rækkevidde af empirisk arbejde indenfor omstillingsstudier såvel som at fremhæve anvendeligheden af tilgange såsom SUDS i byer syd for Sahara.

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Contents

Background to the study

Introduction

> ***"The very sustainability of cities and the practices of everyday life that constitute 'the urban' are predicated upon and conditioned by the supply, circulation and elimination of water" (Sywngedouw, 2004:1).***

Water is central to the existence and functioning of humanity and the environment; it is also the lifeline of cities (Sywngedouw, 2004; Novotny et al., 2010). The urban water sector has undergone various changes in recent history. Since the late 19th century, existing urban water management systems especially in developed cities have been largely based on traditional engineering approaches resulting in the achievement of the "modern infrastructure ideal" i.e. a universal, centralised and network-based system for water supply, sanitation and stormwater management (Furlong, 2014: 139; Rauch & Morgenroth, 2013). These urban water systems were then operationalised and supported through the 'state hydraulic paradigm' featuring large, centralised engineering systems operated through linear, compartmentalised decision-making by engineers (Bakker, 2010; Brown et al., 2011).

In this paradigm the supply, treatment and drainage of all manner of water in urban areas became the sole responsibility of the State through the provisions of a hydrosocial contract (Lundqvist et al., 2001). The hydrosocial contract is the unwritten contract between the public and government relating to normative values upon which the institutional arrangements related to the management and use of water in a society are built. In the Hobbesian[1] hydrosocial contract, which is the basis for the municipal hydraulic paradigm, the State assumed the benevolent role of principal provider and manager of water services as a public good (Turton & Meissner, 2002). Thus individual initiative in the sourcing and elimination of water was removed and so too were the previous intimate links between people and water (ibid; Sywngedouw, 2004).

Within the urban water management sector, the elimination of waste water and stormwater from the city, i.e. urban drainage, has traditionally been progressively concerned with public hygiene, floodrisk management and environmental protection of water bodies respectively (Chocat et al., 2007; Butler & Davies., 2011). In developed countries, most cities have managed to achieve public hygiene and flood protection and are engaging more realistically with ensuring the environmental

[1] In terms of the historical evolution of water management principles there are said to be two variants of the hydrosocial contract, namely Hobbesian and the Lockean. During the late 19th and early 20th century Hobbesian form of the hydrosocial contract came into play as the State became the main agent and executor of water services. The Lockean form of the hydrosocial contract comes into play when the State begins to face difficulty in providing water services due to rising demand and environmental issues. The provision of water services then becomes a shared domain between the State, public and private actors (Lundqvist et al., 2003; Turton & Meissner., 2002).

quality of water bodies. However as water infrastructure begins to decay, these cities are beginning to search for alternative infrastructure renewal options (Brown et al., 2011; Chocat et al., 2007). In developing countries on the other hand, many cities are faced with rapid urbanisation and stubborn infrastructure deficits, thus they struggle to ensure public hygiene and flood protection, as well as provide their citizens with clean and adequate supplies of water (Chocat et al., 2007; Kyessi, 2005). From an urban drainage perspective, the traditional approach to drainage under the state hydraulic paradigm has been increasingly criticised for resulting in a path-dependency on centralised, hard infrastructure solutions in developed cities; solutions which are considered unsustainable in the face of climate change and sustainability challenges (Ferguson et al., 2013; Wong & Brown, 2009). Furthermore, for many cities in the global South, governments have attempted without much success to achieve the so called modern infrastructure ideal as propagated by the state hydraulic paradigm (Bakker, 2010; Furlong, 2014).

Currently, in nearly all cities in the South, part of the population still depends on alternative water services provision (Hordijk et al., 2014) i.e. from buying water from independent suppliers to organising stormwater management through community groups. More specifically the management of stormwater in developing cities represents a critical challenge with potentially severe consequences if neglected, even more so in relation to the climate change phenomenon (Parkinson & Mark, 2005).

Climate change and critical urban infrastructure systems

Over the past two decades there has been growing concern world over of the impacts that projected climate change will have on societies and the natural environment. Increasingly, attention is being directed at mitigating and adapting to climate change at the urban scale as climate change becomes an important policy issue for cities (Evans, 2011; Bulkeley et al., 2014). It is thought the challenge of adapting to climate change is most pressing for cities for several reasons. Firstly, as of 2008 cities are now home to more than 50% of the world's population, a fact that is likely to increase as population growth and urbanisation trends increase, especially in Asia and Africa (UN, 2012). Thus cities are considered to be especially vulnerable to climate change. Secondly, cities concentrate critical infrastructure networks like energy, transport and water systems which are brought under increasing pressure as climate extremes such as increased precipitation and droughts bring further complexity and uncertainty to the challenge of providing and organizing urban infrastructure services (Brown et al., 2011; Bulkeley et al., 2011).

Consequently urban infrastructure systems have begun to feature prominently in urban climate change responses (Bulkeley et al., 2014). While urban infrastructures have until recently been conceived as fairly straight-forward engineering and management issues of largely stationary phenomena (Brown et al., 2011), the uncertainty and complexity accompanying climate change and increased urbanization have brought a rethink of the assumptions on which the provision and management of urban infrastructures are based (Graham & Marvin, 2001; Gleick, 2003; Bulkeley et al., 2011). Critical infrastructure systems are seen as important means of responding to climate change; as such they configure, and will be increasingly configured by, urban responses to climate change (Bulkeley et al., 2014).

The UN predicts that between 2011 and 2050 the world population will increase from 7 billion people to 9.3 billion people (UN, 2012). Geographically-speaking most of the population growth

will be concentrated in cities of the developing world namely Asian and African cities (ibid) and African cities will experience the highest growth rates. The projected increases in population will further increase the rate of urbanisation and deepen the deficits in infrastructure that are already plaguing these cities (Jha et al., 2005; UN, 2014).
If this 'second wave' of urbanisation is coupled with the likelihood that projected climate change impacts will be most keenly felt in developing countries, then a picture of the serious vulnerability of populations and infrastructure in developing cities to climate change and other shocks begins to emerge (UN, 2011). Therefore the risks posed by climate change and increased urbanisation set the contextual backdrop for much academic and policy thinking in urban studies in general and in urban water scholarship more specifically especially for developing cities.

Towards Sustainable Urban Water Management – Sustainable Urban Drainage Systems as a stormwater management alternative

Urban water management systems worldwide are increasingly facing problems of water scarcity, flooding and pollution, so much so that water crises are seen as a primary global risk in the near future (Fontein, 2008; Ferguson et al., 2013; WEF, 2015). In light of these issues and new environmental problems mentioned above such as climate change and biodiversity depletion, the management of stormwater in urban areas is seen as an important challenge (Fletcher et al., 2014; UN, 2011; Steffen et al., 2015). It is predicted that stormwater management infrastructure will come under increasing pressure as the incidence of extreme precipitation, storm surges and rising sea levels increase with the advance of climate change (Revi et al., 2014).

Traditionally, the urban drainage systems developed within the state hydraulic paradigm have been historically centralised and configured to rid the city of storm water as quickly as possible resulting in increased imperviousness in urban areas (Novotny, 2009). However in light of the above problems there are concerns about the ability of the conventional pipe-based stormwater management approach to adequately manage the projected precipitation and hydrologic changes (Burns et al., 2012; Chocat et al., 2007). As such, there has been a tentative turn within the urban water sector towards decentralised, alternative approaches to urban water management in general and urban stormwater management more specifically (Parkinson & Mark, 2005; Mitchell & Howe, 2012; Novotny et al., 2010).

Such decentralised approaches to water management may help cities address not only water supply, flood risk and public hygiene but also provide additional benefits which may increase the resilience of cities to climate change and overall sustainability (Fletcher et al., 2014; Rauch & Morgenroth, 2013; Chocat et al., 2007). This emerging approach, termed Sustainable Urban Water Management (SUWM) is based on the belief that " […] urban waters are the lifeline of cities […]" and may lead to greener, more sustainable urban environments if managed in an integrated and decentralised way (Novotny, 2009:19). SUWM is similar in ideology to Integrated Urban Water Management (IUWM) and Water Sensitive Urban Design (WSUD) (Bos et al., 2013).

SUWM considers green developments and concepts at the micro-scale and links them with larger watershed-level management infrastructures for water supply, sewerage and stormwater (Novotny, 2009). In contrast to the traditional approach to urban water management which compartmentalises the supply, sewerage and stormwater components of the urban water cycle; SUWM emphasises total water cycle management building on the concepts of environmental protection and

sustainability, ideally making connections between the urban water system, green infrastructure and land use planning among other urban functions (Ashley, 2011; Brown et al., 2011). SUWM is seen as one way of achieving water sensitive urban futures i.e. cities that will act as water supply catchments, provide ecosystem services whilst having citizenry that increasingly behaves in environmentally-sustainable ways (Wong & Brown, 2009).

Looking at stormwater management from within the SUWM perspective, one alternative approach to the conventional fast-conveyance, pipe-based stormwater management is that of Sustainable Urban Drainage Systems. Sustainable Urban Drainage Systems (SUDS) is the British term for a stormwater management approach also known as Best Management Practices (BMP's) in North America, Low Impact Development (LID) in North America and New Zealand, Lokal Anvendelse af Regnvand (LAR) in Denmark, Water Sensitive Urban Design (WSUD) in Australia and South Africa or Landscape-based stormwater management (LSM) among other terms depending on geographical context (see Fletcher et al., 2014; Fryd et al., 2012). Contrary to the traditional view of stormwater being a nuisance to be removed quickly, in the SUDS approach stormwater is viewed as a resource and an opportunity for more integrated management of the urban water cycle (Novotny et al., 2010).

Sustainable Urban Drainage Systems are stormwater management systems that mimic the natural hydrological cycle processes by mobilising the urban landscape's green infrastructure for the infiltration, storage, detention, retention, evapotranspiration, conveyance and treatment of stormwater (Charlesworth et al.,2003; Fryd et al., 2012). As a concept SUDS have three main aims: (1) to reduce the **quantity** of runoff through source control and slowing the velocity of runoff; (2) to improve the **quality** of stormwater by providing passive treatment of collected surface water before discharge onto land or a watercourse and (3) to enhance amenity and maintain **biodiversity** (Charlesworth et al., 2003:100; Ashley et al., 2011). SUDS consist of structural and non-structural elements at site-level such as appropriate solid waste disposal practices, rainwater harvesting; green roofs, living walls and permeable paving. They also consist of elements at wider scale (i.e. local and watershed) such as constructed wetlands, infiltration trenches, retention ponds among others (Charlesworth et al., 2003; Armitage et al., 2013).

Figure 1. Examples of different Sustainable Urban Drainage Systems elements in Malmø, Sweden. (1) Pond in Western Harbour. (2) Permeable paving in Western Harbour. (3) Raingarden in Western Harbour. (4) Green roof in Augustenborg.

In practice the promotion of SUWM and the adoption of approaches like SUDS in urban environments are complex issues. It is thought that the challenge of integrating alternative infrastructure approaches like SUDS is best conceived as a 'wicked problem' due to the uncertainty and complexity that drivers like climate change present and also due to the untried nature of SUDS (Fryd et al., 2010; Taylor et al., 2011). For instance, although SUDS and its basic components are seemingly straightforward, the design and implementation of city-wide SUDS retrofits are actually complex (Fryd et al., 2010). In addition there are 'relational complexities' that underlie the implementation of SUDS such as the competition for space in the urban landscape and the inherent need for a transdisciplinary multi-tiered approach that is different from the linear, engineer-driven conventional centralised water systems (Frantini et al., 2012; Fryd et al., 2012).

On a more practical level, it is difficult to precisely quantify the hydraulic and water quality improvement performances of SUDS in the management of runoff, especially at a city-wide level

(Ashley et al., 2011; Goldenfum et al., 2007). Furthermore the need for costly, highly-skilled maintenance and regulation of SUDS elements presents a significant barrier, especially when considering that such skills and resources may not be available in developing countries (Armitage, 2011). Lastly, it remains difficult to assess the value of employing SUDS in an urban context in comparison to conventional stormwater management systems since there are no clear methodologies to measure the 'sustainability' of SUDS yet (Benzerra et al., 2012; Ashley et al., 2011).

As a result, while there is general agreement amongst urban water practitioners (especially in developed cities) of the need to change the trajectory of urban water management towards more sustainable configurations such as SUWM and employ approaches such as SUDS, progress in transforming urban water management systems from conventional systems towards decentralised, green infrastructure-based systems has so far been slow (Brown et al., 2011; Chocat et al., 2007; Rauch & Morgenroth, 2013). Granted, several cities around the world have begun integrating SUDS as part of their stormwater management e.g. cities in Australia, Sweden, UK, Germany and USA. However the approach is yet to become more mainstream in water management practice and large-scale SUDS retrofits of stormwater systems are yet to be achieved (Brown et al., 2013; Novotny et al., 2010; Backhaus & Fryd, 2012).

In relation to the turn towards more sustainable approaches to urban water management, many urban water sectors in cities around the world face already dual challenges: the **sustainability challenge** of how a path-dependent and technocratic sector can change direction towards more sustainable and resilient trajectories as well as a **transition challenge** of how such a change in trajectory could be realised (de Haan et al., 2015). For many in the urban water management fraternity what is entailed in the transformation towards SUWM, through in part the integration of SUDS, is still poorly understood (Novotny et al., 2010; Bos et al., 2013). Thus one of the pressing questions confronting urban water scholarship is *how the shift towards more sustainable configurations of urban water such as SUWM can be enabled and indeed governed in different urban contexts* (van de Meene et al., 2011). This question is the founding inspiration for this thesis.

One approach to conceptualizing the transformation of urban water management sectors towards SUWM in general, as well as the shift towards increased integration of SUDS into urban environments is that of **'sustainability transitions'** (Markard et al., 2012). Theories of sustainability transitions are increasingly employed to understand how socio-technical infrastructure systems change and transform through technological and social innovation. It is from theories of sustainability transitions that the language of transitions has entered the discussion of sustainable development in general (Swilling & Annecke, 2012), and discussions on the sustainability challenge facing urban water infrastructure networks more specifically (de Haan et al., 2015; Brown et al., 2009).

The sustainability transitions conceptualization of the sustainable development challenge has become an increasingly popular framework within urban studies especially in consideration of climate change mitigation and adaption challenge and the need for decoupling urban economic development from intense natural resource. One example of this popularity is in the rising salience of ideas such as 'low-carbon transitions' in urban policy and governance (Bulkeley et al., 2011).

Identifying research gaps

From a global South perspective, the idea of SUDS has yet to gain attention, especially in Sub-Saharan cities where, with the possible exception of fledgling initiatives in Cape Town, Durban and Johannesburg, the approach has still to be recognised as a viable response to projected climate change impacts and the persistent deficits in drainage infrastructure. Yet cities in developing countries may stand to benefit the most from leapfrogging over the modern centralised infrastructure ideal, which most have failed to achieve, towards decentralised, green infrastructure-based approaches such as SUDS (Novotny et al., 2010). While there is an increasing body of work on sustainable/integrated urban water management from a global South perspective (see Reed, 2004; Sharma, 2008; Bahri, 2012; Howe et al., 2012; Goldenfum et al., 2007), there is still a need for further exploration of the applicability of SUDS and the potential for transformation towards SUWM in Sub-Saharan urban contexts.

Within the field of sustainability transitions, critical infrastructural networks such as the urban water are conceived as 'sociotechnical systems' because they are comprised and coproduced by both technological and social dynamics (Bulkeley et al., 2011). As scholars grapple with understanding the dynamics of sociotechnical change towards sustainability in sectors such as urban water, energy, agriculture and health, the main sustainability transitions frameworks they have employed are the Multi-Level Perspective (MLP) on sociotechnical transitions, Strategic Niche Management (SNM), Transition Management (TM) and Technological Innovation Systems (TIS) (Markard et al., 2012).

However the field of sustainability transitions research is said to suffer to some extent from a bias towards the Occidental with most studies of sustainability transitions largely addressing cases in the developed world (Lachmann, 2013; Markard et al., 2012; Swilling & Annecke, 2012). This is changing of course as we see more studies in e.g. energy transitions applying SNM to cases in India, Kenya and Tanzania (See Verbong et al., 2010; Caniels & Romijn, 2008; Eijik & Romijn., 2008; Byrne, 2009); and studies from the perspective of Newly Industrialised Countries or the emergent economies of Asia (See Rock et al., 2009; Berkhout et al., 2011; Bai et al., 2010 and Binz et al., 2012). Within the field the urban scale is also said to be under-explored in favour of studies of sectoral or national transitions, ultimately leading to a lack of sensitivity to the geography of transitions (Monstardt, 2009; Næss &Vogel., 2012; Hodson & Marvin., 2010; Raven et al., 2012; Coenen et al., 2012).

Markard et al (2012) highlight that sustainability transitions literature could benefit from more inclusion of non-OECD contexts which will necessitate more conceptual work within the field. In the same vein, from the perspective of transitions towards SUWM, there is a lack of research done on the potential and on-going transitions in the urban water sectors in the context of Sub-Saharan cities. This is despite the potential usefulness that approaches within the sustainability transition field may have for mapping and analysing past and current changes, as well as the potential for kick-starting radical changes towards sustainable futures in cities of the 'subaltern' (Lachmann, 2013; Harrison, 2006).

Granted, research has been done on the potential for African cities like Accra, Cape Town, Alexandra to integrate SUDS as a resilience-enhancing drainage option (see Butterworth et al.,

2011; Armitage et al., 2013); there is still however room for more empirical engagement with such and other cases from the point of view of sustainability transitions[2]. This is because cities in the global South may be arguably more in need of such 'sustainability transition' analyses (Lachmann, 2013); if they are to avoid the path dependence on centralised pipe-based water systems entrenched in Western cities and possibly leapfrog towards water-sensitive urban futures (Wong & Brown, 2009). As such the need to "[…] examine what transitions look like in ordinary cities and cities in the global South […]" still persists (Hodson & Marvin, 2010:484).

[2] Nastar & Ramasar (2012) use the sustainability transitions heuristic for a governance analysis of Johannesburg's water sector.

Objectives

In line with the above-mentioned research gaps, the overall guiding research question in this thesis is: 'How can cities, especially those in the global South, adopt and integrate SUDS and transition towards SUWM?' The main gaze in this thesis is from a Sub-Saharan perspective and although Copenhagen has been included as case, this was done mainly for purposes of comparison.

Thus the main objective of this thesis is to explore and illustrate potential and ongoing sustainability transitions towards Sustainable Urban Water Management (SUWM) through Sustainable Urban Drainage Systems (SUDS) in Dar es Salaam, Addis Ababa, Johannesburg and Copenhagen. Such explorations and illustrations seek to contribute to both the research fields of sustainability transitions and urban water scholarship by providing empirical engagement with under-represented contexts in both fields, as well as contributing to widening the geography of transitions research. By exploring the potential for shifts towards more sustainable urban water management, this thesis has a normative departure point seeing sustainability as a valid goal to which cities can aspire to in light of the challenges human development is currently confronted with.

The specific objectives are:

(i) To conduct a literature review to assess the theoretical value of using SUDS as a green infrastructure-based complementary alternative to conventional stormwater management in the context of developing world cities (Paper I),

(ii) To perform a comparative analysis of the potential for a transition towards sustainable urban water management (SUWM) in Dar es Salaam and Copenhagen by examining the opportunities and barriers for the integration of SUDS as a flood-risk management option in the two cities (Paper II),

(iii) To analyse the potential for leapfrogging towards SUWM through the integration of SUDS in the water management sectors of Addis Ababa and Dar es Salaam whilst simultaneously exploring the relevance of sustainability transition theories to the cities in the South (Paper III)

(iv) To analyse the ongoing engagement with SUDS currently underway in Johannesburg and how far this engagement may constitute the start of a transition towards SUWM in the Sub-Saharan city (Paper IV)

While this thesis looks at the potential for transitions towards sustainability especially in urban water management sectors in the South, this is not to say the sectors have been static. Indeed, there have been other changes that have taken place in the urban water sectors around the world. For instance, urban water management regimes have been experimenting with different forms of water governance i.e. public-private sector partnerships; neoliberal privitisation and in some instances community governance (Bakker, 2010; Hordjik et al., 2014; Pigeon, 2012). Yet few of these changes have explicitly sought increased integration of urban water functions in a manner that will facilitate more environmentally sustainable configurations.

Theoretical Framework

This section presents the theoretical framework that supports this thesis. It highlights the central concepts of the Multi-Level Perspective, Strategic Niche Management, the hydrosocial contract, transition typologies, leapfrogging and agency as they have been used in the thesis.

Of sustainability transitions in urban water management

Since the emergence of sustainability as a concept in the 1987 Bruntland Report there has been a paradigm shift towards 'sustainable development' in human development policy (Burns, 2012; Mancebo, 2015). Defined as development that meets the needs of the present without compromising the ability of posterity to meet its needs, the concept of sustainable development has been widely applied to urban planning and management (Bruntland et al., 1987; Wheeler & Beatley, 2004). In addition, the debate on climate change has brought new emphasis on adaptation and resilience as paths towards urban sustainability in the face of projected climate change impacts (Evans, 2011). However, despite its wide appeal, the concept of sustainable development has been subject to criticism due to its normative and prescriptive nature as well as the broadness of its definition (Fahy & Rau, 2013).

The challenge of sustainable development is increasingly understood in terms of 'transitions' towards more sustainable configurations of production and consumption (Smith et al., 2010; Markard et al., 2012). As such, one approach to conceptualizing the transformation towards SUWM in general, as well as the shift towards increased integration of SUDS into urban environments is that of 'sustainability transitions' (de Haan et al., 2015). Theories of sustainability transitions have sought to understand how infrastructure systems change and transform through technological and social innovation.

In terms of sustainability transitions challenge in urban water management, it is important to understand that the points of departure and drivers for potential shifts towards SUWM naturally differ between cities in the developed world and those in the developing world. While cities in the developed world such as Copenhagen have relatively fully-developed conventional water service systems, they are increasingly confronted with decaying infrastructure, questions about path dependence, and the choices to be made about the development of appropriate infrastructure in the face of climatic and socio-economic uncertainties (Brown et al., 2011). These cities face the **challenge of retrofitting** existing water infrastructure systems and the built environment in general into more sustainable configurations (Dixon et al., 2014).

On the other hand, most cities in the developing world have urban water infrastructure deficits as it stands, along with deteriorating physical environments (Bhatt, 2014; Bakker, 2010; Hordijk et al., 2014). Thus they are confronted with the question of developing infrastructure that is able to adequately serve current needs whilst also being resilient to projected climate change impacts (Dodman et al., 2009). As such, these cities face the sustainability transitions **challenge of leapfrogging** over the technological path dependencies confronting the water sectors of developed cities and to instead develop more sustainable configurations of urban water systems whilst

simultaneously addressing basic access to water supply and drainage (Swilling et al., 2013; UN 2014).

Socio-technical transitions are long-term, multi-dimensional and fundamental transformation processes through which established socio-technical systems shift towards more sustainable modes of production and consumption (Markard et al., 2012). Socio-technical transitions differ from technological transitions in that they also include changes in dominant cultures, user practices and institutional structures in addition to changes in technologies (Frantzeskaki & de Haan, 2009). Furthermore they require the emergence of complementary technologies and non-technical innovations (Markard et al., 2012) e.g. for SUWM this could mean the emergence of dual reticulation systems, water sensitive behaviours, requisite regulations etc.

Sustainability transitions also differ from historical transitions. Firstly, sustainable development is a normative goal and a 'public good' problem that is subject to deep-seated values and norms on the one hand, and the problems of prisoners' dilemma and free-riding on the other (Geels, 2010). Secondly, while historical transitions were about choices between one or two alternative technologies, sustainability transitions are typically involve choosing from multiple green alternatives, thus bringing to the fore such questions as who gets to choose the alternatives and transition paths that are taken (ibid). Finally, sustainability and resilience are notions seeking to address intangible problems such as climate change likely to come in the future. As such sustainability may not be considered as urgent as were problems of water pollution and acid rain historically (Geels, 2010; Lachmann, 2013). In practice, the multi-dimensional nature of sustainability as a concept, and its on-going definition also presents a challenge for transition studies (Markard et al., 2012).

As aforementioned, there are mainly four conceptual frameworks that have emerged in the burgeoning field of sustainability transitions. Of these, retrospective approaches like the Multi-Level Perspective (MLP) explain how change happens, what the critical factors of a transition are etc (see Rip & Kemp, 1998; Geels, 2004). Perspective approaches such as the Technological Innovation Systems (TIS) look at the recent past and the likelihood or conditions for system innovations towards sustainability (see Markard & Truffer, 2008; Bergek et al., 2008). Prospective approaches such as Transition Management (TM) (see Rotmans et al., 2001; Loorbach, 2007) and Strategic Niche Management (SNM) (see Raven, 2006; Schot & Geels, 2008) investigate how radical transformative change can be purposively triggered and governed. In this thesis the main frameworks used are the MLP (to a large extent) and SNM.

The Multi-Level Perspective on Sustainability Transitions

The MLP is a middle-range framework that utilises process theory in analysing socio-technical transitions (Geels & Schot 2007; Geels, 2011). It is seen as valuable heuristic device whose terminology enables analysts to map and organise the different temporal, technological and social aspects of a socio-technical system into narrative accounts of transitions (Smith et al., 2010). The MLP posits that a sociotechnical system is configured and structured by three analytical levels; namely the sociotechnical landscape, the sociotechnical niche and the sociotechnical regime (Geels, 2010).

At the macro-level is the ‘socio-technical landscape’, which forms the structural backdrop for both the regime and niche levels. Landscape level factors include demographic and environmental changes, new social movements, shifts in political ideology, broad macro-economic trends, emerging scientific paradigms and cultural developments among other factors (Geels &Kemp., 2007; Smith et al., 2010). Landscape factors are the source of pressure for change at the regime level; they prompt responses from within the regime and they generate opportunities for niche innovations to break through (Smith et al., 2010). Changes at the landscape level are slow, happening over decades (Geels, 2005).

At the meso-level is the ‘socio-technical regime’ which is a supposedly stable configuration of institutions, techniques, artefacts, practices and networks based on semi-coherent rules and determining how technologies develop and are used (Geels, 2011; Rip and Kemp., 1998). It is this alignment between the different elements of this configuration that makes the socio-technical regime dynamically stable and resistant to change (Raven, 2006); an alignment, which makes the socio-technical regime “[…] a configuration that works […]” (Rip and Kemp, 1998:330). Socio-technical regimes stabilize existing trajectories through cognitive routines, regulations and standards, adaptation of lifestyles to technical systems, sunk investments in infrastructure and competencies (Geels & Schot, 2007).

Socio-technical regimes constitute the mainstream and highly-institutionalised way of realising societal functions such as urban water services (Smith et al., 2010). However, sociotechnical regimes are currently confronted with new sustainability criteria that were never considered during their installation (ibid). For urban water sociotechnical systems the ‘urban water management regime’ can be delineated as the people and organisations who manage water services as well as the corresponding legislation, policies and practices (van de Meene et al., 2011).

Lastly, the ‘niche’ is the micro-level locus around which radical innovations or alternatives such as SUDS may develop (Geels & Kemp., 2007; Geels, 2005). Socio-technical niches provide protective spaces for path-breaking, radical alternatives whose performance may not be competitive against the selection environment prevailing on the regime (Smith et al., 2010). For niches the rules and other elements such as institutions and social networks are still in the making thus making niches unstable (Geels & Schot, 2007:402).

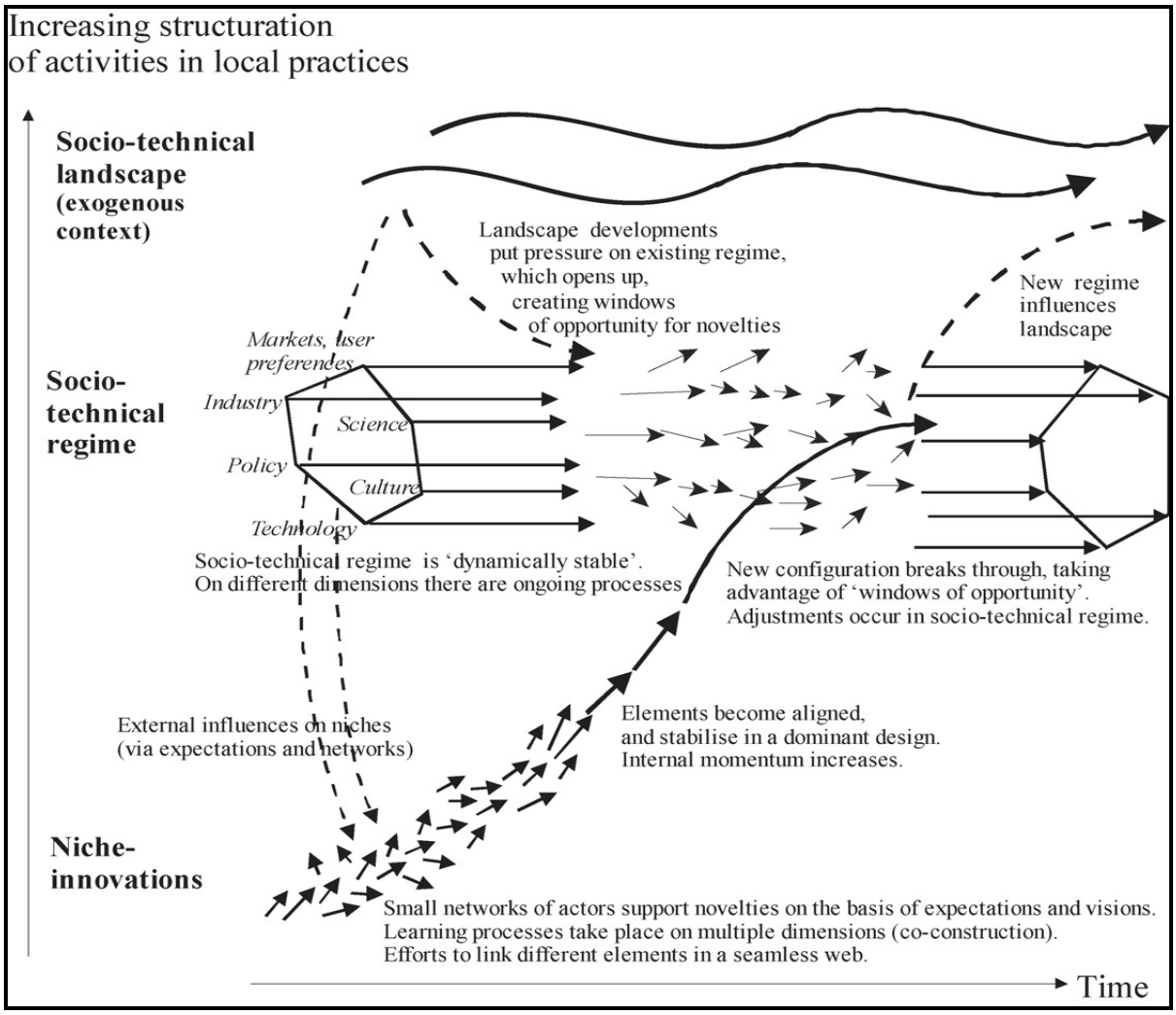

Figure 2. The Multi-Level Perspective on transitions. Source: Geels and Schot (2007, p. 401).

According to the MLP, socio-technical transitions towards sustainability are in essence regime shifts (Geels, 2010; Koppenjan et al., 2012). These regime shifts come about through the interaction and alignment of the following coevolutionary processes between the three analytical levels: (1) niche innovations build up internal momentum to challenge the regime; (2) changes at the landscape level exert pressure on the regime; and (3) destabilization of the regime creates windows of opportunity for niche alternatives (Geels & Schot, 2007; Schot & Geels., 2008). These three processes are also known as selection pressures (Smith et al., 2005).

Criticisms

The MLP, and indeed transition frameworks in general, has been subject to various criticisms which have also been acknowledged to some extent (See Geels, 2011; Smith et al., 2010). I highlight some of the criticisms here. The first critique is that the MLP is too descriptive and structural and as a result lacks a conceptualisation of agency and power (see Smith et al., 2005; Genus & Coles, 2008; Farla et al., 2012). Although, the notion of agency is implicit in the MLP, its static conceptualization of human behaviour (i.e. as agents enacting the transition) is said to constrain its

explanatory power in terms of its description of the processes of change (Pesch, 2015). On a more general level, transition frameworks such as the MLP have also been criticised for having an insufficient conceptualisation of politics and power (a criticism related to the said shortcomings on conceptualising agency) (see Markard et al., 2012; Meadowcroft, 2009; Shove & Walker, 2007).

A second criticism concerns the lack of clarity in the delineation and operationalisation of the landscape, regime and niche concepts in research practice and analysis (see Berkhout et al., 2004; Smith, 2007). In line with this criticism of the difficulty in delineating and operationalising the MLP's analytical concepts, there is a related criticism that the MLP is based on the assumption that the niche-level is made up of market-based innovations that are pursued by competitive, profit-seeking firms (Seyfang & Smith, 2007; Seyfang & Longhurst, 2013).

Instead, Seyfang and Smith (2007) suggest that the 'grassroots initiatives' that are pursued by local communities and other non-regime actors, to address unmet social and environmental needs or to align with sustainability as an ideology, are also a site of innovation and therefore a valid conceptualisation of the niche level too. In contrast to the innovations by profit-seeking firms within a market economy, grassroots initiatives function within a 'social economy' instead (Seyfang & Smith, 2007:591). This social economy provides contextualised and flexible services to communities where the market and State cannot (ibid).

Another criticism has been that the MLP privileges a bottom-up view of transition i.e. from the niche towards the regime, without due consideration of possible transformative change that could come from within the regime itself (Smith et al., 2005; Quitzau et al., 2013). This criticism has been addressed to some extent through the subsequent development of several typologies of transition pathways and transition contexts which have also been used in this thesis (see Geels & Schot., 2007; Geels & Kemp, 2007; Smith et al., 2005).

Finally, critics also highlight the apparent lack of geographical sensitivity in the transitions frameworks, with space and scale often implicit in most studies but still under-theorised (see Coenen et al., 2012; Raven et al., 2012; Truffer & Coenen, 2012). Also, as mentioned before, in terms of empirical work much transition scholarship has dealt with cases from the Occidental, although this has started to change over the past decade (Markard et al., 2012; Hodson & Marvin, 2010).

Despite these caveats, in this thesis the MLP has been used to trace the historical and current dynamics in the urban water management sectors of the four case cities as well as to highlight the normative potential for future transitions towards SUWM through SUDS. In addition, due to the constrained nature of the water management regimes in Dar es Salaam and Addis Ababa, as well as the evidence of various infrastructure provision activities emerging from local level within these cities, I have also employed Seyfang and Smith's (2007) conceptualisation of the local community-level (grassroots level) as a valid site for innovation towards sustainability i.e. as constituting the niche level in the two cities.

The Hydrosocial Contract – The foundations of urban water management

Another concept that is helpful in the study of urban water management, and compliments the transitions research into the potential to integrate SUDS and transition towards SUWM in both

developed and developing cities is that of the 'hydrosocial contract' (Lundqvist et al., 2001; Brown et al., 2009). As highlighted before, the hydrosocial contract is the unwritten agreement giving the State the responsibility to supply society with water as well as urban drainage services (Turton & Meissner, 2002). From the MLP point of view, the hydrosocial contract is the foundation for the existence and configuration of the urban water management regime, as it is expressed and manifested through the regime's institutional arrangements, regulatory frameworks and physical water systems infrastructure (Brown et al., 2009).

According to Turton and Meissner (2002) there are two different forms of the hydrosocial contract identifiable; the Hobbesian and Lockean hydrosocial contracts. As mentioned earlier, the Hobbesian form of the hydrosocial contract is characterised by the State assuming the sole responsibility of providing and managing water services as a public good, usually at subsidized prices to the public (Turton & Meissner., 2002). The emergence of the state hydraulic paradigm in the late 19th century (Bakker, 2010) and the 'modern infrastructure ideal' as a model of urban water service provision (Furlong, 2014) were both based on the Hobbesian hydrosocial contract. Most cities in the developed world can be said to have a functional Hobbesian hydrosocial contract as their water management regimes are generally able to provide reliable water services to their citizens.

However the story is quite different for most developing cities. Whereas urban water infrastructure in most Sub-Saharan cities was historically developed based on a Hobbesian arrangement by colonial governments, the discriminatory mode of service provision at the time meant such cities were saddled with an inherent infrastructure deficit that has been worsened by current factors such rapid urbanisation (see Kironde, 2007; Kyessi, 2005; Bhatt, 2014). As such although the Hobbesian hydrosocial contract prevails officially in many Sub-Saharan cities, in reality the urban water management regimes are incapacitated and the responsibility for water supply and drainage rests mostly with communities and the households there in.

The other type of hydrosocial contract is the 'Lockean' form which is more normative (Turton & Meissner, 2002). In it the responsibility for managing urban water and drainage services is shared by government, the private sector and the public e.g. Civil Society Organisations (CSO's) which include Non-Governmental Organisations (NGO's) and Community-based Organisations (CBO's) as well as small-scale independent water and sanitation providers (SSP's) (Collingnon & Vézina, 2000; Lundqvist et al., 2001).

The hydrosocial contract concept has been useful for the study of sustainability transitions because the potential for sustainability transitions in a city's water sector may depend on the type and status of the prevailing hydrosocial contract within a city's urban water sector. The concept was useful in illuminating the importance of governance as a critical aspect of urban water systems, giving us an analytical departure point to understand the dynamics in the water sectors of the case cities i.e. what the roles and responsibilities of different actors were *officially* and *in reality*; as well as exploring what they could be *normatively* if they were to support sustainability.

Strategic Niche Management – Analysing emergent transitions towards sustainability

To complement the MLP as a framework for understanding current situations in urban water management sectors and to imagine how potential transitions towards SUDS integration may come

about in the case cities, this thesis also uses SNM to analyse an emergent transition towards SUWM through an engagement with SUDS in the city of Johannesburg. The SNM concept extends the MLP's main thesis by suggesting that sustainability transitions can be enabled by the creation of technological niches i.e. "[…] protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures" (Schot & Geels, 2008: 538; Raven, 2012).

In much transitions research practice the MLP and SNM frameworks are increasingly combined (Maasen, 2012; Canïels & Romijn, 2008). By combining the MLP and SNM frameworks I was able not only to map the current and historical dynamics in urban water management in Johannesburg but also to assess how far the on-going engagement with SUDS in Johannesburg may constitute the beginning of a transition towards SUWM. Although mostly used in ex-post analyses of niche development processes (Schot & Geels, 2008), the SNM framework is also applicable to the analysis of ongoing transitions as it provides a view to the conditions necessary for the successful incubation of alternatives such as SUDS.

SNM research distinguishes three niche-internal processes or criteria necessary for the successful development of a niche alternative like SUDS (Schot & Geels, 2008). These criteria are *the articulation of robust, specific and high quality expectations and visions*; *the building of broad and influential social networks*; and the existence of *learning processes* at various dimensions of the sociotechnical system (ibid). First, expectations and visions are critical for attracting attention to the niche alternative and for mobilising resources based on promises of future benefits (Raven, 2006). They are also important for providing direction to learning processes and are most effective when they are tangible and realistic as well as shared by an increasing number of actors (Raven, 2012).

Secondly, the building of broad social networks which include actors from outside the regime helps in enrolling a constituency behind the niche alternative, facilitating stakeholder engagement, mobilisation of resources, institutional embedding and carrying learning (Schot & Geels., 2008; Raven, 2012). Lastly, due the emphasis on 'experimentation' in SNM, learning (distinguished into first and second order learning[3]) is considered important (Raven, 2012; Smith, 2007). Learning may make the niche development process more reflexive and lead to deeper social networks and make expectations and visions more relevant (Raven, 2012; Geels & Raven., 2006). From an SNM perspective, in this thesis the Johannesburg case was analysed based on the extent to which the ongoing initiatives to integrate SUDS in the city satisfy the above mentioned criteria and, by extension, the likelihood of a transition towards SUWM in the city.

On transition typologies: Transition pathways and contexts

[3] First order learning happens when actors analyse a chosen solution within the context of a given problem definition all whilst still retaining the underlying theoretical insights, convictions and values. Second order learning results when actors are confronted with new perspectives which trigger a rethink of dominant mental and action models, particularly of theoretical insights and deeply rooted values and convictions and prompt a search for new forms of action and interaction (Vogelezang et al., 2009).

Part of the agenda in the sustainability transitions research community since 2010 has been to take a look closer at different geographical contexts and how/if these may have any implications for the types of transitions that take place (STRN, 2010). As highlighted above, one of the criticisms towards the MLP and other transition frameworks is that they mainly conceptualise transitions as coming about due to pressure applied by niche alternatives on to the regime. As a result, an array of transition typologies has been developed conceptualising the different pathways that transitions may take depending on the configuration and timing of the interactions between landscape factors, niche-level innovations and sociotechnical regimes (See Geels & Kemp., 2007; Geels & Schot., 2007; de Haan & Rotmans., 2011). Furthermore, Smith et al (2005) also posit a typology of possible 'transition contexts' which conceptualise transformational change from a governance perspective.

Transition pathways

Geels and Schot (2007) distinguish five possible pathways which transitions may take. These pathways depend on the timing of the interactions between the landscape, regime and niche levels in the MLP. They also depend on the nature of the interactions between the three levels i.e. whether landscape factors have reinforcive or disruptive effects on the regime and whether niche-level alternatives have a symbiotic or competitive effect on the regime (Geels & Schot, 2007).

The first pathway is the *'reproduction process' (P0)* where, although there are niche-level innovations that could challenge the regime, the lack of pressure from the landscape on the regime helps stabilise the regime. While there maybe stresses within the regime, the regime still perceives itself as having '[…] sufficient problem-solving capacity […]' (Geels & Schot., 2007:406).

Next is the *'transformation path' (P1)*, where there is moderate landscape pressure on the regime, but niche-level innovations are still immature such that incumbent regime actors respond by modifying development trajectories and innovation activities. In this pathway new regimes grow out of the old through cumulative adjustments and reorientations as incumbents enact the transformation (Geels & Kemp., 2007). Because the pressure from the landscape is perceived and translated by outside actors who then criticize the regime; this pathway is characterised by contestations, power struggles and the need for translation activities (Geels & Schot., 2007).

Thirdly, is the *'de-alignment & re-alignment path' (P2).* If changes in the socio-technical landscape are large and sudden, yet niche-level innovations are immature, the resulting internal problems within the regime from landscape pressures may lead to a de-alignment and 'hollowing out' of the regime such that a vacuum results. The vacuum leads to the emergence and coexistence of multiple niche-innovations until one innovation becomes dominant thus leading to realignment and the formation of the core of a new regime (Geels & Schot., 2007:408).

The fourth kind of change is *'technological substitution' (P3)* whereby large changes in the landscape lead to great pressure on the regime, whilst viable niche-innovations also exist, thus the niche-innovations will break through and replace the incumbent regime (Geels & Schot., 2007:409). The *'reconfiguration pathway' (P4)* is the fifth pathway that takes place when symbiotic niche-innovations are initially adopted by the regime as an add-on component to solve local problems. These innovations trigger further adjustments in the architecture of the regime. Lastly, sociotechnical change can also follow a 'sequence of transition pathways' (P5) (ibid).

In this thesis, the concept of transition pathways was used to first determine of the kind of transition process underway in Johannesburg by allowing us to map the existing dynamics in Johannesburg's water management sector. This then served as a departure point for using SNM to investigate the extent to which current initiatives towards SUDS could be seen as a transformation towards SUWM.

Transition contexts

Smith et al (2005) tackle the different paths that socio-technical change may take from the perspective of the regime. While niche-innovations and their development are seen as imperative for the transition of socio-technical systems, sociotechnical regimes have also become focal units of analysis with the realisation that niche innovations may not be sufficient to bring about a transition on their own but rather, that radical changes at the regime level are necessary for sustainable development (Smith et al., 2005).

They understand regime transformation to be a function of (i) the degree to which selection pressures acting on a regime are articulated by regime members; (ii) the extent to which the responses to the selection pressures are coordinated coherently across the regime; and (iii) the degree to which resources required for regime shift are available within or beyond the regime. The latter two factors i.e. the coordination of responses and availability of resources; represent the *adaptive capacity* of the regime. (Smith et al., 2005: 1492)

Smith et al (2005) suggest that the "transition context" of a sociotechnical system can be mapped and diagnosed based on the two aforementioned dimensions of regime adaptive capacity. They identify four transition contexts, based on the level of regime coordination (i.e. whether or not the transformation is intended and actively coordinated by the regime in response to selection pressures) and the degree to which the responses to selection pressures are based on the regime's resources or not. The transition contexts are namely *emergent transformation*, *endogenous renewal*, *reorientation of trajectories* and *purposive transitions*. (Smith et al., 2005)

An 'endogenous renewal' is likely when regime members make conscious, highly-coordinated and internally-resourced efforts to respond to clearly articulated selection pressures, resulting in an incremental and path-following transition process (Smith et al., 2005:1500). A 'reorientation of trajectories' occurs when there is an uncoordinated, but internally-resourced regime response to poorly-articulated selection pressures. 'Emergent transformations' are the result of poorly articulated selection pressures meeting an uncoordinated regime response drawing on resources external to the regime (ibid: 1501). Lastly, 'purposive transitions' are transitions that have been intentionally pursued to reflect clear societal interests but which draw on resources and capabilities external to the regime (ibid: 1502).

These transition contexts can also be thought of as an expression of the condition of the prevailing hydrosocial contract. Thus the art of governing a transition is said to be in recognising which context for transformation is prevailing and how best to leverage the most relevant drivers so as to achieve transformational change (Smith et al., 2005).

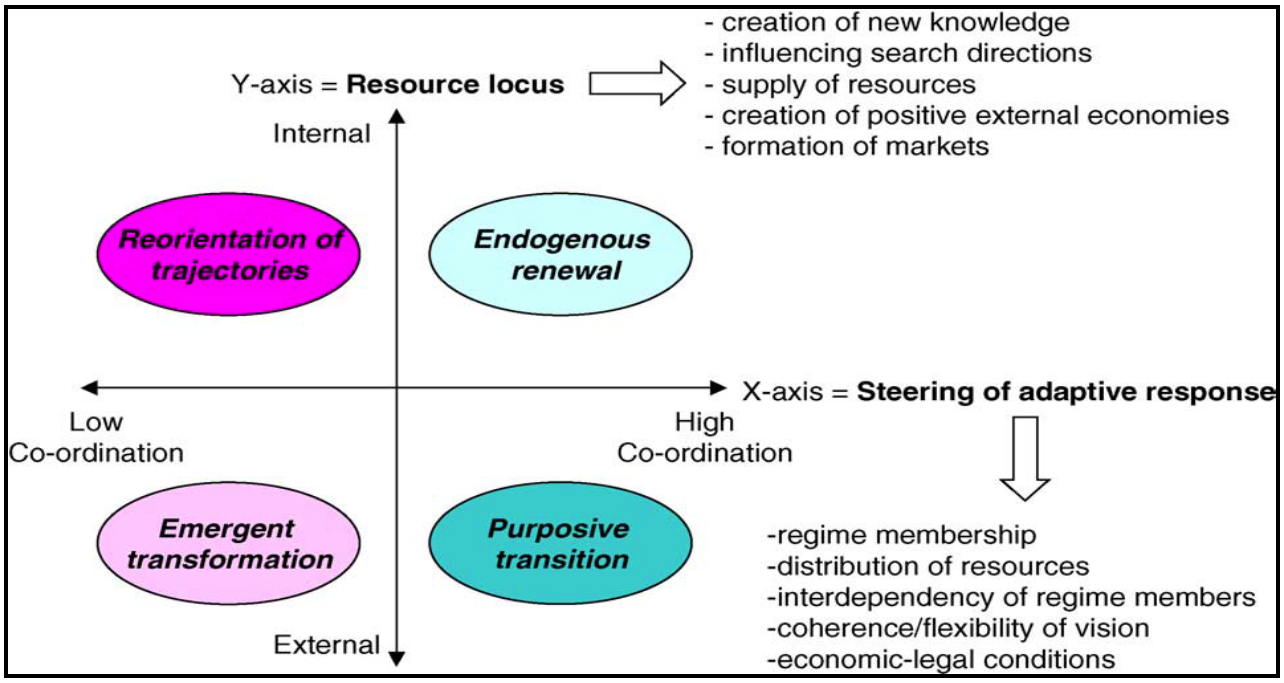

Figure 3. Transition contexts as a function of degree of coordination to selection pressures and the locus of adaptive resources. Source: Smith et al. (2005).

The transition contexts typology (Fig. 3) as posited by Smith et al (2005) was used in this thesis as a diagnostic device to identify the type of transition likely underway in the water management sectors of the four case cities from the perspective of the urban water management regimes. With its emphasis on the regime's adaptive capacity, the model helped emphasize that resource endowments, articulation of selection pressures and indeed coordination capacities differ from regime to regime and results in different transition contexts.

For example, the potential for integrating SUDS in Dar es Salaam would most likely be based on resources from outside the regime as the current regime response was highly uncoordinated i.e. it would most likely be an *emergent transformation*. For Copenhagen and Johannesburg on the other hand, the integration of SUDS is mostly likely to be based on regime internal resources through relatively well-coordinated regime responses i.e. as part of an *endogenous regime renewal* (see Paper II and Paper IV). The integration of SUDS in Addis Ababa on the other hand could be characterised as a dual transition context made up of highly coordinated regime responses that are based on resources from outside the regime i.e. as both an *emergent transformation* and a *reorientation of trajectories* (see Paper III).

However it should be noted that this typology is not unproblematic. While the two axes of the transition contexts in Fig 3. above were based on the two dimensions making up the adaptive capacity of the regime i.e. 'the extent of the coordination of responses within the regime' and 'the availability of resources from within the regime', it was difficult to accurately map the transition contexts of each city without also being able to visualise the third variable of the 'level to which selection pressures were articulated by the regime'.

A transition typology conceptualised through SNM

This thesis has also made use of the criteria for successful niche development as posited in SNM to analyse an emerging SUDS niche in Johannesburg. While the study on Johannesburg made use of the transition pathways typology by Geels and Schot (2007) and identified the type of transformation towards SUWM in Johannesburg as being a regime reconfiguration, there was still space to explore in a little more detail the possible niche-regime interactions that may take place within such a regime reconfiguration. Thus, in relation to the aforementioned three SNM niche development criteria of (i) constructing broad social networks, (ii) articulation of expectations and visions and (iii) facilitating first and second order learning, I also used Raven's (2006) niche-regime model to identify the type of niche the SUDS alternative in Johannesburg most likely resembled.

Raven's (2006) integrated niche-regime model (Fig. 4) posits that in the regime reconfiguration process the potential success of a niche alternative as a symbiotic complement to the regime depends on 2 factors (i) the stability of the niche (i.e. the level to which it satisfies the three SNM criteria of network formation, learning processes and articulated expectations) and (ii) the stability of the regime that it confronts. As mentioned earlier, regimes and niches are considered to be similar kinds of structures, differing mainly in size and stability (with the regime being the bigger and more stable of the two) (Geels & Schot, 2007; Smith, 2007).

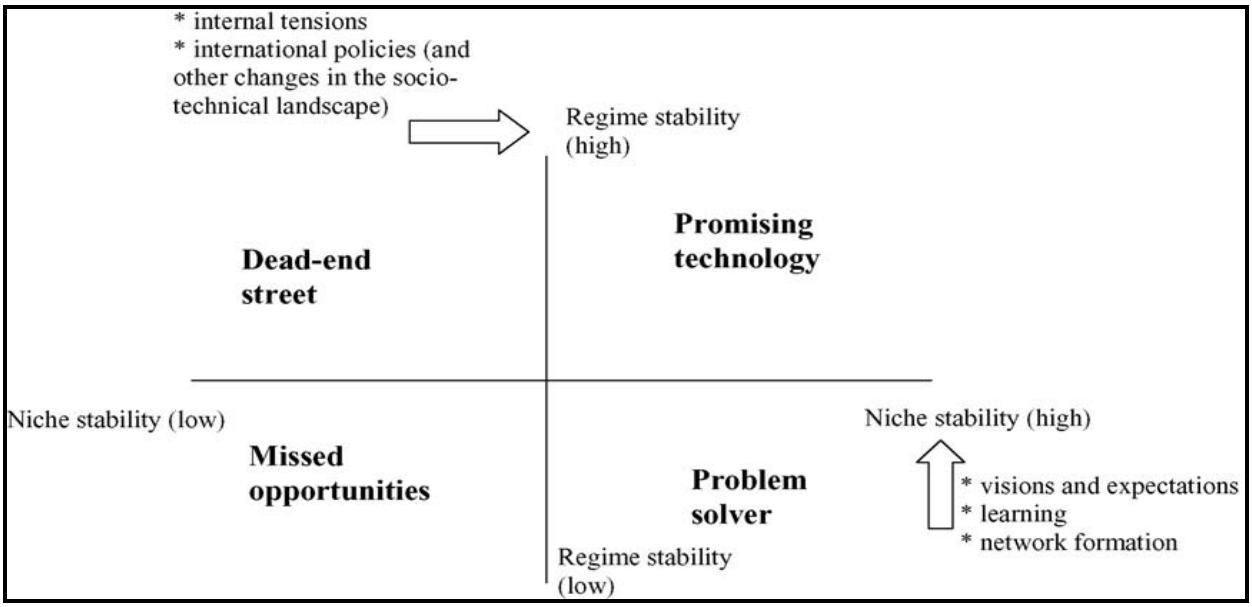

Figure 4. Relation between niche and regime stability. Source: Raven (2006, p. 585).

In this integrated niche-regime typology Fig 4, if a stable niche is absorbed into an unstable regime plagued by internal stresses, the niche becomes a *"problem solver"* (Raven, 2006:586). On the other hand if a stable niche is absorbed by a reasonably stable regime, then the niche remains a *"promising technology"* waiting for windows opportunity to open up within the regime, whilst still competing with the regime (ibid). If a stable regime is confronted by an unstable niche i.e. one that does not satisfy the SNM criteria, then the niche is considered a *"dead end street"*, however if an unstable regime is confronted by an unstable niche then this is characterised as a "*missed opportunity*" (ibid). Raven's typology was used to complement the SNM analysis of the activities

characterising the nascent engagement with SUDS in Johannesburg and it enabled us to designate the SUDS niche as a 'promising technology' as will be shown in Paper IV.

The concept of infrastructural leapfrogging for cities in the South

This thesis also used the concept of leapfrogging to conceptualise the transition challenge facing developing cities like Addis Ababa and Dar es Salaam if they are to shift towards SUWM. Approaches like SUDS have the potential to help Sub-Saharan cities partially address their infrastructural deficits. It could well be possible for cities in the global South to leapfrog towards SUWM and simultaneously adapt to climate change whilst bypassing the problems of path dependency on conventional urban water infrastructure that developed cities now face (Novotny et al., 2010). Leapfrogging in this thesis is conceptualised based on the 'urban water management transitions framework' (see Fig 5) developed by Brown et al (2009). The figure represents the transition challenge that developed cities face i.e. that of retrofitting urban water systems towards more sustainable configurations. Cities like Copenhagen are currently in the fourth stage of the framework, having already moved through the first three stages, and are increasingly seeking to realise the last two water cycle city and water sensitive city goals as represented in the framework.

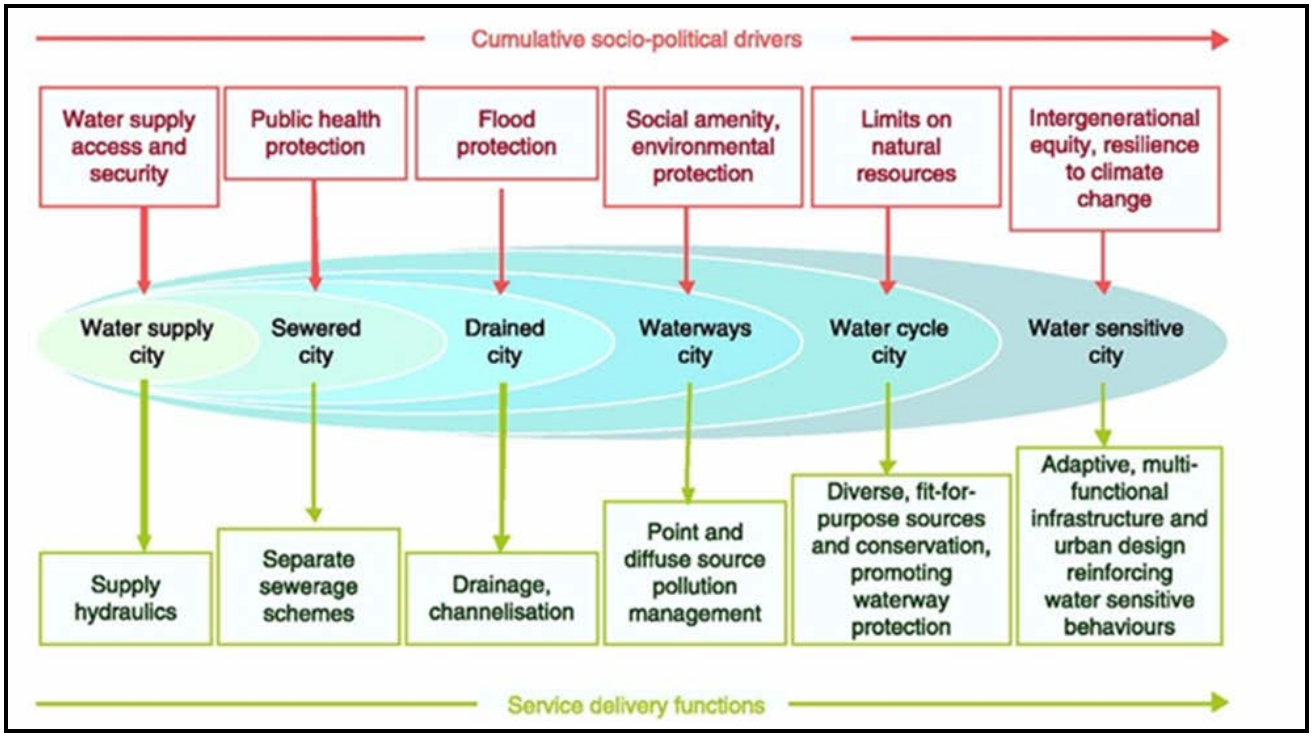

Figure 5. The urban water management transitions framework. Source: Brown et al (2009, p. 585).

However the picture is different for developing cities. Since their challenge is to leapfrog over purely centralised urban water systems towards more sustainable configurations I adapted the framework by Brown et al (2009) to reflect this leapfrogging challenge from an MLP and hydrosocial contract conceptual perspective. In terms of leapfrogging potential, cities in the South have a chance to lead the way in the transition towards green infrastructure-based and decentralised

approaches in urban water management. They can do so by simultaneously moving through the first three stages of the transitions framework in Fig 6 whilst also seeking to achieve the last three stages since they have the benefit of hindsight gained from the experiences of developed world cities

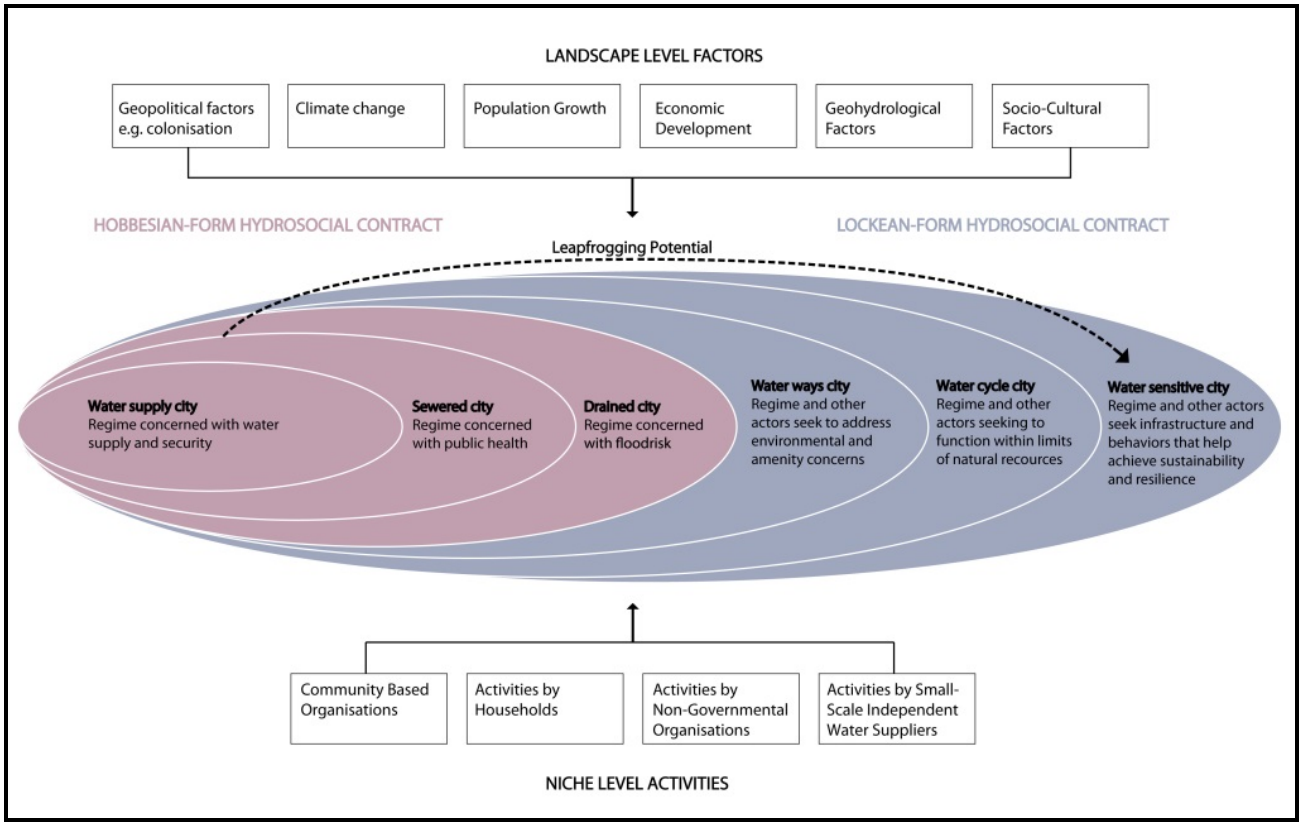

Figure 6. Framework for transitions towards SUWM in Addis Ababa and Dar es Salaam. Adapted from Brown et al. (2009, p. 850).

We note however, that unlike the transition challenge facing most Sub-Saharan cities like Dar es Salaam and Addis Ababa, the transition challenge confronting a city like Johannesburg is different. Johannesburg, unlike Dar es Salaam, has a longer history of parallel infrastructure provision based on past apartheid policies. This is physically manifested by the coexistence of a relatively well-developed water infrastructure system alongside a growing informality and deficit. In the post-apartheid era the State has sought to transform South African cities into more equitable settlements, seeking to move from the discriminatory dualism in infrastructure provision towards one future of sustainability.

As such, in terms of SUWM, Johannesburg faces both a leapfrogging challenge to address the infrastructure deficits in informal areas and a retrofitting challenge to shift existing water infrastructure towards sustainable configurations. This is most aptly portrayed in Fig 7, an adaptation of the Brown et al (2009) urban water management transitions framework by Armitage et al., 2014 depicting the dual transition challenge facing South African cities in terms of water management.

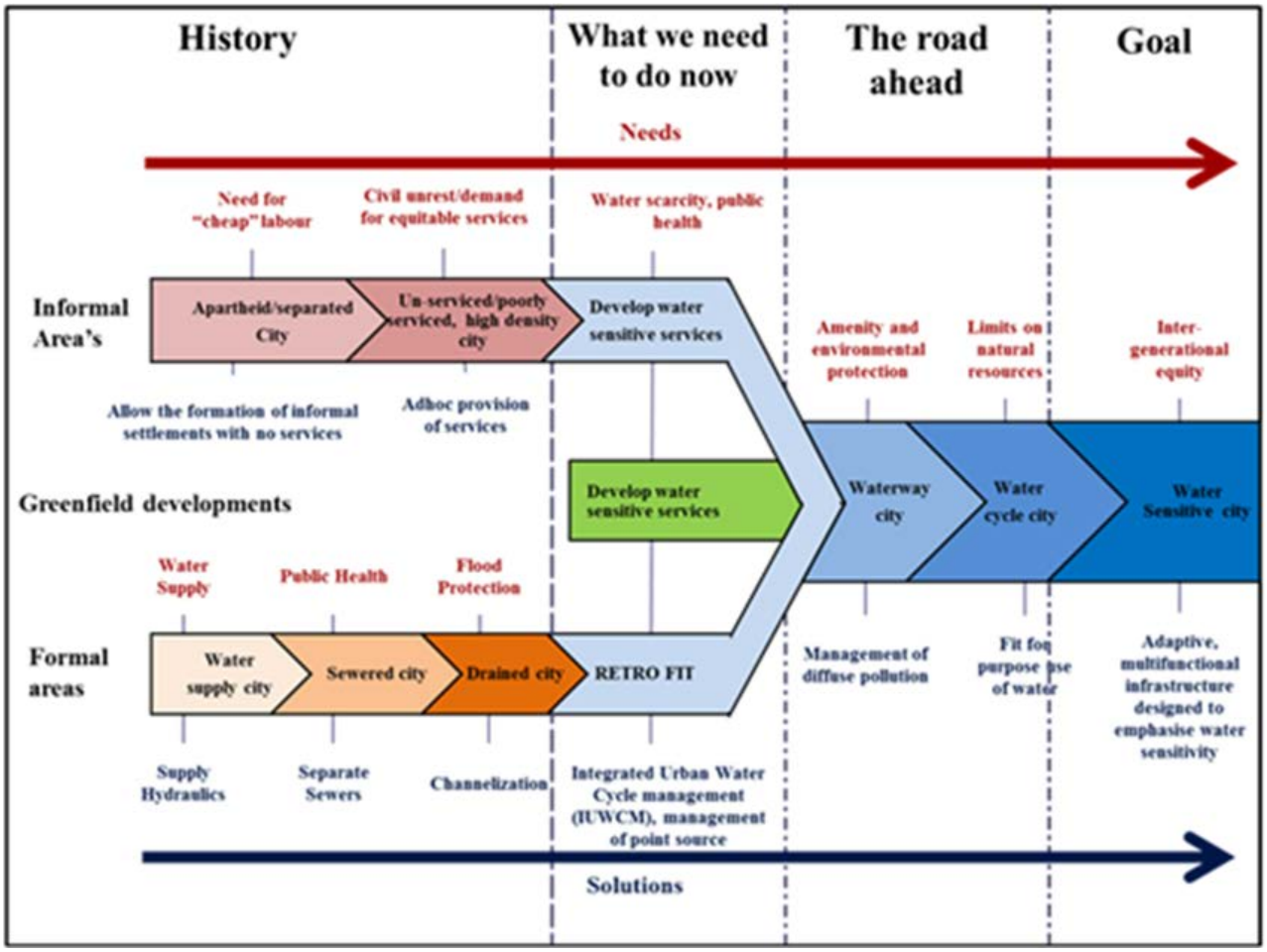

Figure 7. Framework for water sensitive settlements in South Africa, "Two histories, one future". Source: Armitage et al. (2014, p.V)

Due to the concentration on empirical cases in the West, sustainability transitions frameworks are thought to be insufficiently equipped to analyse leapfrogging potential from the point of view of developing countries (Binz et al., 2012). As such it must be noted that the conceptual basis for investigating leapfrogging potential is still unclear within transitions scholarship and as well as within leapfrogging literature itself (ibid). Nonetheless, despite this, technological leapfrogging is increasingly viewed as an alternative infrastructure development option for emerging countries so as to foster sustainable development whilst mitigating and adapting to climate change (Zerriffi & Wilson, 2010; Binz et al., 2012; UNEP, 2014).

Technological leapfrogging however cannot be viewed as a panacea to the infrastructural deficits in developing countries as there are limits to what can be achieved through such a trajectory (Gallagher, 2006; Assefa, undated). With limitations such as weak domestic technological capabilities and inconsistent institutional policies (ibid), technological leapfrogging in developing cities may in reality be a "[…] hard slog of competence building […]" that receiving sociotechnical regimes will have to engage in (Rock et al., 2009:242).

Agency: Enacting sustainability transitions

The transformation of socio-technical systems like urban water systems is **enacted** through the coordination and steering of many actors and resources, regardless of whether these are intended or emergent features of the transformation process in question (Smith et al., 2005; Geels, 2011). Actors within and outside the regime can exhibit agency i.e. the ability to take action and make a difference over the course of events (Giddens, 1984:14 in Smith et al., 2005) so as to push for change towards more sustainable trajectories.

Although agency is said to be under-theorised within sustainability transitions, studies on the adoption of SUWM in Australia have shown that the agency exhibited by emergent leaders in innovation, often called 'champions' or 'frontrunners', plays a critical role in driving change from within the regime (Taylor et al., 2011; Loorbach & Rotmans, 2010). Within regime transformation, incumbent regime members who are champions often perform strategic institutional work such as coalition-building, realigning prevailing institutional practices and expectations with sustainability concerns i.e. translating and contextualising the transition challenge (Farla et al., 2012).

Furthermore, many in the sustainability transitions field highlight the importance of regime outsiders or intermediaries in niche construction (Geels, 2006; Swilling et al., 2013; Hamann & April, 2013; Smith & Raven, 2012). Regime outsiders are crucial to both regime-driven and niche-based transitions as they translate landscape pressures and highlight alternatives in their criticism of the regime (Geels & Schot., 2007). Intermediaries such as scientists, engineers, firms, branch organisations and civic groups are seen as facilitators of system change as they engage in niche-level experiments, help monitor on-going initiatives as well as accumulate and circulate knowledge through workshops, conferences, and journals (Geels & Deuten., 2006; Swilling et al., 2013).

The notion of regime incumbents and regime-outsiders such as intermediaries, firms and developers exhibiting agency and enacting sustainability transitions has been especially useful in highlighting the different actors and the roles they are playing in the integration of SUDS and transformation towards SUWM in Johannesburg (Paper IV).

Summary of theoretical background

The shift from conventional centralised urban water systems towards decentralised green-infrastructure-based such as SUDS as envisaged in SUWM can be conceptualised and explored as sustainability transitions. The **MLP**, **transition pathways** and **contexts**, **hydrosocial contracts** and **leapfrogging** are concepts that have been used in this thesis as a theoretical framework to help map prevailing dynamics in respective urban water sectors as well as the potential for such a transformation in the four case cities. Furthermore, the concepts of **SNM** and **agency** have been used to deepen my understanding of the on-going transitions towards SUWM, giving important criteria for assessing the extent to which efforts to integrate SUDS at city scale in Johannesburg may constitute a transformation towards more sustainable configurations of urban water infrastructure systems.

Research Design

This section details the methodological approach taken in the investigation of the research question and objectives. According to Yin (2014) a research design is a logical sequence that connects empirical findings and their interpretation with a study's initial questions. This PhD study is based on a **qualitative** research design, using **case studies** as the main strategy of enquiry (Creswell, 2009; ibid). Case studies may be descriptive, explanatory or exploratory and can generally be understood as in-depth investigations of "contemporary phenomenon within its real-life context" based on various data collection procedures (Yin, 2014:2; Creswell, 2009).

Within the sustainability transitions field, case studies have formed the cornerstone of research practice (de Haan et al., 2015). Case study methodology seems especially well suited for exploring existing potential for transitions towards the integration of SUDS as well as for the description and analysis of on-going transitions towards SUDS and SUWM within the urban water sector. Case studies may contain a significant element of narrative (Flyvbjerg, 2006), and in transitions research, narratives are used as vehicles to capture complex interactions between the three analytical levels of socio-technical change i.e. the landscape, regime and niche (Geels and Schot, 2007; Geels, 2011). Since most transitions studies address "[…]emergent and reflexive phenomena […]" qualitative narrative accounts are considered useful as compared to formal quantitative approaches which are more suited to stable sociotechnical situations (Smith et al., 2010:444).

Three case studies were performed to explore and illustrate potential and on-going shifts towards the integration of SUDS as a stormwater management option, and more generally as an urban water management option in four cities namely Dar es Salaam, Addis Ababa, Johannesburg and Copenhagen. The three studies formed the basis of three papers. Furthermore a literature review was conducted to evaluate the possible usefulness of SUDS for cities in the developing world using a SWOT analysis; this then forms the basis for the first paper. A literature review provides the foundation for a study, and may be used to frame the research problem at hand and indicate a direction for future research (Imel, 2011; Creswell, 2009).

Literature Review (Paper I): Examining the applicability of SUDS for stormwater management in developing world cities

A literature review was done to a provide foundation for the PhD study as well as provide preliminary framing for the research problem of the applicability of SUDS and their potential from the perspective of Sub-Saharan cities. It was organised as a SWOT analysis of the opportunities and barriers for the integration of SUDS in developing world cities. The review included sustainable urban water management literature, literature on green infrastructure, as well as works on urban management and informality in the Global South.

Case 1: Exploring the potential for SUDS as a flood-risk management option in Dar es Salaam and Copenhagen

The first case was developed as an exploratory pilot study done at various times between June 2011 and October 2013. For this case I explored the applicability of SUDS to two different cities facing a

similar problem of increased flood-risk i.e. Dar es Salaam which has a drainage infrastructure deficit and Copenhagen which has a complete sewer system. Part of the motivation for choosing Dar es Salaam was that it was already one of the case cities of the Climate Change and Urban Vulnerability in Africa (EU) project that the Institute for Geosciences and Natural Resources Management (then known as Forest and Landscape) was involved in.

The aim was to investigate and compare the potential for integrating SUDS as a flood risk management option and for a transition towards sustainability in two different contexts. During the first phase of the case I faced difficulty in analysing the data gathered and this prompted a search for analytical frameworks that could help us conceptualise and analyse the potential for change from a systemic perspective. This resulted in my initial encounter with the sustainability transitions field and the MLP more specifically.

Research methods used in Case 1 (Paper II):

- Literature review (municipal planning and policy documents, research papers)
- Semi-structured and unstructured interviews
- Observation at multiple stakeholder meetings

Case 2: Engaging with sustainability transitions in the urban water management sectors of Addis Ababa and Dar es Salaam

This case is an exploratory study that compares the potential for leapfrogging towards SUWM in Addis Ababa and Dar es Salaam. The study was done in connection with the Water Resilient Green Cities for Africa project. From the beginning the MLP was used to map and illustrate current and historical dynamics in the water sector of each city, the different actors involved and the potential for transformation towards sustainability within the urban water management sectors as a whole. This was a second round of research on Dar es Salaam, whilst Addis Ababa provided a valuable comparative scenario. Data was collected between June and July 2014.

Research methods used in Case 2 (Paper III):

- Semi-structured and unstructured interviews,
- Literature review (i.e. document and archival analysis, newspapers, grey literature)
- Transect walks through local areas

Case 3: An exploration and description of the nascent engagement with SUDS in Johannesburg

This case study sought to explore and illustrate the on-going transformation towards the integration of SUDS and SUWM in the city of Johannesburg. The case was identified with the help of colleagues at the Urban Water Management Group at the University of Cape Town early 2013. Data was collected between June 2013 and October 2014. For this case I was also allowed to sit within

the Environmental and Infrastructure Services Department (EISD) of the City Of Johannesburg (CoJ) as a researcher and observer between June 2014 and October 2014. So for a while, as Flyvbjerg (2002: 6) puts it, I also had "[…] my own desk and coffee mug […]" at the EISD as well as access to interview other relevant departments within the CoJ. Interviewees were identified by snowballing from interviews with key informants.

Research methods used in Case 3 (Paper IV):

- Semi-structured interviews
- Participant observation e.g. through attendance of internal and external meetings at the EISD
- Literature review (CoJ document analysis, newspapers, research papers)

My role as a researcher of sustainability transitions

Systemic change is most times an emergent and reflexive phenomena (Smith et al., 2010), and as such the researcher assumes several roles that may differ from those one takes on when investigating other phenomena. My roles as a researcher included the following:

- As a mapper and analyser of change dynamics (Schot and Geels., 2008)
- As an analyser with the discretion to bound, partition and order the system under study so as to abstract an objective socio-technical system and then offer an empirical operationalization of MLP by engaging it with sustainability transitions in the water management sectors in the 4 cities (Smith et al. 2010; Geels, 2011)
- Illustrate and explore existing realities and potentials for sustainability by adding empirical cases to the sustainability transitions and urban water services fields of research.

Methodological limitations

One main limitation to the use of the MLP, SNM and related concepts as a theoretical framework for studying transitions in the water sectors of both developing and developed world cities was that of the risk of "concept stretching" i.e. the application of concepts beyond environments within which they were developed (see Sartori, 1991; Mossberger & Stoker, 2001). This limitation is directly tied to the criticism levelled at the MLP on the difficulty of delineating and operationalising the concepts of landscape, niche and regime. This limitation was evident in Case 1 and 2 (Papers II and III) where the niche concept as defined in transition theories did not quite fit what was on the ground. However, this limitation also served as the basis for the conceptual suggestions put forward in Paper III, in line with Seyfang and Smith (2007) and Seyfang and Longhurst (2013) on the need to widen the concept of the niche if transition theories are to be more applicable to a wider geographical reach as Markard et al (2012) suggest.

Delimitations of the study

The project focused on the potential for integrating SUDS as an urban stormwater management option that is part of a wider move towards SUWM. However it does not concentrate on the technical functionalities of SUDS as a method per se, instead it investigates the potential for integrating SUDS from a governance of change or management perspective hence the emphasis on sustainability transitions. Furthermore, while the focus has been on the potential for SUDS and SUWM in developing world cities (with the inclusion of Copenhagen for comparison), the project concentrated specifically on Sub-Saharan urban contexts leaving out other 'developing country' contexts that may be found in North Africa, Asia and Latin America. Lastly, the project mostly investigated transitions from a system-level or structural gaze, seeking to apply the MLP analytical elements of landscape, regime and niche among other concepts, to ordering the dynamics prevailing in the urban water management systems under study, and analysing them. As such I did not look too closely at the 'micro-sociological dynamics' (Geels, 2011:3) i.e. the activities of actors reproducing the system elements. Paper IV on the SUDS niche in Johannesburg does however begin to move towards this direction.

Summary of the work

Research papers

The PhD study focused on the prospect for sustainability transitions towards the integration of SUDS and attainment of SUWM in the cities of Addis Ababa, Copenhagen, Dar es Salaam and Johannesburg. In this section the work is presented in four research articles whose content and linkage are summarised below. The author of this thesis was lead author of the first three articles in collaboration with Professor Marina Bergen Jensen and Assoc. Professor Lise Byskov Herslund. The fourth article was a solo effort by the author under the guidance of above-mentioned advisors.

Paper I

Coming from an urban planning background I had little experience with SUDS as an approach to stormwater management. Thus, I sought to better understand SUDS and to explore the approach from the perspective of urban governance in the global South. This paper is based on a literature review exploring the theoretical value that SUDS may have as a green infrastructure-based option to stormwater management in developing world cities. Assessing the potential of SUDS via a SWOT analysis, the article brings together literature from landscape ecology, sustainable urban water management, as well as urban governance literature from a global South perspective to hypothesise the applicability of SUDS to cities in the developing world. This paper serves as a foundation for the other three papers that follow by looking at SUDS (an approach which hitherto has been mostly applied in an integrated way in developed country contexts) from the perspective of urban contexts in the global South and establishing that SUDS may be a viable option for augmenting drainage infrastructure deficits in such cities. The paper was submitted to Natural Hazards, for the Special Issue on adaptive floodrisk management in January 2015.

Abstract: "*Green infrastructure (G.I.) based approaches to urban drainage such as Sustainable Urban Drainage Systems (SUDS) could provide developing world cities with an opportunity to address projected climate change impacts and existing deficits in their drainage infrastructure, even more so due to the synergies between an enhanced green infrastructure stock and sustainable urban development. The objective of this paper is to assess the theoretical value of using green infrastructure for stormwater management as an alternative and supplement to conventional pipe-based stormwater management systems. A SWOT analysis is performed to assess the potential that SUDS hold if adopted and implemented in developing world cities. This analysis is based on a review of sustainable stormwater management as well as urban planning and governance literature. Results show that despite seemingly significant barriers to the adoption of SUDS in developing world cities such as low prioritisation on the urban agenda, lack of data among others; the concept may hold valuable potential for flood risk reduction, even more so due to its multi-functionality and synergies with urban agriculture, amenity and water supply. In light of the existing threats and weaknesses it is recommended that G.I.-based SUDS may be best approached initially as experiments at a local community scale.*"

Results

As a green-infrastructure-based stormwater management solution, SUDS hold significant potential for cities in developing countries, even more so in light of the prevailing infrastructure challenges. The potential strengths of SUDS from a developing city perspective include their foundation on the triple goals of controlling water quantity and quality as well as contributing to biodiversity and amenity; also they may be a more adaptive option that is cheaper in the long run compared to conventional centralised systems. The potential weaknesses of SUDS from a developing world perspective include the requirement for maintenance that could be costly since it requires a particular skills set and the increased complexity in decision-making due to multiple stakeholders among others.

The potential opportunities that SUDS bring include increasing water security through the augmentation of water supply, support for urban agriculture and improved liveability. The likely threats to SUDS in developing city contexts include the low prioritization of urban drainage on the urban development agenda in relation to housing and economic growth, the lack of functional solid waste management, health risks that could result from SUDS elements that are not well-maintained, and the conflicting rationalities and deep differences at play in most developing world cities. Ultimately the applicability of SUDS to developing world cities rests upon tailoring their implementation to the prevailing contexts, in an effort to reorient current urban development trajectories from infrastructural deficit and environmental degradation towards sustainability and resilience.

Paper II

Moving on from seeking to understand SUDS and their theoretical applicability as presented in Paper I, this paper presents an empirical exploration comparing the potential opportunities and barriers for the adoption of SUDS as a green infrastructure-based flood risk management option in Dar es Salaam and Copenhagen. Although the two cities are disparate in context i.e. Dar es Salaam has a drainage infrastructure deficit while Copenhagen has a well-developed sewer system, both cities are projected to have increased flood risk as climate change advances. This serves as the basis for their comparability.

The paper brings together concepts such as the MLP, hydrosocial contract, transition contexts and neo-institutional theory to build up an analytical framework considered relevant to understanding the conditions that may encourage or hinder the shift from urban drainage that is based on centralised networks towards the incremental adoption of decentralised green infrastructure-based options such as SUDS. The framework is then used to analyse the two cities' potential for moving towards SUWM through the integration of SUDS. The case study was iteratively developed over two years and the paper published in the Water Policy journal in February 2015.

Abstract: "*The risk of flooding in urban areas could be better approached by complementing conventional sewer systems with sustainable urban drainage systems (SUDS) for stormwater management. This may be the case for developing world cities like Dar es Salaam with incomplete sewer services, as well as cities like Copenhagen with fully developed sewer systems. This paper explores some theories relevant to understanding how the implementation of SUDS may be one option for supporting a transition towards sustainable urban water management (SUWM). Using interviews, document analysis and observation, a comparison of the opportunities and barriers for the implementation of SUDS in Dar es Salaam and Copenhagen is presented. The results indicate*

that a bottom-up approach in Dar es Salaam is important, with the community level taking the lead, while in Copenhagen the current top-down approach employed is promising. The ability of the institutional frameworks of both cities to support the implementation of SUDS is also discussed."

Results

The paper uses the MLP, hydrosocial contract, transition contexts and other concepts as a theoretical framework with which to analyse the potential barriers and opportunities for the integration of SUDS in Dar es Salaam and Copenhagen. While SUDS have potential as a flood risk management option in both cities, there are several different socio-institutional opportunities and barriers for the integration of SUDS. For Dar es Salaam, due to the institutional fragmentation at regime level that comes from a derelict hydrosocial contract, the most promising opportunity for the integration of SUDS may be as a niche-level experiment in a bottom-up approach within the intra-city local level's community-based adaptation efforts. This bottom-up approach to SUDS integration could be further supported through the activities of NGOs and the prevailing urban infrastructure upgrading activities. As such, the most likely transition context prevailing in Dar es Salaam is that of an 'emergent transformation' as the local community level or grassroots mobilises resources to respond to unclear selection pressures whilst being hampered by uncoordinated regime responses.

In Copenhagen, the main opportunity for integrating SUDS is through a top-down approach with the actors in the water management regime taking the lead as the Sankt Kjelds example shows. However one of the main barriers is the differing emphasis and parallel departure points of the two main regime actors tasked with planning for and implementing SUDS in the city. Another barrier is the individual ownership of buildings at the local level which makes a bottom-up approach impractical. Viewed from a transition contexts perspective, Copenhagen could be said to be characterised by an 'endogenous renewal' where the urban water management regime is using internal resources to respond to relatively well-articulated selection pressures, in a fairly coordinated manner.

Paper III

This paper details an engagement of sustainability transitions concepts with the case of urban water management in Addis Ababa and Dar es Salaam. The paper goes further than Paper II by using the analytical framework developed in Paper II to comparatively explore how cities with infrastructure deficits and incapacitated regimes could begin to integrate SUDS and generates narratives on the potential they have to leapfrog towards SUWM. In addition, the paper also discusses some of the conceptual implications that such cases from the subaltern may have for the field of sustainability transitions. The case study was done during in the third year of the PhD project in conjunction with activities of the Water Resilient Green Cities in Africa project. The article has been submitted to Technological Forecasting and Societal Change in July 2015.

Abstract: "*Most Sub-Saharan cities currently face profound challenges in developing adequate water infrastructure systems and providing related services. Alternative approaches such as Sustainable Urban Water Management may have potential to help these cities address these deficits as well as support their transition towards sustainability. This paper uses the multi-level perspective (MLP), hydrosocial contract and transition contexts concepts to explore the potential for leapfrogging towards SUWM in Dar es Salaam and Addis Ababa with a particular focus on the applicability of Sustainable Urban Drainage Systems (SUDS) to the two cities. In this paper,*

sociotechnical landscape factors are shown to have a constraining influence on the cities' urban water management regimes, thus limiting their capacity to adequately deliver water services. An analysis of niche-regime dynamics in both cities' water sectors indicates that leapfrogging towards SUWM may depend upon the recognition of activities of non-regime (niche-level) actors and the significant roles they play in addressing water infrastructure service gaps. The conceptual implications that Sub-Saharan cases may have for the sustainability transition field are also discussed."

Results

Socio-technical landscape factors such as population growth, historical urban governance modes and the low levels of economic development are shown to have a constraining influence on the ability of both cities' water management regimes' capacity to deliver water services. Consequently, there exists robust niche level activities as communities, households, small-scale water providers and NGO's fill in the gaps in water supply, sanitation and drainage services. However, the relative lack of recognition of such activities by the regime, may serve as a barrier to leapfrogging towards SUWM through SUDS in both cities. Furthermore, the pursuit of the 'modern infrastructure ideal' through the Water Sanitation and Hygiene paradigm serves as a barrier to a more integrated view of urban water based on sustainability as found in SUWM. From a theoretical perspective, the paper also highlights two things; the first is that the assumptions of stable regimes as supposed in frameworks such as the MLP may not hold when looking at Sub-Saharan cases. Secondly, we highlight that the conceptual delineation of the 'niche' level may need to be widened to reflect not only the innovative activities of firms but also the propensity for innovation found at community and household levels as well as NGO activities as is also identified by Seyfang and Smith (2007).

Paper IV

Where Papers II and III look at the ***potential*** for transitions towards SUWM through the integration of SUDS into Dar es Salaam, Addis Ababa and Copenhagen, this paper examines the ***ongoing engagement*** with SUDS, and a possible transformation towards SUWM, in the city of Johannesburg. In addition to the conceptual framework similar to the one employed in Papers II and III, this paper also makes use of SNM's niche development processes as criteria with which to assess the extent to which current efforts towards SUDS integration may indicate a burgeoning transformation towards SUWM. The article has been submitted to Environmental Innovations and Societal Transitions in July 2015.

Abstract: *Sustainable Urban Drainage Systems (SUDS) are gaining attention as a complementary green infrastructure-based approach to stormwater management. While it is mostly in developed cities where the SUDS approach is gaining ground, Johannesburg is one of the few Sub-Saharan cities with a burgeoning engagement with SUDS. This paper uses the Multi-Level Perspective and Strategic Niche Management's (SNM) niche development processes in the analysis of ongoing SUDS initiatives in Johannesburg and the extent to which these initiatives may signal a transformation towards more sustainable urban water management (SUWM). Results indicate that SUDS in Johannesburg are being progressively embraced by different actors at both regime and niche levels as a symbiotic and promising niche within a largely regime-driven transformation. However, social networks and second order learning are still limited as the SUDS niche is still in the early stages of its formation.*

Results

An MLP analysis reveals that there are several landscape factors such as climate change impacts, infrastructure deficit and population growth acting upon Johannesburg's urban management regime in general, which have been perceived and articulated by actors in the water management regime. As a result, some of these actors like the Environmental Infrastructure Services Department and Johannesburg Roads Agency have exercised agency by championing and adopting SUDS as a symbiotic niche approach to the management of stormwater in the city through such instruments as the on-site Stormwater Attenuation policy and Complete Streets programme. Other regime actors such as the Johannesburg Roads Agency are also enrolling behind the idea. At the niche level, there are several SUDS initiatives as companies i.e. Vodacom experiment with SUDS and research institutes like the Water Research Commission act as intermediaries actively lobbying for the adoption of the approach.

However in terms of the SNM criteria on niche development processes the SUDS niche in Johannesburg is in its early stages of development. Although there is evidence of the emergence of social networks around it such as the collaboration between the EISD and JRA; the preliminary articulation expectations and visions via such documents as the Growth and Development Strategies; as well as some level of first-order learning, these niche processes remain diffuse and narrow. This is especially so in light of the barriers highlighted by interviewees such as lack of knowledge and skills about SUDS, lack of coordination within the regime and between the regime and niche levels. These barriers highlight a need for a platform for engagement where different actors can jointly envision, learn and network further around water issues and SUDS more specifically. As such, for now SUDS can be viewed as a promising niche and the shift towards its integration and SUWM in Johannesburg remains nascent.

Discussion and conclusions

This project has looked at two issues, the applicability of SUDS to cities in the global South as an urban stormwater management option that is based on green infrastructure and the possibility for such cities to transition towards SUWM through the integration of the said SUDS approach (with the inclusion of Copenhagen for comparative purposes). These two issues have been approached from a sustainability transitions perspective. A literature review, as well as three case studies have been presented. The literature review (Paper I) explored the theoretical applicability of SUDS as a green infrastructure-based option to stormwater management for developing cities. Case 1 (Paper II) compared the potential for the adoption of SUDS as a green infrastructure-based flood risk management option for Dar es Salaam and Copenhagen. Case 2 (Paper III) comparatively explored how Addis Ababa and Dar es Salaam, cities with infrastructure deficits and incapacitated regimes, could begin to integrate SUDS and possibly leapfrog towards SUWM. Finally, Case 3 (Paper IV) analysed the ongoing engagement with SUDS in Johannesburg, examining how far such an engagement constitutes a possible transformation towards SUWM. This section discusses some of the conceptual matters that came up during the course of the project.

On the delineation and operationalisation of sustainability transitions concepts

One of the main conclusions to emerge from Case 1 and Case 2 (Paper II and III respectively) is that while SUDS is thought to be best approached in a top-down fashion with the regime as the main actor adopting and implementing SUDS retrofits in cities with well-developed infrastructure such as Copenhagen and Johannesburg, that is not the case in developing cities like Dar es Salaam and Addis Ababa (whose infrastructure deficit and informality are representative of many cities in the global South). In such cities instead, it emerged that SUDS may be best approached from the bottom-up through the local community's coping strategies for flood management and water supply. This conclusion brought up one of the criticisms levelled against the MLP and other transitions frameworks on the difficulty of delineating and operationalising the regime, niche and landscape concepts.

Firstly, transition frameworks assume the 'niche' level to be populated by market innovations that are pursued by rent-seeking firms. Instead in this thesis the findings cement Seyfang and Smith's (2007) conceptualization of the grassroots initiatives as valid niche innovations in their own right. Functioning within a social economy as opposed to a market economy, the community initiatives in Dar es Salaam and Addis Ababa were driven by 'unmet social need' (Seyfang & Smith, 2007: 591) i.e. water supply, sanitation and drainage infrastructure deficits, but not necessarily by an ideological commitment to sustainability values.

Secondly, in light of these so called unmet needs, Cases 1 and 2 highlight the difficulty of conceptualising urban water management 'regimes' as stable and able to discharge their mandates when it comes to developing cities. Instead, the water regimes in many cities in the global South are functioning under great socio-economic constraints, making them, at worst, highly unstable configurations that do not 'work' (at least not in the way they were expected to), in contrast to Rip and Kemp's (1998: 330) assertion; and at best, ambiguous configurations functioning between the

two types of Hobbesian and Lockean hydrosocial contracts without explicitly acknowledging that this is so (see Quitzau et al., 2013; Berkhout et al.,2011).

Thirdly, Cases 1 and 2 also hint at the tensions that sometimes ensue between constrained urban water management regimes in the global South, which though highly unstable in terms of resources may still be resistant to change in their pursuit of the so called 'modern infrastructure ideal', and thus resistant to the unsanctioned and possibly disallowed grassroots initiatives such as hand-dug wells, rainwater harvesting etc. While under the MLP, regime instability would imply opportunities for niche-level alternatives to breakthrough, the great level of instability coupled with this institutional inertia to be found in most urban water management regimes in southern cities could be detrimental to the development and maturation of community level efforts that support SUDS elements (see Verbong et al., 2010's analysis of Indian biomass gasification niche prospects). For instance, the uncertainty in Dar es Salaam surrounding the 'official' Hobbesian hydrosocial contract which the regime functions under and the more Lockean hydrosocial contract that prevails in reality renders many niche-level efforts at water supply and drainage illegitimate or without requisite support.

On the explanatory power of sustainability transitions frameworks

The MLP and SNM have helped us conceptualise the potential for moving towards SUWM in Addis Ababa, Dar es Salaam, Johannesburg and Copenhagen, enabling us to map the different transition dynamics at play and the actors into an interrogable problematic from a more structural view. However, with these frameworks it was difficult to get into the finer details at play within these dynamics such as actor strategies or providing causal explanations as to why things stood as they did especially for Case 3 on the ongoing engagement with SUDS in Johannesburg. This limitation seems to be borne out of the criticism that the MLP and related frameworks lack a conceptualisation of agency and power.

While the MLP and SNM cannot be expected to be 'truth machines' (Geels, 2011:34), perhaps further benefits could be gained by complimenting them with Actor Network Theory, Practice theory or Discourse Analysis as has been done by Caniëls & Romijn (2008), Jørgensen (2012), Maassen (2012) and Pesch (2015) among others. These other theories, with their attention to the finer details of social action, everyday practices and the discursive nature of socio-technical change could help to further illuminate the strategies, roles and resources mobilized by actors within the regime as in the Johannesburg case as well as assist in the exploration of the 'popular agency' (Roy, 2011) practised by local communities in conjunction with, or independent of, the regime as in the case of Addis Ababa and Dar es Salaam.

On the applicability of SUDS and the transition towards SUWM in cities in the global South

An important consideration when looking at the applicability of SUDS to cities in the global South has been of the different points of departure for most developing cities as compared to developed cities. While the conversation around SUDS integration in cities of the Occidental centres mainly on how to implement SUDS retrofits into the existing urban fabric as part of a larger infrastructure renewal agenda, I have highlighted that in most developing cities like Dar es Salaam and Addis

Ababa, the question is mainly how to address current infrastructure and environmental deficits while leapfrogging over the technological path dependencies faced by developed cities.

For one, the potential shift towards SUWM through approaches like SUDS in developing cities does not invalidate current efforts towards achieving universal centralised water infrastructure under the Water Sanitation and Hygiene (WaSH[4]) paradigm. However, in case 2 (Paper III) we highlight that the undeviating attention paid to achieving WaSH objectives within the water sectors of cities in the global South, may be inadvertently disqualifying the consideration of more integrated approaches to water management such as SUWM. Even though most urban water management regimes in developing cities are functioning under severe constraints, they currently seem to lack the reflexivity to seek alternative ways of doing things outside the mainstream municipal hydraulic paradigm and modern infrastructure ideal which the WaSH agenda is an extension of.

Maybe one starting point is to accept that the goal for developing cities may no longer be to achieve the modern infrastructure ideal of centralised, pipe-based water and drainage services but rather to seek appropriate and sustainable infrastructure instead. To be able to leapfrog towards SUWM, cities in the global South need to begin to experiment with alternative configurations not just of water service infrastructures but of all critical urban infrastructure networks. Such experimentation should acknowledge the environmental and economic costs of centralised systems. In the water sector, this experimentation should also accept the inherent coproductive nature of urban water infrastructure provision and management in the global South and by doing so validate the local community initiatives by non-regime actors like households, communities, NGO's and independent small-scale suppliers of water. Perhaps with the new emphasis on urban resilience, sustainable management of water and resilient infrastructure as part of the proposed Sustainable Development Goals[5] this shift in attention towards experimentation with sustainability in urban water management may already be underway.

From an urban planning and governance point of view, experimentation with alternative configurations of water infrastructure also implies changes in the way in which urban infrastructure is governed. It is now widely accepted that water crises are mainly problems of governance and not so much due to a lack of resources or technology (Castro, 2007; Pahl-Wostl, 2008; Bakker, 2010; Brown et al., 2011). As such, sustainability transitions in the global South such as those necessary for SUWM, should not only seek to address infrastructural and environmental issues, but also societal concerns too.

As Swilling and Annecke (2012) also highlight, for cities where infrastructure deficits are an expression of historical discrimination and prevailing inequality, it is necessary for transitions to be concerned with social justice as well. As such transitions towards SUWM in the global South should be based on adaptive governance that emphasizes infrastructural democracy and 'inclusive

[4] The WaSH agenda is an international development programme drive seeking to address the overlapping challenges of water, sanitation and hygiene mainly in developing countries so as to improve health, reduce poverty and support overall development (See Mara., 2003 and UN-Water, 2012).

[5] Sustainable Development Goals are proposed as the main post-Millenium Development Goals agenda under negotiation in the UN since the Rio+20 in 2012 (see Osborn et al., 2015)

innovation'[6] and takes advantage of the existing 'energetic society' that is made up of an intelligent, articulate citizenry with unprecedented capabilities for learning, creativity and responsiveness (Hajer, 2011:9).

Limitations of the study

As with all human endeavours this PhD study is beset by some practical, methodological and conceptual limitations. The first and most obvious limitation lies in the number of cases cities making up the case studies. For a PhD project, studying the water management sectors of four cities meant not all case cities received in-depth treatment. As such I chose to concentrate on Johannesburg as the main case city and thus I was able to go further than just the 'MLP-hydrosocial contract-transition contexts' theoretical framework I had in cases 1 and 2 and include further analysis based on SNM.

Secondly, the study is based on a normative departure point, and thus biased towards assuming the desirability of sustainability as a goal and exploring how the four case cities may move towards it. Yet this departure point may be somewhat naïve, considering the rather contested nature of the sustainability concept itself and the realrationalität (Flyvbjerg, 1996) often at play in societies. The sustainability project, with its prescriptions for a more equal and inclusive society may not be as benign as it seems. In it are embedded potentially disruptive qualities which also need to be acknowledged and perhaps dealt with along with the more hopeful points of normativity.

For instance, sustainable urban water management may mean that the millions of people without adequate sanitation in the world cannot reasonably hope to have access to a flush toilet as many currently have in the developed world. Instead it may mean sustainable eco-sanitation that will harvest nutrients and recycle water. However, such alternative sanitation may evoke imageries of eras past where discrimination was made manifest through the provision of 'inferior' services for the disenfranchised[7]. This project does not really address this 'dark side' (ibid) of sustainability, but perhaps that is beyond its scope and is better suited to future academic endeavours.

Lastly, from a conceptual perspective, this thesis mainly used the MLP, with some use of related frameworks like SNM and did not make use of other (possibly complimentary) frameworks outside the sustainability transitions field e.g. practice theory. As mentioned in the methodology chapter, as a middle-range framework the MLP itself has some flaws which translate into flaws of the research that employs it as I have done in this thesis. The MLP enabled us to give a partial picture of the way things stand in the cities under study especially from a structural perspective, without offering much in the way of possibilities of populating the transition dynamics identified by the application of the framework, with finer details of what makes up these dynamics.

[6] As a concept 'inclusive innovation', defined as innovation by and for the disenfranchised, is gaining academic and policy interest (See Smith et al., 2014 and George et al., 2012)

[7] See Robins' (2014) article on the politics of sanitation in post-apartheid South Africa.

Reflections and future research

This project has in essence been an exploration of the potential for sustainability transitions towards SUWM through the integration of SUDS within the urban water management sectors of Dar es Salaam, Addis Ababa, Copenhagen and Johannesburg. One logical next step would be to seek a deeper understanding of on-going transitions towards SUDS such as is the case in Johannesburg. As mentioned in previous sections, the MLP and SNM have been useful tools helping me to map and begin to analyse prevailing transition dynamics however to get a better view of the agency involved in enacting transformations towards SUDS I may seek deeper analysis by employing Actor Network Theory, Practice Theory or even Discourse Analysis as other researchers have done.

Looking at the prevailing dynamics in the water management sectors of Dar es Salaam, Addis Ababa and Johannesburg, Transition Management and its emphasis on reflexive governance may be one way of exploring new forms of infrastructure governance necessary for the transition towards SUWM and SUDS integration. For Addis Ababa and Dar es Salaam initiating a transition management process may be a way of kick-starting an engagement with the need for integrated and inclusive management of urban water services linking the different stages of the hydrological cycle and increasing the involvement of non-regime actors in decision-making. For cities like Johannesburg, engaging in transition management could provide the necessary platform for the engagement of different stakeholders and enable the modulation of on-going transition trajectories towards more sustainable directions.

The concept of technological leapfrogging could be another potential line of research for the future. Leapfrogging as a concept is still in its infancy (see Binz et al., 2012; Perkins, 2003), and most studies on technological leapfrogging have been done from the gaze of Newly Industrialising Countries in Asia (see Rock et al., 2009; Binz et al., 2012). More studies on what infrastructural leapfrogging could entail from a Sub-Saharan perspective and how it can be stimulated are also needed. Considering the constrained nature of urban infrastructure regimes in the global South, should not efforts at stimulating leapfrogging and technological transfer be directed at the grassroots level in light of the flexibility and propensity for appropriately translating technological innovations at this level (e.g. most citizens in developing countries leapfrogged over fixed telephone lines towards mobile telephony in many countries)? These are some of the questions that begin to come up when considering the possibilities for infrastructural leapfrogging in the South.

Furthermore, what of sustainability transitions in fragile states? Studies about how societies engage with possible infrastructural malfunction and disruption during times of limited statehood as well as the prevailing cultures of infrastructural governance during times of crisis may be helpful in helping us conceptualise how sustainability transitions may be mainstreamed in the reconstruction of such cities should the opportunity present itself. A seemingly strange but powerful case in point is that of the humanoid traffic[8] robots in Kinshasa developed by Congolese female engineers and installed in 2013 to control traffic. While it is not an innovation in water management, this case does point to the capacity for apposite innovation even in contexts regarded as tumultuous. This is a quality that needs to be studied and supported.

[8] http://www.theguardian.com/travel/2015/mar/05/robocops-being-used-as-traffic-police-in-democratic-republic-of-congo

Lastly, as is already being discussed within the sustainability transitions research community, research is needed that takes into account gender and poverty as some of the defining features of Sub-Saharan urban realities. This is especially relevant for the study of sustainability transitions in urban water management. Due to socio-economic and cultural factors, women in Sub-Saharan cities are important actors in the water management sector. Based on their lived experiences of gathering water, managing sanitation, hygiene and flooding episodes as well as the general management of water use at household level, women are an essential constituency to be understood and supported in terms of encouraging more sustainable water management practices such as rainwater harvesting or the integration of green infrastructure. Poverty, as a defining context for any efforts towards sustainability in the global South, also has to be given due conceptual attention within the study of sustainability transitions especially when considering that infrastructural alternatives in developing cities should simultaneously address environmental and support poverty alleviation.

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Papers

Paper I

Sustainable Urban Drainage Systems: Examining the potential for green infrastructure-based stormwater management for cities in the developing world

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Sustainable Urban Drainage Systems: Examining the potential for green infrastructure-based stormwater management for cities in the developing world

Abstract

Green infrastructure (G.I.) based approaches to urban drainage such as Sustainable Urban Drainage Systems (SUDS) could provide developing world cities with an opportunity to address projected climate change impacts and existing deficits in their drainage infrastructure, even more so due to the synergies between an enhanced green infrastructure stock and sustainable urban development. The objective of this paper is to assess the theoretical value of using green infrastructure for stormwater management as an alternative and supplement to conventional pipe-based stormwater management systems. A SWOT analysis is performed to assess the potential that SUDS hold if adopted and implemented in developing world cities. This analysis is based on a review of sustainable stormwater management as well as urban planning and governance literature. Results show that despite seemingly significant barriers to the adoption of SUDS in developing world cities such as low prioritisation on the urban agenda, lack of data among others; the concept may hold valuable potential for flood risk reduction, even more so due to its multi-functionality and synergies with urban agriculture, amenity and water supply. In light of the existing threats and weaknesses it is recommended that G.I.-based SUDS may be best approached initially as experiments at a local community scale.

Keywords: Green infrastructure, stormwater management, SUDS, SWOT analysis, developing world cities.

1. Introduction

Sub-Saharan cities are confronted with two major imminent challenges: the so called "second wave of urbanization" as well as the impending "climate departure" heralding historically unprecedented climate (UN, 2012; Mora et al., 2013). The UN predicts that between 2011 and 2050 the world population will increase from 7 billion people to 9.3 billion people. Most of the population growth will be concentrated in cities of the developing world i.e. Asian and African cities. African cities will experience the highest growth rates, with urban populations likely to treble (UN, 2012:12), further intensifying rapid urbanization and its attendant problems of deficits in infrastructure and unplanned expansion already plaguing these cities (Jha et al., 2012; Parkinson & Mark 2005).

The move from recent climate variability towards a "climate with no modern precedents" (climate departure) is also expected to occur earlier in the tropics (Mora et al., 2013:183) which are where most low income countries lie. This could further worsen the problems in cities in low income

countries. Depending on the carbon emissions scenario[9] used, this means that between 1-5 billion people currently live in areas where climate is likely to exceed historical bounds by 2050 (ibid). Projected climate change impacts such as increased incidence of droughts, more intense precipitation and rising sea levels suggest that human welfare will be adversely impacted through changes in food and water supply as well through increased flood risk among other impacts (Jha et al., 2005; Mora et al., 2013). Although local climate change projections for individual cities may still be uncertain, if they are coupled with the projections for a new wave of urbanization, they begin to highlight the vulnerability of urban populations and infrastructure in developing world cities to climate change impacts. This further underscores the need for robust adaptation options (Jha et al., 2005) that simultaneously support sustainable urban development goals whilst helping increase the resilience of urban systems to climate change.

It is being increasingly asserted that one such adaptation option could be the use of the green infrastructure (GI) in the urban landscape to manage stormwater in what is seen as a departure from the conventional pipe-based (also known as grey infrastructure) approach to urban drainage (Kitha & Lyth 2011; Van de Meene et al., 2011). Such approaches are known as Sustainable Urban Drainage Systems (SUDS), Landscape-based stormwater management (LSM), Best Management Practices (BMP's), Low Impact Development (LID) and Water Sensitive Urban Design (WSUD) among other terms (Fryd et al., 2012:865). They consist of 'soft' or 'green' elements e.g. green roofs, rain gardens and swales etc, all of which depend on the natural processes of infiltration, evapotranspiration, conveyance, retention and detention of stormwater using the urban landscape (ibid). In this article we shall use the term SUDS.

Over the past three decades, much research has gone into exploring the applicability of SUDS to cities in developed countries i.e. USA, Australia and Europe directed at the biophysical processes, technological aspects, aesthetics, transdisciplinarity, decision-making and institutional aspects of SUDS (see Fryd et al., 2012:866). There is, however, a growing recognition that SUDS might present a viable adaptation and stormwater management option for cities in the developing world as well (Armitage, 2011; Reed, 2004). More research therefore needs to be directed towards exploring the theoretical applicability of SUDS in contexts that may be characterized by drainage infrastructure deficits, burgeoning populations, informality and poor service delivery.

Looking at the substantive issue of urban drainage from a theoretical perspective, exploring the value that GI-based approaches like SUDS could offer developing world cities may contribute valuable insights to on-going research on the potential SUDS possesses as a no–regrets adaptation option to climate change impacts. It may also widen the scope of appeal of SUDS from being just an urban drainage and adaptation option to include SUDS as an opportunity for cities in the developing world to harness the second wave of urbanization through land-use policies that support the development of a comprehensive GI. Such an opportunity brings with it a possibility of

[9] Representative Concentration Pathways (RCP) represent contrasting mitigation efforts between a 'concerted rapid carbon dioxide mitigation' scenario (RCP 45) and a 'business-as-usual' scenario (RCP85) (see Mora et al. 2013:183).

reconstructing this wave of urbanisation into a transformation of developing world cities from cities of crisis towards resilient cities of the future that are based on an alternative, and possibly more sustainable, paradigm of "watercentric urbanism"[10] (Novotny et al., 2010:71).

The aim of this paper is to offer a preliminary analysis of the possible value of SUDS to cities in the developing world (mainly Sub-Saharan cities), an analysis which may be useful to urban managers and practitioners concerned with enhancing the resilience of their cities to climate change whilst still addressing the pressing issues of managing rapidly urbanizing cities. Such a preliminary analysis may form part of the basis for land use policy engagement and experimentation with SUDS in cities in the developing world. Hence the main objective of this paper is to assess the theoretical value of using green infrastructure as an alternative to conventional stormwater management in the context of developing world cities.

To this end we perform a literature review of the SUDS concept as presented in sustainable stormwater management literature and then proceed with a SWOT analysis of SUDS presenting the possible strengths, weaknesses, opportunities and threats to the approach from the perspective of cities in the developing world. The SWOT analysis is based partly on a review of urban planning and governance literature mainly concerned with Sub-Saharan cities as well as sustainable stormwater management literature. The article concludes by giving thoughts and recommendations on how SUDS may be approached in such contexts as well as the different issues that need to be taken into consideration when thinking about the possible value that SUDS may hold for developing world cities.

2. Using Green Infrastructure for Stormwater Management: The concept of SUDS

Urbanization and the resultant process of increasingly impervious surfaces alter the hydrological cycle of an area and lead to increased surface runoff (Butler & Davies, 2011:3). As such, one of the main objectives of urban drainage is to provide flood protection through stormwater management (Chocat et al., 2007). Conventional stormwater drainage, whose main purpose is the rapid removal of all stormwater from the urban landscape, has been found to have some undesirable effects on the urban environment such as lowering the water quality of receiving water bodies due to increased sediment yields and related contaminant fluxes, a decrease in hydrological amenity and an increase in flood risk (Charlesworth et al., 2003:99). Moreover, conventional stormwater drainage is said to be expensive in terms of the costs of developing and maintaining the infrastructure, whilst its overall efficacy as a flood risk management option has also been questioned (Kitha & Lyth, 2011).

SUDS are stormwater management systems that are designed to mimic the natural hydrological cycle process by using the natural processes of infiltration, storage, detention, retention, evapotranspiration, conveyance and treatment of stormwater in the green infrastructure of the urban

[10] According to Novotny et al (2010:71) "water centric urbanism" considers urban waters to be the lifeline of cities, a lifeline that must be managed, kept and restored with hydrological and ecological sustainability as the main goal.

landscape (Jensen et al., forthcoming; Fryd et al., 2012). The SUDS concept has three wide-ranging aims of: 1. Reducing the **quantity** of runoff though source control and slowing the velocity of runoff; 2. Improving the **quality** of stormwater by providing passive treatment of collected surface water before discharge onto land or a watercourse and 3. Enhancing **amenity** and maintaining **biodiversity** (Charlesworth et al., 2003:100; Ashley et al., 2011).

As can be seen in the description of SUDS above, green infrastructure (G.I.) is an integral part of SUDS. G.I. is defined as "… an interconnected network of green space that conserves natural ecosystem values and functions […] providing related benefits to human populations", flora and fauna (Benedict & MacMahon, 2006:5). Unlike the open space planning hitherto used to provide green spaces in urban areas, the G.I. concept is centred on providing a hydrological/drainage network that compliments and links green space with built infrastructure (Ahern, 2007:267). Furthermore, G.I. has to be functionally and physically contiguous emphasizing connectivity (ibid; Kitha & Lyth, 2011). G.I. is seen as one way of approaching the sustainability goals of urban areas (Benedict & MacMahon, 2006) due to the ecosystem services it offers such as the "…moderation of climatic extremes, cycling of nutrients, detoxifying of wastes, maintenance of biodiversity […] and the purification of water and air" (Ahern, 2007: 268; Gill et al., 2007).

What then do SUDS consist of? To achieve the three broad aims of SUDS listed above, SUDS employs four hydrological processes also identified hitherto namely: temporary storage, infiltration into the soil, evaporation into the air and conveyance of the water, as well as treatment of the water (Jensen et al., forthcoming). All SUDS structural elements are thus based on the four hydrological processes. Besides the structural elements that make up SUDS, a very important part of SUDS is that of non-structural elements that are not based on G.I. i.e. pre-treatment of the stormwater to minimize the release of pollutants like pesticides, solid waste into the environment (Ashley et al., 2011; Armitage et al., 2012). SUDS structural elements are individually designed to be attached to existing developments thus complimenting the existing hard infrastructure of the sewer system in what is also known as "retrofitting" (Charlesworth et al., 2003: 100). SUDS elements can also be established in new developments (ibid) thus partially bypassing the need to provide hard infrastructure for stormwater management in such areas.

SUDS elements, both structural and non-structural, are arranged in a treatment/ management train (Ashley et al., 2011; Armitage et al., 2012). The first part of the train is largely non-structural element of prevention or "**good house-keeping**" e.g. good solid waste disposal, avoidance of harmful pesticides, recycling of waste water for re-use etc. The second stage of the train are the "**source controls**" which try to manage runoff close to its source e.g. rainwater harvesting, green roofs and permeable pavements. The third stage of the train are the "**local controls**" which manage water within a local area e.g. biorentention areas, grassed swales and infiltration trenches. Lastly, "**regional controls**" handle combined stormwater runoff from several developments e.g. constructed wetlands, retention and detention ponds. For more details on the individual green infrastructure elements of SUDS the reader is advised to see Ashley et al. (2011); Armitage et al. (2012).

Inherent in G.I.-based approaches such as SUDS, is the desire to address multiple objectives of economic, environmental and social sustainability (Fryd et al., 2012). Unlike conventional pipe-based stormwater drainage, the implementation of SUDS requires an understanding, not only of the technical aspects of drainage, but of socio-political, institutional and biophysical contexts of the area in which they are to be implemented (Fryd et al., 2012: 866; Chocat et al., 2007). As such, in order to unlock the full potential of G.I.-based approaches like SUDS in any context, a highly transdisciplinary approach is essential (Ahern, 2007); drawing on professionals from urban planning, civil engineering, hydrology, ecology, landscape architecture and social scientists among others (Fryd et al., 2012). Besides the professionals, who will plan for, design, implement and manage the SUDS, the clients or "locals" are very important actors. This is because they (the larger public) are the end-users of the product, thus how they view and interact with the SUDS elements is a very important aspect of the implementation and maintenance aspects of any SUDS.

How then should the implementation and management of SUDS be approached? Fryd et al. (2010) suggest that city-wide SUDS retrofits could be best approached through a top-down process with the planning arm of the municipal level taking the lead, while the public is brought in at a later stage or engages in niche-level SUDS experiments. Under such a top-down approach, Ahern (2007: 274-276) suggests that the city could articulate a GI-based spatial and drainage vision for adaptation and urban development. Secondly, those planning and managing the city could employ strategic thinking, seeking ways to integrate SUDS into the city by protecting and using existing as well as new GI for SUDS.

For increased sustainability, Ahern (2007) suggests that G.I. should be multifunctional enabling varied uses at different times or simultaneously i.e. implementation of SUDS options suitable for amenity, food production, recreation and water supply. Most importantly, since G.I. based approaches like SUDS do not possess the security of empirical evidence that more than 150 years of existence has granted conventional drainage systems, Ahern (2007), Bulkley and Broto (2012) and Ashley et al (2012) suggest a learning-by-doing approach that embraces experimentation, knowledge and mutual learning and appreciating the possibility of success or failure. The following section presents the urban water management context in developing world cities and how SUDS could be more applicable to such cities than conventional drainage systems have been thus far. Such a contextualisation may aid in the theoretical assessment of the applicability of SUDS to Sub-Saharan cities.

3. The context: Urban water management in the developing world

Although the modern urban drainage system as we know it has been around for at least 150 years (Fryd et al., 2012; Sørensen et al., 2007) in cities in the developed world, cities in the developing world have been struggling to adequately provide urban drainage based on this hard/grey infrastructure paradigm. While many cities in the developing world were first established during colonial times based on the assumption that they would develop in the similar trajectory as those of

the developed world , this has proved to be misestimation as third world cities experience a mode of urbanization that is not like any experienced in the developed world (Watson, 2009).

The rapid *"urbanization-without-development"* (Cheru, 2005:2) that developing cities have experienced has meant that where developed cities were able to provide urban drainage infrastructure that was commensurate with the pace of urban development; developing cities have struggled to keep up with the pace of urban growth. This has led to the prevalence of an infrastructure deficit in developing cities that is characterized by an ageing infrastructure that is inadequate in its coverage and unlikely to be renewed and improved adequately in the near future. This situation is so prevalent that some view the most visible manifestation of an urban crisis in the developing world to be the lack of access to urban drainage services of the urban poor (ibid).

As rapid urbanization continues, local governments have continually failed to meet these growing needs due to institutional fragmentation and lack of institutional capacity (UN HABITAT, 2011). As a result the number of actors in urban governance and development in developing world cities has also grown as community and individual household initiatives at the local scale seek to fill in governance gaps by playing vital roles in infrastructure provision, job creation and food security (Lindell, 2008). This has meant that in many developing world cities there are *"multiple sites of governance"*, at different scales of the city, displaying various modes of power and contestation (Lindell, 2008: 1879). It should be noted however that when it comes to urban water management and the potential for transition towards such approaches as SUDS, the problem of poor governance seems to be a worldwide phenomenon. Pahl-Wostl et al (2010) suggest that in general many problems with the management of water are a result of governance failures.

The rapid mode of urbanization in the context of high unemployment, poor governance and service delivery, as well as weak public institutions has also produced a specific characteristic of *informality* in developing world cities (Lindell, 2008; Cheru, 2005; Watson, 2009; Roy, 2005). Informality is the outcome when the reality of increasing socio-economic inequality confronts the "techno-managerial and marketised" (Watson 2009:2260) systems of urban governance thus highlighting the conflicting or multiple rationalities at work in developing world cities (Harrison 2006; Watson 2009:2267). In more practical terms, this informality has come about as the urban poor in developing world cities pursue a suite of survival strategies in sectors outside the formal structures that govern cities, so as to fill in the service and governance gap. Informality is therefore a major aspect of the urban economy, housing among other aspects of negotiating life in the city; it is the norm in most of the cities in the developing world (Watson, 2009; Roy, 2005).

As a result of rapid urbanization and the informality identified above, urban development in most developing world cities has been uncontrolled as most existing laws are not followed while policies and urban plans do not materialize (Lindell 2008). This has led to widespread settlement on environmentally fragile areas such as flood plains and wetlands especially by the poor (Kiunsi et al., 2009; Parkinson, 2003). There has also been extensive **environmental degradation** as the green infrastructure stock is appropriated for energy supply in informal areas with no formal power supply, while solid waste presents a pollution problem of massive proportions (Dodman et al.,

2009; START, 2011; Goldenfum et al., 2007). Such settlement patterns coupled with the associated environmental degradation and pollution serve as multipliers of vulnerability to climate change impacts.

It is no surprise then that the appropriateness of conventional pipe-based stormwater management in such contexts has been questioned especially in light of the techno-institutional and socio-economic obstacles prevalent in such cities (Kitha & Lyth, 2011: 251). In such a scenario a more sustainable solution to a problem such as urban drainage would need to address multiple goals at once. The following section presents an SWOT analysis of the theoretical potential a GI-based approach to urban drainage such as SUDS could have in the context of developing world cities where rapid urbanization, poor governance, informality, environmental degradation and imminent climate departure define urban realities and futures dissimilar to those in the developed world where the approach has so far been employed.

4. Results: A SWOT analysis of the of the theoretical potential SUDS holds in developing world cities

In this section we perform an analysis of the strengths, weaknesses, opportunities and possible threats to the potential that SUDS possesses as a G.I.-based stormwater management approach in developing world cities. This analysis is based mainly on insights pooled from sustainable stormwater management, urban planning and governance literature that has been reviewed. A SWOT analysis is a useful strategic planning tool for mapping and analysing the prospects of an organization or policy (Panagiotou, 2003; Helms & Nixon 2010) and in our case, the unit of analysis is the SUDS approach to stormwater drainage. A SWOT analysis of the theoretical value of SUDS in the context of developing world cities could provide policy makers and urban management professionals with more accessible knowledge on the possible merits and demerits of SUDS, thus making SUDS a more visible alternative to conventional stormwater drainage as well as support initial policy engagement with SUDS.

4.1 Strengths of G.I.-based SUDS

Within a SWOT analysis of SUDS, the strengths are the internal advantages that SUDS as an approach possesses over the conventional stormwater management approach. A reading of current guides, manuals and sustainable water management literature suggests that, beside the water and flood risk management function; there are five other strengths that G.I. based approaches such as SUDS possess which give it an advantage over pipe-based systems. The first is SUDS' simultaneous consideration and promotion of the three goals of water quantity, water quality and amenity/biodiversity (Ashley et al., 2011). With these three goals in mind, the ecosystems services that are the result of an enhanced G.I. are particularly important for the urban poor in developing world who depend on them for adaptive capacity and for their livelihoods (UN-HABITAT, 2011). Therefore, by considering these three goals, instead of just one goal of removing water from the

surface as quickly as possible, SUDS could provide cities with an opportunity to progress towards environmental, social and economic sustainability and resilience to climate change impacts (Novotny et al., 2010).

Secondly, from an economic perspective, using G.I. for stormwater management could be cheaper than conventional stormwater management infrastructure in the long run, even when capital and operating costs are compared (Ashley et al., 2011:25). Furthermore if the environmental benefits of ecosystem services provided are monetized, the net present value of G.I. could highlight it as a more viable investment option climate change adaptation even for developing world cities (ibid; CCAP, 2011). If the G.I. on which SUDS are based are truly characterized by functionality and contiguity as Ahern (2007) recommends, then SUDS has a third inherent strength compared to conventional grey infrastructure systems: that of the potential to generate urban form (Backhaus & Fryd, 2012). This could mean SUDS may possibly serve as a departure point for a newer paradigm of "water centric urbanism" where urban water and its related infrastructures serve as the central concept along which developing world cities are planned and managed (Novotny et al., 2010: 5).

A fourth strength of SUDS, is that when compared to conventional grey infrastructure systems in the context of developing world cities, SUDS seems to be a more flexible and adaptable option in relation to avoiding lock-in to old infrastructure technologies that developing world cities are now trying to replace (Swilling et al., 2013). This is especially more so in light of the uncertainty inherent in climate change and how that may translate into unclear urban futures (Ashley et al. 2011). The last strength that SUDS has, in comparison to conventional hard infrastructure systems, is that it presents a more holistic way of addressing urban water management and as such provides more opportunities to close the urban water cycle loop (Armitage, 2011) through water harvesting and waste water recycling. The water storage elements of SUDS could help augment water supply and ameliorate water scarcity problems prevalent in many developing world cities (Turton, 2002). This is a critical advantage for cities where the main manifestation of urban crisis is considered to be the lack of access to basic water and sanitation as mentioned earlier (Cheru, 2005).

4.2 Weaknesses of G.I.-based SUDS in the context of developing world cities.

In a SWOT analysis of SUDS, the weaknesses are the possible obstacles internal to SUDS, which would need to be avoided or addressed. The use of SUDS as the main stormwater management approach does present several challenges and these internal weaknesses of SUDS may need to be addressed in relation to the theoretical value SUDS hold for developing world cities. The first weakness is the difficulty of precisely quantifying the hydraulic and water quality improvement performances of G.I.-based SUDS in the management of runoff, especially at a city-wide or catchment-wide scale (Ashley et al., 2011:18; Goldenfum et al., 2007). Compared to conventional grey/hard infrastructure, the calculation of flow rates and volumes for SUDS is "[…] something of an art […]" and thus a major weakness for the SUDS approach which increases reluctance among practitioners to employ it (Ashley et al., 2011:18).

The second weakness of the SUDS approach concerns the maintenance level required for some of the elements. According to Charlesworth et al. (2003) surface elements of SUDS such as swales and dry ponds have a high failure rate unless frequently maintained. Furthermore, such maintenance is costly and requires skills which may not be readily available in developing countries (Armitage, 2011). A third weakness of SUDS is the possibility for increased complexity that stems from the multi-stakeholder decision-making and the transdisciplinary aspects that are essential to SUDS (Fryd et al., 2010; Ashley et al., 2011:32). Divergent stakeholder interests and parallel professional views could mean that the process of planning for and designing a SUDS retrofit strategy and implementation is a much more intricate and longer undertaking when compared to the fairly linear process of planning and implementing grey/hard infrastructure (Ashley et al., 2011; Fryd et al., 2010). Moreover, the high level of coordination between different institutions that is required to operationalize and manage SUDS at a citywide level could be a major weakness considering the sometimes highly fragmented and unclear nature of the institutional set up in many cities in the developing world (Dodman et al., 2009).

The fifth weakness of SUDS relates to the first: SUDS is still a fairly new science, thus more research still needs to be done on all its aspects (Fryd et al., 2010; Ashley et al., 2011) including its applicability to developing world cities. Furthermore there are still no clear methodologies to measure the 'sustainability' of SUDS, or to truly evaluate the full suite of potential added benefits of using SUDS in an urban context (Benzerra et al., 2012:46; Fryd et al., 2010; Ashley et al., 2011:25). This weakness is directly related to some of the threats that will be identified in one of the forthcoming sections. The last weakness of SUDS is the inherent requirement for large open urban space by some of its elements and even more so if the functionality and contiguity requirement for the G.I. is to be convincingly achieved. Many developing world cities are already densely developed and have little space available to put aside for SUDS elements especially in informal areas (Charlesworth et al., 2003; Armitage, 2011) but then again when informal areas are considered this weakness also applies to conventional stormwater infrastructure (Parkinson et al., 2007).

4.3 Opportunities from G.I.-based SUDS

From a SWOT analysis perspective, **opportunities** represent the possible external additional benefits that could accrue as a result of the strengths of SUDS. Compared to conventional drainage systems, there are other benefits for urban areas that employ SUDS besides the water management function and ecosystems services that accompany an enhanced G.I. mentioned above. The possibility of closing the water cycle loop and augmenting water supply is a prospect that could produce two multi-faceted opportunities for cities in the developing world. Many cities in the global South, especially those in arid regions, suffer from water scarcity (Turton, 2002). As urban populations in developing world cities rise, so does the demand for water and other services. This in turn leads to deficits in water supply that are currently difficult to address, and yet such deficits could form the basis for social and political instability if the capacity to adapt to the water scarcity is not cultivated (ibid). While SUDS cannot be heralded as the ultimate panacea to such water

scarcity, they can however provide a stimulus for adaptation to it on a large scale and maybe even ease the day-to-day difficulties of water supply for informal households during the rainy season.

The second multi-faceted opportunity that is born out of the possibility of an augmented water supply is the potential support this would have for urban agriculture. According to Gleick (2003) irrigation is the largest water use in the developing world, and although not entirely legal, most open spaces in Sub-Saharan cities are actually used for urban agriculture (Bryld, 2003:79). As such the possibility of a better water supply through SUDS could go a long way in supporting and possibly improving urban agriculture in developing world urban areas where such an activity is a crucial livelihood strategy and integral part of the urban fabric (Schmidt, 2012). Moreover, an improved urban agriculture sector could by extension help address the chronic food insecurity that is prevalent in some cities as well as enhance livelihoods. As such, urban agriculture could provide an avenue through which to approach and integrate SUDS in developing world cities, whilst conversely G.I.-based SUDS retrofits could provide a physical and strategic framework within which to shift urban agriculture from being an informal (possibly illegal) issue of urban survival (Schmidt, 2012:131) towards being an issue that is addressed and supported within urban policy.

A third opportunity for SUDS could the potential it may have for community infrastructure upgrading programs that many developing world cities implement in informal areas and other sectors with the help of NGO's and organizations such as the World Bank (Mguni et al., 2015). Such infrastructure upgrading programmes may afford the opportunity to link SUDS as a solution for drainage issues to the provision of other essential services such as access, solid waste collection and sanitation (Parkinson et al., 2007). Even more so, linking SUDS to these upgrading programmes helps avoid the problem of city administrators seeking specific funds for SUDS projects which could result in the shelving of SUDS projects since resources are hard to come by in many developing world cities. Improvements as a result of upgrading based on SUDS could also improve the liveability and the "image" of the informal settlements thus prompting a possible rise in the value of the land or properties thereof (Parkinson et al., 2007: 140; Ashley et al., 2011).

Lastly, by requiring the involvement of a wider range of stakeholders, SUDS bring the potential for more inclusive decision-making which could be possibly more democratic than the usually linear and narrower (top-down) institutional decision-making required for conventional stormwater systems (Backhaus & Fryd, 2012). Such a form of decision-making could be particularly valuable in many developing world cities where the informality, poverty and inequality mean that those in informal areas are often outside the decision-making arena and are consequently marginalized.

4.4. Threats to G.I.-based SUDS

In a SWOT analysis of SUDS, threats represent the possible external obstacles to SUDS that could hinder the applicability of SUDS to developing world cities. The first threat to SUDS relates to the way urban service delivery is prioritized in developing world cities. Due to the acute housing shortage that plagues many cities, it is likely that, if SUDS are not conceptualized strategically, the

approach could suffer from lower prioritization as the housing provision agenda is likely to be given more importance. However this threat could be defused if new housing provision projects were conceived holistically and based on sustainability principles such that rainwater harvesting tanks as well as soft drainage infrastructures are considered an integral part of the developments.

On the other hand the lower prioritization of solid waste disposal on the urban management agenda of many cities could also threaten the value that SUDS could have for developing world cities. In many developing world cities, the poor drainage and flooding problem is aggravated by poor solid waste management as solid waste enters and blocks drains and reduces the hydraulic capacity of the drainage system (START, 2011; Parkinson, 2003:120). It should be noted however that the solid waste threat currently affects the conventional drainage infrastructure that currently exists in developing world cities all the same, so it is not a threat that would make SUDS any less valuable when compared to the conventional drainage system.

A weakness identified previously, of SUDS being a new science that is in need of further research, may be the basis of another threat. This is the possible difficulty of convincing policymakers of the viability of the SUDS option when compared to the more developed science that supports conventional drainage system. For some cities which may already have functional and established conventional drainage systems this threat could be exacerbated by path dependencies and dominance of old hard-engineering approaches such as Johannesburg's dependence on Inter-Basin Transfers for water supply (Turton & Meissner, 2002). Even where policy makers may be willing to engage with alternative G.I.-based approaches like SUDS, most developing world cities do not have collated and readily available data that is prerequisite for the implementation of SUDS e.g. information on the size and value of existing G.I. in the city (Schäffler et al., 2013:172). As such it may be necessary to dedicate resources to the gathering of the required data in each city such as the capacity of the existing drainage network before proceeding towards planning, design and implementation of GI-based SUDS (Goldenfum et al., 2007).

The need for high levels of costly maintenance that is characteristic of some elements of SUDS could result in another threat to the value of SUDS' in developing world cities in that threat to SUDS. Most developing world cities are already facing problems generating income from their small formal tax bases, such that the resources required for maintenance may be unavailable (Armitage, 2011; Cheru, 2005:11). This could lead to some SUDS elements becoming health threats if elements are not properly maintained and water is allowed to remain stagnant for long periods. If coupled with the possibility of solid waste that is inappropriately disposed of, stagnant water could become contaminated and become a breeding ground for mosquitos and diarrhoeal diseases (START, 2011:62).

Another possible threat to SUDS in developing world cities concerns the interface between users and SUDS elements (Ackrich, 1992). There is a risk of unanticipated uses and appropriation of SUDS elements especially in informal areas which could ultimately lead to SUDS having negative impacts. Some SUDS elements like detention ponds can be large open swathes of flooded land, raising practical safety concerns especially in light of the risk of drowning and the possibility of

them becoming spaces of criminal activities (Charlesworth et al., 2003:105; Watson, 2009). However, this threat could conversely be regarded as an opportunity for the hybridization (Watson, 2009) of SUDS by the urban poor to suit local contexts (depending on the nature of the activity concerned) possibly adding to the multifunctionality of SUDS elements.

An additional threat to the value of SUDS for developing world cities is related to the opportunity SUDS may have as part of community upgrading programmes that rehabilitate the image of informal settlements, maybe even up to the point of raising the value of the land these settlements are situated on. Such improvements may have unanticipated effects. Firstly, if upgrading is not accompanied by a commensurate improvement of the socio-economic and legal status of informal settlements inhabitants, SUDS could inadvertently serve as the 'aestheticization of poverty', merely painting over deep-rooted problems faced by a majority of the urban populations in developing world cities (Roy, 2005). Secondly, as land values increase so does the risk of the urban poor being displaced by real estate market forces to make way for what are seen as more desirable developments. Ultimately, SUDS' requirements for space could also result in the forced removals of informal settlers in cities where the urban poor have limited socio-political capacities for resistance (Watson, 2009; Roy, 2005).

Another possible threat to the value that SUDS may hold for developing world cities could be the central-local government jurisdictional issue that is yet to be resolved in some developing countries. According to Cheru (2005:11) central governments in African cities tend to exercise a substantial amount of fiscal, regulatory and legal control over city administrations which stifles innovation on the part of the local government. Yet having ample space for innovation is a critical component of engaging with approaches like SUDS which are inherently experimental in nature, before they can be meaningfully implemented. Even more critical, the lack of municipal autonomy prevents cities from securing alternative financing for water and sanitation infrastructure upgrading such as Foreign Direct Investment (Cheru, 2005).

Lastly, in the context of inequality, informality and widespread poverty, the SUDS requirement for an inclusive decision-making with multiple stakeholders may not be easy to satisfy when compared to the usually expert-driven and top-down approach to conventional drainage systems. This is because the multiple and sometimes conflicting rationalities often at work in developing world cities preclude consensus-based approaches as those requisite for SUDS (Watson, 2009). The reality in many cities of the developing world is that global and local market forces have in some cases resulted in socio-economically, politically and ethnically polarized cities where public interest is at best splintered and differences are large (Watson, 2006). In such a context, power thus becomes a very convenient concept to understand and acknowledge especially when seeking to accommodate the wishes and requirements of the diverse stakeholders (ibid).

5. From cities of crisis to cities of the future – Discussing the potential for SUDS in developing world cities

This section presents a discussion of some of the issues to have in mind when considering the theoretical value that SUDS may hold for developing world cities based on the SWOT analysis performed in the previous section. Firstly, while a scan of the SWOT analysis would seem to reveal seemingly more threats to the value of SUDS than there are opportunities in developing world cities, this does not suggest that SUDS would be predestined to fail. What this indicates is that due to the informal mode of urbanization experienced by most developing world cities, great care must be taken when approaching any type of urban problem in such contexts. A direct export of ideas like SUDS from developed world cities, without the appropriate scaling and reconfiguration to suit the particular context of each city could produce unintended and unanticipated results which may well be negative. As such any attempt to engage with SUDS in developing world cities should be highly context-specific, designed to take advantage of the socio-economic, political and environmental and physical peculiarities that constitute each city's reality without exacerbating the existing situation i.e. adding to the difficulties the urban poor face.

Critical to the value that SUDS hold for developing world cities is how the informality and infrastructure deficits in these cities are viewed. Contrary to the prevalent conceptualization of developing world cities in terms of crisis due to their informal nature (Robinson, 2002 in Roy, 2005) it may be more practical to view informality and the resultant deficits as providing a specific opportunity for developing world cities to develop in a manner that will be relevant to the current projected futures of climate departure and population growth. Informality affords developing world cities the opportunity to pursue an urban development trajectory that is possibly more experimental, adaptive and reflexive than can be pursued in developed cities which are already locked-in to their existing urban infrastructure systems. Such a slightly more optimistic view could help in the harnessing of the strengths and opportunities that SUDS have the potential to offer developing world cities.

Pursuing a development trajectory that is adaptive, experimental and reflexive implies that developing world cities should then actively embrace experimentation, mutual learning and innovation as fundamental components of their governance (Ashley et al., 2012; Bulkley & Broto, 2011). The ability to engage with multiple stakeholders, learn from possible sociotechnical and policy failures and to learn from how different segments of the population experience the city would help in integrating SUDS into the urban fabric in a manner that is incremental and relevant to the prevailing context. Also, the education of the different stakeholders on the value of ecosystem services, systems (holistic) thinking as well as SUDS and how they are to be used could also help in evading some of the threats to SUDS identified above.

According to McCormick et al (2013) cities around the world have different starting points in the journey towards sustainable urban transformation[11]. The important thing in the case of SUDS is to

[11] Unlike sustainable urban development, sustainable urban transformation places a stronger emphasis on structural processes both multidimensional and radical change, which can direct urban development towards sustainability (McCormick et al. 2013:4).

move beyond the identification of possible barriers and challenges to SUDS and to begin to envision how a transition towards watercentric urbanism through SUDS can be deliberately brought about within each city's context so as so foster sustainability and resilience. To this end, one recommendation would be to take advantage of the 'multiple sites of governance' (Lindell, 2008) that exist in developing world cities and approach the adoption and implementation of SUDS from the sub-city or local community scale (Hamann & April, 2013; Mguni et al., 2015). Such an approach is cognizant of the difficulties developing world city governments already face in delivering services as well as the institutional fragmentation that may exist at the city government (top) level.

There are indeed several practical advantages of engaging with the local-scale when thinking of the adoption and implementation of SUDS. The local scale allows for the creation of spaces of innovation where SUDS niche experiments can be done with the active engagement of the local community. Additionally such an approach would be more practicable, avoiding the paralysis and pessimism that may result in trying to overhaul the drainage infrastructure of an entire city at once. Lastly, the implementation of SUDS at the local scale may provide opportunities for learning and collaboration between stakeholders which may be difficult to attain were SUDS to be approached in a top-down (McCormick et al., 2013). A closer look at the coping strategies of particular local communities and the undertakings of that area's community-based organisations may provide clues as to what form of SUDS experiments may serve the water supply, flood protection as well as amenity and biodiversity needs of the local community best.

6. Conclusions

This article has presented a review of the literature on the SUDS approach to stormwater management, highlighting SUDS' multiple goals of addressing water quality, water quantity, amenity and biodiversity through the elements organized in a treatment/ management train. It has also highlighted some of the issues that make up the context of urban water management in many developing world cities. These issues include rapid urbanization, informality and numerous sites of governance. Furthermore a SWOT analysis of the potential value that the SUDS approach may hold for developing world cities has been performed. The strengths of SUDS include the stronger viability of G.I.-based SUDS as an investment option when compared to conventional stormwater management systems, flexibility and the possibility for an augmented water supply. The weaknesses of G.I.-based SUDS include difficulties in quantifying hydraulic performance and water improvement, the requirement for high levels of maintenance which may also be costly, the need for coordination between stakeholders among others.

The opportunities that accompany G.I.-based SUDS include possible support for urban agriculture, support for on-going community infrastructure upgrading programmes and a possibility of more inclusive decision-making. There are likewise numerous possible threats to the potential value that SUDS may hold and these include low prioritization on the urban development agenda, lack of data, and possible malarial and diarrheal health risks among others. In light of the SWOT analysis one of

the main recommendations has been that SUDS may be best approached from the local community scale, taking advantage of the multiple sites of governance that exist and avoiding the barriers that exist at the city government level. Moreover, however much SUDS may be deemed more sustainable than conventional storm water management systems, its adoption and implementation in developing world cities should be approached with a full knowledge of the socio-economic, technical and political context of each particular city so as to avoid unintended consequences that may worsen the lot of the urban poor.

While G.I-based SUDS may not be panacea to all the drainage problems of developing world cities, they could potentially offer these cities more in terms of value and function than is currently offered by the sole use of conventional drainage systems. For now however, it may be too optimistic to think all the identified opportunities and strengths of SUDS can be realized, or that the weaknesses and threats against SUDS can be easily addressed. Nonetheless, if SUDS are viewed from a holistic perspective, those concerned with the governance of developing cities may harness the potential benefits that G.I.-based approaches like SUDS offer in helping them reorient urban development trajectories towards sustainability and resilience.

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Paper II

Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: exploring the potential for transitions towards sustainable urban water management

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Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: exploring the potential for transitions towards sustainable urban water management

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Abstract

The risk of flooding in urban areas could be better approached by complementing conventional sewer systems with sustainable urban drainage systems (SUDS) for storm-water management. This may be the case for developing world cities like Dar es Salaam with incomplete sewer services, as well as cities like Copenhagen with fully developed sewer systems. This paper explores some theories relevant to understanding how the implementation of SUDS may be one option for supporting a transition towards sustainable urban water management (SUWM). Using interviews, document analysis and observation, a comparison of the opportunities and barriers to the implementation of SUDS in Dar es Salaam and Copenhagen is presented. The results indicate that a bottom-up approach in Dar es Salaam is important, with the community level taking the lead, while in Copenhagen the top-down approach currently employed is promising. The ability of the institutional frameworks of both cities to support the implementation of SUDS is also discussed.

Keywords: Flood risk; Institutional framework; Sustainable urban drainage systems; Sustainable urban water management; Transition

1. Introduction

At a time when the effects of climate change are starting to be felt around the world, urban managers and engineers have begun to search for alternative ways to increase the resilience of urban settlements against increased flood risk. Such a flood risk emanates from storm surges from the ocean and from more intense precipitation, that is, pluvial flood risk (Loftus *et al*., 2011). Hitherto, responses to increased flood risk in some affected cities have been based on enlarging the capacity of the existing sewer systems. However, such an approach is linked to economic and technical constraints, which

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may put its sustainability in question, especially in developing countries where there may already be an infrastructure deficit (Chocat *et al*., 2007).

There has been a growing call for a shift from a hard infrastructure-based approach to urban storm-water management towards combining it with, and increasing the role of, green infrastructure-based approaches[1], such as sustainable urban drainage systems (SUDS). Such an approach could be a more flexible and economical option to cope with the increased flood risk (van de Meene *et al*., 2011). SUDS is based on disconnecting storm-water drainage from the sewer system and using the green infrastructure of the urban landscape to store, filter and evaporate the storm-water within the local catchment area (see Jensen *et al*., forthcoming).

In theory, the implementation of SUDS offers several advantages, such as the possible creation of multiple synergies with a sustainable urban form through an enhanced green infrastructure within the city, improved conditions for urban agriculture, freshwater aquifers' recharge, and facilitating a more inclusive decision-making process in urban management based on multiple stakeholder involvement (Holman-Dodds *et al*., 2003; Fryd *et al*., 2010; Jensen *et al*., forthcoming). Approaches such as SUDS are therefore accompanied by the prospect of increased resilience against climate change and, more importantly, by a possibility of accelerating the transition of cities towards sustainability (van de Meene *et al*., 2011; Frantzeskaki *et al*., 2012).

Dar es Salaam was chosen as a case because it is a city facing a high infrastructure deficit and it may need alternative solutions such as SUDS to address the current pluvial flood risk (Dodman *et al*., 2009); while Copenhagen has identified SUDS as its preferred initial adaptation option against increased flood risk (Copenhagen Climate Change Adaptation Plan; CCAP, 2011). For cities in the 'global south', like Dar es Salaam, which are experiencing a 'rapid urbanization in poverty' (Kyessi, 2005: 3) and a general decline of the urban infrastructure fabric in a changing climate, it is essential that the opportunities for the implementation of possibly cheaper and more sustainable approaches to flood risk, such as SUDS, are analysed within the governance framework.

Similarly, for Copenhagen, the implementation of green infrastructure approaches like SUDS not only supplements the existing sewer system capacity but it also provides an opportunity to address increased flood risk without continued path dependencies on hard infrastructure solutions, especially in light of the uncertainty inherent in climate change scenarios. Additionally, in old post-industrial cities like Copenhagen, adaptation to climate change based on SUDS could provide the chance to counteract urban decay and pollution since the development of green infrastructure may revitalise the urban milieu and improve liveability.

The overall goal of the paper is to identify opportunities and barriers, from a governance perspective, for the adoption and implementation of SUDS in Dar es Salaam and Copenhagen, as one of the options for a transition towards sustainable urban water management (SUWM). Such a perspective centres on diagnosing the transition context for each city (Smith *et al*., 2005) through the identification of the actors involved in the governance of urban drainage and associated issues of institutions, agency and power relations. More specifically, the first objective is to provide a review of theoretical works that highlight how the implementation of alternatives such as SUDS may be approached. The second objective is to validate the selected theories through application to a city with a fully developed sewer system

[1] The green infrastructure concept is based on providing a hydrological/drainage network through interconnected green spaces that conserve natural ecosystem values and functions (see Benedict & McMahon, 2002; Ahern, 2007).

(Copenhagen) and a city with a hard infrastructure deficit (Dar es Salaam), and trace the potential for transition towards increased sustainability in both cities.

2. Methods and materials

A literature review of theories on sustainability transitions, planning and urban governance, and sustainable urban water management was performed to identify concepts relevant for understanding the conditions for introducing a green infrastructure for flood-risk management. The theoretical findings were used as a basis for the case study analysis approached from a governance perspective by first identifying actors in the storm-water management sector of each city and then looking for examples of adaptation to flood risk that may illuminate our understanding of the potential for SUDS implementation in each city. Both Dar es Salaam and Copenhagen face increased pluvial and storm surge flood risks, and represent very different economic and urban development realities.

2.1. Dar es Salaam

Data were gathered over two periods in June 2011 and March 2013. Seven semi-structured interviews were conducted with: one urban planner and one civil engineer from Kinondoni Municipality; three physical planners with the Ministry of Lands, Housing and Human Settlements Development (MLHHSD); one waste management official from Temeke Municipality; and the Chairman of the Magomeni Suna Sub-ward in Kinondoni Municipality. Furthermore, two unstructured interviews were held with officials from Dar es Salaam Water and Sewage Authority (DAWASA) and the National Environment Management Council (NEMC).

The interviewees were asked to trace where storm-water management was situated within the governance framework of the city. They were then asked to give an opinion on how effective the city's storm-water management was in relation to the flood risk the city faces. Respondents were also asked to detail what they saw as the causes of the flooding, as well as existing barriers to, and opportunities for, effectively addressing flood risk. Finally, respondents were asked to give examples of flood-risk management activities at different levels of city governance.

Multiple-stakeholder sessions that were held as part of the project's activities in Climate Change and Urban Vulnerability in Africa during June 2011 and March 2013 also provided opportunities for participant observation of the interactions between multi-sectoral officials, local-level leaders and academics as they discussed the climate-change challenges facing the city as well as possible ways forward. Furthermore, an analysis of local academic literature, planning and regulatory documents was performed for further contextualisation.

Dar es Salaam is a coastal city that receives over 1,000 mm of rain annually during two rainy seasons. While the city has historically experienced climatic variability, climate changes are projected to bring an increase in mean rainfall of up to 6% by 2100 during the main rainy season. The projected increase in rainfall, coupled with a projected decrease in the number of rainy days, suggests an increase in rainfall intensity. Therefore, it is predicted that the magnitude and frequency of floods and drought in Dar es Salaam will increase as climate variability increases with the progression of climate change (START *et al.*, 2011).

Any consideration of the risks posed by climate change and possible adaptation options in Dar es Salaam has to consider that of the 3.3 million residents; 70–80% of the population live in unplanned settlements (Lerise *et al*., 2004; Dodman *et al*., 2009). The annual population increase in the city of 4.3% and the resultant increase in demand for urban services and land have set a rapid pace of urbanisation, thereby worsening the city's adaptation deficit. Due to heavy rainfall, many parts of the city, especially the unplanned settlements, currently experience annual flooding episodes, the worst being the floods of June 2012. The problem of flooding in Dar es Salaam is exacerbated by poor stormwater drainage infrastructure, inadequate solid-waste disposal, and the blockage of natural drainage systems through unregulated urban development (START *et al*., 2011).

2.2. Copenhagen

The initial findings for the Copenhagen case study are based on a desk study of internal reports and papers of the 2009 Danish national research programme 'Black, Blue and Green: Integrated Infrastructure Planning as key to Sustainable Urban Water Systems' (2BG, 2009) as well as the Copenhagen Climate Change Adaptation Plan, and the accompanying Cloudburst Management Plan. Additional information was obtained from two semi-structured interviews in October 2012 and October 2013 with two project managers within the Copenhagen Climate Change Adaptation Team; one is an official from the Municipality of Copenhagen working on the St Kjelds Klimakvarter, the other is an official from HOFOR working with another area in the city. HOFOR (Greater Copenhagen Utility) is a subsidiary wholly owned by the city of Copenhagen with the mandate to manage all utility services, such as drainage, within the municipality as efficiently as possible without profit.

The respondents were asked about their views on SUDS and how the municipality and utility are approaching them as an adaptation option. They were also asked what the potential and current barriers and opportunities were for achieving city-wide SUDS retrofits, vis-à-vis the St Kjelds Klimakvarter project and their experiences.

Copenhagen is a low-lying coastal city with an average annual rainfall of just over 600 mm (www.climatemps.com). The city has about 1,400 km of main sewer and service pipes covering 6,800 hectares. About 90% of the area is covered by a combined sewer system and the rest is covered by a separate sewer system (Sørenson *et al*., 2006: 7). Copenhagen is facing significant challenges with respect to climate change. The A2 scenario climate-change forecasts for the city predicts a 25–55% increase in precipitation in winter months by 2100, while precipitation in summer may decrease by 0–40% (CCAP, 2011). Therefore, the primary climate-change challenge that Copenhagen faces is the likelihood of an increase in the frequency and intensity of rainfall, with rainfall intensity increasing by 20–50% (CCAP, 2011: 13). In addition, the city is also vulnerable to storm surges (Hallegatte *et al*., 2008). The serious floods that the city experienced on 14 August 2010 and on 2 July 2011 seemed to confirm the climate-change predictions.

3. Results

3.1. Implementing sustainable urban drainage systems: a theoretical framework

The idea behind conducting the theoretical review is to gain a better understanding of the conditions that may encourage or hinder a transition from urban water management based solely on hard

infrastructure towards the incremental adoption of green infrastructure-based systems such as SUDS to complement existing conventional sewer systems. The following sections detail some of the concepts found in the literature that we consider relevant to such an understanding.

3.1.1. SUDS: a flood-risk management approach that is a complex and wicked problem. SUDS involve the disconnection of storm-water drainage from the sewer system and the use of the urban landscape to convey, store, treat, filter and evaporate the storm-water (Jensen *et al*., forthcoming). Although SUDS and its basic components are seemingly straightforward, the design and implementation of city-wide SUDS retrofits are actually complex (Fryd *et al*., 2010). In addition to the 'functional complexities' that are directly linked to the physical urban landscape, there are also 'relational complexities' that underlie the implementation of SUDS (Frantini *et al*., 2012b). One such complexity is the competition for space in the urban landscape vis-à-vis the frequently divergent interests of the numerous stakeholders. Another form of relational complexity in the implementation of city-wide SUDS retrofits arises from the intrinsic need for a transdisciplinary and multi-tier approach (Ingvertsen *et al*., 2011).

SUDS are also plagued by practical barriers such as the difficulty of precisely quantifying their hydraulic and water-quality improvement performances in the management of run-off, especially at a city-wide level (Goldenfum *et al*., 2007; Ashley *et al*., 2011: 18). Also, the need for costly, high-skilled maintenance and regulation of SUDS elements presents a significant barrier, especially when considering that such skills and resources may be unavailable in developing countries (Armitage, 2011). Moreover, without clear methodologies to measure the 'sustainability' of SUDS, it is difficult to estimate the value of employing SUDS in an urban context (see Ashley *et al*., 2011; Benzerra *et al*., 2012).

As one considers the complexities inherent in SUDS, it is important to acknowledge that some of the complexity stems from the problematic nature of the flood risk itself. Urban flood risk presents a particularly 'wicked problem' (Rittel & Webber, 1973) to urban managers: a 'persistent problem' (Loorbach, 2010: 164). This is an unstructured problem that cannot be solved with simple short-term solutions because it is rooted in different societal domains with multiple actors and values at play (Frantzeskaki *et al*., 2012). Due to such complexities, city-wide SUDS retrofits may not be achieved in the usual linear planning and implementation process of data collection, analysis, design and implementation. Rather, SUDS retrofits must themselves also be approached as a wicked problem that requires a reflexive process of problem-solving and identification, supported by continuous communication between actors and evaluation of design solutions at all levels by the different stakeholders (Fryd *et al*., 2010).

Indeed, recent climate-change governance literature has highlighted the difficulties associated with the implementation of adaptation measures such as SUDS at the city level. Although it is becoming accepted that adaptation to the effects of climate change in the urban water sector may partly entail a transition towards SUWM, there still has to be a shift from the traditional technocratic mode towards a more adaptive and integrated approach within the institutions concerned with the management of water (Brown, 2007).

The implementation of flood-risk management measures, such as SUDS, requires wider participation in decision-making and a change in traditional management methods to be successful (Jha *et al*., 2011: 39). Participation in decision-making would help address the potential barrier of ownership, especially where SUDS elements are to be implemented on individually owned plots of land or buildings. It is partly because of such complexities that the implementation of SUDS has for the past three decades

been focused on small-scale demonstration projects, while little has yet been attempted at a city-wide level (Backhaus & Fryd, 2012).

As a result, a major set of hurdles to the implementation of adaptation measures such as SUDS lies within the very institutions tasked with managing water and implementing flood-risk adaptation policies. These obstacles constitute yet another layer of relational complexities and they 'include institutional fragmentation, limited political incentives, technological path dependencies, poor community capacity to meaningfully participate' (Brown, 2007: 222) and competition for resources from other issues on the urban agenda. Furthermore, many cities lack the data that are a prerequisite for the adoption of SUDS, that is, the size and value of existing green infrastructure and the extent of sewer system coverage (Goldenfum *et al*., 2007; Schäffler *et al*., 2013).

3.1.2. Transitioning towards SUWM: the urban water regime, hydro-social contract and selection pressures. How then do we deal with such barriers and how do we identify opportunities for implementing SUDS as one of the options that could promote a transition towards SUWM? Van de Meene *et al*. (2011) suggest that one starting point to deal with the gap between policies for increased resilience and meaningful implementation is to look at the urban water management of a city as a 'regime'. A city's water management regime refers to the people and organisations who manage water as well as the corresponding legislation, policies and practices. A regime comprises four elements: actors, processes, structures, and influences (van de Meene *et al*., 2011).

The water management 'regime' of a city is based on a 'hydro-social contract'. The hydro-social contract refers to the values and implicit agreements between all the levels of society on how water should be managed. This contract is influenced by cultural perspectives, contextual historical urban water values, ecologies, geographies and sociopolitical dynamics. The hydro-social contract is expressed through institutional arrangements and regulatory frameworks, and it is physically manifested through the water systems' infrastructure (Turton & Meissner, 2002; Brown *et al*., 2009: 848).

Transitions are defined as the fundamental changes within the levels of a societal sub-system to deal with a persistent problem that confronts society (Loorbach, 2010; Frantzeskaki *et al*., 2012). When looked at from the Multi-Level Perspective by Geels (2002), transitions can be said to be a form of regime shift (Koppenjan *et al*., 2012: 5). Regimes function within a wider societal context called the 'landscape' (macro level) and they are therefore subject to the influence of so-called landscape factors, that is, changes in economy, politics, and climate (Koppenjan *et al*., 2012). Regimes are also influenced by innovations in the micro-level 'niches' (Koppenjan *et al*., 2012), that is, alternative technologies and practices emerging at a smaller scale. Additionally, regimes are influenced by the hydro-social contract on which they are based (Turton & Meissner, 2002).

In light of the above, it could be said that a regime can shift and become more sympathetic to approaches such as SUDS when three things happen simultaneously (see Figure 1). First, according to Koppenjan *et al*. (2012) a regime can shift if it can no longer adapt to changes in the 'landscape', for example, increased flood risk due to climate change. Second, it can also shift when changes in the landscape foster a definite change in the terms of the hydro-social contract (Turton & Meissner, 2002). Third, a regime may shift when it faces increased challenges from maturing niche-level alternatives, for example, experiments in SUDS (Koppenjan *et al*., 2012; Brown *et al*., 2009). The landscape changes, maturing niche-level alternatives and changes in the terms of the hydro-social contract represent what are also known as 'selection pressures' (Smith *et al*., 2005: 1492).

According to Smith *et al*. (2005), how a regime will transform is based on three factors: first, the degree to which selection pressures acting on a regime are articulated towards a particular problem

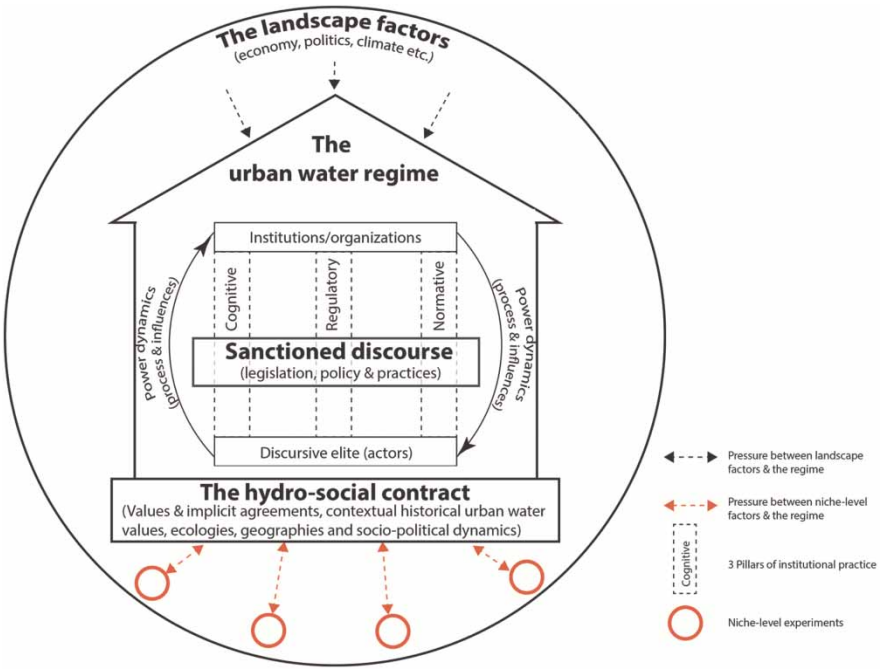

Fig. 1. Transition towards sustainable urban water management as a function of the pressure applied by landscape factors and niche-level experiments on the urban water regime.

or direction by the regime members; second, the extent to which responses to the selection pressures are coordinated coherently across the regime; and third, the degree to which resources required for regime shift are available within or beyond the regime. The availability of resources and the coordination of responses represent the adaptive capacity of the regime (Smith *et al*., 2005: 1492).

Smith *et al*. (2005: 1498) further suggest that there are four possible contexts within which the transformation of a regime towards sustainability may occur and be governed. These contexts are mapped according to whether the transformation is intended and actively coordinated by the regime in response to selection pressures. The contexts are also mapped according to the degree to which the responses to selection pressures are based on the regime's resources. The four transition contexts that emerge from such a framework are endogenous renewal, emergent transformation, reorientation of trajectories, and purposive transition (for a diagrammatic representation of the transition contexts, see Figure 1, p. 1499 in Smith *et al*. (2005)).

According to Smith *et al*. (2005: 1500), 'endogenous renewal' happens when regime members make conscious, highly coordinated and internally resourced efforts to respond to clearly articulated selection pressures, resulting in an incremental and path-following transition process. A 'reorientation of trajectories' occurs when there is an uncoordinated, but internally resourced regime response to poorly articulated selection pressures. 'Emergent transformations' (Smith *et al*., 2005: 1501) are the result of poorly articulated selection pressures meeting an uncoordinated regime response drawing on resources external to the regime. Finally, 'purposive transitions' (Smith *et al*., 2005: 1502) are transitions that have been intentionally pursued to reflect clear societal interests but which draw on resources and capabilities external to the regime. From this typology of transformations, it should be possible, according to Smith

et al. (2005), to diagnose the transition processes taking place, in our case, within a city's water management sector, and to prescribe appropriate governance approaches.

3.1.3. Unpacking the transition: the discursive elite, power and champions for SUDS. As can be seen in the preceding section, institutions and how their practices change are central to any inquiry into the opportunities and barriers to implementing SUDS as one of the options for transitioning towards SUWM. According to Scott (1995: 49), institutions are durable social structures comprising social activities and material resources and they are made up of three mutually reinforcing pillars that shape practice, that is, cognitive, regulatory, and normative pillars[2].

Healey (1997) further asserts that institutions are articulated through 'hard' institutional infrastructures, that is, formal organisational structures, laws, etc., and through 'soft' institutional infrastructures, that is, informal networks, administrative routines, professional cultures and social worlds, etc. For a transition to occur there needs to be a change in institutional practice, and this can happen only when there is a simultaneous shift within the cognitive, regulative and normative pillars of institutional practice (see Figure 1). Most attempts at fostering a transition fail because they address only one of the pillars of institutional practice (Brown *et al*., 2009).

To comprehend where and why barriers and opportunities to SUDS implementation are to be found within institutions and planning processes, it is important to have an understanding of the power dynamics within the regime that governs water in a city, since institutions are sites for the play of power relations, holding and transmitting different kinds of power between actors (Lukes, 1974; Faulks, 1999). It is within these institutions that the powerful 'discursive elite' of the urban water regime are found. The discursive elite are those members of the regime in dominant institutional positions who determine the nature, form and content of prevailing discourse on urban water management, that is, the 'sanctioned discourse' within a regime (Turton & Meissner, 2002: 1).

As such, the transition process is therefore an inherently political process where the play of power relations between actors is what ultimately decides what is discussed and implemented and what is not (Faulks, 1999). In most urban water regimes, the discursive elite comprises mainly engineers and scientists whose traditionally positivist approach to water problems (Turton & Meissner, 2002) may not be initially well suited to more adaptive approaches such as SUDS.

However, just as urban flood risk and indeed the approaches to it such as SUDS are multifaceted in nature, there is a need for a transdisciplinary approach to decision-making and the implementation of SUDS. This means that not just engineers, but planners, politicians and citizens have to be involved (Frantini *et al*., 2012a). Since different actors have varied understandings of the problem based on their different epistemological standpoints, decision-making for implementing SUDS should ideally be based on collaboration, negotiation and mutual learning (Frantini *et al*., 2012a).

This, however, means that SUWM first has to find its way into the sanctioned discourse. If not, then the discursive elite may prove to be a barrier to the implementation of SUDS. This is because the discursive elite hold much institutional power to set the agenda to include or exclude SUWM in the sanctioned discourse of the urban water regime, as well as the power to circumscribe any efforts towards

[2] Scott (1995) asserts that the cognitive pillar relates to dominant knowledge and skills within the institution; the normative pillar relates to values and leadership within an institution; and the regulative pillar relates to administration, rules and systems within the institution.

SUWM by actors outside the regime. As such, an appreciation of power relations and the actual processes of communication between transdisciplinary actors is essential to understanding decision-making as it relates to implementation and ultimately transition in an urban water regime (Albrechts, 2003: 249, citing Flyvbjerg, 1998).

It is only fitting then that some scholars suggest that there is a need for shrewd strategic actors who understand the power dynamics of the wider political context of the water regime, as well as the necessary agency required, if the implementation of such approaches as SUDS is to contribute meaningfully to a transition towards SUWM (Healey, 1997; Flyvbjerg, 1998). Such actors are said to be 'front-trunners' in transition management theory. These front-trunners are experts, networkers and opinion leaders who have some measure of authority within various actors' networks (Loorbach, 2010). They are also known as 'champions' (Farrelly & Brown, 2011) who, through their intimate understanding of the power dynamics within the urban water regime, may set the agenda towards a discourse that supports SUDS and decision-making that prioritises experimentation whilst also maintaining the momentum that leads to implementation.

In light of the above-stated theories, it would seem that there are ways, at least theoretically, to identify and address the barriers and opportunities for the implementation of SUDS as an option for transitioning towards SUWM. One of the first actions is to understand the urban water regime itself, the hydro-social contract that underpins it, and other selection pressures that are acting on it. Next, it is important to diagnose the prevailing context for transition within a city's water management.

In the case of urban water management, the landscape factors of climate change and population growth are already applying pressure on the current urban water regimes around the world. Niche-level experiments in SUDS are beginning to mature and indicate that there are viable alternatives to the current water management approaches. Under such conditions, the hydro-social contract that underpins current conventional water management approaches needs to be overhauled to initiate a transition towards more sustainable water management (Wong & Brown, 2009).

As such, it is possible that the biggest barrier to the transition towards SUWM and the implementation of SUDS lies within the existing hydro-social contract. In it are enshrined the old ways of knowing, decision-making and the conventional approach to water management. Ideally, in place of the existing hydro-social contract there should emerge a new hydro-social contract that prioritises the maintenance of ecosystem integrity, public health, flood control, liveability and economic sustainability (Brown *et al.*, 2009).

The establishment of such a new hydro-social contract in conjunction with other selection pressures should provide the space for the emergence of a more sympathetic urban water regime (van de Meene *et al.*, 2011). A sympathetic urban water regime would be characterised by a discursive elite whose sanctioned discourse is supportive of alternative approaches to urban water management. Such a scenario would encourage the break from technological path dependencies whilst also creating space for the meaningful implementation of SUDS.

Finally, it is of great importance to understand where the power to implement SUDS as part of a transition towards SUWM lies within the urban water regime and its institutions. Gaining a sufficient understanding of the power dynamics within the said context will help to identify institutional barriers as well as barriers in the form of individuals and policy. More importantly, it will help to identify possible champions who can help set the urban water management agenda towards transition and implementation of SUDS, whilst also helping to maintain the momentum that is required for city-wide implementation.

3.2. Opportunities and barriers for implementation of SUDS in Dar es Salaam and Copenhagen

3.2.1. Dar es Salaam. The interviews, observations and document analysis highlighted that there are several actors in Dar es Salaam's storm-water and flood-risk management sector with varying and overlapping responsibilities. The city of Dar es Salaam is governed by the Dar es Salaam City Council (DCC) (El Sioufi *et al.*, 2009). The DCC is divided into three municipalities: Kinondoni, Ilala, and Temeke. According to respondents, each individual municipality is the main authority responsible for the management of storm-water drainage and solid-waste disposal within their constituency through the guidance of their respective engineering services and urban planning departments. However, storm-water drainage at the national level seems to fall under the Ministry of Works and the Tanzania National Roads Agency. The Ministry of Lands, Housing and Human Settlements Development (LHHSD) oversees issues of urban development, master planning, urban services provision, etc.

The municipal officials interviewed referred to the fast pace of uncontrolled settlement as one of the major causes of increased flood risk in Dar es Salaam. Since the expiry of the 1979 Master Plan in 1999, and while a new Master Plan is in the pipeline, the city lacks a clear development framework to guide planning and development. Planners currently use strategic plans to address urban development issues that arise. However, these strategic plans are made on a seemingly ad hoc basis and fall behind in regulating settlement that is increasingly taking place on natural drains and hazardous land, thus exacerbating flooding. Most of the officials also put emphasis on solid waste, for example, diapers and plastics, as another prime cause of increased flood risk as it blocks storm drains.

According to the DAWASA official, the city has a separate sewer system[3]. DAWASA is responsible only for the provision of drinking water and the treatment and disposal of domestic sewage but not for storm-water drainage. The fact that Dar es Salaam has a separate sewer system is an opportunity, as it means that in terms of the separate sewer requirements for implementing SUDS, Dar es Salaam may already be one step ahead. The NEMC, which falls under the Ministry of Environment, is another actor in the flood risk and urban drainage sector of Dar es Salaam. According to the NEMC official, parts of the NEMC's activities involve clearing blocked storm-water and malaria drains. He highlighted that one of the biggest causes of flooding (and malaria) in the city was due to the blockage and abuse of storm drains by members of the public who sometimes fill in the drains with soil and plant vegetables. Thus, although the NEMC is a key player in the maintenance of storm drains, it seems that the NEMC engages in its activities almost independently of the other actors' activities in the same sector.

The executive arm of the national government also plays a part in the storm-water and flood-risk management sector of the city. The Disaster Risk Management Department, located within the prime minister's office, has intervened in recent years in some areas that are at risk of flooding in the city. These interventions include supporting research initiatives on flooding, resettling affected populations, and providing technical expertise and financial support for the implementation of flood-risk reduction activities (Kiunsi *et al.*, 2009). In addition, the vice president's office plays the role of spearheading the mainstreaming of climate-change policy in all arms of government through the Ministry of Environment. There is evidence of fragmentation and overlap since it seems that the activities of the Disaster

[3] Urban drainage systems handle two types of flow: wastewater and storm-water. In the combined sewer system, wastewater and storm water flow together in one pipe, and in a separate system, the wastewater and storm water are kept in different pipes (Butler & Davies, 2011: 18).

Risk Management Department at the prime minister's office are not coordinated with the functions being discharged by the institutions under the vice president's office (Kweka & Kombe, 2012).

Finally, the local level of urban government, that is, the ward and the sub-ward (Mtaa), is an important actor in the storm-water and flood-risk management of Dar es Salaam. Administratively, the wards are made up of sub-ward committees including the flood management committee. It is at this level that the reality of the vulnerability to flood risk is most acutely felt. Since unplanned settlements are home to almost 80% of the city's population, the local level's propensity for self-organisation and the resultant community-based climate adaptation activities provide short- and medium-term flood-risk reduction.

Discussions with the chairman of the Suna sub-ward of Magomeni indicated that a good example of local-level adaptation to flooding activities can be found in the sub-ward, which comprises both planned and unplanned settlements. Suna is bordered by three rivers: Msimbazi, Ngombe, and Hananasif, where the first two are said to contribute to the flooding problem the area experiences. Of the 770 houses in the sub-ward, 370 are said to be located in the flood zone (John *et al*., 2012: 17). The chairman identified that the biggest cause of flooding was the sub-ward's poorly constructed storm-water drainage infrastructure, which is frequently blocked with solid waste.

To address the problem, he and the sub-ward residents organised themselves and contributed money towards cleaning the blocked drain. They then approached Kinondoni municipality for further financial and technical assistance, and hired an excavator to clean the drain. The drain was cleared, leading to temporary relief from flooding. However, the chairman stressed that the problem still persists because of the solid-waste disposal practices of the wards upstream of the storm-water drain.

3.2.2. Copenhagen. To tackle the problem of adaptation to climate change, the city of Copenhagen published the Copenhagen Climate Adaptation Plan (CCAP) in 2011. The CCAP is underpinned by several key considerations: decisions and investments into adaptation are to be based on sound technical knowledge; adaptation is flexible; adaptation is in strong synergy with urban development goals in general; and adaptation should ideally result in an attractive city that is based on green growth (CCAP, 2011: 6).

One of the initiatives identified as essential to adapting the city to climate change is the establishment of green infrastructure solutions such as SUDS to reduce the flood risk (CCAP, 2011: 7). Calculations show that unilateral adaptation based solely on investments into the expansion of sewer capacity will produce a negative societal gain for the city. Accordingly, the CCAP identifies the disconnection of storm water from the sewer system and the employment of SUDS as part of the primary response to increased rainfall frequency and intensity. Disconnecting storm-water drainage from the sewer system could reduce the load in the sewer system by up to 30%, thereby also decreasing the chances of combined sewer overflows (CCAP, 2011: 25). The Cloudburst Management Plan of 2012 is a part of the CCAP. It also favours the use of green infrastructure to manage flood risk but it concentrates on addressing extreme rain in the short term.

According to the municipal official, the city of Copenhagen put together a climate adaptation team in January 2012 whose task has been to look into how the SUDS adaptation option can be best implemented throughout the city, with the St Kjelds Klimakvarter demonstration project as an integral part. St Kjelds is a 105-hectare neighbourhood that lies in the outer eastern part of Copenhagen (www.klimakvarter.dk). The project seeks to address issues pertaining to how storm water can be used to make the city greener and more liveable whilst also protecting the city from flooding, and how the SUDS adaptation option can be best implemented.

According to the municipal official, although the city of Copenhagen drew up the Climate Adaptation and Cloudburst Management Plans and the accompanying policies, the real task of financing and implementation lies in the hands of the utility company HOFOR. To ensure that its finances are dealt with responsibly, HOFOR is also answerable to the Forsynings Sekretariat, which is in the finance department of central government. Both the municipal and HOFOR officials identified the owners of the individual buildings and roads in St Kjelds and around the city as important actors. Although the city cannot legally compel owners to retrofit their buildings, it can educate them on the advantages of doing so and provide incentives.

In the view of the municipal official, there have been some challenges concerning the financing and implementation of the SUDS adaptation option, at least for the St Kjelds project. According to him, whilst the municipality seems more inclined to implement SUDS, HOFOR is unsure about the viability of SUDS in terms of implementation and maintenance costs and may prefer the more tried-and-tested solution of expanding sewer capacity instead. This, he suggests, may be a result of benchmarking done by HOFOR in an effort towards efficiency and competitiveness. In contrast, the HOFOR official highlighted that their objective is to reduce the cost of adapting to the increased flood risk by investing in green infrastructure instead of enlarging the sewer capacity. However, he views the lack of space as well as issues with ownership of buildings and roads as bigger challenges to retrofitting despite the financial incentives HOFOR offers developers and owners for disconnecting their storm water.

4. Dar es Salaam and Copenhagen: a comparison of opportunities and barriers for the implementation of SUDS

One of the barriers to the implementation of SUDS in Dar es Salaam may be the institutional set-up for managing storm water and flood risk. There seems to be a certain level of institutional fragmentation and overlap in the responsibility for storm-water drainage and solid-waste disposal services. The interviewees tell of a frustrating lack of coordination within the municipalities' departments, between the three municipalities, the city administration and the various government ministries.

This problematic institutional set-up may emanate from what seems to be a problematic hydro-social contract that is tied to the city's colonial heritage and is incompatible with Dar es Salaam's current rapid urbanisation trajectory. Thus, the city's hydro-social contract may not provide an adequate framework that can support the institutional arrangements, regulatory frameworks and resultant water systems' infrastructure required to address current infrastructure deficits. It could be said that the biggest obstacle to the implementation of SUDS and a potential transition towards SUWM in Dar es Salaam may be a hydro-social contract that is derelict, leading to a highly fragmented institutional set-up within the city's water management regime.

Another barrier to the SUDS implementation can also be traced back to the city's derelict hydro-social contract. The hard institutional infrastructures of the water management regime of Dar es Salaam are weak, as is evident in the increasing infrastructure deficit facing the city and the decline of service provision. It is plausible that the barriers identified hitherto have diminished the power and authority that institutions in Dar es Salaam's water management regime may need to systematically push through such measures as the implementation of SUDS.

In such a scenario, it is difficult to envisage the implementation of SUDS in Dar es Salaam being the result of regime-driven (top-down) decision-making supported by the 'hard institutional infrastructures' of the incumbent water management regime. Although the regime in Dar es Salaam may not be

unsympathetic towards SUDS, it may be, for now, too fragmented and preoccupied with more pressing urbanisation problems to allow for the meaningful implementation of SUDS.

On the other hand, looking at the Suna example, it seems that the local level provides a promising opportunity for the implementation of SUDS. As community groups at the ward and sub-ward level organise themselves to fill the infrastructural and service gaps left by centralised institutions, it is easier to foresee that the implementation of SUDS may very well start as a local niche-level experiment in alternative approaches to flood-risk management at ward and sub-ward level. From there it could then be scaled up towards the upper institutional levels in the regime, that is, in a bottom-up governance approach. This in itself indicates that the local level in Dar es Salaam is a site of power that could be tapped into to provide the impetus for an incremental transition towards SUWM.

Whilst the sanctioned discourse within the water management regime of Dar es Salaam may seem unclear, there could be an opportunity for SUDS in what appears to be Dar es Salaam's prevailing discourse on urban infrastructure upgrading as well as in the more tentative discourse on climate-change adaptation. SUDS experiments at the local level could be approached as part of the upgrading of water and sanitation services within community infrastructure upgrading programmes that also seek to support community-based adaptation to climate change (Parkinson *et al.*, 2007). The implementation of SUDS could begin as a demonstration project in an affected sub-ward, with the community playing a significant part in the planning and implementation process. However, such an approach would require extensive support from non-governmental organisations (NGOs), whose ability to link resources with knowledge and institutional capacity-building could help gather the momentum needed to initiate a transition towards SUWM in cities of the 'global south'.

There is, however, a drawback to such a bottom-up approach to flood-risk adaptation in the face of a growing infrastructure deficit such as is illustrated by the Suna case. Without supporting essential services such as solid-waste disposal, and without significant coordination support from the authorities, most community-based solutions can provide only short-term relief from flooding. As such, the overall responsibility for adapting Dar es Salaam to flood risk still rests with the governing institutions. Nonetheless, the bottom-up approach may provide an opportunity for the community level and the authorities to work together, acknowledging the important roles both levels of actors have in adaptation and sustainable urban development through the mutual learning that such collaboration could offer.

Although the formal institutional relations within the storm-water management regime seem to be uncoordinated in Dar es Salaam, there is another window of opportunity for SUDS to be found in the rich layer of informal networks and relationships, that is, 'soft institutional infrastructures' between the practitioners within these organisations, and between practitioners and academics in Dar es Salaam's universities. It is possible that some of the negotiations, agreements and effective governance decisions may be finalised on an informal personal network basis that exists within the planning and engineering fraternity in the city of Dar es Salaam, that is, the discursive elite. Moreover, these networks may also serve to diffuse the power that the formal institutions hold, such that the power to implement strategies does not lie exclusively within formal institutions.

The links between practitioners and academics could provide the opportunity needed to generate a prevailing discourse within the water sector that supports transition towards SUWM. Even more so, these links could ultimately provide an interesting avenue to approach and navigate the complex decision-making and implementation process that city-wide SUDS retrofits would require in Dar es Salaam, while also supporting the cognitive pillar of institutions by providing a suitable knowledge base on which to set the agenda towards institutional practices that support SUDS. Such strong informal

networks could also provide prime conditions from which champions for a transition towards SUWM could ultimately emerge.

We would therefore argue that the above-cited characteristics of the Dar es Salaam case could well point to an 'emergent transformation' being the most likely context for transition. Although the city has many problems resulting from rapid urbanisation, the problem of climate change and the resultant flooding have yet to be explicitly addressed in policy documents by the water management regime since the city has no climate-change adaptation plan yet. While these selection pressures are not clearly articulated, the regime struggles with issues of fragmentation and resource constraints, so there has been no coordinated response to increased flood risk from the regime either. As we have highlighted, it is more likely that a transformation towards SUWM could well be a result of the mobilisation of resources and capacities by actors outside the regime, in a bottom-up effort characterised by niche-level experiments driven by the local wards with the help of NGOs.

Looking at the Copenhagen case, it would seem that, unlike Dar es Salaam, Copenhagen's water regime is undergoing the initial, albeit tentative, stages of a transition towards SUWM, which could be characterised as an 'endogenous renewal' transition context. Climate change, exemplified by the cloudbursts and floods in 2010 and 2011, can be viewed as the landscape factor that has pressurised the current water regime to rethink its storm-water management options. It could also be said that the city's Adaptation and Cloudburst plans represent a clear articulation of selection pressures by the regime. Furthermore, the city's investment in a local-level SUDS experiment like St Kjelds Klimakvarter may also provide the impetus for a regime shift if the experiment demonstrates that SUDS is a viable alternative to sewer-based flood-risk reduction.

The biggest barrier to a transition towards SUWM in Copenhagen may lie in what appears to be an epistemological dissimilarity between the organisations tasked with planning and implementing the flood-risk reduction options laid out in the CCAP. The seemingly parallel points of view between the municipal official and the HOFOR official, who are both in the adaptation team, are a good example of barriers that can arise due to the transdisciplinary and multi-institutional nature of the SUDS implementation process. It may be that the two officials represent different departure points towards what seems to be the same end. HOFOR, with its emphasis on economic efficiency, may favour SUDS implementation as a flood-risk management option because they can help reduce the cost of flood-risk management, with additional benefits. Such a motive is different from, although not a contradiction of, that of the municipality, which supports SUDS implementation because it can simultaneously help support urban development goals such as liveability whilst addressing the flood risk.

The fact that Copenhagen's discursive elite within the water management regime is made up of different professional groups with differing ideas provides a good opportunity for a change in the sanctioned discourse around storm-water management from a sewer-based approach towards the consideration of alternative approaches like SUDS. However, since the sanctioned discourse is a manifestation of power (i.e. agenda setting), changing it will involve actively empowering the discourse that supports transition towards SUWM. Nevertheless, it still remains to be seen whether the current efforts towards SUDS can succeed in making SUDS the sanctioned discourse in Copenhagen.

The St Kjelds project illustrates that the institutional framework within Copenhagen's water regime provides a good opportunity for the implementation of SUDS. Thus, unlike the bottom-up approach that we argue might be viable in Dar es Salaam, the St Kjelds project seems to illustrate a highly coordinated regime (top-down) response to clearly articulated selection pressures using resources from inside the regime, which is then translated to a niche-level experiment. The reasonably strong nature of the

institutional set-up, as well as the official policy drive to operationalise the CCAP and Cloudburst Management Plan, has provided a functional policy framework, that is, the hard institutional infrastructures, within which to establish the implementation of SUDS. This is especially so when one considers that one of the main barriers to SUDS implementation in Copenhagen is individual ownership of buildings at the local level, which means that a bottom-up approach towards the implementation of SUDS would be impractical in Copenhagen.

5. Conclusion

The theoretical review has highlighted that although SUDS implementation is a complex 'wicked' problem, there are concepts that may help to identify the barriers and opportunities for the implementation of SUDS as an option for a transition towards SUWM. As the two cases have shown, SUDS have potential as a flood-risk reduction option for cities that are faced with the challenge of increased frequency and intensity of rainfall. However, there are barriers within the socio-institutional set-up of both cities that may hinder the implementation of this approach. For Dar es Salaam, the main barrier lies in a derelict hydro-social contract, which leads to other barriers such as an institutional framework that is too fragmented to support the implementation of SUDS. For Copenhagen, one barrier lies in the differing emphasis, yet parallel departure points, of the municipality and HOFOR in relation to SUDS implementation, while another barrier is the individual ownership of the buildings at the local level.

Addressing and countering such barriers entail exploiting the opportunities that are adjacent to them. Such opportunities include approaching SUDS implementation in Dar es Salaam from the bottom-up, that is, as part of community-based adaptation within the prevailing discourses of urban infrastructure upgrading. For Copenhagen, the opportunity lies in approaching SUDS implementation from the top-down, that is, implementation by existing institutions within the water management regime. In terms of transition contexts, Copenhagen is characterised by an endogenous renewal, with the regime taking the lead in implementing SUDS and transitioning towards SUWM. In Dar es Salaam, however, an emergent transformation is more likely, with the local level mobilising resources to respond to unclear selection pressures but hampered by a poorly coordinated regime response.

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Paper III

Engaging theories of sustainability transitions with Sub-Saharan cities: The case of water management in Addis Ababa and Dar es Salaam

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Engaging theories of sustainability transitions with Sub-Saharan cities: The case of water management in Addis Ababa and Dar es Salaam

Abstract

Most Sub-Saharan cities currently face profound challenges in developing adequate water infrastructure systems and providing related services. Alternative approaches such as Sustainable Urban Water Management may have potential to help these cities address these deficits as well as support their transition towards sustainability. This paper uses the multi-level perspective (MLP), hydrosocial contract and transition contexts concepts to explore the potential for leapfrogging towards SUWM in Dar es Salaam and Addis Ababa with a particular focus on the applicability of Sustainable Urban Drainage Systems (SUDS) to the two cities. In this paper, sociotechnical landscape factors are shown to have a constraining influence on the cities' urban water management regimes, thus limiting their capacity to adequately deliver water services. An analysis of niche-regime dynamics in both cities' water sectors indicates that leapfrogging towards SUWM may depend upon the recognition of activities of non-regime (niche-level) actors and the significant roles they play in addressing water infrastructure service gaps. The conceptual implications that Sub-Saharan cases may have for the sustainability transition field are also discussed.

Keywords: sustainability transitions; sustainable urban water management; SUDS; Addis Ababa; Dar es Salaam; leapfrogging.

1. Introduction

Sub-Saharan cities are currently facing complex socio-economic, infrastructural and environmental challenges. While rapid urbanization, economic decline and poverty have long been identified as problematic, the vulnerability of such cities to climate change is also increasingly well documented (Swilling et al., 2011; Fankhauser & McDermott, 2014). With Africa's urban population likely to treble by 2050, the demographic pressure coupled with the above challenges will reinforce the negative urban externalities already plaguing Sub-Saharan cities (UN-Habitat, 2014).

Sub-Saharan cities face profound sustainability and resilience challenges as they have neither the requisite physical infrastructure nor the economic and institutional capacity to adapt to projected climate changes (Anguelovski et al., 2014; Jha et al., 2012). Furthermore, with the sheer scope of current challenges and without coherent policy strategies to address them, achieving sustainability and resilience to climate change may be a mirage for many cities in the South. This predicament is most visibly represented in the water systems of Sub-Saharan cities. The provision of water services i.e. supply, sanitation and drainage infrastructure in many of these cities has failed to keep up with the rapid rate of urbanization resulting in large infrastructure deficits that simultaneously translate into climate change adaptation deficits when considering (Mora et al., 2013; Dodman et al., 2009).

Urban water services provision in Sub-Saharan cities has been historically based on the publicly-provided, centralized infrastructure model or 'municipal hydraulic paradigm' adopted from the Occidental through colonisation (Bakker, 2010:35; Bhatt, 2014; Lundqvist et al., 2001). However, further development and reproduction of this infrastructure in Sub-Saharan cities has followed paths vastly different from those taken in the Occidental. Due to the colonial modus operandi, in most cities access to such infrastructure was limited to the colonial minority, leading to most post-

colonial cities inheriting a bifurcated service that was not universal in its reach (Bhatt, 2014). As a result of such historical and socio-economic factors, the bulk of urban dwellers in the South still lack access to adequate water services.

While the extension of universal access to water supply and sanitation have been central to the UN's Millennium Development Goals (MDG's) through the Water Sanitation and Hygiene (WaSH)[12] agenda, the emphasis on water and its management for sustainability and resilience are becoming important goals for cities. The steps necessary to move towards sustainable urban water management, by utilising such concepts as Sustainable Urban Drainage Systems (SUDS) may be clearer for cities in the West where the concern is more for breaking path-dependence on the conventional hard infrastructure-based approach (Domenech et al., 2014). However, progress towards urban water sustainability in the West has been slow (Wong & Brown, 2009; Novotny et al., 2010). More importantly, it remains unclear how cities in the South, whose current concern is providing universal access based on the above hard infrastructure-based hydraulic paradigm, can employ such approaches as SUDS in a simultaneous pursuit of the additional goal of sustainable urban water management (SUWM).

Sustainability challenges such as SUWM are increasingly understood in terms of 'transitions' towards more sustainably-configured socio-technical systems (Smith et al., 2010; Markard et al., 2012). However, studies of sustainability transitions in general, and more specifically in the urban water management sector, have so far suffered from a bias towards the Occidental leading to a paucity of research directed towards examining on-going transitions and potential for sustainability transitions in cities of the Subaltern (Markard et al., 2012; Hodson & Marvin, 2010). Yet cities in the developing world may be arguably more in need of such analyses (Lachmann, 2013), if they are to avoid the path dependence on pipe-based water systems entrenched in Western cities and possibly leapfrog towards water-sensitive urban futures (Wong & Brown, 2009).

The objectives of this paper are three-fold: the first is to identify an analytical framework that can help in the exploration of current dynamics and potential in the water management sectors of cities in the global South from a sustainability transitions perspective. The second is to apply the analytical framework to the case of urban water management in Addis Ababa and Dar es Salaam's with a view to generating narratives on the historical evolution and current dynamics of water management as well as exploring the applicability of SUDS as an alternative approach. The third objective is to discuss the potential for leapfrogging[13] towards SUWM in both cities as well as the possible implications these two cases may have for the relevance of sustainability transition theories to cities in the South. As such one contribution of this paper is to provide an '[…] empirical engagement […]' (Hodson & Marvin, 2010:484) of sustainability transitions frameworks with the realities and futures of Sub-Saharan cities. Although, SUDS is a stormwater management approach,

[12] The WaSH agenda is an international development programme drive seeking to address the overlapping challenges of water, sanitation and hygiene mainly in developing countries so as to improve health, reduce poverty and support overall development (See Mara, 2003 and UN-Water, 2012).

[13] Environmental and technological leapfrogging as a concept posits that emerging countries can decouple their infrastructural and economic development from the resource intensive paths taken by industrialised countries and instead opt for newer green technologies that are more sustainable (Perkins., 2003)

in this article we contextualise its applicability to Dar es Salaam and Addis Ababa from an urban water management perspective in general.

The next section outlines the methods used in the case study. Section 3 presents the results in two parts, the first part (3.1) outlines the Multi-Level Perspective (MLP) framework on sustainability transitions, hydrosocial contract and leapfrogging concepts as exploratory lens with which to view the current and prospective dynamics in the urban water management sector. Section 3.2 uses the analytical framework developed in 3.1 to describe and comparatively analyse of the current state of water management in Addis Ababa and Dar es Salaam. Section 4 is a discussion of the findings, highlighting the potential for leapfrogging towards SUWM in both cities and underlining some conceptual implications that empirical cases in the South may have for sustainability transitions frameworks.

2. Methodology

A broad review of literature on theories of sustainability transitions, water management in the developing world, policy documents, grey literature from NGO's and newspaper articles was performed. The literature review was used to develop an analytical framework for the case studies as well as to give snapshot of historical and current conditions in the water services sector of Addis Ababa and Dar es Salaam. The data were collected between June and July 2014, and were qualitatively analysed using concepts from sustainability transitions, highlighting current status of water management sectors in Addis and Dar, as well as the potential for the integration of alternative approaches to water management like SUDS.

Table 1 provides a description of the research activities undertaken i.e. document analysis, semi-structured and unstructured interviews as well as transact walks in local areas. Officials in both cities were asked to detail the role of their organisation within the water sector; the water supply, sanitation and drainage challenges their cities and organisations faced and the relationships between State organs, Civil Society Organisations (CSO's), private sector and local levels. Interviewees were also asked about their view of approaches like SUDS and the potential for utilising them in their cities. During transact walks, members of the community were asked about everyday water supply, sanitation and drainage issues i.e. ease of access, sources, technologies, frequency, quality, costs and security. Finally they were asked about any efforts they engaged in as households, communities and organisations to secure access to water services as well as the relationship with other stakeholders such as NGO's and the city authorities.

Addis Ababa is the capital of Ethiopia and its current population stands at over 3, 1 million (UNDESA, 2014). The city has both the highest proportion of slum dwellers in East-Africa, i.e. 80% of the population (UN-Habitat, 2014). Addis Ababa faces a challenging infrastructure deficit as only 10% of built up area is served by the existing sewer system; there is also a shortage of potable water (UN-Habitat, 2008). Although, in 2005, 68,8% of households had access to piped water in the city mostly in the form of yard pipes, and 8,9% have access to sewerage, there have been recent improvements in the water supply figures (UN-Habitat, 2014; Sharma & Bereket, 2008).

Dar es Salaam in Tanzania had a population of over 4, 4 million (National Bureau of Statistics, 2013). Dar es Salaam is a highly informal city with 70–80% of the population living in unplanned settlements (Dodman et al., 2009). Dar also plagued by infrastructural deficits, in 2004 only 62,1%

of households had access to piped water, while only 10% had sewerage connections (UN-Habitat, 2014).

Concept	*Method*	*Addis Ababa activities*	*Dar es Salaam activities*
Landscape	Document analysis, literature review	Water Sanitation and Hygiene (WaSH) Implementation Framework (WIF), One WaSH Programme (OWNP)	Water Sector Development Programme, Kironde (2007),
Regime	Semi-structured interviews (in person and via skype)	8 interviews with Addis Ababa City Road Administration, Ministry of Water Irrigation & Energy, Addis Ababa Water & Sewerage Authority, Housing Development & Administration Agency, UNICEF, Vitens Evide International, Addis Ababa Master Plan Office's Drainage Section and	4 interviews with Ministry of Water, Dar Es Salaam Water and Sewerage Authority, Dar Es Salaam City Council, Ilala Municipality
Niche	Transact walks, semi-structured and unstructured interviews	13 interviews with Mekanissa Seminarium, Mekanissa Horticulture Association, Jemo Condominium Development Committee and residents, Housing and Development Office Kolfe Keraniyo Sub-City 7, Reppi Idir Chairman, peri-urban farmers, community women, water bowser operators, Jemo concrete-block manufacturer	8 interviews with WaterAid, community members in Goba subwards of Kibururu & Matosa and a small-scale independent water supplier.
Hydrosocial Contract & Transition Context	Document analysis, semi-structured interviews	Concurrent with above activities	Concurrent with above activities

Table 1: Research methods and activities

The analytical framework developed in Section 3.1 then forms the basis for the analysis of data gathered from interviews, documents analysis and transact walks in the two cases.

3. Results and analysis

3.1. On socio-technical transitions, the hydrosocial contract and the potential to leapfrog towards water sensitive futures in the South.

This section puts together an analytical framework[14] based on the MLP, hydrosocial contract and transition contexts concepts which may be helpful in an exploration of the dynamics in water management sectors of developing world cities. With the progression of climate change and realisation that economic growth should be decoupled from environmental degradation; all spheres

[14] Similar frameworks have been employed before in the analysis of water management in Australian cities. (See Brown et al., 2009; Wong & Brown, 2009; Farrelly & Brown, 2011).

of human activity now face critical sustainability challenges. The urban water services sector, especially in developing countries, is confronted with problems including water scarcity, insufficient access, extreme events and pollution (Markard et al., 2012).

As such there have been growing calls for shifting from the conventional centralised pipe-based urban drainage systems towards more decentralised, green infrastructure-based approaches such as Sustainable Urban Drainage Systems (SUDS)[15] (Wong & Brown, 2009; Chocat et al., 2007). SUDS use the urban landscape to convey, store, treat, infiltrate and evaporate stormwater (Fryd et al., 2012). Consisting of rain water harvesting, detention ponds, green roofs and swales among other elements, SUDS not only help in flood risk management, but also offer other advantages such as augmenting water supply, supporting urban agriculture and improving liveability due to their multi-functionality (ibid).

It is thought that the challenge of shifting towards the integration of approaches such as SUDS and more sustainably-configured urban infrastructure is better framed as the challenge of socio-technical[16] transitions towards sustainability or sustainability transitions (Smith et al., 2010; Markard et al., 2012). Sustainability transitions are defined as long-term, multidimensional and fundamental transformation processes where established socio-technical systems shift towards more sustainable modes (Markard et al., 2012). They include changes in user practices, institutional structures and technologies (ibid). One of the main approaches to studying transitions is the Multi-Level Perspective (MLP) by Geels (2002).

The MLP[17] is a middle-range framework for analysing socio-technical transitions and it consists of three analytical levels: the sociotechnical landscape, the socio-technical regime and the sociotechnical niche level (Geels, 2011). The socio-technical "regime" is a central concept of the MLP as sustainability transitions are also described as "regime shifts" (Koppenjan et al., 2012:5). One definition[18] of the regime posits it as a stable configuration of institutions, techniques, artefacts, rules, practices and networks that determine the how technologies develop and are used (Rip & Kemp, 1998). These different elements that make up the regime are also a manifestation of how modern technology is organised; as "[…] a configuration that works" (ibid: 330). For empirical demarcation, the 'urban water management regime' is defined as the people and organisations who manage water as well as the corresponding legislation, policies and practices and is comprised of four elements namely: actors, processes, structures and influences (van de Meene et al., 2011).

The 'niche' is a micro-level protected space where radical innovations that can challenge the regime emerge; developed or carried by outside or fringe actors e.g. alternative approaches such as SUDS emerging at a smaller scale (Geels & Schot, 2007; Koppenjan et al., 2012). The sociotechnical 'landscape' forms an exogenous environment under which regimes and niches functions e.g.

[15] SUDS are also known as Landscape-based stormwater management (LSM), Best Management Practices (BMP's), Low Impact Development (LID) and Water Sensitive Urban Design (WSUD) among other terms (Fletcher et al., 2014)
[16] Socio-technical systems consist of technological/material artefacts and the associated networks of actors, institutions, and knowledge (Markard et al., 2012).
[17] Transition theories such as the MLP are not without criticism. For these, see Smith et al. (2010), Coenen et al. (2012), Markard et al. (2012), Genus & Coles (2008). For a summary and responses to the criticisms see Geels (2011)
[18] Depending on the context, the regime, niche and landscape concepts in the MLP may have different meanings and are used in diverse ways. For a summary of these see Raven et al. (2010).

climate change, population increase, global economic shifts (Geels & Schot, 2007). The principal thesis of the MLP is that socio-technical transitions towards sustainability come about when there is interaction of the following co-evolutionary processes at the three levels: 1. niche innovations build up internal momentum to challenge the regime; 2. changes at the landscape level exert pressure on the regime; and 3. destabilization of the regime creates windows of opportunity for niche alternatives (Schot & Geels, 2008). These three processes are also known as selection pressures (Smith et al., 2005).

A related concept that is helpful for understanding the reality of infrastructural deficits in urban water management in the South and the potential for moving towards SUWM is the "hydrosocial contract" (Lundqvist et al., 2001; Brown et al., 2009). The hydrosocial contract is the unwritten contract between the public and government that results when individuals are no longer able to satisfactorily provide water management services for themselves. There are two forms of hydrosocial contracts, the Hobbesian and Lockean. In the Hobbesian hydrosocial contract, the State assumes the benevolent role of principal provider and manager of water services as a public good. (Turton & Meissner, 2002)

It is the Hobbesian hydrosocial contract that has been the basis for the emergence of the state hydraulic paradigm and its pursuit of the 'modern infrastructure ideal' of universal access to a pipe-based water supply, sanitation and drainage system managed by regime members (Lundqvist et al., 2001; Furlong, 2014:139; Bhatt, 2014). Thus it can be said that the Hobbesian hydrosocial contract has underpinned the first three stages through which developed cities have transitioned in the 'urban water management transitions framework' by Brown et al (2009: 850) i.e. the Supply City, the Sewered City and the Drained City (see Figure 1 adapted from Brown et al., 2009: 850).

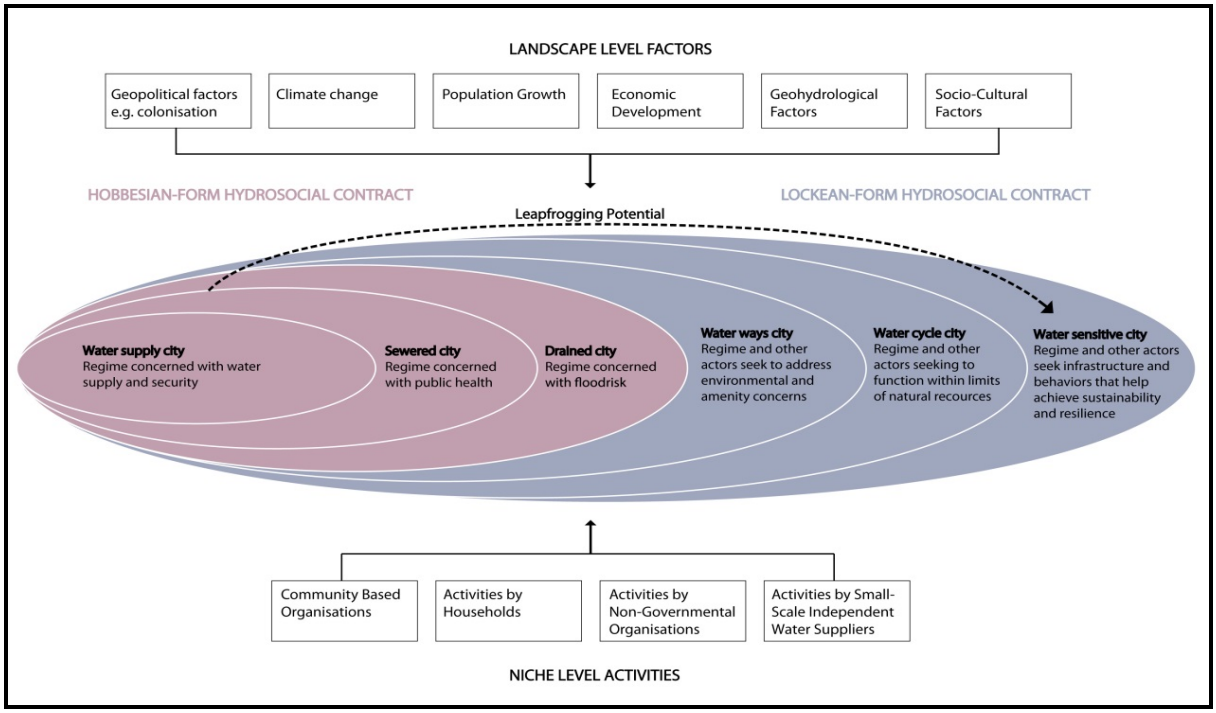

Fig 1. Framework for transitions towards SUWM in Addis Ababa and Dar es Salaam. Adapted from Brown et al. (2009, p. 850).

However, when the supply-sided solutions from the Hobbesian contract result in water supply and infrastructural deficits and values within society change towards sustainability, the Lockean hydrosocial contract is formed. The Lockean form of the hydrosocial contract is the basis, to varying degrees, for the last three transitional stages through which cities will likely transition towards sustainability in the urban water management transitions framework (See Figure 1). These stages are the Waterways City, the Water Cycle City and finally the Water Sensitive City, each stage seeking to progressively attain sustainability and resilience goals. Under the Lockean hydrosocial contract, the management of water and sanitation services becomes the shared domain between government, the public and Civil Society Organisations (CSO's) which include non-governmental organisations (NGO's), small-scale independent water providers (SSP's), and community-based organisations (CBO's).

As is evident, the hydrosocial contract is a key concept when operationalising the MLP to analyse actual and potential transitions in urban water systems as Brown et al. (2009) and van de Meene et al. (2011) have shown. Thus in urban water management, the relationship between the landscape, regime and niche levels of the MLP is based on the unwritten edicts of the prevailing hydrosocial contract. The urban water management regime with its rules, responsibilities, artefacts and professionals is an extension of the State and under the Hobbesian contract, it has the technical task of water supply, sanitation and drainage provision (Turton & Meissner, 2002).

However in the global South where the pursuit of centralised water service infrastructure based on the Hobbesian contract has failed and infrastructure deficits are the norm, households, N.G.O's, C.B.O's and (SSP's) could be viewed as crucial actors involved in the niche level (Bhatt, 2014; Lundqvist et al., 2002). The coping strategies and operations that these non-regime actors embark on could be viewed as innovative alternatives or the site where innovations are more likely to emerge within what seems to be an unacknowledged Lockean contract (Mguni et al., 2015).

Instead of the achievement of the modern universal infrastructure ideal, as has been the case in the Occidental, the reality in the global South is of a socio-technical co-existence of water infrastructure (Furlong, 2014) i.e. the coexistence of conventional pipe-based system with low-technologies of rainwater harvesting, wells, pit latrines etc. This is a coexistence that is coproduced by the regime, households and CSO's. How then can cities in the South move from failed aspirations of the modern infrastructure ideal towards urban water management for sustainability and resilience? How can the present realities of infrastructure deficit and malfunction be governed to facilitate leapfrogging towards more sustainable urban water management futures of the water sensitive city based on approaches like SUDS among others?

To begin to address these questions, Smith et al. (2005: 1491) suggest first diagnosing and mapping the prevailing 'transition context' of a city's water management system. This mapping is based on two factors (i) how well the incumbent regime articulates prevailing selection pressures and (ii) the degree to which the responses to these selection pressures are coordinated and based on resources available within the regime. Based on these two factors, four transition contexts are identified i.e. emergent transformation, endogenous renewal, reorientation of trajectories and purposive transitions. These transition contexts can also be thought of as an expression of the condition of the prevailing hydrosocial contract.

An 'endogenous renewal' is likely when regime members make conscious, highly-coordinated and internally-resourced efforts to respond to clearly articulated selection pressures, resulting in an

incremental and path-following transition process (ibid: 1500). A 'reorientation of trajectories' occurs when there is an uncoordinated, but internally-resourced regime response to poorly-articulated selection pressures. 'Emergent transformations' are the result of poorly articulated selection pressures meeting an uncoordinated regime response drawing on resources external to the regime (ibid: 1501). Lastly, 'purposive transitions' are transitions that have been intentionally pursued to reflect clear societal interests but which draw on resources and capabilities external to the regime (ibid: 1502).

It must be noted that there are caveats to the ultimate practicability of environmental and technological leapfrogging towards water sensitive futures envisioned in SUWM. Gallagher (2006) argues that leapfrogging may be problematic if developing countries do not have the requisite technological capabilities to integrate advanced technologies. For example, although SUDS are presented as a low-technology alternative to conventional pipe-based systems, they do require skills and infrastructures that may at first be challenging for developing countries (Armitage, 2011; Mguni et al., 2015). Rock et al. (2009: 241) also argue that leapfrogging by developing countries, may instead be a "[…] hard slog […]" of cumulatively building competence as prevailing socio-political landscapes render potential transitions complex and contingent.

3.2. The analytical framework to Addis Ababa and Dar es Salaam

3.2.1. Landscape factors in affecting water management in Addis Ababa and Dar es Salaam Applying

Several landscape factors have influenced the current state of water management in Addis Ababa and Dar es Salaam; they also play an integral part in determining the potential which the two cities have for leapfrogging towards a water resilient future. One landscape factor influencing both cities is the low level of economic development of both Ethiopia and Tanzania which makes them highly aid-dependent (Furtado & Smith, 2009; Harrison et al., 2009) and constrains the capacity of the state to deliver services. Below we present more city-specific landscape factors.

3.2.1.1. Addis

The socio-political evolution of government within Ethiopia during the 20th century has been an influential landscape factor. Under the successive governments[19] the main policy of the State has until recently been one of centralization leading to the conscious or inadvertent neglect of the development and management of urban areas like Addis Ababa in favour of rural areas (UN-Habitat, 2002). This has meant that until the recent redevelopment drive through programmes like the Integrated Housing Development programme (2004) and other slum and infrastructure upgrading efforts, urban infrastructure and service delivery had been lowly prioritised (UN-Habitat, 2007; UN-Habitat, 2002).

[19] The successive governments were under the Imperial Era (1923-1974); the Marxist "Derg" (1974-1991) and the current rule of the Ethiopian People's Revolutionary Democratic Force respectively (excluding the Italian Occupation from 1936 -1941) (UN-Habitat, 2002).

The second landscape factor affecting the water management sector in Addis Ababa is the historic prevalence of climatic variability leading to severe droughts and flash flooding in Ethiopia (You & Ringler, 2011). The progression of climate change is predicted to further intensify these phenomena (Niang et al., 2014). Another landscape factor to consider especially in terms of the physical applicability of SUDS to Addis Ababa is the undulating topography which, according to officials, has an effect on the availability and pressure of piped water as well as on the rate of stormwater infiltration. Lastly, Addis Ababa's population, which is projected to reach 4,7million by 2025 (UNDESA, 2012) is also a significant landscape factor as the resultant rapid urbanisation will exert pressure on existing water service infrastructure (UN-Habitat, 2007).

3.2.1.2. Dar es Salaam

As in Addis Ababa, one important landscape factor in the Dar es Salaam case is that of historic governance. The colonial era that Tanzania underwent from 1890's until 1961 under German and British rule represents an important "socio-political" landscape factor for Dar es Salaam's water service infrastructure. The current state of Dar's infrastructure can be traced directly to the initial discriminatory and bifurcated system of building codes, land laws and infrastructure provision during the colonial administration between the late 19th century up to 1945 (Kironde, 2007; Smiley, 2013). During this time, a concern with public (European) health formed the basis for the development of the limited sewerage and drainage system for European areas, however this system was not extended to non-European areas as it was thought different races had different infrastructural requirements (Kironde, 2007). Although after 1945 efforts were made to redress the service disparities (ibid), the initial discriminatory approach left a lasting infrastructural legacy for Dar es Salaam, one of a widening deficit as well as an entrenched urban informality.

Population growth trends in Dar es Salaam are another key landscape factor. Dar es Salaam's population is projected to reach 7, 2 million in 2025 (UN-Habitat, 2014). Thus Dar also faces a major challenge in addressing the current and future infrastructural deficit resulting from the rapid urbanization that is fed by the population growth. The third landscape factor at play is that of historical climatic variability and projected climate change impacts. Climate changes are projected to result in increased rainfall intensity (see START, 2011). If this factor is combined with the geohydrological factor of the high water table present in some parts of the city, the result is increased flood risk and a deepening adaptation deficit (Msindai, 2004; Dodman et al., 2009).

3.2.2 Current regime-niche dynamics and the prevailing hydrosocial contract in Addis and Dar

The prevailing hydrosocial contracts on which the management of water in Addis Ababa and Dar es Salaam is based can be seen through the interplay of the incumbent water management regimes and niche-level activities in the two cities.

3.2.2.1 Addis Ababa

As a legacy of the centralization towards federal government pursued by the successive governments mentioned above, Addis Ababa has generally strong water management regime. The mandate for water supply and sanitation falls mainly under the Ministry of Water Irrigation and Energy (MoWIE) at national level, while at city-level it falls under the Addis Ababa Water Supply

and Sewerage Authority (AAWSA). According to the officials interviewed there is no institution as yet with the mandate for managing stormwater drainage in general with the exception of road-side drainage which falls under the Addis Ababa City Road Authority (AACRA).

In terms of the current hydrosocial contract, in 2013 the federal government of Ethiopia launched the One Water Supply, Sanitation and Hygiene (WaSH) National Programme (OWNP). This seven year programme (2013-2020) along with the more operational WaSH Implementation Framework (WIF) of 2011 lay out the ambitions for improving the state of water supply and sanitation in the country, acknowledging the partnerships and roles played by State organs, donors and CSO's in achieving this. Although the State (regime) still maintains a pervasive role as the mobilizer and manager of water services and infrastructure in what seems to be a Hobbesian hydrosocial contract, the OWNP and WIF are strong indicators of the emergence of a Lockean Hydrosocial contract for Addis and Ethiopia as a whole.

With the OWNP and WIF, the management of water in Addis (and Ethiopia) is becoming a shared domain between different actors in a transition through the first three stages of the urban water management transition framework (Fig 1) with the goal of achieving adequate water supply and hygiene. Community members and N.G.O's now also play a crucial role in the operationalization of water and sanitation programmes. Such strong policies on the part of the government as well as partnerships with donors, have led to an increase in the number of people with access to a water supply within 0,5km to at least 68% (MoWIE, 2014:8).

While there maybe signs of the beginning of a Lockean contract in Addis, there still seems to be an overriding preoccupation with enabling access to water and hygiene services which is part of the pursuit of the modern infrastructure ideal. As such there is a lack of engagement with "sustainability" as a normative value in service delivery within the water sector. SUDS elements such as rainwater harvesting have a long tradition in Ethiopia, and are viewed as part of an alternative water supply delivery portfolio in policies such as Self-Supply Acceleration Programme (SSAP) of 2012 (MoWIE, 2014; Butterworth et al., 2013). Self-supply[20] through rainwater harvesting is also advocated for and supported by NGO's e.g. the Water harvesting for Multiple Use in Ethiopia (MUStRAIN) project of 2011-2014. However, from interviews and document analysis it seems self-supply policies and programmes are directed primarily towards rural areas, and are not actively considered for urban areas like Addis Ababa. This apparent discord in policy could be the result of, first, the pursuit of the modern infrastructure ideal which relegates low-technologies to rural environments, and second, the low profile sustainability values hold within the water management regime.

While Addis has a relatively strong urban water management regime, the infrastructure deficit and the occasional malfunction of existing infrastructure mean that there exists an active niche level as households, SSP's and CSO's step in to fill the gaps in conjunction with the regime or with their

[20] Self-supply is the augmentation of water supplies through investments by households or small groups of households in low-technologies such as hand dug wells pumps, household water treatment and storage and rainwater harvesting (MoWIE, 2014; Butterworth et al., 2013)

own resources. In one part of the Reppi Woreda[21], the traditional mutual assistance community group (Idir) has also been used as a structure within which to pool resources and commission a hand-dug well. Furthermore, most households engage in some level of rain water harvesting during the rainy season with interviewees highlighting that it is an old tradition to harvest and store rainwater. In reality, although lacking in terms of policy, self-supply practices such as rainwater harvesting represent a crucial coping strategy for communities in Addis Ababa. There also exists a thriving water-kiosk business in many communities such that where water supply infrastructure is problematic then households purchase water from CBO's, other households and SSP's for an average of 1,5ETB per 20 litres.

Stormwater drainage is also characterised by a form of community self-provision and the manner in which it is set up further exemplifies niche-regime dynamics in Addis. In general stormwater has no institutional home and communities are expected to shoulder the full costs of drainage infrastructure. However the Addis Ababa City Administration (ACCRA) began a drainage infrastructure co-funding scheme at Woreda-level in 2011 whereby communities can connect to the new cobblestone roads' drainage infrastructure built by AACRA at a subsidised cost. Local government pays 35% of the cost whilst the community pool their resources to pay the remaining 65%. According to an official in the Kolfe Keraniyo Woreda, as the scheme matures more communities are signing up for it as is shown by the increase in the resources pooled from 4 million ETB[22] in 2013 to 13 million ETB for 2014. The co-funding drainage infrastructure scheme further points to the existence of a strong community-level capacity to cope with infrastructure deficits and to the complimentary relationship between the regime and niche levels in Addis.

3.2.2.2 Dar

The Water Supply and Sanitation Act of 2009 as well as the National Water Policy (NAWAPO) of 2002 provide the legal and policy framework for the management of water resources and services in Tanzania. According to interviews, in Tanzania the general mandate for urban water supply and sanitation resides with the Ministry of Water (MoW) at the national level. In Dar es Salaam the mandate for the provision of water supply and sanitation services falls under the Dar es Salaam Water and Sewerage Authority (DAWASA) which owns the water infrastructure assets and the Dar es Salaam Water and Sewerage Corporation (DAWASCO) which is the operator of the water infrastructure assets. The responsibility for stormwater management falls under the engineering departments of the three municipalities which make up Dar es Salaam City Council i.e. Ilala, Kinondoni and Temeke. Thus, despite problems of coordination identified by interviewees, the Dar es Salaam water management regime seems to have a reasonably well-defined institutional architecture on paper.

The hydrosocial contract in Dar has gone through a curious evolution since 1997 when DAWASA was created as a semi-independent entity to address the poor conditions of water services. Unlike in Addis where privatisation of water services has not been tried, the government of Tanzania privatised water supply and sanitation services in 2003 under a 10-year concessionaire agreement

[21] Woreda is the district or community level in Ethiopian local government consisting of several neighbourhoods (kebeles).
[22] One US dollar was equivalent to about 18,9 Ethiopian Birr in 2013

with City Water Services (CWS) - a consortium of British, German and Tanzanian companies (Pigeon, 2012). Privatisation thus changed some of the terms of the hydrosocial contract making the responsibility of the provision of water and sanitation services, the shared domain between the State and the private sector.

Unfortunately this experiment with privatisation, and the implied move towards a Lockean hydrosocial contract, ended in 2005 as CWS was unsuccessful in the management, cost recovery and maintenance of the water supply and sanitation infrastructure assets (Pigeon, 2012). As a result, in 2005 there was a return to a more Hobbesian hydrosocial contract as the MoW once again became the principal player in the management of water and sanitation in Dar es Salaam, bringing CWS under its helm as DAWASCO.

In the same year, the Water Sector Development Programme (2005 – 2025) was introduced by the MoW, highlighting government plans for ensuring the attainment of water supply and sanitation targets through a sector-wide approach, in line with the Tanzania Development Vision 2025 (Planning Commission, 2006). The Water Sector Development Programme and the accompanying Implementation Manual give the overall responsibility of water services principally to the State through DAWASA and possibly later on to municipalities. However, these documents also emphasise the important roles played by External Support Agencies (donors) such the World Bank and CSO's. According to four interviewees, donors and CSO's such as WaterAid and Community-Owned Water Supply Organisations play a critical role in providing some of the funding for infrastructure investments in Dar es Salaam.

Even though on paper the hydrosocial contract on which the management of water Dar is based seems primarily Hobbesian, the conditions on the ground point to a different reality. Water supply, sanitation and drainage infrastructure is in a poor state and coverage is limited (Dodman et al., 2009). Interviewees tell of the high percentage of non-revenue water i.e. 54 % of water that leaves treatment plants is lost. Estimates given by interviewees put city dwellers with access to some category of tap water (communal, kiosk or in-house) at around 70-86%, while the sewer network covers around 10-17% of the households. Even then, the service is neither continuous nor is the quality of the water assured as the system is plagued by frequent malfunction.

Drainage infrastructure is also inadequate in coverage and frequently filled with solid waste thus leading to increased floodrisk (START, 2011). To help address this deficit the World Bank-funded Dar es Salaam Metropolitan Development Project (DMDP) proposes urban drainage infrastructure upgrades as one of its activities (Bald, 2014). Despite these efforts however, the water management regime in Dar still presently lacks the capacity to satisfactorily provide water, sanitation and drainage services to the public. Officials in Ilala municipality, DAWASA and the MoW all highlight that the regime is further constrained by the lack of reliable data on water use, the extent and condition of the system as well as demand. As such the Hobbesian hydrosocial contract seemingly officially prevailing in Dar es Salaam may be derelict (Mguni et al, 2015).

Concerning niche-level activities, households have found ways to cope with the infrastructural deficit and malfunction, relying partly or sorely on alternative means for water supply, sanitation and drainage. In the Kibururu and Matosa subwards of Goba as well as the Masuru subward of Kawe, all interviewees reported buying low quality water from local boreholes for an average of 5Tsz/L and 25Tsz/L for better quality DAWASA water sold by SSP's with water bowsers. In the places where the DAWASCO communal taps are still functional, the price of water is 10Tsz/L. For

sanitation, most report having pit latrines, which are emptied into nearby rivers during the rainy season. Furthermore river water is used for washing and cleaning if it is not too polluted. For stormwater management some of the sub-wards have CBO's which pool money and hire excavators to remove solid waste blocking storm drains. During the rainy season most households interviewed cut costs through rainwater harvesting however, adequate storage remains a problem.

As such, to fill the water supply service provision gap, there has emerged a thriving market for the sourcing and sale of water within communities. These entrepreneurs, also called "small DAWASCO's" by the officials, are an example of the small-scale independent water providers (SSP's) identified earlier. For example, in Kibururu one household sunk a 110m-deep borehole in 2013 at a cost of about 10 million Tanzanian Shillings (Tsz) (around 5000 USD). To this borehole they have connected two communal kiosk stations, as well as pipe connections to six other households who pay monthly tariffs for this service. The coping strategies that the communities engage in and the flourishing water market point to two things; the presence of a dynamic niche level within Dar's water management domain, as well as to the existence of a form of unacknowledged but robust Lockean hydrosocial contract.

It seems in reality, the responsibility for the provision of water supply, sanitation and drainage services is the shared domain of DAWASCO (as an agent of the State), households, civil society organisations such as CBO's and NGO's and the SSP's in the form of the legally-ambiguous 'small DAWASCO's.' To further highlight this point, there has been a call for the legal recognition and support for innovation by allowing individuals and companies "[…] to invest in production and distribution of tap water for domestic use" in Dar es Salaam (The Guardian, 2014). Currently the SSP's are unregulated as they have no legal standing under the Water Supply and Sanitation Act.

3.3 Probable transition contexts in Addis Ababa and Dar es Salaam

Present policies and on-going activities such as OWNP and WIF in Ethiopia, as well as the WSDP and DMDP in Tanzania indicate that both Addis Ababa and Dar es Salaam are currently moving through the first three stages of the urban water management transitions framework (Fig 1) i.e. the Water Supply, Sewered and Drained cities respectively in a transition towards water supply and public hygiene. In both cities the pursuit of reliable water services through infrastructure investments also points to the modern infrastructure ideal as being the pervading rationale within the cities' water management regimes. As a result, the general discourse on environmental sustainability and the possibilities for increased water sensitivity through decentralised approaches like SUDS is still underdeveloped in both cities.

However it should also be noted that for both cities there are attempts at exploring the implications of sustainability values for the cities' water management sectors. In Addis Ababa the on-going master plan drafting process has begun to consider SUDS concepts in this direction, while in Dar es Salaam, the DMDP contain plans for employing detention ponds in upstream areas as an option to control and reduce stormwater runoff. Nonetheless, it still remains to be seen if such attempts will result in more concrete policies towards SUWM and a reconsideration of the direction of policies like OWNP and SSAP (in Ethiopia) and WSDP (in Tanzania), which acknowledge water supply options like rainwater harvesting but regard it as supplementary and relegate it to rural areas and small towns.

In light of the prevailing hydrosocial contracts, regime-niche dynamics and how these reflect the potential for transitions towards sustainable urban water management, Addis Ababa and Dar es Salaam both exhibit aspects of an "emergent transformation" to varying degrees. The reliance on resources from non-regime actors e.g. SSP's, donors, NGO's and CBO's for infrastructure development by both cities' water management regimes as well as the equally dynamic response to infrastructure deficit by communities at the grassroots level in both cities seems to support this. However this is more so in Dar than in Addis. While there is a strong basis for regime action through policies like the WSDP in Dar, the situation on the ground points to an inability of the regime to adequately address current infrastructure deficits. On the other hand due to the strong, fairly coordinated regime response to the need for safe water supply and even drainage, Addis Ababa could also be characterised as undergoing a "reorientation of trajectories" to some degree.

As such, if Addis Ababa and Dar es Salaam are to move towards more water sensitive futures, there may need to be a broader and more explicit rearticulation of selection pressures beyond population pressure, rapid urbanisation etc. so as to reflect a consideration of sustainability values. This would allow for the emergence of a discourse around alternative approaches to urban water management such as SUDS so that self-supply options like rainwater harvesting become an integral part of a complimentary water service delivery model for the urban and rural areas alike.

Furthermore, for Dar es Salaam there may be need for an explicit renegotiation of the terms of the hydrosocial contract so as to reflect the reality of non-regime actors using non-regime resources to address part of the infrastructure deficit. A more complementary approach that acknowledges, regulates and coordinates SSP, community and NGO efforts towards water services may reduce pressure on the regime as well as providing impetus for leapfrogging towards water sensitive futures based on SUWM through decentralized approaches like SUDS.

4. Discussion: On the potential for leapfrogging towards water resilience and the conceptual relevance of the MLP to cases in the Global South

This section looks at the conceptual implications that cases such as Dar es Salaam and Addis Ababa may have on frameworks such as the MLP within transitions studies. It also presents a discussion of the potential, challenges and recommendations for cities in the South to avoid path dependence on conventional drainage infrastructure and instead leapfrog towards more sustainable futures through decentralised, green infrastructure-based approaches such as SUDS.

4.1 Conceptual implications for studies in sustainability transitions

The study of on-going and potential transitions within the water management sectors of Addis Ababa and Dar es Salaam has highlighted the applicability of the transition studies' analytical frameworks such as the MLP to urban contexts in the Global South. Although the MLP has been useful as a heuristic for mapping the dynamics of historic and on-going transitions in the two cities, the results from the two cases may also have conceptual implications for the MLP.

Firstly, as Berkhout et al. (2011) also highlight, the central assumption of intransigent and dominant incumbent sociotechnical regimes may not always hold in developing countries contexts. Oftentimes, as the results indicate, the sociotechnical regime in the global South is a 'configuration that is not working'; it is incomplete and unable to fully discharge its mandate. Nevertheless, the

regime architecture in the water management sectors of both Addis Ababa and Dar es Salaam is still based on an idealised but derelict Hobbesian hydrosocial contract thus still making the regimes somewhat resistant to change despite obvious deficiencies.

Secondly, the concept of the niche level is expressed in more differentiated ways in Addis Ababa and Dar es Salaam than is assumed for Occidental cases. For water supply, the emergence of SSP's (e.g. small DAWASCO's) as an alternative to DAWASCO and AAWSA water supplies is indeed in line with the characterisation of the niche in the MLP as being the locus of market-oriented, alternative technological innovations by firms (Seyfang & Smith, 2007). However the persistence of the Hobbesian hydrosocial contract serves as a barrier to market entry as it renders efforts by SSP's illegitimate. Furthermore for both water supply and urban drainage in Addis Ababa and Dar es Salaam, local CBO's and NGO's fill in the service gap by pooling and providing resources for the regime as is the case for stormwater management in Addis or by pooling resources to address drainage issues within the community as is the case in Dar.

Thus the activities of non-regime actors to fill in service gaps in urban water supply, sanitation and drainage in developing world cities e.g. rainwater harvesting, use of pit latrines etc, do not fit the common delineation of the niche in the MLP as characterised by market-oriented innovations by firms. Instead, these non-regime activities in Dar es Salaam and Addis Ababa may highlight the need to expand the concept of the niche so as to encompass the propensity for innovation found in local community coping strategies as well as NGO-supported initiatives.

Thus, here we cement Seyfang & Smith's (2007:591) notion of 'grassroots innovation' i.e. conceptualising the grassroots (local community) level as a valid 'niche' level for innovation motivated by unmet social and environmental need. As such, to improve the applicability of the MLP and other sustainability transition theories to cases in the global South, there is a need to acknowledge community and household-level coping strategies as well as NGO's development support activities as existing and potential sites for the uptake of innovative and alternative approaches like SUDS.

It should also be noted that while NGO's may be considered niche actors as they are outside the regime and they have a role as innovation intermediaries, they may not be as innovative as is requisite for the integration of sustainability-based approaches into urban water management. This may be partly due to their (as well as the regime's) subscription to the WaSH paradigm which is an extension of the modern infrastructure ideal.

4.2 On the potential and barriers to leapfrogging towards more sustainable water management in cities in the South

While it is clear that water management systems in cities of the South are socio-technical configurations that failed to work, hence there are serious infrastructural deficits that incumbent regimes do well to address, infrastructural informality gives cities in the South a considerable, albeit hidden, advantage in terms of the potential for transitioning towards SUWM. In reality most Sub-Saharan cities seem to function based on an unacknowledged Lockean hydrosocial contracts to varying degrees and these Lockean contracts are physically expressed through the coexistence and coproduction of centralised infrastructure managed by the regime and decentralised low technology infrastructure at community and household level.

The coproduction of infrastructure by regime and non-regime actors e.g. use of SUDS elements like rainwater harvesting to augment water supply at household level in Addis and Dar are good indicators for the possibilities of leapfrogging towards sustainable urban water management. As such, the coproduction and coexistence of infrastructure prevalent in most Sub-Saharan cities may provide the sociotechnical space for experimentation with alternative approaches than is currently possible in cities in the developed world. In such a scenario it is easier to imagine, for cities in the South, a shift from the current decentralised infrastructure deficit towards sustainable decentralised water systems based on green-infrastructure.

The main barriers to leapfrogging may lie within the existing governance frameworks for water Sub-Saharan cities. The first barrier may be the linear pursuit of the modern infrastructure ideal which effectively disqualifies a more systematic integration of innovative low-technologies such as rainwater harvesting and pit latrines into the infrastructural fabric of urban water systems. The second governance barrier is the usually unacknowledged Lockean hydrosocial contract. The belief that the Hobbesian hydrosocial contract subsists in the beleaguered cities of the Global South is misguided and serves to stifle innovation and capacity at the niche level as well as exert unrealistic pressure on the regime as the sole authority legally responsible for the provision of water supply, sanitation and drainage services to society.

4.3. Recommendations for steps forward

There are several points for consideration in light of the above analyses on the potential for leapfrogging towards sustainable urban water management and the implications that the findings from Addis Ababa and Dar es Salaam may hold for the analytical concepts of the MLP. Firstly, there may need to be an adjustment of the current urban development agenda which places WaSH as the main paradigm for urban water management. While the subscription to the WaSH paradigm rightly fosters aspirations of urgently achieving water supply, sanitation and adequate drainage in cities in the South, it may not give due recognition to the need to aspire to overall sustainability in urban water management. Perhaps this shift towards sustainability as part of the development agenda is already underway, in light of the proposed Sustainable Development Goals[23].

To be able to leapfrog towards SUWM, cities in the South may have to move through the stages of the urban water management transitions framework simultaneously, thus emphasizing all service delivery functions at once. Although this is a seemingly impossible task, one way of doing so would be for an active engagement by both regime and non-regime actors with sustainability values in addition to the prevailing WaSH paradigm. On a practical level, this could mean changing the policy discourse from a preoccupation with WaSH, towards sustainable urban water management which is more holistic since it integrates urban water supply, sanitation, drainage, amenity and sustainability concerns. This would make it easier for cities to adopt approaches such as SUDS and integrate hitherto disqualified technologies such as rainwater harvesting.

Secondly, while changing the agenda from WaSH towards SUWM may help to initiate a transition towards SUWM, officially acknowledging the existing Lockean hydrosocial contracts in cities in

[23] Sustainable Development Goals are proposed as the main post-Millennium Development Goals agenda under negotiation in the UN since the Rio+20 in 2012 (see Osborn et al., 2015)

the South would also help to accelerate such a transition into leapfrogging towards SUWM. Formally recognising the numerous non-regime actors and resources currently involved in the management of urban water would align policy with reality and thus ideally lead to a change in the governance framework to include more non-regime stakeholders.

Such an enabling environment is essential for the development and uptake of city-specific innovations in the water management sector as well as for making water sector policies more adaptive to uncertainties. On a practical level, dialogue on and renegotiation of the different roles that regime and non-regime actors may play in a water resilient city would also be timely, for example the regime may well give up part of its responsibility as the sole provider of infrastructure and services and take on a more managerial role of coordinating and regulating niche-level activities.

Finally, the existence of differentiated niche activities and actors identified above also prompts questions of how such ongoing niche activities may be best supported and infused with more innovation and sustainability. Should the water management regimes in developing cities be expanded to include SSP's or should SSP's remain non-regime stakeholders supported by more enabling regulation? Another question is how to configure, coordinate and empower ongoing niche-level efforts by communities, NGO's and households in the water sector so as to achieve a systematic, decentralized and sustainable urban water infrastructure. Thus the more stakeholders begin to actively engage with such questions, the better the potential for cities in the South to move towards water resilient futures.

5. Conclusion

In seeking to understand what it may take to move towards water sensitive futures in Sub-Saharan cities, the first objective of this paper has been to present an analytical framework based on the MLP, transition contexts and the hydrosocial contract concepts among others. The second objective has been to apply this framework to the case of water management in Addis Ababa and Dar es Salaam, generating narratives describing and analysing historical and current dynamics in water management sectors of the two cities as well as exploring the applicability of SUDS. Lastly, the analytical framework and the narratives generated are used to explore the potential for leapfrogging towards SUWM in Addis Ababa and Dar es Salaam through such approaches as SUDS as well as highlighting possible conceptual implications the two cases may have for theoretical frameworks such as the MLP.

Analysis has revealed that centralization policies, pursued by successive governments in Ethiopia and colonial policy in Tanzania endowed Addis Ababa and Dar es Salaam with water management regimes and regime architectures that are relatively strong to some degree. However, these and other landscape factors such as low economic development, population growth and climatic projections, have saddled the two cities with inherent water supply, sanitation and drainage infrastructure deficits.

The prevailing hydrosocial contracts in both cities seem to be Hobbesian to varying degrees as the regimes retain the roles of principal mobilizer, provider and manager of water and related services. In Addis Ababa however policies like the OWNP and WIF which give roles and responsibilities to other stakeholders point to the emergence of a Lockean form of hydrosocial contract. These policies do acknowledge, to some extent, the vital role that local communities and NGO's play in filling in

water infrastructure services gaps. In terms of prevailing transition contexts, this article presents Addis as possibly manifesting a 'reorientation of trajectories' as well as an 'emergent transformation'. This dual contextualisation is because while there is a fairly strong regime response to issues of urban water management, the regime also relies on resources from non-regime actors at the dynamic niche level such as donors, NGO's and the community.

For Dar es Salaam, policies such as the WSDP point to the prevalence of the Hobbesian hydrosocial contract as they place the responsibility for water management firmly in the hands of the regime, with some acknowledgement of the roles played by donors, NGO's and the community. But the regime's lack of capacity to deliver water services has led to the emergence of a dynamic niche level as SSPs, NGO's and households fill in the service gaps functioning under an unacknowledged yet functional Lockean hydrosocial contract. This points to an emergent transformation being the most likely transition context in Dar.

The urban water management sectors in both cities seems to be geared towards a pursuit of the modern infrastructure ideal emphasizing the expansion of centralised and universal water service infrastructure, as part of the WaSH agenda, whilst seemingly lacking an engagement with sustainability as a goal within the sector. As a result although SUDS elements such as rainwater harvesting are central to policies such as Self Supply Acceleration programme in Ethiopia and WSDP in Tanzania, they are relegated to rural areas or small towns.

For both cities to begin to move towards water sensitivity a more comprehensive rearticulation of selection pressures so as to include sustainability values is necessary. For both cities, the current deficits in water infrastructure systems as well as the resultant coproduction and coexistence of sociotechnical systems may provide the experimental space necessary for avoiding path dependence and leapfrogging towards SUWM through the integration of alternative approaches such as SUDS.

Finally, the two cities have also shown that to enhance the applicability of sustainability transition frameworks such as the MLP to cases in the South there is a need to reconsider the assumptions on which concepts such as the sociotechnical regime and niche are based. Suppositions of intransigent incumbent regimes and market-oriented niche level activities may not always hold in realities of infrastructural deficit, coproduction and coexistence. Instead a more nuanced definition of the socio-technical regime as well as a wider delineation of the niche concept may prove helpful for studying ongoing and potential transitions in the urban water management sector in developing cities.

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Paper IV

Regime reconfiguration towards sustainable urban water management? The nascent engagement with Sustainable Urban Drainage Systems in Johannesburg

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Regime reconfiguration towards sustainable urban water management? The nascent engagement with Sustainable Urban Drainage Systems in Johannesburg

Abstract
Sustainable Urban Drainage Systems (SUDS) are gaining attention as a complementary green infrastructure-based approach to stormwater management. While it is mostly in developed cities where the SUDS approach is gaining ground, Johannesburg is one of the few Sub-Saharan cities with a burgeoning engagement with SUDS. This paper uses the Multi-Level Perspective and Strategic Niche Management's (SNM) niche development processes in the analysis of ongoing SUDS initiatives in Johannesburg and the extent to which these initiatives may signal a transformation towards more sustainable urban water management (SUWM). Results indicate that SUDS in Johannesburg are being progressively embraced by different actors at both regime and niche levels as a symbiotic and promising niche within a largely regime-driven transformation. However, social networks and second order learning are still limited as the SUDS niche is still in the early stages of its formation.

Keywords: Johannesburg; sustainable urban water management; SUDS niche; sustainability transitions; Strategic Niche Management; Multi-Level Perspective.

1. Introduction

Cities around the world are currently confronted with persistent environmental problems among them climate change, pollution, loss of biodiversity and resource depletion (Steffen et al., 2015). Such challenges are simultaneously aggravated by the ageing and deterioration of critical urban infrastructures in developed world cities or by the persistence of infrastructure deficits in developing world cities (Brown et al., 2011; Dodman et al., 2009). The question most cities now face is how to ensure sustainable development and resilience in the context of resource constraints and climate change using ageing or insufficient infrastructures (Bulkeley et al., 2011). While the provision and management of critical urban infrastructure networks such as water have hitherto been approached as uncomplicated technical and administrative tasks (Graham & Marvin, 2001), addressing climate change and ensuring sustainable urban development will require major transformations in these infrastructure networks (Bulkeley et al., 2011).

The problems associated with the management of urban water infrastructure are an illustration of the struggles that cities currently face in responding to persistent environmental problems (Wong & Brown, 2009; Cisneros, 2014). Urban water systems are increasingly confronted by water scarcity, flooding as well as looming water crises that are predicted to become the top global risk in the near future (Fontein, 2008; Ferguson et al., 2013; WEF, 2015). Within the urban water sector, stormwater management (drainage) infrastructure will come under increasing pressure as the incidence of extreme precipitation, storm surges and rising sea levels are predicted to increase (Revi et al., 2014). In light of such pressure there are concerns about the ability of the conventional pipe-based stormwater management approach to adequately manage projected precipitation and hydrologic changes (Burns et al., 2012; Chocat et al., 2007).

Thus, the idea of Sustainable Urban Drainage Systems[24] (SUDS) has gained purchase as a complementary alternative[25] to conventional pipe-based stormwater management, and as one way of approaching sustainable urban water management and moving towards water sensitive futures (Wong & Brown., 2009; Chocat et al., 2007). Due to their emphasis on employing green infrastructure to store, convey, treat, and infiltrate stormwater, SUDS are seen as a multifunctional approach towards sustainable and resilient urban futures (Ashley et al., 2011; Lennon et al., 2014).

Several cities around the world have begun integrating SUDS as part of their stormwater management i.e. cities in Australia, Sweden, UK, Germany, USA among others (Backhaus & Fryd, 2012). However the approach is yet to become mainstream, and progress towards large-scale retrofitting is slow (Brown et al., 2013; Novotny et al., 2010; Backhaus & Fryd., 2012). From a global South perspective, the idea of SUDS has yet to gain attention in Sub-Saharan cities where, with the possible exception of fledgling initiatives in Cape Town, Durban and Johannesburg, the approach is still to be recognised as a viable alternative response to the stubborn deficits in drainage infrastructure.

One approach to understanding sustainability and resilience challenges such as integrating SUDS into urban areas in a bid to achieve sustainable urban water management (SUWM) has been to conceptualize them as the challenge of socio-technical transitions (or low carbon transitions) towards more sustainable configurations such as water-sensitive futures (Markard et al., 2012; Bulkeley et al, 2011). Some of the conceptual frameworks making up the sustainability transitions field are the Multi-Level Perspective (MLP) and Strategic Niche Management (SNM).

Sustainability transitions scholarship is a young field which has so far been dominated by cases from the developed world[26] (Lachmann, 2013; Markard et al., 2012). The urban scale within sustainability transitions is also said to be under-explored in favour of studies of sectoral or national transitions, ultimately leading to a lack of sensitivity to the geography of transitions (Næss & Vogel, 2012; Hodson & Marvin., 2010; Raven et al., 2012; Coenen et al., 2012). More specifically, while some work has been done on the potential for African cities to integrate SUDS as a resilience-enhancing drainage option (see Butterworth et al., 2011; Armitage et al., 2013; Mguni et al., 2015), there has been little empirical mapping and analysis of on-going (albeit tentative) transitions towards SUDS within the Sub-Saharan context.

This paper seeks to contribute to this gap[27] by presenting an analysis of the ongoing engagement with SUDS currently underway in Johannesburg, South Africa and how far this engagement may constitute the start of a transition towards a water-sensitive future in the Sub-Saharan city. The paper has two objectives, the first is to detail on-going initiatives and prevailing transition dynamics

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[24] SUDS are also known by other names; Landscape-based stormwater management (LSM), Best Management Practices (BMP's), Low Impact Development (LID) and Water Sensitive Urban Design (WSUD) among other terms (See Fletcher et al., 2014).

[25] SUDS cannot completely replace conventional stormwater management systems for the near future but they can contribute largely to the restoration of predevelopment hydrological cycles in urban areas (Chocat et al., 2007).

[26] This is changing as more empirical cases are added. See Rock et al (2009); Bai et al (2009), Verbong et al (2010), Eijik and Romjin (2008), Jolly et al. (2012) and Sangawongse et al. (2012).

[27] For earlier work that uses the sustainability transitions heuristic on Johannesburg from a general water governance perspective see Nastar & Ramsar (2012).

in the nascent transformation towards SUDS in Johannesburg based on the MLP of sustainability transitions. The second objective is to use SNM's niche development processes i.e. social network formation, articulation of expectations and visions as well as good learning processes, to explore the extent to which current SUDS-based initiatives in Johannesburg may constitute the start of a successful transition towards sustainability.

In Section 2, I present the qualitative case study methodology used within the study. Section 3 puts forward some theoretical insights from sustainability transitions scholarship, namely MLP and SNM, which form the framework to analyse the current initiatives towards SUDS in Johannesburg. Section 4 presents an MLP-based description of the case. Section 5 presents an analysis and discussion of the SUDS niche in Johannesburg based on SNM criteria to gain insight on current status of SUDS niche with respect to its possible contribution to transformation towards water sensitive future. Section 6 provides concluding remarks on possible contributions that the Johannesburg case could have to the study of sustainability transitions in the urban water sector from a Sub-Saharan perspective.

2. Methodology

Johannesburg was chosen as a case to explore the transition dynamics towards SUWM because it is one of a few African cities that have begun to engage with SUDS. Furthermore in terms of urban water management, it is a city struggling to redress the systemic deficiencies inherited from the apartheid era whilst searching for ways to maintain and improve existing infrastructure (Nastar & Ramasar, 2012; Armitage et al., 2014). Several research methods were employed to facilitate the identification and analysis of the emergence of SUDS as a niche within, and external to, the urban water management regime in Johannesburg. A review of sustainability transitions scholarship enabled the development of a conceptual framework for the analysis of the case based on the MLP and SNM. Secondary data was gathered through a review of policy documents from the City of Johannesburg (CoJ) and other respondents, retrieved from the Internet or given to the author during interviews.

Primary data was collected between June 2013 and October 2014 through 22 semi-structured interviews conducted with 22 individuals i.e. officials within the CoJ and its municipal entities and other stakeholders i.e. researchers and consultants. Interviewees included CoJ officials from Environmental Infrastructure Services Department (EISD), Johannesburg Roads Agency (JRA), Johannesburg Water (JW), Johannesburg City Parks (JCP) and Johannesburg City Transformation (JCT) from within the CoJ; Vodacom (South Africa), the Water Research Commission of South Africa (WRC) and engineering consultants.

Respondents were asked to first highlight SUDS-related initiatives within the city and their organisations; secondly, to identify perceived difficulties and opportunities for further integration of different SUDS elements; as well as to highlight the relationships between stakeholders involved in the integration of SUDS into the city. Furthermore, participant observation was conducted through attendance of meetings at the EISD and JRA between June 2014 and October 2014. Readers can find a contextualisation of the city under Section 4.1.

3. Exploring and understanding sustainability transitions towards SUWM

As the adaptation of stormwater systems to climate change becomes more pressing (Gersonius et al., 2012), the integration of approaches like SUDS, becomes an increasingly salient strategy for cities to work towards SUWM and water sensitive futures (van de Meene et al., 2011; Brown et al., 2009). SUDS mimic the natural water cycle by using green infrastructure for retention, treatment, infiltration and evapotranspiration and conveyance of stormwater in the urban landscape (Backhaus & Fryd, 2012).

Consisting of rain water harvesting, green roofs and swales among other elements, SUDS not only help in flood risk management, but may also augment water supply, support ecosystem services and urban agriculture and improve liveability due to their multi-functionality (Fryd et al., 2012).It is beyond the scope of this paper to provide further details on individual SUDS elements, however in-depth descriptions of SUDS and their potential contribution to stormwater management can be found in Charlesworth et al., (2003), Chocat et al., (2007) and Ashley et al., (2011).

How then can water management systems in Sub-Saharan cities, contexts which are characterised by "…stubborn realities of both a material and discursive nature…" such as infrastructural deficits, inequality and rapid urbanisation (Watson, 2012: 82), begin to integrate approaches like SUDS in pursuit of water sensitive futures? Increasingly, this envisaged shift from conventional pipe-based drainage systems towards green infrastructure-based approaches like SUDS is framed as the challenge of a sociotechnical transition towards more sustainable urban water management (Wong & Brown, 2009; Farrelly & Brown, 2011; Domenech et al., 2014). Sociotechnical transitions towards sustainability have emerged as a field of study[28] in their own right, as the burgeoning field of transitions studies has put forward historical and prospective analyses of transitions within technological, systemic and sectoral areas (Truffer & Coenen, 2012; de Haan & Rotmans, 2011).

Within the field of transitions studies the MLP, with its emphasis on the coevolution of technology and society, has emerged as a useful heuristic with which to understand transitions within energy, water and agriculture among other areas (Geels, 2002; Smith et al., 2010). Other approaches within transitions studies have an iterative and complementary connection to the MLP such as SNM (Kemp et al., 1998) and Transition Management (TM) (Rotmans et al., 2001; Loorbach, 2007). SNM and TM provide further analytical dimensions to the study of sustainability transitions and have been used in the analysis and modulation of on-going sustainable urban water management initiatives in Australia (See Bos & Brown, 2012 and Ferguson et al., 2013).

The Multi-Level Perspective on sociotechnical change distinguishes three analytical levels in system innovation: the sociotechnical landscape, the sociotechnical regime and the niche level (Geels, 2005). The 'socio-technical landscape' forms an exogenous 'macro' context to society e.g. population, geography, economic growth and politics (Geels & Kemp, 2007). At the meso-level is the 'socio-technical regime'[29] which is a stable configuration of institutions, techniques, artefacts, rules, practices and networks that determine the how technologies develop and are used (Rip & Kemp, 1998). Lastly, the 'niche' is the micro-level locus around which radical innovations or

[28] For a fuller picture of the field of sustainability transitions see Markard et al. (2012).

[29] Due to the flexibility of the MLP framework, the regime, niche and landscape concepts may have slightly different definitions and are used in diverse ways hence the need for delineation. For a summary of these see Raven et al. (2010).

alternatives such as SUDS may develop (Geels, 2005). In the case of urban water sociotechnical systems, the 'urban water management regime' is delineated as the people and organisations who manage water services as well as the corresponding legislation, policies and practices (van de Meene et al., 2011). It is physically manifested by the water services infrastructure in a city (ibid) and it is based on the prevailing hydrosocial contract (Turton & Meissner, 2002).

The core logic of the MLP is that for a sustainability transition to occur three processes are necessary: niche-innovations build up enough momentum to challenge the regime; changes at the landscape level such as climate change, rapid urbanisation, economic decline exert pressure on the regime; and finally stress within the regime creates windows of opportunity for the uptake of niche-innovations (Geels, 2014). In a process of sociotechnical change, some niche innovations may be 'boundary-crossing', such that niche developments may be subject to influences from different regimes to the niche's benefit or detriment (Raven & Verbong, 2009). While the MLP is seen as a helpful exploratory device (Smith et al., 2005), enabling the mapping of elements and analysis within system change, it has been criticised[30] for, among other things, the privileging of niche-driven transition paths (Smith et al., 2010).

In response to the criticism of niche–driven bias, where transitions are seen as mainly coming about due to pressure from niche-level innovations, an array of transition typologies has been developed conceptualizing the different pathways that transitions may take depending on the configuration and timing of the interaction between landscape factors, niche-level innovations and regime stresses (See Smith et al., 2005; Geels & Kemp., 2007; Geels & Schot., 2007; de Haan & Rotmans., 2011). While the breakthrough of niche-innovations is seen as imperative for the transition of socio-technical systems, sociotechnical regimes have also become focal units of analysis with the realisation that radical changes at the regime level are necessary for sustainable development (Smith et al., 2005). This article focuses on the 'regime reconfiguration' transition pathway in Geels & Schot's (2007: 411) typology[31] since studies have shown that at the urban scale, sustainability transitions are likely the result of city governments, being incumbent regimes, using internal resources to consciously shift development trajectories and practices towards more sustainable and resilient directions (Quitzau et al., 2013).

'Regime reconfiguration' occurs when landscape pressures force incumbent regime actors to modify development trajectories and innovation activities by adopting symbiotic niche-innovations as an add-on component to solve local problems (Geels & Schot, 2007; Raven, 2006; Verbong & Geels, 2007; Smith, 2007). The adopted niche-innovation may trigger changes in the regime's basic architecture as regime actors explore new combinations between old and new elements of the socio-technical system (Geels & Schot., 2007). Other relevant characteristics of regime-driven transitions like regime reconfiguration can also be extrapolated from Smith et al (2005)'s 'endogenous renewal' transition perspective, where regime members make conscious, highly-coordinated and internally-resourced efforts to respond to clearly articulated selection pressures, resulting in an incremental transition process (ibid:1500).

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[30] See Genus and Coles (2008), Coenen and Truffer (2012), Shove and Walker (2007) and Meadowcroft (2011).

[31] According to Geels and Schot (2007: 406-413) the other possible transition pathways are reproduction (***P0***), transformation (***P1***), de-alignment and re-alignment (***P2***), technological substitution (***P3***) and finally a sequence of transition pathways (***P5***).

Thus, while sociotechnical regimes are often regarded as dynamically stable and therefore resistant to change (Geels, 2014), within the regime-driven transitions like regime reconfiguration, it is incumbent regime actors who enact the transition path (Geels, 2006). Similarly, from an urban management perspective, Quitzau et al. (2012: 1052) highlight that regime actors may drive transformation through 'niche planning' i.e. performing strategic work that incrementally establishes and nurtures a sustainability niche.

In regime-driven transitions, the regime's cognitive, regulative and normative dimensions are changed as incumbents gradually modify development trajectories, altering their perceptions, goals, roles, knowledge and practices (Geels, 2006; Brown et al., 2009). It is this kind of endogenous regime transformation which is most relevant for the analysis of on-going and potential infrastructural transitions towards the integration of alternatives like SUDS in cities as actors within urban infrastructural regimes increasingly make conscious efforts to change current routines and practices using existing resources as part of efforts to adapt to climate change (Quitzau et al., 2013; Bulkeley et al., 2014).

Thus in regime-driven transitions niche approaches like SUDS can be mainstreamed if they align with on-going regime and landscape processes, leading to co-evolutionary and mutually-adaptive change processes (Schot & Geels, 2008). SNM is based on this perspective and further posits that sustainability transitions can be facilitated by creating technological niches i.e. "[…] protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures […]" (Schot & Geels, 2008: 538). As such, SNM scholarship provides insight into the conditions under which niche approaches like SUDS may succeed or fail, as well as possible measures that may modulate emerging windows of opportunity in the regime (ibid; van der Laak et al., 2007; Geels & Raven, 2006).

Although mainly used in ex-post analyses of niche development processes (Schot & Geels, 2008), SNM is also applicable to the analysis of ongoing transitions as it provides a view to the criteria necessary for the successful incubation of alternatives such as SUDS. This enables us to explore the extent to which the existence of a seemingly symbiotic SUDS niche coevolving with and within the urban water management regime could constitute an on-going transformation towards more sustainable urban water management in Johannesburg.

One of the criteria for the successful development of a radical niche is the *articulation of specific and high quality expectations and visions* (Schot & Geels, 2008). Expectations and visions are critical for providing direction to learning processes, for attracting attention and for mobilising resource based on promises of future benefits (Raven, 2006; 2012). Expectations are most effective when they are shared by an increasing number of actors and when they are tangible and realistic (van der Laak et al., 2007; Raven, 2012). When expectations are held by many actors, they then provide a structuring role in innovation or niche development processes, allowing actors to either draw on them for legitimation of their work or to align their work with them if formerly unconvinced (Bakker et al, 2012; Raven, 2012).

Another condition for niche success is the *building of broad and influential social networks* (including regime outsiders) which helps in enrolling a constituency behind alternatives such as SUDS, facilitating stakeholder engagement, mobilisation of resources, institutional embedding and carrying learning (Schot & Geels, 2008; Raven, 2012). In regime-driven transitions, regime

outsiders are crucial as they translate landscape pressures and highlight alternatives in their criticism of the regime (Geels & Schot, 2007). Thus, the presence and activities of intermediary actors within a social network including regime actors is viewed as key in transition processes (Hamann & April, 2012; Swilling et al., 2013). Intermediaries such as non-regime scientists, engineers, firms, branch organisations and civic groups are seen as facilitators of system change as they help monitor on-going initiatives as well as accumulate and circulate knowledge through workshops, conferences, and journals (Geels & Deuten, 2006; Swilling et al., 2013).

Thirdly, *learning processes* are also seen as a critical condition for successful niche development that ultimately may lead to regime reconfiguration. Learning is most instrumental for niche development if it is both *first-order learning* i.e. learning that is concerned with data and technical performance of infrastructures usually resulting in regulations and rules; as well as *second-order learning* i.e. learning that enables changes in cognitive frames and assumptions on which the incumbent socio-technical system is constructed leading to coalition-building and deepening networks (Smith, 2007; Geels & Raven, 2006; Vogelezang et al., 2009). Learning processes may impart reflexivity into niche development and transition processes by further informing expectations and visions (Raven, 2012).

To further refine the concept of regime reconfiguration, Raven's (2006) integration of the regime concept and the three niche development processes mentioned above offers valuable insight into the possible configurations that may result when the urban water management regime adopts a niche alternative like SUDS from the onset. If a stable niche i.e. a niche satisfying the three SNM criteria of network formation, learning processes and articulated expectations, is absorbed into an unstable regime plagued by internal stresses, the niche becomes "problem solver" (Raven, 2006:586). On the other hand if a stable niche is absorbed by a reasonably stable regime, then the niche remains a "promising technology" waiting for windows opportunity to open up within the regime, whilst still competing with the regime (ibid). If a stable regime is confronted by an unstable niche i.e. one that does not satisfy the SNM criteria, then the niche is considered a "dead end street", however if an unstable regime is confronted by an unstable niche then this is characterised as a "missed opportunity" (ibid). These four niche-regime scenarios are illustrated in Fig. 1 below.

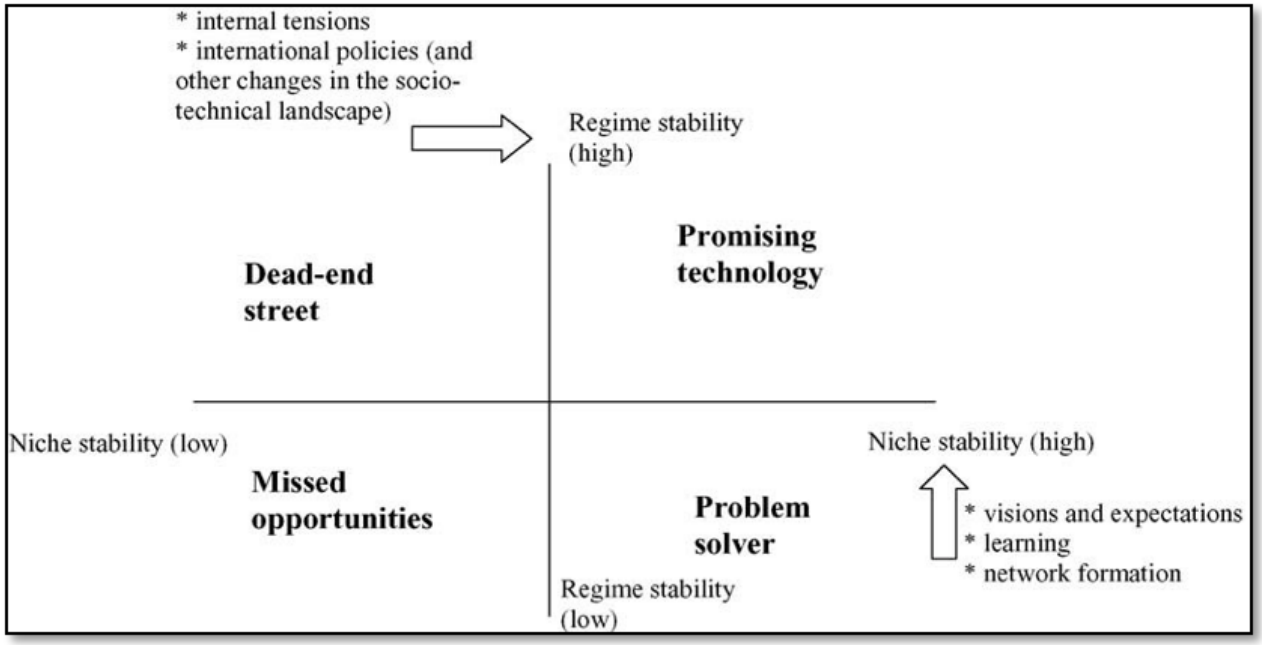

Fig 1. Relation between niche and regime stability. *Source: Raven (2006, p. 585).*

Finally, regime-driven transitions are subject to contestation and conflict as there may be little consensus between actors over the directionality, content or necessity of and for change as highlighted before (Smith et al., 2005). While in niche-driven transition pathways regime stability would constitute powerful resistance to niche development (Geels, 2014), even within regime reconfiguration there may still be resistance in the form of institutional and material inertia as actors in other regimes and existing infrastructure resist or discourage perceived changes (Smith et al., 2005).

This is especially relevant to transitions towards integrating SUDS which require interdisciplinary collaboration between planners, engineers, landscape architects, ecologists (who may be members of different regimes) and a shared understanding of both the problem at hand and prioritisation of possible solutions (Fryd et al., 2012). As such, actors seeking to enact the transformation process may form coalitions, devise tactics and strategies and deploy resources in strategic exercises of agency and power (Smith et al., 2005; Geels, 2006). The following section presents a description and analysis of the prevailing context and on-going transition dynamics in the integration of SUDS in Johannesburg based on the analytical levels of the MLP.

4. A Multi-level Perspective analysis of transition dynamics in the on-going engagement with SUDS in Johannesburg

4.1 Salient landscape factors

There are several global and local landscape factors whose interplay may influence the scope of SUDS integration in Johannesburg. Firstly, as the economic hub of a middle income country, Johannesburg is a reasonably better-resourced local government authority in comparison to other Sub-Saharan cities. The operating budget for the CoJ's infrastructure and service delivery

obligations for the 2014/2015 financial year was an estimated R22.6-billion[32], well over 60% of the city's total operating budget for the same period. However, interviewees highlight that the city still functions under some resource constraints. The city considers rapid and pragmatic infrastructure service provision as central to its post-apartheid transition towards a presumably more equitable vision of "…a World Class African City of the Future" (Beall et al., 2002; CoJ, 2011:36). This channelling of a large proportion of the city's resources towards infrastructure services highlights an opportunity for the regime to integrate alternatives such as SUDS.

Prospects for the integration of SUDS in Johannesburg are also influenced by the city's climate variability and projected climate change impacts. Johannesburg experiences variable summer rainfall between October and February with mean annual precipitation of 600mm (Turton et al., 2006), characterised by occasional short and high-intensity thunderstorms. Climate change impacts are projected to lead to a 27% increase in annual rainfall by 2100 (CoJ, 2009) on the one hand, and a possible shortening of the rainy season on the other thus likely indicating increased rainfall intensity (Fatti & Vogel, 2011), which will elevate floodrisk and further burden existing stormwater infrastructure (CoJ, 2011).

In terms of physical geography, Johannesburg straddles the Witwatersrand watershed with no close major water source (Turton et al., 2006). Thus the city relies primarily on the Vaal River System for its water supplies, which is itself reliant on complex Inter Basin Transfers (IBTs) from the Lesotho Highlands (CoJ, 2011). As recent studies of water resources within South Africa indicate imminent scarcity (Hedden & Cilliers, 2014) cities like Johannesburg will face increased water supply challenges (CoJ, 2011). Furthermore Johannesburg's reliance on a spatially-dislocated supply system based on water from Lesotho's Highlands leaves Johannesburg vulnerable to the environmental and political landscape factors in Lesotho[33].

From a socio-technical perspective, Johannesburg's infrastructure is also coming under increasing strain. Interviewees highlight that although the city officially has a separate sewer system, as the infrastructure ages and population increases e.g. in the city centre, the sewerage and stormwater infrastructure are failing leading to increased flood risk as well as a decline in wetland ecosystem and riverine health as the city's watercourses become polluted (JRA, undated; CoJ., 2010). Furthermore, the city's water supply services were interrupted in September 2014 leaving many residents stranded for up to three weeks (Hesse & Allen, 2014). While these water supply problems were caused by the failure of reservoir pumps due to stolen electricity cables (ibid), this infrastructural 'malfunction' (Furlong, 2014) highlighted the possible coalescing of infrastructural deficits into a landscape factor that is further pressurising the urban water management regime to consider alternative approaches such as SUDS to increase water resilience.

Geological factors may also influence efforts to integrate SUDS in Johannesburg. Dolomitic land underlies some areas of Johannesburg, especially in the West Rand area (De Bruyn & Bell, 2001). It poses a development hazard due to increased risks of sinkhole formation and subsidence linked to groundwater abstraction, destabilization during construction and increased infiltration of

[32] Equivalent to over USD 1.7-billion as of 19th March 2015

[33] Lesotho was rocked by a political crisis in September 2014 in an alleged failed blood-less coup attempt (Lesotho Times, 2014)

concentrated stormwater runoff among other factors (ibid). Furthermore, acid mine drainage (AMD), an externality borne out of Johannesburg's mining history (Rössner & Van Schalkwyk, 1999), could be another constraining factor for SUDS integration in Johannesburg. While increased stormwater infiltration and conveyance elements of SUDS may have negative implications for acid mine water levels from decommissioned mines, i.e. leading to decanting, as well as for AMD from tailings dams, some SUDS elements such as constructed wetlands have been employed in the biological remediation of AMD (Johnson & Hallberg, 2005).

Population trends and attendant infrastructural challenges are another influential landscape factor. Johannesburg's population in 2010 was estimated to stand at 3,8million (UN-Habitat, 2014) and it is estimated to stand at 4.1 million in 2015 (CoJ, 2011). Like many African cities, Johannesburg is confronted with informal settlements due in part to a housing and infrastructural backlog inherited from the apartheid era as well as population growth (Beall et al., 2002). In 2012 there were an estimated 180 informal settlements, home to around 25% of the city's population (CoJ, 2008; HAD, 2012). While the city continues efforts to deliver housing units to its citizens whilst also pursuing regularisation and upgrading processes for informal settlements, these settlements still present a service delivery challenge in terms of the provision of water, sanitation and drainage infrastructure (CoJ, 2011), a challenge which in South Africa sometimes leads to service delivery protests (Atkinson, 2007; UN-Habitat, 2014).

The interplay of these landscape factors forms the general context within which the potential integration of SUDS in Johannesburg has to be considered. These landscape factors present drivers and opportunities for the adoption of SUDS; such as addressing projected climate change impacts, possibilities for augmenting water supply and a possible contribution to the upgrading of informal settlements through green infrastructure-based stormwater management. Simultaneously some landscape factors such as prevalence of AMD and dolomitic geology may have a constraining influence on attempts to integrate SUDS in Johannesburg.

4.2. On-going SUDS engagement at meso-level: Prevailing regime dynamics

In this section I highlight the relevant regime actors who are engaged with SUDS as well as existing SUDS-based initiatives in the city. There are two regimes within which SUDS are situated in Johannesburg. As a stormwater management option which employs rainwater harvesting among other elements, SUDS is mainly found within the water management regime in Johannesburg. In this regime the main actors are Johannesburg Roads Agency (JRA) which is a municipal entity under which the roads and stormwater management mandate falls and Johannesburg Water (JW), which is the municipal entity responsible for water supply and sanitation services.

However, due to its predication on green-infrastructure for stormwater management, SUDS also partly fall within the jurisdiction of the green infrastructure regime of the city, the main actors being Johannesburg City Parks (JCP) and Environment and Infrastructure Services Department (EISD). JCP is the municipal entity responsible for development and management of public green infrastructure such as open space, greenery and cemeteries. The Environment and Infrastructure Services Department is an oversight department within the CoJ's core administration, whose responsibilities include environmental services policy formulation as well as monitoring and compliance. To ensure better institutional coordination the EISD and the municipal entities identified form part of the Sustainability Services Cluster within the CoJ.

One characteristic of the urban water management regime in Johannesburg emerging from the interviews conducted is its stability. Although interviewees identified internal tensions and barriers such as lack of institutional coordination between actors and ill-matched mandates, ageing infrastructure, infrastructure backlogs and lack of capacity and knowledge to implement SUDS, it is still a reasonably well-resourced functional regime that is able to fulfil its functions to a large extent. For example for the 2014/2015 year the JRA has received a R2.1-Billion budget allocation from the CoJ (JRA 2014:27). This regime stability is an extension of the stability found within the wider urban planning and management regime in Johannesburg, which is able to reproduce itself based on strategies and frameworks such as the Growth and Development Strategy 2040 (GDS2040) and the annually-reviewed Integrated Development Plans (IDP's).

Within the GDS2040, IDP's and the 'City of Johannesburg: The State of the Environment Report' (2008) can be also found an articulation of the selection pressures which the city is facing i.e. climate change, population growth, water and drainage infrastructure deficits. There is also an articulation of a vision and expectations for the city at large e.g. aspirations towards resource resilience, sustainable and compact urban form (CoJ, 2011). More specifically, the GDS 2040 envisions Johannesburg becoming a "[…) resilient, liveable, sustainable urban environment – underpinned by infrastructure supportive of a low-carbon economy […]" by 2040 (CoJ, 2011:91).

Actors within the water management regime have thus been able to further refine these expectations, finding points of alignment with their mandates as well as using them as search heuristics leading to an engagement of options like SUDS. According to a majority of the CoJ officials interviewed, the GDS 2040 vision and the principles of ensuring resource security and environmental sustainability on which it is partially founded, inform the policies pursued by the different organisations within the CoJ. As such, in line with the vision different actors within the regime have increasingly adopted SUDS-related initiatives. The following is a summary of on-going SUDS-related initiatives in the CoJ.

a. *Catchment Management Policy and Stormwater Management By-Laws*

The Catchment Management Policy (2008) and the Stormwater By-Laws (2009) are the main policy tools currently used by the CoJ (i.e. JRA and EISD) to address issues of stormwater management and flooding. The Catchment Management Policy provides strict controls on development and land-use adjacent to water courses, flood plains and wetlands, and promotes the use of sustainable urban drainage practices. The Stormwater By-Laws were promulgated to reduce runoff volumes discharged to downstream areas, improve infiltration and groundwater recharge and to reduce the damaging effects of stormwater such as sedimentation and erosion of watercourses by making on-site attenuation on new developments mandatory.

b. *JRA's On-Attenuation Policy*

As a result of the National Water Act (1998) and supported by the Catchment Management Policy and Storm Water By-Laws, the EISD and JRA have, from 2002, enforced an on-site attenuation policy for all developments larger than 8500m^2 based on its construction and design standards for stormwater (CoJ, 2010; JRA, 2010). For such developments, developers are required to submit a stormwater management report, detailing among other issues how the runoff is to be attenuated such that the predevelopment flows for the 1:5 year as well as the 1:25 year storm events are not

exceeded (ibid). Furthermore, the attenuation facility must be able to withstand the 1:50 year storm events. JRA and EISD are currently reviewing its design standards for storm-water specifications so as to incorporate improved SUDS-based design details which will help in the implementation and enforcement of the on-site attenuation policy such as requirements for the onsite attenuation of 1:1 and 1:2 year storm events.

c. *The Stormwater Manual*

Most interviewees highlight that in terms of stormwater management the CoJ is seeking a paradigm shift towards SUDS as one option to boost water resource resilience. In line with this shift the EISD and JRA are jointly working on a proposed Stormwater Manual which will be an extension of the Stormwater By-Laws. The Manual will enable the implementation of the By-Laws by providing detailed design criteria and requirements for stormwater management based on SUDS and Water Sensitive Urban Design Systems (WSUDS) principles in as far as they are applicable to the context of Johannesburg.

d. *The Rainwater Harvesting Master Plan*

In line with the GDS 2040's requirement to link resource sustainability and service delivery, the CoJ has put in place a Water Demand Management Strategy and is also currently looking at alternative water sources to augment water supply. Rainwater harvesting, has been identified by Johannesburg Water as a viable alternative water source for the city through the capturing of urban runoff as well as the development of rainwater catchment systems (Johannesburg Water, 2013). To this end, Johannesburg Water in 2013 worked in conjunction with universities in Johannesburg on a life-cycle costing of rainwater harvesting at a household level to obtain a clearer picture of the practicalities of domestic rainwater harvesting potential.

Additionally, JW is working on drawing up a Rainwater Harvesting Master Plan which will include a water audit for each use category as well as research into the existing conditions for rainwater harvesting i.e. extent of roof tops and paved areas (ibid). Some of the interviewees were tentative about the possible contribution of rainwater harvesting to the reduction of water demand in general compared to other sources such as groundwater. One official interviewed highlighted a need for further research into the feasibility of rainwater harvesting at household level, which he considered as less practicable compared to harvesting runoff at catchment level and treating it. He argued that placing rainwater harvesting within a 'livelihoods support' frame as opposed to the GDS2040's 'resource resilience' frame may have more impact in terms of rainwater harvesting at household and local community level in Johannesburg.

e. *Complete Streets Design Guideline*

In 2014, the JRA released the Complete Streets Design Guideline as a policy tool to direct the development and redevelopment of the City's to roads so as to accommodate diverse modes, users and activities and to improve liveability in line with GDS 2040's vision and principles (JRA, 2014). Central to the Complete Streets Guideline is the explicit mainstreaming of the SUDS approach through the use of biorention areas, infiltration trenches and porous pavements etc in managing stormwater quantity and quality adjacent to roads (ibid). Officials also highlight that the Complete Streets Design Guideline will support the City's on-going flagship transit-oriented development

drive i.e. the “Corridors of Freedom” programme, ideally incorporating SUDS and greening into the Corridors.

From the above initiatives, it would seem that the urban water management regime within the CoJ is progressively moving towards adopting GI-based approaches such as SUDS into its functioning. Thus the regime could be characterised as endogenously reconfiguring itself by adopting the SUDS as an *add-on component* in response to landscape pressures as well as to improve its functioning. Despite this shift in paradigm, most officials highlighted the biggest barrier to integrating SUDS at a city-level to be the lack of capacity i.e. requisite skills and knowledge about SUDS at both policy and operational levels to implement, maintain and monitor SUDS. This is partly because the SUDS approach is still a largely untested method that requires new knowledge and socio-technical configurations that are yet to be established.

4.3. SUDS-related initiatives at niche-level in Johannesburg

While the transition towards the integration of SUDS into Johannesburg seems to be mainly a top-down process of regime reconfiguration, there are non-regime actors within the niche level engaged with integrating SUDS into their activities. One such actor is the telecommunications company Vodacom, which completed a 4.2million rand rainwater harvesting project in 2013 (Vodacom, undated). According to an official, the initiative sought to align with the CoJ’s GDS 2040, and centred on reducing the use of potable municipal water by constructing an underground reservoir to harvest 12 Ml/annum of rainwater from a run-off area of 0.04 km^2 . The water is then used for cooling the company’s premises and for irrigation of the campus gardens.

Another non-regime actor is Sasol, a petrochemicals company. Sasol completed a desktop study in 2013 in partnership with the CoJ, on existing and potential rainwater harvesting initiatives in the CoJ. The study recommended targeting high water-users i.e. hospitals, malls and industrial parks with large roof-top surface areas and implementing rainwater harvesting on these sites, to get the largest reduction in water demand. The Green Building Council of South Africa (GBCSA) can also be viewed as a niche-level actor with an intermediary role engaged in the integration of SUDS in Johannesburg. It is a non-profit company seeking to encourage and facilitate green building in the South African property and construction industry. The GBCSA has established the Green-Star South Africa rating system to reduce the environmental impact of development and raise awareness of the benefits of green building among other objectives. Among other green star-earning green building strategies, developers are encouraged to reduce potable water demand through rainwater harvesting and greywater recycling systems (GBCSA, 2011). Furthermore, developers may earn green star innovation points for building innovations that go beyond the scope of the GBSCA’s rating tools while still satisfying requirements for certification.

Equally important in the incorporation of the SUDS approach in South African cities like Johannesburg is the intermediary role played by the Water Research Commission (WRC). The WRC promotes and coordinates of research and development in the water sector, identifying research needs, funding research and promoting the transfer of knowledge and technology as well as capacity-building within the water sector (WRC, 2015). In 2013 the WRC launched the Water Sensitive Design Lighthouse in a bid to develop a critical mass of knowledge around the integration of Water Sensitive Design concepts like SUDS that will in turn help to foster the transition of human settlements towards water sensitive futures in South Africa (WRC, 2014).

Some of the WRC's SUDS-related activities have included the funding and publication of the 'South African Guidelines for Sustainable Drainage Systems' (2013) and the 'Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines' (2014). Furthermore, in 2014 the WRC initiated a five year programme on the development of a Water Sensitive Design 'Community of Practice'. One of the project's aims is to create a Community of Practice in South Africa, with all relevant actors who together with research partners test the concepts, framework and options of Water Sensitive (Urban) Design (WRC project document). All three initiatives have been done in partnership with the University of Cape Town's Urban Water Management Group which has also played an intermediary role as a SUDS knowledge-broker, raising awareness on the need for South African cities to work towards water sensitive futures.

5. Analysis of the development and potential of the SUDS niche in Johannesburg based on SNM

In this section I use SNM to analyse the dynamics of the SUDS niche in Johannesburg.

5.1. Articulation of expectations and vision for SUDS

The GDS2040 as well as other CoJ documents such as the State of the Environment and Spatial Development Framework have served to articulate prevailing and expected problems (landscape pressures) that the regime is increasingly confronted with. These documents also place emphasis on expectations and visions of Johannesburg attaining liveability and resource resilience. While SUDS is often implicit in these policies, the policies have been translated by regime and niche actors in a way that mobilizes momentum around SUDS as an urban water management option such as the JRA's on-site attenuation policy, the pending Stormwater Management Manual, Vodacom's Rainwater Harvesting initiative etc. Within most of these initiatives one articulated expectation is of SUDS aiding in resource sustainability and adaptation.

Moreover, upcoming initiatives the Stormwater Management Manual, with its projected corroboration of SUDS/WSUDS principles, represent an expression of the city's expectations of incrementally integrating water sensitivity into the socio-technical fabric of Johannesburg. Furthermore, niche actors like Vodacom and developers have sought to integrate SUDS approaches based on expectations of future savings from reduced municipal water demand. However, a consultant highlighted that for developers especially, integrating SUDS elements may also be motivated largely by an expectation of branding benefits potentially emanating from a 'green' image (which accompanies a green star rating) and not so much from an engagement with sustainability per se.

Despite the momentum generated by policies such as GDS2040 and the green building practices, the city could benefit from a universal water-specific vision within which SUDS/WSUDS approaches and principles can be detailed, different actors enrolled and the diverse initiatives coordinated, all contextualised to the specificities of Johannesburg. Such a vision could well start with an alignment with the WRC's vision for water sensitive settlements within its WSUD Lighthouse initiative.

5.2. Formation of a broad social network around SUDS

The institutional work involved in pushing the SUDS agenda in the CoJ can also be traced to the agency of two SUDS champions[34] working within the EISD and JRA. As a result, a coalition has been built between the EISD and JRA, enabling the two regime organisations to work together towards the development of the Stormwater Management Manual. Furthermore these two regime members have started to build a network with like actors in the City of Cape Town, seeking to share experiences and lessons in best practice, SUDS technologies and strategies for institutional embedding. However participation in a social network around the issue of SUDS within Johannesburg is currently not broad. While there is an array of SUDS-related activities by actors spanning both the niche and regime levels, these actors seem to be dispersed, lacking a platform for engagement leading to weak social network formation. In the absence of such a platform, SUDS initiatives by different actors in Johannesburg presently lack coordination. As one meeting participant put it:

"*In Johannesburg a lot of energy is lost in brokering and negotiating for the planning and implementation of SUDS, because mandates related to SUDS lie within different entities."*

Establishing such a platform may, firstly, help widen the coalition around SUDS beyond existing champions such as EISD and JRA towards a network including other important regime actors within the CoJ e.g. Johannesburg City Parks, Johannesburg Water; as well as fostering a network between regime actors and niche-level actors such as developers, companies and intermediaries like NGO's. Secondly, it should ideally facilitate "collective sense-making" (Garud & Gehman, 2012: 989) on SUDS thereby supporting the development of an appropriate water-related vision by giving actors with different agendas and indeed different expectations a space for dialogue and alignment of activities and expectations. Finally, the coordination likely to accompany such engagement should ideally foster second-order learning processes between actors, learning which could instil reflexivity into the fledgling transition towards SUDS integration in Johannesburg.

The WRC's activities as an intermediary are also promising in this regard, with its on-going Communities of Practice programme that partly seeks to facilitate information exchange between practitioners, researchers, developers and other stakeholders in the water sector. Finally, building a broader social network around SUDS in Johannesburg may require reframing SUDS beyond their designation as a stormwater management and water supply augmentation option, to emphasize SUDS' multifunctionality and their potential contribution to improving food security and livelihoods. Such a reframing may further promote the enrolment of other important actors such as NGO's, community based organisations and households into the network.

5.3. Learning processes around SUDS in Johannesburg

While existing SUDS-related initiatives in Johannesburg have formed the basis for increased learning about SUDS in general, most respondents highlighted the lack of capacity and knowledge about SUDS as the biggest barrier to the approach's integration. The majority of interviewees across the different CoJ organisations interviewed emphasised that the lack of technical and

[34] SUDS champions are defined as emergent leaders who have specific personality, leadership and professional attributes and are adept at influencing others to adopt SUDS principles and practices (Taylor, 2009).

practical integrating SUDS was an issue because it points to the need for retraining and equipping the staff at JRA's operational depots in SUDS practices, technologies and maintenance. In terms of the depth of learning, on-going initiatives like the On-site Stormwater Attenuation Policy, Catchment Management Policy and Stormwater Manual seek to integrate SUDS through regulation. These policies, though a positive step in the SUDS direction, are nonetheless an indication of the prevalence of first-order learning since regulation emphasises the changing of stormwater management as a socio-technical practice and thus does not encourage the different actors involved to question the assumptions that have hitherto underpinned stormwater management practice in the city.

However like the lack of a water-specific vision, the apparent lack of second-order learning processes around SUDS in Johannesburg, may in part be linked to the absence of a broad social network with an appropriate platform for engagement which itself is due to the fact that SUDS as a niche approach in Johannesburg is still relatively new. As far as learning goes two main gaps are evident in the case of SUDS in Johannesburg. The first is a lack of technical knowledge on how to do SUDS i.e. technical and professional implications of developing a decentralised, green infrastructure-based stormwater management system. The second is a lack of knowledge on the organisational logic to best support the collaborative interaction necessary for approaches like SUDS.

5.4. The extent to which SUDS-related initiatives in Johannesburg support regime reconfiguration towards SUDS

As a niche alternative to conventional stormwater management, SUDS in Johannesburg have been adopted by a stable regime seeking to address landscape and internal pressures, while niche-level actors are engaging with the SUDS approach for expected savings, for green branding or also due to anticipated landscape pressures such as water resource problems. Within the SUDS niche in Johannesburg, the processes crucial for niche development as prescribed by the SNM approach are present to varying degrees. The process of articulation of expectations and a vision has generally been satisfied to some degree as the urban water management regime has translated these from the GDS2040 and other relevant policies. While a vision specifically for sustainable urban water management is yet to be developed, the GDS2040 and other policies have provided good impetus for regime reconfiguration towards integrating SUDS.

Current regime efforts towards integrating SUDS have also managed to foster first-order learning around SUDS as an alternative stormwater management approach primarily through regulation. However, there has been little formation of social networks or fostering of second-order learning processes making the SUDS niche in Johannesburg relatively unstable. As such there remains a need to broaden the social network around SUDS and facilitate more reflexive learning such that non-regime actors like developers are not mere recipients of perceived sustainabilities through regulation but active constituents in the process of integrating SUDS. As a result of these deficiencies the various on-going SUDS-related initiatives at regime and niche levels in the city are not yet well coordinated. The lack of a platform where various stakeholders can engage may be the biggest barrier to realising a broader network and second order learning around SUDS in Johannesburg.

In terms of Raven's (2006) typology of niche-regime engagement, it could be said that the SUDS niche in Johannesburg represents a 'promising technology' because despite its apparent instability i.e. lacking a social network and second order learning attributes; the niche is being adopted by a relatively stable regime nonetheless. This may point to the power of expectations, such as those found in the GDS2040, in fostering 'transformative initiatives' (Quitzau et al., 2012) especially in the face of uncertainty associated with climate change and sustainability challenges in urban areas. In light of the various on-going SUDS initiatives in the city, the SUDS approach seems to be a promising policy niche which is established within a nascent but definite regime reconfiguration towards SUWM.

6. Conclusion

This paper has presented a narrative of the on-going engagement with SUDS in the city of Johannesburg and the extent to which this signals a transition towards water sensitive future, basing its analysis on the MLP and SNM concepts. Findings indicate that Johannesburg is undergoing a fledgling 'regime reconfiguration', shifting paradigms from conventional stormwater management towards the integration of SUDS. This is part due to the agency exhibited by as regime members in the JRA and the EISD, championing the adoption of the SUDS niche within the regime and its manifestation through the On-Site Attenuation policy and the Stormwater Manual among other initiatives. There also seems to be vibrant niche-level engagement with SUDS such as Vodacom's Rainwater Harvesting initiative and the intermediary roles played by the WRC and GBCSA.

This shift towards SUDS can be viewed partly as a response to perceived landscape-level pressures such as anticipated water supply problems and increased floodrisk, as well as articulation of expectations and visions for sustainability found in the city's strategies and frameworks such as GDS2040. Thus in terms of SNM niche development processes, the SUDS niche in Johannesburg seems to have relatively well articulated expectations, though it still lacks a water-specific vision. However there is little evidence of a broad social network formation around the issue of SUDS in Johannesburg, save for the coalition between EISD and JRA. As a result there is little coordination between on-going initiatives and second-order learning processes are lacking highlighting the current instability of the niche. Thus the paper has identified one way of encouraging broader network formation, coordination and reflexive learning could be for the city to develop a platform, as other cities in South Africa have begun to do, where the diverse actors may engage, coordinate and align current and future SUDS activities.

Despite its immaturity the SUDS niche in Johannesburg seems to be a promising niche which is serving as the foundation for a burgeoning regime reconfiguration towards more sustainable urban water management in the city. Whether this shift will result in a water sensitive future for Johannesburg remains to be seen, but since there is no one way of doing sustainability, Johannesburg's incremental experimentation with SUDS represents an attempt towards addressing water infrastructure system problems and learning about what will work best within the context of Johannesburg.

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