

TRANSITION PATHWAYS OF SPLINTERED REGIMES

Addressing sanitation provision challenges in informal settlements

Mara Johanna van Welie

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TRANSITION PATHWAYS OF SPLINTERED REGIMES

Addressing sanitation provision challenges in informal settlements

Transitiepaden van versplinterde regimes
Aanpak van de uitdagingen op het gebied van sanitaire voorzieningen in informele
nederzettingen

(met een samenvatting in het Nederlands)

Transitionspfade in zersplitterten Regimen
Ansätze zu Herausforderungen der Sanitärversorgung in informellen Siedlungen

(mit einer Zusammenfassung in deutscher Sprache)

Proefschrift

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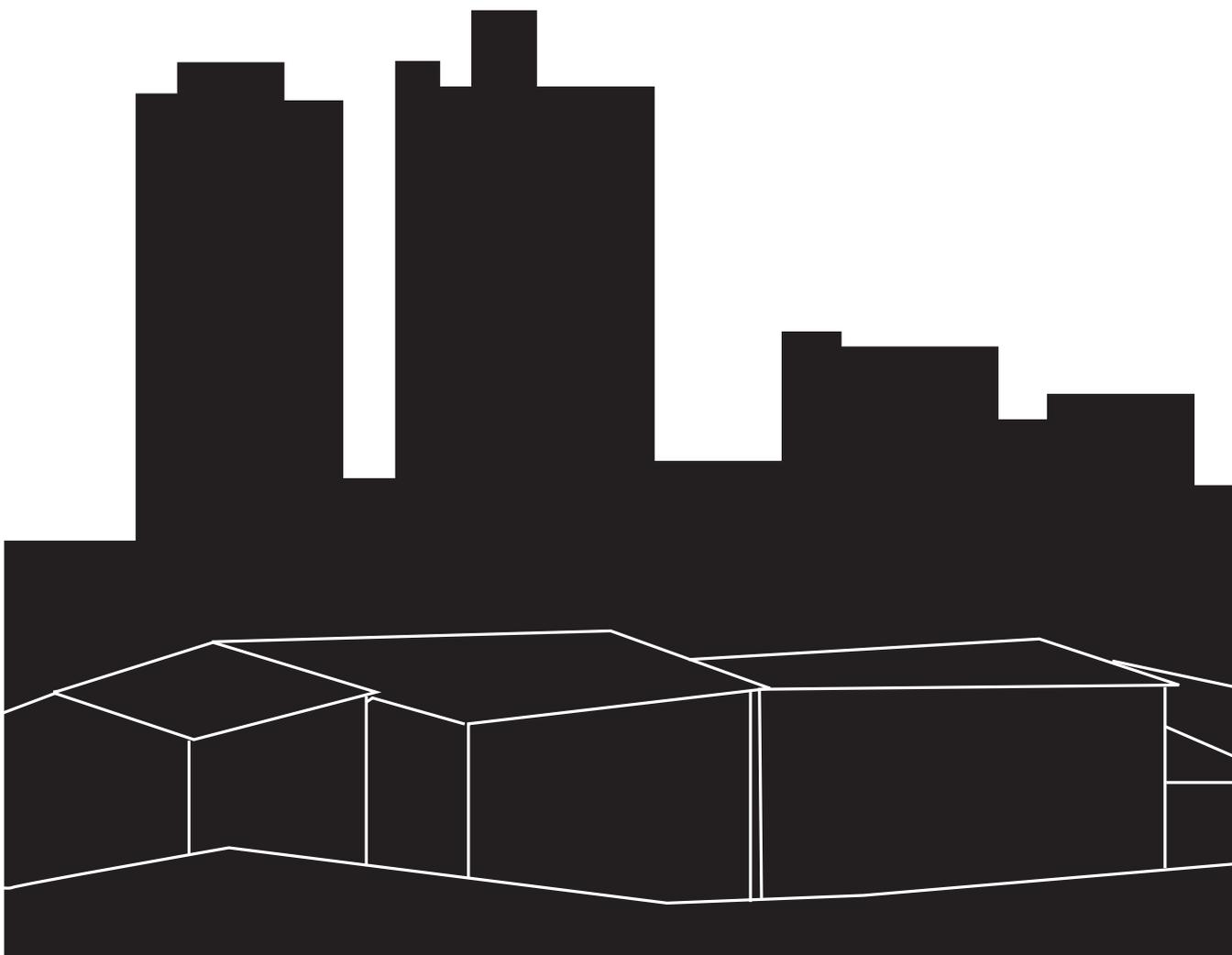
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Chapter I

Introduction



I.1 Sustainability transitions in cities in low-income countries

The world is rapidly urbanizing and more than half of the world's population resides in urban areas UN-Habitat (2016b). This leads to a multitude of problems in the provision of urban basic services such as transport, water, sanitation, solid waste and electricity. A lack of basic services leads to many sustainability issues, such as poor health and environmental contamination. Especially in cities in low-income countries, urbanization goes hand in hand with a growing number of poor residents living in informal settlements¹ where the provision of basic services is extremely challenging (UN-Habitat, 2016b, 2016a). The lack of urban basic services has been a persistent problem for decades. Solving this problem is highly complex and has been hampered by various factors, such as weak governmental support, lack of financial resources, misaligned expectations, lack of maintenance, and too much focus on technology. Actors that try to pursue innovations in basic service provision face a multitude of challenges related to technical, political, institutional, cultural, and financial aspects. Overcoming these multidimensional challenges and improving urban basic service provision requires fundamental transformations of these sectors. This thesis aims to understand how innovative activities can contribute to such changes towards improving the sustainability of urban basic service sectors in cities in low-income countries.

In the last two decades there has been increasing attention for so called “sustainability transitions” in practice as well as research (Markard et al., 2012; Chappin and Ligtoet, 2014; EEA, 2017; Loorbach et al., 2017; TransitionResearchNetwork, 2018). These are long-term and fundamental structural change processes towards more sustainable modes of production, provision, and use, and form the main object of study in the scholarly field of sustainability transition studies (Markard et al., 2012). At the core of this body of literature are fundamental change processes of socio-technical systems. Socio-technical systems consist of (networks) of actors and institutions, such as regulations, policies, societal and technical norms, culture, as well as material artefacts and knowledge (Markard et al., 2012; Schot et al., 2016). These dimensions are interrelated and can evolve into stable configurations over time, which form path-dependencies and lock-ins. These so called socio-technical regimes, depict

¹ Informal settlements can be defined as “areas where groups of housing units have been constructed on land that the occupants have no legal claim to, or occupy illegally; or unplanned settlements and areas where housing is not in compliance with current planning and building regulations” (UN, 1997, p. 43). We understand informal settlements also as places in the city where activities take place that are not registered, taxed, or regulated by the state (Fourchard, 2011, p. 235). Worldwide, about a billion people live in such areas (UN-Habitat, 2016a, p. 2). Informal settlements are also called “slums”.

the “normal” way of doing things in a given sector or societal subsystem, are widespread, and have existed for a long time (Geels, 2004; Fuenfschilling and Truffer, 2014). Socio-technical transitions have originally been conceptualized as the result of the interaction between socio-technical regimes, niches, and landscape factors (Geels, 2002). Niches are emerging alternative socio-technical configurations where novelties develop, protected from selection pressures of the prevailing regime (Kemp et al., 1998; Geels, 2002). The landscape is formed by external structures and processes that only slowly change. Landscape factors might put pressure on existing regimes, which give niches the opportunity to break through and contribute to fundamental changes in socio-technical regimes. Such socio-technical transition processes are long-term and unfold over many years (Markard et al., 2012).

The literature on sustainability transitions can be used to shed a new light on the persistent challenge of providing urban basic services in low-income cities. The systemic perspective offers an integrated analysis of the interrelated factors that lead to obdurances in these sectors, as well as identifying the challenges that initiatives face when addressing the problems. Because of these appealing possibilities, an increasing number of studies recently started to apply transition perspectives in low-income countries (Wieczorek, 2018). In these contexts, specific conditions influence the way transitions unfold (Berkhout et al., 2009; Rock et al., 2009; Hansen et al., 2018), such as weak states, vulnerable communities, informalities, large inequalities, ill-functioning institutions, high levels of poverty, dependence on foreign knowledge and financial resources, and the involvement of external donors. Many of the authors that have applied existing transition concepts in low-income countries, have at the same time shown inadequacies and/or argued for extensions of transition frameworks to be able to take these conditions into account (among others Hansen and Nygaard (2013); Ahlborg (2015); Blum et al. (2015); Murphy (2015); Tigabu et al. (2015b); Ramos-Mejía et al. (2018); Sixt et al. (2018)).

The application of core transition concepts in low-income countries thus provides an opportunity to develop the transitions research field further, as the main attention so far has been on sustainability problems in high-income western countries² (Markard et al., 2012; Hansen and Coenen, 2015; Loorbach et al., 2017). These contexts are typically characterized by stable institutions, relative socio-cultural and economic homogeneity, formal economies, and standardized and centralized infrastructures. A vast amount of empirical cases in the

² The term “western” is not necessarily used as a geographical indicator, but rather to refer to countries where sustainability challenges and transition dynamics show similarities. Examples of western contexts are Northern and Western Europe, the USA, and Australia.

transitions research field has focused on energy, transport, food, and water (STRN, 2018), which have particular characteristics in western contexts. In the energy and water sector for example, regimes are based on large, centralized infrastructures and mostly converge into homogenous configurations which serve the majority of users in a particular area. For example, electricity sectors can be characterised by a centralized grid to which the large majority of households are connected. Similarly, in urban water management sectors in western countries, the majority of households are connected to a centralized sewerage system. These basic service sectors are thus mostly dominated by rather homogenous socio-technical regimes. Transport sectors are much more diverse, but the analytical focus in the literature so far has often been limited to the “dominant” regime of automobility (see for example (Geels, 2012; Epprecht et al., 2014)). As a consequence, socio-technical regimes in transport have also mostly been perceived as rather homogeneous.

The realities of many cities in low-income countries³ deviate in many respects from this homogenous ideal type. They are characterized by a multitude of service offerings, large socio-cultural and economic inequalities, severe poverty and insecurities, lack of centralized and standardized infrastructure, and informal structures and institutions. In many of these cities large infrastructural and socio-economic inequalities stem from racial segregation of neighbourhoods during colonial times (Coutard, 2008; Fernández-Maldonado, 2008; Jaglin, 2008; Kooy and Bakker, 2008; Lüthi et al., 2010; Furlong, 2014; Swilling, 2014; Lang, 2016). Consequently, socio-technical regimes in urban basic service sectors are much more heterogeneous and consist of multiple regimes, as for example has been shown in work in cities in India and Thailand on public transport regimes (Ghosh and Schot, 2019), and informal transport regimes (Sengers and Raven, 2014). However generally, regime analyses have so far not taken this multiplicity into account, because of the field’s original focus on specific infrastructure sectors in western contexts, which represent rather exceptional cases of homogenous regimes⁴.

The specific conditions in low-income countries and the multiplicity of socio-technical regimes, also influence how regime change unfolds. This is more complex than the

³ In Chapter 3 the term “Global South” is also used to refer to low-income countries, to align with the international journal to which the journal article is submitted.

⁴ A multiplicity of socio-technical regimes is not unique to low-income countries. Also food, housing, and transport sectors worldwide may consist of multiple socio-technical regimes (e.g. (Konrad, et al., 2008), (Raven and Verbong, 2007)). For example, automobility, bicycle, public transport, and pedestrian regimes exist in the transport sector. This multiplicity has been acknowledged (among others by (Kemp, et al., 2011), (Moradi and Vagnoni, 2018)), but not taken up in analysis.

interactions between regimes and niches, as conventionally understood. Since there are multiple regimes in a sector, all sort of innovative activities are in place that aim to transform these. Some of these activities can be more niche-like, while others take place within one or more regimes. Actors might be incumbents in one regime, while being niche players in another, and distinguishing between them becomes increasingly difficult. Innovations may comprise of different types of novelties, based on a range of different capabilities and resources, and not just radically new technologies based on R&D (Hansen et al., 2018). Moreover, often international development agencies and donors are involved (Tigabu et al., 2017; Sixt et al., 2018). Multiscalar interactions between actors at the city and international level might thus play a key role (Coenen et al., 2012; Hansen and Nygaard, 2013; Wieczorek et al., 2015). Therefore, analysis of innovation activities in such contexts asks for greater attentiveness to processes taking place at different scales, such as cities and global networks.

As a result of the multiplicity of socio-technical regimes and the more complex set of innovation activities that aims at transforming the regimes, potential transition pathways can be much more diverse. Transition pathways are understood as patterns of change of socio-technical regimes over time. It has been recognized that transition pathways are context dependent, and unfold differently under different conditions (e.g. Smith et al. (2005); Geels and Schot (2007); Hansen and Coenen (2015); Lindberg et al. (2018)). Most elaborations of different types of transition pathways have, however, focused on niche-regime interactions, and have an implicit assumption of a dominant regime as the end-point of transitions (Geels and Schot, 2007; Foxon et al., 2010). Innovation activities in low-income countries not necessarily lead to radical destruction and shifts of regimes, but instead can lead to “upgrading” and “improving” of regimes, as observed by Ghosh and Schot (2019), who warn for a “western bias” focusing on regime shifts relying on niches as sources of change. A simplified view on regime change has already been criticised by several scholars arguing that transition processes can be much more variable and messy (e.g. Smith et al. (2005); Genus and Coles (2008)).

In short, in urban basic service sectors in low-income countries heterogeneous regimes exist. As a consequence, multiple innovation strategies are pursued by different actors towards changing these regimes, aimed at solving the persistent problems and thereby improving the sustainability of these sectors. Innovations at the local level might rely on resources from the international level, and processes at multiple scales thus play an important role. Altogether, to be able to identify how innovative activities can transform these regimes, this thesis elaborates the following conceptual challenges. First, the homogeneous conceptualization

of socio-technical regimes needs to be opened-up. Second, the variety of actors that pursue innovation strategies aiming at transforming the different regimes, need be taken into account. Third, processes at different scales that support innovation processes at the local level, should be identified. The following two perspectives are proposed to deal with these challenges.

First, the socio-technical regime concept needs to be opened-up to be able to address a multiplicity of socio-technical regimes in urban basic service sectors in low-income countries. These regimes are formed around diverse types of service options. They cannot be identified through an analysis of formal regulations, standardized infrastructures and their related technological artefacts. Such analysis rather requires an epistemological/methodological strategy that enables the identification of a variety of other factors which stabilize regimes, which are more diverse. Practice theory can be used as such a perspective to unravel socio-spatial unevenness's and different types of stabilizing features, which are otherwise not visible through a focus on formal regulations and technological artefacts (Shove and Walker, 2010; Spaargaren, 2011; Hargreaves et al., 2013; Cohen and Ilieva, 2015). Practices are “stabilized, routinized, or improvised social actions that constitute and reproduce economic space, and through and within which socio-economic actors and communities embed knowledge, organize production activities, and interpret and reive meaning from the world” (Jones and Murphy, 2011, p. 367). The reproduction of practices stabilizes particular regimes in different places. Multiple regimes can thus be identified through the examination of practices that are associated with different configurations of particular technologies, user and provider routines, organizational forms, and shared meaning.

Second, the variety of innovative activities requires to take different actor attempts into account to develop and diffuse new technologies, services and products, and how existing regime structures support or hamper these attempts. The Technological Innovation System (TIS) approach provides a well-developed perspective to assess the emergence of new technologies, services or products. TIS emphasizes how the interactions of actors in their networks, as well as the role of institutional arrangements, promote or hinder innovations (Carlsson and Stankiewicz, 1991; Truffer, 2015). A TIS typically interacts with one or more socio-technical regimes, which represent barriers for the innovation and, at the same time, may be challenged by the innovation as it can replace existing services, products or technologies in the regime (Markard and Truffer, 2008). Furthermore, the systemic perspective allows for analysis of innovation processes at different scales (Binz et al., 2014; Gosens et al., 2015; Binz and Truffer, 2017). Within TIS, several processes should take place in order for the

system to perform well: knowledge production and diffusion, resource mobilization, market formation, legitimization creation, guidance of search, and entrepreneurial activities (Hekkert et al., 2007; Bergek et al., 2008). Processes, or “functions” that are insufficiently developed indicate a need for action by actors that want to support the innovation. Additionally, the identification of capability, institutional, and interaction deficits, or “system failures” gives insight in the innovation development and provide pointers for improvement (Klein Woolthuis et al., 2005). Because of these characteristics, a TIS perspective is proposed to enable a rich analysis of the diverse strategies and challenges of actors and networks, which aim to transform existing regime structures (in line with Markard and Truffer (2008); Foxon et al. (2010)).

In this thesis, cities in low-income countries are understood as challenging “new” contexts for transition studies, to explore how core concepts and frameworks can be applied beyond their original western settings. This can ultimately lead to new insights and refinements that can inspire and further develop this field of study (Loorbach et al., 2017; STRN, 2017; Truffer et al., 2018).

1.2 Research questions

The aim of this thesis is to analyse how innovative activities can contribute to fundamental changes in urban basic service sectors in cities in low-income countries. This means in conceptual terms that the aim is to identify potential transition pathways towards improved service provision and sustainability in these sectors. To that end, I first analyse the characteristics of heterogeneous socio-technical regimes. Second, the various innovative activities that different actors pursue to change these regimes are identified. The challenges that these actors face are analysed, as well as the distinct capabilities that they employ to overcome their challenges. Third, because not all resources for innovative activities can be mobilized in the city, relevant processes taking place in networks at the global level are analysed. Finally, potential transition pathways are identified, based on how the different innovation strategies might change regimes over time. This leads to the following research questions:

1. What are the characteristics of socio-technical regimes in cities in low-income countries?
2. What are the challenges of innovators that aim at transforming these socio-technical regimes, and how do they try to overcome them?

3. How do networks/actors at the global level build up resources that can support innovation processes at the local level?
4. What are possible transition pathways towards sustainability that result from these activities?

1.3 Case selection

The provision of urban basic services in low-income countries is a persistent and complex problem, but has so far largely been ignored in the literature on sustainability transitions. A particular “extreme” case is the provision of sanitation services, in which relatively little progress has been made in the last decades, despite high ambitions (Jones et al., 2013; Seetharam, 2015; Andersson et al., 2016). The sanitation sector is therefore taken-up as a case to answer the research questions. In this thesis, the term *sanitation* is used to refer to “...facilities and services for the safe management of human excreta from the toilet to containment and storage and treatment on-site or conveyance, treatment and eventual safe and end use or disposal” (WHO, 2018b).

Despite increasing global attention for the problem⁵, the sanitation target of the Millennium Development Goals (MDGs) was not reached (WHO, 2015), and the progress towards the Sustainable Development Goal (SDG) on sanitation is slow⁶. In 2015, 60% of the global population (4.5 billion people) still lacked safely managed sanitation – defined as the use of a toilet or improved latrine, not shared with other households, with a system in place to ensure that excreta are treated or disposed of safely⁷ (WHO, 2017, 2018c). A lack of sanitation hinders a healthy and productive life in cities (Andersson et al., 2016; WHO, 2018a) and leads to environmental contamination, especially ground water pollution.

⁵ Attention for sanitation on the global development agenda has increased since 2008, the “UN International Year of Sanitation”, followed by the recognition of the human right to water and sanitation in 2010. Safe management of sanitation, as well as treatment and reuse of wastewater, was given a central place under the Sustainable Development Goals (SDGs) (WHO, 2018a).

⁶ SDG6 - “ensure availability and sustainable management of water and sanitation for all” (UN, 2015).

⁷ *Improved sanitation facilities* “are those designed to hygienically separate excreta from human contact. These include wet sanitation technologies (flush and pour flush toilets connecting to sewers, septic tanks or pit latrines) and dry sanitation technologies (ventilated improved pit latrines; pit latrines with slabs; or composting toilets)” (WHO, 2017, p. 16). The fact that shared sanitation is classified as a “limited” sanitation service is contested, because especially for informal settlements’ residents shared sanitation might be the only viable option to improve sanitation services (Evans, et al., 2017).

Moreover, a lack of sanitation is closely linked to other urban problems, such as health and wellbeing, poverty, energy and food. Improving sanitation might thus help solving other development challenges as well (Andersson, Otoo, et al., 2018; Dye, 2018).

However, especially in cities in low-income countries, providing sanitation services is very complex. Sanitation provision is among other aspects challenged by geographical and economic conditions, regulations, infrastructures, societal values and norms, and user preferences (Gutierrez, 2007; Markard and Lüthi, 2010; Jewitt, 2011; Jones et al., 2013; Kennedy-Walker et al., 2014). Furthermore, the challenge of sanitation in cities is particularly burdensome compared to rural areas, because it goes beyond achieving a defecation free environment: there is a need for proper disposal of household wastewater and faecal sludge management (Lüthi et al., 2010; Reymond et al., 2016; Mara, 2018). Feasible technology options are often lacking, sewer systems are too expensive and require too much water; and conventional pit latrines fill up quickly and managing the waste is difficult and costly. Moreover, the specific challenges in informal settlements are manifold, among others, many residents lack formal tenure and a high socio-cultural diversity is present, which complicates the provision of sanitation services. Many of the past interventions have been overly focused on technological solutions and particular aspects of the problem, such as the lack of toilets, not leading to fundamental improvements of the overall situation.

Despite these challenges, there are high ambitions for sanitation provision. Reaching the SDGs in 2030 requires a much higher speed of improving sanitation, compared to what could be achieved during in the MDG period (2001-2015) (Mara and Evans, 2018). This asks for fundamental changes of urban sanitation sectors in many low-income countries. A wider array of solutions and innovative approaches needs to be considered. Some argue that the number of initiatives attempting innovations in sanitation provisioning around the world is already “booming” (Andersson, Otoo, et al., 2018, p. 856). Innovations vary for example from the use of mobile toilet technologies and waste-separating toilets to recover nutrients, to market-based service models. The question is, however, how different types of innovations contribute to long-term transition processes of the entire sector.

This thesis focusses on the case of sanitation provisioning in Nairobi, the capital of Kenya. Nairobi is a typical city in a low-income country. Its population is estimated at 4.2 million (in 2014 by UN-Habitat (2018)), whereof 36% live in informal settlements (Mansour et al., 2017). Nairobi is characterized by large inequalities between neighbourhoods in terms of sanitation provisioning (Gulyani et al., 2006; Darkey and Kariuki, 2013). It varies from

households using sewerred flushing toilets in the city centre and high-income residential areas, to residents of peri-urban and informal settlements who have to combine public sanitation services with coping strategies such as open defecation, on a daily basis to meet their needs (Cherunya et al., 2018). These inequalities are inherited from the colonial era when city planners created a social and spatial segregation between African, Asian, and European neighbourhoods (Nilsson, 2011; Darkey and Kariuki, 2013; Blomkvist and Nilsson, 2017). Sewerage systems were developed to serve colonial elites, while native populations in other areas of the city were forced to develop on-site sanitation systems. The main activities of sanitation for less affluent residents at that time were bucket latrine systems with collection and burying of waste (Nyanchaga and Ombongi, 2007). The current situation is also a result of Kenya's fragmented governance framework for sanitation, which is situated between the Ministry of Water and the Ministry of Health, and has changed many times over the last century (Nyanchaga and Ombongi, 2007). Furthermore, investments in sanitation have been too low. Sewer infrastructure have failed to keep up with the demand in Kenya's urban areas (Okoth et al., 2017, p. 60), and sanitation for the poor was anyway a low investment priority in Kenya, and has mostly come from donors (Mansour et al., 2017). In absence of sufficient coordinated governance and finance of the sanitation sector, many NGOs have tried to increase sanitation coverage in Nairobi since the 1970s, but the improvements could barely keep pace with the rapid population growth of the city (Szanto et al., 2012).

As a result today, it has been estimated that approximately 66% of the sanitation waste generated in Nairobi is not safely treated (research by the African Population and Health Research Center Mutavi (2018); Okello-Juma (2018)). One of the biggest shares that is not treated, is the waste from on-site sanitation facilities that does not reach the city's treatment plant. Latrines and septic tanks are used in an uncontrolled manner and irregularly emptied. Exhauster truck operators and manual pit latrine emptiers are supposed to safely dispose the waste they collect, but many tend to dump it where it is most convenient for them, such as in nearby streams, rivers, lakes and bushes (Okoth et al., 2017, pp. 60-61). The lack of safely managed waste in Nairobi leads to many undesired outcomes such as sanitation-related diseases, environmental pollution, and lowered school attendance. These effects are especially felt by residents in informal settlements, which are often located within the flood plains, valleys and wetlands of Nairobi (Darkey and Kariuki, 2013).

Nairobi is an interesting case to answer the research questions, because the city struggles with sanitation provisioning for its entire population, and has been a popular testbed for a large variety of sanitation innovations, implemented by Kenyan and foreign social

enterprises, NGOs, and development agencies. Many organizations operate in Nairobi, because of the severe problems and its convenient location in practical terms, as many donors and development agencies are located in the city. As a result, the city has even been called the “Silicon Valley of Shit” (Kalan, 2011). Examples of innovations that have been implemented in the city are among others, pit latrine emptying devices; container-based toilets; biodegradable single-use toilets; reuse of waste as biogas, fertilizer and animal feed; simplified PVC sewer systems, and sanitation services run as a business (Wegelin-Schuringa and Coffey, 2000; WorldBank, 2012; Graf et al., 2014; UmandeTrust, 2014; O’Keefe et al., 2015; Thieme, 2015; Wamuchiru, 2015; Auerbach, 2016; Parker and Tremolet, 2017).

All said, it is expected that a variety of providers operate in Nairobi’s sanitation sector, in multiple regimes. Furthermore, different actors pursue innovation strategies based on distinct capabilities and access to resources from multiscalar networks to change these regimes. They encounter challenges, related to institutional mismatches, and capability and coordination deficits. The innovative activities of different actors are expected to transform regime structures over time, which can result in a wide variety of potential transition pathways. The possible end-points of these transitions are expected to be much more diverse than a homogeneous regime based on a centralized sewerage system, envisioned by many policy makers and city planners.

1.4 Methods and data collection

The research follows an embedded case study approach (Yin, 2014), with sanitation provision in Nairobi as the larger unit of analysis, and several innovation strategies of actors as embedded subunits. First, the characteristics of the socio-technical regimes in Nairobi are studied (Chapter 2). Second, in order to gain insights into innovative activities in urban basic service provisioning, two embedded cases are selected. Each case includes distinct actor strategies to transform specific regime structures in Nairobi. The first case revolves around the public utility that aims at expanding its services to informal settlements (Chapter 3). The second case focusses on social enterprises and NGOs working on novel on-site sanitation chains (Chapter 4). Last, processes in networks at the global level are studied, with a case study of an innovation intermediary in international development cooperation focused on safely managed non-grid sanitation in low-income countries (Chapter 5).

The empirical work in this thesis is based on qualitative data and methods. Chapter 2-4 are based on five months of fieldwork between February-March and October-December in 2016

in Nairobi. In total, 104 face-to-face semi-structured expert interviews were conducted (39 in the first round; 65 in the second round) with actors such as policymakers, utility officials, NGO representatives, social entrepreneurs, and exhaustor truck operators. For Chapter 5, an additional 21 interviews with experts in international development cooperation were conducted, mostly held using Skype, between February and October 2018. The interviews were recorded, transcribed⁸, and coded with MAXQDA software. The insights from the interviews were complemented by information gained from focus group discussions with informal settlement residents, and project visits of NGOs, social enterprises and the utility. Furthermore, I spent several days in the utility's and other governmental offices (mostly while waiting for scheduled interviews), I was taken along to some activities of the utility, and was invited to attend meetings of Kenyan sanitation stakeholders at the Ministry of Health and County of Nairobi. These opportunities led to informal conversations with utility employees and representatives of other (governmental) organizations, which was important to build relationships with these informants. Moreover, this time spent helped me to write field notes to better understand relevant practices and events that were not necessarily discussed in interviews. Last, various documents were used, such as organizational and project reports, newsletters, policy documents, academic literature, and newspaper articles accessed online. The different types of data were triangulated to validate the findings. The data was analysed in an iterative process, while at the same time conceptual frameworks were developed. Each individual chapter introduces a more detailed methodology.

The thesis is part of a broader research project titled “Sustainability Transitions of Sanitation Regimes in Urban Africa: Assessing the prospects for disruptive innovations”, which includes the work of one other PhD student, Pauline Cherunya. Both PhD theses are about sanitation in Nairobi, but Pauline focuses on the role of users, while in this thesis I focus on service providers. The first step in this project was the creation of a common understanding of the sanitation sector in Nairobi (Chapter 2), therefore the first 26 interviews and two focus group discussions in Nairobi were conducted together with Pauline. We did an intercoder reliability check for the coding process of the interviews of the first fieldwork.

Finally, during three weeks of fieldwork in 2018, several follow-up visits to relevant organizations and community groups in Nairobi were conducted to disseminate results and discuss the findings of the research project. Moreover, we organized a dissemination

⁸ The majority of the transcriptions were done by 8 Kenyan university students. I checked and corrected all their transcriptions in detail.

workshop at Kenyatta University in Nairobi on July 6, 2018, in which 56 stakeholders from the water and sanitation sector participated, who represented among others Nairobi County, the Ministry of Health, community groups and the utility. In this full day workshop, the findings of the research were presented and discussed.

1.5 Thesis outline

The thesis is based on four journal articles⁹. Each of these articles constitute a chapter.

In *Chapter 2* the high complexity and persistence of the sanitation sector in Nairobi is analysed using the regime concept. To be able to take the heterogeneity observed in low-income cities into account, the chapter introduces a conceptual extension of socio-technical regime analysis, distinguishing the two levels of service and sectoral regime. The service regimes are identified through a focus on practices. Challenges of socio-technical transitions might be identified by missing alignments within and between the two levels. Misalignments within service regimes cause ineffective ways of providing and accessing a service, while misalignments between service regimes are a result of a lack of coordination in the sector. This leads to the introduction of a typology of sectoral regimes (monolithic, polycentric, fragmented, and splintered). A *splintered regime* is for example a sectoral regime that consist of several service regimes that are partially aligned internally and misaligned at the sectoral level. Based on this typology of sectoral regimes, a generic set of alternative transition pathways can be formulated depending on how a sectoral regime changes from one to another type. In the chapter, the framework is applied to analyse the regime in the sanitation sector in Nairobi, and to gain a first insight in potential transition pathways in the city. The findings show that Nairobi's sanitation sector represents a splintered regime, because many services do not function optimally and the different service regimes lack coordination at the sectoral level.

Chapter 3 and 4 provide an in-depth understanding of innovative activities that aim at changing specific service regime structures in Nairobi. The challenges of different types of actors who innovative in different sanitation service regimes are identified, and insights are gained in their strategies to overcome these.

The public water and sewerage utility in *Chapter 3* is the main incumbent actor in the high-

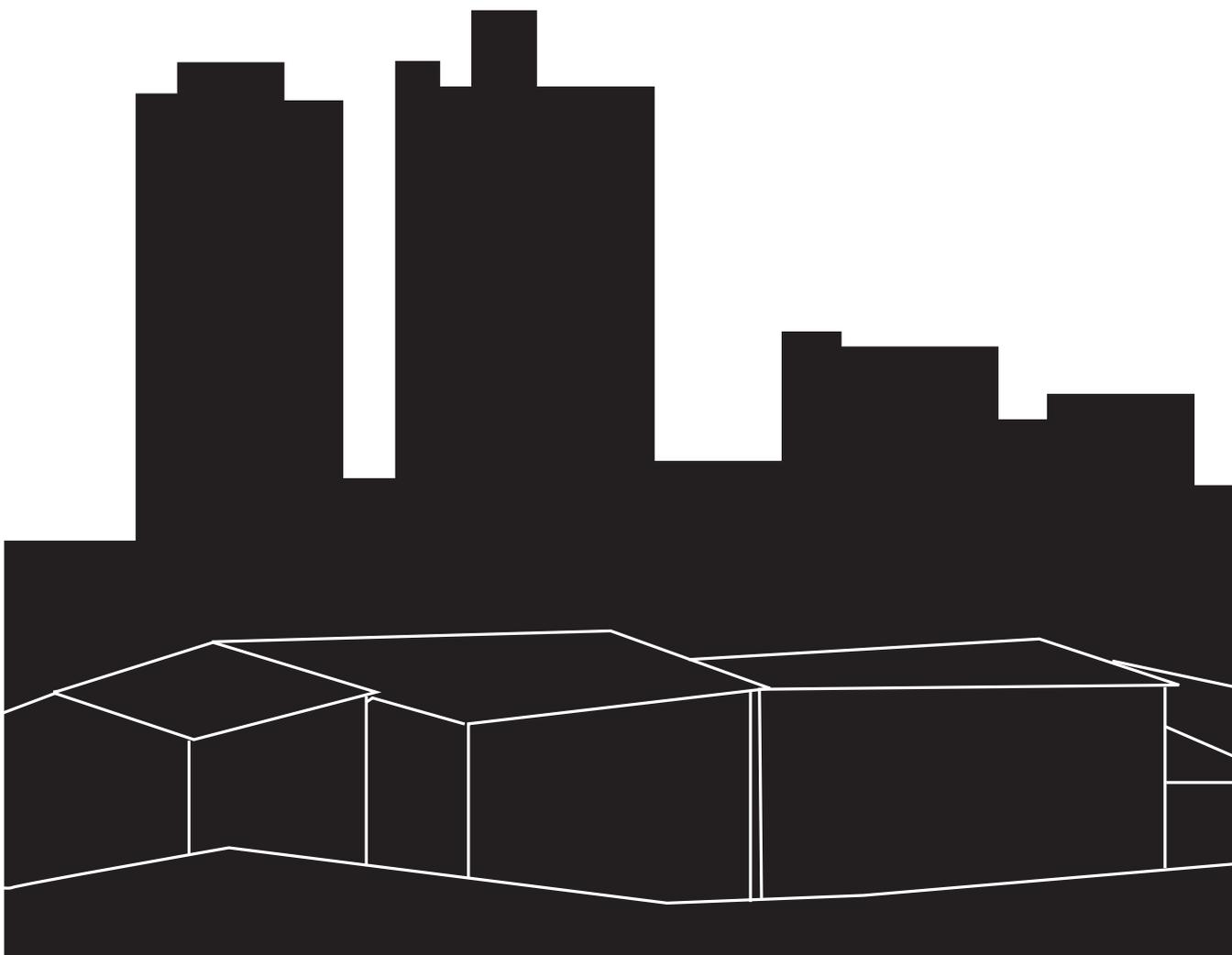
⁹ Two journal articles are published (Chapter 2 and 3), one article is resubmitted (Chapter 4), and the last journal article is under review (Chapter 5).

income neighbourhoods of Nairobi, and recently started to extend its operations into informal settlements, where it has to deal with different types of service regimes. Pursuing innovations in these service regimes is challenging for the utility, because its capability portfolio is aligned with the service regime in high-income neighbourhoods. Chapter 3 presents a framework to analyse the organizational challenges of incumbent actors that have the ambition to be innovative and extend their operations to other service regimes.

Chapter 4 studies an NGO and two social enterprises that pursue another type of innovation strategy and establish new on-site “sanitation value chains” in informal settlements. Sanitation chains consist of various interlinked activities which lead to the production of faecal sludge based products, while at the same time providing sanitation services. A TIS perspective is used to analyse the initiatives, which leads to the identification of system failures that hamper their success. Conceptually, the TIS methodology is extended to the level of value chains to be able to take into account the interlinked innovation activities that have to be coordinated along the sanitation chain. The findings show that the initiatives operate largely in isolation, and that overall innovation success might be improved by leveraging synergies among the initiatives.

Not all resources for innovative activities such as analysed in Chapter 4 can be mobilized at the local level. *Chapter 5* provides insights in activities that take place at the global level, in the networks in international development cooperation. Currently in the sanitation sector, several organizations worldwide aim to establish a globally accepted paradigm focused on safely managed non-grid sanitation. These efforts are conceptualized as an emerging transnational innovation system. Such processes increasingly need coordination, in which innovation intermediaries might play an important role. The chapter presents a case study of the “Sustainable Sanitation Alliance” (SuSanA), an intermediary network that facilitates and coordinates these efforts in international development cooperation.

Chapter 6 synthesizes and integrates the findings and outlines potential transition pathways in splintered regimes, by answering the research questions. Furthermore, it elaborates the conceptual and practical implications of the findings. The thesis concludes with limitations and ideas for future research.

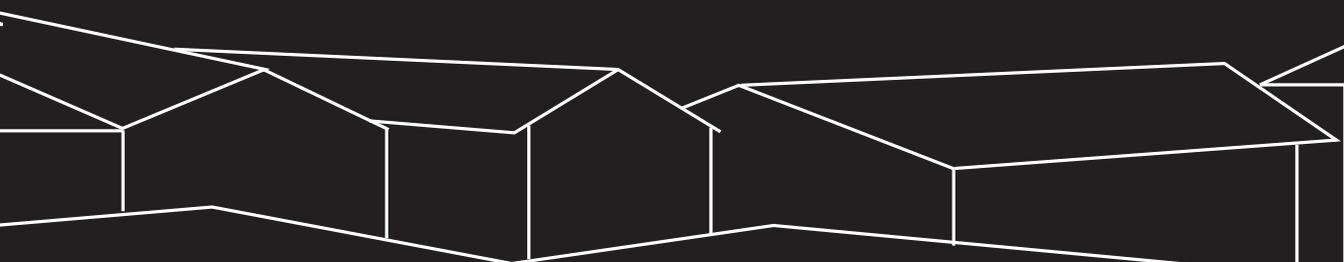


Chapter 2

Nairobi's splintered sanitation regime



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Abstract

Today's rapid global urbanization highlights the need for long-term transformations of basic service sectors in developing cities in order to improve the livelihoods of the urban poor. Sustainability transitions frameworks have proven fruitful for addressing these sort of challenges. However, they have been at pains so far in accounting for the heterogeneity and complexities that typically characterize informal settlements in the Global South. We therefore propose a conceptual framework that extends the conventional analysis of socio-technical regimes by distinguishing the two levels of sectoral regime and service regime. Challenges for sustainability transitions may then be identified by missing alignments within and among the two regime levels. The framework is applied to the sanitation sector of Nairobi, Kenya, a city experiencing rapid population growth and a highly uneven provision of basic services. Drawing on a set of 152 in-depth interviews, observations, and five focus group discussions, the paper reconstructs the prevailing service regimes and shows how they suffer from misalignments and dysfunctionalities creating all sorts of problems at a sectoral level. We conclude that Nairobi's sanitation sector can best be characterized as representing a splintered regime. The paper concludes with a discussion of how the new conceptualization of socio-technical regimes suggests some new sustainable transition pathways and how this framework might also be instructive for transition challenges in cities of the Global North.

2.1 Introduction

We are currently witnessing urbanization at a scale like never before. Fifty-four percent of the world's population is living in cities and the urban growth rates are particularly high in the developing parts of the world, especially in Africa (UN-Habitat, 2016b). Rapid urbanization creates huge challenges for city planners who are not able to keep pace with the number of people moving into developing cities in search for work and life opportunities.¹⁰ New city dwellers often end up impoverished, living in informal settlements without access to proper basic services and infrastructure, such as housing, safe drinking water, and sanitation, solid waste management, reliable electricity and access to healthcare (UN-Habitat, 2004). Such circumstances demand long-term transformations to basic services and infrastructure such that the urban poor are able to improve the quality and resilience of their livelihood strategies.

In order to identify ways to improve service delivery to the urban poor, we propose that a socio-technical system perspective offers a promising approach, one able to account for the socioeconomic complexities of basic service provisioning in developing cities while providing a means to analyse the dynamics of transition processes with respect to these (Markard et al., 2012). Particularly useful is the concept of a 'socio-technical regime'— the institutionalized set of rules in an organizational field related to actors, artefacts, and markets that governs the presence of basic services and which determines the pace and direction of transition processes (Geels, 2004; Fuenfschilling and Truffer, 2014). Regimes related to urban basic services are key determinants of their quality, accessibility, affordability, sustainability, and resilience in the face of rapid urbanization. As such, they provide a critical object of analysis through which one can understand the challenges to and possibilities for improvements to service delivery systems.

Much of the literature related to socio-technical regimes and their evolution is based on analyses in advanced industrialized countries and regions. In these contexts, basic service regimes are often uniform spatially, characterized by a dominant governing authority, and marked by consistent levels of quality throughout (de Haan et al., 2015; Fuenfschilling and

¹⁰ With "developing city" we mean a city in a low-income (GNI per capita < \$1.005) or lower-middle-income economy (GNI per capita \$1.006 to \$3.955). Kenya is a lower-middle-income economy (<http://data.worldbank.org/about/country-and-lending-groups>; accessed 5 February 2018).

Binz, 2018). This is not the case in developing cities of the Global South¹¹, however, as recent applications of socio-technical transition frameworks have demonstrated (Ramos-Mejía et al., 2018). In such contexts, conventional interpretations of socio-technical regimes are too simplistic given the complexity of basic service sectors and the highly uneven distribution of infrastructure in these cities (Fernández-Maldonado, 2008). For example, in urban East Africa multiple arrangements of actors, artefacts, and spaces coexist to meet the sanitation needs of residents (Letema et al., 2014).

Given the limitations, a reconceptualization of socio-technical system analysis is needed in order to enable the analysis of multiple co-existing regimes (Raven and Verbong, 2007; Konrad et al., 2008). Such a reframing would take into account the heterogeneity that exists in the basic service sectors of developing cities – such as the modernized mixtures approach (Letema et al., 2014; Van Vliet, Van Buuren, & Mgana, 2014) and recent scholarship on the “splintering” of infrastructure services along socioeconomic, racial, gender, and other lines of difference (Graham and Marvin, 2001; Jaglin, 2008; Swilling, 2014). These perspectives acknowledge that large, centralized, and homogenous infrastructures may fail to account for the present-day realities facing urban residents, and thus fail to offer realistic visions for sustainability transitions. Instead, service differentiation, spatial heterogeneity, and pro-poor distributions of services may be crucial strategies to achieve decent living conditions for the city dwellers (Botton and Gouvello, 2008). All told, sustainability transitions frameworks need to better account for the heterogeneity and unevenness of actually existing socio-technical regimes in developing cities so that planners, policymakers, and donors might better develop alternative pathways to sustainability.

The goal of this paper is to make a conceptual contribution to the literature on socio-technical transitions. We propose a conceptual framework that seeks to overcome the limitations on extant regime conceptualizations, particularly related to highly heterogeneous contexts such as those in developing cities. We do so by re-conceptualizing socio-technical regimes at two levels: the level of service provision and the level of the sector. “Service regimes” form around specific institutionalized combinations of technologies, user routines, and organizational forms for providing the service. An example would be the automobile regime as a means to provide personal mobility services. “Sectoral regimes” refer to the provision

¹¹ The terms Global North and Global South in this paper are not direct reference to the Northern and Southern Hemispheres, but applied to differentiate nations in terms of socio-economic capabilities and related characteristics. Global North are higher-income nations (with a GNI per capita > \$3956), while Global South are lower-income nations (GNI per capita < \$3.955). For more discussions on these contested terms, see (Pagel, et al., 2014).

of broad societal functions like transport, food, safe urban water, electricity, and so forth. In making this distinction, the goal is to provide conceptual space wherein the configurations of service options as well as the alignments between them are more clearly visible. Alignments, as in the complementarities of various services and smooth inter-operability between the different service regimes, increase the strength of the sectoral regime while making it more accessible to a diverse range of residents. As such, the mixtures of service options and their alignments might help to better understand prospective pathways towards future sustainable regime structures in developing cities and beyond.

We further argue that analysing the multiple service regimes constituting sectoral regimes in developing cities requires a grounded approach, one able to inductively identify these differentiations and their characteristics. To do so, we draw on insights from practice theory (Shove, 2004; Shove and Walker, 2010; Jones and Murphy, 2011) in order to reveal the agencies, structural features, spaces, times, social interactions, and material factors that constitute differentiated service regimes and which make them more or less aligned within the context of sectoral regimes. We deploy the conceptual framework through an analysis of sanitation supply, demand, and use practices in a developing city (Nairobi, Kenya). Our analysis reveals the differentiated service regimes that constitute the city's sanitation (sectoral) regime, the strength of their alignments both internally and with respect to other service regimes, and the obstacles that service providers and consumers/users face in making transitions towards sanitation regimes that provide higher quality, sustainable, and more justly distributed services.

The case of Nairobi's sanitation sector is well suited to demonstrate the value of this approach. The city is facing significant infrastructure challenges as it rapidly grows and the gap between the rich and the poor has become increasingly extreme in recent years. Adequate provision of sanitation services is a fundamental challenge to the city's inhabitants, and a major task for city officials, especially in the informal settlements where 36% of Nairobi's population lives (Mansour et al., 2017). The highly uneven spatial differentiation of sanitation configurations was initiated during the colonial period of residential segregation and it has become more pronounced and complicated during the era of neoliberalism (Nyanchaga and Ombongi, 2007). The sanitation sector today is characterized by a high variety of access options and conditions, multiple providers, different institutional arrangements, different spatial structures, and user practices, and complex formal and informal governance structures (Juuti et al., 2007; van Vliet, van Buuren, & Oosterveer, 2014). Complicating matters further is the fact that different sanitation configurations are operated within single

geographical areas and residents typically use more than one configuration in the course of their day. To describe these complexities our analysis draws on semi-structured interviews with experts from the sanitation sector, direct observations, and focus group discussions with residents collected by two of the co-authors over a five month period in 2016.

The paper is structured as follows. In the next section, the literature on transition studies of infrastructures and basic services in developing cities is reviewed followed by a discussion of the relevance of practice theory for socio-technical regime analysis. We then introduce a conceptual approach to identify regime structures in developing cities' basic service sectors. The framework is then applied to the case of Nairobi's sanitation sector. The results identify the variety of service regimes which coexist in the sanitation sector in Nairobi. The final sections discuss the implications of these findings for sustainability transitions in Nairobi and highlight the broader relevance of the conceptual approach for transition studies in general.

2.2 Sustainability transitions in developing cities: basic services and their heterogeneity

Basic service sectors can be understood as socio-technical systems consisting of (networks of) actors and institutions, as well as material artefacts and knowledge (Markard et al., 2012). In order to understand the dynamics of socio-technical systems, the concept of socio-technical regimes is used to analyse the logic and direction for incremental socio-technical change along established pathways of development (Markard et al., 2012). An adequate understanding of a socio-technical regime in a developing city is an important starting point to identify potential future transition pathways of a basic service sector. However, sustainability transitions research has only recently started to focus on the Global South, while the origins of transitions research are based on empirical cases in industrialized countries. The recent increase of empirical applications in the Global South is challenging the conventional notions of transitions frameworks (Byrne, 2011; Ahlborg, 2015; Murphy, 2015; Ramos-Mejía et al., 2018).

Some previous transition studies recognize the complexity of regimes in the Global South. Sengers and Raven (2014) note that diverse (informal) services characterize the urban transport regime in Bangkok and van Eijck and Romijn (2008) state that the energy regime in Tanzania consists several sub-systems that can be separate regimes on their own. However, these studies lack an explicit analysis of how these diverse socio-technical structures

constitute a regime. Other studies do not specifically mention the diversity of regimes in their cases in the Global South, but apply a rather highly aggregated understanding of what a regime could be: the “energy/power regime” in India (Verbong et al., 2010) or the “energy regime” in Malaysia (Hansen and Nygaard, 2013) to just name a few. Lastly, several studies have pre-dominantly focused on niche growth and diffusion of new technologies in the Global South without elaborating how the regime looks like towards which these developments could contribute (Blum et al., 2015; Kamp and Vanheule, 2015; Tigabu et al., 2015c).

2.2.1 Heterogeneity of basic services in developing cities

Although sustainability transitions research has not extensively dealt with urban contexts in the Global South, much can be learned from other literature on basic services and infrastructures in developing cities (Kooy and Bakker, 2008; McFarlane and Rutherford, 2008; Ranganathan, 2014; Rutherford and Coutard, 2014). These works reveal the material and political challenges associated with potential transition pathways, and highlight the inadequacy of extant transition frameworks for understanding the complexity and heterogeneity of basic service regimes and for identifying potential transition pathways in the short-to-medium term. Negative or unsustainable urbanization pathways are often associated with the “splintering” of urban infra-structures and basic services along class, gender, or ethnic lines which can create extreme inequalities with respect to public utility access and social services (Amin and Graham, 1997; Graham and Marvin, 2001; Jaglin, 2008; Swilling, 2014). Such intra-city differentiations occur when there is insufficient redistribution or investment in infrastructure and social services such that the poorest urbanites and recent migrants are forced to rely on informal, ad hoc, inefficient, and/or low-quality alternatives in order to meet their basic needs. Splintering processes undermine the “modern infrastructural ideal” of ubiquitous, monopolistic, integrated, and standardized networks of service provisioning, which was common until the 1960s; serving as a regressive development dynamic that have driven the withdrawal of the State from urban planning decision-making processes.

Perhaps most significantly, the splintered urbanism literature highlights the heterogeneity, spatial unevenness, and complexity of basic services in most cities, regardless of whether they are developed or developing. While Coutard (2008) argues that there has never been a modern infrastructure ideal in many contexts, this is especially true in developing cities (Kooy and Bakker, 2008). Rather than there being a short-term potential for a universalized ideal of service provision, there will be a persistent pattern of differentiation of services.

As such, one should be wary to view such a city with a “Northern lens”, and to instead be sensitive to coexisting systems of basic services (Bakker et al., 2008; Kooy and Bakker, 2008; Furlong, 2014).

Beyond the splintered urbanisms literature, the modernized mixtures approach also acknowledges the diverse governance structures in service provision and links them with the institutional and technological diversities, thereby moving away from the binary about technology and management as either being centralized or decentralized. Building on socio-technical approaches for sustainable provision of services, the approach conceptualizes urban infrastructures and services as an interplay of spatial, social, and technical dimensions, capturing the various possible combinations of actors and technologies other than only large centralized networks (Van Vliet, Van Buuren, & Mgana, 2014). It argues that multiple regimes can operate in a single geographical area (Letema et al., 2014), such as a city, where they are embedded in the different socio-spatial contexts found in close proximity.

In sum, the literature highlights intra-urban differentiations of basic services and infrastructures in developing cities, demonstrating the ways in which these are spatially constituted and geographically embedded despite being co-located in a single city. We argue that this heterogeneity should be taken seriously as a means to advance a more geographically sensitive transition approach; one that deploys a place-sensitive analysis of the everyday practices through which people from different neighbourhoods, genders, classes, and ethnic groups access and provide infrastructures and services. An alternative framework for a socio-technical regime analysis of a basic service sector in a developing city should be able to identify multiple co-existing regime structures and detail the contextual diversities they are embedded in, resulting from spatial unevenness (Truffer and Coenen, 2012; Murphy, 2015). Doing so will require extensions to the conventional understanding of socio-technical regimes and their evolution. We follow Fuenfschilling and Truffer (2014) and recognize that the co-existing regimes may have different strengths based on their degree of institutionalization. Additionally, we draw on insights from practice theory (Shove, 2004; Shove and Walker, 2010; Jones and Murphy, 2011), to use the everyday practices of users and providers of basic services to create a coherent, grounded, and spatially sensitive framework to analyse transition pathways of the regimes.

2.3 Conceptualizing and analysing heterogeneous regimes

A framework for a transition analysis of basic services in developing cities needs to embrace

the diversity of social and technical structures present, in order to identify potential transition pathways towards more sustainable socio-technical systems. It should also be open for a variety of potential end-points of transitions, and identify what systemic problems hinder these processes. Besides highlighting structural conditions, the framework should account for agency, and be sensitive to the specificities of the broad variety of geographical contexts that are typical for many developing cities.

We propose that such a framework can be developed by building on the concept of socio-technical regimes, but we have to differentiate the extant interpretation by explicitly distinguishing two levels: “service regimes” and “sectoral regimes”. Service regimes form around specific institutionalized combinations of technologies, user routines and organizational forms for providing the service. An example would be the automobile regime as a means to provide personal mobility services. Sectoral regimes refer to broader economic and societal realms (or organizational fields) that cover a societal function like transport, food, safe urban water, electricity, and so forth.

Our concept of service regimes is very similar to the term socio-technical regimes as applied in most of the transitions literature. We prefer the term service regime because our concept highlights the specific aspects of everyday life that are often overlooked in socio-technical regimes research. The concept of sectoral regimes has been less consistently addressed in the extant literature. Many studies merely refer to the broader “sector” or “domain” where specific socio-technical regimes are embedded (e.g. the transport sector, when the analysis deals with the automobile regime or the “electricity sector” in studies about wind power). In some studies the sectoral context was claimed to constitute the broader socio-technical system in which the regime is embedded (Geels, 2004). In sectors that are dominated by specific socio-technical configurations, scholars have claimed that the two levels are identical, for example in the transport domain, the automobile regime is used as the dominant regime in an assessment of the transition to low-carbon transport systems (Geels, 2012). Others proposed that delimiting different hierarchical levels would be a pure question of the specific analytical interest of the researcher (Geels and Schot, 2007). Only very few scholars have endeavoured to elaborate regime structures at and between different levels of abstraction (Raven and Verbong, 2007; Konrad et al., 2008).

In most cases, a hierarchical relationship exists between service regimes and a specific sectoral regime. The latter will typically consist of various service regimes. E.g. the personal mobility regime (sectoral level) typically consists of more or less aligned service regimes

related to i) the automobile, ii) busses and trams, iii) bicycling, iv) trains and v) pedestrian mobility forms. Each one of these service regimes consists of coherent and institutionalized arrangements of technologies, infrastructures, regulations, symbolic meanings, user routines, and public discourses. And all of them interact with each other at the sectoral level to provide the specific services in a more or less seamless way. In the following, we first describe our approach for studying regimes based on practice theory. We then specify the different components that constitute service and sectoral regimes, and describe how we assess the strength of these regimes.

2.3.1 Analysing regimes: a practice-oriented approach

Before unpacking service and sectoral regimes conceptually, it is important to highlight the epistemological/methodological strategy that we apply to their analysis. Our approach focuses on the everyday practices that users and providers employ in the access, provisioning, maintenance, etc. of basic services.¹² Practice theory has been applied to socio-technical transitions research but the conceptualization and delineation of practices and their constitutive elements is sometimes underspecified (Shove, 2010; Shove and Walker, 2010; McMeekin and Southerton, 2012; Cohen and Ilieva, 2015). The contributions of these studies are significant and helpful, but we think that practice theory can be deployed more productively, specifically to identify key features that stabilize regimes and/or offer points of intervention not otherwise visible through a focus on technological artefacts or individualized behaviours.

Following Jones and Murphy (2011, p. 367), we define practices as the ‘stabilized, routinized, or improvised social actions that constitute and reproduce economic space, and through and within which socio-economic actors and communities embed knowledge, organize production activities, and interpret and derive meaning from the world’. Practices are constituted, enabled, and shaped by behaviour patterns, performances, perceptions, power relations, materials, and the time-space contexts where they are normally carried out. While the precise details of each of these elements may vary by individual, there are generalizable trends that mark and differentiate service regimes. In order to discern these elements

¹² Following (Giddens, 1979), (Giddens, 1984), (Bourdieu, 1980), (Certeau, 1984), (Wenger, 1998), (Reckwitz, 2002), (Schatzki, et al., 2005), and others, practice theory has been of interest to social scientists, particularly those striving to navigate between individualist and structuralist explanations for how institutions, organizational fields, firms, and other socioeconomic phenomena function, reproduce themselves, become embedded in particular contexts, and change over time.

and their differentiations, our approach examines the practices associated with particular combinations of technologies, user/provider routines, organizational forms, and shared meanings in order to construct generalized heuristics or models of service regimes. The focus on practices allows us to identify service regimes such that we can then determine how, why, and where, and how strongly they are embedded in the city.

2.3.2 Service regimes

We consider a specific configuration of technologies and their associated user and provider practices as a service regime. A stabilized service regime is marked by routinized practices that may be difficult to change once established. This stability is caused by various processes and patterns, like the reproduction of professional routines such as shared protocols about how to install water pipes or connect households to the electricity grid, or when there is a clear division of roles and responsibilities among service providers in a well-established value chain. Additionally, service regimes may be stabilized through shared understandings about how, when, and where to provide and use a basic service. An example is the structured habit of households putting their old paper waste at the street in countries like Switzerland on a weekly basis, for regularized waste collection. Providers and users know when, where, and how to arrange this service of picking up old waste paper. In more specific terms, we conceptualize the processes and patterns associated with service regimes along five basic dimensions that we reveal through an analysis of sanitation servicing practices: infrastructure and artefacts; organizational mode; time and space; rationale/meaning; and social interaction. When these dimensions are aligned with one another, a stabilized service regime comes into being. These dimensions are:

- (1) Infrastructure & artefacts: artefacts are physical material entities (Shove et al., 2012) such as toilets and water taps. Infrastructures are physical structures that enable the functioning of collections of artefacts (Shove et al., 2015), for example water pipelines, or electricity lines.
- (2) Organizational mode: an organizational mode is a group of actors with complementary strategies and a particular set of capabilities and procedures to fulfil the provisioning of basic services. Within a certain organizational mode a group of actors typically have a shared understanding about the hardware and services they provide. A core practice in the organizational mode concerns operating and maintaining the artefacts and infrastructures, i.e. all the activities that

are required for the day-to-day running of a basic service facility and its long-term regular maintenance. Specific forms of expertise and “competence” (Shove et al., 2015) are important preconditions for operations to be carried out successfully.

- (3) Time and space are the “when? why then?” and the “where? why there?” of accessing basic services (Jones and Murphy, 2011). Operations and services of providers, as well as everyday operational activities of users, are performed within or in relation to particular times and spaces. Basic services are operated in specific spatial locations and the timing for access is regulated.
- (4) Rationale/meaning: the mental activities, emotions, and motivational knowledge, which represent social and symbolic significance of participation, or doing something, at any one moment (Shove et al., 2012). They enable for an understanding of an actor’s role and expectations, and the rules, both formal and informal, that govern the provision and access to a basic service.
- (5) Social interaction: the contact and exchanges between people as they are enabled/scripted by specific artefacts. Through social performances, one can identify the social roles, rules, power asymmetries and intentions (Jones and Murphy, 2011). Social interactions form an important enabling or hindering factor for users’ access to basic services and for providers to maintain regular practices, because they can lead to mutual understanding, trust building, social capital and help to identify roles and identities.

These five dimensions of a service regime may be (mis)aligned with each other to a higher and lesser degree, and by this determining the strength of the regime. Alignments at the service regime level are determined by the complementarities between different service regime dimensions. Alignments between rationale/meanings and time and space dimensions of a service regime would, for example, result from a shared understanding among the users and providers about their roles and the timing and location of a provided service/artefact. Such alignments create mutual trust among users and providers and stabilize the service regime. Another example would be when artefacts are aligned with users’ preferences such that the service is more accessible given resource, mobility, and capability constraints.

In contrast, misalignments occur when there is a lack of complementarity among the dimensions. For example the provision of a service that does not fit the expectations and wishes of the users, because of the type of infrastructures that are used. Another misalignment

can be an inconvenient location to access the service, or a complex organizational mode that leads to misunderstandings or conflicts about the expected roles of users and providers. Typically in the course of service regime maturation, socio-technical configurations will become increasingly aligned internally. This is the process that is commonly described in manifold niche maturation accounts and the historical reconstructions of regime emergence (Geels, 2005; Raven and Gregersen, 2007).

In addition to the alignments between the dimensions, the strength of a regime and its degree of institutionalization depends on how widely diffused and taken for granted certain characteristics of the regime are, how long it has been in place, and to what degree it is contested by different societal actors (e.g. because of being exposed to conflicting institutional logics) (Fuenfschilling and Truffer, 2014, p. 777). A service regime is stronger when there is a shared consensus about the technical design, while a service regime that inhabits various heterogeneous designs will be less persistent and less strong. A service regime is strong when large populations of providers and users take it for granted.

Importantly, the service regime needs to fit with the manifold external structures and local contexts where it is situated, which also determines its strength (Fuenfschilling and Truffer, 2014; Bergek et al., 2015). A strong service regime will in general be in congruence with the major social, geographical, and technological requirements that often coincide with so-called landscape forces (Geels and Schot, 2007). The better this fit, the more stable a service regime will be. Beyond landscape fit, an effective service regime also has to fit in with or be embedded in sometimes complex local contexts (Bergek et al., 2015). Because local conditions may vary quite substantially within close spatial distances, generic service regimes need to be adapted and modified such that they can function effectively in a wide range of contexts. To do so, a regime has to fit the heterogeneous practices, competences, beliefs and routines, and the physical conditions that mark a particular location.

All said, service regimes may be ranked regarding their strengths. On the one extreme we may witness very well established internal alignments, a good fit with contextual requirements (local or landscape factors) and a low level of contestation by different actors. However, service regimes may also show deficiencies in one or several of these dimensions and thus appear as being only semi-coherent (Geels, 2004; Fuenfschilling and Truffer, 2014). They may exhibit only partial alignments, be it in contradiction with rapidly changing and/or locally specific external conditions or being contested by powerful actors. At the other extreme we may witness very weak service regime structures, where several of the dimensions are not

well established yet and alignments are poorly developed or even creating tensions. We therefore propose to conceive regime strength as a gradient that varies from uncontested dominant regimes towards weakly structured, newly emerging regimes (which may under certain conditions equal emerging niches). By this we aim to overcome a binary depiction of the relationship between regime and niches and to capture, conceptually, the heterogeneity of service regimes in developing cities (Smith et al., 2005; Geels, 2011; Fuenfschilling and Truffer, 2014).

This conceptualization immediately begs the question of how the strength of particular regimes relates to negative outcomes or externalities. Negative outcomes can affect society as a whole or hamper the functioning of other sectors (environmental pollution or high costs for accessing or providing a basic service), and can also lead to local conflicts and frictions with prevailing social or economic structures (low acceptance of a technology or shame when using a basic service without privacy). Weak service regimes can generate negative outcomes mainly through poor quality of service delivery or misalignments with other services and infrastructures. But also strong service regimes, can cause substantial social, economic, or environmental problems (e.g., fossil fuelled power plants contributing to global warming). While positive externalities can help to further stabilize a service regime, negative outcomes do not inevitably destabilize them as long as internal alignments and connections with other contextual factors remain strong (e.g. fossil fuel prices remain affordable through subsidies).

2.3.3 Sectoral regimes

Sectoral regimes typically encompass several service regimes. A sectoral regime is characterized by alignments or misalignments between the different service regimes. Alignments at the sectoral level are a function of the complementarities between various services and inter-operability between the different service regimes. Well-aligned sectoral regimes typically ensure that: (1) users have access to a combination of different complementary and matching service regimes; (2) infrastructures which are used in the different service regimes complement each other and are connected by appropriate interfaces; (3) providers in different service regimes complement each other's competences and offerings; and (4) sectoral regulations are in place to warrant the smooth inter-operability between the different service regimes. Misaligned sectoral regimes instead may correspondingly suffer from one or several problems: (1) inefficiency in service provisioning in the different service regimes (e.g. basic service providers are not complementing each other in order to improve

their services); (2) physical infrastructures that could align the different service regimes are absent; (3) the differentiated needs of users can only be met through the users' own efforts to actively find a way to meet their daily basic needs; and (4) regulations or policy actors do not recognize all the service regimes that exist (e.g., marginalizing certain practices) and/or are not supportive of novel service regimes.

This leads us to propose four basic configurations of sectoral regimes (Fig. 2.1):

- *Monolithic regime*: a sectoral regime consisting of one dominant service regime.

For example: urban water management in countries like the Netherlands and Switzerland, where the dominant service regime takes up about 95% of the service structures in the sector.

- *Polycentric regime*: a sectoral regime that consists of several service regimes. At the sectoral level, the different service regimes are well-aligned with each other.

For example: transport in the Netherlands, where the service regimes of automobile, biking and public transport exist in parallel and are well-aligned because physical infrastructures for bicycles exist, and both formal and informal rules of using the physical road infrastructures for biking and driving a car are in place.

- *Fragmented regime*: a sectoral regime that consists of several service regimes, however at the sectoral level the service regimes are misaligned.

For example: transport in most parts of the USA, where the regimes of automobile and biking exist in parallel but where physical infrastructures for bicycles and sector standards for managing bicycles on the roads are often missing or unevenly distributed.

- *Splintered regime*: a sectoral regime that consists of several service regimes that are partially aligned internally. At the sectoral level the service regimes are misaligned.

For example: many basic service sectors in developing cities.

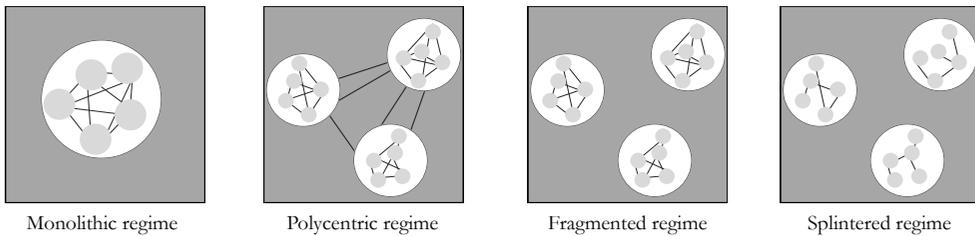


Figure 2.1 Four typologies of sectoral regimes - sectoral regime (grey square), service regimes (white circles), dimensions of service regimes (grey circles), alignments (lines)

2.3.4 Transitions in sectoral regimes

In dynamic terms, the sectoral regime typology enables the identification of alternative future configurations towards which a sectoral regime could transition. Transitions have been defined as “changes from one socio-technical regime to another” (Geels and Schot, 2007, p. 399). However much of the literature has focused on transitions from one dominant regime to an alternative one. According to our framework, we may identify a variety of endpoints that a transition could lead to. For example, transition processes can be characterized by improvements of the alignments between the service regimes in the sectoral regime. Service regimes can become better aligned, whereby a sectoral regime transitions from a splintered to a fragmented or polycentric regime. Obviously, all sorts of partial trajectories, or different transition pathways (Geels and Schot, 2007) are possible as well and these can lead to various different endpoints of a transition.

The different transition endpoints cannot be ranked a priori in terms of their sustainability performance. A splintered regime for instance is typically associated with many negative outcomes in a developing city such as limited access to basic services for users, or non-organized and unproductive competition between alternative service providers. A fragmented regime may equally show negative outcomes due to misalignments between the different service regimes. However, polycentric and monolithic sectoral regimes may also be riddled with negative environmental, economic, or social externalities. A centralized approach to urban water management may for instance lead to excessive waste, pollution, and costs when compared to a polycentric regime which allows decentralized service regimes to coexist and serve specific user segments. The analysis of sectoral regime typologies can help to identify a broader range of future endpoints of transition process compared to the conventional view.

To summarize, the framework provides a conceptual approach for mapping diverse basic service structures present in a developing city and to specify alternative transition pathways. This approach can be instructive for researchers, policy makers, and practitioners for systemically identifying barriers to sustainability transitions in a specific sector. The framework differentiates between problems of misalignments within service regimes, such as too high costs for accessing or providing a basic service, and misalignments between service regimes at sectoral level, which for example lead to coordination problems between basic services.

2.4 Methodology

The empirical analysis of this paper is based on qualitative data collected through interviews and observations during two stays in Nairobi: the first one between February and March and the second one between September and December 2016. In the first stay, two of the co-authors conducted a total of 49 semi-structured interviews with a diverse range of actors within the sanitation sector. In the second period, we conducted 103 further interviews that went deeper into aspects of practices. Relevant people in government agencies, the local government, Non-Governmental Organizations (NGOs), international agencies, sanitation enterprises, formalized and non-formalized sanitation service providers, and individual inhabitants were interviewed (Table 2.1). We selected the interviewees based on their knowledge about and experience with the sanitation sector, and through snowball sampling. Additionally, we conducted five focus group discussions in informal settlements with women community groups. We combined these focus group discussions with visits to the homes of 32 residents in three informal settlements to discuss and observe their living conditions and their everyday domestic practices. Lastly, we analysed relevant documents such as policies and action plans, as well as available literature on sanitation access and provisioning in Nairobi.

We were interested in developing an understanding of user and provider perspectives and practices in the sanitation sector in Nairobi in order to be able to reconstruct distinct service regimes and to understand and document the alignments and strengths of the city's sanitation sectoral regime. The data collection was guided by the current user, provider, and governance situation of sanitation in Nairobi, and important historical developments which led to this situation; developments and innovations taking place; and the actors' perceptions of the future of the sector. We continued the interviews until no major new information

about the sector's situation emerged.

All interviews were recorded, transcribed and, coded using the qualitative data coding software MAXQDA 12. The coding process led to an extensive coding scheme covering the major characteristics, developments, challenges, and future predictions of the sanitation sector in Nairobi. This organized data was used in an iterative process, together with information found in literature, to develop the conceptual framework. Thus, in the development of the framework both inductive and deductive thinking were applied. In the section that follows, we deploy these data and this analysis to reconstruct how Nairobi's sanitation sector can actually be characterized as a splintered sectoral regime.

Table 2.1 Overview interviews

Interviewees
Governmental agencies (22)
Local government (11)
Non-Governmental Organizations (36)
International agencies (8)
University (1)
Sanitation enterprises (17)
Sanitation waste collectors (7)
Key local informants in informal settlements (18)
Residents of informal settlements (32)
Focus group discussions (5, with 8 to 10 participants in each)

2.5 Nairobi's splintered sanitation regime

2.5.1 Identifying the set of service regimes

Through the analysis of practices and the study of secondary data, we identified five service regimes that operate in Nairobi. We characterized the core dimensions of each of these. The five service regimes vary greatly in one or more of their dimensions: (1) The domestic sewer regime encompasses a flushing toilet used by one household, connected to the sewer system which is provided and operated by the utility. (2) The shared on-site sanitation regime encompasses a shared on-site toilet located either inside a plot or off-plot. It is shared by multiple households and mostly provided and installed by the landlord of the plot or by an NGO. (3) The public sanitation regime consists of toilet services in public places which provide pay-per-use services. They are mostly operated by Community Based

Organizations (CBOs) or by private enterprises. (4) The coping sanitation regime denotes practices of people to relieve themselves in their homes using improvised domestic items or defecation in the open. Finally, (5) the container-based regime consists of toilets equipped with containers or biodegradable bags to collect the faeces and the urine. The containers or bags are regularly collected and the waste is normally treated and the resulting sludge is re-used. Container-based services function as a public pay-per use or as in-home toilets, and are provided by social enterprises. The core dimensions of the five service regimes are summarized and compared in Table 2.2.

The different service regimes show quite high levels of institutionalization of their core elements and varying degrees of internal alignment. In the following, we will illustrate major examples of how the different alignments play out in each service regime. The domestic sewer regime is characterized by the internationally established dominant design of sewer technologies for domestic use. The service regime is internally well-aligned. The dimensions fit well together, for example the operational aspects are neatly aligned with the shape and position of the artefacts, for example the installed water meters that measure the water consumption (the water that is also required for flushing toilets) are easy to reach for meter reading or repairing:

“...they (utility staff) are dealing with areas which are well organized. And the issues are clear such that if you would want to disconnect a meter in a formal area, it is easy for you to find that meter.”
(utility officer)

The rationale of the utility is to deliver a high quality and modern service, and the users perceive this service as comfortable. The organizational mode and infrastructure thus align well with the users' perceptions and meanings:

“The good thing about having a sewer option is that they (the toilets) are cemented (thus clean) and have flush water inside the toilet (so you do not have to carry yourself)” (informal dweller 1)

Table 2.2 The detailed dimensions of the service regimes

	infrastructure & artefacts	rationale & meaning	social interaction	organizational mode	time & space
domestic sewer regime	central sewer system + (pour) flush toilet	- users: comfortable, good image, costly, consumes too much water - provider: sanitation using high quality modern technologies	- none	- daily maintenances by households - waste management by utility	- timing users: anytime - location: inside the house or on the plot
shared on-site regime	latrine + pit or septic tank	- users: accessible, convenient, low costs, dirty conflicts among households - provider: arranging sanitation for tenants	- coordinating access and cleaning among households	- organized by landlords or NGOs - daily maintenance by households - waste management by manual emptiers or private exhauster trucks	- timing users: anytime when on-plot and only during the day-time when off-plot - location: off-plot or on-plot
public sanitation regime	latrine + pit or septic tank, bio- & compost latrines, hanging toilet, central sewer system + pour flush toilet	- users: convenient, costly, dirty, risk of diseases, insecure during the night - provider: business opportunity	- trust building: being a “customer” - everyday interaction between operator and user	- daily commercial operations by CBO, NGO or enterprise - waste management by manual emptiers, private exhauster trucks or utility	- timing users: during the day when user has money - location: commercial areas, public residential, hanging over a river

Table 2.2 continued

	infrastructure & artefacts	rationale & meaning	social interaction	organizational mode	time & space
coping sanitation regime	cleaning bucket, plastic bag	- users: convenient option, no costs, useful in the setting of informal settlements, shameful, indignity, bad smell, done secretly, dirty, risk of diseases, insecure, acceptable for children	coordination within the family, being accompanied by others	- organized by households and individuals - no safe disposal of the waste	- timing users: anytime - location: inside the house, close to the home, around shared toilets, at open defecation hotspots (rivers, bushes)
container based sanitation regime	waterless system with urine diversion, biodegradable bags, containers	<i>As in-house service</i> - users: convenient, indignity, not appropriate for adults, culturally unfit & uncomfortable for men, useful for children, useful at night <i>As public service</i> - users: convenient, costly, risk of diseases - provider: environmental friendly sanitation, creating value from recycling waste	<i>As in-house service</i> coordination within the family <i>As public service</i> - trust building, being a „customer“, a lot of interaction between operator and user	<i>As in-house service</i> - daily operations by household - enterprise collects the waste and re-uses it as fertilizer, biogas, animal feed <i>As public service</i> - daily commercial operations by enterprise - waste is collected and re-used as fertilizer, biogas, animal feed	<i>As in-house service</i> - timing users: anytime, especially at night - location: in- house toilet <i>As public service</i> - timing users: during the day when user has money - location: public locations: commercial areas, public residential

The regime is strongly embedded in certain (mainly higher-end) neighbourhoods of the city, but does not fit well with the material and socio-spatial conditions faced by the majority of residents in the informal settlements.¹³ Insecurity of tenure and low economic capabilities in informal areas, for example, lead to limited investments into sewer systems by dwellers:

“I would have really liked to connect my house with a sewer toilet, but I think to myself – what if I invest and then the government decides to resettle me somewhere else?” (informal dweller 1)

All-in-all this is a strongly institutionalized and persistent service regime in certain areas of the city, because the dimensions align well among each other. Additionally, it is strengthened through ties to the international networks and actors associated with the global sanitation sector and their preference for large-scale centralized infrastructure (Fuenfschilling and Binz, 2018).

A second common service regime is the shared on-site sanitation regime. This regime is characterized by sanitation options that are not connected to the centralized sewer system, but that are constructed as pit latrines or toilets connected to a septic tank. Landlords typically provide this service to their tenants. Alternatively some community groups install these toilets with the help of NGOs and provide maintenance. Several households typically share such a toilet. Manual pit emptiers and exhauster trucks are hired to periodically remove and manage the waste. This is a well-aligned aspect of the organizational mode in this service regime, as a Water Sanitation and Hygiene (WASH) coordinator of an NGO explains about the situation in the informal settlements:

“...they (residents) normally opt for the manual pit emptiers to exhaust, because they are affordable and they are easily reachable”.

Also the social relationships between the landlords and tenants are well-developed and relatively well-aligned with the organizational aspect of hiring exhauster services:

“When the toilet needs to be exhausted, the landlord is responsible. He pays for the service (...) when the landlord delays we contribute towards the services as tenants, since we have a plot representative. He will

¹³ Estimates of the percentage of Nairobi’s total population that is connected to the sewer vary (48% or 66%) (CCN, 2007), (UN-Habitat, 2016b), as well as for the percentage of Nairobi’s informal settlements population that is formally connected to the sewer (10% or 12%) (CCN, 2007), (Gulyani, et al., 2006). Additionally, these estimates do not only include domestic connections, but also sewer connections to public and shared toilets. The exact percentage of households that have a domestic sewer connection is thus unknown, but we estimate it to be lower than these numbers.

inform the landlord and the amount will be deducted from the upcoming rent” (informal dweller 2)

Despite the fact that waste management is well organized in practical terms for users, it has a negative effect on the environment, because many manual pit emptiers dump the waste in rivers. Shared on-site toilets are widespread in the informal settlements, because the service is compatible with the lack of space in these areas.¹⁴ As well in low-income residential areas with high-rise buildings, the service regime is widespread. The service is compatible with low-income housing arrangements in plots and in high-rise buildings where shared facilities are cheaper. The timing and location of this service regime are also matching well with the expectations of the informal settlements' residents. A focus group discussion with women living in one of the informal settlements of Nairobi noted that they perceive shared toilets to be ideal as their location within gated areas makes them secure to visit any time of day or night. This service regime is also institutionalized because of the use of simple technologies that are affordable, especially in comparison to sewer connected toilets, as a WASH advisor of an international NGO explains:

“...it is not easy to have those (sewer) connections, so in a way that was a major reason why they (residents of informal settlements) would go for onsite sanitation solutions.”

Some misalignments in this service regime derive from the fact that users often perceive the infrastructure as dirty and because conflicts can arise among the households about the maintenance aspect of the organizational mode. In a focus group discussion with women, they noted that cleanliness is sometimes a challenge in shared toilets because it is difficult to agree on a protocol for maintenance among many people. All-in-all, because of several well-aligned and a few misaligned dimensions within the service regime, and the fit with the local context, this is a strong and persistent service regime in the informal settlements and suburban areas of Nairobi.

Another persistent service regime is the public sanitation regime. This service regime is characterized by sanitation services that are offered in public places. Several different artefacts and infrastructures are used to provide public sanitation services in Nairobi, from pit latrines to pour flush toilets that are connected to the sewer. This service regime is historically found in many commercial neighbourhoods and the city centre of Nairobi (Ngugi and Ndegwa, 1992; Njeru, 2014). Additionally, today this service regime is widespread in informal areas

¹⁴ In two of Nairobi's large informal settlements (Mukuru & Kibera) 50% of the households share a latrine with other households (O'Keefe, et al., 2015). We would like to emphasize that informal settlement's residents often use more than one option every day.

where public services are used by many people as an important daily sanitation option.¹⁵ Despite the important role of this service regime in informal settlements, the timing, location, and cost of these services are often misaligned with the realities facing users, thus forcing them to rely on adaptive and coping strategies (see below) to fulfil their needs. As a founder of a social-enterprise and a resident explain:

“... most people who are using it have to walk, maybe half a kilometer or something to get there. Maybe it's right around the corner but the majority of the users are going to come from further...”

Sometimes the services are perceived as costly:

“Public toilets are very costly. If you calculate the cost for large family like mine on a monthly or annual basis it's a lot of money (...) this competes with other domestic needs like food so we often opt for coping strategies” (informal dweller 3)

At the same time, various providers profit from this regime. The public services are run by a diversity of actors, among others, private enterprises, CBOs and NGOs. As such public sanitation services provide a business opportunity for community members in informal settlements that form CBOs that operate public toilets.

“Public toilet groups give opportunities for jobless youths to earn an income (...) they saw the opportunity to provide better management of the toilets and the users were happy because the toilets became cleaner” (informal dweller 4)

Also some community members consider public toilets ideal because many users lack land tenure rights and hence would not want to invest in private toilets. There is a risk that they are relocated because of insecure land tenure.

“I am fine with the public toilet. What if I build a private one then eventually I am relocated? I will waste a lot of money” (informal dweller 1)

All told, despite several misalignments in the public sanitation regime, it remains relatively highly institutionalized because the services are widespread, match the context conditions for majority of city dwellers without tenure rights, and are perceived a business opportunity by community groups.

¹⁵ In two of Nairobi's large informal settlements (Mukuru & Kibera) 45% of the households use pay-per-use facilities (O'Keefe, et al., 2015). We would like to emphasize that informal settlement's residents often use more than one option every day.

In the absence of public, domestic or shared sanitation services in certain areas of Nairobi, mainly in the informal settlements, people have developed coping strategies to relieve themselves.¹⁶ These services constitute the coping sanitation regime. Different coping strategies are practiced, for example, using a bucket or a plastic bag inside the house or open defecation. These services are organized by individuals themselves, in order to have a low-cost and safe sanitation solution. This service regime is highly institutionalized, because of several well-aligned dimensions. For example people in the informal settlements perceive these practices as normal strategy to manoeuvre the lack of other alternatives, despite the fact that they think that it is undignified and unhygienic. A WASH advisor of an international NGO explains:

“...If you look at the social norms perspective, it's accepted. However, people would not dare to defecate in a nice park, as nobody is doing it. That's the kind of perception, like I cannot do it here. But, if you go to the urban areas you go to this corner that corner, there is so much of dirt (open defecation) here and there. So people feel like everyone is doing it, well they can do it themselves as well”

Practices associated with coping strategies, like having specific hotspots for defecation or a popularly adapted practice known as “flying toilets”¹⁷ become commonplace - as coping is compatible in regard to timing – used at night when other public toilets are closed and people do not dare to go out because of insecurities. All-in-all these alignments and fit with the local context result in a relatively strong coping sanitation regime.

The fifth regime observed in Nairobi the container-based regime is based on (urine-diverting) dry toilets. This regime has gained legitimacy among international development donors in recent years as an attempt to break with the stagnant situation of the failure of existing options to serve all the millions of people in informal settlements during the last several decades. In Nairobi, this service regime is initiated by international enterprises who provide dry sanitation services such as urine diversion toilets using containers or biodegradable bags that are collected on a regular basis. These services are clean and environmental friendly, because waste management is in place and the waste is treated and re-used. These services are only found in the informal settlements and their embedding is not so extensive because several dimensions of the service regime still need to be aligned. For example the placing of

¹⁶ 6% of Nairobi's informal settlements residents have no toilet facility and use “flying toilets” (Gulyani, et al., 2006, p. 48).

¹⁷ Flying toilet is when a plastic bag is used for defecation, then secretly thrown away in ditches and on rooftops.

the container toilet inside the house misaligns with the perceptions of the users on privacy and dignity:

“...the men refused to use it. They perceive it as a “potty” for children (...) men would not want to sit on it and the rest of the family is in the small one or two roomed house.” (informal dweller 5)

Also, the perception among users of this service does not align with social norms and interactions, it is by some perceived as strange:

“When this (a container-based option) was introduced we (the women) were not shy to use it. We didn’t have other options, toilets were very far away. Now that we have more public options we question and laugh at ourselves really what this is that we used” (informal dweller 6).

The providers in this service regime are also struggling to find a well-functioning efficient organizational mode concerning the waste collection and transport in the informal settlements, as one of the employees of a social enterprise explains about the amount of container-based toilets somebody can collect per day:

“...in some other areas where we don’t have a dense network then someone will have to move long distances then you will be able to collect maybe ten toilets per day in that area. So depending on things like those and also the topography of that area, it varies between maybe ten to twenty toilets”.

And then there is the challenge of accurately timing when to collect waste from inside people’s homes:

“... accessing the toilet faeces (toilet containers) inside somebody’s house could be a bit challenging for us, so we have to learn the behaviours of the users, or rather of the owners (of the houses)...”.

Providers in this service regime struggle with aligning their organizational mode; the timing of accessing the houses in which container-based toilets are used, and the location where the users can leave them efficiently for collection. They are also still improving the frequency of waste collections. Despite these misalignments, the service regime is scaling-up¹⁸ in certain informal settlements thanks to the support of international actors such as donors, who support safe management and treatment of wastes through this service regime. The providers in this regime work on the legitimization of their services among (potential) users,

¹⁸ One of the large providers in this regime started its operations in 2011 and currently franchises more than 1100 container-based toilets, which serve over 53,000 people per day in Nairobi’s informal settlements (Sanergy, 2018).

and try to improve the alignments of the service to the times and spaces that match with the daily practices of potential users. All-in-all this service regime is not strongly institutionalized but it is maturing quickly as internal alignments are being strengthened.

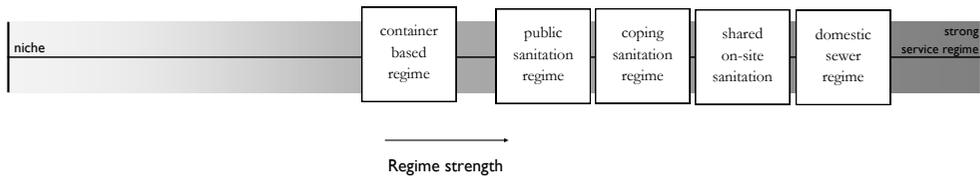


Figure 2.2 Regime strength of the five service regimes

Overall, all the five service regimes have different degrees of internal alignments and all show relatively strong degrees of institutionalization of certain elements. The five service regimes all have a different fit with the local context and are each more or less contested. We used this section's analysis of the (mis)alignments, the fit to the local context, and the contestation of the various service regimes to create Fig. 2.2 which illustrates the differing strengths of the service regimes in Nairobi. Regime strength is rather high for all service regimes. This is at odds with some of the preconceived views on sanitation in informal settlements, which see non-sewered options as provisional or informal and easy to replace, once a "better" solution would be available. It also illustrates that we cannot clearly oppose between regimes and niches in such complex environments. Such as container-based options, which are still very much under-development, but have already a number of highly institutionalized elements and local embedding. Other options like public or shared toilets or open defecation show quite high degrees of institutionalization while creating many externalities to its residents. Sewered systems are expanded into informal settlements as rather provisional and experimental simplified sewer projects, which have a number of characteristics of niche processes. With our framework, we can therefore replace the rather dichotomous niche-regime distinction which has been prevalent in the literature so far, by a gradient of alternative service regimes exhibiting different degrees of regime strengths and local embeddedness.

Taken together, these five service regimes constitute the city's splintered sanitation regime at the sectoral level. However, not every service regime is present everywhere as some neighbourhoods are characterized by a single service regime (e.g. high-end areas have only the domestic sewer regime) or a mixture of two-to-three (e.g. certain low-income residential

areas have shared on-site sanitation regime and public sanitation regime). Because all five service regimes are institutionalized to a certain degree, it is unlikely that one of the service regimes will suddenly replace another or disappear on a city-scale in the near future.

2.5.2 Mapping out the splintered sectoral regime

The five services regimes identified in Nairobi have different strengths, not one of them is dominant, and they are weakly aligned to one another thus meaning that the city's sectoral regime has to be characterized as splintered. One indicator for weak sectoral alignments is the lack of adequate sanitation planning as expressed by the program manager of an international NGO working on sanitation issues:

“... when they (the utility) are doing their masterplan they must consider different technologies in terms of a mix of technologies, but they won't do that. They will only do a masterplan for sewerage, if they do that. So, that's where you have the big gap”

The absence of effective planning is part and parcel of more general lack of effective governance structures, translating in unilateral legislation¹⁹ favouring sewer systems and not providing standards for different types of service regimes:

“Nairobi city bylaw does not recognize pit latrines and does not recognize any other sanitation option except the sewer connection” (WASH program officer, international NGO)

“I can assure you that there is no day an on-site system can meet the conventional treatment standards. It is not possible. So we need some kind of a flexible standard” (lecturer, Kenyan university)

Misalignments are also visible in the coordination deficits between the different sanitation providers, for example between NGOs and public utilities:

“The problem with all these interventions is there is a disconnectedness (...) so everybody just kind of puts up their own intervention” (executive director, Kenyan NGO)

“They (NGOs) don't consult when they are trying to provide solutions (...) we are unable to provide services there because one of the risks and again because of the vandalism so the community tends to feel that it is our company that is refusing to offer the services, but you see right from the word go, we are not involved” (community development officer, utility).

¹⁹ In May 2016 a new “Environmental Sanitation and Hygiene Policy 2016–2030” was launched by the Kenyan Ministry of Health which might improve this situation in future.

Lastly, physical infrastructures that could align different service regimes are absent:

"...in the areas where we work there are no sewer trunks. That is where you find there is the biggest issue of faecal sludge management. So currently what we are doing is talking with them (the utility) on how to handle this. If nearby there is a sewer place, how can we be able to support the communities (to use it)? Because you find that they will not be able, actually when the pit fills up, to dig another one (pit latrine), because there is not that space" (WASH coordinator, international NGO)

All told, the splintered sectoral regime results in a situation in which the differentiated needs of users can only be met through the users' own efforts to actively find a way to meet their daily basic needs, often resulting in negative outcomes. For example, the lack of access to public toilets at night leaves many users with coping mechanisms at home:

"You have to go like three hundred meters to get access to the toilet and there you are passing through alleys and there is no lighting." (project officer, Kenyan NGO)

"The toilet is closed for the day at 10pm in the night. We have to persevere until morning or we just decide to use a small container (coping strategy) in the bathroom, and then very early in the morning before others wake up we dump the faeces into the drainage outside." (informal dweller 6)

And children, in particular, suffer from a lack of complementary/accessible services:

"The performance, (...) the attentiveness of the kids during the classes. It's impaired, because this kid needs to go and help himself or herself but they don't have anywhere to go. So they are waiting to go home in the evening to relieve themselves." (country program manager, international NGO)

These circumstances mean that the user has to put much more effort into serving her/his needs, and this has a knock-on negative effect on productivity, security, and, in the case of education, the development of human capital.

In order to visualize the splintered nature of the sanitation sector, we constructed a stylized map of Nairobi's sanitation provision depicting the mixtures of service regimes that prevail in several parts of the city (see Fig. 2.3). The most complex constellations are found particularly in informal settlements and low-income residential areas. Wealthy neighbourhoods and the central business district have sectoral regimes that are more homogenous.

How could a future more sustainable sanitation map look like? Most of the city planners assume that, over time, the heterogeneity will disappear in parallel with economic

development. As a consequence the domestic sewer service regime will become dominant and the sectoral regime will change from splintered to monolithic. Based on our analysis, we argue however that other developments could be much more realistic. The sectoral regime in low-income and informal settlements will probably not see a strong diffusion of the domestic sewer service regime for still some time into the future. Therefore other service regimes (i.e., the container-based, public sanitation, and shared on-site regimes) should still be improved and alignments among them at the sectoral level could have a strong effect on service quality for the residents. The sectoral regime would transition from a splintered state to a perhaps fragmented or even a polycentric typology. If this can be achieved, a replacement of the still widespread coping regime and the negative externalities related to it are likely to disappear. The discussion that follows outlines a few inroads for potential pathways for such a transition.

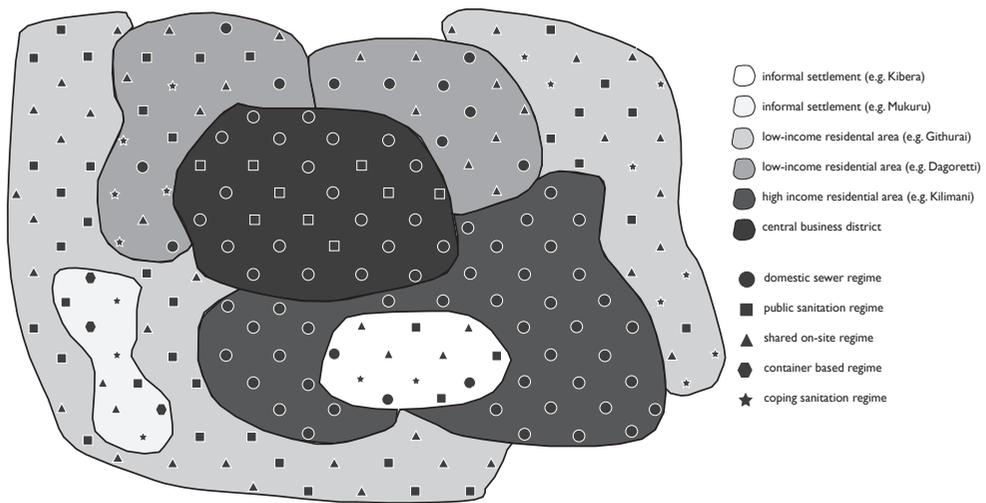


Figure 2.3 Conceptual representation of Nairobi showing the splintering in the sanitation sector of Nairobi projected in space

2.6 Discussion: potential transition pathways in Nairobi's sanitation sector

The thorough identification and mapping of the socio-technical structures that create the service regimes and sectoral regime of sanitation in Nairobi gives pointers for how the

transition from the current splintered regime towards a well-aligned polycentric regime could happen. This would lead towards a sanitation sector that provides higher quality, more sustainable, and justly distributed services. Potential transitions will depend on how the five service regimes develop individually and whether developments will lead to better alignments among one another. The primary goal is to assure that basic needs can be met twenty-four hours a day without having residents resort to coping regimes, and faecal waste is safely managed.

The systemic analysis of the splintered regime presented in this paper helps to identify possible strategies to overcome misalignments at the sectoral regime level. This is useful because actors usually work and innovate mostly within their service regimes. For example, providers improve the design of container-based toilets or the waste collection carts, improve the payment systems for public toilets, or improve the conversion of waste into biogas or fertilizer. As these examples show, these innovations are rather incremental changes within service regimes, while misalignments at the sectoral regime are not recognized. Actors within the different service regimes have their specific independent views on the future of Nairobi's sanitation sector, and work on specific projects to achieve this goal.

For example, the future pathway that is envisioned by the actors in the domestic sewer regime is mostly focused on the "Nairobi as a modern city" perspective: a complete sewerage system covering the whole city. Achieving this in medium term (next 10–20 years) is unrealistic and contested given the costs, pace, and complexities associated with the installation of sewerage infrastructure. Regardless, Nairobi City Water and Sewerage Company remains mainly focused on this pathway (NCWSC, 2014). The domestic sewer regime is politically expedient, supported by large international donors, and is well-aligned with a business-as-usual approach. More diverse service models and technologies would require new forms of knowledge, skills and experiences that are currently unavailable.

In order for the utility to be able to serve more people in the different neighbourhoods, other capabilities and service models are needed. Possible alignment building processes could stem from the development of sanitation policies that address the needs of all five service regimes. The capabilities to manage and further develop the other service regimes are typically available with other actors (i.e. NGOs, CBOs, etc.). The public utility would therefore have to collaborate more closely with non-state actors, like private enterprises, NGOs, and CBOs, in order to provide reliable services.

“For now I think we are still stuck up to our old system where we improve the sewer line, but for the future we are very open to such innovations (i.e. dry sanitation) (...) but I don't think we have the capacity now to start doing this” (project officer at the utility)

Other scenarios might call for improved alignments between the public sanitation regime and the shared on-site sanitation regime. In both service regimes, NGOs, CBOs and self-help groups are actively involving the residents in the informal settlements in service provisioning. Consequently, these non-state actors envision delegated service provision as the ideal future. A local NGO representative noted:

“Neighbourhood associations are new opportunities that have come with devolution in the government (constitution of Kenya of 2010) (...) the so called illegal illicit supply of water, electricity, sanitation and waste services (...) communities can negotiate to be delegated some service provision functions by the local government (...) this will enable better revenue collection.”

Currently, the public and shared service regimes are not well-aligned. The (international) NGOs and CBOs in both service regimes are not purposely referring to each other. The organizational modes of CBOs and NGOs could be improved by learning from each other's service approaches. For example, the timing and location of the services could be improved regarding the manual pit emptier services. These are used in both service regimes, but are not officially recognized, and thus not regulated and coordinated:

“We need to have guidelines on issues of faecal sludge management, they (the authorities) need to recognize the manual pit emptiers. As much as they are saying they are illegal they are playing an important role in the sanitation value chain so they need to be recognized.” (program coordinator, international NGO)

Another scenario relates to entrepreneurial strategies in the container-based regime. These actors typically imagine a future in which private enterprises play a key role and would collaborate with actors in the domestic sewer regime. Such public-private partnerships could support their preferred transition pathway.

Furthermore, there is some potential for collaborations in the field of waste treatment between actors of the container-based regime, the public sanitation regime, and the shared on-site sanitation regime. The first is focused on treating and reusing sanitation waste but does not always collect enough waste from its containers, while in the shared and public sanitation regime a lot of waste is collected from pit latrines without it being properly

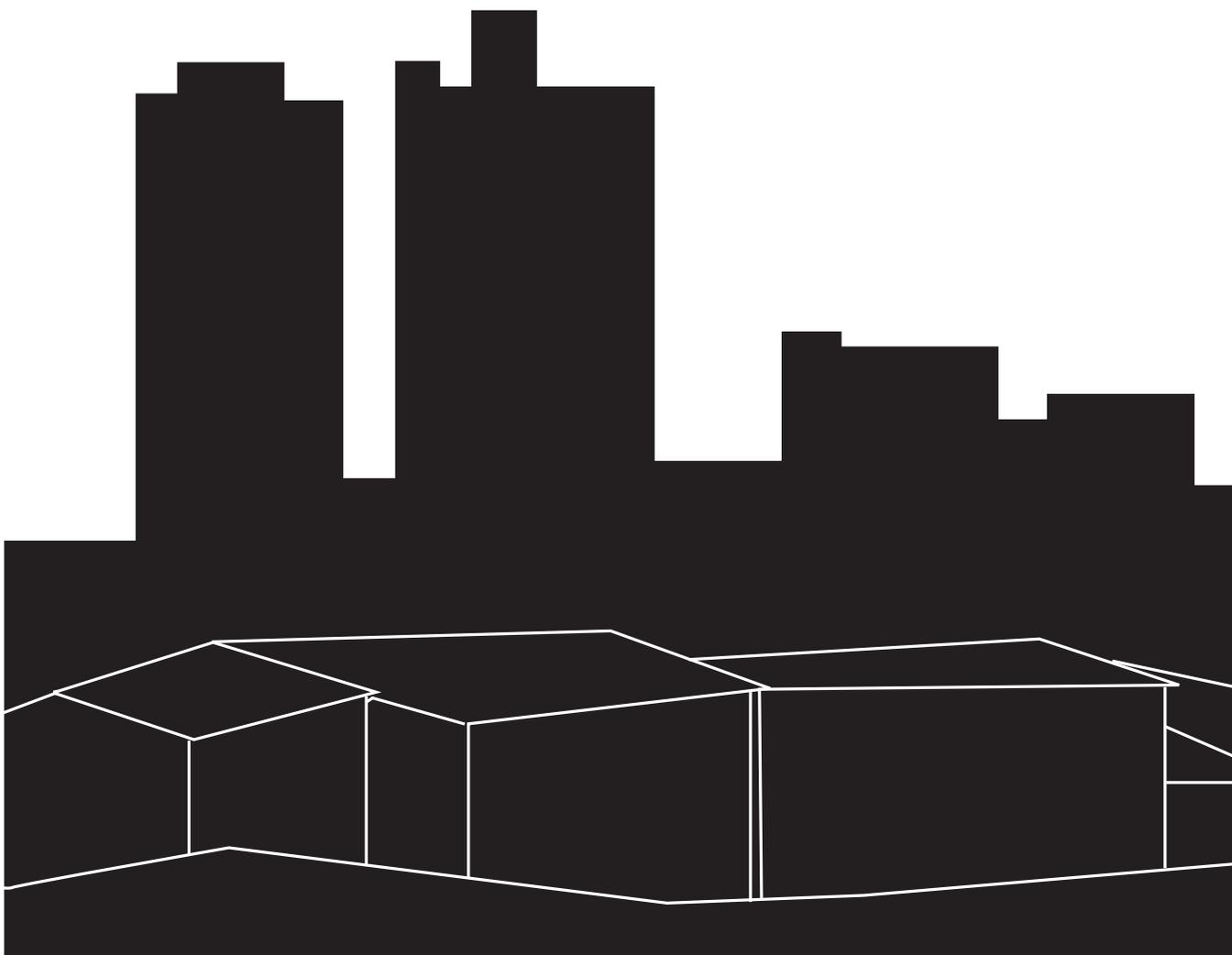
treated or disposed. Collaborations would lead to positive environmental outcomes.

Through the systemic perspective on splintered regimes that we developed, an overview of a broader set of possible transition pathways could be identified. Disregarding the issue of inter-service alignments will likely lead to the prolonging the state of splinteredness for a long time into the future.

2.7 Conclusion

Sustainability transitions frameworks are increasingly called to account for the heterogeneity and unevenness of socio-technical systems in developing cities. In this paper, we developed a conceptual framework that extends conventional regime analyses by differentiating two levels: sectoral regime and service regime. The use of a practice-oriented perspective leads to a coherent, grounded, and spatially sensitive framework to analyse transition pathways of heterogeneous regimes in various complex contexts, not only in developing cities.

In a wider sense, the hope is that this paper's contribution will find applications beyond developing city contexts such that socio-technical transitions research moves beyond its often overly homogeneous interpretation of regimes and towards a recognition of the diversity of service regimes that mark sectors like transport, food, water, electricity etc. in all cities. In doing so, it will be possible to more systematically distinguish between, for example, the transport regime in Dutch cities in which several service regimes (automobile, busses and trams, bicycling, trains, pedestrian mobility forms) are well-aligned, compared to US cities where the regime is often more fragmented (e.g., the bicycling service regime is not well aligned to the other service regimes). Through such comparisons the framework enables the identification of a broader set of alternative transition pathways and ultimately more fine grained policy advice may be derived from a regime based analysis. In particular, the approach overcomes the niche-regime binary which is implicitly oriented at the overthrowing of a monolithic sectoral regime. This paper opens up for much more heterogeneous and uneven sector constellations and therefore provides new perspectives for planners, service providers, and policy makers. The framework finally also provides a useful starting point to gain a more spatially-sensitive understanding of regime configurations. The practice inspired interpretation in particular enables to emphasize the importance of local contexts for successful transition processes.

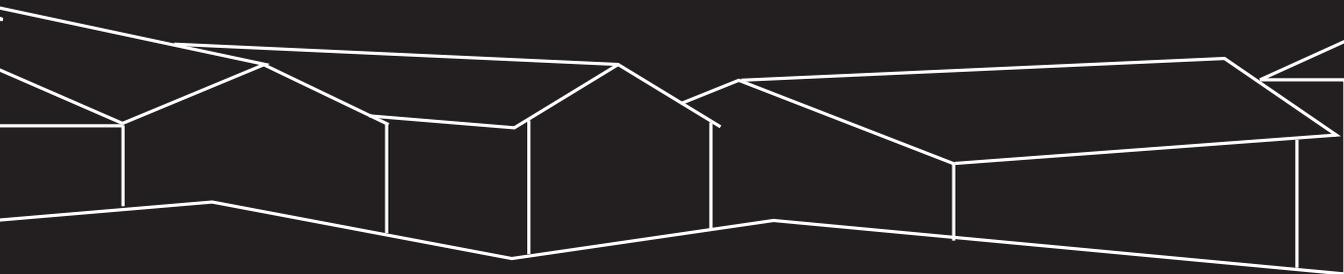


Chapter 3

Innovation challenges of utilities in informal settlements



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Abstract

The provision of basic services is falling short in informal settlements of cities in the Global South. In particular, public utilities have had difficulties expanding their services to the urban poor. Why is this the case despite utilities having improved their capabilities substantially over the last years? This paper investigates how innovation strategies of utilities are aligned or misaligned with the broader contexts in informal settlements, which are populated by different socio-technical regimes. We propose a framework to identify new capabilities needed by utilities to deal with these different regimes. The paper reconstructs pro-poor initiatives of a water and sewerage utility in a large East-African city and explains why they tended to fail in terms of livelihood improvement. We show how the alignment between capability portfolios and specific regime structures have set limits to the success of pro-poor innovation strategies in informal settlement contexts.

3.1 Introduction

The provision of basic services is notoriously falling short in informal settlements of cities in the Global South²⁰. Despite major international initiatives in the context of the Millennium Development Goals (MDGs) and more recently the Sustainable Development Goals (SDGs), services like water and sanitation continue to lag behind set targets (WHO, 2015). In particular, public utilities have had difficulties expanding their services to the urban poor, even more so to those living in informal settlements (Njiru et al., 2001; Cross and Morel, 2005; Murungi and Blokland, 2016a; Nyarko et al., 2016; Van Dijk and Blokland, 2016). This failure is despite the fact that over the last few decades, utilities in cities in the Global South have substantially improved their capabilities (see for example the overview by Danilenko et al. (2014)). Especially in urban water management, they have increasingly aligned with the standards set by the worldwide large-scale centralized infrastructure paradigm (Fuenfschilling and Binz, 2018). In cities in the Global South this global standard has been linked to the ideology of modernization (Nilsson, 2017). It is perceived by many city planners and utility managers as the aspirational standard to supply utility services in an appropriate way (Schwartz and Sanga, 2010; Monstadt and Schramm, 2017). However, in reality millions of poor people have been waiting for decades to see the promises realized (McGranahan, 2015; Nilsson, 2017).

One of the core reasons for this failure is that the large-scale centralized infrastructure paradigm depends on a number of institutional and organizational conditions that are often only weakly developed or even absent in informal settlements of cities in the Global South. Expanding operations into these areas therefore challenges the conventional rationales and capabilities of most utilities. These utilities need to tackle much higher complexities associated with multiple informal institutional arrangements, poor infrastructure conditions, inefficient governance structures and very heterogeneous user needs, that typically go hand in hand with rampant poverty. In other words, informal settlements represent unfamiliar business contexts for the utilities. They would have to develop entirely new organizational structures, business models and, as a consequence, new capabilities in order to successfully

²⁰ The terms Global South and Global North in this paper are not a direct reference to the Northern or Southern Hemispheres, but applied to differentiate nations in terms of socio-economic capabilities and related characteristics. Global North are higher-income nations (with a GNI per capita > \$3,956), while Global South are lower-income nations (GNI per capita < \$3,955) (<http://data.worldbank.org/about/country-and-lending-groups>; accessed 29 January 2018). For more discussions on these contested terms, see (Pagel, et al., 2014).

expand their operations to reach the entire population in the respective urban areas.

While these conditions may explain the limited provision of water and sanitation services in many cities in the Global South, utilities are increasingly called on to expand their services to poor residents in informal settlements (see Cross and Morel (2005); Murungi and Blokland (2016a)), resulting from pressure to fulfil the human right to water and sanitation and meet the SDGs (UN, 2014). Additionally, informal settlements may represent a new market for state-owned utilities that operate as a business, so a number of utilities have started to tap these. As a consequence, utilities have increasingly started to pursue innovation strategies in order to expand their business activities and to develop new kinds of capabilities (see for example Castro and Morel (2008); Murungi and Blokland (2016a); Tinsely and Navarette (2017); NAWASCO (2018)). Innovation related to new organizational structures, new business models and new capabilities is, however, a challenge that utilities are often not well prepared for in the Global South as well as in the Global North (Kiparsky et al., 2013).

This paper analyses innovation strategy challenges faced by utilities that aim to expand services into informal settlements. We want to explain why initiatives often fail and thereby identify potentially successful innovation strategies. We posit that this requires conducting an analysis from two different vantage points. The first perspective focusses on the utility as a specific form of service provider, which tries to explore radically different business contexts. This implies a considerable expansion of the utility's capability portfolio. In the management literature, this problem has been widely addressed under the label of ambidexterity (Duncan, 1976; Gibson and Birkinshaw, 2004). It elaborates how companies may balance explorative strategies (developing new capabilities, innovation) in order to address new business contexts successfully with exploitative strategies at the same time (using an organization's conventional capabilities) (March, 1991). The second perspective focuses on how to understand the new business contexts, in order to identify the need for new capabilities. These business contexts encompass much more than merely market preferences, but also include local institutional arrangements, or competing technological paradigms or business models. We propose analysing these business contexts through the lens of alternative socio-technical regimes (Fuenfschilling and Truffer, 2014). Specific organizations, have typically optimized their organizational structures and capabilities in order to operate in particular socio-technical regimes. Serving radically different regime contexts therefore poses major challenges in terms of adapting their capability portfolios.

In the case of urban water management, most of the utilities worldwide have been optimized to run in the context of the “centralized regime” aligned with centralized large-scale infrastructures. Even though governance and regulatory frameworks of water sectors differ from place to place, this underlying regime rationality guides actions of water utilities in a similar way all around the world (Fuenfschilling and Binz, 2018). As a consequence, utilities around the world have installed very similar organizational structures and capabilities, which shapes how they conceive their products and services, the way they run their infrastructures and operational processes, and what to expect from its users (Kiparsky et al., 2013; Fuenfschilling and Binz, 2018). Conditions for service provision in informal settlements typically do not accord with taken-for-granted assumptions in the centralized regime, such as: non-existence of infrastructures, unclear land tenure rights, prevalence of crime, users having to cope with unsteady income streams, informal vendors who will defend their existing businesses, and so on (Gulyani et al., 2006; UN-Habitat, 2016a). Informal settlements are, however, not devoid of service offerings. Alternative service regimes which fit the diverse and unstable context conditions have emerged over the years (van Welie et al., 2018). These alternative service regimes encompass different core technologies (e.g. public and shared toilets vs. in-home toilets), dominant suppliers of the services (e.g. CBOs vs. utilities), steadiness of service provision (e.g. few business hours vs. 24 hours per day), payment models (e.g. per use payments vs. monthly bills), and so on. In order to identify which sort of capabilities a utility would have to build up in order to operate successfully in informal settlements, these alternative service regimes may provide useful insights. The proposed framework will elaborate how utilities have to leverage explorative and exploitative strategies in order to balance running their conventional business in the centralized regime while being able to successfully operate in contexts served by alternative service regimes. This framework will be illustrated by analysing successes and failures of pro-poor strategies of a state-owned water and sewerage utility of a major city in East-Africa. This utility has recently started to expand its operations to informal settlements while its core business had until then been focused on high-income neighbourhoods.

The paper is organized as follows. In the next section we review the literature on service provision by utilities in cities in the Global South and advocate the virtues of a combined socio-technical regime and capabilities perspective to better understand what is needed in this context to successfully operate basic services in different regimes. Section three introduces the specific context of the case study and presents the methodological approach. Section four reconstructs the innovation strategies of the utility and how it dealt with the balance

between explorative and exploitative strategies when exposed to the context of informal settlements. Section five discusses how the proposed framework can explain the observed successes and failures. The final section concludes and proposes lines for further research.

3.2 Combining capabilities and socio-technical regimes

Only a few previous studies have addressed the challenges of utilities when providing water and sanitation services to the urban poor in informal settlements (Njiru et al., 2001; Cross and Morel, 2005; Castro and Morel, 2008; Murungi and Blokland, 2016a; Schwartz et al., 2017). Most of these studies pay attention to possible “solutions” that utilities can focus on when working in informal settlements, such as innovative (delegated) service models, new financial mechanisms, innovative technologies, or possible structural reforms. These studies are mostly descriptive (see for example, Ravet (2016); Chan (2009); Schwartz and Sanga (2010); Wakiru and Kayaga (2013)), and often lack a theoretically-grounded understanding of the challenges that utilities face when applying pro-poor strategies in terms of capabilities.

In this section, a framework is proposed which relates the capability perspective to public utilities and characterizes the new business contexts by means of alternative socio-technical regimes. There are a number of previous studies that have explored the potential of combining management literature with insights from transition studies, mostly to better understand the role of actors in transition processes. Some of these studies draw on the management literature to analyse the behaviour of incumbent/regime actors (Wesseling et al., 2015; van Mossel et al., 2018). Others studied the dynamic capabilities of investors in onshore wind power to understand investments in renewable energy (Darmani et al., 2017), or the leveraging of dynamic capabilities under different regulatory framework conditions in the urban water sector (Lieberherr and Truffer, 2015) or the relationship between innovations and dynamic capabilities for water system transitions (Hartman et al., 2017). Yet another line of transition research explored the business model innovation literature in order to strengthen the firm-level perspective in transition studies (Sarasini and Linder, 2018). Business models were, for instance, proposed to enable the assessment of potential niche upscaling (van Waes et al., 2018), or to argue that business models embedded in specific socio-technical contexts could inform the governance of sustainability transitions (Bolton and Hannon, 2016).

In this paper, we build on the capability approach from management studies and focus

on how such a perspective can provide insights into the challenges and opportunities that utilities face within their organization when they move into new business environments. The socio-technical regime perspective enables a systemic analysis of the structure and dynamics of this new business environment to which the capabilities have to match.

3.2.1 Capabilities and ambidexterity within organizations

The management literature has dealt extensively with the innovativeness of organizations in dynamically changing business environments. A changing environment requires an organization to reconfigure or acquire new resources and capabilities (Eisenhardt and Martin, 2000). Organizations can sustain their competitive advantage through the “... ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” (Teece et al., 1997, p. 516). An organization’s capabilities are embedded in routines inside the organization, and thus conditioned by its history (Teece and Pisano, 1994).

To adapt capabilities, Lavie (2006) introduced three capability reconfiguration mechanisms in response to technological change: *capability substitution, evolution, and transformation*. These processes are based on different learning sources and mechanisms and lead to newly acquired, transformed, or modified capabilities (Table 3.1).

Table 3.1 The 3 capability reconfiguration mechanisms as proposed by Lavie (2006)

Reconfiguration mechanism	Explanation
Capability substitution	The replacement of obsolete capabilities by newly acquired ones. The learning source for this mechanism is the external environment. Substitution is the most drastic response to new requirements and “offers an immediate response at the level of the overall capability portfolio” (p.154).
Capability evolution	The modification of existing routines or adaptation of existing capabilities to new requirements. As capabilities are strongly path dependent, dynamic capabilities are key in this mechanism. The learning source is internal to the organization. This mechanism involves “continuous experimentation that occurs at the level of particular routines” (p.154).
Capability transformation	An intermediate response to new requirements and involves “objective-driven capability transformation, in which some routines are modified, others are discarded, and new ones are acquired, resulting in a transformed capability, which incorporates both existing and new knowhow” (p.158). The learning stems from a combination of internal and external sources. It is “an intermediate response that applies at the level of a particular capability” (p.154).

The newly acquired, transformed, or modified capabilities are to be managed within the existing organization. An organization which has to deal with such dynamics is more likely to succeed if the organization embraces ambidexterity. Ambidexterity is the ability of an organization to pursue seemingly paradoxical routines at the same time, for example responding to existing market demands, while simultaneously being adaptive to changes in the market environment (Duncan, 1976; March, 1991; Gibson and Birkinshaw, 2004). Various forms of ambidexterity have been distinguished in the literature. Early work on ambidexterity did not discuss pursuing opposite goals simultaneously, but rather recommended a sequential mode of operation, called *temporal ambidexterity* (Duncan, 1976). Later, March (1991) argued that organizations need to simultaneously balance the need to *exploit* an organization’s conventional capabilities versus the need to *explore* new capabilities and hence to innovate. This requires *structural ambidexterity* that is characterized by having distinct units within an organization enabling both explorative and exploitative activities at the same time. The successful operation of structural ambidexterity requires managing the contradictions between the differentiated sub-units (Aoki and Wilhelm, 2017). An organization needs to coordinate explorative and exploitative activities. Therefore, certain targeted integration mechanisms might be needed to successfully enable operation of newly developed capabilities in the entire organization (Jansen et al., 2009). External partnerships can complement or even substitute the building of separate internal organizational structures,

to simultaneously grapple with the exploration/exploitation tension. Different types of external partnerships can help to build up new capabilities (Hoffmann, 2007; Jansen et al., 2009; Kauppila, 2010; Lavie et al., 2011). The literature on *contextual ambidexterity* does not focus on achieving ambidexterity through structural separation, but sees it as the behavioural capacity to coherently reconfigure all activities in a business unit. In such a constellation individuals are enabled and encouraged to divide their time between conventional tasks and reconfiguring activities to adapt to new market environments (Gibson and Birkinshaw, 2004).

Ambidexterity of an organization may help to understand how an actor shapes and reshapes its organization to enable the reconfiguration of its capabilities. Using a capability approach to study a utility is original since, generally, management innovation studies tend to focus on private (social) enterprises and not on (public) utilities. We claim, however, that the capability perspective provides general insights into how organizations may adapt to new contexts. We thus argue in line with Dominguez et al. (2009) that also public service organizations have to deal with capability related constraints.

3.2.2 Socio-technical regimes as structures in business contexts

The capability perspective provides an inside view on the necessary reconfigurations an organization has to manage when confronting dynamic environments. In the simplest case, new “environments” appear when novel market segments emerge (Weerawardena and O’Cass, 2004), which emphasize new customers with specific needs, preferences, and requirements. However, customer segments are only one dimension of business environments. As Teece et al. (1997, p. 522) put forward, “environments cannot be defined in terms of markets alone”. Other aspects such as institutional arrangements, infrastructures, and governance structures can also shape business environments. A systemic perspective might be useful to take these interdependent dimensions of (business) environments into account. The concept of *socio-technical regimes*, elaborated in the sustainability transition literature, provides a potentially fruitful approach to tackle this problem (Markard et al., 2012). Socio-technical regimes consist of aligned technological paradigms, organizational modes, technology, institutional arrangements, as well as user practices and preferences (Geels, 2002; Fuenfschilling and Truffer, 2014). These dimensions create highly institutionalized interdependencies over time which lead to strong path dependencies.

van Welie et al. (2018) proposed a specific operationalization of socio-technical regimes

of basic service sectors in city contexts in the Global South. To be able to account for the complexities typically observed in these cities, they distinguish the two levels of *service* and *sectoral regime*. A sectoral regime consist of one, or more service regimes. In cities with informal settlements, the sectoral regime of basic services consists of multiple service regimes that cater for the social and economic inequalities and distinct contextual characteristics of the different neighbourhoods. These service regimes are unevenly distributed across different neighbourhoods in the city. In high-income residential neighbourhoods, sectoral regimes are typically dominated by one service regime (e.g. the centralized service regime), while more complex constellations of service regimes are found in informal settlements. Because of these characteristics, such sectoral regimes are called *splintered regimes*. In contrast, in western cities, sectoral regimes are typically much more homogeneous, based on one dominant service regime that covers the whole sector, which are called *monolithic* regime structures (van Welie et al., 2018). In this paper we build on this understanding of regimes to analyse the challenges that an actor is confronted with when moving from operating in one service regime (e.g. the dominant service regime in high-income neighbourhoods) to another context where another constellation of service regimes prevails (e.g. in informal settlements).

Service regimes are specific configurations of technologies and their associated user and provider practices. An example is the routinized practice of commuters taking the train, which runs at scheduled times. Providers and users both know when, where, and how to make use of, and arrange this transport service. To operationalize the identification of service regimes van Welie et al. (2018) differentiate five dimensions: artefacts and infrastructures, rationale and meaning, organizational mode, social interactions, and time and space (see Table 3.2), all of which are derived from recent elaborations of practice theory (Shove, 2010; Shove and Walker, 2010; Jones and Murphy, 2011). This approach is based on the idea that socio-technical regimes structure everyday practices of users accessing and providers providing basic services. A practice interpretation of regimes is particularly well suited for elaborating on the micro-meso link, as institutional structures (that are key to a regime) express themselves in the everyday activities and practices of specific providers and users. The five dimensions are interdependent. For example, for a service to function well, there is a need for a shared understanding among users and providers about their roles and the timing and location of a provided service. This shows interdependencies between social interaction, the organizational mode, and the timing and location of a service. Another example is that artefacts of a service need to be accepted by the users, which shows the interdependency between rationale/meaning and artefacts in a service regime.

Table 3.2 Dimensions of a service regime (following van Welie et al. (2018))

Infrastructure and artefacts	- Artefacts (e.g. toilets, water taps, cars trains, etc.) - Physical structures that enable functioning of an artefact (e.g. water pipelines, rails, roads, power lines, etc.)
Rationale and meaning	- Mental activities, emotions and motivational knowledge - An actor's role and expectations, and the (informal) rules that govern the provision and access to a service
Organizational mode	- Group of actors (utility, customer, regulator, and so forth) with complementary strategy to fulfil the provisioning of a service (e.g. maintenance, activities for the day-to-day running of a service) - Shared understanding about the hardware and services to be provided
Time and space	- The when? And where? of accessing and providing a service - Locations of services and the regulated timing for accessing a service
Social interaction	- The exchanges between people that enable or hinder the user's access to services and for providers to maintain regular practices - Leads to trust building, social capital, identification of roles and identities

3.2.3 Framework for analysis

Based on these conceptual elaborations, we propose a combined approach that builds on insights from the two perspectives. Actors have developed optimized capability portfolios in order to operate in a specific service regime. As a consequence, organizational capabilities tend to exhibit obduracies at the micro-level that are connected to the obduracies of the corresponding service regime at the meso-level. It is exactly the congruence between internal capabilities and routines and the specific service regime structures that makes it challenging for actors to operate in different business contexts that are interpreted here by alternative service regime structures. This requires acquiring thorough and comprehensive knowledge of these structures and their internal interdependence, and capability portfolios have to be adapted accordingly. For example, major automobile manufacturers have optimized their capability portfolio to the service regime of personal mobility, where individual ownership of cars is a key institution (Truffer et al., 2017). Interactions with customers are therefore mostly limited to “selling cars”. More recently the automobile manufacturers have moved into car sharing and integrated mobility services (which we consider different kinds of service regimes) and are confronted with challenges to interact more intimately with the users in terms of renting, maintaining and tracking cars over the car's whole lifetime, an activity that is nearer to the core capability portfolio of car rental companies. Automobile

manufacturers showed great difficulty moving into these new business environments (Truffer, 2003; Canzler and Knie, 2016).

In order to identify what type of new capabilities a utility would need to operate in informal settlements, we propose to look at the kind of service regimes that have actually evolved there. Informal settlements are populated by different service regime structures in which a host of different service providers have built up capabilities that are aligned with these structures. Utilities should therefore carefully analyse these other service provider's capabilities and try to build them up internally. The comparison between different service regimes therefore provides a systematic basis for identifying alternative sets of capabilities that a utility might have to develop and manage for successful operation in informal settlements.

This suggests the following analytical procedure: (1) analyse the characteristics of the current service regime in which the actor operates; (2) identify the matching capabilities for this service regime; (3) analyse the characteristics of alternative service regimes that have been established in the new business context; (4) determine capabilities that would enable the actor succeeding in the alternative service regimes; (5) identify the capability reconfiguration mechanisms that are applied by the actor, in order to reconfigure its capability portfolio in line with the new business context.

3.3 Case & methodology

To gain in-depth understanding of the challenges of utilities' pro-poor innovation strategies in informal settlements and to illustrate the explanatory ability of the framework, we conduct a case study (Yin, 2014). We build on qualitative methods to develop thick and detailed descriptions (Gray, 2004; Creswell, 2013). This approach enables the identification of the micro-practices and meso-structures that we outlined in section 2. The selected case is that of a water and sewerage utility in a major East-African city characterized by large inequalities. 36% of the population live in informal settlements (Mansour et al., 2017), which are unplanned areas with houses that have mostly been constructed illegally (UN, 1997). We understand informal settlements also as places in the city where activities take place, which are not registered, taxed, or regulated by the state (Fourchard, 2011, p. 235). The city's water and sanitation sector is characterized by an unequal distribution of services. The city's wealthy neighbourhoods are equipped with the centralized service regime consisting of large-scale centralized water and sewer infrastructure. Since its establishment the utility has mainly been active in high-income neighbourhoods and is perceived by many

as the main service provider of water and sanitation services in the city. The alternative service regimes in informal settlements are characterized by a wide variety of water and sanitation services like domestic, shared and public services, but also encompass a fair share of coping strategies like open defecation (van Welie et al., 2018). The case is informative for the aim of this paper, because the city's informal settlements are large and complex, and the utility has employed a variety of strategies in the settlements over the years. The case is furthermore chosen because it represents a typical major city in the Global South, because of its persistent and complex problems of basic service provisioning in its informal settlements.

The utility is a state-owned, but privately operating company established in 2004. The company has seven directorates that are further divided into departments and sections. In addition to this structure, there are six business departments serving different regions in the city, which are headed by department managers who report to the managing director (Figure 3.1) (Castro, 2009). These business departments are responsible for operations, support, maintenance, and revenue collection (meter reading and billing) in a specific area of the city. Only recently has the utility started to expand its operations to informal settlements in order to tap into this new market. Another inducement was the new constitution in 2010, which gave all citizens the right to clean and safe water and access to sanitation. Consequently, the state-owned utility could no longer justify the inequalities in public service supply between different areas in the city (Katko et al., 2013, p. 170). Moreover, international goals such as the SDGs have pushed the utility to try to extend their services to informal settlements (12, 37).

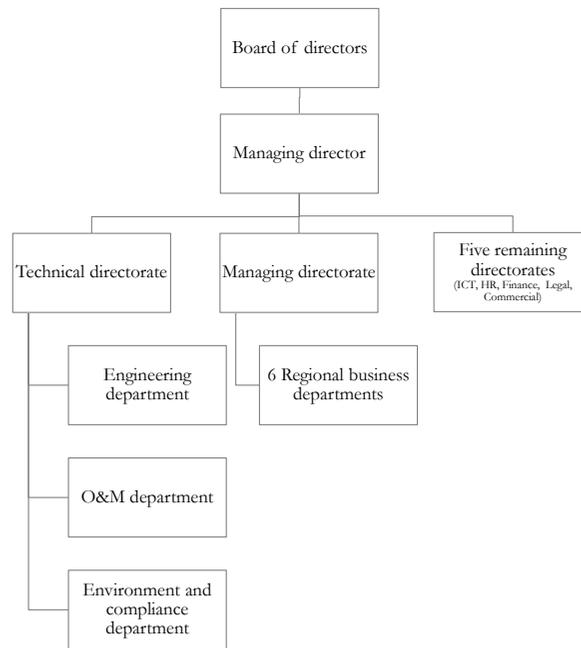


Figure 3.4 Organizational structure utility (ICT - Information and Communication Technology; HR - Human Resources; O&M - Operation and Maintenance)

The empirical analysis of this paper is based on qualitative data collected through semi-structured interviews, project visits, and participant observations between October-December 2016. A total of 37 semi-structured in-depth interviews were conducted. An overview of the interviewees is presented in Table 3.3. The qualitative approach enabled the utility to be studied in its local context and led to rich, in-depth data that give insight into the complexity of the case (Miles et al., 2013, p. 11). In addition, we used various secondary data sources: reports, online articles, and literature to triangulate the information and thereby increase the validity of the study (Cresswell, 2009).

We selected the interviewees using snowball sampling (Gray, 2004). The sampling was iterative and progressed in line with the study. Observations, semi-structured interviews and documents led to new “samples” of interviewees, observations and documents. This process led to an in-depth understanding of the case (Miles et al., 2013, pp. 32-33). Besides utility personnel, we also approached and interviewed partners of the utility in order to triangulate different perspectives to increase validity (Cresswell, 2009). This was especially necessary as some utility employees seemed to feel uncomfortable talking about challenges

and problems in the respective projects. All interviews were recorded and transcribed, and coding was done by means of MAXQDA software. The service regime dimensions from van Welie et al. (2018) were used as starting concepts to structure the first steps of the coding process. Most codes, however, emerged inductively during the coding process. The coding process led to an extensive coding scheme, which is presented in Appendix A. The coded data lead to an iterative updating of the conceptual framework.

Table 3.3 List of interviewees (Numbers in the first column refer to individual interviewees)

Interview number	Interviewee function	Organization
1-6	Managers (various sections and departments, all managers have an engineering background)	Utility
7-9	Engineers (pro-poor unit/department and other departments*)	Utility
10-17	Sociologists (pro-poor unit/department*)	Utility
18-19	Former utility employees	-
20-21	Engineer and social expert	Water Board
22-25	Project and program officers	International development agency 1
26	Senior adviser	International development agency 2
27	Coordinator	International Non-Governmental Organization 1
28	Country director	International Non-Governmental Organization 2
29-31	Manager and program officers	Local Non-Governmental Organization 1
32	Program officer	Local Non-Governmental Organization 2
33-34	Manual pit emptiers	Community Based Organization 1
35	Founder	Social enterprise
36	Specialist	International development bank
37	Lecturer	University

* In order to operate in informal settlements the utility established a “pro-poor unit” and transformed this into a “pro-poor department”. The next Sections will extensively introduce and discuss these exploratory units of the utility.

3.4 Results: changing capabilities for pro-poor innovations

3.4.1 Identifying fitting capabilities to different service regime contexts

Following the first four steps in the analytical procedure introduced in Section 3.2.3, we describe the centralized service regime, the aligned capabilities of the utility, the alternative service regimes in informal settlements, and finally the new capabilities that the utility would have to develop.

The centralized service regime and aligned capabilities of the utility

The water and sanitation service regime for which the utility has established most capabilities is characterized by centralized infrastructure with domestic connections of water taps and flushing toilets. This “centralized service regime” is predominant in high-income residential areas. The utility and the local Water Board take care of installing infrastructures, the supply of water, and the treatment of waste water. Customers in this service regime pay monthly service fees and are accustomed to access their own toilet and water tap 24/7. The utility’s capabilities are strongly aligned with the characteristics of this centralized service regime and largely congruent with water utilities in other more developed countries (Fuenfschilling and Binz, 2018). Its protocols guide the installation of infrastructure and maintenance activities in these safe, planned and spatially well-organized areas of the city. The utility’s offices are mostly located in middle- and high-income areas. Customers’ apply for connections and complaints are handled in written form. Payments are expected on a monthly basis, based on the assumption that customers earn a regular income. The utility does not promote its services very actively. At best, it informs potential customers about its service offerings. The characteristics of the centralized service regime and the aligned capabilities of the utility are summarized in Table 3.4.

Alternative service regimes

The centralized service regime is not present in informal settlements, because expansion of centralized infrastructure often proves to be too costly, the location of settlements in river beds and flood plains makes expansion not possible, sewer lines suffer from water scarcity, and it requires skills for operation and maintenance which are often lacking. The alternative water and sanitation service regimes that prevail in informal settlements consist of different

sanitation services (shared, public, and domestic), coping strategies (van Welie et al., 2018) and diverse water services provided by vendors, stand pipes or water kiosks. The sectoral regime is thus splintered, as it consists of several distinct service regimes.

The majority of the sanitation facilities in informal settlements are thus not connected to the central sewer system. Commonly established services are ablution blocks with pit latrines, but also hanging toilets above rivers are sometimes used. However, sometimes houses have been built on-top of old broken-open sewer lines (6, 10, 18, 23). These illegal connections combined with the habit of disposing of solid waste in toilets leads to frequent sewer blockages in informal settlements (14, 19, 20, 23). The water facilities are mostly public standpipes. Many water pipes are connected illegally, to provide the “last mile” of water supply in these areas (Blomkvist and Nilsson, 2017, p. 293). The large diversity of sanitation and water facilities is necessary to enable supply of services in the context of informal settlements, which are often difficult to access because of their lack of space and complex, unplanned housing structures and high population densities (4, 5, 6, 12, 17).

These alternative water and sanitation service regimes are characterized by specific actor groups with distinct capabilities, and institutional contexts. The services are provided by private enterprises, informal water vendors, Community-Based Organizations (CBOs) and Non-Governmental Organizations (NGOs). Many residents are actively involved in providing services themselves through their membership in CBOs (Cherunya and Truffer, 2017). The different actors possess capabilities that align with characterises of these alternative service regimes. For example, they have developed several types of service models for residents who are mostly transient tenants and who are not formally registered and lack land ownership certificates (17, 20). Another example are the payment models, which are differentiated according to individual customers and often based on trust. These trust-based and flexible payment schemes are necessary because most residents earn an irregular income, making regular payment difficult (14, 17).

Residents in the informal settlements also have to develop specific capabilities that fit with the diversity of alternative service regimes. They have to combine a variety of different services (public, shared, and domestic) on a daily basis depending on their location, the time of the day and their access to money. Coping strategies are also commonly used when residents have no money, and during the night when it is unsafe on the streets. Residents combine these options frequently (Cherunya et al., 2018) and they seem unaware about the potential benefits of having utility services and thus do not demand them (1, 6, 11, 12, 13, 14,

18). Educational levels are generally low, which results in a low awareness of the importance of having hygienic water and sanitation services (13, 14, 18).

In terms of institutional conditions, residents fear formalization of water and sanitation services because they assume it would lead to higher costs to access services and, moreover, threaten the business of their CBOs that provide services. Local leaders, CBOs and informal water vendors have strong power positions and regulate the service provisioning. Sometimes these organizations fuel mistrust towards the utility among residents. Utilities are consequently faced with a highly insecure business environment as regime ‘outsiders’ working in informal settlements, which necessitates close collaboration with these local actors. Utilities need to put a lot of effort into social-relationship building (10, 17, 18, 19). The characteristics of the alternative service regimes are summarized in Table 3.4.

Capability challenges for the utility operating in informal settlements

By comparing characteristics of the centralized service regime with those of the alternative service regimes, we now identify challenges in terms of its capability portfolio that the utility is confronted with, when operating in informal settlements. A summary of these results is presented in Table 3.4. As it is common practice to use multiple technologies in each of the various locations and diverse operating hours in the alternative service regimes, the utility needs to use multiple infrastructures and artefacts, provide services at a larger variety of locations, and at different times compared to their normal operations in high-income areas. Providers in the alternative service regimes are, by comparison, very flexible, for example when looking at service registration procedures and payment options. The utility would need to develop service models that can fit the paying ability of customers. Furthermore, the utility should learn how to install toilets and water taps in dense unplanned neighbourhoods. Promotion activities would need to place greater emphasis on education, informing potential users about the general importance of safe water and sanitation services, addressing in particular lower-educated customers. This might also help to overcome potential customers’ fears concerning the formalization of water and sanitation services. As a consequence, the utility would need to develop strong social skills to be able to actively expand their customer base in informal settlements. It needs to adapt its communications to the capabilities of various new types of customers and have more frequent social interactions with residents. Related to the latter, the utility could actively involve the residents in their planning and operation activities. The utility should also develop skills to communicate and negotiate with informal water vendors. All-in-all,

the utility needs to reconfigure many of its existing capabilities of its capability portfolio to align with the interrelated dimensions of the alternative service regimes. It therefore needs to learn how to balance explorative and exploitative strategies, so that it aligns its capabilities to more than one service regime context.

Table 3.4 Summary of utility’s capabilities related to the centralized service regime, and the alternative service regimes, leading to the identification of new capabilities the utility would have to develop

Dimension	Centralized service regime	Aligned existing capabilities utility	Alternative service regimes	New capabilities the utility would have to develop
Infrastructure and artefacts	Central network with domestic connections	Use of “modern” piped infrastructure and fitting artefacts	Diversity of infrastructures and artefacts	Employ a diversity of other (innovative) technologies
Rationale and meaning	Users demands comfortable “modern” domestic services	Utility assumes that users are aware of the benefits of utility services	User fears formalization and is unaware of most benefits derived from utility services	Active demand creation for utility services to overcome fear of formalization
Organizational mode	One mandated service provider	Utility rarely collaborates with other service providers	Various providers of services: NGOs, CBOs, entrepreneurs	Establish essential collaboration with actors in alternative service regimes
	Daily maintenance by households	Utility not involved in daily cleaning toilets and water taps	Public service providers responsible for daily cleanliness of service offering	Capacity to consider collaborative daily management services (social interaction)
	Waste (water) management by the service provider	Waste (water) management by utility	Waste (water) is managed by CBOs, NGOs and entrepreneurs	Capacity to collaboratively manage waste (water) (social interaction)
	Payments on a regular basis	Monthly payment system	Various different payment models	New payment models that allow for flexible payments by user
	Illegal connections are not tolerated	Utility disconnects illegalities and considers informal water vendors illegal that should be stopped	“Illegal” connections are commonly used and informal water vendors have strong positions in service provisioning	Negotiation skills to deal with illegal connections and to interact with informal water vendors

Table 3.4 continued

	Centralized service regime	Aligned existing capabilities utility	Alternative service regimes	New capabilities the utility would have to develop
Organizational mode	Installation of domestic connection	Formal, written procedures for applications and complaints based on land titles	Public/shared services do not require formal registration	Flexible administrative procedures to apply for a connection
	User requests are dealt with by customer services in centrally located offices	Utility offices in high-income areas	Service providers are reachable and close to user	Offices in the informal settlements
	Installation points are located in safe places	Procedures to install infrastructure in high-income areas	Informal settlements can be insecure for “outside” actors	Skills to deal with unsafe situations
Time and space	Domestic connections, 24/7 access in planned areas	Use of private toilets and individual water taps in high-income areas	Shared/public services at different locations fitting dense and unplanned areas	Increase variety of service models to fit people’s daily lives and installation in dense, unplanned neighbourhoods
Social interaction	Business relationship between provider and customer	Interaction with customers is formal and adheres to a hierarchical manner	Providers interact intensively with customers	Capacity to interact, built trust and sensitize residents in informal settlements
	Provider operates alone	Users are not involved in service provisioning	Users often act as providers as members of CBOs	Utility should consider involving users in service provision

3.4.2 Analysing the utility's pro-poor innovation strategies

Based on the mapping of different capabilities that we identified for the centralized and the alternative service regimes, we now reconstruct two innovation strategies that the utility implemented consecutively in order to establish service offerings in informal settlements. We furthermore identify the capability reconfiguration mechanisms that were used, following the 5th step of the analytic procedure introduced in Section 3.2.3.

In a first phase spanning from 2008 to 2015, the utility established a largely detached “Pro-Poor Unit” (PP_{unit}) with rather large autonomy in how they organized their activities. Thereby, the utility created an ambidextrous organizational structure. The PP_{unit} tried to establish the services in a way that aligned with alternative service regimes. After a number of problems encountered with this organizational structure, the structural ambidexterity was reversed, and the unit was turned into a “Pro-Poor Department” (PP_{dep}) from 2015 onwards (Figure 3.2). The PP_{dep} was organized according to the model of the regional business departments that operate in specific middle or high income neighbourhoods. Instead of focusing on a specific city area, it had to take care of all the informal settlements in Nairobi. The mandate, organizational structure and performance criteria were identical to those of the regional business departments. In the following, we will outline the motivations, set-up, problems, and achievements of both the PP_{unit} and the PP_{dep}.

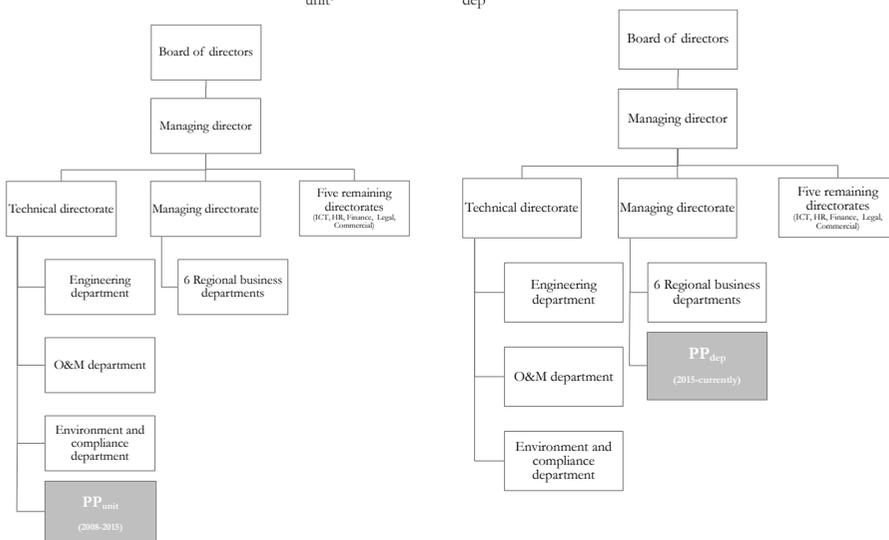


Figure 3.2 Organizational structure utility including the Pro-Poor Unit (PP_{unit}, 2008-2015) on the left and the Pro-Poor Department (PP_{dep}, 2015-currently) on the right.

Set-up of a pro-poor unit (2008-2015)

A major reason for the city government officials to not serve informal settlements so far was that the residents were considered “illegal”. However, the general recognition that these residents deserve access to basic services increased through advocacy of civil society organizations and international agreements over the years, as well as a human right to water and sanitation recognized by the UN in 2010. When the water and sewerage utility was established as a privately operating company in 2004, it started to deliberate on how to serve informal settlement residents, which was also considered a business strategy to tap into a new market. The first step was the development of a strategic plan, which resulted in the foundation of a separate pro-poor organizational unit (the PP_{unit}), which was implemented in 2008. Its mandate was to specialize in providing services in informal settlements (4, 16, 19, 23). The utility recognized the limitations of its conventional capabilities in informal settlements and therefore kept the unit separate from the existing regional business departments so as to provide it with substantial leeway to develop new offerings and develop specialist skills and knowledge (1, 2, 10, 11, 16, 19).

The utility’s management “acknowledged the inadequacy of a pure engineering approach” (Ruhui et al., 2009, p. 4) and added sociologists to the unit to complement the engineering competence base of the majority of the utility’s employees. One of the sociologists involved (16) explained the shortcomings of a pure engineering approach in informal settlements:

“For engineers, (...) they think: ‘These people need water, so why should I sit with them and talk? Talk about what? If they need water, lay water’, but (...) even the way you lay that water could be offensive to them. These people (informal settlement residents) think ‘We have lived here for years without those pipes of yours (...) and we have never died and we had water.’ But when you tell the engineers that they think you are a joke, but they really, really need to understand the social aspect of a human being.”

The sociologists developed new capabilities in following ways. First, they set-up collaborations with experienced partners such as NGOs, CBOs and international development agencies to learn about working in informal settlements (18, 19, 23, 29). Together with several partners, strategic guidelines were developed to guide service supply for the poor in the city (18). Second, the utility’s managers visited several utilities in other countries to learn from their service models for the urban poor (4, 10, 24, 29, 36). These activities helped the PP_{unit} to substitute existing capabilities and develop new ones. For example, in order to overcome the lack of trust, the sociologists of the PP_{unit} organized community meetings in which they intended to (i) increase awareness about the people’s rights to adequate water and

sanitation services (1, 4, 11, 12, 13, 19); (ii) explain the benefits of formal services above illegal connections (e.g. safety, water quality); and (iii) explain why people should pay for such (4, 10, 11, 16, 19). The sociologists consulted the residents about their priorities for improvements (2, 11, 16) and involved them in projects as security guards, for manual work, and for monitoring and evaluation (1, 11, 16, 17). One of the utility's sociologists (11) explained:

“During the stakeholder engagement (...) we ask stakeholders to assist us in managing the issues that arise. We try to get in the different interest groups, especially youth, women and the disabled to be represented so that we get their views (...) we are engaging community based organizations to run the facilities and we try to give priority to the disabled, the youth and women”

The increased attention to residents and local leaders led to trust building. By cooperating with NGOs, the utility could strengthen the social relations with communities (Wamuchiru and Moulaert, 2017). Local chiefs and opinion leaders helped to negotiate with informal water vendors, which originally offered much resistance against the utility's presence in the informal settlements (19). The PP_{unit} managed to “legalize” several illegal water connections through negotiations with the residents and informal water vendors, instead of shutting them down (18, 19). For example, if an informal water vendor would register itself and get a water meter, it would not have to pay for all the years that it had been selling illegally acquired water (18). The PP_{unit} also developed models to support the installation of public service facilities, such as communal water kiosks and ablution blocks²¹. CBOs were trained and licensed to manage these facilities, and sold the water and sanitation services for regulated tariffs (20). An engineer of the Water Board (20) explained this argument as follows:

“after we identify (...) the CBO which will manage the facility, even during construction they are trained (...) “this is how you are supposed to appoint the committee members”, “this is how you are supposed to bank your money”, and “this is how you are supposed to invest” (...) By the time you hand over it (the facility) is something they are able to manage”

In order to gain more interest among CBOs to work with the utility, the PP_{unit} promoted the running of public service facilities as a business. Additionally, the sociologists would listen

²¹ Public service models were not new for the residents of informal settlements (Njoroge, 2004). The City Council (the utility's predecessor in service provisioning) had already installed water kiosks. Those water kiosks were predominantly owned by individuals (Bousquet, 2010, p. 140) authorized to sell water by obtaining a license from the City Council's Water and Sewerage Department (WSP, 1997).

to the group's problems, such as low water pressure, and try to resolve some of their issues (18). The PP_{unit} opened local offices in several informal settlements to better assist residents with complaints and applications. The application procedure was adapted so that people that illegally occupy houses could be allowed to apply for household water connections. Flexible payment systems via SMS were introduced in some areas to enable customers to pay for water and sanitation service more frequently instead of only once a month (4, 10, 12, 17).

All said, during a period of seven years, the PP_{unit} developed many new capabilities (substitution) and transformed several conventional capabilities. Thereby it aligned its services with those of the alternative service regimes. This was for a great part achieved as a result of increased recognition of the shortcomings of the existing capabilities and the involvement of sociologists within the unit. All-in-all the innovation strategy of the utility therefore consisted of drawing on radically new capabilities (e.g. by hiring sociologists) and granting the unit leeway to learn about the business contexts and their associated service regimes in informal settlements (e.g. by setting less stringent profitability targets for the unit). Table 3.5 summarizes the capabilities the PP_{unit} developed.

Through the PP_{unit}, the utility was successful in providing services in the informal settlements. For example, the unit was able to gain trust among the local customer base. Furthermore, it developed new public service offerings (e.g. water kiosks and ablution blocks), supported existing public sanitation facilities, opened new offices, developed flexible payment systems, and expanded infrastructure networks in informal settlements.

These offerings created, however, a number of tensions with the rest of the organization. After the completion of the establishment of a service, the PP_{unit} would typically hand the operation and management to the respective business department (meter reading, billing, etc.). The conventional departments had, however, not been involved in the reconfiguration of capabilities, but rather learned in an incremental, evolutionary manner. The department's employees largely lacked specific competences, knowledge and time to work in these areas (1, 11, 18). The transfer of PP_{unit}'s projects to the conventional departments was thus problematic as they mismanaged or sometimes even ignored the facilities in informal settlements because the staff was reluctant to serve the poor (1, 11, 18) (Castro, 2009, p. 13).

“...the infrastructure used to be developed (by the PP_{unit}) and then it was handed over to the [business departments] for operations and maintenance. (...) it never used to work very well, because informal settlement people have different needs and requirements than those who are in the formal areas. The

people in the [PP_{unit}] worked closely with the communities. They used to know a lot about them unlike the [business departments]. (...) when the project was to be handed over to the [business departments] they more or less leave it to suffer because there used to be a disconnect between the employees of the [business departments] and the community.” – a former manager of the PP_{dep} (1)

A former utility employee (18) explained how the lack of motivation, time, and energy invested in informal settlement projects by employees of conventional departments hindered the success of the PP_{unit}'s projects, which caused tensions within the utility:

“... Then came the operational aspect when people (projects in informal settlements) needed to be connected, to be metered on time, their bills to come on time, the bills to be correct... the operation failed because there was not enough energy invested in dealing with the operations (by the business departments) as there was in the project (by the PP_{unit}).”

A former employee of the utility (18) detailed some of the specific limitations of the department's capabilities in informal settlements:

“if he (a business department's employee) has to read in an informal settlement, and he has been allocated three days to read the 1000 m that are in [the informal settlement], he can't even read 10% of those because all of them requires him to do a lot of community engagement, it requires a lot of negotiation a lot of good will also was required. They did not have the skills or the time, for them the capacity wasn't there to do the routine services in the informal settlements”

Transformation of the pro-poor unit into a conventional business department (2015-currently)

To solve the tensions with the conventional departments, the utility decided to extend the mandate of the PP_{unit}. For that purpose it had to be reorganized to operate very much like a conventional department. Its name was changed into Pro-Poor Department (PP_{dep}) in 2015 (Figure 3.2) (1, 2, 4, 11, 13, 17). With this change, the ambidextrous organizational structure was reversed. The PP_{dep} became responsible for the operation and management of the facilities. The PP_{dep} lost its special status and room for manoeuvre, because its mandate was aligned with those of the other business departments which are mostly focused on revenue collection. To meet its new objectives, the innovation strategy of the PP_{dep} therefore focused more on new service models and approaches that created less tensions with the capabilities available in the rest of the utility.

We focus on two innovative service approaches that the PP_{dep} prioritized in its strategy. A

first service that got promoted was communal “Pre-Paid Dispensers” (PPDs). These are communal water points that deliver water via a standpipe at which users pay with a pre-charged token. The goal of the PPD model was to (i) sell water for low water prices to outcompete the informal water vendors (13, 15, 16, 17); (ii) reduce illegal water connections (15); and (iii) solve the problems with non-revenue water²² (2). The PPD model aimed at cutting out “intermediaries”, the CBOs that are responsible for daily operations of water kiosks. This saved the PP_{dep} time and difficult interactions with such groups. It enabled the utility to collect revenue directly from the customer, as a utility’s manager (2) explained:

“With the new innovations, the customers buy the actual credit direct from (the utility) and there is no middleman.”

The underlying assumptions of the PPD innovation align with the centralized service regime’s focus on modern infrastructures and artefacts, as stated by a utility’s manager (1): “We have come up now with ways of now modernizing the water dispensing module by using prepaid solutions”. And another utility’s manager (2) also emphasizes the focus on new technologies: “now with the creation of the (department) we are more sophisticated with technological oriented supply methods of the water ATMs (a certain type of PPD)”. The model also aligns with the centralized service regime’s rationale of having access to services 24/7:

“They (the customers) are also able to access water twenty four hours per day, unlike before when they could only get water when the kiosks were open” - a utility’s manager (2)

As a positive outcome, PPDs in the city resulted in lower water prices compared to what people paid for water from a water vendor or kiosk (Heymans et al., 2014, p. 15). However, the PPDs faced several challenges. The PP_{dep} did not always manage the social interaction with CBOs well. As a utility’s sociologist (17) explained about the conflicts around a PPD in a certain area, which a CBO opposed: ‘...the group that deals with selling water never wanted it (a PPD) because they never saw any profit, but they (the utility’s management) said (...) you cannot remove this meter.’ The utility thus faced issues with the residents concerning the locations of installing PPDs:

“...the launching was to be on Monday, but the communities’ guys said ‘no this thing (the launch of the project) is not going on, unless you remove the machines (the PPDs) from where you have

²² Physical water leakage or water that is pumped and then lost or unaccounted for.

installed them and install them where we want' ..." - a utility's sociologist (15)

Moreover, providing security for the standpipes in public space was an issue. The PPDs were sometimes vandalized because the community did not possess a sense of ownership of the standpipes, which they did with respect to the water kiosks that they operated (15, 17). The lack of interactions of the PP_{dep} with communities about PPDs also led to undesirable ways of using them. For example, some alcohol producers connected pipes to PPDs and used them all day. As a result they blocked it for other users. There was also local political opposition against the idea of pre-paid water in some neighbourhoods, because people in other neighbourhoods did not have to pre-pay for their water. People also feared the lack of access to water using PPDs in the case of outbreaks of fire, which are common in informal settlements.

The second innovative service arrangement that the PP_{dep} prioritized was the "social connection policy". One of the projects under this policy was the expansion of water and sewer networks and household connections in one of the city's low-income areas. The utility rehabilitated pit latrines and turned them into pour-flush toilets using PVC simplified sewer systems. This project was a cooperation of the PP_{dep} and the engineering department. The connection fees were subsidized and a local bank provided loans to the customers to pay back the connection fee gradually (WorldBank, 2012). As part of the social connection policy, a self-metering system was developed, which allowed customers to read their own meter and pay their bills through text messaging in instalments at their convenience (12). This allowed customers to pay bills in line with their piecemeal, irregular incomes (4, 10).

The expansion project also faced challenges. The necessary behaviour change when using flushing toilets was difficult to achieve, which sociologists spent substantial effort on. People were educated on how to use the flushing toilets properly (e.g. by not throwing in solid waste, pampers, menstrual hygiene products, and so forth.) (9, 14). The sociologists were, however, only involved during the infrastructure installation period, which was too short to establish substantial behavioural change. Sewers still clogged regularly, also resulting in part from the water scarcity in the area.

All-in-all, the PP_{unit} mostly focused on projects that required new capabilities developed by transformation and substitution mechanisms. The transformation from the PP_{unit} to the PP_{dep} resulted in a loss of several of the formerly acquired capabilities, because of the focus on new service models and approaches that required less new capabilities. The PP_{dep} still

reconfigured some existing capabilities, but mostly using evolutionary mechanisms, instead of transformation and substitution. Table 3.5 indicates which capability reconfiguration mechanisms were used by the PP_{unit} and PP_{dep} , and to what extent both the PP_{unit} and PP_{dep} thereby managed to apply new capabilities that align with requirements of the alternative service regimes.

Table 3.5 Summary of newly developed capabilities by PP_{unit} versus PP_{dep} (Yes – fully applying a new capability, No – not using a new capability, Middle – partly applying a new capability)

Dimension	New capabilities the utility would have to develop to align to the alternative service regimes	PP_{unit}	Mechanism used by PP_{unit}*	PP_{dep}	Mechanism used by PP_{dep}*
Infrastructure and artefacts	Employ a diversity of other (innovative) technologies	Middle (only PVC sewer)	Transformation	Middle (only PVC sewer and PPDs)	Transformation
Rationale and meaning	Active demand creation for utility services to overcome fear of formalization	Yes	Substitution	Middle (promotion activities instead of information activities about projects)	Evolution
Organizational mode	Establish essential collaboration with actors in alternative service regimes	Yes	Transformation	No	None
	Capacity to consider collaborative daily management services (social interaction)	Yes	Substitution	No	None
	Capacity to collaboratively manage waste (water) (social interaction)	No	None	No	None
	New payment models that allow for flexible payments by user	Yes	Transformation	Yes	Transformation (inherited from the PP _{unit})
	Negotiation skills to deal with illegal connections and to interact with informal water vendors	Yes	Substitution	Middle (skills are still there, but no priority and informal water vendors are seen as competitors of the PPDs)	Evolution

Table 3.5 continued

Dimension	New capabilities the utility would have to develop to align to the alternative service regimes	PP _{unit}	Mechanism used by PP _{unit} *	PP _{dep}	Mechanism used by PP _{dep} *
Organizational mode	Flexible administrative procedure to apply for a connection	Middle (offices in settlements, support from sociologists, but only for water connections)	Transformation	Middle (offices in settlements, support from sociologists, but for domestic sewer project land ownership is necessary)	Evolution
	Offices in the informal settlements	Yes	Transformation	Yes	Transformation
	Skills to deal with unsafe situations	Yes	Substitution	Yes	Substitution (inherited from the PP _{unit})
Time and space	Increase variety of service models to fit people's daily lives and installation in dense, unplanned neighbourhoods	Yes (public standpipes and ablution blocks)	Substitution	Middle (PPDs, but no public sanitation) (low-income but no informal neighbourhoods)	Evolution
Social interaction	Capacity to interact, build trust and sensitize residents in informal settlements	Yes	Transformation	Middle (much less than PP _{unit})	Evolution
	Utility should consider involving users in service provision	Yes	Substitution	Middle (much less than PP _{unit})	Evolution

* The reference state is the former capability portfolio of the utility, aligned to the centralized service regime

3.5 Discussion: successes and challenges of different pro-poor innovation strategies

The framework presented enabled a better understanding of the challenges that a utility of an East African city was confronted with while pursuing pro-poor innovation strategies. We will now discuss to what extent the two strategies exemplified by the PP_{unit} and the PP_{dep} can be regarded as more or less effective for extending utility services to informal settlements.

As a first step, the utility set up a PP_{unit} as a separate entity providing it with enough leeway to understand the different dimensions of alternative service regimes and to create appropriate capabilities. The PP_{unit} successfully transformed and substituted many capabilities of the utility's portfolio to be better able to fit to the alternative service regimes (Table 3.5). The substitution and transformation mechanisms were informed by the PP_{unit}'s collaboration with experienced actors of these service regimes. The PP_{unit} learned which conventional capabilities were obsolete and which new capabilities it needed to acquire. Partner NGOs, for example, helped the PP_{unit} to develop social interaction capabilities and informed them about alternative organizational models. The new capability portfolio helped the PP_{unit} to initiate and support several successful public services like ablution blocks and water kiosks. These created employment opportunities for the local residents (see (Athi, 2013, p. 13; WSUP, 2017b)), and therefore created trust and support among the residents.

With the establishment of the PP_{unit} the utility created an ambidextrous organizational structure. The utility needed to balance the explorative strategies to develop new capabilities in the PP_{unit}, and exploitative strategies to continue their conventional business through the other departments. The utility proved, however, unsuccessful at operating this complex organizational model. Tensions built up because the utility was not able to integrate the newly developed capabilities in the portfolio of the rest of its organization. The identified tensions can be used to understand the obdurances that the utility had to overcome when it tried to reconfigure its existing practices. For example, one of the practices that was most difficult to change among "conventional engineering" employees, was to interact with the residents in informal settlements during O&M activities. This would require changes in several interdependent capabilities. For example, related to the organizational mode (developing negotiation skills to deal with illegal connections), as well as social interaction (developing the capacity to build trust in informal settlements).

In order to solve the problems of operating this complex organizational model, the utility

reversed the ambidextrous organizational structure and redefined the PP_{unit} to become similar to a conventional regional business unit. As a consequence, the PP_{dep} implemented a much more incremental innovation strategy. It favoured evolutionary mechanisms to only marginally adapt and employ conventional capabilities. The capabilities built up by the PP_{unit} were only partially retained and the department stopped exploring new capabilities (Table 3.5). For example, the rationale for the PPDs (using sophisticated, modern technologies) and organizational mode (24/7 access) aligned very neatly with the established utility routines. PP_{dep} also operated under the assumption that hierarchical and formal interaction with customers would be appropriate, as in high- or middle-income areas. CBOs and users were rarely involved in managing and securing the PPDs, which led to some of the dispensers being vandalized. The expansion of water and sewer networks focused on low-income areas, but no longer on informal settlements. This enabled the utility to proceed with only slightly modified capabilities: the use of household water taps and flushing toilets, the utility as the sole service provider, hierarchical business relationships between the utility and the customers, facility installation in low-income but relatively planned neighbourhoods, and the independence from users in service provisioning. Lastly, while the separate status of the PP_{unit} created leeway to reach out and work with NGOs and CBOs, the PP_{dep} did not engage in community work anymore, because its employees lacked time under the department's mandate. The department subsequently lost most of the trust acquired via these external partnerships. It could therefore no longer explore or enhance capabilities that were built up in the PP_{unit} .

The establishment of the PP_{dep} lowered tensions with the other departments because of its incremental innovation strategy, the use of well-known performance indicators and its conventional business mandate. The PPDs, for instance, were an important strategy to significantly lower the share of “non-revenue water” (1, 5) (Heymans et al., 2014), which is one of the major indicators of the performance of utilities worldwide (Danilenko et al., 2014). These indicators are, however, based on high-income countries, and several studies have argued that “pro-poor benchmarking” of water utilities in low-income contexts need other indicators (Murungi and Blokland, 2016b; Van Dijk and Blokland, 2016). Furthermore, the focus on a market that was more similar to the conventional centralized service regime (low-income communities instead of complex informal communities) helped to realign with the rest of the organization.

Whereas the tensions between the PP_{dep} and the rest of the utility were lowered, its innovative

service models did not effectively fulfil the needs of the urban poor in informal settlements. Because the PP_{dep} used an incremental innovation strategy in the new business context, it was not able to properly fit its service models to the alternative service regimes of the informal settlements. For example, the envisioned benefits of the PPDs – of having 24/7 access to water – is questionable in most informal settlements: As it is usually unsafe to leave homes at night in informal settlements, technical availability is not equal to actual access. Moreover, in some areas the utility disconnected illegal domestic connections and installed PPDs instead, leading to a lower service level for those residents who lost their illegal domestic connections (17). In the sewer and water pipes expansion project, households were required to hand over ownership certificates, which was problematic because many people occupy the land illegally (9). Another problem was the expansion of the sewer. Despite the use of simplified systems and PVC pipes, this required space that was not available in unplanned and dense settlements. Some also doubted the affordability of the service model for the poorest of the poor despite the subsidized price (9). In some cases, the project resulted in higher rents, which affected the poor (7, 14).

The case study shows that the PP_{dep} removed certain newly acquired capabilities from its portfolio and was not able to maintain its partnerships as part of the conventional organizational structure, which prevented its success in aligning with alternative service regime dimensions and resulted in a reduced impact in terms of the pro-poor performance. For example, the PP_{dep} did not focus on public service models because such models demand transformation of the conventional organizational mode. It instead focused on centralized, domestic service models well known in the centralized service regime. The utility's neglect of complex public service models was not a novelty. In the past the major financiers of the City Council (the utility's predecessor) also shifted away from financing public models such as water kiosks and instead financed individual connections (Katko et al., 2013, p. 176).

The conceptual lens helped to understand that the setup of a normal business department (PP_{dep}) might have been the right move to deal with the problems that the utility encountered with an ambidextrous organizational structure, having a separate organizational unit. The tensions between the PP_{unit} and the rest of the organization are in line with the ambidexterity literature that has extensively reported on the challenges that organizations may face when balancing exploration and exploitation (e.g. (Gibson and Birkinshaw, 2004; Lavie et al., 2011)). After reducing the organizational tensions, the utility should however have paid attention to maintaining and further developing the new capabilities that had been built up through interaction with the alternative service regimes. Furthermore, our study suggests that a

department focusing on the urban poor needs other types of performance indicators and success criteria than conventional business departments so as to provide sufficient leeway to establish external partnerships. This might enable a successful management of newly developed capabilities in the organization (Jansen et al. (2009)). The findings are in line with management literature suggestion that partnerships might be important means to achieve a balance between exploration and exploitation activities in an organisation (Kauppila, 2010; Lavie et al., 2011).

3.6 Conclusions

We set out to analyse the challenges a utility is confronted with when trying to expand services into informal settlements in the Global South. We developed a framework to show why organizational capabilities are difficult to establish if they do not conform to the primary service regime contexts that a utility is mostly operating in. This limits the expansion strategies of utilities and therefore hampers the ability to provide services to a majority of the local population in these cities. The case study of a water and sewerage utility in a large city in East Africa illustrated how the utility's capabilities are aligned with the centralized service regime and how this limited the ability to operate in alternative service regimes. The utility reported in this paper largely failed to achieve effective pro-poor service provision by reverting back to its established capability portfolio.

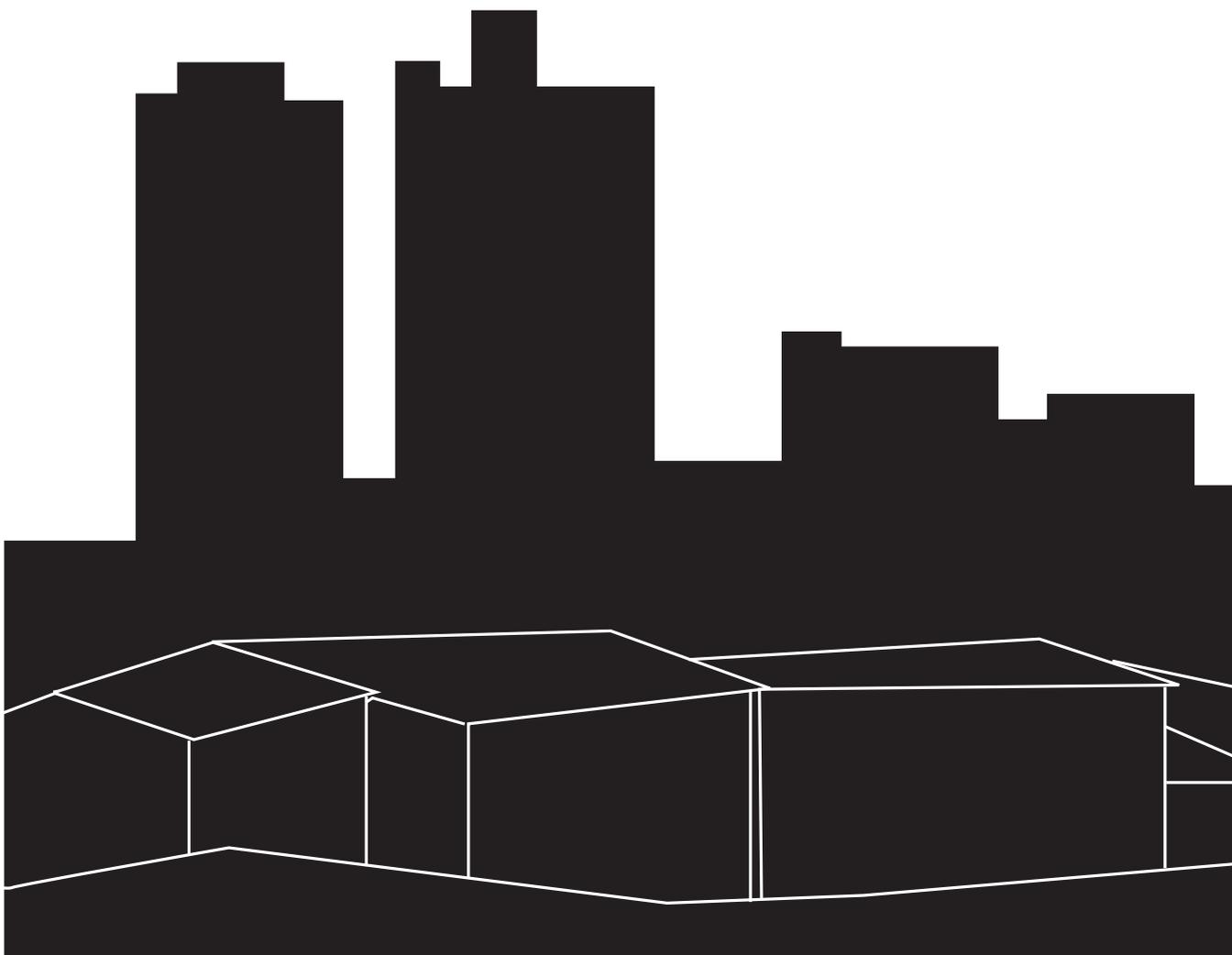
Based on this analysis, we claim that a more explicit understanding of the interrelationship of capability portfolios and service regimes would have enabled the utility to be more successful in its pro poor strategies. Utilities that aim to expand into in the business context of informal settlements therefore need to gain a systemic and thorough understanding of the various interrelated dimensions of the new service regimes in which they want to operate. Different types of social interaction, rationales, use of infrastructures at different locations, and organizational modes need a coherent approach to changing the capability portfolio. Utilities do need to develop capabilities entering these new business environments, while still being able to run their conventional business. An ambidextrous organizational structure enables utilities to be successful in this situation. However, when a separate organizational structure causes too many tensions, utilities can also embrace contextual ambidexterity instead to carry out both explorative and exploitative strategies. This would entail that the mandate leaves sufficient room to divide time between conventional tasks and developing new capabilities, for example through establishing external partnerships.

In more conceptual terms, we showed how the combined analysis of capability and regime structures helps to better understand actor's challenges in transition processes. The framework proposed in this paper therefore provides a tentative inroad to elaborate on the linkage between the micro level of actors and the meso-level of social structures (Farla et al., 2012). However, the present paper only provided some first illustrations of this research field, and suggests a much broader agenda of future research.

First, the socio-technical regime concept might provide an opportunity for management scholars to analyse the interrelationships among technical, institutional and capability related dimensions that define a new business context. This might provide a more systematic understanding of how to approach capability transformations and assess the need for ambidextrous organizational structures. The operationalization of socio-technical regime concept in business contexts however needs further elaboration compared to what could be achieved in the present paper.

Second, the capability perspective may inform transition studies about the challenges that actors are confronted with in transition processes. The findings of this research may in particular lead to a better understanding of the role of incumbent actors in regimes, in line with previous work done (Wesseling et al., 2015; van Mossel et al., 2018)). The three capability reconfiguration mechanisms and insights from ambidexterity literature can be used to assess how incumbent actors respond to potential regime change. For example, what learning sources and mechanisms do they use to modify their capability portfolios, and if this is sufficient to align their portfolio to the envisioned future regime. This indicates if incumbent actors are able to solve their capability deficits in transition processes, or are actually even pro-actively contributing to it.

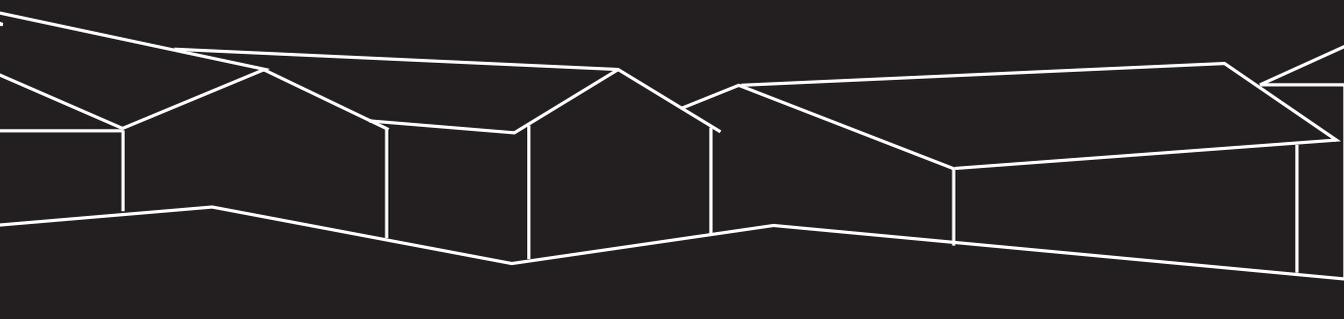
Third, these results challenge the traditional notion of a priori distinguishing “niche” and “regime” actors in conditions of heterogeneous regime structures. An actor that moves in a splintered sectoral regime from one service regime to another one (e.g. from the centralized to alternative service regimes in our case), has to be considered as an incumbent in one, but also as a new entrant in all other service regimes. Consequently, a much broader set of potential transition pathways has to be considered under these conditions.



Chapter 4

A TIS analysis of sanitation value chains in Nairobi

van Welie, M.J., Truffer, B., & Yap, X.S. Towards sustainable urban basic services in low-income countries: A TIS analysis of sanitation value chains in Nairobi. *Resubmitted to Environmental Innovation and Societal Transitions*



Abstract

The provision of basic services suffers from a multitude of sustainability challenges in many cities of low-income countries. Sanitation in particular has proven to be riddled with environmental contamination, high costs, and large inequalities between urban residents. In recent years, an increasing number of innovations in on-site systems have been developed, which have not yet developed into fully functional alternatives to the existing regimes. We study three prominent recent on-site sanitation initiatives in informal settlements in Nairobi, Kenya that aimed at developing entire “sanitation value chains”, which we conceptualize as an emerging Technological Innovation System (TIS). The analysis leads us to propose alternative governance modes of the TIS to overcome system failures like capability, coordination and institutional barriers. Conceptually, the paper provides an extension from conventional TIS analyses towards entire value chains, which enables addressing a wide range of transition processes also beyond informal settlements and low-income countries.

4.1 Introduction

Fundamental changes in urban basic service provisioning in low-income countries are urgently needed to create more environmentally sustainable, socially just, and affordable services, and thereby improve the livelihoods of the residents in rapidly growing cities. Innovative basic service offerings have great potential to tackle sustainability challenges and transform sectors such as energy, transport, water, and sanitation. However, the promises of many of these service provisioning innovations have not been met. Some are not being adopted, or adopters face many challenges. Others fail to be maintained, or are not scaled-up/diffused (Jones et al., 2013; Kebede and Mitsufuji, 2014; Tigabu et al., 2017; Cherunya et al., 2018). One of the core reasons for failure stems from the fact that innovation processes have to relate to manifold aspects that are not directly tied to technology questions, such as regulations, finance, institutions, social issues, the environment, etc.

Socio-technical system perspectives used in the sustainability transitions and innovation system literature can help to gain insight into these multiple dimensions that affect innovation development and transition processes. The concept of innovation systems covers a broad variety of actors, their networks and institutions (Weber and Truffer, 2017). One of the system frameworks that has extensively been applied to sustainable technologies is the Technological Innovation System (TIS). TIS are described as “socio-technical systems focused on the development, diffusion and use of a particular technology” (Bergek et al., 2008, p. 408). The TIS framework has mostly been applied to specific technologies or technological fields. This has been adequate for cases in which the innovation success depends primarily on the fate of a specific artefact (like PV cells or electric vehicles) and where it can be assumed that all other dimensions of a socio-technical system will follow suit, once the core technology is established. This rather specific focus of many extant TIS studies led to the criticism that the framework is barely suited to address complex transition processes (Kern, 2015). Following Markard and colleagues (2015) we argue that one should distinguish between how a concept has been applied in the past and what its actual explanatory potential is. In order to expand the applicability of the framework to address transition processes, we have to consider the broader embedding of technologies in various contexts (Bergek et al., 2015) and ultimately shift focus from single technologies to socio-technical systems that encompass production and consumption aspects. The shift generates questions about how to govern simultaneous and interconnected innovations as part of such socio-technical systems.

A first step in this direction is to extend the TIS framework by perceiving interconnected innovations as happening at and across different segments of a value chain that leads to the provision of the basic service. A value chain is conceptualized as “the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use” (Kaplinsky and Morris, 2001, p. 4). The literature on value chains deals both with value chains within companies in business and management scholarship (Porter, 1985), as well as with value chains that span across industries and geographies (global value chains - see (Kaplinsky, 2000; Gereffi et al., 2005)). We take the latter meso- (industry-) level perspective to extend the TIS framework. The literature on value chains has extensively dealt with understanding the interlinkages between segments of value chains, such as the inter-actor relationships, or vertical (dis)integration processes leading to different governance modes by which value chains can be coordinated (Gereffi et al., 2001; Kaplinsky and Morris, 2001). As compared to the single-technology approach, the value chain perspective therefore guides attention to technical, social, and organizational innovations in provision, transportation, use, and disposal of new products and technologies, and hence provides a useful step along the way to understand the emergence and transformation of entire socio-technical systems.

In this paper, the boundary of a TIS is therefore conceptualized as a socio-technical system encompassing different segments that span across the entire value chain of an innovative service offering. We first apply the well-established TIS functional analysis to each segment of the value chain, separately. However, beyond this rather straightforward extension of the methodology, we take the critical complementarities of the different segments into account. This leads to the important question how actors coordinate among themselves and how different power positions get established in a TIS. To tackle this question we can draw on the existing value chain literature, which has developed a broad body of insights on different types of “governance modes”. We propose to extend the notion of governance modes from value chain to system level. This entails identifying the relative power positions of actors in the context of the entire innovation system. Unlike conventional governance modes in value chains, a broader range of actors can occupy a strong coordinating role in innovation systems.

We use this enlarged framework to answer the question why technology-focused service provisioning innovations often fail in urban informal settlements in low-income countries. Based on the above perspective, we claim that this is mostly due to neglecting two

complexities: First it can be due to a too narrow focus of development interventions, focusing predominantly on technical artefacts instead of the production and value distribution networks that are necessary to provide safe and affordable services. This represents a neglect of the value chain dimension of new service offerings (Springer-Heinze, 2018). The second reason of failure is because many initiatives are considered in isolation, without addressing potential synergies with other initiatives in a given region. We identify this as neglecting the innovation system dimension, which may give rise to all sorts of “system failures” (Klein Woolthuis et al., 2005).

The empirical case that we use to illustrate these claims reports on on-site sanitation innovations in informal settlements of Nairobi, Kenya. The study is based on qualitative data from interviews, reports, observations, and project visits. On-site sanitation technologies are promising to improve the dire situation of sanitation in many cities in low-income countries, especially in informal settlements. However, a focus on one individual technological innovation (the toilet/latrine) is often not sufficient to develop and diffuse sustainable urban sanitation services (Koné, 2010; Wald, 2017; WSUP, 2017a). The toilets should be managed in the context of a coherent sanitation chain including emptying, collection, transportation, treatment, and safe disposal or use of waste. The development of such sanitation chains depends not only on technological, but also on organizational, social, and institutional innovations that are interconnected (exemplifying the value chain dimension). Several initiatives were therefore started by Non-Governmental Organizations (NGOs), donors, and social enterprises in Nairobi over the past few years that build up entire “sanitation value chains” with the aim to sell end products out of faecal sludge. The current situation of Nairobi’s manifold innovation projects can be understood as an emerging TIS, which is exhibiting all sorts of system weaknesses (exemplifying the innovation system dimension). Analysing these weaknesses leads to suggesting potential synergies between the extant initiatives. Considering both dimensions at the same time could accelerate the development and institutionalization of well-managed on-site sanitation services in the city.

The paper is organized as follows. In the next section we review literature on TIS and value chains in order to elaborate an extension of the TIS functions methodology. Section 3 introduces the case and methodology. Section 4 presents the results from the case of on-site sanitation in Nairobi. It outlines the evolution of three major on-site sanitation innovation projects in Nairobi and identifies the most salient system weaknesses. In section 5, we discuss potential improvements in the innovation activities in informal settlements of Nairobi that result from our systemic analysis. The last section concludes and elaborates

implications for broader research activities and management strategies.

4.2 Theoretical foundations and analytical framework

Innovative service offerings often fail to meet goals tackling sustainability challenges in low-income countries. One of the reasons for this failure is that the multiple dimensions that impact innovation development, such as regulations, finance, institutions, social issues, the environment etc., have not been given sufficient attention in the innovation processes. Romijn and Caniels (2011, p. 375) emphasize the “need for policy makers in the international development-cooperation community to adapt an integral dynamic innovation-systems perspective for stimulating innovation in developing countries”, in order to realize technological change that fits the local context and meet local needs.

4.2.1 Broadening the perspective of TIS analysis

The innovation system literature provides insights on the role of a diversity of actors, their interaction in networks, and the role of institutional arrangements in the promotion or hindering of innovations (Weber and Truffer, 2017). One salient concept is the Technological Innovation System (TIS), which has been applied to many sustainable technology innovations internationally and which has increasingly been focused on cases in low-income countries, recently (Blum et al., 2015; Kebede and Mitsufuji, 2017; Tigabu et al., 2017; Kriechbaum et al., 2018; Sixt et al., 2018). The TIS approach denotes a diverse set of actors, their networks, and institutions that aim at developing a specific technology or infrastructure. The TIS concept does not only focus on aspects exclusively dedicated to the technology of interest, but incorporates all components that have an influence on the innovation process for that technology (Bergek et al., 2008, p. 409). The dynamics of TISs are commonly analysed using their “functions” (Hekkert et al., 2007; Bergek et al., 2008). These are core processes that drive the development and maturation of a TIS such as gaining technology legitimation, mobilizing resources, forming markets, guiding search activities, entrepreneurial experimentation, and knowledge development (Hekkert et al., 2007). Analysing these functions over time and comparing them across cases leads to the identification of system weaknesses in the form of coordination, capability, and institutional failures (Klein Woolthuis et al., 2005; Jacobsson and Bergek, 2011). These failures can be addressed by different actors who want to support the innovation, for example through developing specific forms of knowledge exchange, forming professional networks, or

by changing the division of labour within the value chain (Stephan et al., 2017). A TIS therefore provides an integrative view on how individual innovation activities are in broader social contexts.

When applied to cases of low-income countries, the TIS framework has mostly been applied to single technologies or clearly delimited technological fields (see for example Agbemabiese et al. (2012); Blum et al. (2015); Tigabu et al. (2015a)). This mirrors the broader TIS literature, even though the framework was originally cast in much broader terms, referring to entire industry sectors or technology fields (Markard et al., 2015). The narrow focus on single technologies is defensible in cases where innovation success depends on a key artefact, like photovoltaic modules, wind power plants, or electric vehicles where supply chains and institutional contexts can be supposed to follow suit with the rapidly increasing deployment of the core technology. However in general, the success of technological innovations may be influenced by various “external” conditions, such as other TISs (Bergek et al., 2015), geographies (Binz et al., 2014; Binz and Truffer, 2017), or sectoral configurations (Stephan et al., 2017). For example, the development of battery technology is related to mobile applications such as laptops, as well as to the integration of intermittent renewables in electricity grids (Stephan et al., 2017, p. 713). In rapidly scaling industries, such as solar photovoltaic energy, the globalization of value chains may influence the maturing of an innovation system (Dewald and Fromhold-Eisebith, 2015). Its success does, furthermore, not only depend on the development of the photovoltaic cells and modules alone, but ultimately can be developed into entire socio-technical systems, for instance in the form of stand-alone systems that can operate rather independently from the grid (Dewald and Truffer, 2012). Different technologies may also get increasingly interdependent over time (Kieft et al., 2017). For example in agrifood, where the strongly interconnected components of the system are often managed separately, which leads to innovation processes in one domain that deal with constraints of the other (Meynard et al., 2017).

In order to address these complexities, the functional analysis of TIS has to be extended. It has to go beyond the siloed assessment of each single segment of the value chain and address the interrelationships between them. This is a stepping stone to the analysis of interlinked technological, organizational, and institutional innovation processes and by this the transformation of entire socio-technical systems. And in particular, we maintain that this extension enables a better understanding of the underperformance of innovations in low-income countries.

4.2.2 Value Chain Governance in a TIS

In cases where technologies become interrelated, it is important to explicitly account for up- and downstream dynamics in value chains that the technologies are related to. A specific issue that has to be tackled when moving from single technologies to entire value chains is how the different actors relate to each other across different segments and how these relationships are governed. The literature on global value chains (GVC) has been most explicit about this dimension. It offers a globalized perspective of how and where activities are organized across the value chains and how values are distributed across different geographies under the conditions of increasing globalization (Kaplinsky, 2000; Gereffi et al., 2001; Humphrey and Schmitz, 2001).

Complementarities between actors in value chains ask for (more or less) explicit coordination in order to realize functioning research and development (R&D), production, and distribution networks. Gereffi et al. (2005, pp. 83-84) have categorized these relationships into five value chain governance modes: *market governance*, *modular value chains*, *relational value chains*, *captive relationships*, and *hierarchy*. Three key determinants help to characterize these modes: 1) *complexity of transactions*²³ (i.e. how complex is the process of information and knowledge transfer in order to sustain a transaction); 2) *codifiability of information* (the extent to which this information and knowledge can be provided in written form and hence be transferred from one context/step to another one without transaction-specific investments); and 3) *capability of suppliers along the value chain* (the absorptive capacity of actual and potential suppliers in relation to the requirements of the transaction).

The five modes of governance are characterized by different combinations of these three determinants (Table 4.1) and represent different forms of power asymmetries, which range from full integration of activities within a single vertically-integrated company on one end, to pure market-based interactions on the other end. In between, we find different forms of networked relationships with a decreasing power position of the lead firm (Gereffi et al., 2005, p. 83). The framework laid out in Table 4.1 can also be used in a diagnostic form: e.g. a hierarchy mode is potentially very appropriate when “product specifications cannot be codified, products are complex, and highly competent suppliers cannot be found. This forces firms to develop and manufacture products in-house” (Gereffi et al., 2005, p. 87). On

²³ As assets differ, (Gereffi, et al., 2005, p. 84) emphasizes “mundane” transaction costs – the costs involved in coordinating activities along the chain.

the other extreme, pure market coordination only works if transactions are rather simple, products can be easily standardized, and there are enough companies in the supply base that meet the required levels of capabilities.

Table 4.1 Key determinants of value chain governance (Gereffi et al., 2005)

Determinants	Complexity of transactions	Ability to codify transactions	Capabilities in the supply base	Degree of explicit coordination and power asymmetry
Modes				
Market	Low	High	High	Low
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchy	High	Low	Low	

Governance modes are however not static. In many industries, increasing capabilities in the supply-base helped push the GVCs away from hierarchy and captive networks toward relational, modular, and market types (Gereffi et al., 2005). Changes in governance modes can also be the result of new standards that enable codification of product and process specifications. Standards are different across different sectors and are constantly evolving; they can for example become obsolete as technologies change (Gereffi et al., 2005, p. 97). But governance modes are not only relevant for production and manufacturing. They also have implications for innovation processes (Gereffi et al., 2005; Pietrobelli and Rabellotti, 2011; Zhang and Gallagher, 2016). Learning in the GVCs can take place by adopting international standards, “or be facilitated by direct involvement of the value chain leaders when the suppliers’ competence is low and the risk of failure to comply is high” (Pietrobelli and Rabellotti, 2011, p. 1261). Chain leaders play an important role in knowledge transfer and technological learning to their suppliers (Morrison et al., 2008). Or, if the competencies of actors in value chains are complementary, learning can be mutual and take place through face-to-face interactions (Pietrobelli and Rabellotti, 2011).

These insights from value chain governance add an important new level to the analysis of a TIS. The governance modes introduced by the GVC literature enable to discuss the important question on who has a coordinating role in aligning the different segments of the value chain. While governance modes have been conventionally applied to value chains, we propose in this paper to extend this notion to entire innovation systems. The governance mode of a TIS can accordingly be differentiated by the degree by which core actors (be it a company, an association, a government program, or even a grassroots organization)

coordinate the different activities in a technological field. If a single actor would be able to control most of the activities that are necessary to develop an innovation, this would result in a strongly coordinated mode in a TIS. An extreme form would be a single multinational company, which tries to control most of the TIS functions within its own organizational boundaries. In that case, a hierarchical value chain governance mode would coincide with a strongly coordinated TIS governance mode. On the other extreme, a lowly coordinated TIS governance mode would be successful when system functions develop quite spontaneously and harmonically. In between, we may identify many different governance constellations where all sorts of coordinative structures are set up to deal with certain capability, coordination or institutional deficits. These may be managed by a broad set of actors such as individual companies, industry associations, government offices, or even civil society organizations. In particular, we also have to consider that not all relationships among these actors have to be harmonious for a well-performing TIS. There is room for divergent strategies and even competition among sub-groups of actors in the TIS.

It is beyond the scope of this present paper to provide an exhaustive typology of different TIS governance modes. Such an endeavour would need to be based on a large sample of different cases. We can however start to develop such a typology by distinguishing different degrees of coordination that are appropriate in order to improve the performance of a TIS given some specific context conditions. Building on the insights of the GVC literature, it is useful to elaborate how the three determinants of value chain governance modes correspond to the three types of system failures that are key to the innovation system literature. We thereby extend the notion of governance modes of the value chain literature to entire innovation systems. First, the *complexity* of transactions is neatly related to the network and the institutional dimension of a TIS. The more internal institutions are developed in a TIS and the less coordination deficits prevail, the lower transaction costs will be. Second, *codifiability* denotes the ability to transport specific knowledge stocks from one local context to another one. This depends on the types of knowledge that are predominant in the TIS, the quality of networks that exist among the diverse actors, and also on how congruent institutional contexts are between different segments of the value chain. Standards and regulations play a particularly important role here. And finally, *capabilities of the supply base* relate rather naturally to capability deficits in a TIS. However, the TIS perspective would consider a broader range of actors than only suppliers and buyers. It highlights also the role of government offices, research institutions, civil society actors, and so forth, that may support an innovation development. The three determinants proposed then reflect proximate conditions to how strongly coordinated a governance mode of a TIS should be. A

TIS, of which strong capability deficits exist, coordination failures abound, and institutional mismatch problems are strong, will require a rather centrally coordinated governance mode. On the other extreme, a TIS of which institutional conditions are mature, supportive contexts are in place, and capabilities of suppliers are rather equally developed, might work optimally under weakly coordinated mode.

Particular governance modes will therefore be more or less appropriate for enabling innovation system development and the appropriate modes will most likely change over system maturation. For example, strongly coordinated governance modes might hinder the entrance of new actors to the TIS, the development of supplier capabilities (learning), or the creation of markets, which all hamper further the development of a TIS. This may be due to high entry barriers in terms of technologies and financial investments. When a TIS matures, economies of scale can enable the rise of industry standards and the development of specialist competencies among suppliers, which might require a more weakly coordinated governance mode. An evolving TIS can lead to reduced complexity (of technologies, processes, activities, etc.), which may increase the ability to codify knowledge and transactions. To move from the analysis of single technologies towards entire socio-technical systems, the TIS analysis therefore has to be extended by considering governance modes at both value chain- and system levels in order to capture the dynamic coordination between upper and lower segments, as well as among the broader system actors.

4.2.3 Assessing TIS performance using a value-chain perspective

So far only few TIS studies explicitly addressed value chains in their research (for example (Hellsmark, 2010; Musiolik and Markard, 2011; Sandén and Hillman, 2011; Stephan et al., 2017; Andersson, Hellsmark, et al., 2018)). Some of these studies emphasize that the set-up of value chains is an important part of the system building process. Hellsmark (2010) reconstructs how value chains in biomass gasification are developed and Planko et al. (2016, p. 2330) take-up “coordination along the value chain” as one of the main aspects of their framework for strategic collective system building. Musiolik and Markard (2011) analyse the creation of an emerging fuel cell value chain. They conclude that the creation of a value chain is a crucial task in an immature technological field, and emphasize that analytically, value chain development is not well covered by the existing TIS functions. Other authors use value chain arguments to delineate TIS boundaries. Andersson, Hellsmark, et al. (2018) for instance define their TIS by the artefacts, actors, and rules along the industry-level value chain of electricity from a tidal kite power plant. Lastly, some of the studies used value

chains to emphasize the connections of TIS to different sectors and technologies (Stephan et al., 2017). Sandén and Hillman (2011) use value chain arguments to define different modes of relationships between technologies in innovation development. However, none of these studies have elaborated how the assessment of TIS development has to be extended in order to account for the interdependencies among the different segments of a value chain.

In the following, we propose a specific approach for analysing TIS performance across value chains. Before starting a TIS analysis, the system boundaries have to be defined (Bergek et al., 2008). In our case this implies that all the actors, networks, and institutions that contribute to the segments of a value chain have to be included, instead of treating them as part of the larger context or sector (see Andersson, Hellsmark, et al. (2018) and Stephan et al. (2017) for a similar view). We propose to start with a functional analysis of each segment of the value chain to identify the level of performance and the system weaknesses that characterizes them (see Table 4.2). Reading the table along a specific column results in a conventional TIS analysis of that particular segment of the value chain, e.g. of the panel manufacturing process in PV production, or strengths and weaknesses of innovation activities at the level of cell manufacturing. Reading each individual function from left to right provides a first indication of how well the innovation activities are balanced (integrated or not) across the different segments of the value chain, and whether bottlenecks can be identified (e.g. in terms of legitimacy problems or limits in the mobilization of resources). The virtual example that we have constructed in Table 4.2 describes a case in which innovation activities are well developed in segment 3 (e.g. the construction of the end product) but major legitimacy problems exist in terms of the extractions of core minerals and the disposal of the end products (such a configuration may be typical for high density batteries or smart phones).

Table 4.2 Functional profile of the TIS.

Functional analysis of each individual segment of the value chain (a darker shade indicates a further developed function). The lowest line represents the overall functional TIS assessment of each segment, the last column a first reading of the performance of each function across all segments. The lower right corner stands for the integration of all the partial analyses and adds the governance at the system level in order to achieve an integrated assessment of the TIS.

Functions	Segment 1	Segment 2	Segment 3	Segment 4	Assessment of functions across segments
Entrepreneurial activities					<i>Focused on 3</i>
Knowledge development					<i>Restricted to 3</i>
Guidance of search					<i>Restricted to 3</i>
Market formation					<i>Strong 1-3</i>
Resource mobilization					<i>Deficient in 4</i>
Legitimation creation					<i>Difficult 1&4</i>
TIS analysis for each segment	<i>Weakly developed</i>	<i>Emerging</i>	<i>Strongly scaling</i>	<i>Largely neglected</i>	Integrated assessment of the TIS & analysis of the degree of coordination at system level (complexities, codifiability, capabilities)

Reading Table 4.2 along horizontal lines however, only provides a first glance at the overall innovation performance of the value chain. Deficiencies in a specific segment may be more or less important for the overall functionality, depending on how each segment relates to all the others. We therefore have to specify mutual interdependencies among the different segments in order to provide an overall assessment of the entire value chain. This is done through an analysis of the three governance determinants (complexity of transactions, codifiability of information, capability of suppliers along the value chain) to explain the established governance modes in the TIS. This leads to the discussion of how different governance modes for the TIS can support or hinder overall innovation performance. As elaborated above, substantial deficiencies in the three determinants, both in terms of value

chains and system weaknesses, require a stronger coordination role by a lead firm or a manager of the TIS. Given that most of the pre-existing institutional conditions are weak, the system requires a key actor aiming at specific innovation development to take the necessary initiatives in leading and guiding most of the processes.

4.3 Methodology

In this paper we use a case-study design (Yin, 2009). The case is innovative on-site sanitation²⁴ provisioning in cities in low-income countries. The lack of sanitation supply in these cities is one of the most persistent development challenges. Increasing urbanization and the failure of sewer systems in the majority of urban contexts in low-income countries enlarge this problem (Koné, 2010) and ask for new types of solutions to solve the urban sanitation crisis. Innovative safely-managed on-site sanitation has the potential to improve sanitation services in these cities (Andersson, Hellsmark, et al., 2018).

This case can usefully be assessed with an extended TIS assessment, because providing a specific technology (e.g. the toilet/latrine) will not solve any of the problems without appropriate emptying, collection, transportation, treatment, and safe disposal or use of waste. This has not always been obvious in development cooperation initiatives, especially during the times of the Millennium Development Goals, when governments, development agencies, and NGOs responded to the lack of sanitation infrastructure by implementing programs to improve latrines, without consideration of what to do with the waste (Koné, 2010; Wald, 2017). This led to cities in which overflowing pit latrines, and waste being dumped in ditches and drainages in informal settlements became a normality.

Since 2008 the “sanitation chain” has become the standard terminology to describe the necessary components of sustainable urban sanitation: *user interface, storage, conveyance, treatment, use or safe disposal* of waste (Tilley et al., 2014). In this paper, we conceptualize these different segments as forming an ideal type sanitation value chain (Figure 4.1). Focusing on only one segment of the chain is insufficient to successfully develop sustainable sanitation services for urban low-income populations at scale (WSUP, 2017a).

²⁴ On-site sanitation is characterized by systems in which excreta and wastewater are collected and stored on the plot where they are generated. The treatment of excreta takes place on the plot or is conveyed for treatment elsewhere. On-site sanitation is different than off-site sanitation systems, in which excreta and wastewater are collected and conveyed away using a sewer technology (Tilley, et al., 2014, p. 173).

Innovating the sanitation chain requires therefore a number of innovations at different segments of the value chain. The extended TIS perspective is appropriate to analyse the role of governance modes both at the level of the value chain and at the system level. The sanitation chain does not represent a traditional value chain in the sense that actors have shifted the focus from selling toilets towards dealing with the “unwanted side product” of this market, namely faecal sludge. However, we may interpret the recent shift in the sanitation chain as an attempt to make sellable products out of the faecal sludge, mostly biogas, animal feed, and fertilizer (see below). Even though, the different initiatives have not yet achieved a convincing business case for these products, the associated innovation activities can be understood as innovating the whole value chain, considering upstream and downstream activities associated with human defecation. Moreover, although the on-site sanitation system in cities in low-income countries is rather localized than a globalized value chain, applying the notion of governance modes helps to inform us about the organization and coordination of the different innovation activities within a well-demarcated system.

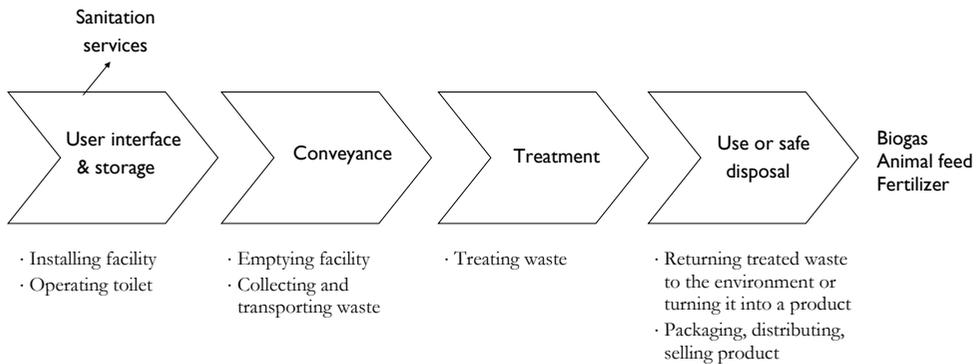


Figure 4.1 Segments, core activities and outputs of the sanitation chain

We specifically focus on the empirical case of on-site sanitation innovations in informal settlements of Nairobi, Kenya. Adequate provision of sanitation services to the city’s inhabitants is a fundamental challenge, especially in the informal settlements where 36% of Nairobi’s population lives (Mansour et al., 2017). The city has become a popular testbed for on-site sanitation innovations (Kalan, 2011; Bwire, 2016). Several social enterprises, NGOs, entrepreneurs, and Community Based Organizations (CBOs) try to introduce on-site sanitation innovations, which are more safe, dignified, clean, and well-organized than the sanitation options that are currently in use in informal settlements – such as pit latrines, septic tanks, hanging- and flying toilets, or even open defecation.

The analysis draws on semi-structured interviews with key informants in the sanitation sector in Nairobi. Interviews were conducted in two data collection periods between February-March and October-December 2016. The first data collection period was used to gain an overview of the sanitation sector in the city (see (van Welie et al., 2018)). The second data collection period was specifically focused on gaining in-depth knowledge about on-site sanitation innovations for this paper.

The interviewees were selected from different stakeholder groups. Several interviewees were identified during the first data collection period and snowball sampling was used to identify additional key informants. The sampling evolved during the field work based on the newly acquired insights. This paper builds on 36 interviews with actors that represent organizations implementing innovative solutions, as well as Ministry and Nairobi County officials, Water Board officials, representatives of NGOs, CBOs, and international developmental agencies. Appendix B provides an overview of the interviewees, we will refer to the interview codes in the remaining sections. An interview guideline was developed beforehand. Questions were structured around the TIS functions and the different activities in the segments of the sanitation chain. For example, questions focused on the availability of resources for on-site sanitation innovators; the acceptance of on-site sanitation services, conveyance, and reuse activities; the undertaking of activities related to knowledge development; and the expectations of the future growth potential of on-site sanitation services in Nairobi. Additionally, the interviewees were asked about their organizations' role in the different segments of the on-site sanitation chain, their alignments to other organizations, and their prospects for the field. The guidelines included small variations for the different stakeholder groups. Based on insights gained during the process, the interview guidelines were updated. In addition to the interviews, the first author also wrote notes based on observations during the field work. Lastly, various secondary data sources were used: reports, websites, journal articles, online newsletters, and online articles. As much as possible, all the data sources were triangulated.

All interviews were recorded, transcribed, and checked. The field notes and interviews were coded using MAXQDA 12 software. The TIS functions and value chain activities provided starting points for the coding scheme that evolved during the process in which new and more detailed codes were defined. This process can be described as “open coding”; labelling the phenomena in terms of concepts or categories (Gray, 2004, p. 331). As a first analytical step, an overview of the various actors' histories, projects, and pilots along the sanitation chain was created. Secondly, both the TIS functions in each segment of the sanitation

chain (vertical dimension Table 4.2), as well as across all segments (horizontal dimension Table 4.2) were analysed. Finally, an analysis of the value chain governance determinants (complexities, capabilities, codifiability) lead to insight in the governance modes in the TIS.

4.4 Results: assessing the performance of the on-site sanitation TIS in Nairobi

In this section, we outline the evolution of on-site sanitation innovations in Nairobi and analyse the three different sanitation chain initiatives that are currently implemented in the city. We then apply the TIS assessment framework to analyse the integrated functioning in each segment of the value chain and identify appropriate governance modes.

4.4.1 Evolution of on-site sanitation innovations in Nairobi

In the last decades several innovative on-site sanitation activities in Nairobi's informal settlements focused on individual segments of the sanitation chain. One example was several initiatives involving the introduction of portable in-home toilets. These innovations never exceeded the pilot phase, because the initiators failed to set up a reliable collection system for the waste. Consequently, residents stopped using the in-home toilets and converted them for various other uses (Cherunya et al., 2018). A second example was an innovative project aimed at improving the conveyance of sanitation waste through the professionalization of manual pit emptiers. Several emptiers were being equipped with protective clothes and special mechanical pumps to empty the pit latrines (NGO4, iNGO4, CBO2, CBO3). They also received management training. A designated disposal point into the sewer was created in agreement with the utility (NGO4, iNGO4). This project failed because the designated waste collection point vanished quickly as slum dwellers built houses around/over it, and the utility never really took care of the disposal point (NGO4, iNGO4, CBO2, CBO3). Also, the legitimization of manual pit emptiers among customers remained low, so their service was not always accepted. In this project, both the connection to the earlier and later segments in the chain were not well established. The focus was too much on the conveyance segment. The pit emptiers went back to (illegal) business as usual, which included dumping the waste into nearby rivers (NGO4). Concluding, these two examples of innovative on-site sanitation activities were not successful, because they did not address the interdependencies along the entire sanitation chain.

In order to overcome this oversight, several actors recently adopted more holistic approaches. They set-up and manage entire sanitation chains on their own. Currently, three individual sanitation chain initiatives are developed by independent actors in Nairobi's informal settlements: bio-centres, biodegradable bags, and Container Based Sanitation (CBS).

Bio-centres are community centres that have several functions, one of them are public sanitation facilities. A biogas reactor in the bio-centre treats faecal sludge to produce biogas. The biogas is used by local communities for cooking and to heat the showers in the centres (Wamuchiru, 2015). The residues of digestion are collected and transported by exhauster truck services. The concept was developed by a Kenyan NGO that introduced it in Nairobi in 2007. Up to 2014, 42 bio-centres have been installed in Nairobi's informal settlements (UmandeTrust, 2014).

The second value chain configuration is built around *biodegradable bags*, these are personal single-use biodegradable bags used in people's homes or at schools. On the inside the bag is coated with urea to disinfect the faeces directly (Tilley et al., 2014, p. 166). The bags are regularly collected and transported to a storage location for composting, after which they are reused as a fertilizer by coffee farmers (Patel, 2011; Wirseen, 2013). This approach was introduced in Nairobi in 2009, by an international social enterprise (Wirseen et al., 2009; Graf et al., 2014; Peepoole, n.d.). In the first years, the bags were sold to households, and there was a good demand among informal settlements' residents (SE8, SE9). Because of the high production costs the bags are currently not sold anymore (iNGO6), but about 100 schools in informal areas are provided with biodegradable bags for free, which is supported by donors (SE9).

The last configuration forms around *container based sanitation* (CBS). CBS services consist of stand-alone waterless toilets that capture waste in (portable) containers (Tilmans and Russel, 2015; WSUP, 2017c). The container toilets in Nairobi are so called "Urine Diverting Dry Toilets" that separate urine and faecal matter. The containers are installed as public toilets, shared toilets, at schools, and in homes. The containers are regularly collected, transported and the waste is treated and disposed or reused. The waste is composted and treated in a location outside of the city. Animal feed and fertilizer are produced and sold to farmers (Auerbach, 2016). CBS was introduced in Nairobi in 2011 by an international social enterprise (Esper et al., 2013; Auerbach, 2016). Until the end of 2017, 1134 CBS toilets have been installed in the city (Sanergy, 2018).

In order to identify system weaknesses and potential synergies among these initiatives, we

conceptualize the three initiatives as part of a local TIS of on-site sanitation.²⁵ Figure 4.2 provides an overview of the major actors and networks that make up the TIS.

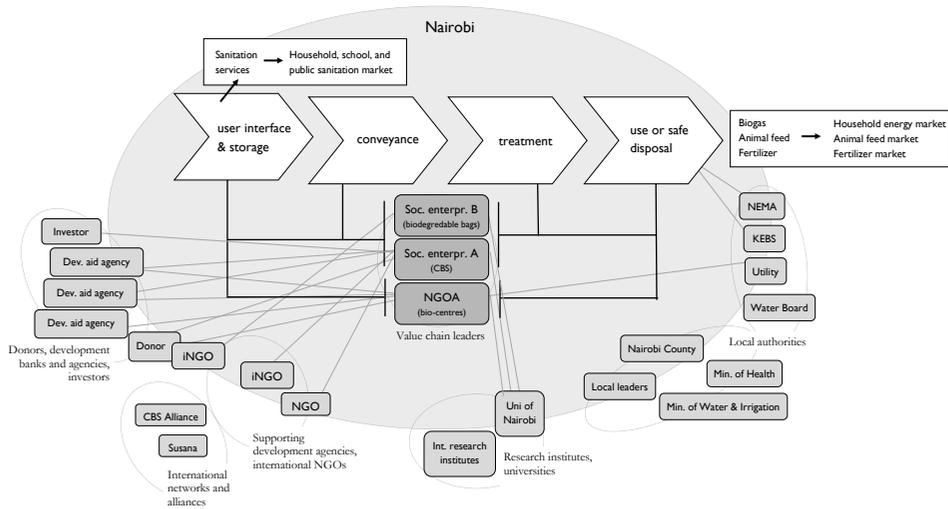


Figure 4.2 Main actors of Nairobi's on-site sanitation TIS in 2016 (compiled by the authors)

4.4.2 Functional TIS analysis of the individual segments of the value chain

The on-site sanitation TIS in Nairobi is only emerging. There are three main actors in the system driving the operations. These three sanitation chain leaders manage different value chains in a vertically integrated way. In the following, we present the most salient points of the functional analysis of each individual segment of the value chain across the three initiatives (vertical dimension in Table 4.3).

User interface and storage

Many different experiments and entrepreneurial activities take place in the first segment of the chain in the TIS. We see that this segment has progressed farthest in terms of TIS development. The experimentation and development in the TIS have resulted in

²⁵ In this paper we only focus on on-site sanitation initiatives that take place in informal settlements, are highly innovative, take care of the complete sanitation chain, and aim to scale-up. Unhygienic on-site sanitation practices of pit latrines and septic tanks that are not emptied; or whereof the waste is dumped in rivers, are not considered to be part of the TIS. We also exclude small initiatives such as a CBO that runs public sanitation facilities using composting toilets (see (KDI, 2014)), as there is no aim for scale-up. Lastly, we exclude on-site sanitation services such as mobile toilets for events, as these are not being developed for informal settlements.

approximately 76.000 daily users²⁶ of the different types of innovative on-site sanitation services in Nairobi's informal settlements. Innovation activity in this segment comes in various forms. For example, innovative designs of container toilets as Urine Diverting Dry Toilets are being developed to separate urine and faecal matter (Tilley et al., 2014, p. 46). New types of “in-home” CBS toilets are being developed (SE1, SE4). And a local production plant to produce biodegradable bags is being set up (iNGO6). Research is being done into various aspects, such as improving toilet designs and catering for different preferences of users. Other research focuses on the production of different types of biodegradable bags (SE8) or improved construction methods of the CBS toilet (lighter, smaller) (SE6). Some research is conducted on how to convert pit latrines into CBS toilets (SE1). These research projects are often done in collaboration with (international) research institutes and universities (SE2, SE8, iNGO6). Resources from international donors were mobilized to develop and conduct various innovative pilot projects with improved toilet designs and models (SE4, SE10, iNGO1). Especially for the CBS approach, international investments and grant capital was mobilized (Auerbach, 2016).

Most on-site toilet innovations have generally been accepted among users. However, for completely new toilet interfaces, such as biodegradable bags or Urine Diverting Dry Toilets, socio-cultural issues have had to be overcome (SE5). The founder of a social enterprise explains what sort of sensitivities innovators have to adapt their toilet to:

“... (some) communities will not accept to have children sit on the same toilet as the adult, or a man and a woman, you know, cultural taboos that are kind of sometimes difficult to understand... so the sensitivity around our design model in terms of service was very hard to be well-structured around different communities ... trying to be as general as possible so it serves as many people as possible...”

The sanitation chain leaders therefore organize different education and sensitization activities for residents in informal settlements to support market formation (and promote sanitation in general) (SE5, SE8, SE9, iNGO6). The bio-centre approach has already gained widespread legitimation through the active involvement of local community groups (NGO1, NGO3) (Binale, 2011; Otsuki, 2016; Wamuchiru, 2017).

The legitimation of innovative on-site sanitation services among policymakers has

²⁶ 1134 container-based toilets, 53.436 daily users (Sanergy, 2018); 42 bio-centers, 5000 daily users (derived from (UmandeTrust, 2014)); biodegradable bags provided to 100 schools, 18.000 children per day (Peepoople, n.d).

progressed in recent years. This resulted in the recognition of well-managed on-site sanitation as a legitimate toilet option in cities (in addition to seweraged toilets) in the Kenya Health and Sanitation (KESH) policy of the Ministry of Health (Kenya, 2016). Especially the bio-centre model is an accepted on-site sanitation option: both by the Nairobi County government (NGO1, NGO3, GOV5) and the public utility (Wamuchiru, 2015). In contrast, the biodegradable bags are sometimes perceived as a sub-standard sanitation option among policymakers (IDO2), and only accepted as a temporary solution. The international social enterprise plans to lobby at the government to take it up as a viable solution for schools (iNGO6).

The innovative on-site sanitation services hold a small share of the market for public and shared toilets (GOV1). A market for public toilets has existed for many years in Nairobi.²⁷ Many informal settlement residents use pay-per-use public sanitation services on a regular (daily) basis (Cherunya et al., 2018). In the bio-centres, innovations to improve the payments for public toilets, using cashless systems, have been tested (NGO1, NGO2, NGO3). Not all on-site sanitation services in the TIS are paid for, biodegradable bags are given for free to schools (SE8, SE9) (Wirseen, 2013; Graf et al., 2014). The CBS approach also fuelled new types of market development: in the first segment of the chain the enterprise operates a franchise system in which entrepreneurs are provided with a toilet and run it as a business (Auerbach, 2016).

Conveyance

In the conveyance segment of the sanitation chain only a few innovations take place, focused on improving the collection efficiency in order to lower the costs of collection in the individual initiatives (SE6). This is perhaps the most poorly developed segment in terms of TIS performance. There is relatively little experimentation and research done to develop new technologies. Mostly conventional wheelbarrows, handcarts and trucks are used to manually transport the waste to collection points from where trucks transport the waste to treatment plants (SE6, SE8, SE9, NGO1). The bio-centres only need conveyance services for the residues from the anaerobic digestion, which is taken care of by conventional exhauster trucks. Only few experiments with different manual and mechanical collection models for biodegradable bags and containers have been undertaken (SE6, SE8) (Wirseen

²⁷ The market for public sanitation increasingly gained attention as a result of the success of the “Ikotoilets”, a public sanitation concept in Nairobi run by Ecotact, that as one of the first actors introduced a clean and good public sanitation service in 2006 (NGO6, SE11).

et al., 2009). More research in this segment seems to be necessary, because collecting waste in the narrow streets of informal settlements is sometimes difficult with the means that are currently being used, and without proper collection, on-site sanitation systems are bound to produce many negative side effects.

Waste is collected and transported on a relatively small scale by the individual sanitation chain leaders in the TIS. Increased legitimacy for the manual collection of containers and biodegradable bags is necessary. Local communities need to be sensitized to overcome the stigma surrounding human waste collection. For example a CBO's founder points at a cultural problem that CBS innovations on conveyance of waste need to overcome:

“...a lot of people do not want to have their shit carried around in containers (...) the cultural issues around these are so many. And also there is something people attach to dignity, you know.”

A social enterprise's founder explains how the taboo around human waste complicates the work for TIS actors in informal settlements as follows:

“...in Kenya ... we have very many cultures and when we talk about slums we have to be considerate of the different sections of the slums ... certain cultures in Kenya are sensitive on who or how their waste is handled ... there are all these taboos that go around how the waste is managed...”

Trust needs to be created in different settlements by the TIS actors that the collection services are safe, clean and reliable. In container based sanitation systems QR codes can for example be used to track if the collected waste reaches the treatment site (Saul and Gebauer, 2018). Sanitation chain innovators thus have to prove that they can handle faecal sludge safely, which is a critical point for many Kenyans (IDO1). Chain leaders also have to convince potential employees that it is a proper job to do (SE6, SE9).

The sanitation chain leaders successfully lobbied to get permission to handle human waste at various Ministries and regulators (SE3). The conveyance services get licenses from the National Environment Management Authority (NEMA) to transport human waste in containers and bags on trucks (SE3, SE9). A market of human waste transportation services already exists in the city, provided by manual pit latrine emptiers and exhauster truck operators who empty septic tanks using a vacuum pump (CBO2, CBO3, PA1). This market is not well-regulated and controlled, however, so a lot of waste is dumped (iNGO2). The collection and transport services run by the on-site TIS initiatives are well-managed and

hygienic, compared to these services.

Treatment

Many different innovative treatment technologies have been implemented by the TIS actors, such as anaerobic digestion, (co-)composting, and black soldier flies (NGO1, SE2, SE3, SE7, SE8). Also some research on recovering nutrients from urine have been conducted (Sanergy, 2016). These treatment technologies are all used on a relatively small-scale. The corresponding TIS analysis of this segment therefore shows an emerging field of innovation, which experiences increasing activities. Much research and testing is done to develop these treatment technologies further, in collaboration with local universities and international research institutes and universities (NGO1, SE2, SE7, SE8, iNGO6). Other options are also explored, for example the potential to install a separate treatment plant for the residues from anaerobic digestion in the bio-centres. Financial support for this research comes mainly from international donors.

The other system's functions in this segment are relatively underdeveloped. There seem no clear goals for the (large-scale or central) treatment of waste from on-site sanitation systems in Nairobi. Even though handling human waste is legal, the TIS's small-scale treatment activities of faecal sludge from on-site sanitation systems have not gained the same legitimacy as the publicly run large-scale waste water treatment plants. This can be derived from the fact that it is difficult to obtain land and permission to build a treatment plant for faecal sludge (NGO1, SE3). The possibilities of treating faecal sludge other than using anaerobic digestion are also somewhat unknown (NGO3). The legitimization for this segment of the value chain might furthermore be hindered by the earlier mentioned taboos of handling human waste in Kenya.

Use or safe disposal

Several reused products have been developed in the TIS, such as fertilizers, animal feed and biogas. This segment of the value chain is only emerging in terms of TIS performance, but has a high potential to enter other markets. A lot of research and experiments are conducted by the sanitation chain leaders in cooperation with (international) research institutes and local universities to optimize the reused products (NGO1, SE2, SE8, iNGO6). For example, experiments have been conducted in bio-centres with transporting biogas from the centres to households (NGO1, NGO3) (Umande, 2016). And waste from CBS was

used to experiment with the production of liquid fertilizer and bio char (Auerbach, 2016). The “waste as a business” paradigm at policy level contributes to the legitimacy of reusing human waste. The 2009 Implementation Plan for Sanitation of the Ministry of Water and Irrigation states that facilities receiving high volumes of effluent, such as on-site sanitation facilities in public places and institutions, should be “designed for reuse of effluents to produce biogas, fertilizers, and water for irrigation to protect the environment and generate the advantages of sanitation for production” (Kenya, 2009). Also the KESH 2016 policy encourages technologies that enable safe recycling and reuse of waste streams (p.52). Reused products such as insect-based animal feed also feature in the Kenyan press (see for example Mwendwa (2016)). And attention for reusing human waste in the international press often focuses on the innovations in Nairobi (see for example Whitehead (2014); Scherer (2015); Njoroge (2016); Ruiz-Grossman (2016); Arbogast (2017)).

The reused products in the TIS start to access various existing markets. Some of the products are licensed and sold as new (types of) products in markets of fertilizers, energy, and animal feed (SE3). For example, the organic fertilizer made from CBS sanitation waste is a new product in the organic fertilizer market (Auerbach, 2015). The insect-based animal feed from CBS complements the animal feed market. This market is underserved in Kenya, and relies currently on fishmeal. According to the founder of the CBS enterprise, farmers are dissatisfied with currently available options (quality, inconsistent supply) (Auerbach, 2015). The fertilizer made from the biodegradable bags is currently given away to farmers, as it still lacks the necessary licenses to be sold (iNGO6). The biogas produced in the bio-centres has so far mostly been used as an energy source to heat showers and cooking, services for which users pay a low price at the bio-centres (NGO1, NGO2, NGO3) (Wamuchiru and Moulaert, 2017). The NGO implementing the bio-centres looks into other possible usages of biogas, because it aims to commercialize its fertilizer and biogas production (NGO1) (Umande, 2016).

Despite the policy support towards reuse, the adoption and sales of the reused products are to a certain extent hindered by the taboo of using human waste. The TIS actors have to gain user acceptance for their reused products (NGO1, NGO3, SE12). Especially users with insufficient information about the product’s safety can be hesitant towards using fertilizer or biogas made from human waste (NGO6). An iNGO’s environmental health project officer explains this problem:

“... there is a knowledge gap to close, from the policy makers to the community, who have never

seen waste as a source of income. We have always treated it as a waste and should not interact with it, we have always seen it as something that should be discarded away from the human environment...”

Different strategies are used in the TIS to overcome these issues: marketing of fertilizer without mentioning the raw material that is used, demonstrations of the products to show their effectiveness, and education about the use and safety of the products (NGO1, NGO3, SE8, SE9, iNGO6) (Farmstar, 2016).

4.4.3 Overall functional profile of the TIS

In this section we present the assessment of the functions across all segments (the horizontal dimension in Table 4.3), in order to suggest different governance modes for coordinating the overall TIS in the next section.

Despite various activities in each segment of the value chain, overall the different TIS functions are mostly still rather poorly developed across all segments. The *development of knowledge* takes place in all segments, to different degrees. The *diffusion of knowledge* in most segments of the TIS is however very limited. For example, many different treatment technologies have been developed and tested by different actors in the city, which led to some replication (NGO1, SE7, SE8). A potential platform to exchange more information on on-site sanitation chains is the “Technical Working Group Urban Sanitation” consisting of NGOs, CBOs, and social enterprises under the Ministry of Health, aiming at accelerating sanitation in cities (NGO6, iNGO2). Conferences, meet-ups, and networks at the international level seem stronger in coordinating knowledge exchange, for instance the “Sustainable Sanitation Alliance” and the “CBS Alliance” (CBSAlliance, 2017; SuSanA, n.d.). Most of the chain leaders in the TIS have strong connections to these international networks in which they coordinate with likeminded actors around the world. These coordination efforts do not show much effect at the local level though.

Guidance of search for all segments of the TIS is hindered by the unclear and fragmented institutional mandate for sanitation in Kenya: the Ministry of Health is responsible for sanitation and the Ministry of Water and Irrigation for sewerage²⁸ (GOV4, IDO1). Additionally, the preference for sewerage systems as “modern, high-tech infrastructures” in

²⁸ This splintered responsibility for sanitation is supposed to be solved in new policies that are currently being developed in line with the new constitution of 2010.

cities among most policymakers, planners, and the utility hinders the TIS (GOV1, GOV2, NGO6, iNGO2, iNGO3). The Technical Working Group Urban Sanitation of the Ministry of Health has advocated for the creation of County guidelines for urban sanitation to guide on-site sanitation innovation developments (NGO6, iNGO2).

Market development is only just starting to take place and is correspondingly still rather weak; most notable developments happen in the first and last segment of the value chain. The variety of sanitation services that are offered in the first segment create some competition in the offerings of sanitation services in informal settlements. Market developments in the last segment are very recent, reused sanitation products have started to be sold in energy, animal feed and agriculture sectors. The links to these sectors and the demand for the reused products however have high potential.

Resource mobilization for the TIS from the County- and National Government is low (GOV1, NGO5, NGO6, iNGO2, IDO2). If these governmental actors invest in sanitation at all, their support will mainly focus on sewerage infrastructure. Private investments in the TIS are also low because sanitation businesses are not very lucrative (iNGO3). In contrast to the lack of resource mobilization for the TIS in Kenya, grants and investments from the international development cooperation community are increasing, especially for treatment and reuse activities (NGO6, SEI1). An NGO's environmental health project officer explains:

“...of late donors don't want to fund “flush and forget”, they want it renewable: either reuse or recycle ... they are more environmental friendly.”

As described for the individual segments in Section 4.4.2, *legitimation* for on-site sanitation has overall progressed in recent years, especially at a policy level, where it is now recognized as an appropriate option. However, the taboo of handling human waste continues to hinder the creation of legitimacy in individual segments of the sanitation chain especially for the conveyance segment, also fuelled by the widespread idea that sewerage systems are the most superior form of sanitation systems. Table 4.3 shows the overall functional profile of the TIS.

Table 4.3 Functional profile of the TIS.

Functional analysis of each individual segment of the sanitation chain in Nairobi (a darker shade indicates a further developed function). The lowest line represents a summary the functional TIS analysis of each individual segment of the sanitation chain (section 4.4.2). The last column summarizes the assessment of each function across all segments (section 4.4.3).

Functions	Segment 1 User interface & storage	Segment 2 Conveyance	Segment 3 Treatment	Segment 4 Use and/ or safe disposal	Assessment of functions across segments
Entrepreneurial activities					<i>Well developed, mainly focused on 1, increasingly 3&4</i>
Knowledge development					<i>Well developed, mainly focused on 1, increasingly 3&4; Diffusion of knowledge is poor</i>
Guidance of search					<i>Lacking along all segments</i>
Market formation					<i>Various developments in 1, high potential in 4</i>
Resource mobilization					<i>Lacking behind, mostly deficient in 2</i>
Legitimation creation					<i>Difficult, especially in 2, but also to a lesser extend 3&4</i>
TIS analysis each segment	<i>Relatively well-progressed</i>	<i>Poorly developed</i>	<i>Emerging, increasing activities</i>	<i>Emerging and high potential to enter other markets</i>	TIS functions developed differently in each segment. Overall functional development is relatively poor, due to lack of coordination between different initiatives

4.4.4 Explaining established governance modes in the TIS

We now finally assess the currently dominant governance modes that can be observed in the presented on-site sanitation chain TIS, and in how far alternative governance modes would contribute to improving the innovation success of this case.

As a first step, we have to identify the interdependencies among the different value chain segments. The activities in the individual segments of the value chain interrelate in many ways. Use and disposal depend on the reliable collection, conveyance, and treatment of the faecal sludge. Treatment depends in particular on a reliable conveyance system. Toilets can only be operated safely if conveyance works in a reliable mode. This requires coordination of the location, size, and type of toilet facility and the frequency of the conveyance services. Conveyance needs to have access to the treatment facilities in order to be successful. Through analysing these strong interdependencies, we see for instance that the most weakly developed segment (conveyance) is also the one which all the other segments depend on. We can therefore already identify a major weakness in the whole TIS, which substantially hampers innovation development. We will now proceed in analysing the governance mode based on three determinants as introduced in Section 4.2.2 (complexity of transactions, codifiability of information, capability of suppliers along the value chain), based on which alternative ways to organize the TIS in Nairobi are identified in the next section.

Complexity of transactions

The complexity of information and transactions in the sanitation chains is high. A variety of on-site toilet types are developed and used in the TIS to meet the demands of the diverse informal settlement residents. These toilets are used at various locations, depending on the availability of space in the dense informal settlements. Facilities are operated in public spaces, used in homes, shared on plots and installed in schools. Emptying of the facilities and collection of waste is a precise job in the narrow streets and bad road conditions. These services are organized differently by the three initiatives. The vertically-integrated operators try to control the waste that is captured. For example, in the CBS initiative urine and faeces are separated and the toilet operators have therefore to control which waste is captured in the containers, in order to not hamper the treatment process. Similarly in the bags, waste that is captured has to be very well controlled: toilet paper is allowed, but no menstrual hygiene products or pampers. It is difficult to control how bags are used, for example some schools only use the bags for urine collection and not for faeces (SE8). Many different

innovative treatment technologies are used by the TIS actors, such as anaerobic digestion, (co-) composting, and black soldier flies (NGO1, SE3, SE7, SE8). These are enabled by the incoming waste streams, but in some cases the treatment is also restricted by the quantities and qualities of the incoming waste (SE3).

All said, the information that needs to be exchanged between the activities in the segments of the sanitation chain is diverse and concerns various aspects (e.g. technical specificities, quality and quantity of waste, physical conditions, social habits, etc.). Given that the basic conditions in Nairobi are rather poor, and institutions for the sector are still not well developed, transactions take often place on the basis of informal communications and depend highly on the local relationships, and specific forms of know-how. This may lead to miscommunications and irregular requirements or expectations that need to be fulfilled. The complexity of transactions in the innovative on-site sanitation chain in Nairobi is therefore considered high.

Ability to codify transactions

The complex information in the transactions in the sanitation chain (e.g. toilet types, type of waste that is captured, quantity of treatment, characteristics of fertilizer from human waste, etc.) is currently barely codified. The new KESH policy ideally enables the development of guidelines and standards for sanitation and hygiene in the city. However, the policy is still being operationalized at the County level (GOV1, GOV4, NGO6, iNGO2). So far, County guidelines and standards are either vague or do not exist. There are some transnational guidelines set by the WHO, and the SDGs (NGO6, IDO2), but these are very general and do not help codification on a local level. For example, no standards exist for fertilizer from human waste, and at the bio-centres standards from the World Food Program are being used, which say that fertilizer from human waste can only be used on indirect crops (NGO1). All-in-all, the TIS lacks workable guidelines and specific standards, and the codifiability of the transactions is low.

Capabilities of the supply base

The analysis shows that the complexity of innovating in on-site sanitation in Nairobi has increased since the value chain initiatives have started operating. The number of actors involved in operating sanitation chains is low. In Nairobi only three organizations act as sanitation chain leaders, almost without outsourcing any of the activities, because the

capabilities of potential suppliers is low. There are many potential suppliers specialized in conveyance of waste in the city, but these have barely been included by the initiatives (these exhauster truck businesses and manual pit emptiers work in rather unhygienic and unprofessional ways). Concluding, the sanitation chain leaders in the TIS do not source these services because capabilities of these suppliers are low.

In sum, we may posit that the complexity of transactions is high, the codifiability of transactions is low, and the capability of suppliers in the current TIS can be described as low. To accommodate for these characteristics, individual sanitation chain leaders in Nairobi opted for a hierarchical value chain governance mode. This way, the leaders are in control of the core processes, and coordination among the segments can be dealt with inside of the respective organizations. However, at the TIS level, coordination between the initiatives is minimal. We therefore are confronted with a highly coordinated governance mode at the level of each value chain, but rather weakly coordinated activities at the TIS level. This implies that a high number of system weaknesses will not be tackled by the individual initiatives and in the end will hamper innovation success of the overall field.

4.5 Discussion: improving the governance mode of the on-site sanitation TIS

We presented an approach to scrutinize how both the value chain dimension and the innovation system dimension could be leveraged to improve the overall innovation success in the on-site sanitation sector in Nairobi. In general, we can say that the corresponding TIS is still in a “formative phase” (Bento and Wilson, 2016), as several innovation system functions are absent or underdeveloped. The functional analysis of the value chain segments revealed a heterogeneous set of innovation activities in the different segments and also exposed considerable system weaknesses. Furthermore, we identified the governance modes of the local TIS that encompasses the three value chains. We saw that the individual sanitation chain initiatives adopted hierarchical governance modes: the chains are internally highly coordinated and the sanitation chain leaders have vertically integrated all the segments. While at the system level, we identified that there is little coordination among the core actors, and so the governance mode of the TIS provides rather weak coordination.

The governance modes at the system and the value chain level might hamper the overall innovation performance of the TIS. The hierarchical governance mode of the individual

initiatives is appropriate to compensate for current system weaknesses. However, due to the lack of coordination at the system level it also leads to a high overall complexity of the individual innovation processes and a lack of sufficient critical mass to run certain segments of the value chain effectively. This is most obvious in the treatment part. As soon as treatment capacities will be built up at an effective scale, the corresponding sanitation chain leaders will be confronted with bottlenecks in terms of collection and transport. Indeed, some sanitation chain leaders lack sufficient waste stream to utilize their treatment plants at full capacity (SE3).

The vertical integration of the initiatives may also create problems for new actors to enter the TIS, who could provide higher levels of capabilities and resources. The hierarchy mode of governing the individual initiatives might thus ultimately hinder coordination and the scaling up of on-site services in the city. We will now discuss how this analysis can inform the future improvement of on-site sanitation innovation by strengthening of system functions through the establishment of alternative governance modes.

At the system level, governance mode should likely change from a very distributed form, to a more coordinated mode. Firstly, this requires conditions for a better *codification of transactions* which can enable/stimulate knowledge diffusion among the different TIS actors, especially among the chain leaders. They have complementary skills, but currently do not interact much. This represents a missed opportunity, because the different chain leaders conjointly have access to a broader set of knowledge sources, e.g. by translating knowledge from global networks to the city level through their research collaborations. Increased codifiability would ease the exchange of complex knowledge, create mutual learning opportunities, and deliberate knowledge transfer between TIS actors. Codification could for example include explicit strategies in the realm of guidance of search activities regarding innovative products (e.g. for urine diverting toilets) or process specifications (e.g. guidelines for innovative treatment of waste) (see also, Yap and Truffer (2019)). Additionally, increased codification might help to mobilize new actors (e.g. entrepreneurs, implementing NGOs) who can provide complementary capabilities and resources, to enter the TIS. For new actors interested in contributing to the reuse activities, explicit knowledge about the quality and quantity of faecal waste is important to enter the sanitation chains. One way of codifying transactions in the sanitation chain is through innovative digital technologies (e.g. using QR codes on containers to ensure that all the collected waste ends at the treatment site (Saul and Gebauer, 2018)). Lastly, increased codification in the form of standards for reused products or standards for toilets (hygiene, location, opening hours etc.) by the Kenyan Bureau of

Standards (KEBS), is essential for market formation of the TIS in the first and last segment.

Secondly, reducing the *complexity of transactions* would also contribute to reconfiguring the TIS' governance mode. Complexities can be tackled when building on synergies at the system level. This could also help to overcome challenges of individual sanitation chains leaders. The different TIS actors could meet to exchange complementary knowledge and to potentially reduce the complexity of transactions in their current sanitation chain for instance regarding the management of different waste streams or the coordination of the conveyance processes. This would reduce transaction complexities, and help to scale and legitimize one or a few of the innovative conveyance and treatment systems. Thus, the TIS could benefit from a more coordinated type of governance in the second and third segment of the sanitation chain, by installing a dialogue between more or less equal partners (Gereffi et al., 2005). The recent efforts of Nairobi County's Health department trying to set-up a coordination mechanism between the different actors working on on-site sanitation in Nairobi, could maybe contribute to achieving such changes (GOV1).

Lastly, *increasing the potential supplier competences* could seemingly help to develop the TIS. In this paper, the chain actors barely rely on suppliers, mostly because the competences of incumbent suppliers in Nairobi - mostly exhauster truck operators and manual pit emptiers - is low. These incumbents do however deal with the majority of conventional (not hygienic, dignified) on-site sanitation services in the informal settlements. Increasing the capabilities of these actors might help scale-up the volumes of waste that are treated and reused. The capacities of the city's small-scale private service providers should be improved in order to comply with the requirements of sustainable services provision (e.g. use of protective gear, professional customer interaction, etc.). And more importantly, the links between the conveyance segment and the treatment, use and disposal processes should be carefully organized, in order to not repeat the mistake of previous projects. An additional benefit of increasing potential supplier's capabilities, is that it could prevent manual pit emptiers from becoming the losers of a transition to well-managed on-site sanitation services. For such small-scale sanitation service providers, participation in new sanitation chains can be a crucial mean to obtain information and learn about hygiene standards set by the local government, or accessing new types of markets. However, working with manual pit emptiers has proven to be difficult, and increasing their capabilities might require substantial learning efforts and knowledge transfer.

All told, we provided new insights into how to improve the overall on-site sanitation TIS

in Nairobi's informal settlements through illustrating how more coordinated governance modes would be appropriate at the system level. This has also some implications on how the individual value chain initiatives will be managed. The strong hierarchical mode will also have to give way to more relational configurations to reap the synergies. We see for instance that the user interface and storage segment is amenable to competition and entrepreneurial experimentation. A competitive relationship is probably appropriate for defining the relationship between the different operators, to stimulate the current successful systemic innovation development of this segment. Conveyance, however, shows the highest coordination deficit and interdependency with other value chain segments and should therefore be more strongly coordinated by the different initiatives. Therefore, the individual initiatives would have to disintegrate this segment of their value chains and by this implement more relational value chain governance modes. This might help to generate stronger guidance for innovation activities, improve legitimation and attract more resources. Treatment, use, and disposal are important segments for the success of the integrative value chains and would need intermediary intensity of coordination, in order to enable experimentation to test a variety of alternative approaches, to tap alternative markets, and to improve legitimacy. Finally, we may ask who could take over leadership in these new governance arrangements. As the current initiatives are run by rather independent organizations with clearly delimited business models, coordination would probably need support from actors that control resource flows such as local governments or international donors. We assume that these actors would have a strong interest in improving the overall effectiveness of their investments after so many years of rather limited successes.

Figure 4.3 illustrates a summary of the development of on-site sanitation innovation in Nairobi. It started with splintered innovations focused on individual segments of the sanitation chain and has developed in an emerging on-site sanitation TIS based on three sanitation chain initiatives observed today. As discussed in this section, potential future improvements of innovation development and diffusion could include a more coordinated governance mode at the system level.

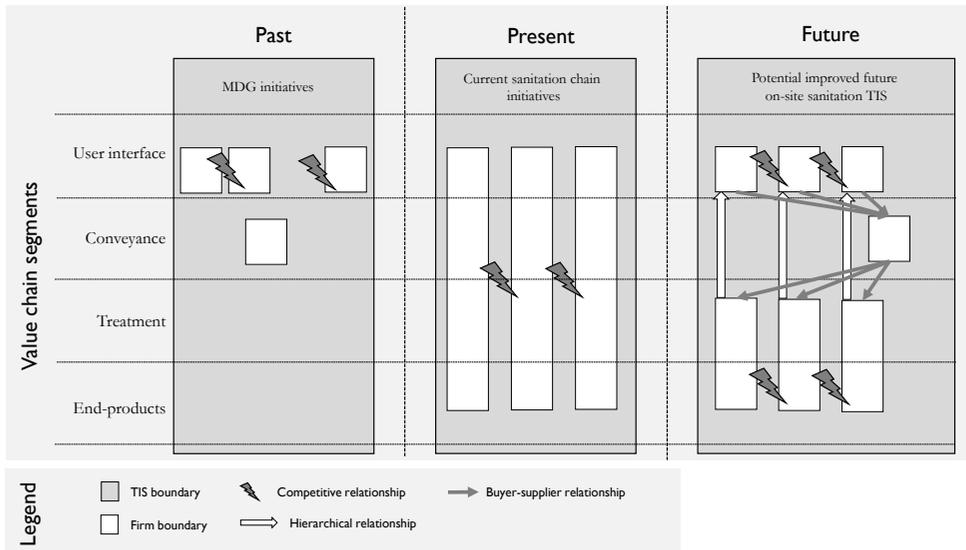


Figure 4.3 Three phases of on-site sanitation innovation in Nairobi: Innovations focused on individual segments of the sanitation chain in the past; three sanitation chain initiatives in the present; and possible changes in governance mode of the on-site sanitation TIS in the future.

4.6 Conclusion

The extension of the TIS analysis to entire value chains provides substantial insight into the challenges that innovations in urban informal settlements in low-income countries need to address to transform basic service sectors. This paper showed how on-site sanitation innovations in Nairobi recently shifted focus from individual artefacts to the establishment of entire value chains. By extending the TIS approach towards value chains, we were able to identify a number of system weaknesses and mismatches in the governance modes, at and between segments, of individual value chains and the TIS level, which explain (at least partly) the limited effectiveness of extant initiatives. Currently, social enterprises and NGOs have adopted rather hierarchical governance modes to coordinate the respective value chains. Through a systemic perspective that analyses the different initiatives as one TIS, the paper identified the conditions of more relational or modular governance modes, which promises actors a fresh look on how to improve innovation successes towards transforming the sanitation sector towards a more sustainable state.

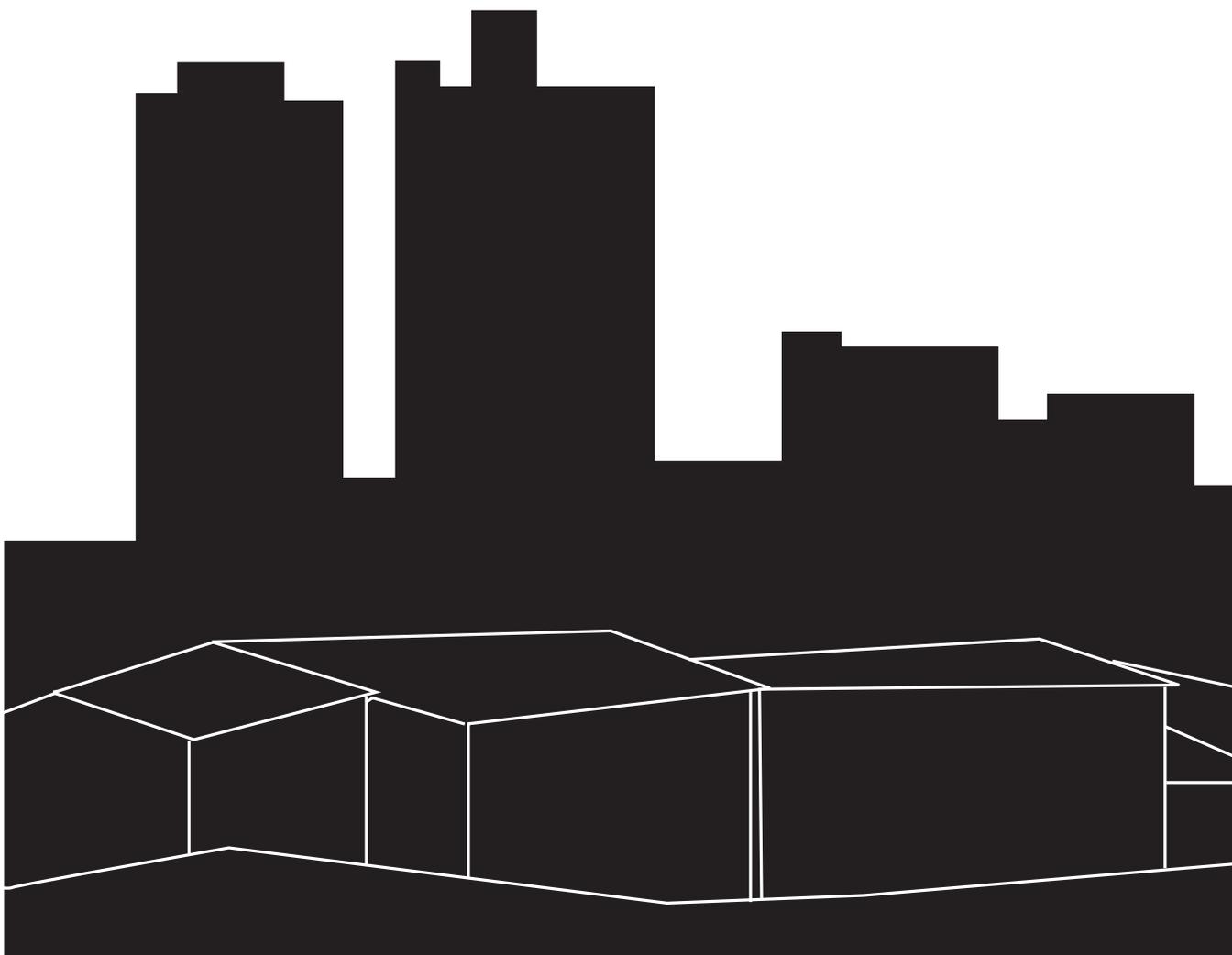
The contribution of this paper has therefore been twofold. As a first attempt to explicitly adopt the value chain perspective and its governance modes in TIS analysis, the paper opens

up a broad variety of possible policy recommendations to improve innovation development by taking into account the interdependencies across different segments of the value chain. Our analysis identified how functional weaknesses could emerge out of inefficient coordination between upper and lower stream activities. A value chain perspective broadens the scope of TIS analyses and gives pointers for strategic “system building” in the form of potential coordination of actors and activities along the value chain (Musiolik et al., 2012; Planko et al., 2016).

Second, the paper translated the notion of governance modes to the level of innovation systems, which can encompass multiple (competing) value chains as well as broader system actors and processes. The proposed determinants of systemic governance modes in this paper provide new insights into the context conditions for desired governance modes at the TIS level and serve as points of interventions for lead actors and policy makers. In so doing, the paper also argues for a more proactive re/configuration of systemic governance modes by actors, especially under the conditions of a formative or newly emerging sector where key system managers play a crucial role. The Nairobi case shows how a conventional hierarchical model of single value chains might hamper new actors to enter and interact in the TIS, and how certain innovation activities could be more coordinated (e.g. conveyance and treatment of waste) when taken into account the multiple existing initiatives. Also, including new actors outside a TIS can contribute to overcome individual capability failures and functional weaknesses, such as the lack of legitimation. The systemic perspective therefore helps generate integrative lessons about how individual sanitation chain leaders in Nairobi may improve the local situation, especially when aligning their respective initiatives through a more strongly coordinated governance mode in the overall TIS. Considering governance modes in order to improve TIS performance is therefore a novelty.

Although this paper has a limited focus on one particular sector in a city, the framework may be applied to other relevant cases in which the success of a TIS is also highly dependent on strategic coordination between upper and lower stream segments across the value chain of an entire socio-technical system. Extending the TIS framework in these directions will not only apply to cases in low-income countries, but opens up for a whole set of new innovation and transition processes. Although the presented case only demonstrates the dynamics of governance modes within a value chain situated in Nairobi, the framework may be applied to the context of a globalized value chain provided that it refers to a sector/ socio-technical system i) that is emerging and is still in its early formative phase globally; ii) of which system building processes are still immature; or iii) that is undergoing transformation of

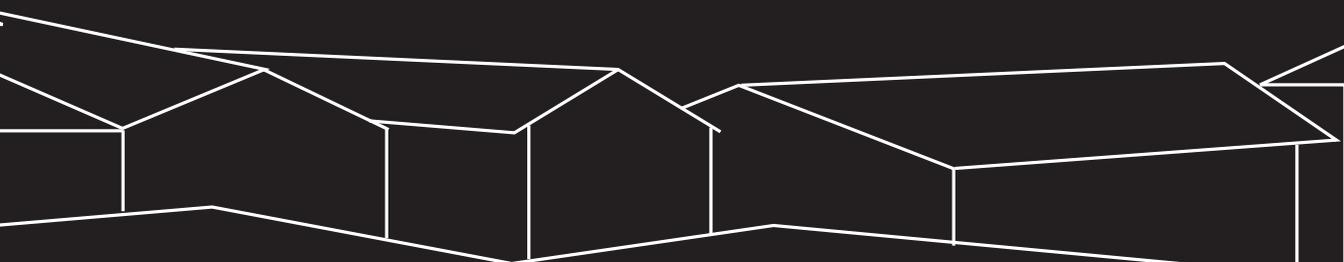
which actors aim at changing the determinants/context conditions. These exemplify cases that require a coordinating role of lead firms or system managers in actively reconfiguring the governance modes of a TIS. In the present paper, we were not able to develop a fully-fledged typology of TIS governance modes, due to the limitations of a single case study. We hope, however, to have paved the way for such an endeavour by elaborating conditions for stronger and weaker coordination within a TIS, and revealing some possible modes of governance. Further studies could elaborate what sort of alternative governance modes at both value chain and system levels are impacting innovation developments in the growth phase of a TIS.



Chapter 5

The formation of innovation systems in international development cooperation

van Welie, M.J., Boon, W.P.C., & Truffer, B. The formation of innovation systems in international development cooperation: The role of intermediaries in urban sanitation.
Revised version under review at Science and Public Policy



Abstract

The transformation of urban basic service sectors towards more sustainability is one of the “grand challenges” for public policy, globally. A particular urgent problem is the provision of sanitation in cities in low-income countries. The globally dominant centralized sewerage approach has proven incapable to reach many of the urban poor, which are left with unhygienic non-grid options. Recently, an increasing number of actors in international development cooperation have started to develop alternative *safely managed non-grid approaches*. We analyse their efforts as an emerging “global innovation system”, and investigate how its development can be supported by systemic intermediaries. We present the activities of the “Sustainable Sanitation Alliance” (SuSanA), an international network that coordinates and facilitates activities in the international sanitation sector, based on 21 in-depth interviews and secondary data. The findings show how SuSanA supported this emerging innovation system, and discuss how it will need to adapt its role to deal with different challenges as the innovation system grows.

5.1 Introduction

Transforming urban basic service sectors towards more sustainability is one of the “grand challenges” for public policy, globally. For this purpose, the United Nations (UN) have formulated first the Millennium Development Goals (MDGs) in 2000, which were followed by the Sustainable Development Goals (SDGs) in 2015. They provide targets that all countries should achieve regarding the provision of services in energy, water, housing, health, etc. A particularly pressing area for the improvement of life conditions are informal settlements in cities of low-income countries. Rapid urbanization and insecure tenure rights lead to a general under-provision of basic services. Sanitation in particular has been a sector where the UN goals have not seen much improvement over the last decades, despite myriads of initiatives by donors, NGOs, private and public actors. Over the years, it became more and more apparent that conventional centralised sewerage systems are confronted with major problems in informal settlements and the situation is unlikely to change anytime soon. Therefore, international donors, the private sector, development agencies, and research institutes have started to experiment with a wide variety of technologies and business models around innovative non-grid systems. However, these initiatives have not yet gained the same legitimization as the globally dominant centralized sewerage approach. We analyse the conditions for these alternative systems to mature while addressing the grand societal challenges in sanitation by framing these initiatives as part and parcel of an emerging (global) technological innovation system, and ask in how far this innovation system needs to be coordinated at a global level and which kind of actors can take a lead in this endeavour.

For many years, international development cooperation²⁹ focused on providing sanitation for all residents in cities of low-income countries. This has been difficult because of a lack of city-wide sanitation planning, large inequalities between neighbourhoods, rapidly expanding informal settlements where there are issues with land tenure, low education levels, and institutional and political challenges (Letema et al., 2014; Okurut and Charles, 2014; Andersson et al., 2016; Ramôa et al., 2016). Two approaches have dominated most

²⁹ International development cooperation is increasingly diverse and includes a range of diverse activities and actors. Its goals can be summarized as: (i) guaranteeing universal basic standards of social protection; (ii) promote convergence among countries’ standards of living; (iii) support efforts of low-income countries to participate in provision of international public goods. It is explicitly meant to support national or international development priorities; not driven by profit; discriminates in favor of low-income countries and is based on cooperative relationships that seek to enhance low-income country ownership. International development cooperation can have the form of financial transfer, capacity support or policy change (Alonso and Glennie, 2015).

sanitation projects in international development cooperation: in city centres *grid* approaches, based on waterborne centralized sewerage systems became widely adopted. Rural areas and urban informal settlements saw the promotion of several forms of traditional *non-grid* options, mostly focusing on the provision of toilets, like pit latrines. The two approaches, however, did not result in hygienic and affordable sanitation services for a majority of citizens in these cities. Sewerage systems are considered to be the global “gold standard” of sanitation and have therefore been implemented in many countries of the world in a rather uniform way (Fuenfschilling and Binz, 2018). In cities of low-income countries they are mostly restricted to city centres and high-income neighbourhoods. Initiatives to expand them into informal settlements often proved to be too costly. Also, they suffered from water scarcity and required skills and financial resources for operation and maintenance, which are often scarce. As a result, these infrastructures hardly ever reach the urban poor (Esrey et al., 1998; Black and Fawcett, 2008; Lüthi et al., 2010; Jewitt, 2011; Strande et al., 2014; Andersson et al., 2016; Reymond et al., 2016). The problem of insufficient sanitation provision is rapidly exacerbating because of the massive urbanization rates in most low-income countries. At the same time, traditional non-grid options notoriously lead to serious environmental and health problems in cities: latrines contaminate ground water sources, are unhygienic when they fill-up and overflow, and the emptied sludge is often disposed without appropriate treatment (Esrey et al., 1998; Koné, 2010; Strande et al., 2014).

As a reaction to this persistent sustainability challenge, the United Nations declared 2008 the “International Year of Sanitation” to increase attention and stimulate action towards solving this problem and achieving Millennium Development Goal 7c on sanitation (UN-Water, 2008, p. 2). The International Year of Sanitation increased awareness for the global sanitation problem among actors in international development cooperation. The initiative stimulated the development of innovative approaches and technologies, which was further strengthened under the Sustainable Development Goals (SDGs) after 2015. Leading actors started to agree that the existing non-grid options had serious shortcomings because of overly focusing on toilets and by this ignoring the safe collection, transportation, and disposal of the human excreta. A new technological field therefore took shape that we label here as the *safely managed non-grid sanitation (SaMaNG)* approach. It aims at providing hygienic services to users while enabling safe management of the waste, to prevent contamination of the operators and the environment. Until today, SaMaNG has not developed into a fully spelled-out sustainable sanitation approach yet. It still encompasses a wide variety of technologies, which are promoted by different actors and rely on various supporting infrastructures and institutional arrangements. This leads to a diversity of service offerings

and business models that depend on continuous support by international donors and city-wide implementation so far. Therefore, SaMaNG represents a promising and emerging, yet not fully-developed field that still has to mature to provide safe and affordable sanitation services.

We propose to analyse the conditions of successful development of this field by framing it as an emerging (technological) innovation system (TIS). A TIS consists of different types of actors that interact in networks and define/shape institutions to contribute to the generation, diffusion, and utilization of a new technology or a new product (Carlsson and Stankiewicz, 1991; Markard and Truffer, 2008). For an innovation system to function well, processes of knowledge creation, market formation, resource mobilization, and legitimation need to be developed in a balanced way (Hekkert et al., 2007; Bergek et al., 2008). The seamless operation of these processes requires a whole set of resources and capabilities of different actors, the formation of appropriate networks and the adaptation to, or change of institutional context conditions (Klein Woolthuis et al., 2005). The innovation system perspective implies that some conditions for innovation success are not under control of individual actors, but emerge only through the interplay of strategies by different actors. The maturation of a specific technological field is therefore not only conditioned by the sum of all resources that actors can provide, but also by the ability to overcome coordination deficits and institutional mismatches. TIS research has repeatedly shown that innovation success often depends on the existence of appropriate intermediaries, who identify lacking capabilities, help to overcome coordination failures, and work on the removal of institutional barriers (van Lente et al., 2003).

Besides these structural conditions, innovation systems research has elaborated how time and space intervene as core variables to explain innovation success. In dynamic terms, it is well established that innovation systems develop in stages: In the formative phase, they often consist of loosely coupled initiatives by diverse actors that pursue a wide variety of alternative designs. In the subsequent growth phase, the number and intensity of intermediary activities tends to increase, networks get densified and more and more specific institutions emerge. This leads to the formation of dominant designs and increasingly standardized markets. In a third stage of maturation, knowledge, resources, legitimacy and markets further grow and align until the point where they converge into a widely accepted new paradigm for the field (Bergek et al., 2008; Markard, 2018a). Regarding the spatial characteristics, innovation system research was traditionally restricted to developments occurring in specific countries or regions (Cooke et al., 1997; Asheim and Gertler, 2005; Lundvall, 2007). More recently

however, scholars have criticised this containerized view of space (Coenen et al., 2012) and formulated frameworks for addressing multi-scalar relationships in innovation systems and ranging all the way up to the global level, as evinced by the notion of “global innovation systems” (Binz and Truffer, 2017).

Taking the dynamic and spatial perspectives into account, tackling the sanitation challenge can be understood as a need for managing an international innovation system that provides solutions to a global societal challenge. The innovation system therefore becomes particularly conditioned by public policy interventions, or as some authors have called it, it is a case of a “mission-oriented” innovation system (Boon and Edler, 2018; Mazzucato, 2018). In the context of such systems, we expect intermediaries to play an important role in enabling cooperation between different types of actors, facilitate flows of knowledge, or contribute to articulating visions of future solutions, etc. (van Lente et al., 2003; Howells, 2006; Klerkx and Leeuwis, 2009). Especially in early phases, intermediaries need often to take a neutral stance with regard to specific technologies or actors, while still supporting specific directions of the innovation system building processes (Kivimaa et al., 2018). In a transnational setting, intermediary activities might be even more challenging because the wide variety of geographical contexts may require different solutions, which hamper the alignment of visions among different actors.

In this paper we analyse the formation of a global innovation system in the field of SaMaNG sanitation by focussing on the work of a globally operating intermediary. We analyse how intermediaries can contribute to overcoming capability deficits, coordination failures and support the formation of specific institutions, how they contribute to the generation of new knowledge, the mobilisation of resources and the generation of legitimacy for the field, while having to accommodate for a variety of geographical scales and technological alternatives. For this purpose, we conduct an in-depth case study of a specific international intermediary in the SaMaNG field: the Sustainable Sanitation Alliance (SuSanA). SuSanA was established in 2007. Its founders were convinced that for the further establishment of sustainable sanitation approaches, the rather large number of isolated initiatives in the field had to be better coordinated, especially with regard to knowledge generation, resource mobilization, and technology legitimation for non-grid alternatives. SuSanA was set up as a network of member organizations (including research institutes, private sector, NGOs and development agencies) and individuals who wanted to contribute to achieving the Sustainable Development Goal on water and sanitation (SuSanA, n.d.). The network brought together actors from all over the world by organising meetings, webinars, and

by providing a website and online discussion forum. We reconstruct how the SaMaNG innovation system developed since the 1970s, and identify how SuSanA supported all sorts of innovation related processes over the last decade, based on 21 in-depth expert interviews and extensive secondary data.

The paper is organized as follows. In the next section, we introduce the innovation studies literature in order to provide an analytical lens to assess the role of intermediaries in mission-oriented, transnational innovation systems. In the third section, the case and data sources are explained. Section four elaborates the results of our study. We provide an assessment of the developments in the SaMaNG field, which leads to the current challenges that the innovation system is confronted with. Particular emphasis is on the specific contribution of SuSanA to these developments. In section five, we discuss how the structure and activities of SuSanA might have to be adapted in the future to accommodate for the changing needs of a maturing innovation system. The conclusions elaborate general requirements that can be derived for intermediaries that aim at supporting transnational, mission-oriented innovation systems in the longer run.

5.2 Theoretical background

5.2.1 Global societal challenges and innovation systems

To solve the global sanitation problem, there is a need for all sorts of technological and social innovations. In the academic literature, there has been growing interest in how to formulate innovation policies that are able to tackle these grand societal challenges (Kuhlmann and Rip, 2018; Robinson and Mazzucato, 2018). We join them in using the term “mission-oriented” to specify this particular focus on solving global societal challenges. The innovation literature distinguishes two types of mission-oriented policies: a “type 1” use of missions focused on technological challenges such as putting a man on the moon, and a “type 2” of complex missions focused on solving global societal challenges (Foray et al., 2012; Mazzucato, 2018; Robinson and Mazzucato, 2018). We focus on type 2 missions that others have similarly described as mission-oriented innovation policy centred on complex (wicked) societal problems, focused on long-term goals, and having a transformative character (Schot and Steinmueller, 2018). As for solutions we do not focus solely on ‘big science’ or single technological fixes, but strive for a wider variety of interrelated innovations (Wanzenböck et al., 2018) developed and championed by a diverse set of actors, including demand-side

actors (Boon and Edler, 2018). In this paper, we start from the premise that type 2 missions call for a systemic approach: rather than stimulating a focal technology and set of actors, multiple technologies, approaches and actors are necessary to address the challenge, at least in the first stages of development.

The literature on innovation systems takes a systemic perspective on the interaction of actors in networks and the role of institutional arrangements in the promotion of innovations (Weber and Truffer, 2017). Innovation is broader than just developing new technologies, but also applies to new services, management arrangements, and business models. Furthermore, innovation happens as a result of the interplay of actors (e.g. firms, government, research institutes, NGOs, etc.) situated in networks and contextualized by institutions (e.g. formal rules and regulations as well as norms and values). Innovation system studies have introduced notions and concepts to better understand the emergence and implementation of innovations. Moreover, innovation systems have been applied to development contexts in order to analyse persistent development problems and the role of (technological) innovations therein (Blum et al., 2015; Kebede and Mitsufuji, 2017; Kriechbaum et al., 2018; Sixt et al., 2018) and are argued to be relevant new perspectives for development scholarship (Romijn and Caniels, 2011).

A specific type of innovation system focuses on the emergence of one (or a related set of) new technologies and is called the Technological Innovation System (TIS). A TIS “is a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” (Markard and Truffer, 2008, p. 611). Within TIS several system processes should operate in order for the system to perform well: knowledge production and diffusion, resource mobilization, market formation, legitimation creation, guidance of search, and entrepreneurial activities (Hekkert et al., 2007; Bergek et al., 2008). System processes that are insufficiently developed indicate need for action on the side of policy makers or other actors wanting to support the innovation. Additionally, one can identify “system weakness/failures” in an innovation system in the form of coordination, institutional, or capability deficits, that need to be corrected in order for an innovation to develop successfully (Klein Woolthuis et al., 2005). Recent TIS studies have started to extend their focus from single technologies to entire socio-technical systems (Sandén and Hillman, 2011; Bergek et al., 2015; van Welie et al., submitted) and this has prepared the ground for analysing technological innovation systems that explicitly address grand societal challenges (Frenken, 2017).

Grand societal challenges typically span across a wide range of geographical regions. The analysis of such processes should explicitly address innovation dynamics occurring at different scales (Coenen et al., 2012). To take spatial scales and boundaries into account, Binz and Truffer (2017) propose a conceptualization of transnational TISs as being constituted of different functional subsystems that can be attributed to specific geographical scales: transitional, regional, national, etc. A “global innovation system” performs well, if the functional developments happening in different subsystems are effectively coupled so that a coherent innovation trajectory develops (Binz and Truffer, 2017). These “structural couplings” are shared elements (actors, networks, institutions, technologies) between different subsystems of a global TIS or between them and specific contexts (Bergek et al., 2015). They can be formed by partnerships, transnational cooperation’s, academic network, or international trade fairs. Structural couplings can in particular be facilitated by intermediary organizations.

5.2.2 Intermediaries in innovation systems

Intermediary organizations have been identified as key actors in the innovation literature since the 1990s. Early studies focused on knowledge brokering intermediaries in the context of innovation management and technological development (e.g. Bessant and Rush (1995)). In this line, Howells (2006) defined the term “innovation intermediary” as an organization or network that acts as a broker or agent in any aspect of the innovation process between two or more parties (Howells, 2006). Examples of intermediaries are industry associations (Watkins et al., 2015), user organizations or product development partnerships in the health sector (Moran et al., 2010; Boon et al., 2011), innovation platforms in agriculture (Lamers et al., 2017), NGOs and consultancies in the energy sector (Bush et al., 2017), or transition intermediaries (Kivimaa et al., 2018).

In the early 2000s, the role of intermediaries in the context of innovation systems was signposted by Van Lente and colleagues (2003). These “systemic intermediaries” enable cooperation between different types of actors for successful innovation. They can close cognitive, normative, or managerial gaps that can hamper the proper functioning of an innovation system (Klerkx and Leeuwis, 2009). Intermediary organizations might for example “connect, translate and facilitate flows of knowledge” (van Lente et al., 2003, p. 248). Especially in the context of low-income countries, maturing innovation systems are often characterized by several system weaknesses, e.g. capacity and coordination deficits (Shou and Intarakumnerd, 2013; Klerkx et al., 2015; Tigabu et al., 2015c; Kriechbaum et al.,

2018). Strengthening intermediaries could improve the functioning of innovation systems in these contexts, for example towards more coordinated innovation processes (Kilelu et al., 2011; Szogs et al., 2011; Intarakumnerd and Chaoroenporn, 2013; Klerkx et al., 2015).

In the literature several lists of intermediary functions have been proposed (see for example Howells (2006); Boon et al. (2011); Kivimaa (2014)). Systemic intermediaries typically pursue three key intermediary functions in innovation and transition processes: “1) *articulation of options and demand*, which includes the stimulation of technological variety and the search for possible applications. This also includes of the awareness of possible futures; 2) *alignment of actors and possibilities*, by initiating and strengthening linkages between the various parts of the innovation system. It includes the building and sustaining of networks and the facilitation of interfaces; 3) *support of learning processes*, by enhancing feedback mechanism and by stimulating experiments and mutual adaptations” (van Lente et al., 2003, p. 256). Distinct key activities and processes in the various phases of innovation system development, suggest different roles for systemic intermediaries over time (van Lente et al., 2003).

The literature has so far mainly focused on intermediaries that act in innovation systems that are clearly demarcated in time and space. Recently, Kivimaa and colleagues defined intermediaries that contribute to sustainable transitions, presented an agenda for future research on this topic (Kivimaa et al., 2018) and showed how the roles of transition intermediaries change during the different phases of transitions (Kivimaa et al., 2019). The latter paper showed that systemic intermediaries are relevant to all transition phases. They articulate visions and a variety of technological options in the early stages as neutral, unbiased facilitator and broker, whereas they later aim to engage in market creation and creating new institutions. Furthermore, a few recent studies have discussed intermediaries in innovation systems in multi-scalar contexts (Lamers et al., 2017; Lukkarinen et al., 2018). However, still not much is known about how intermediaries connect subsystems in global innovation systems (Binz and Truffer, 2017, p. 1295). In this paper we seek to better understand the potential role of intermediaries in supporting system building activities in a transnational context, towards overcoming a persistent global societal challenge. This means that we explicitly consider intermediation across different spatial scales, and discuss the challenges and lifecycle of such intermediaries in different phases of innovation system building.

5.2.3 Conceptual approach

We propose to analyse the contribution of a specific intermediary to overall system development by assessing its impact on the core innovation system processes (knowledge production and diffusion, resource mobilization, market formation, legitimation creation, guidance of the search, and entrepreneurial activities, see Hekkert et al. (2007); Bergek et al. (2008)) in subsystems at different geographical scales. We focus on networks that, just like individual actors or organizations, can act as a systemic intermediaries, when they have a certain agency and organizational core with which they facilitate the three systemic intermediary functions of articulation, alignment, and learning (van Lente et al., 2003). Our analytical framework builds on the following two conceptual perspectives.

First, we elaborate how the three key functions of a systemic intermediary as identified by van Lente et al. (2003) contribute to the innovation system processes. We do that building on a recent proposal by Lukkarinen et al. (2018) who specify how a broader set of intermediary activities (based on Kivimaa (2014)) can be classified under the system processes. We sort this broader set of intermediary activities into the three key intermediary functions. We then used Lukkarinen et al. (2018) to add the innovation system processes to the activities sorted under the three key intermediary functions. This which leads to the following proposal:

- 1) *Articulation*: articulation of needs, expectations and requirements; advancement of sustainability aims; strategy development; policy implementation (*guidance of search*); acceleration of the application and commercialisation of new technologies (*market formation*).
- 2) *Alignment*: creation and facilitation of new networks, managing financial resources, identification and management of human resource needs (*resource mobilization*); gatekeeping and brokering, configuring and aligning interests (*legitimation*).
- 3) *Learning*: knowledge gathering, processing, generation and combination; communication and dissemination of knowledge; education and training; provision of advice and support (*knowledge development and diffusion*); prototyping and piloting, investment in new businesses (*entrepreneurial activities*); technology assessment and evaluation (*legitimation*).

Second, when addressing grand societal challenges, we expect that intermediation has to play a different role in different phases, and has to address processes across different spatial scales. We thus have to take into consideration that the needs for intermediation change over the different maturation phases of an innovation system (van Lente et al., 2003). Furthermore,

we frame the innovation processes as part of a “global innovation system” (Binz and Truffer, 2017). This implies to consider the existence of potential subsystems emerging in various countries or regions as well as the interlinkages between them through adequate structural couplings. We thus propose to extend the conventional understanding of system intermediation focused on a TIS in a specific country or region, by a geographical dimension. Intermediaries therefore have to not only contribute to innovation system processes in one specific subsystem, but also to the creation or strengthening of structural couplings, as an additional process to ensure system maturation and innovation success (e.g. by means of discussion platforms, and in establishing partnerships between actors from otherwise isolated regions). This means that the intermediary function of “alignment” should be expanded to include contributions to coordination among existing subsystems in different countries and regions as well as the creation and strengthening of structural couplings between them.

This leads to our analytical framework as illustrated in Figure 5.1. We identify how actors (left side of Figure 5.1 e.g. international development agencies, donors, NGOs, states, research institutes, community groups, etc.) can team up in networks to fulfil the three key intermediary functions for the development and maturation of a global innovation system (middle of Figure 5.1). We further propose to analyse how intermediary functions contribute to different system processes in different phases, in specific subsystems at particular spatial scales (right side of Figure 5.1). Finally, we identify how intermediaries contribute to the creation or strengthening of structural couplings between the different subsystems (thick lines between the boxes at the right side of Figure 5.1).

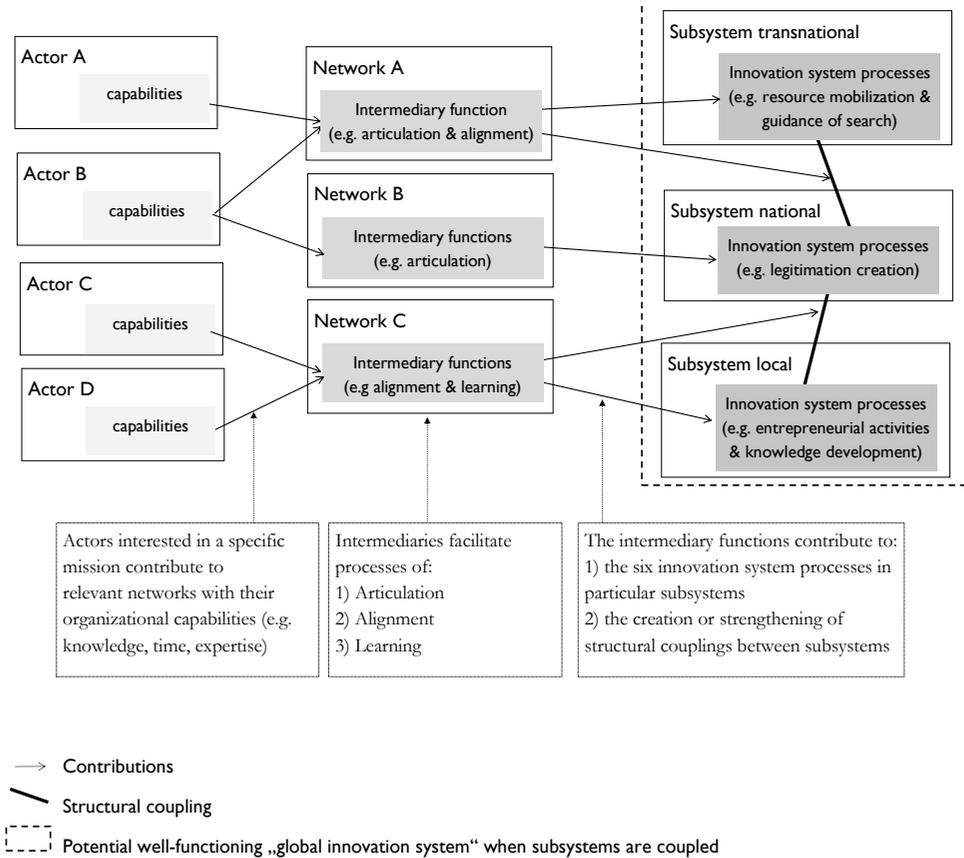


Figure 5.1 Analytical framework combines insights from (van Lente et al., 2003; Binz and Truffer, 2017; Lukkarinen et al., 2018)

5.3 Case selection, data and method

We conduct a case study of the “Sustainable Sanitation Alliance” (SuSanA) in the period 2007-2017 (Yin, 2014), to gain in-depth insights about the role of an intermediary in an innovation system. SuSanA is a network that facilitates and coordinates sanitation activities in international development cooperation, aiming to contribute to SDG6 on sanitation. It was founded in 2007, by several key individuals from Western and Northern-European development agencies and research institutes. It was established to address the lack of coordination in the sanitation sector, strengthen the sector’s capabilities, and raise awareness, promote and create a vision on sustainable sanitation. It has grown into a coordination and knowledge sharing platform, organizer and supporter of meetings and conferences, and

takes a role in advocacy. SuSanA has currently 330 partner organizations and about 10.000 individual members (SuSanA, 2019). It has 13 thematic working groups and a “core group” of experts which takes operational decisions for the network. The SuSanA secretariat, based at GIZ³⁰, facilitates and coordinates the organization and outputs of the SuSanA network.

SuSanA is a unique case in the context of sanitation, because there has been no other similar network and knowledge platform that has been solely focused on sanitation in the last decade; and it is a typical case in the sense that it represents an intermediary network that connects multiple scales in international development (comparable to networks in global health, agricultural research for development, or diffusion of renewable energy technologies, see Boon et al. (2011); Platonova (2013); Lamers et al. (2017)).

The case study is based on data from 21 in-depth, semi-structured interviews conducted with experts between February and October 2018 (see Appendix C). The experts were identified using snowball sampling. The interviews lasted between 30 and 120 minutes. All interviews were recorded, and were either transcribed or extensive summaries were written. The interviews were triangulated with secondary data, such as scientific literature, organizational reports, books, and webpages, to increase validity (Cresswell, 2009). The extensive information about SuSanA available on the network’s website and forum was also used. Among others, documents produced by SuSanA (e.g. vision, factsheets, etc.), minutes and agendas of SuSanA meetings, and recordings of meetings and webinars were used. Lastly, the secretariat shared basic data on their partners, including the year in which the organizations became a SuSanA partner. A list of the most important books, reports, and webpages used for the case study is provided in the Appendix D.

We analysed the data in several steps. First, we created an overview of SuSanA’s characteristics and history, as well as of the broader historical sectoral developments. This included ordering and linking key events and actors along a time-line. Second, we created an overview of the main actors in the emerging innovation system on safely managed non-grid sanitation. Third, we used the intermediary functions and innovation system processes to analyse the innovation developments, and distinguished development phases in which different intermediary and innovation system processes became dominant. Finally, we wrote a narrative and created a summarizing figure of the development of safely managed non-grid sanitation and SuSanA, based on the previous steps. The narrative was checked by two experts to validate the interpretation of the data.

³⁰ GIZ – Gesellschaft für Intern Zusammenarbeit (German Corporation for International Cooperation)

5.4 Results

In this section we present the evolution of urban sanitation in international development cooperation since the 1970s until today, and explain how new safely managed non-grid sanitation approaches have developed. We then analyse the activities focused on safely managed non-grid sanitation in the last decade as an emerging innovation system, and identify the role of SuSanA as an intermediary in these.

5.4.1 Evolution of urban sanitation approaches

Sanitation in low-income countries has been a topic of international development cooperation since approximately the 1970s. While most work in international development cooperation was focused on rural areas, some early work on urban sanitation was initiated by John Kalbermatten and his colleagues at the World Bank, who set-up the Water and Sanitation Program (WSP) in 1978 (Figure 5.2). The program started to look into different, at that time still very controversial, technologies that took non-sewered sanitation as a starting point. Many called this direction “unethical”, because it contrasted with the grid-based sewerage systems that were considered as the international standard, safeguarding public health (esp. among public health sector actors and engineers). Even though the WSP was a program unit hosted within the World Bank, the Bank did, at that time, not finance the controversial work; the WSP was mainly financed via the United Nations Development Program and bilateral organizations.

The development of both sewerage systems and non-sewered sanitation options continued over the past decades. This led to two main approaches in sanitation provisioning in international development cooperation: 1) *Grid* approaches, based on centralized and decentralized waterborne sewerage systems. Sewerage systems originate from Europe in the 19th century, where they were invented to deal with the outbreak of waterborne disease (Geels, 2006). Ever since, sewerage has been considered the standard and most viable approach for sanitation in urban areas worldwide among most urban planners, utility managers, and donors. 2) Traditional *non-grid* approaches focussed on on-site toilet facilities without regular emptying and adequate treatment of the accumulated waste. These two approaches have dominated international development cooperation for decades. In projects in urban areas, the grid approach has been dominant and preferred by most influential donors and development agencies, because it was associated with modernity and seen as the ultimate solution for the urban sanitation problem. Traditional non-grid approaches

were mainly used in projects in rural areas, but on-site projects, such as installing pit latrines, have also been implemented in cities, especially during the Millennium Development Goals (MDGs) period (2000-2015), when latrines were installed in large numbers to reduce open defecation to meet the MDG's sanitation goal. Until the 1990s innovations in both approaches were mostly incremental, for example in non-grid “Ventilated Improved Pit latrines” (VIPs) and pour flush toilets were introduced, in the 1980s (Figure 5.2). At the same time in grid approaches, incremental innovations to lower the costs of grid systems were introduced: condominal and simplified sewerage, and related decentralised wastewater treatment plants (Figure 5.2).

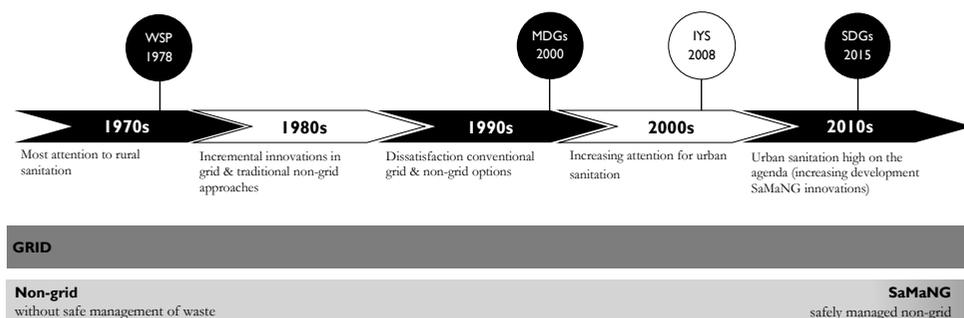


Figure 5.2 Representation of the history of international development cooperation on urban sanitation (by the Authors)

The worldwide acceleration of urbanization in the last two decades led to increasing attention for the shortcomings of both approaches to establish city-wide inclusive sanitation. To tackle these shortcomings new approaches, ideas, and technologies have been developed since the 1990s, to complement existing options.

One of the early alternatives that was proposed was ecological sanitation or *ecosan*³¹. Based on ecosystem thinking, this approach focused on “closing the loop” and reuse of nutrients from human urine and faeces for agriculture. The approach was mainly promoted by a group of actors in western and northern Europe, such as development agencies (e.g. German and Swedish development organizations GIZ and SEI), during the 1990s (Figure 5.2). These

³¹ The principles underlying *ecosan* were not new. Sanitation systems based on ecological principles have been used for hundreds of years in different cultures. However, at the end of the 1990/2000s there was a revival of interest in *ecosan* (Langergraber and Muellegger, 2005). *Ecosan* especially gained renewed attention as an option for low-income countries in the international development community. Exemplary is that the most widely cited source of ecological sanitation, (Esrey, et al., 1998), is written by the Swedish International Cooperation Agency and focused on low-income countries (Brands, 2014).

agencies considered ecosan as a sustainable solution for the global sanitation problem, and invested in several ecosan projects around the world between the 1990s and the early 2000s. The promoted advantages were preventing (water) pollution, enhanced hygiene as a result of source separation and dehydration of faeces, safe use of products of human excreta for energy, nutrients and soil conditioner, and little material and energy use, compared to the existing approaches. The first International Ecosan Conference was organized in China in 2001. At the same time however, the ecosan approach was contested by several research institutes, development agencies and banks. It was criticized for its potential public health risks, lack of demand and acceptance among users, and cultural inappropriateness in certain contexts (e.g. the Arab countries). Opponents of ecosan feared that the ecological dimension of sanitation would overtake the priority of improving public health as the main goal of sanitation systems. It caused a lot of tension in the sector and proponents were even referred to as “ecosan warriors” and “freaks” (Black and Fawcett, 2008, p. 123). Despite some successful pilot projects in different countries, the acceptance and uptake of ecosan was limited, even after decades of donor support. Towards the end of the 2000s, a majority of the actors in international development cooperation eventually agreed that ecosan was not an encompassing one-size-fits all solution for the shortcomings of the other approaches, but only appropriate in specific cases. Ecosan, or prioritizing ecological principles, has never become an established alternative approach for urban sanitation. The term has been less-and-less used, and the last International Ecosan Conference was held in 2007.

Ecosan alone was a too narrow solution for the complex shortcomings of grid and non-grid approach. However, one could argue that the attention for resource recovery in the ecosan concept was the start of various other innovation developments focused on handling the waste from non-grid sanitation facilities in cities, from the early 2000s onwards (Figure 5.2). These innovations were not characterized by a particular technology, but rather utilized a large variety of different approaches to establish sanitation systems. Many innovations that have been developed since the 2000s were non-grid focusing on safe capture, transport, treatment, and disposal or use of waste. They became known as *safely managed non-grid sanitation (SaMaNG)* approaches. This emerging technological field is envisioned to replace traditional non-grid facilities without waste management in cities, and complements grid approaches, which remain very important in terms of investments and widespread implementation in cities worldwide. Slowly, leading international organizations start to agree a combination of SaMaNG, as well as grid systems, are both needed to reach city-wide inclusive sanitation in low-income countries.

In the 2000s, the new emerging technological field was still populated by various actors that were separately testing many different types of SaMaNG approaches. Its further development was hampered by a lack of coordination, capabilities and absence of a supportive institutional environment. Further developed of the field required solving these system failures, in which intermediaries could play an important role.

5.4.2 SuSanA and safely managed non-grid sanitation innovation development

The developments of this emerging SaMaNG field during the last decade can be conceptualized as an emerging innovation system, because new types of institutional structures have been created, and actors started to engage collectively to build a favourable environment for new types of approaches (Musiolik et al., 2012; Planko et al., 2016). One of the prime movers in solving the coordination deficits in the sector and engaging in the development of SaMaNG has been the SuSanA network. We will now turn to its role as an intermediary in the activities since 2007.

As presented, since the early 2000s various development actors promoted different SaMaNG approaches, and there were several controversies about the newly developed concepts and approaches. As sanitation was put on the (political) agenda in the International Year of Sanitation (IYS) in 2008 (Figure 5.2), there was an urgent need for consensus building and coordination among sanitation actors. Collective advocacy for the general importance of sustainable sanitation during this year was required. Furthermore, the IYS provided a chance to improve legitimization, mobilize resources, increase knowledge, and create markets for SaMaNG innovations. Therefore, in preparation of the IYS, a small number of German, Swedish, and Swiss research institutes, private companies, and development agencies established SuSanA. SuSanA supported the development of sustainable sanitation approaches³² through the coordination of activities, compiling information, and development of visions.

Phase I (2007-2009) – alignment and articulation

In its establishing year 2007, 38 organizations joined SuSanA as partners³³. A core group

³² SuSanA supported any sustainable sanitation approach. In this paper, however, we focus specifically on SuSanA's role in supporting safely managed non-grid innovations for cities.

³³ Research organizations dominated the partner base of the network in this first phase (Figure 5.6), and most partner organizations were based in Europe (Figure 5.5).

of individual experts representing different organizations was established to govern the network. Contributions to the network were voluntary. In this phase, advocacy for the general recognition of the importance of sanitation was very necessary, because water provision dominated the policy agendas of most large development agencies and donors. SuSanA established a network and raised awareness of the sanitation problem, and about particular sustainability problems of the conventional grid and non-grid approaches. The early partners of SuSanA tried to reach consensus among each other on basic principles of sustainable sanitation, and created a joint vision document to broadly articulate the innovation needs, in 2008 (Figure 5.3). This document pleaded for action in the sanitation sector and outlined five aspects that should be considered to design sustainable sanitation systems, related to: health and hygiene; environment and natural resources; technology and operation; financial and economic issues; socio-cultural and institutional factors. At that time, the vision was innovative because it was not just pleading for access to sanitation, but explicitly opened-up the discussion that urban sanitation is a very complex problem for which no simple solutions based on a single approach exist. This document was based on joint knowledge of individual actors and gave a broad direction for guidance of search in the sector (Figure 5.3). SuSanA's vision document was translated into eleven languages. New organizations that became partner of SuSanA agreed with the network's vision on sustainable sanitation. Not all important actors in the sector joined SuSanA in these early years, however, because several of SuSanA's founders were closely associated with ecosan. Their association with ecosan made that SuSanA, initially, met with a lot of scepticism by these actors. The ecosan-image hindered SuSanA in its early years, but this perception slowly disappeared and more and more organizations became partners of the network (Figure 5.4).

SuSanA established various thematic working groups which deal with specific aspects of sustainable sanitation, such as capacity development, sanitation systems and technology options, cities, and renewable energies & climate change. These working groups created factsheets, which outlined a specific aspect relevant for sustainable sanitation and how to address this aspect. Much of the attention went to SaMaNG solutions, compared to grid solutions. The creation of these factsheets brought together individual organizations that contributed knowledge, expertise and data. The discussions in the working groups led to consensus building among SuSanA partners about the different aspects of sustainable sanitation, and thereby supported knowledge production for the broader innovation system (Figure 5.3).

A concept that gained broad interest in this period within SuSanA as well as the wider sector,

was “sanitation system thinking” using the concept of a “sanitation chain” that include: capture, transport, treatment, and use or disposal of waste. This idea was strengthened by an influential new knowledge source, the Compendium of Sanitation Technologies, published by Eawag-Sandec in collaboration with SuSanA partners in 2008 (see Tilley et al. (2008)) (Figure 5.3). This publication elaborated all different technologies that can be used to design a sanitation system covering the steps of the sanitation chain. This was a fundamentally different way of thinking than in the traditional non-grid approach, which only focused on the first step of the sanitation chain: capturing waste. Moreover, the Compendium incorporated for the first time both grid and non-grid approaches in one framework, and showed how both can safely manage waste, which contributed to legitimization creation for SaMaNG innovations. The sanitation chain concept also formed the basis for the principles of “Faecal Sludge Management” (FSM). Faecal sludge is the waste that comes from on-site sanitation systems, such as pit latrines, septic tanks, dry toilets, or non-sewered public ablution blocks. FSM includes the storage, collection, transport, treatment, safe end use or disposal of faecal sludge. In this period, innovation development in the sanitation sector was also strengthened by a large number of evidence-based research projects. For example, the World Health Organization published work on sanitation investments, showing that sanitation improvements were cost-effective in low-income countries (see Hutton et al. (2007)).

In this phase (2007-2009) SuSanA focused mainly on network formation and started to articulate the needs of the emerging SaMaNG field, for example in the factsheets of the working groups. This contributed to legitimacy creation and the start of developing guidance of search (Figure 5.3). In this phase, the achievements of SuSanA and the other actors, represented important building blocks for the development of the SaMaNG innovation system.

Phase 2 (2010-2016) – supporting learning processes

In this period, the SaMaNG field became more and more established. First, the concept of sanitation chains was increasingly applied by (influential) actors in the sector. This led to increased knowledge production and legitimacy. The involvement of influential actors led to increased resource mobilization for SaMaNG innovation (Figure 5.3). For example, the Bill and Melinda Gates Foundation (BMGF) entered the sector as a very important donor organization around 2011, and strongly supported SaMaNG innovation development. Second, from 2012 onwards, the Joint Monitoring Program of the United Nations (led by

WHO and UNICEF) started to consult key sanitation experts in the process of developing the successor of the MDGs. In this process, many research organizations and development agencies were consulted, among them many partners of SuSanA influenced this process (Figure 5.3). Ultimately this led to a new set of goals, the Sustainable Development Goals (SDGs), introduced in 2015. In terms of sanitation, the discourse of the MDGs changed radically in the SDGs. The SDGs did not just aim for increased “access to sanitation”, but instead called for “safely managed sanitation services”. This strengthened the legitimacy and guidance of search of innovative activities in the emerging innovation system (Figure 5.3). With the introduction of the SDGs, discussions about SaMaNG innovations became mainstream. More and more actors, including donors, got involved in innovation development, SuSanA’s membership rose (Figure 5.4).

Furthermore, some other specific organizational structures were set-up, which improved system building. An example was the FSM Committee, established in 2011, in which leading global sector organizations coordinated their ideas on FSM and initiated the first International FSM conferences. These conferences led to knowledge diffusion and the number of participants attending these conferences grew rapidly. The first conference in 2012 in South Africa assembled less than 100 participants, while the most recent conference in 2017 in India attracted over a 1000 participants. Knowledge production and diffusion was also strengthened in an increasing number of publications and books, education programs, toolboxes and online courses. Resource mobilization also steadily increased – especially the BMGF had a very influential role in supporting FSM research and projects. Furthermore, in the last decade, the World Bank began to show interest in SaMaNG innovation, among other things, FSM. Initially, the developing banks found it challenging to fund small (innovative) FSM projects as these include multiple (private) stakeholders, while the banks conventionally funded large (sewer-based) projects through one (public) institution. FSM projects could thus not be funded, because of the above outlined characteristics. New funding approaches needed to be developed, in which FSM was included as components of large sewerage projects.

As major actors started to show interest in SaMaNG innovation, the role of SuSanA in demand articulation and network formation declined. Many of the original working groups became relatively inactive. In this phase, however, SuSanA was still an important initiator of many activities related to learning and retained its role as coordination platform. It facilitated discussions, shared knowledge, and compiled information. The network established an online library and project database dedicated to sanitation. This became one of the most

extensive online information source solely dedicated to sanitation, available. The network also launched an online discussion forum in 2011, where individuals could ask questions and discuss issues related to sustainable sanitation. It was open to anyone and was used by a variety of sanitation practitioners, which gave a boost to the individual membership counts as it increased SuSanA's visibility and people could easily follow relevant discussions. The forum was sometimes also criticized for being difficult to navigate to find the right information. In addition to managing the online discussion and knowledge platforms, SuSanA organized meetings and webinars, which contributed to knowledge diffusion in the innovation system (Figure 5.3). The German Ministry of Economic Cooperation and Development and BMGF supported SuSanA³⁴ for its role as important knowledge sharing platform in the sector, during this phase. Moreover, all BMGF grantees were expected to share the outcomes of their projects and research on the SuSanA platforms, which also contributed to the rise of members of SuSanA. Various SaMaNG technologies and approaches were discussed on the SuSanA forum. For example, faecal sludge transport and treatment, faecal sludge characteristics, public awareness for non-grid sanitation, business models for non-grid systems, and city-wide inclusive sanitation planning. SuSanA also played a key role in sharing presentations, reports, and documents from relevant conferences, such as all the International FSM conferences.

In this period (2010-2016) SuSanA's main role was related to learning: it enhanced learning processes across multiple actors, and facilitated discussions and cooperation for innovation. Figure 5.3 summarizes how SuSanA contributed to the broader innovation system building activities, which strengthened the new SaMaNG field in international development cooperation.

³⁴ BMGF has financed the SuSanA secretariat based at GIZ since the start. The secretariat maintains the platform and organizes SuSanA meetings.

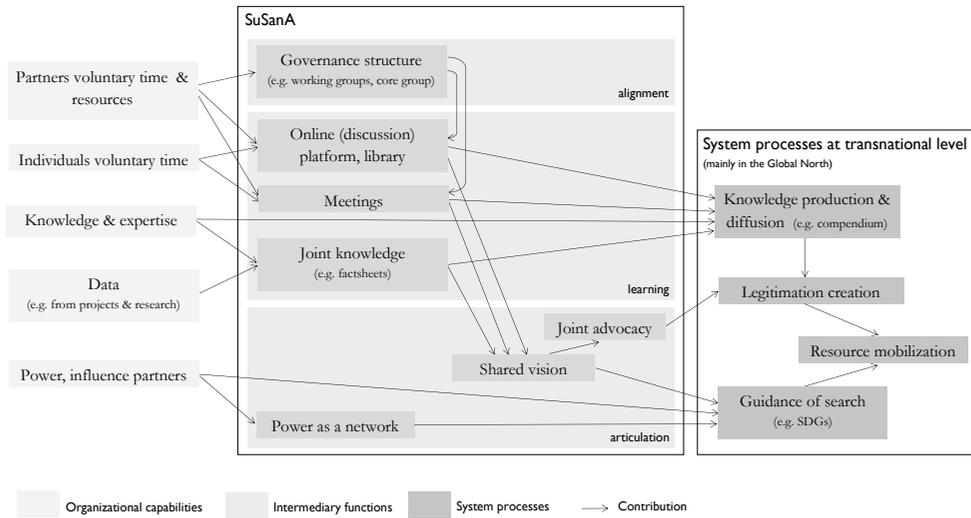


Figure 5.3 SuSanA's contribution to innovation system building for safely managed non-grid sanitation in the period 2007-2016

Phase 3 (from 2017 onwards) – directionality and global reach

In the third and latest phase, the growing SaMaNG innovation system was challenged to contribute to developing specific institutions, selecting dominant designs, and forming (local) markets.

However, despite the consensus reached on the sustainability criteria, little further agreement had been reached in terms of which technologies and approaches are most promising towards maturing the SaMaNG innovation system (guidance of search). Actors were still developing a wide variety of options. Furthermore, despite the system building activities in the previous phases, implementation beyond experimentation was still rare, which hampered market formation for SaMaNG innovations in cities (legitimation). Only in a few countries successful experiments with city-wide implementation were conducted, which could serve as examples for other cities. Many uncertainties about which technological options or approaches to select and develop still prevailed. The lack of directionality was also reflected in SuSanA. The network had so far formulated general sustainability criteria that should be considered, but within the network all different kinds of SaMaNG technologies were nurtured. The emphasis had been on technological variety, not on selection. SuSanA was hesitant to move away from this strategy, because of the large variety needed to cater for different geographical contexts. Furthermore, NGOs and private sector actors have

constituted a majority of SuSanA's partners since 2012 (Figure 5.6). This implies that actors that worked on small-scale implementation and experiments were connected to the network. However, SuSanA did not have a large share of partners that are important for city-wide implementation of SaMaNG innovations, such as Ministries, local governments and city planners (Figure 5.6). This hampered SuSanA's ability to support the articulation of demand-side needs that could lead to market formation of SaMaNG innovations on a city-wide scale.

Another problem that hampered the SaMaNG innovation system, was the limited geographical reach of its developments so far. These had mainly led to system processes at the transnational level in the Global North (Figure 5.3). Experiments and increased legitimization for SaMaNG innovation in cities in low-income countries were limited to a few countries in the Global South, compared to the increased legitimization and knowledge production and diffusion at transnational level among actors in the Global North. This was also reflected in SuSanA, the activities of the network so far had a tendency to take place and be driven by European actors in the Global North. In the partner base of SuSanA most actors tended to only connect to partners located in the same economic zones,³⁵ and most of SuSanA's founders as well as partners were based in Europe. Although the share of Asia- and Africa- based partners grew over the last decade, European research institutes and development agencies still took the lead (Figure 5.5). Among other things because these actors had more (financial) resources that enabled them to contribute voluntarily to the network. The Global North bias of SuSanA was acknowledged by its core group, and in order to improve the link to specific regions in the Global South, SuSanA recently set-up local "chapters" in India, West Asia and North Africa, and Latin America. The chapters are supposed to help these regions with their local needs in terms of coordination, demand articulation, and knowledge development, and to make SuSanA's knowledge and services more accessible on the ground.

All in all, safely managed non-grid sanitation innovations became more prominent on the global agenda, but progress on the ground had not been made at the required scale and speed.

³⁵ A network analysis of SuSanA showed that "cliques" (groups of partners connected to many of the same partners) are formed among five key partners, which are all research institutes and development agencies from Europe (Saffer, 2014).

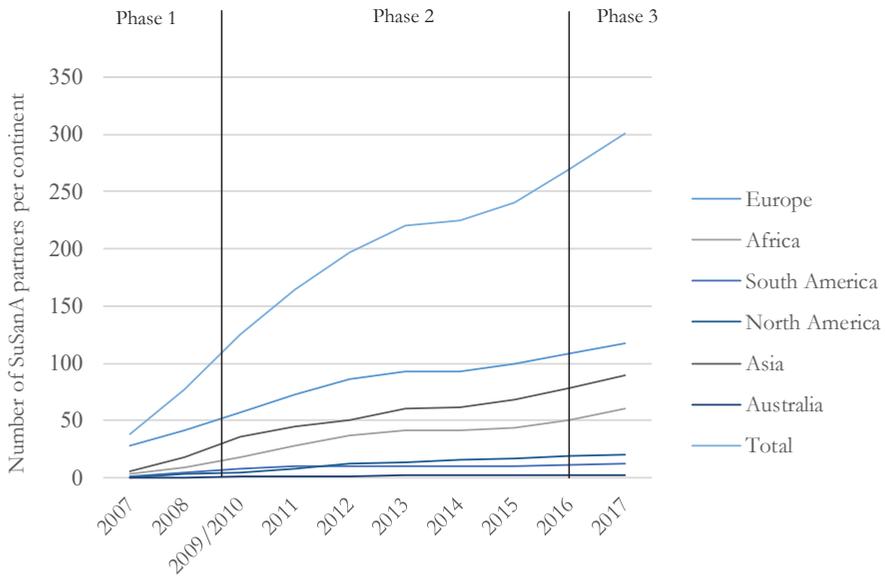


Figure 5.4 Total partner growth SuSanA and per continent 2007-2017 (made by the authors based on data from the SuSanA secretariat)

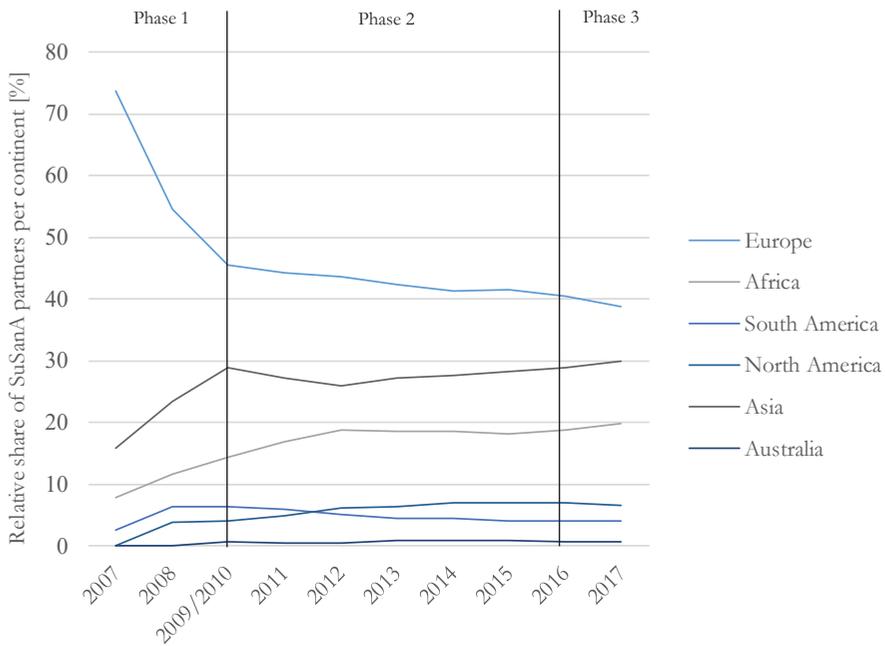


Figure 5.5 Relative share of SuSanA partners based on different continents 2007-2017 (made by the authors based on data from the SuSanA secretariat)

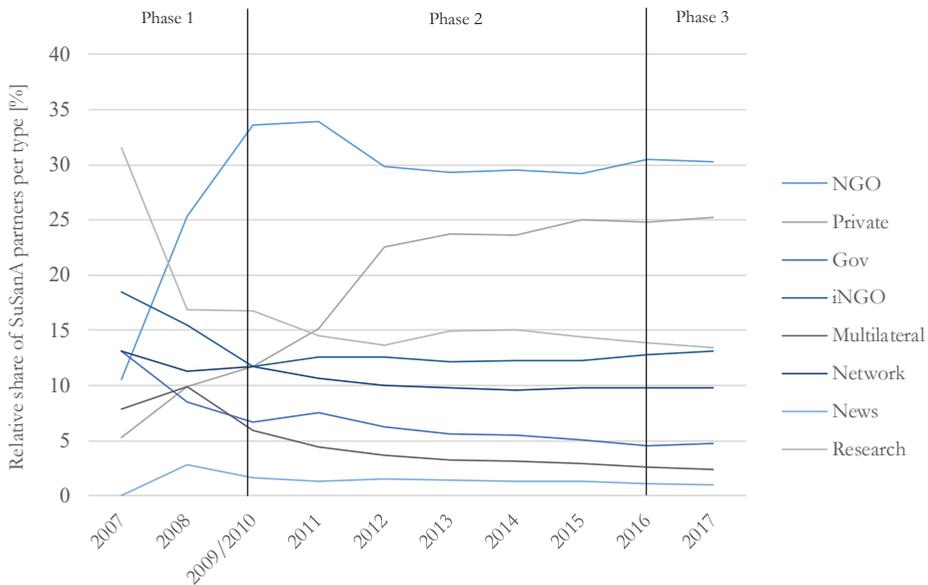


Figure 5.6 Relative share of SuSanA partners per type 2007-2017 (made by the authors based on data from the SuSanA secretariat)

5.5 Discussion: next phase of innovation system building and the changing role of SuSanA

SuSanA contributed to mission-oriented system building activities that strengthened the development of a new safely managed non-grid sanitation field to overcome the shortcomings of the previously dominating sanitation approaches. In the first phase (2007-2009), SuSanA facilitated activities that contributed to *articulation* and *alignment*. These intermediary functions contributed to the development of system processes, most notably legitimation and general guidance of search. At an early stage SuSanA shaped a general shared vision that safely managed non-grid sanitation is an important approach towards creating sustainable sanitation systems. In the second phase (2010-2016), SuSanA's role changed and it mainly contributed to *learning*: knowledge gathering and dissemination among multiple actors, and facilitating discussions. These activities contributed to knowledge production and knowledge diffusion. The alignment activities also indirectly contributed to resource mobilization in the field.

In the latest years (third phase), the SaMaNG innovation system has been growing. However,

necessary steps towards maturation, such as the formation of specific institutions, the selection of dominant designs, and formation of markets, are still not fully developed. To cope with these challenges, intermediaries could address the following two aspects.

First, stronger forms of guidance of search are required to strengthen resource mobilization and market formation. This asks for a better understanding of local conditions and demand-side development, to be able to select promising potential dominant designs. However, stronger forms of guidance of search can come at the expense of a broad variety of alternative designs that is required to accommodate for the needs in different geographical contexts. For SuSanA, strict technology neutrality has been programmatic for its strategy so far. A gradual shift towards supporting (selection processes of) dominant designs, might decrease its ability to unite actors, and jeopardize its legitimacy as an intermediary that it has build-up in the field. In general, there is nothing wrong with systemic intermediaries becoming more directional (Kivimaa et al., 2018), but this requires different sets of skills and resources, and that other actors agree with the new positioning of the intermediary (van Lente et al., 2003).

Second, transnational intermediaries have to broaden the geographical scope of innovation system developments, to strengthen local institutional contexts. SuSanA has so far mainly supported system processes at the transnational level that mostly assembled actors located in the Global North. The structural couplings between these transnational developments and local implementation contexts were insufficient or even absent. This may seriously hamper the emergence of a well-established global innovation system. Structural couplings thus need to be improved, as they help to effectively combine knowledge, investments, markets and legitimacy across different geographical scales. Transnational intermediaries should support and connect implementation related system processes in different parts of the world. They would for example have to warrant that the systemic resources that are developed in different places, e.g. regarding specific knowledge stocks, forms of legitimation, resource mobilizations etc. are made available to actors in other regions. Establishing these structural couplings is, however, more complicated than solving conventional coordination deficits.

For SuSanA, this has the following implications. It might be difficult to expand to a truly global network of thousands of partners running local initiatives all across the world. Rather, innovation system building efforts in different parts of the world should be supported and connected. This could be achieved by linking local intermediaries, actors, and networks

(e.g. local city advocacy groups, national sectoral platforms, utilities, municipalities) to the transnational system processes. Ultimately, such developments could lead to the development of several subsystems that are connected in a well-functioning global innovation system. This, however, requires a substantial extension of the current mandate, resources, and actor coverage of SuSanA. Some developments in this direction are observed by the recent foundation of an Indian, Latin American, and a West Asian and North African regional chapter of SuSanA. These try to coordinate different actors in these respective regions, and try to link local organizations and intermediaries to the broader transnational SuSanA network.

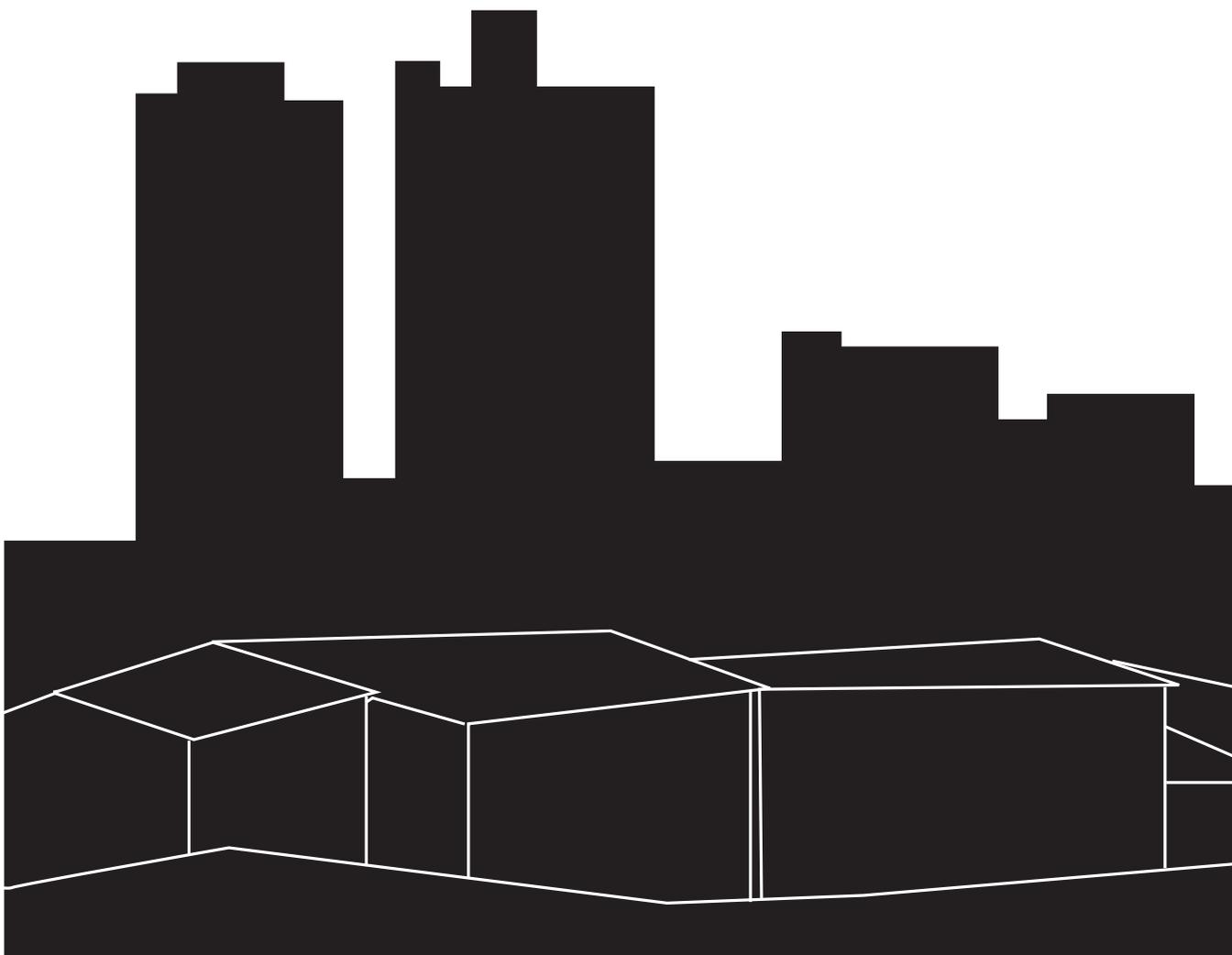
5.6 Conclusion

In this paper we argued that a new technological field emerged around safely managed non-grid sanitation. Processes of knowledge development, legitimation creation, mobilization of resources and guidance of search strengthened, all contributing to mission-oriented innovation system building in the field. During the last decade, SuSanA supported these system building efforts, and important contributions were made to demand articulation and increasing legitimacy of safely managed non-grid sanitation. SuSanA contributed transnational system processes, primarily in the Global North. The results also show that the next phase of innovation system building activities ask for a shift of intermediary functions. Structural couplings should increasingly be supported to ultimately link different subsystems worldwide, and the direction of the innovation system building activities need to increasingly be specified. This is, however, very challenging for intermediaries, because becoming more directional might contradict the need to be sensitive for different contextual conditions and could thus lower their capacity to unite different actors. And supporting structural couplings asks for efforts that go beyond “just” solving coordination deficiencies, and require increasing resources and actor coverage.

These findings reveal that it is demanding to fulfil an intermediary role in a mission-oriented innovation system in a transnational context, because of the need to change roles and consider system processes at different scales, in each phase of innovation system building. Intermediaries might have a more neutral role in the formative phase, in which they facilitate general demand articulation and build networks. Subsequently, in the growth phase they need to contribute to stronger forms of guidance of search and have to take care of supporting subsystems at different geographical scales as well as structural couplings between them.

The scientific relevance of our study is that it contributes to the literature on intermediaries in transitions (Kivimaa et al., 2018; Kivimaa et al., 2019) with first insights into the changing role and functioning of intermediaries vis-à-vis missions, and the specific challenges and tasks that should be taken into account. The study also highlights how these roles and activities have to shift over time according to the maturation of the respective innovation system in different transition phases. Furthermore, we provided insights in global innovation system development in the context of missions. A specific challenge comes from the tension between the need for a broad variety of alternative designs to accommodate for different geographical contexts, versus the need to select potential promising designs that can guide a global innovation system towards maturation.

The explorative character of this research gives several pointers for further research. In the imminent literature on innovations systems addressing missions, intermediaries might play a crucial role in facilitating learning and articulation processes. Alternative research designs, such as cross-case comparisons could further elaborate the role of other types of intermediaries in innovation systems addressing other types of global societal challenges. Furthermore, this research was a first attempt to combine insights from global innovation systems and the mission-oriented literature. The combined use of these literatures seems a promising way forward to better understand efforts towards addressing grand societal challenges. Therefore, the development of global innovation systems over time and in space, need to be further spelled out.



Chapter 6

Conclusion



In this final chapter, the main findings are presented by answering the four research questions (Section 6.1). Second, the theoretical and practical implications of this research are discussed (Section 6.2). Finally, based on the limitations several lines for further research are suggested (Section 6.3).

6.1 Main findings

6.1.1 Socio-technical regimes in low-income cities

To be able to take the complexities typically observed in basic service sectors in cities in low-income countries into account, an extension of the socio-technical regime analysis was introduced, distinguishing the two levels of service and sectoral regime. A sectoral regime consist of one or more service regimes. Service regimes are institutionalized configurations of technologies and their associated user and provider practices of basic services. They can be analysed through the identification of everyday practices of users and providers that stabilize the regime: organizational modes, time-space constellations, artefacts and infrastructures, rationale and meaning, and social interactions. Service regimes can be more or less aligned within and between each other. This leads to a novel typology of sectoral regimes: a monolithic regime (consisting of one dominant service regime), a polycentric regime (consisting of several internally well-aligned service regimes, well-aligned at the sectoral level); a fragmented regime (consisting of several internally well-aligned service regimes, misaligned at the sectoral level); and a splintered regime (consisting of internally partially aligned service regimes, misaligned at the sectoral level). The answer to the first research question is based on this conceptual extension of socio-technical regime analysis and its empirical application in Nairobi's sanitation sector.

1. What are the characteristics of socio-technical regimes in cities in low-income countries?

First, regimes in basic service sectors in low-income cities typically consist of *multiple service regimes*. For example, the sectoral sanitation regime in Nairobi consists of five service regimes (domestic sewer, public sanitation, shared on-site, container-based, and coping sanitation regime). Within these service regimes, various actors take care of service provisioning: the utility, social enterprises, NGOs, community groups, entrepreneurs and residents themselves. Furthermore, many different artefacts, infrastructures, and organizational models are used for provisioning in the five service regimes.

Second, socio-technical regimes of basic service sectors in low-income cities typically represent a *splintered or fragmented sectoral regime*. The contextual characteristics of inequalities, severe poverty, weak institutions, and informalities, lead to a lack of sectoral planning and coordination between providers, differentiated user needs, and missing links between infrastructures, which typically result in a splintered or fragmented sectoral regime. Nairobi's sanitation sector represents a splintered regime type, because the service regimes are weakly aligned to one another and none of them is dominant. The sector is weakly planned and governed, coordination deficits between different sanitation providers exist, and physical infrastructures are not linked. Users in many areas of the city can only meet their needs through putting a lot of effort and actively combining different services.

Third, *service regimes are typically unevenly distributed across different neighbourhoods in the city*, because of the large inequalities between them. Different constellations of service regimes are present in different areas. In Nairobi, the most complex constellations of service regimes are found in informal settlements and low-income residential areas. In high-income residential neighbourhoods, sectoral regimes are more homogeneous, dominated by the domestic sewer regime.

Fourth, service regimes in cities in low-income countries might lead to negative externalities that result from misalignments within and between the different service regimes. However, *service regimes can be highly institutionalized, despite these negative externalities*. The provision and use of the services in the various services regimes are highly routinized, taken for granted, widespread, and these constellations have been in place for many years. As a result, the service regimes in Nairobi are all institutionalized to a certain degree, and moreover, fit neatly with the contextual conditions in place. As a consequence, despite their negative externalities in terms of environmental pollution and unhygienic situations for users, most public and shared sanitation options and coping strategies show quite high degrees of institutionalization.

6.1.2 Innovations to transform service regimes

The case studies of Chapter 3 and 4 are used to answer the second research question. These cover a range of prominent innovators that pursue different strategies in Nairobi, based on distinct capabilities and access to resources from multiscale networks, to transform regime structures into a more sustainable direction.

2. *What are the challenges of innovators that aim at transforming these socio-technical regimes, and how do they try to overcome them?*

The innovators in Nairobi act in different service regimes. The public water and sewerage utility (Chapter 3), is an incumbent in the domestic sewer regime that extends its services into low-income areas and informal settlements, where it is a new entrant in the public sanitation regime. The two social enterprises (Chapter 4) are new entrants in the sectoral sanitation regime in Nairobi. Their container- and biodegradable bag-based services are increasingly becoming institutionalized, and form a maturing service regime. The bio-centre NGO (Chapter 4) is an incumbent that innovates within its “own” public sanitation regime. The innovators of Chapter 3 and 4 are summarized in Table 6.1.

Table 6.1 The role of the innovators of Chapter 3 and 4, as well as the other sanitation service providers in the different sanitation service regimes in Nairobi

Service regime	Domestic sewer regime	Shared on-site regime	Public regime	Container-based regime	Coping sanitation regime
Providers					
Utility (chapter 2)	Incumbent		New entrant		
Biodegradable bag social enterprise (chapter 3)				Maturing incumbent	
Container-based social enterprise (chapter 3)				Maturing incumbent	
Bio-centre NGO (chapter 3)			Incumbent		

Table 6.1 shows that innovators can at the same time be perceived as incumbent actors, as well as new entrants, within one sectoral regime, depending on the area of the city and the service regime in which they act (e.g. the utility). Table 6.1 also shows that incumbent actors innovate within their own service regime (e.g. the bio-centre NGO). These findings are in line with recent studies that argue that incumbent firms may take a proactive role in regime change and pursue different explorative and exploitative strategies at the same time (Berggren et al., 2015; van Mossel et al., 2018). The findings show that not only incumbent firms develop innovations, but also other types of incumbent actors, such as utilities or NGOs, might play such pro-active roles in transition processes. Additionally, the innovative activities in such splintered regimes challenge the traditional notion of a priori distinguishing “niche” and “regime” actors. Actors can be incumbents in one service regime, as well as

new entrants in another, and can thus fulfil different roles in one sectoral regime. This fits calls to avoid “stereotypical conceptualizations” of actors in transitions research (Berggren et al., 2015, p. 1027).

After this overview of the innovators in particular service regimes, I now turn to the institutional mismatches, capability deficits, and coordination deficits that challenge the innovators in informal settlements, and their strategies to overcome them.

Institutional mismatches and strategies

Innovators can encounter various regulative and normative institutional mismatches at different scales, and in different service regimes and contexts. In Nairobi, several *regulatory mismatches* are identified. At the city level, Chapter 4 shows there is an absence of guidelines and regulations for on-site sanitation. This forces the social enterprises and NGO to obtain special permission to implement all segments of their on-site sanitation chains. At the national level, the absence of health and safety standards for faecal sludge based products, has challenged the social enterprises. They had to obtain special permission to sell these products, and the lack of standards lowers their general acceptance. The utility in Chapter 3 does not deal with regulatory mismatches, as its focus on sewerage systems is supported by governmental agencies and the national regulators.

Furthermore, several *normative mismatches* challenge the innovators in informal settlements, for example taking the form of a lack of trust by residents and local leaders. This was hardest for the utility in Chapter 3, because they did not serve the residents of informal settlements for many years, and local leaders feed mistrust against them. Community groups also mistrust the utility because they fear competition and loss of customers. The NGO and social enterprises in Chapter 4 encounter less trust issues, because they work closer together with residents and local leaders. Other challenges are related to legitimation. As shown in Chapter 4, different activities in the on-site sanitation chains, such as openly reusing human waste by social enterprises, are a taboo and not well-accepted. Further, using dry toilets or sharing an in-home container toilet among adults, children, men and women, is not accepted in certain communities. Furthermore, on-site sanitation systems are still considered a sub-standard and temporary option among many policy makers, donors, and government officials, despite recent improvements shown in Kenya in Chapter 4 (e.g. the recognition of on-site sanitation in new policy documents). Last, some innovative service offerings do not fit well with existing user practices. For example in Chapter 3, the simplified

sewers installed by the utility regularly blocked, because residents used to throw solid waste into their toilets.

Innovators pursue different *strategies* to overcome both these regulative and normative institutional mismatches. To overcome the regulatory vacuum and absence of standards for novel on-site sanitation chains, the NGO and social enterprises in Chapter 4 are involved in or support lobby activities for the use of a variety of sanitation systems in cities, both sewerred and non-sewerred. They are furthermore active in the Technical Working Group Urban Sanitation of the Ministry of Health to develop specific on-site sanitation standards and guidelines for Kenyan cities. To tackle the lack of trust, the innovators in Chapter 4 actively include residents and community groups in planning, construction, operation, and maintenance activities. The utility in Chapter 3 also tried to overcome mistrust issues through collaboration with public ablution block operators. However, it has not yet overcome all mistrust that has built up over many years, because it recently reduced these type of collaborations, to solve internal organization problems. To overcome legitimation issues, the social enterprises educate residents about how they safely handle human waste from container-based toilets and biodegradable bags; the social enterprises and NGO promote the effectiveness and safety of their faecal sludge based products; and the utility and NGO sensitize residents about the importance of having hygienic water and sanitation services. Furthermore, the innovators in Chapter 4 advocate at the city and national level for the acceptance of on-site sanitation systems as a full-fledged option. To improve the fit of the service offerings to users' daily practices, the utility conducts behaviour change campaigns, teaching residents how to use flushing toilets properly. The innovators in Chapter 4 try to improve their service offerings through research and testing with users, understanding the complex user practices in different informal settlements is a time-consuming process.

Capability deficits and strategies

Innovators can be challenged by various types of capability deficits in their work in service regimes in informal settlements. First, innovators might lack specific *skills and knowledge* to effectively operate in a new service regime. A different service regime represents a whole new operational context for an incumbent actor that moves to a new service regime. For example, the utility in Chapter 3 encounters many deficits in its activities in informal settlements. Among others, it lacks a diversity of technology options and service models; it is not skilled to create demand for its services actively; it has no flexible payment models; and lacks capabilities to interact and build trust among residents. Skills and knowledge deficits

might also challenge new entrants in a sectoral regime. The social enterprises in Chapter 4 need to gain skills to test and develop novel ways of treating and reusing faecal sludge.

Second, *intra-organizational struggles* hint at capability deficits. When an innovator develops new capabilities, they need to be managed and integrated within the existing organizational structures. For example, the new capabilities developed by the utility in Chapter 3 resulted in tensions within the organization. These intra-organizational challenges are prominent for incumbent actors that have an established strong capability portfolio linked to a particular service regime, such as the utility to the domestic sewer regime. In contrast, new entrants build new capability portfolios from scratch, such as the social enterprises in Chapter 4.

The innovators use the following *strategies* to overcome their capability deficits. The innovators involve other types of actors that have, or can help them develop, necessary skills and knowledge. For example, the on-site sanitation chain innovators in Chapter 4 collaborate with different (international) research institutes and universities, and partner with international development agencies and other international social enterprises, to develop necessary technical skills. Furthermore, they collaborate with community groups and residents to gain a good understanding of local livelihoods. The utility in Chapter 3 hires sociologists to improve their ability to build relationships with residents. Last, to deal with internal struggles, innovators experiment with different types of organizational structures. For example, the utility in Chapter 3 tested different organizational structures as part of its innovation strategy in informal settlements.

Coordination deficits and coordination as a strategy to deal with challenges

Most of the innovators attempt to coordinate with other actors to overcome their capability deficits and institutional mismatches. Coordination is thus a strategy to overcome challenges, but can also be a challenge on its own. The innovator's (lack of) coordination with different actors at the city and global level are now presented.

First, several innovators try to interact with *users and local leaders*. For example, the social enterprises build strong relationships with local communities through their franchise systems and collaborations with local schools. This helps them to solve several institutional mismatches and overcome capacity deficits. The bio-centre NGO has years of experience working in the public sanitation regime, and already has strong partnerships and experience collaborating with local community groups. In contrast, the pro-poor unit of the utility temporarily collaborated with local community groups.

Second, establishing partnerships with *manual pit emptiers*, and thereby creating alignments between different service regimes, is challenging for the innovators. Generally, manual pit emptiers work in rather unhygienic and unprofessional ways, and are oftentimes not officially recognised or even considered illegal by local authorities, which has so far let to their exclusion from the new on-site sanitation chains presented in Chapter 4. The NGO and the utility worked on a project with manual pit emptiers in the past, but this was unsuccessful because the disposal points that the utility established, disappeared quickly under illegal house expansions. Furthermore, it was challenging to change the pit emptiers' practises. The container-based social enterprise very recently started exploring partnerships with manual pit emptiers in a pilot project, in which it provides a disposal point and takes care of the waste that emptiers dispose.³⁶ This pilot is supposed to increase the waste stream, which might help the social enterprise to utilize their full treatment capacity and produce more products in the future.

Third, coordination of activities *among innovators in the city* is minimal. Most innovators focus primarily on their own activities and work with their own international partner network. There are some interactions among the social enterprises and the NGO as part of their lobby activities for on-site sanitation. However, other than that, most interactions between the innovators have been project-based in the past or are only explorative for the future. Chapter 4 shows that even the innovators that pursue similar types of on-site sanitation chains operate largely in isolation, which hampers the potential for system building for on-site sanitation innovations in the city.

At the same time, the NGO and social enterprises partner a lot with *actors at the global level*. Capabilities, knowledge, and resources that are absent in the city are oftentimes obtained via international partners. For example, the social enterprises and NGO depend on international donors, development agencies, and investors for their funding. Moreover, they develop a lot of their capabilities together with other like-minded international actors, such as other NGOs, private sector actors, research institutes and universities, and development agencies. The utility has its own basic funding as a state-owned company, but also depends on international development banks for financing large infrastructure projects. The utility's conventional mode of operation in the domestic sewer regime links to the globally prevailing regime in urban water management (Fuenfschilling and Binz, 2018). The links between actors in the city with actors at the global level are based on a shared focus and interest in

³⁶ Learned in a follow-up visit in the summer of 2018.

particular service provision approaches.

All-in-all, the most striking finding is that partnerships and collaborations among innovators and other sanitation service providers in the city seem less developed than relationships between the innovators and their international partners. Partnerships between the providers at the city level seem to be absent or of temporary nature. This hampers the alignments between the service regimes.

Answering the second research question, these findings show that the challenges and strategies of innovators in cities in low-income countries are diverse and take place in a multiscalar setting. The innovators' strategies lead to improving and expanding existing service regimes, as well as to maturing service regimes. Innovation does not take place in clearly delineated niches that eventually become dominant and form a new (monolithic) regime. Some activities have the potential to improve the alignments between service regimes, however, most activities focus on improving individual service regimes.

To be able to improve and expand service regimes, many challenges need to be overcome. These are mostly related to introducing novelties or being a new entrant in an existing service regime or context. The strategies that are employed to overcome these challenges are, among others, lobbying for standards and guidelines, collaborating and involving local actors, working on educational activities, and research activities. An important strategy of all innovators is to partner or collaborate with international actors, and to a lesser extent with other actors in the city.

6.1.3 Innovation developments at the global level

Not all resources for innovations in low-income cities can be mobilized at the local level. The case study of Chapter 5 shows how actors at the global level aim to build up resources for safely managed non-grid sanitation innovations, and the role of an innovation intermediary herein. These insights lead to answering the third research question:

3. How do networks/actors at the global level build up resources that can support innovation processes at the local level?

At the global level, a large group of actors in international development cooperation (donors, private sector, research institutes, development agencies, etc.) have started to develop new technologies and business models for safely managed non-grid sanitation approaches,

as a response to the shortcomings of centralized sewerage and non-grid approaches in low-income cities. These efforts at the global level increasingly require coordination, the formation of appropriate networks, and the set-up of specific institutions. An international innovation intermediary has contributed to coordinating the large number of isolated initiatives in the last decade, and supported particularly processes of knowledge generation, resource mobilization, and technology legitimation. The intermediary for example, facilitated activities that contributed to the articulation of demand and the alignment of actors, such as the set-up of a member based network and the development of a shared vision among the members. It also contributed to several learning processes at the global level, such as the facilitation of discussions on its online discussion forum and the organization of a variety of meetings.

In the last decade, these developments among international actors led most notably to the creation of legitimacy, knowledge and increased availability of financial resources for safely managed non-grid sanitation innovations. These resources at the global level can be of support to innovators in cities in low-income countries. For example, local actors can build on the legitimacy created at the global level to advocate for their innovation and try to gain traction. However, Chapter 5 shows that so far structural couplings between processes at the global level and the local implementation context have been insufficient or even absent, and should be improved to enable effective future combinations of knowledge, investments, formation of markets, and legitimation creation across different geographical scales.

6.1.4 Identification of potential transition pathways

The insights in the regimes and innovative activities of different actors lead to the identification of possible transition pathways, and to answering the fourth research question:

4. What are possible transition pathways towards sustainability that result from these activities?

Potential transition pathways are identified through an analysis of how service provision can be improved by changes in individual service regimes and/or alignments among them. Several possible transition pathways of a splintered regime are discussed, illustrated by the case of Nairobi.

In a splintered regime one of the service regimes can become dominant, while at the same time the other service regimes destabilize and ultimately disappear or transform. Such changes would lead to a *transition pathway to a monolithic regime* (Figure 6.1). This would be a

complete transformation of most service regimes and related provider and user practices.

This transition pathway fits with the aspirations of many policy makers and city planners, who aim for a monolithic domestic sewer regime as the preferred end-state of a transition. However, in Nairobi, it is not very likely that the domestic sewer regime will become dominant, because it is difficult to expand this service regime into informal settlements. Additionally, the four other service regimes are stabilized based on established practices of users and providers. Moreover, the current service regime constellations fit the contextual conditions in different areas in the city. All said, the variety of service regimes will probably not disappear in the coming years. Based on the innovation activities that have been analysed, it seems more likely that the splintered regime will follow one of the possible alternative transition pathways.

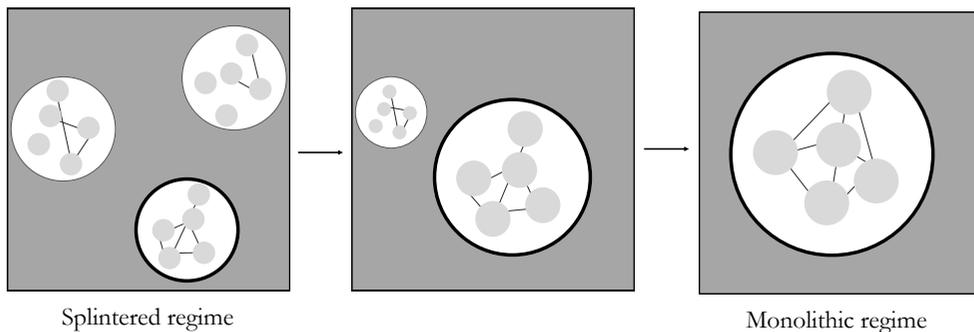


Figure 6.1 Illustration of a possible transition pathway from a splintered regime to a monolithic regime (sectoral regime (grey square), service regimes (white circles), dimensions of service regimes (grey circles), and alignments (lines))

First, splintered regimes can only undergo incremental change which does *not result in a transition pathway* to another type of sectoral regime. This happens when internal alignments within and between service regimes are not significantly improved. In Nairobi, such pathway seems likely to happen, because the current innovative activities observed are operating in isolation from each other, are not substantially improving misalignments in existing service regimes, and do not address misalignments at the sectoral level.

Second, the alignments within service regimes can be optimized. For example through improving the timing and location of a service offering to better fit the users' daily practices. Coordinated efforts towards improving existing service regimes in a splintered regime would lead to *a transition pathway to a fragmented regime* (Figure 6.2). In a fragmented regime, service

changes would lead to a *transition pathway to a polycentric regime* (Figure 6.3). This would lead to a sector in which the service quality for users is higher and service provision more effective, because they have 24/7 access to well-functioning hygienic services, waste is well managed, and environmental pollution is reduced. A polycentric regime could thus be a result of improved sectoral governance or better complementarities between different service offerings. In such regime, different service offerings are complementing each other and are distributed in a way that makes it easier for users to satisfy their needs. This transition pathway changes the sector from being a set of individually operating services, to a much more complementary set of service offerings.

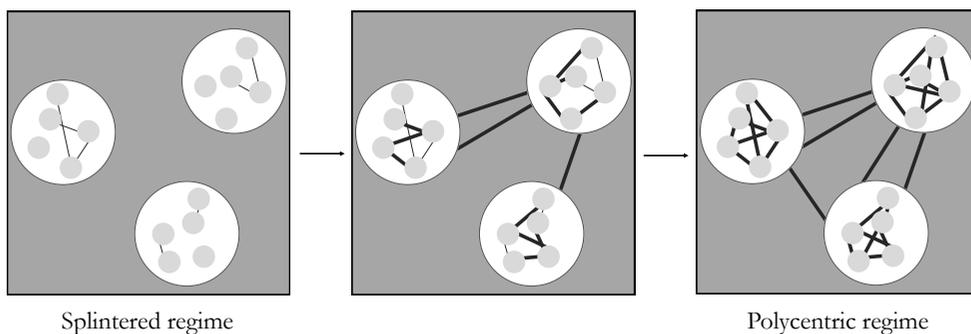


Figure 6.3 Illustration of a possible transition pathway from a splintered to a polycentric regime (sectoral regime (grey square), service regimes (white circles), dimensions of service regimes (grey circles), and alignments (lines))

In the splintered sanitation regime in Nairobi a polycentric pathway seems only possible when several of the coordination deficits are overcome. However, currently not many activities contribute to such a pathway: efforts to align different service regimes are scarce. Most innovators are busy solving capability deficits and institutional mismatches to improve alignments within their own service regime, as seen in Chapter 3 and 4. Moreover, reaching out to different service regimes is difficult because it would cause new types of capability deficits and institutional mismatches, as is shown in the case of the utility in Chapter 3.

However, a few activities that (are planned) to take place in Nairobi, have the potential to create alignments at the sectoral level. For example, further development of the on-site sanitation chains in Chapter 4 can lead to linkages between the on-site shared, public, and container-based service regimes. Examples are coordinated collection services and shared treatment plants for faecal sludge. To make that happen, complementarities between the NGO and social enterprises that implement on-site sanitation chains need to be optimized,

and existing other service providers need to be involved. This could be enabled with different governance modes of the on-site initiatives presented in Chapter 4. Furthermore, the attempts to include manual pit emptiers in novel service models can lead to alignments between different service regimes, such as the on-site shared sanitation, public sanitation, domestic sewer, and container-based sanitation regime. An example would be through the installation of more disposal points for waste collected from different types of sanitation systems. The utility and the NGO piloted an exposal point in informal settlements in the past. And the container-based social enterprise recently started to work on a disposal point pilot with manual pit emptiers. Similar initiatives by other actors in the past have not always been successful, and have shown that it requires a lot of effort and time to successfully engage with and change practices of pit emptiers. Last, the utility's expansion of services to informal settlements as shown in Chapter 3 provides opportunities to create alignments between the domestic sewer regime and public and on-site shared regimes, such as collaborations with Community Based Organizations (CBOs), which could manage sewer based public services installed by the utility. However, this requires time because the utility has to put effort in overcoming their capability deficits, and needs to open-up for more diverse service models and on-site sanitation technologies, than it has done so far, as is shown in Chapter 3.

If alignments between service regimes would be improved, distinct capabilities and resources of different types of actors would more effectively complement each other than is currently the case. For example, the utility's access to government money and investment funds, could be beneficial for NGOs and social enterprises. At the same time, NGOs can complement the utility with their skills to work with communities in informal settlements. Last, improved alignments between service regimes ideally lead to a situation in which residents can meet their needs twenty-four hours a day without having to resort to coping regimes.

These findings show a broader set of potential transition pathways than those considered by policy makers and city planners so far. Instead of portraying one monolithic regime as the aspirational endpoint, sustainability transitions should rather be oriented at managing various service regimes and the improvement of alignments between these regimes, which relies on a broad range of activities and capabilities of different types of actors. Such framing departs from a naïve conception of a one-leap transition towards a sustainable future and instead argues for the potential of stepwise and parallel transformation processes, where different constellations of improved service provision options are developed over time. This would also require a shift of management to more pluralistic modes, compared to

centralised state-based management in a monolithic regime (Letema and van Vliet, 2014). As such, this understanding of regime change is a contribution to the call for “a more fine-grained analysis of transition pathways” (Berggren et al., 2015, p. 1027).

6.2 Implications

6.2.1 Implications for sustainability transitions research

In this thesis the attention of transitions research (Markard et al., 2012; STRN, 2017) was turned to the context of cities in low-income countries, to ask what extensions are needed to identify transition pathways in heterogeneous regimes. The application of key concepts of the transitions literature in this context, led to introducing several conceptual extensions and identification of possible alternative transition pathways.

Compared to earlier work on transition pathways (among others by (Smith et al., 2005; Geels and Kemp, 2007; Geels and Schot, 2007; de Haan and Rotmans, 2011)), the pathways that are identified in this thesis are based on a different starting point, namely the multiplicity of service regimes. This has the following implications. A variety of pressures on the regimes can be identified, these can for example occur from misalignments within and between regimes, and can as well be contextual (this is in line with the diversity of internal and external pressures on regimes described by Smith et al. (2005)). Furthermore, it is not always possible to understand regime change based on interactions between regimes and niches, which has been the focus of most of the work on transition pathways so far.³⁷ Rather, regime change can be the result of innovative activities that are pursued simultaneously by new entrants, by incumbents that innovate in their own service regime, and by incumbent actors that act as new entrants in another service regime. As a result of these diverse innovation strategies, different trajectories emerge, which lead to a variety of possible end-points of transitions, other than a dominant monolithic sectoral regime. This contrasts with several of the earlier defined transition pathways that (implicitly) assume that the end-point of a transition is a dominant monolithic regime (for example the “de-alignment and re-alignment” path (Geels and Schot, 2007), or the “reconfiguration path” (de Haan and Rotmans, 2011)). The thesis presents a distinction between service and sectoral regimes which enables to perceive possible transition pathways going beyond the classic understanding of transitions based

³⁷ Ghosh and Schot (2019) are an exception to this rule as they focus on transformation pathways within public transport regimes.

on niche-regime interactions, and thus opening up for “non-conventional” cases. It allows to be much more specific about how pathways might look like in different contexts (a need already expressed by Smith et al. (2005)).

The conceptual extensions can possibly be applied to cases beyond the context of informal settlements. In particular cases that include sectors that consist of multiple regimes, innovations that might transform sectors that consist of multiple regimes, and transition pathways in monolithic regimes.

The distinction of service and sectoral regimes, and a practice perspective to understand these, can be used to analyse transition processes in *sectors that consist of multiple regimes* in various sectors worldwide, such as personal mobility, in which the multiplicity of regimes has been acknowledged, but so far not been taken-up in analysis (see for example (Kemp et al., 2011; Moradi and Vagnoni, 2018)). Furthermore, it helps to unpack the heterogeneity and spatial variety of regimes, which is one of the current challenges of the transitions research field (Hansen and Coenen, 2015; STRN, 2017), but has received less attention than understanding place-specificity and geographical variation of niche developments (Hansen and Coenen, 2015). One particular dimension that can be tackled is the differentiation of service regime constellations in different spatial contexts. The recent application of the service and sectoral regime concepts by Schippl and Truffer (2018) in the mobility sector in Germany illustrates how this latter dimension can now be dealt with. They show how sectoral regimes of personal mobility have developed differently in urban and rural areas: service regimes form a polycentric sectoral regime in urban areas, while in rural areas the sectoral regime is fragmented.

The distinction of service and sectoral regime can also be applied to analyse how *innovations might transform sectors that consist of multiple regimes*. For example, in the field of smart mobility, ICT-related innovations lead to new types of travel services and business models, such as apps and platforms that help people to undertake multimodal trips or share cars or bikes (Cohen-Blankshtain and Rotem-Mindali, 2016; Manders et al., 2018; van Waes et al., 2018). These innovations do not lead to a substitution of existing regimes by new dominant regimes based on another technology. Rather, they aim to alter the way personal mobility is organized, for example by optimizing the combined use of public transport and cycling, and thereby creating alignments between different service regimes. The transformative effect of these type of innovations on regimes can thus be effectively analysed in transition studies as improving alignments between service regimes, which ultimately lead to improved

sustainability performance and user comfort in the case of personal mobility.

Last, the typology of sectoral regimes can be used to identify a variety of *potential end-points of transition processes observed in monolithic regimes* in sectors such as electricity, district heating, and water in western contexts. Many of these monolithic regimes are undergoing changes because of the decentralization of infrastructures. For example, caused by renewable energy technologies in electricity and district heating sectors (Hojčková et al., 2018; Markard, 2018b; Rämä and Wahlroos, 2018), and by decentralised wastewater treatment plants in the water sector, which lower maintenance costs and improve the sustainability performance (Larsen et al., 2016; Eggimann et al., 2018). This will not lead to the substitution by another monolithic regime. Decentralization of infrastructures and their related institutional structures, rather turn monolithic regimes into polycentric, fragmented, or splintered regimes (Figure 6.4). Such transition pathways are the result of new service regimes that mature around small-scale (modular) renewable energy technologies, or waste-water treatment plants and their associated user and provider practices. A monolithic regime will be transformed into a polycentric regime when these new service regimes are well-aligned, for example by coordination of different wastewater treatment operators, smart-grids, and/or appropriate organizational structures to govern all different technologies in a sector. However, when such alignments between new service regimes are not taken care of, a monolithic regime can also transform into a fragmented regime, or even into a splintered regime. The latter happens when alignments within service regimes are not optimized. In such scenario, decentralised renewable energy and wastewater treatment systems do not operate in a reliable manner, and some people might be not be assured of basic services. Such negative types of unbundling/disconnection processes that lead to inequalities in cities are the topic of the splintering urbanism literature (Graham and Marvin, 2001).

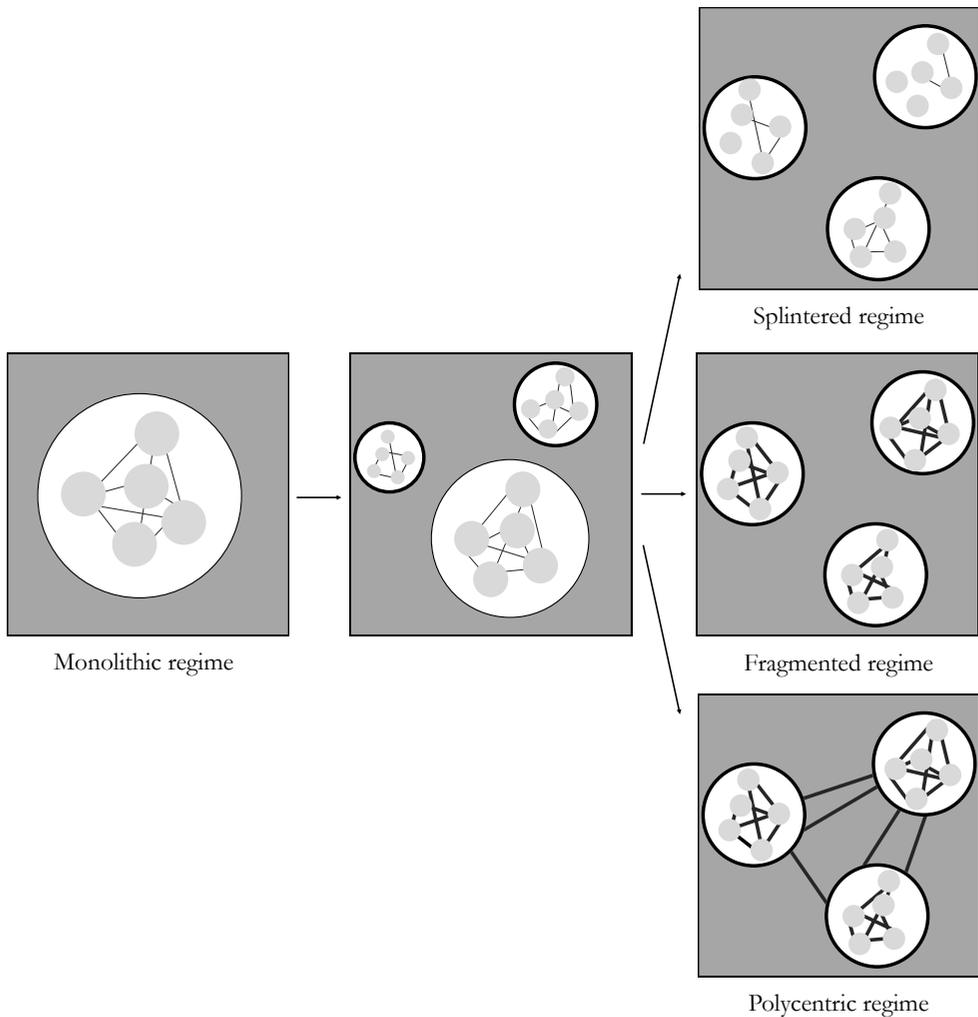


Figure 6.4 Illustration of possible transition pathways from a monolithic to a splintered, fragmented, or polycentric regime (sectoral regime (grey square), service regimes (white circles), dimensions of service regimes (grey circles), and alignments (lines))

6.2.2 Practical implications

The findings of this thesis are of general relevance for actors that aim to transform basic service sectors, as they might help to identify areas of intervention towards the creation of fundamental changes in these sector. Generally, this thesis shows the added value of a socio-technical system perspective, which enables an in-depth analysis of the interplay between technologies, infrastructures and their associated actors networks, institutions

and user and provider practices. This contrasts with commonly used approaches that are solely focused on specific aspects of service provision, such as technologies and artefacts, behaviour change of individuals, or willingness to pay for services. Based on the findings in this thesis, implications are formulated for different types of actors, with a specific focus on the context of informal settlements.

With regard to *city governments*, the findings suggest that step-wise transformation processes need to be planned, instead of aiming for a complete substitution of the current diversity of service offerings. An exemplary step is the identification of coordination failures between innovations and established service providers. Coordination among different innovators can improve the effectiveness of parallel innovative processes, as shown in Chapter 4. Furthermore, in search of new, more sustainable solutions to recover nutrients and energy from wastes, it is important to develop an understanding of where competition, and where uniting forces would be necessary to effectively organize value chains.

Chapter 3 shows that *utilities* have to overcome many capability deficits in informal settlements, because they have to break with their business-as-usual-approach developed in high-income areas, and have to move beyond the (inter)national prevailing “modern infrastructure ideal” (Furlong, 2014). They would benefit from interactions and partnerships with incumbent actors. These actors, such as local NGOs and community groups, have an extensive understanding of the user needs and are strongly locally embedded, which could help the utility to tailor their service offerings to these needs and gain trust. The latter is important, because utilities face large mistrust, as they have not provided services in informal settlements for many years. Effective forms of collaboration and co-development between utilities and incumbent actors might lead to new types of well-functioning individual service offerings as well as partnerships to optimize the co-management of different types of services.

For *NGOs and social enterprises* that aim to pursue innovation activities in informal settlements, it is important to coordinate their efforts and to interact with residents, local leaders, and community groups, to gain trust, and understand their needs, shown in Chapter 4. Furthermore, interactions with other service providers are important to leverage synergies between otherwise not-connected service offerings, particularly those of manual pit emptiers and exhauster truck operators. Service offerings and user routines vary between areas in the city, as shown in Chapter 2. Scaling an innovative service offering is thus quite precarious, and requires lots of adaptations to local conditions, even within one city. Therefore, it is

important to partner with other service providers, especially those that take care of the majority of the services already. Such partnerships can help to embed novel service offerings in local contexts, and overcome particular capability deficits.

International donors and development agencies could contribute to fundamental changes of urban basic services through long-term commitment to step-wise transformation processes, instead of supporting short-term projects or “silver bullet” solutions that claim instant transformations towards a sustainable future. The conditions under which financial support is granted, should be open for such long-term approaches that might not lead to predefined/tangible outputs in a short time-span. The systemic perspective on innovation processes (in Chapter 4 and 5) shows that supporting coordination, capability development, and improving institutional aspects, is important for successful innovation development. Donors and development agencies can effectively support coordination through facilitating or funding city working groups and international innovation intermediaries. Furthermore, they could focus on improving links between innovative activities at different geographical scales, shown in Chapter 5. Such linkages are essential to increase legitimacy across these scales, produce knowledge which includes both demand and supply side, tunnel investments, and create markets for innovative service approaches.

6.3 Limitations and further research

Several lines of future research have been outlined throughout the chapters of this thesis. Additionally, in section 6.2.1 suggestions are given on how some of the conceptual ideas might be applicable beyond the context of this thesis. This requires further research. In this section, I do not repeat these points, but rather suggest two other lines of further research based on the limitations of this thesis.

Transitions of interlinked urban basic service sectors

Sanitation is only one of the urban basic service sectors in low-income cities in which persistent problems prevail. Further research should extend the view to other urban basic service sectors in informal settlements, and the interlinkages between them. In particular, the specific challenges and strategies of innovators in other sectors might deviate from the ones that were identified, and require further investigation. The challenges that innovators face as new entrants in informal settlements are, however, likely not sector-dependent.

Generic issues such as the need to gain trust and learn about the specific socio-cultural local conditions, might be similar in other sectors. Furthermore, the interdependencies between sanitation, water, energy, solid waste and food influence how transition pathways in different sectors unfold. For example in the context of informal settlements, improved sanitation can lead to better water quality, which helps residents to save the use of charcoal for boiling water to reduce pathogens. Improvements in one sector, can thus accelerate transformations in other sectors, and vice versa. Such linkages and sectoral interdependencies require further research. Literature on the “WEF” (water, energy, food) nexus takes a multi-sectoral perspective, but at the macro scale (see for example (Hoff, 2011; Leck et al., 2015)). The analysis of inter-sectoral linkages in informal settlements can be operationalized with a practice approach to the WEF (as introduced by Hiteva (2018); Van Vliet and Marshall (2018)). Interactions between water, energy, and food are identified through the analysis of practices, to understand how people’s daily routines create overlaps between different sectors. This seems a promising approach in line with the practice approach used in this thesis, to better understand how transition pathways in different urban basic services sectors can effectively take place in parallel, or can even be mutual beneficial.

Place-specificity and multiscale in transitions

In the realm of the geography of transitions (Hansen and Coenen, 2015; Truffer et al., 2015), the following points could be elaborated. First, it requires further investigation how transition pathways in heterogeneous regimes exactly unfold in different areas within a city. Two particular aspects typically differ in space: the constellation of service regimes and their strength. As a consequence, regime change may follow different patterns in different neighbourhoods. For example, developments in one neighbourhood lead to better alignments among service regimes, while in another only individual service regimes are improved. Or specific service regimes might fit the context very well and have a high strength in a certain area, compared to other places. As a consequence, in particular areas there might be more leeway for regime change than in others. This also sparks the question how innovations have more or less transformative potential in different parts of a city. To better understand this, requires further operationalization of the analysis of the strength of regimes, as well as comparative case studies of regime change in different areas within a city. Second, in research on global innovation systems (Binz and Truffer, 2017) and global regimes (Fuenfschilling and Binz, 2018), further investigation is needed to understand how processes and/or rationalities at the global scale influence transition processes in low-income

countries. In particular, how processes of legitimation creation and resource mobilization at the global level, influence which innovations become legitimate, are tested, and diffuse in low-income countries. This requires a better understanding of “structural couplings” and an operationalization how to identify and analyse them. Last, a question worthwhile exploring is how the limits of using “globally dominant” solutions in low-income countries, such as central sewerage systems, might challenge global regime rationales that support these and thereby create opportunities for alternative solutions worldwide.

In this thesis an explorative in-depth case study on potential transition pathways in sanitation in Nairobi was conducted. Turning the attention of transitions research to cities in low-income countries as a new “discovery context” for the field, led to several conceptual extensions that can also be used beyond this context, to better understand cases of heterogeneous regimes, how these are transformed, and lead to alternative transition pathways. The step to a non-conventional context for transitions research provided a fresh view on transitions challenges in general, and is a promising approach to further extend and strengthen transition frameworks.

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Appendix A

Final coding scheme Chapter 3:

Pro-poor unit/department

 Activities pro-poor unit

 Activities pro-poor department

 Shortcomings pro-poor unit

 Shortcomings pro-poor department

 Changes over time

Code for each year from 2004 onwards

 Reasons for the need for a pro-poor unit

 Reasons for the need for a pro-poor department

Differences pro-poor unit vs. pro-poor department

Other departments utility

Innovations/projects

 Ablution blocks

 Bio-centers

 Connection of water pipes

 Self-metering

 Pit emptying CBO

 Social connection policy

 PPDs

 Water kiosks

Specific characteristics of centralized service regime

 Infrastructures and artefacts

 Organizational mode

 Rationale & meaning

 Social interaction

 Time and space

Specific characteristics of alternative service regimes

 Infrastructures and artefacts

 Organizational mode

 Rationale & meaning

 Social interaction

 Time and space

Differences between low vs. high-income neighbourhoods

Challenges of embedding of innovations in alternative service regimes

 Reasons for failure of projects

 Infrastructures and artefacts

 Organizational mode

 Rationale & meaning

 Social interaction

 Time and space

Other actors / partners utility

Codes for each specific actor mentioned as well as for each partner of the utility

 Collaboration with other service providers

 Sharing/developing knowledge together

 Funding & resources

Appendix B

Table Appendix B Interviewees Chapter 4

Stakeholder Group	Interviewees	Code	Total
Government – ministries and other governmental bodies (GOV)	Nairobi County Health Department (3 interviews)	GOV1, GOV2, GOV3	5
	Ministry of Health	GOV4	
	Water Board	GOV5	
Local Non-Governmental Organizations (NGOs)	NGO A (4 interviews) Implementing bio-centers	NGO1, NGO2, NGO3, NGO4	7
	NGO B	NGO5	
	NGO C (2 interviews)	NGO6, NGO7	
International Non-Governmental Organizations (iNGOs)	iNGO A (Skype)	iNGO1	6
	iNGO B (3 interviews)	iNGO2, iNGO3, INGO4	
	iNBO C	iNGO5	
	iNGO D (owner of the biodegradable bag brand)	iNGO6	
International development (aid) agencies/organizations (IDO)	IDO A (2 interviews)	IDO1, IDO2	2
Firms/Social Enterprises (SEs)	Social enterprise A (7 interviews) Implementing CBS	SE1, SE2, SE3, SE4, SE5, SE6, SE7	12
	Social enterprise B (2 interviews) Implementing biodegradable bags	SE8, SE9	
	Social enterprise C	SE10	
	Firm D	SE11	
	Firm E	SE12	
Community Based Organization (CBO)	CBO A	CBO1	3
	CBO B (2 interviews)	CBO2, CBO3	
Professional (industry) Association (PA)	Private Exhauster Truck Association	PA1	1
Total			36

Appendix C

Table Appendix C Interviewees Chapter 5

	Position	Organization	Location
1	Researcher	Research institute	Switzerland
2	Manager	Research institute	Sweden
3	Researcher	Research institute	Switzerland
4	Consultant	International development agency	Germany
5	Researcher/Coordinator	Research Institute / Consultancy	Switzerland
6	Researcher	Research institute	Sweden
7	Manager	International development agency	Germany
8	Manager	Non-Governmental Organization	US
9	Consultant	Consultancy	UK/Brazil
10	Researcher	Research institute	South Africa
11	Consultant	International Non-Governmental Organization	UK
12	Manager	Foundation	US
13	Manager	International Non-Governmental	Bangladesh
14	Advisor	International development organization	Germany
15	Consultant	International development agency	Germany
16	Manager	Research institute	Sweden/Kenya
17	Coordinator	Research institute	Switzerland
18	Coordinator	International development organization	Germany/Lebanon
19	Researcher	Research institute	Switzerland
20	Researcher	University	UK
21	Researcher	Research institute	Switzerland

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Summary

The world's rapid urbanization leads to a multitude of problems in the provision of urban basic services such as transport, water, sanitation, electricity in cities in low-income countries, especially in informal settlements. Sanitation is a particular challenging urban basic service, in which relatively little progress has been made in the last decades: 60% of the global population still lacks safely managed sanitation. This leads to sustainability issues, such as environmental contamination and hinders a healthy and productive life in cities.

The aim of the thesis is to analyse how innovations can contribute to fundamental changes towards sustainability in urban basic service sectors in low-income countries. To that end, insights from the field of sustainability transitions research are mobilized to analyse the interrelated factors that lead to obdurances in these sectors, as well as to identify challenges that innovators face when addressing the problems, and how their activities lead to potential *transition pathways*. However, the main attention of the transitions research field has so far been on high-income western countries, and the realities of many low-income cities are distinctively different. Therefore, the thesis elaborates conceptually how transitions might unfold in these contexts.

The thesis focusses on the case of sanitation provisioning in Nairobi, the capital of Kenya. A city that is characterized by large inequalities between neighbourhoods in terms of sanitation provisioning. Especially the problems in informal settlements are severe. The empirical analyses were conducted using qualitative data and methods. Data was collected through semi-structured expert interviews, observations, project visits, focus group discussions, and additional documents and literature.

The findings provide insights in the provision and use of sanitation services in different neighbourhoods in Nairobi. The daily practices of users and providers are associated with particular well-established configurations of technologies, organizational forms, and user/provider routines, which are called "service regimes". Five service regimes exist in Nairobi's sanitation sector based on domestic sewer, shared on-site, public, and container-based services and coping strategies. This large variety of service regimes has developed over the years to cater for the different contextual characteristics in the city. Especially in informal settlements, a complex variety of service regimes is found. The sector is weakly planned and the different service regimes are not coordinated. This means that many services do

not function optimally and effectively for users and providers: waste is not well-managed and users do not have 24/7 access to well-functioning hygienic services. The service regimes thus form a *splintered regime* at the sectoral level.

Several actors in Nairobi pursue innovation strategies to improve this situation. The public utility recently started to extend its operations into informal settlements, after having neglected these areas for decades. This is challenging for the utility, because it has to break with its business-as-usual approach developed in high-income areas. The findings show how the utility aimed to develop new capabilities and organizational structures to be able to operate successfully in informal settlements, and show that their success has been limited. Another innovation strategy is pursued by social enterprises and NGOs, which try to develop new on-site “sanitation value chains” in informal settlements. Sanitation chains consist of various interlinked activities that lead to the production of faecal sludge based products, while at the same time providing sanitation services. Three initiatives have so far all set-up a functioning sanitation chain, but at the same time face challenges related to capability deficits and institutional mismatches. The findings show that the initiatives operate largely in isolation, and how the overall innovation success might be improved by leveraging synergies among them.

Not all resources for innovative activities can be mobilized at the local level. At the global level, several actors and networks in international development cooperation aim to establish a globally accepted paradigm of safely managed non-grid sanitation. An international innovation intermediary contributes to the coordination of their efforts. In the last decade, these developments among international actors led most notably to the creation of legitimacy, knowledge, and more financial means for safely managed non-grid sanitation innovations. These resources at a global level could even be better utilized to support future implementation and market creation for innovative non-grid sanitation options.

As a result of these innovation strategies, Nairobi’s splintered regime will develop over time. The often aspired transition to a “monolithic regime” based on a centralized sewerage system seems unrealistic in the coming years, because it is difficult to expand the domestic sewer regime into informal settlements, and various other service regimes are well-established. Instead, a much broader set of possible end-points of transition pathways towards sustainability can be identified. These can be reached through stepwise and parallel transformation processes, where different constellations of improved service provision options are developed over time. This would require a focus at managing various

service regimes, and the improvement of alignments between these regimes, which relies on efforts of a broad range of different types of actors. A service regime can for example be optimized through changing the timing and location of a service offering to better fit the users' daily practices. Better alignment between service regimes requires more coordination among different service providers, adequate sector planning, and optimization of the complementarities between different services.

All in all, the thesis provides conceptual and empirical insights in transition processes in basic service sectors in cities in low income countries. It elaborates how sustainability transitions research can take into account a multiplicity of service regimes in which diverse innovation activities take place, which leads to the identification of a variety of possible end-points of transitions, other than a dominant monolithic regime. These conceptual extensions are also of relevance for transition research beyond the context of cities in low-income countries.

Samenvatting

De snelle verstedelijking in de wereld leidt tot vele problemen bij het treffen van basisvoorzieningen zoals transport, water, sanitaire voorzieningen, elektriciteit in steden in lage-inkomenslanden. Vooral in het leveren van sanitaire voorzieningen is in de laatste decennia relatief weinig vooruitgang geboekt: 60% van de wereldbevolking heeft nog steeds geen toegang tot veilig beheerde sanitaire voorzieningen. Dit leidt tot duurzaamheidsproblemen zoals milieuvervuiling en belemmert een gezond en productief leven in steden.

Het doel van dit proefschrift is om te analyseren hoe innovaties kunnen bijdragen aan verbeterde duurzaamheid van stedelijke basisvoorzieningen in lage-inkomenslanden. Om dit doel te bereiken worden inzichten uit het onderzoeksveld van duurzaamheidstransities gebruikt om de factoren die bijdragen aan het overwinnen van een gebrek aan innovativiteit in deze sectoren te analyseren. Daarnaast worden de uitdagingen waarmee innovatoren worden geconfronteerd bij het aanpakken van deze problemen geïdentificeerd en hoe hun activiteiten leiden tot potentiële *transitiepaden*. De aandacht van het transitieonderzoek is echter tot nu toe voornamelijk gericht geweest op westerse, hoge-inkomenslanden, terwijl de situatie in veel lage-inkomenssteden in vele opzichten anders is. Daarom stelt dit proefschrift de vraag centraal hoe transities zich in deze context zouden kunnen ontploffen.

Het proefschrift richt zich op de casus van sanitaire voorzieningen in Nairobi, de hoofdstad van Kenia. Een stad die wordt gekenmerkt door grote ongelijkheden tussen wijken op het gebied van sanitaire voorzieningen. Vooral de problemen in informele nederzettingen zijn groot. De empirische analyses zijn uitgevoerd met behulp van kwalitatieve data en methoden. Data is verzameld in semigestructureerde interviews met experts, en in observaties, projectbezoeken, discussies met focusgroepen en aanvullende documenten en literatuur.

De resultaten bieden inzicht in de levering en het gebruik van sanitaire voorzieningen in verschillende wijken van Nairobi. De dagelijkse praktijken van gebruikers en aanbieders zijn verbonden met specifieke configuraties van technologieën, organisatievormen en routines, die “serviceregimes” worden genoemd. In de sanitaire sector van Nairobi bestaan vijf verschillende serviceregimes, gebaseerd op: huishoudelijke rioolvoorzieningen, gedeelde on-site voorzieningen, publieke voorzieningen, op container gebaseerde voorzieningen, en coping strategieën. Deze grote verscheidenheid aan serviceregimes heeft zich in de loop van de jaren ontwikkeld om tegemoet te komen aan de grote verschillen in context in de stad.

Vooral in informele nederzettingen vind je vele verschillende serviceregimes. De sectorale planning is zwak en de verschillende serviceregimes worden niet gecoördineerd. Dit betekent dat veel voorzieningen niet optimaal en effectief functioneren voor gebruikers en dienstverleners: afval wordt niet goed afgevoerd en gebruikers hebben geen 24/7 toegang tot goed functionerende hygiënische voorzieningen. De serviceregimes vormen op sectoraal niveau dus een *versplinterd regime*.

Verschillende actoren in Nairobi streven innovatiestrategieën na om deze versplinterde situatie te verbeteren. Het publieke waterbedrijf is recentelijk begonnen met het uitbreiden van zijn activiteiten naar informele nederzettingen, na deze gebieden van de stad decennia niet te hebben bediend. Dit is een uitdaging voor het waterbedrijf, omdat het zijn business-as-usual aanpak die is ontwikkeld in de rijke wijken in de stad, moet veranderen. De resultaten laten zien hoe het waterbedrijf nieuwe competenties en organisatiestructuren heeft ontwikkeld om te kunnen opereren in informele nederzettingen, maar tonen ook dat het succes in informele nederzetting tot nog toe beperkt was. Een andere innovatiestrategie wordt nagestreefd door sociale ondernemingen en NGOs die proberen nieuwe decentrale “sanitaire waardenketens” te ontwikkelen in informele nederzettingen. Sanitaire waardenketens bestaan uit verschillende aan elkaar gelinkte activiteiten die leiden tot het fabriceren van producten gemaakt van “fecal sludge”. In drie projecten zijn recentelijk een functionerende sanitaire waardeketen opgezet, maar deze initiatieven hebben tegelijkertijd te maken met problemen gerelateerd aan capaciteitstekorten en institutionele discrepanties. De resultaten tonen aan dat de deze actoren grotendeels geïsoleerd van elkaar werken en dat het algehele innovatiesucces kan worden verbeterd door synergiën tussen de initiatieven beter te benutten.

Niet alle benodigde middelen voor innovatieve activiteiten in de stad kunnen worden gemobiliseerd op lokaal niveau. Op mondiaal niveau streven verschillende actoren en netwerken in internationale ontwikkelingssamenwerking naar een wereldwijd geaccepteerd paradigma van veilig beheerde sanitaire voorzieningen die niet verbonden hoeven worden aan rioleringsystemen. Een internationale innovatie-intermediair draagt bij aan de coördinatie van hun inspanningen. In het laatste decennium hebben deze internationale ontwikkelingen met name geleid tot het creëren van legitimatie, kennis en meer financiële middelen voor innovaties die bijdragen aan de ontwikkeling van dergelijke veilig beheerde sanitaire voorzieningen. Kennis, legitimatie, en financiële en andere middelen op mondiaal niveau kunnen in de toekomst echter nog beter worden gebruikt om implementatie en marktcreatie van innovatieve sanitaire voorzieningen die niet verbonden zijn aan rioleringsystemen te

ondersteunen.

Als een gevolg van de innovatiestrategieën zal het versplinterde regime van Nairobi zich in de loop van de tijd ontwikkelen. De vaak nagestreefde transitie naar een “monolithisch regime” op basis van een gecentraliseerd rioleringsstelsel lijkt onrealistisch in de komende jaren, omdat het moeilijk is om het serviceregime gebaseerd op rioolvoorzieningen uit te breiden naar informele nederzettingen. Daarnaast zijn de vier andere serviceregimes ook sterk ontwikkeld. In plaats daarvan kan een veel breder scala aan mogelijke eindpunten van duurzame transitiepaden worden geïdentificeerd. Deze kunnen worden bereikt door stapsgewijze en parallelle transformatieprocessen, die in de loop van de tijd leiden tot het ontwikkelen van verschillende configuraties van verbeterde voorzieningen. Dit scenario vereist een focus op het managen van verschillende serviceregimes en het verbeteren van de afstemming tussen deze regimes, wat afhangt van de inspanningen van een breed scala van verschillende soorten actoren. Een serviceregime kan bijvoorbeeld worden geoptimaliseerd door het veranderen van de timing en locatie van een voorziening zodat het beter bij de dagelijkse activiteiten van gebruikers past. Beter afstemming tussen serviceregimes vereist meer coördinatie tussen verschillende dienstverleners, adequate sectorale planning en optimalisering van de complementariteit van verschillende voorzieningen.

Al met al biedt dit proefschrift empirische en conceptuele inzichten in transitieprocessen in stedelijke basisvoorzieningen sectoren in lage-inkomenslanden. Het gaat in op de vraag hoe onderzoek naar duurzaamheidstransities rekening kan houden met een veelvoud aan serviceregimes waarin diverse innovatieactiviteiten plaatsvinden, wat leidt tot de identificatie van een verscheidenheid aan mogelijke eindpunten van transities, die afwijken van één dominant monolithisch regime. Deze conceptuele uitbreidingen zijn ook van belang voor transitieonderzoek in andere contexten dan steden in lage-inkomenslanden.

Resümee¹

Die zunehmende Urbanisierung der Welt führt zu zahlreichen Problemen bei der Bereitstellung von urbanen Grundversorgungsleistungen wie Wasser, Abwasser, und Stromversorgung in Städten einkommensschwacher Länder, insbesondere in informellen Siedlungen. Unter diesen Grundversorgungsleistungen stellt die Bereitstellung von Sanitär- und Hygieneinfrastrukturen eine besondere Herausforderung dar, bei deren Lösung es in den vergangenen Jahrzehnten nur sehr wenig Fortschritt gegeben hat: 60% der Weltbevölkerung hat noch immer keinen Zugang zu einer zuverlässigen und sicheren Sanitärversorgung. Dies führt zu Nachhaltigkeitsproblemen, wie etwa Umweltverschmutzungen und verhindert vielerorts ein gesundes und produktives urbanes Leben.

Das Ziel dieser Doktorarbeit ist es zu analysieren wie Innovationen zu einem fundamentalen Wandel hin zu nachhaltigeren städtischen Grundversorgungssektoren in einkommensschwachen Ländern beitragen können. Vor diesem Hintergrund greift die Arbeit auf Erkenntnisse aus dem Forschungsfeld der Nachhaltigkeitstransitionen zurück, um die miteinander verflochtenen Faktoren zu analysieren, die zur Starrheit dieser Sektoren führt. Ferner sollen Herausforderungen identifizieren werden vor denen Innovatoren stehen, die diese Probleme angehen, um zu zeigen, wie deren Aktivitäten potentielle Transitionswege eröffnen können. Der Hauptfokus der Transitionsforschung hat bisher auf einkommensstarken westlichen Nationen gelegen, während sich die Realitäten vieler einkommensschwacher Städte drastisch davon unterscheiden. Die Arbeit erläutert daher konzeptionell, wie sich Transitionen in diesen Kontexten vollziehen mögen.

Die Arbeit legt ihren Fokus auf den Fall der Sanitärversorgung in Nairobi, der Hauptstadt von Kenia. Eine Stadt, die von großer Ungleichheit in Bezug auf die Sanitärversorgung innerhalb der verschiedenen Stadtteile charakterisiert ist. Insbesondere in den informellen Siedlungen der Stadt bestehen in diesem Bereich gravierende Probleme. Die empirischen Analysen wurden auf Grundlage von qualitativen Daten und Methoden durchgeführt. Daten wurden mithilfe von halbstrukturierten Experteninterviews, Beobachtungen, Feldbegehungen, Fokusgruppendifkussionen sowie weiteren Dokumenten und Literatur erhoben.

¹ Aus Gründen der Lesbarkeit verzichtet die deutsche Übersetzung des Resümeees darauf, geschlechtsspezifische Formulierungen zu verwenden. Soweit personenbezogene Bezeichnungen nur in männlicher Form angeführt sind, beziehen sie sich auf Männer, Frauen und Andersgeschlechtliche in gleicher Weise.

Die Ergebnisse liefern einen Einblick in die Bereitstellung und Nutzung verschiedener Sanitär- und Hygieneinfrastrukturen in unterschiedlichen Stadtteilen von Nairobi. Die täglichen Handlungspraktiken von Nutzern und Bereitstellern hängen mit spezifischen, wohl-etablierten Konfigurationen von Technologien, Organisationstypen, sowie Routinen von Nutzern und Bereitstellern zusammen – den sogenannten „Dienstleistungsregimen“. In Nairobi existieren fünf solcher Dienstleistungsregime im Sanitärsektor basierend auf an die Kanalisation angeschlossenen Spültoiletten, unter Nachbarn geteilten sanitären Anlagen, öffentlichen und Container-basierten Sanitärdienstleistungen sowie alternativen Bewältigungsstrategien. Die Vielzahl von Dienstleistungsregimen hat sich über Jahre hinweg herausgebildet, um den verschiedenen kontextuellen Merkmalen der Stadt gerecht zu werden. Besonders in informellen Siedlungen findet sich eine komplexe Vielzahl von Dienstleistungsregimen. Der Sektor ist kaum geplant und die verschiedenen Dienstleistungsregime sind nicht koordiniert. Dies bedeutet, dass viele Dienstleistungen nicht optimal und effektiv für Nutzer und Bereitsteller funktionieren können: Abfallstoffe werden unzureichend gemanagt und Nutzer haben keinen durchgängigen Zugang zu funktionierenden Sanitär- und Hygieneinfrastrukturen. Die Dienstleistungsregime formen daher ein zersplittertes Regime auf sektoraler Ebene.

Zahlreiche Akteure verfolgen Innovationsstrategien, um diese Situation in Nairobi zu verbessern. Der öffentliche Abwasserbetreiber hat kürzlich begonnen seine Dienstleistungen auf informelle Siedlungen auszuweiten, nachdem er diese Gebiete für Jahrzehnte vernachlässigt hatte. Dies stellt eine Herausforderung für den Betreiber dar, da er mit seinen üblichen Betriebspraktiken, die in einkommensstarken Stadtteilen entwickelt worden sind, brechen muss. Die Ergebnisse der Arbeit zeigen, wie der Betreiber nur mäßigen Erfolg bei dem Versuch hatte, neue Kompetenzen und organisationale Strukturen für Dienstleistungen in informellen Siedlungen aufzubauen. Ein andere Innovationsstrategie wird von sozialen Unternehmen und NGOs verfolgt, die versuchen neue Sanitär-Wertschöpfungsketten basierend auf dezentralen sanitären Anlagen in informellen Siedlungen zu entwickeln. Sanitärketten bestehen aus zahlreichen miteinander verbundenen Aktivitäten, die neben der Bereitstellung von Sanitärdienstleistungen auch die Produktion von auf Fäkalschlamm basierten Produkten ermöglichen. Drei Initiativen ist es bisher gelungen eine funktionierende Sanitärkette zu etablieren, wobei sie jedoch aufgrund von fehlenden Kompetenzen und institutionellen Diskrepanzen vor Herausforderungen stehen. Die Ergebnisse zeigen, dass die Initiativen hauptsächlich voneinander isoliert arbeiten, und wie ihr aggregierter Innovationserfolg, durch die wirksame Unterstützung von Synergien zwischen ihnen verbessert werden könnte.

Nicht alle Ressourcen für innovative Aktivitäten können auf lokaler Ebene mobilisiert werden. Auf globaler Ebene, versuchen zahlreiche Akteure und Netzwerke aus der internationalen Entwicklungszusammenarbeit ein globales Paradigma um sicher betriebene on-site Sanitärlösungen herum aufzubauen. Ein internationaler Innovations-Intermediär trägt zur Koordination dieser Bestrebungen bei. Im vergangenen Jahrzehnt haben diese von internationalen Akteuren getragenen Entwicklungen vor allem zur Schaffung von Legitimität, Wissen und Finanzierungsquellen für sicher betriebene on-site Sanitärinnovationen beigetragen. Die auf globaler Ebene mobilisierten Ressourcen könnten dabei noch gezielter auch für die zukünftige Implementierung sowie die Formierung von neuen Märkten für innovative on-site Sanitärlösungen eingesetzt werden.

Als Ergebnis dieser Innovationsstrategien wird sich das zersplitterte Regime von Nairobi im Laufe der Zeit weiterentwickeln. Die oft angestrebte Transition zu einem „monolithischen Regime“ auf der Grundlage eines zentralisierten Kanalisationssystems erscheint in den kommenden Jahren unrealistisch, da es schwierig ist, das lokale Kanalisationssystem auf informelle Siedlungen auszuweiten, und verschiedene andere Dienstleistungsregime bereits etabliert sind. Stattdessen kann eine viel breitere Palette möglicher Endpunkte von Transitionspfaden zur Nachhaltigkeit identifiziert werden. Diese können durch schrittweise und parallele Transformationsprozesse erreicht werden, bei denen im Laufe der Zeit unterschiedliche Konstellationen verbesserter Dienstleistungsoptionen entwickelt werden. Dies würde eine Konzentration auf die Verbesserung der unterschiedlichen Dienstleistungsregime und eine bessere Abstimmung zwischen diesen Regimen erfordern. Ein Dienstleistungsregime kann beispielsweise optimiert werden, indem der Zeitpunkt und der Standort eines Dienstleistungsangebots geändert werden, um besser auf die Alltagspraktiken der Benutzer einzugehen. Eine bessere Abstimmung zwischen den Dienstleistungsregimen erfordert eine bessere Koordinierung zwischen den verschiedenen Dienstleistern, eine angemessene Sektorplanung und die Optimierung der Komplementaritäten zwischen den verschiedenen Diensten.

Zusammengefasst liefert die Arbeit konzeptionelle und empirische Einblicke in Transitionsprozesse in Grundversorgungssektoren in Städten einkommensschwacher Länder. Sie erläutert, wie die Forschung zu Nachhaltigkeitstransitionen eine Vielzahl von Dienstleistungsregimen berücksichtigen kann, in denen unterschiedliche Innovationsaktivitäten stattfinden. Dies führt zur Identifizierung einer Vielzahl von möglichen Endpunkten von Transitionen, die weit über das monolithische Regime hinausgehen. Diese konzeptionellen Erweiterungen sind auch für die Transitionsforschung

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Curriculum Vitae

Mara van Welie (Amsterdam, 1990) obtained a BSc degree in Architecture, Building and Planning (2012) and an MSc in Innovation Sciences (2015, cum laude) from Eindhoven University of Technology, Netherlands. In between her bachelor and master she set-up and managed a biogas project in Kigali, Rwanda. While studying for her MSc she did an exchange semester in Urban Ecological Planning at the Norwegian University of Science and Technology in Trondheim, Norway.

In September 2015, she started as a PhD researcher in the Department of Environmental Social Sciences at Eawag (Swiss Federal Institute of Aquatic Science and Technology), Switzerland. She was affiliated with the Innovation Studies group of the Copernicus Institute of Sustainable Development at the Faculty of Geosciences of Utrecht University, Netherlands. She published in international journals, presented her work at various conferences and meetings, and (co-)organized international workshops and conferences, among others as an organizer of the Network of Early career researchers in Sustainability Transitions (NEST).

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