

Anchoring innovations in oscillating domestic spaces: Why sanitation service offerings fail in informal settlements

Pauline Cherunya^{1,2}, Helene Ahlborg³, Bernhard Truffer^{1,2}

1: Department of Environmental Social Sciences, Eawag, Switzerland

2: Copernicus Institute, Utrecht University, the Netherlands

3: Department of Political Science, Gothenburg University, Sweden

Abstract

The provision of basic services represents one of the core challenges for sustainability transitions in rapidly growing cities of the Global South. A persistent conundrum for practitioners and researchers is that often new offers are not adopted and maintained by users, despite seemingly superior functionality and user convenience. We posit that one major reason is inappropriate understanding of the context where users have to manage their daily lives. We propose an analytical approach to assess the sets of practices informal settlement (slum) dwellers build up to fulfil their daily needs. The focus on practices provides a middle-ground perspective between under-socialized accounts that see users as isolated rational actors and over-socialized accounts which expect highly routinized behaviour prescribed by cultural and economic structures. We posit that informal settlement dwellers have to cope with *oscillating domestic spaces*, by which we mean that people need to constantly rearrange daily practices in time and space, and to develop *response strategies*, in order to accommodate quickly changing *practice preconditions*. We illustrate the framework by a case study on introduction of a container-based sanitation service option in informal settlements of Nairobi, Kenya. This analysis shows how innovations often anchored onto only a very small part of the complex domestic space, and was in disarray with the actual needs - when a systemic, middle-ground, perspective is not considered. By this, we contribute to the understanding of how users have to be conceptualized in sustainability transitions, and to a more elaborate understanding of the space-time by analysing a highly complex context for practices. We conclude by arguing that the conceptual framework can be applied to a wide variety of transition cases, also in the Global North.

1. Introduction

A lack of access to hygienic, safe, and consistent basic service systems, for water, sanitation, energy and solid waste management, threatens the well-being of one in eight people that live in informal settlements (slums) (Ezeh et al., 2017; Sheuya, 2008; UN-Habitat, 2016, p. 12). In Sub-Saharan Africa, the persistence of unsustainable systems results from a combination of historical and current processes, with institutional, economic, political, infrastructural, demographic, and social factors, that create a complex situation that is difficult to understand and tackle (Beall, Guha-Khasnobis, & Kanbur, 2010; Jaglin, 2016). Public utility actors lack technical, institutional and financial capacities – sometimes also the motivation – to provide services in a context characterised by overcrowding, tenure legality problems, insecurity, and the high rates of unplanned expansions (Andersson, Dickin, & Rosemarin, 2016; Jaglin, 2016; O’Keefe, Lüthi, Tumwebaze, & Tobias, 2015; Van Welie & Truffer, Submitted-a). Sanitation, in particular, faces some of the greatest transformation challenges for developing cities. The Millennium Development Goals for sanitation were not met by great margins (UNSD, 2015).

Increasingly, public and private sector actors are attempting alternative service provision models. Compared to large-scale models of public utilities, decentralized and small-scale sanitation systems offer promising opportunities for informal settlements (Katukiza et al., 2012; Larsen, Hoffmann, Lüthi, Truffer, & Maurer, 2016; O’Keefe et al., 2015) - including possibilities for rapid installations, cost reductions, local adaptation to available spaces and preferences, and possibilities for local experimentation and learning. However, while the economic and technical merits of small-scale systems are many, successes are few in local embedding and diffusion with failures to scale beyond pilot projects (Bhagwan, Still, Buckley, & Foxon, 2008; Lüthi, McConville, & Kvarnström, 2010; Sijbesma, 2006).

It is fair to state that small-scale basic service innovations have often been technology - and product - oriented, rather than needs-driven and context-sensitive. Behaviour change, urban governance and engineering approaches have prominently informed implementation of small-scale sanitation initiatives in developing cities – and often in isolation. Behaviour change models have offered valuable conceptual contributions in understanding the non-hardware factors of technology-acceptance but often in form of controlled experiments (i.e. Inauen, Hossain, Johnston, and Mosler (2013) and Mosler (2012)). Behaviours should be positioned within a broader sphere of influence, beyond the minimalistic focus on individuals and rational conceptions of agency (Dreibelbis et al., 2013, p. 1015). Urban political ecology field has made contributions to understand tenure, informality, inequality, economic, social, cultural and political factors, and development aid

strategies among others. However, the field tends to inform higher-level politics, and does not assist with knowledge specific enough to make sense of the local-level where innovations are piloted. For engineers, they often focus on optimal functionality of artefacts in terms of environmental and/ or economic benefits. A consequence of these three approaches is that under-socialized behaviour change interventions or over-socialized economic and cultural approaches dominate the thinking about users (Marshall & Farahbakhsh, 2013, p. 988). The demand-side actors have been treated as passive adopters, without significant agency when novel service offerings are introduced (Letema, van Vliet, & van Lier, 2014; Ostrom, 1996; Schramm & Wright-Contreras, 2017). We suggest that this represents a simplistic and fragmented understanding, contributing to the limited uptake among users.

The aim of this paper is to contribute to the sense-making of the conditions for successful introduction, acceptance and embedding of novel service offerings in informal settlements. We develop an approach to analyse the daily activities of users of basic services to elaborate where, when, why and how dwellers deal with accessing basic services. This perspective allows us to understand the conditions for success from a systemic, balanced view of individual rational choices and determinist structural accounts. Our specific vantage point is a “socio-technical systems” (Fünfschilling, 2014; Geels, 2011; Markard, Raven, & Truffer, 2012), which refers to a broad, but tightly interrelated, variety of institutional elements (societal and technical norms, regulations, standards of good practice and public opinion), material artefacts and infrastructures, as well as agency in networks of actors, dependent on each other (Markard et al., 2012). Transitions in socio-technical systems entail sets of processes that lead to a fundamental shift involving far-reaching changes along technological, material, organizational, institutional, political, economic, and socio-cultural dimensions (Markard et al., 2012).

We argue that this stream of work has significance beyond the current status of its applications. Transitions research has often focused on purposeful interactions between state and market actors in attempts to achieve certain goals. Considerably less attention has been directed towards understanding how local-level actors in their everyday lives and activities are part of transitions to sustainability (Avelino, Grin, Pel, & Jhagroe, 2016; Fischer & Newig, 2016; Wittmayer, Avelino, van Steenberg, & Loorbach, 2016). Also, the literature has been developed based largely on Global North¹ empirical experiences, and only recently have Global South transition questions been

¹ 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 > \$3,956), while Global South are lower-income nations (GNI per capita < \$3,955). For more discussions on these contested terms, see (Pagel, Ranke, Hempel, & Köhler, 2014). We also use “OECD” in this paper interchangeably to refer to countries in the “Global North”.

explored (Van Welie, Cherunya, Truffer, & Murphy, Resubmitted; Wieczorek, 2017). Based on these critiques, we aim at contributing in two ways to the socio-technical systems literature.

First, by putting the agency of demand-side actors at the core of the analysis, we recognize the relevance of user dimensions in particular for our empirical context (developing cities). Actor-centred theory and methodology is of particular relevance for understanding the expanding prospects for users in diverse sectors globally, to become agents of transformative change (initiating, accelerating and stabilizing transitions) in their roles as prosumers, co-producers, legitimators, intermediaries and lobbyists (Schot, Kanger, & Verbong, 2016). In particular, we follow Ahlborg (2017) and Shove and Walker (2007) who have pointed to the risk that socio-technical system approaches that do not theoretically and methodologically pay attention to demand-side actors' logics, roles and practices could become technocratic, and in this way disregarding or downplaying human needs, political struggles and conflicts of interest inherent in societal transitions. To counteract this shortcoming we will base our approach on 'practice theory' in order to understand and explain how stabilization and change come about in socio-technical systems (Shove & Walker, 2007).

Our second contribution to literature is to operationalize a practice theory approach when it is applied to life contexts that are riddled with uncertainty, heterogeneity and fragmentation of service provision arrangements, which are typical for informal settlements in developing cities. To operationalize a practice approach, we elaborate on the space-time characteristics of everyday practices of users. In particular, we conceptualise the *oscillating domestic space*, i.e. the fluctuations combinations of practice preconditions and its complimentary response strategies, in time-space where users have to carry out their daily domestic tasks, resulting in ongoing adjustment of how, when, and where practices are carried out.

We illustrate the virtues of this analytical approach by an empirical case of sanitation in the informal settlements of Nairobi, in Kenya. We ask the following questions: (i) how can we identify practices in the complex, rapidly changing and highly uncertain contexts in which informal settlement dwellers have to access basic services? (ii) How do they establish practices to provide themselves with the needed basic services? (iii) Why do seemingly superior technological innovations fail to reconfigure practices in the long-term? We address the third question through an analysis of the introduction of container-based toilets in informal settlements in Nairobi. This new service was offered to provide an in-house family toilet and to solve the problem of the unsafe disposal of untreated faecal waste into the local living environments by substituting open defecation. Our analysis shows that the offer did not replace open defecation as had been the goal of the provider. Users appropriated the service offering differently based on contextual possibilities and limitations.

The paper is structured as follows: The next section reviews practice theory literature and its integration with socio-technical transitions literature, and also elaborates on the conceptual approach we propose. Section three introduces the empirical case of sanitation in Nairobi's informal settlements and describes the research methodology. The results section shares the case evidences, and illustrates the complexities informal settlement dwellers are confronted with daily when taking care of their domestic and sanitation needs. The discussion section elaborates how a practice-based analysis, that captures the daily fluctuations of practice preconditions, explains the reason for the limited uptake of seemingly superior services offerings. We conclude by commenting on the usefulness of the analytical approach for socio-technical transitions questions in other sectors and geographies.

2. Theory

2.1 A practice understanding of socio-technical transitions and limitations

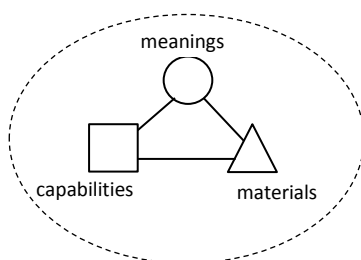
Socio-technical transitions are sets of processes that lead to a fundamental shift in socio-technical systems, and involves far-reaching changes along technological, material, organizational, socially, culturally, regulatory, political and economic dimensions, as well as everyday user practices (Markard et al., 2012). In analysing these systemic changes that are triggered by innovations, practice theory is increasingly used as an approach that takes practices, rather than structural features or individual rational choices, to be the foundation in understanding the "social" in socio-technical transitions (Cetina, Schatzki, & von Savigny, 2005; Shove, 2004). As such, practices are "sites" of the social that can reveal key insights into the ways and means through which organizations and socio-technical regimes operate and change over time (Schatzki, 2002). Practice theory is strongly associated with, and builds upon, early works of Giddens (1979, 1984), Bourdieu (1980), Wenger (1998), Reckwitz (2002), and Schatzki (2002). For Giddens (1979), practices are understood as foundational building blocks of society that reflect the relationships between actions in everyday life worlds and the long-standing structures that govern and mediate these. In this understanding, a focus on practices can overcome the structure-actor dualism, a problem encountered and discussed in many fields, including earlier formulations of transitions frameworks (Spaargaren, Oosterveer, & Loeber, 2013, p. 10).

A number of more recent studies have involved themselves in bringing a practice-thinking into transition studies. They include Cohen and Ilieva (2015), Hargreaves, Longhurst, and Seyfang (2013), Gram-Hanssen (2011), McMeekin and Southerton (2012), Pantzar and Shove (2010), (Shove & Walker, 2007, 2010), Stengers (2010), and Watson (2012). For Hargreaves et al. (2013), they

understand humans as skilled agents who actively negotiate and perform a wide range of practices in the normal course of everyday life. People perform practices while embedded in webs of relations between human actors and non-human elements, and the practices are shaped by and reshape the context of which they are part. In addition, Shove and Walker (2007, p. 2) indicate that practice-oriented approaches make studies of systems in transition less retrospective and distanced, and in this way is better able to make propositions about how individuals and organisations can act to steer transitions. The added advantages of practice approaches, also, include giving explicit attention to politics of transitions, to the agency of the demand-side, to the role of citizens as part of a transition, and as well being able to concentrate on normality as much as on novelty (Hargreaves et al., 2013; Shove & Walker, 2007).

Practices are spatially and temporally organised ‘ways of doing’ certain activities, with a recognizable conjunction of interlinked elements (Schatzki, 2002; Shove, Pantzar, & Watson, 2012). Practice elements are delineated as materials – the technical infrastructures and artefacts; meanings – the images, symbols, rationales, and perceptions; and capabilities – the know-how and forms of competence (Hargreaves et al., 2013; Shove et al., 2012).

Figure 1: Interlinked elements of a practice



In the domains of everyday life, practices co-exist and elements may overlap across practices. Consider for example cooking, which combines materials (ingredients; gas-cooker), meanings (diet choices; responsibility - who is meant to cook?; preferred cooking times), and capabilities (knowing cooking procedure; ability to purchase cooking-gas). Cooking is also linked to other, analytically distinguishable, practices of acquiring the ingredients, eating and cleaning the kitchen. The co-existence of practices is conceptualized as “ecologies of practices” and “bundles of practices” respectively by Stengers (2013) and Shove et al. (2012). The bundling can occur by overlap of elements (Shove et al., 2012), such as when both practices of room-heating and cooking require same material element – gas, or in the form of sequencing of different practices in time and space (Shove, Trentmann, & Wilk, 2009), i.e. establishing a routine of daily scheduling of cooking-eating-cleaning. Users develop routines across different activity-domains for plural reasons – reflecting meanings and taste, comfort, necessity, constraint, obligation, and resource maximization (Shove et al., 2012).

Figure 2: Bundling by overlap of elements

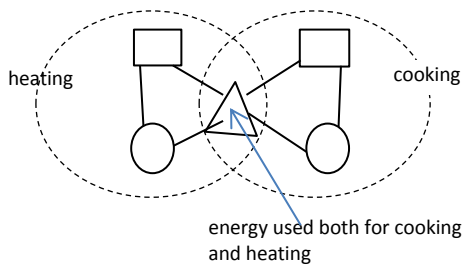
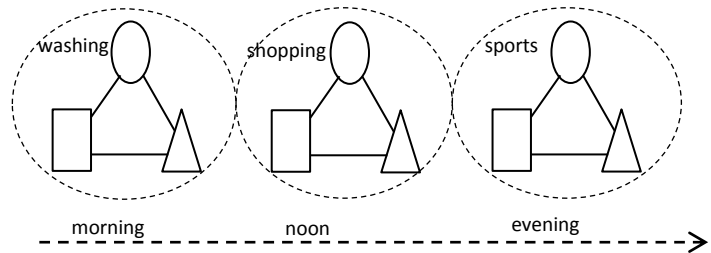


Figure 3: Bundling by sequencing different practices



The bundling of practices is significant for the maintenance, stabilization and reproduction of a practice (Watson, 2012). Bundling can become routinized - and the consequences of the performance of routinized practices can persist in the temporal-spatial fabric of society (Jones & Murphy, 2011; Watson, 2012). The stabilization of arrangement of practice elements (sociotechnical configurations), that scale up and gain momentum over time and space, at some point become what we understand as 'structures' or socio-technical 'regimes' (Hargreaves et al., 2013, p. 408). As such, the disentanglement of the space-time provides a useful analytical approach to understand the interplay of individual and structural constituents of social phenomena (Jones & Murphy, 2011; Shove et al., 2012; Watson, 2012).

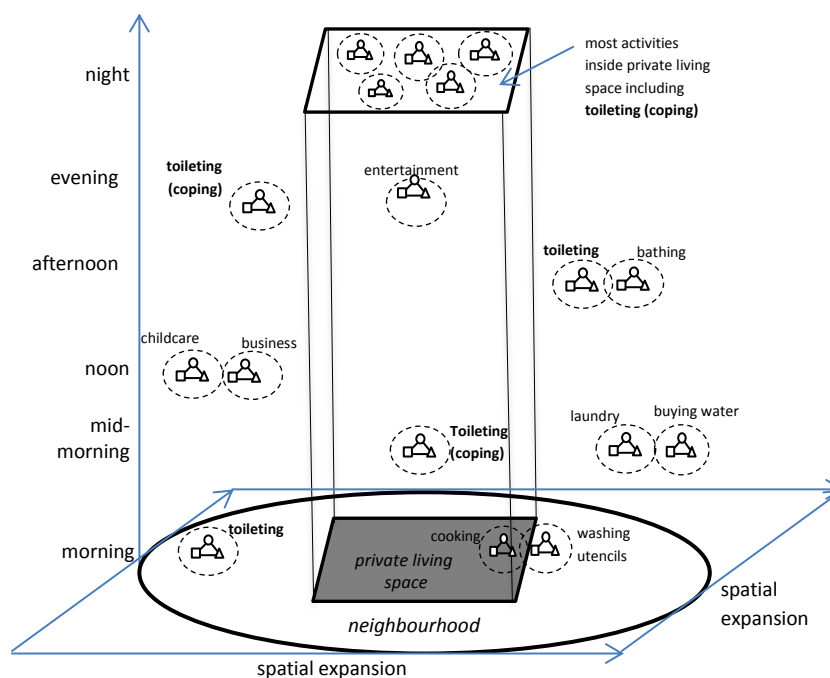
Application of the time-space dimension, nonetheless, has often been implicit or simplified in the analysis of practices. Operationalization of the time-space has largely focused on optimisation of time-resources as practices become "overall more demanding and hungrier of time" (Shove et al., 2012, p. 96). What we can see in literature, the main focus in understanding the everyday practice dynamics has been on structuring of the temporal rhythms of daily life, re-scheduling, i.e. Shove et al. (2009) and (Watson, 2012) – both taking empirical examples from OECD contexts. We suggest that the time-space dimension of practices become more critical as multiplicity of elements are required to perform a specific practice, and when context conditions cannot allow individuals to partake a practice according to the way they want or prefer – as is the case in basic service access in cities in the Global South, and more prominently in informal settlements.

How practice theory has been integrated in transition studies has largely been informed by empirical cases from the Global North (i.e. referring to all the list of contributions presented earlier in this section). The implication is that operationalization of a practice analysis as is currently done cannot be replicated for cases in cities in the Global South - as it will inadequately account for all the factors that shape performance of practices. Particularly, informal settlements are contexts characterized by much higher complexities for basic service access, associated with poor infrastructure conditions, inefficient governance structures, inadequate and unreliable service provisioning, and rampant poverty. In cities in the Global North, conditions for performance of practices are rather stable by

virtue of reliable and adequate infrastructures, efficient monitoring of basic service systems, and much more stable economic conditions of individuals in regard to accessing basic necessities. There is more certainties about how, where and when to undertake a task or a project.

Using mobility as an example, time-schedules for public transport function in a more or less stable manner in the Global North. Services often incorporate reliable communications when delays are expected, and provision of alternative means is common (i.e. a replacement bus when the train fails). With well-functioning and reliable systems, scheduling across time-space becomes standard practice. A contrast is observed and experienced for transportation in most cities in the Global South. Time-schedules may not be present – and if available they do not function efficiently. As such, uncertainties cannot allow users to make efficient schedules and plans about when to take a bus and when to arrive. For example, to commute into the city in Nairobi, a person may wait at the bus-stops either five minutes or for up to an hour, as there are no time-based departures and traffic may delay the vehicles (Kumar & Barrett, 2008, p. 22). To cover the costs for such delays, travel charges (which are unregulated) may be inflated by the service provider. All these uncertainties force users to depend on several fragmented alternatives in the course of a day. For example, transport in Nairobi (Kumar & Barrett, 2008, p. 22) and sanitation in Nairobi and Kampala (Lawhon, Nilsson, Silver, Ernstson, & Lwasa, 2017; Van Welie et al., Resubmitted). As such, analysing practice bundles in time-space (Figure 4) is required to understand practices in contexts with multiplicity of elements, and when context conditions cannot allow individuals to partake a practice according to the way they want or prefer.

Figure 4: Bundling of practices in time-space



Instabilities are not only related to the technical elements that are directly influence a practice. They also concern supporting infrastructures, and social and economic conditions. Altogether, we conceptualize these factors as *practice preconditions*. We group them into three broad and interacting categories that correspond to the categorization of practice elements: (i) material factors – importantly the functionality of service infrastructures and artefacts, (ii) meanings – the individual and shared socio-cultural norms and values, social relations and local institutions, (iii) capabilities (economic) of individuals and groups. These are further elaborated in the analytical framework.

Instabilities related to meanings and capabilities have implications for our understanding of the role of “routine”. We understand routines as a response to the unreliabilities of practice preconditions, rather than being an indication of overall stabilization. We build on the work by philosopher Isabelle Stengers, who emphasizes that “hesitation” is what differentiates a practice from a normative or rule-following activity: “Practices are not free from norms, but conformity is not the most important and does not determine the practice” and “to act without hesitation is to act based on habit, conviction, convention and custom in order to deal with a situation without having to think or hesitate” (Stengers, 2010, p. 18). As such, not every action is a practice. To act ‘automatically’, such as following orders or rules without thinking, is, in this understanding, not a practice. A practice implies a thoughtful ‘way of doing’ that may develop into routine over time, but was formed based on “hesitation” and reflection on meanings, options and outcomes. ‘Hesitation’ is an important underlying factor that is often not visible through a descriptive analysis of scheduled routinized practices.

To conclude, the instabilities of practice preconditions, the multiplicity of practice elements, and development of response strategies to deal with quickly changing practice preconditions suggest a more intricate operationalization of practices is required. We propose a practice analysis that places the time-space dimension at the core. Incorporating response strategies places people’s active and thoughtful reflections at the centre of the struggle to acquire basic necessities. From this perspective, the introduction of an innovation can be seen as a situation pushing people to stop and think about their material and non-material attachments, and their various obligations under changing circumstances.

2.2 Analytical framework: Oscillating domestic spaces and response strategies

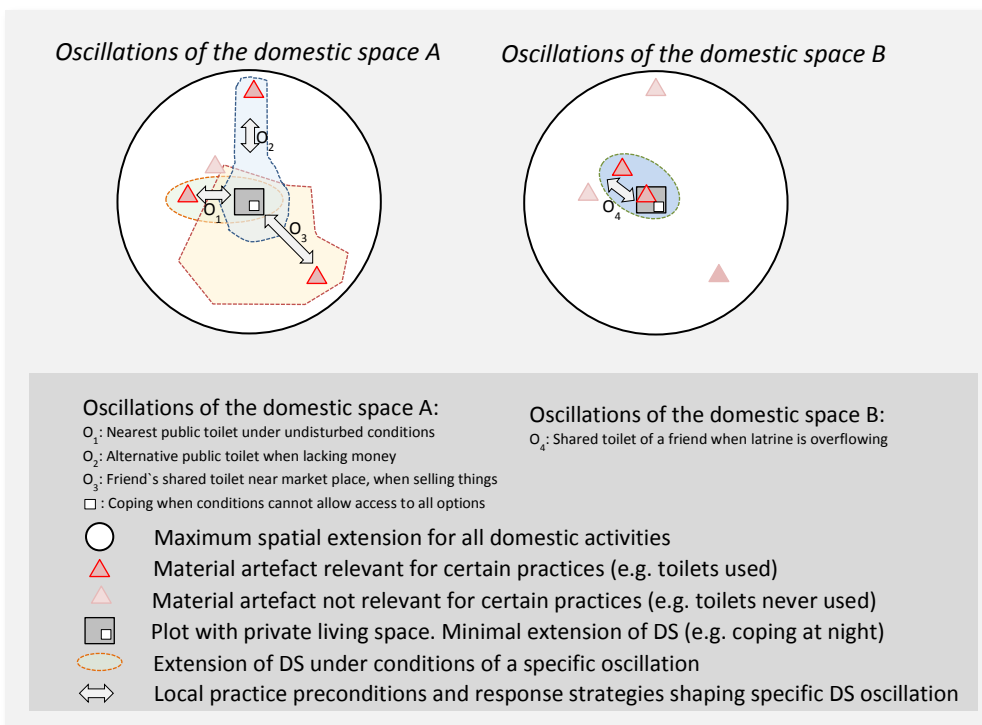
The analytical approach we propose makes an intricate and grounded analysis of a practice (sanitation), as one among many domestic practices that are performed by inhabitants of informal settlements, constituted by elements and practice bundles arranged in time-space. We center our

analysis on a phenomenon we call the *oscillating domestic space*. It captures ongoing interactions between *practice preconditions*, which enable or disable individuals and groups to perform certain tasks in their daily domestic engagements, and the *response strategies* utilized when practice preconditions cannot enable a practice. We define the *domestic space* as the symbolic and material space in which people engage in daily tasks related to making a 'home', and is manifested in interactions with other people and the material world in time and space. As such, it includes the maximum spatial extension for all domestic activities and the interactions between people and the material world (Figure 5).

Oscillating domestic space

The domestic space is *oscillating* because there are continuous fluctuations in the practice preconditions, resulting in daily changes about possibilities for access to the multiple, but fragmented and unreliable, service options. We see, daily and seasonal, regular and irregular, predictable and unpredictable, individual and structurally caused, changes in the practice preconditions. Hence, the *oscillating domestic space* is our concept to capture these instabilities, and how individuals and groups combine the preconditions to enable the performance of a practice. Figure 5 shows how the domestic spaces are extended (the shaded shapes) under specific preconditions for practice and the response strategies applied (double-pointed arrows).

Figure 5: Visualization of oscillating domestic space (DS)



The dynamic nature of practice preconditions is influenced directly by multiple external factors that cannot be managed at the local level – and are complex to manage also at higher-level interventions.

But they affect practice preconditions locally in important ways. There are several of these factors including weather seasonality, external project-fundings and activities of NGOs, political tensions and social instabilities, and economic meltdowns, practices of (informal) service providers, land tenure situations, norms and legislation shaping gender roles and women's access to resources, ethnicity, religion, and governments' activities and mandates in normal settlements. We highlight these external factors and only explain them to the extent that they are relevant for the empirical stories we have selected.

Based on the external factors, three practice *local preconditions* are specified: (i) material factors – importantly the functionality of service infrastructures and artefacts – that directly (as elements) and indirectly (as support infrastructure) enable practices, (ii) meanings – the individual and shared socio-cultural norms and values, social relations and local institutions, (iii) capabilities of individuals and groups – these are dynamic capacities to carry out domestic tasks by drawing on relations, institutions and material resources. These preconditions tend to influence many domestic tasks (not only sanitation) and combine to create highly complex situations that challenge both existing and novel service options.

We may now give a partial answer to the leading question of this paper, why innovations often fail due to limited uptake by the users. The oscillations make it difficult to categorize informal dwellers in binaries like individuals “with access” and those “without access”. This is however often done in innovation management in order to identify specific ‘market segments’, like those that lack technical facilities, whose values align with the new service offering, and who have a critical ability to pay. Market segmenting rests often on the assumption of stable practice preconditions. Oscillations, however, means that informal dwellers have to manage domestic tasks in a complex entanglement of constantly changing state between functioning and non-functioning services, socio-cultural enablers and barriers, and economic capabilities and inabilities. The domestic space is constantly changing, partly in foreseeable oscillating rhythms (like between day and night), but more importantly in rather unpredictable ways. To perform practices under such unstable conditions, inhabitants need to develop a variety of strategies and maintain multiple alternative options. Embedding novel service options is therefore often rationalized by users as a useful “add-on” to create a diverse portfolio and not as a reliable option fitting for all sorts of daily constellations. These uncertainties push them into situations where they have to – in Stengers' phrasing – stop, think, feel and hesitate, rather than engage in conscious rational decision making or fully routinized behaviours. This contrasts to sanitation practices in OECD contexts that are comparably neatly bundled and fitted with little effort into daily routines. The same uncertainty and complexity characterize basically all domestic tasks in informal settlements, resulting in this situation – what we call the oscillating

domestic space – of constant adjustment in time-space patterns around practices. We now elaborate the reasons for instabilities and unreliabilities of three sanitation practice preconditions in informal settlements.

First is the functionality of service infrastructures and artefacts (material factors). The functioning of sanitation service facilities is unreliable in informal settlements, thus access is often uncertain. There are a number of reasons for this. Insufficient material infrastructures - resulting from high number of users per toilet unit, sub-standard construction (i.e., small piping systems), and insufficient supply of water and electricity - lead to frequent blockages (Kariuki & Schwartz, 2005; Satterthwaite, Mitlin, & Bartlett, 2015). Also, toilets that are located in public areas are not available all the time. Public toilets are open only during regular business hours, and for all other publicly-located toilets, they cannot be accessed in the night due to insecurity (Amnesty-International, 2010; O'Reilly, 2016). Seasonal rainy conditions also often lead to deteriorated road infrastructure during these periods therefore limiting the movements of people – thus limiting toilets access. These factors limit providers to consistently make services available and limits users' access by users under the specified conditions. Important to note is the lack of formally regulated provision whereby the services are made available only at the convenience of the service provider (Kariuki & Schwartz, 2005). These conditions mean users cannot predict availability, forcing them to find alternative service options every other time (Lawhon et al., 2017).

Second, we argue that the requirements of individual and shared socio-cultural norms and values, social relations and local institutions (meanings) are flexibly adhered upon in informal settlements. In the contingencies of everyday life in informal settlements where people struggle to maintain their well-being in a context of high poverty and health hazards, socio-cultural practices are sometimes overlooked. Inhabitants can engage in activities and practices that they find unacceptable, shameful and not in accordance with what are socio-culturally expected of them. This aspect has not been adequately explored. The socio-cultural studies that are common in sanitation literature are those that understand actors to follow rules and by all means conform to socio-cultural beliefs. However, we understand the socio-cultural preconditions for practice to be full of tensions between plural and diverging meanings and obligations, resulting in hesitations between conforming-to and bending the norms.

Being sensitive to “hesitations” is not to say that norms and cultures are without influence. Indeed, social relations are influenced by differences of gender, age, class, ethnicity etc., which combine with formal and informal institutions (laws, rules, norms, religious beliefs), and resource distribution to restrain or enable individuals spatially, materially and socially in daily life (Desai, McFarlane, & Graham, 2015; Lawhon, Ernstson, & Silver, 2014; Truelove, 2011). Gender-based vulnerabilities, for

example, in relation to insecurity, crime and harassment are prominently discussed to create limitations on women's mobility and access to resources and services. (See a review of literature on gender and sanitation by Tilley, Bieri, and Kohler (2013)). Here, there are two points to make: first, categories of social differences do not, in a simple way, determine the social position of individuals or what practices are possible, as individuals experience and occupy multiple, intersecting, and fluid positions and subjectivities (Nightingale, 2011; Valentine, 2007). The effects of norms around gender and class tend to show as patterns at group level, as they shape the domestic spaces in specific ways for individuals 'belonging' to some groups. The consequence is differentiated rights and access to networks, material resources and services, and decision-making arenas. Close proximity to artefacts or services does not necessarily imply access, as social arrangements may exclude only some people. There can, in this sense, be a discontinuity and mismatch between the material and symbolic domestic space. Second, cities and informal settlements are generally very heterogeneous socially and culturally, a mishmash of norms, values, beliefs, and perceived belongings. This creates a diverse symbolic space, with variations of networks and unclear hierarchies, which may both expand and shrink people's various possibilities. We suggest that because of the fragmentation and ambiguity of the symbolic space, one finds a plethora of finely splintered and highly dynamic "dispositions" among inhabitants instead of rather well-behaved 'market segments'. This would call for more intricate approaches in identifying the marginalized individuals within seemingly homogenous social groups, and being sensitive to their specific needs.

Third, there are fluctuations in the capabilities of individuals and groups to carry out domestic tasks by drawing on resources, relations and institutions (capabilities). The fluctuations are perhaps most prominent for the economic capabilities of informal dwellers. Typically, informal settlements are inhabited by low-income communities that depend on irregular incomes. The majority hold a variety of casual employments, use savings and borrowings simultaneously, and save money using a mixture of formal and informal instruments (Collins, Morduch, Rutherford, & Ruthven, 2009). The irregular cash flow influences sanitation practices, as most informal dwellers access toilets for primary domestic use based on pay-per-use offerings (Corburn & Hildebrand, 2015; WSUP, 2011). The intermittent incomes imply that people's economic capabilities, to pay at every toilet visit, are precarious, and competing needs mean changing prioritizations. Another important aspect of individual capability is how physical conditions enable or disable people's access to sanitation. Sickness and old age may reduce people's domestic space and the use of specific basic service facilities. In informal settlements, health risks and diseases are recurrent – especially those that are water-borne (Corburn & Hildebrand, 2015).

Response strategies to precarious practice arrangements

In response to the way the local preconditions are unreliable and unstable, inhabitants in informal settlements have develop and maintain multiple, albeit fragmented and unreliable, practice arrangements in order to successfully perform a domestic task. The links between these preconditions that make up, and enable, a practice can break down as local contextual conditions are shaped by external factors, e.g. when there is suddenly no water or electricity, and an alternative must be found. Deciding among several uncertain service options can expend considerable time and effort. People develop response strategies² for different situations to manage domestic activities – especially that of toileting which naturally cannot be abstained from. Response strategies are the dynamic processes of rearranging the possible linkages between practice preconditions in time and space to enable performance of practices, and are contingent of creativity and innovations. We identify four generic response strategies. Two represent proactive, socially desirable, responses (*navigating*, and *negotiating*), and two are bending or even breaching socially accepted rules (*contravening* and *coping*) (Figure 6).

Figure 6: Response strategies to enable different practices in context of unreliable and unstable practice preconditions

Institutional meaning & locus of action	Response strategy
Rule following & Social interaction	– <i>Negotiating</i> – <i>Navigating</i>
Rule breaking & Personal accommodation	– <i>Contravening</i> – <i>Coping</i>

Navigating are strategic actions to leverage on social relations and institutions, by expanding social contacts, and in this way expand possible toilet options. Reciprocity, social status, and entitlements are key features of navigating access. An example would be to join an exclusive community of users of a specific option. Closely related to navigating is *negotiating* which entails enabling access through bargaining the terms of access. For example, requesting for cheaper access, or use on credit terms. Both navigating and negotiating strategies are often socially desirable and they draw on social relations, institutions and material resources. *Contravening* is when people go against rules and customs for the immediate benefit and in situations when their perceived rights are denied. For example, trespassing to access a public toilet. *Coping* is when a whole new practice with specific recognizable materialities and meanings are developed - that leave full control of the practice to the individual user. An example is open defecation. Both contravening and coping are mostly socially

² The strategies are comparable to what is discussed by Krantz (2006, p. 232), that the manipulations of social and physical environments are perceived to be constitutive acts to facilitate the realisation of a domestic tasks

non-desirable but prevalent – to mean everyone is doing it but often no one acknowledges that publicly.

To summarize the analytical framing and what this tells us about embedding novel service offerings, the uncertainty and complexity that characterize the performance of domestic tasks in informal settlements results in this situation that we call oscillating domestic space. In these highly dynamic context for practices, novel service options is therefore often rationalized by users as a useful “add-on” to create a diverse portfolio, and not as one reliable option fitting for all sorts of daily constellations. In analysing practices in oscillating domestic spaces, the underlying uncertainties, logics and social relations that influence practices become more pronounced. Importantly, moments of hesitation provides an analytical bridge between past and present, between the life experiences a person draws on to make a decision about a specific situation here and now – including how introducing a novel service option feedbacks both positively and negatively on all activities within the domestic space.

3. Methods

The investigation of everyday domestic tasks and practices was conducted in three neighbourhoods within three informal settlements in the city of Nairobi, Kenya. Nairobi is a popular site for innovative interventions in the basic service sectors. A growing interest by the private sector, to complement the struggling public sector, has led to several novel sanitation innovations to be piloted in the city (O’Keefe et al., 2015; Van Welie & Truffer, Submitted-b), making Nairobi an interesting case to study. We selected *Mathare-Bondeni*, *Kahawa-Soweto* and *Mukuru-Rorie* neighbourhoods³ based on the presence of small-scale sanitation interventions.

Table 1: Historical, demographic, and innovation profiles of three neighbourhoods we investigated (Data source for historical & demographic profiles (Karanja & Makau, 2012))

	Year established	Population	Innovations
Mathare-Bondeni	1920s	A neighbourhood of 2,500 people (part of the larger Mathare informal settlement of 188,183 inhabitants containing 13 neighbourhoods)	<i>Fresh Life</i> public container-based toilet. Introduced but was not scaled <i>Banza</i> in-house container-based toilet. Introduced but was not scaled
Kahawa-Soweto	1980s	3,000 people (made up of the one neighbourhood)	Shared Water-Closet toilet. Five of the 4 toilets not in use
Mukuru-Rorie	1998	A neighbourhood of 5,832 people (part of the larger Mukuru informal settlement of 100,000 inhabitants containing 11 neighbourhoods)	<i>Jitegemee</i> in-house container-based toilet. There was initial acceptance but very low levels of embedding. <i>Fresh Life</i> public container-based toilet introduced and successfully scaled locally

³ A focus on the neighbourhood level is motivated by the empirical problem posed in this paper by the presence of semi-formal administrative governance structures along these neighbourhoods. Interventions often make use of these structures – including the cases we use in this paper

The first author collected data in Nairobi for five months: in February, March 2016 and October to December 2016. In order to investigate sanitation practices in an oscillating domestic space, we needed multiple types of data. First, it is primarily women who are responsible for domestic tasks in the informal settlements of Nairobi. Thus, one data set investigates the everyday domestic tasks of women, focusing on how they interact with places, spaces, persons and artefacts, how they successfully manage domestic tasks in time and space, and what this means for them personally and for their livelihoods. Domestic tasks include, but are not limited to, cooking, washing clothes, cleaning utensils, childcare, fetching water from a water kiosk, bathing, relaxing after finishing domestic chores, and toileting. For the informal settlements context, we consider toileting a domestic task as it requires time and mobility to reach the toilet artefacts, it competes with other domestic tasks for resources (i.e. time, money), and daily negotiations and navigating are required to gain access.

The respondents are 30 women living in the informal settlements. We used semi-structured interview schedules as the main form of inquiry. Interviews were complemented with observations of where, how and when the domestic tasks are carried out. Interactions with each interview respondent lasted 65 minutes on average. We approached the interview respondents in a formal manner. However, the interactions were less structured to allow them to freely share how much they wished to. As sanitation is still perceived as a shameful topic to openly discuss, creating a relaxed interviewing environment enabled respondents to open up and to give more personal views. Complementing the interviews, the first author conducted two initial exploratory Focus Group Discussions (FGDs) with the women during the first fieldwork, and three validating FGDs at the end of the second fieldwork. The interviews were recorded in the local language, Kiswahili, and later transcribed into English.

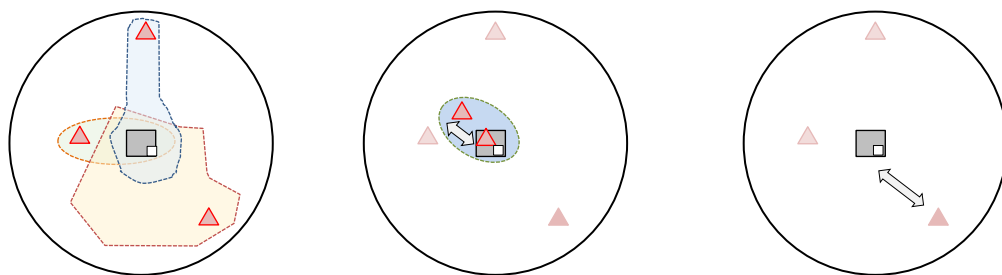
A second set of interviews for additional perspectives includes inquiries with 37 local experts and informants, such as community health extension workers, local community-groups leaders, NGOs representatives, and male inhabitants. The full list of interview respondents is presented in Appendix 1. The first author also spent considerable time in the neighbourhoods observing and experiencing everyday situations and conditions. Interviews and notes have been coded by use of MaxQDA-12 software. The second and third authors participated in analysis of data, resulting in joint reflection and discussion on interpretation of findings.

To understand practices through an intricate time-space approach, we make use of the framework and start by mapping the time-space where domestic tasks are undertaken. This results in a physical outline of the spatial extension for all domestic activities. We use the family house as the reference

point⁴, thus representing the minimum spatial extension. Important to note, various domestic tasks in informal settlements are undertaken outside - in front of the house, in the yard, or in public spaces such as next to the street, fields, pathways and at service-points. Small housing units, often one or two-roomed family houses, leave little space for domestic tasks. Also for convenience, householders prefer to carry out domestic tasks at service-points (i.e. laundry at the yard-taps and water kiosks) rather than carrying water to the house, a tedious and cumbersome task.

In the mapping of the spatial extension, one can notice that we do not start from a description of sanitation practices using specific artefacts, a common approach in conventional application of practice analysis, but in the more complex time-space of domestic tasks. In Figure 7, we distinguish three potential extensions of the domestic space under conditions of a specific oscillations. The three extensions are *detached*, *adjacent* and *limited*. “Detached” represents those that have several options but lack an in-house option. “Adjacent” represents those who have one in-house or on-plot option. “Limited” represents those who may have toilet artefacts within their maximum spatial extension but lack access to various reasons (no access in symbolic space). We maintain, however, that differences in accessing services lie in unique situation of individuals and how they combine practice preconditions and response strategies to enable service access. In the results section (4.1), we present stories of three women – among the 30 interviewed – who are categorized accordingly. Their stories illustrate what challenges these respective positions bring. We use descriptive stories of the women as a way to provide the reader with an understanding of the context and preconditions for performance of practices.

Figure 7: Visualization of positions of toilets in the spatial extension for domestic tasks in Nairobi’s informal settlements, and visualization of thee possible oscillations in relation to toilet access



Detached: several toilets in the spatial extension for domestic tasks

Adjacent: presence of toilet within the plot (adjacent to house)

Limited: no freely accessible toilet within the spatial extension for domestic tasks

⁴ This makes the analysis comparable to other analyses in previous studies where domestic tasks are investigated. Three examples of research that conceptualize the domestic living spaces in socio-technical studies are Khalid and Sunikka-Blank (2017), Eon, Breadsell, Morrison, and Byrne (2017), and Strengers (2013)

4. Results

We present the findings in two ways, in section 4.1, we describe the everyday life of three women interviewed, who represent the three positions of having limited, detached or adjacent access to toilets. The women's three stories do not capture all relevant findings and plurality of situations, materialities, meanings, capabilities, and response strategies in our data. Therefore, in Section 4.2, we provide a summary of findings from the other twenty-seven interviews. To guide the reader, we highlight in brackets how the data corresponds to analytical categories.

4.1 The stories of three women and their tasks in domestic space

Case 1: Gladys, about 40 years old. Physical domestic space: limited

Gladys is a widow who lives with her 6 children in a one-room house. Gladys is the sole breadwinner of her family of seven, and she depends on irregular casual jobs for an income. Having a large family and relying on irregular jobs means that Gladys and her family live "from hand to mouth".

"Yesterday when I woke up, I had a little sugar that had remained from the previous day, so I made breakfast for my children (...), lunch I didn't have anything..., whenever I am successful (to make some money during the course of the day) I stock up for two or three days - I buy sugar, maize flour, and the firewood that is lying outside the house. We can then have a meal and sleep..., the days to follow God will provide".

On a regular day, Gladys wakes up at 5:30am to prepare breakfast for her children. The children will help each other get dressed, have breakfast and within an hour head out to a nearby school. A two-year-old child remains at home and accompanies Gladys all day. Gladys then tidies her one-roomed house, takes the dishes to wash along a public path, and once every two days she washes the dirty clothes that have accumulated. She washes the clothes at a water-point about 100 meters from the house. When Gladys finishes her domestic tasks between 9am and 11am, she visits friends and neighbours to check if she can get a job for the day.

"There are no jobs; even now I was just about to leave the house to "hustle" (unreliable income). I just arrived back from a job I was given to clean the church. Now I want to go to the village-centre and see if I will meet someone else who can have a job for me (...) perhaps a farming job, as it is raining right now (...), whatever job comes I will take".

Gladys and her family are not part of an agreement to use shared toilets that are found close to her house. She does not own a private toilet. The closest public toilet to her house is about 500 meters away. Gladys considers the toilet too far away and so she does not use the option.

“We do not have access to a toilet (...), we just try and ask around from neighbours (navigating), I ask one neighbour today, another tomorrow, all my children do the same, it becomes hectic for us and the neighbours, so for my children when time allows (i.e. at night – daily oscillation) I let them use plastic bags (coping) which we dispose into the solid waste (...), all other private and shared toilets, including that of the church nearby, are padlocked (...) even for a pay they will not allow non-congregants (excluding norms). The only one that we are able to use for a pay is very far (...), we cannot go all the way there to use the public toilet, it is just too far (...), this whole area does not have a public toilet (no toilet within her domestic space) (...) at night you would not want to wake up your neighbours (daily oscillation) so we do “what we can” (coping).”

Gladys tell that, if there could be a public toilet within the area where she carries out her daily tasks, she would consider herself as having some access, because she informs that she still may not afford to always pay for her entire family (income uncertainties). Considering the demanding obligation to take care of her large family, Gladys is not in a position to invest in sanitation by buying a toilet, building a toilet or getting membership to a shared toilet group. Furthermore, lack of space to construct and being excluded because she is a minority ethnic group limits her from constructing or getting membership.

“So where can I build and this room is so small even to live with my children? There is no space (no place for infrastructure). (Also) I have tried to speak with neighbours to collectively get space for a toilet (negotiating), but my neighbours are of a different ethnicity, they will not want to invest with me (disabling socio-cultural meanings).”

Case 2: Caroline, 36 years old. Oscillation type: detached

Caroline lives in Mukuru-Rorie in a two-roomed house together with her husband and 3 children. Caroline is dependent on irregular casual jobs for an income, among them is a weekly travel to a smaller town about 100 kilometres from Nairobi to sell second hand clothes. The husband of Caroline works in an industry nearby. The youngest of Caroline`s children is nine years old.

On a regular day when she does not have to travel out of town for business, she goes to a higher-end estate nearby where she sits outside the gate and waits in case someone gives her a house-cleaning job for the day. She comes home empty handed more often compared to days when she manages to get the cleaning jobs (income uncertainties). Caroline wakes up at 6am, and twice a week she goes to a large second-hand clothes market in the city of Nairobi to buy her business stock. The other days she would do regular household tasks like purchasing water from a nearby kiosk or cleaning utensils

and clothes, mostly at the water kiosk. She finishes her domestic tasks at 10am, after which she visits friends in their houses or goes out to look for casual jobs.

“Visiting friends is nice. You get to know what is going on in the village (...) that’s how you easily get involved in community projects (navigating), (...) maybe an NGO is having a workshop and you get some little money”

There are about 3 public toilets she and her family can access within the areas where Caroline carries out her domestic tasks (spatial extension). She does not have access to a private toilet. The closest public toilet to her house that was previously accessible to her was about 20 meters away, but due to some problems within the management group, services have stopped indefinitely (unreliable artefacts and infrastructures). Other alternative public toilets within her domestic space are, respectively, 20 and 50 meters away. One of them is *Fresh Life* public toilet, a new innovative option by a social enterprise. Whenever Caroline has money (income uncertainties), she prefers to use the new option as it is very clean and does not smell. But when she does not have money, or late at night (daily oscillation) when the *Fresh Life* is closed (limited availability of preferred artefact) she will use the other public toilet which she considers to be very dirty (navigating; hesitation). At night when she cannot go outside (daily oscillation), Caroline uses a plastic bag to defecate – locally referred to as “flying toilet”, which she disposes off in the drainage or with solid waste.

At night? Which choice is there? You just use “flying toilet” (coping) (...) sometimes you find someone has dropped it outside your door. (...) if you see a nice shiny plastic bag lying on the street, do not trust it!”

Caroline and the family have a routine to visit the toilet right before the toilet is closed at 10pm (routine as a navigating strategy). This way, there is a possibility of getting through the night without needing a toilet.

Caroline was one of the beneficiaries of an innovative in-house container-based toilet named *Jitegemee*, about 2 years earlier. She stopped using it and stored the *Jitegemee* toilet away when her children joined boarding school. She found it to be useful only for the children (socio-cultural meaning of artefact). For herself, she preferred to find ways to navigate access by asking friends, going to the local bar, or just “holding” until morning (coping). For her, the new task of taking the container to the public toilet to dispose the collected faecal disposal, and cleaning the container was unnecessary effort. All in all, she still brings it out and uses it when she is unwell (physical capability). While she could still use *Jitegemee* despite the negative socio-cultural perceptions attached to it (bending socio-cultural norms; hesitation), her husband would never use it

“My husband said he will not use it. Men here refused to use it (...) they said that it is a “potty” for children (following socio-cultural norms) (...) you know the houses are small so my husband cannot use it here and the children are here. (...) even in the bathroom he cannot use it there, he prefers to walk around even at night to find an option outside (gender-based social differentiation of domestic spaces; navigating)”

“When Jitegeme was introduced we (the women) were not shy to use it (hesitation). 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” (needs-driven bending of socio-cultural expectations)

For Caroline, knowing people who manage toilets is very important as one is able to use the services on credit, when without money. Previously, her friend used to operate a public toilet. Her family would use this specific one whenever possible.

“It was nice because my children would go to this toilet whenever I was not home to provide them money for the toilet payment (navigating). I would later pay this friend the accumulated amount (negotiating)”.

Rise of insecurity in the neighbourhood often limits Caroline’s movement. Interestingly, insecurity conditions fluctuate. When insecurity becomes unbearable, community members often mobilize themselves to “flush” out the offenders who are mostly local community members.

“After such an operation, the community is much safer but after some time we start fearing again (...) right after those operations you can walk around even in the night (and go to the toilet) and no one will touch you (seasonal oscillation)”

The security situation often affects female members of the neighbourhood. Caroline’s 16 years old daughter is more vulnerable in public spaces, and her mother worries about issues of sexual harassments. Caroline navigates this situation by making sure she accompanies her daughter to the toilet when it gets dark (gender-based social differentiation of domestic spaces; daily oscillation; navigating).

The husband of Caroline prefers to use the toilets at her workplace every morning to avoid the morning hustle of looking for a functioning toilet (navigating). This saves costs as well. In the evening when he comes back from work, it is common that male adults spend time at the local social hall to follow the news on TV, where they get free-of-charge toilet access (navigating). Caroline’s role as a homemaker means she deals more with the everyday access challenges. As a woman, she is also expected to meet her toileting needs in more private areas compared to male counterparts (gender-

based differentiation based on culture). Also, to meet her menstrual needs, Caroline would require more toilet visits compared to her husband (gender-based differentiation based on physiology). Caroline thinks these differences are the reasons why toilet management groups are populated by women. *“It is an important way to survive for the women”* (navigating). Caroline’s engagement in the past in a toilet management group had helped her to expand access opportunities as she became known (social relations – navigating) and thus could use toilets at a cheaper rate, or even cost-free (negotiating).

Case 3: Harriet, 49 years old. Oscillation type: adjacent

Harriet lives with her husband and 8 years old grandchild in a two-room apartment block in Mathare-Bondeni. Harriet has been selling peanuts for a living at the main street within her neighbourhood for the past seven years. Harriet’s husband is a mason worker, meaning his job takes him out of town for weeks, followed by an unemployment period until he finds another masonry contract (income unreliability). In this case, Harriet is happy that her stable but low-income business sustains the family during her husband’s unemployment periods.

Harriet often wakes up at 6am, prepares her grandchild for school, then carries out domestic tasks. She does most of these tasks inside her apartment. In the mid-morning, she roasts the peanuts for her business and all afternoon she spends selling peanuts. Harriet has an in-house pour-flush and sewer-connected toilet. Compared to her previous house in the same area, where she only had public toilet options, life is less difficult.

“Even if we got used to the previous life, now I see that I had to do a lot of things, sometimes you have to carry your own water to the toilet (service non-functioning), sometimes you have to walk so far away. When we didn’t have money to pay for the toilet we would go down to the river to defecate when it was dark (daily oscillation; coping), (...) the toilets were also very dirty, (...) it was very hard especially in the beginning in 1986 when I had just arrived here from my rural home”.

The costs for maintaining the in-house toilet are included in the rent and she does not have to bother about having money for toilet use. As she also uses her toilet space as a bathroom, and as she has a water connection inside her house, she does most of her domestic tasks like washing and cooking inside the house. However, water shortages are commonplace in her neighbourhood. Harriet often has to use water kiosk services (service functioning; navigating). She sometimes cleans clothes at the water kiosk. Over the seven years she has lived in the apartment, Harriet has not experienced any problems with the toilet and therefore she has never required alternative options. As her small-scale business is only a few meters from her apartment, Harriet prefers to walk back home during the day

whenever she requires toilet access. Interestingly, one of Harriet`s daughters (also a respondent in the interviews) often comes around to use her toilet (navigating), to save on costs from public toilet use.

Harriet is aware that her in-house toilet is connected to a broken sewer that leads to the local stream nearby. Despite having an in-house hygienic toilet artefact, Harriet finds the area where she spends most of her day (spatial extension) to be unhealthy and unhygienic.

4.2 Further case studies and generalizations

Focusing on toileting, Table 3 presents a summary of the strategies that were drawn from all 30 women interviewed. Here, new details that were not captured in the stories of the three women (like contravening as a strategy) are presented. We have organized the Table to capture the response strategies associated with changing practice preconditions. We cluster the respondents according to how close their sanitation practice arrangements fit the three physical domestic spaces.

Table 2: Summary of response strategies used by 30 women interviewed

Practice preconditions	Response strategies to precarity		
	“Limited” toilet access	“Detached” toilet access	“Adjacent” adjacent access
Service functioning	N/A	<ul style="list-style-type: none"> - negotiate (cheaper access; access on credit) - navigate (more convenient options to consider; more socio-culturally fitting options to consider; use options of friends; use options managed by women; routinized toilet visits) 	<ul style="list-style-type: none"> - no strategies necessary, one stable option at home - negotiate (get exclusive access; improve maintenance)
Service non-functioning	N/A	<ul style="list-style-type: none"> - coping (open defecation; flying toilet) - navigate (ask friends; use at work; walk further to other toilets) - contravene (illegal access by breaking public toilet doors; misbehaving by using more than paid for; dumping faecal waste from container-based options in drainages) 	<ul style="list-style-type: none"> - coping - navigate (using public toilets; ask friends; use at work)
Enabling socio-cultural meanings	<ul style="list-style-type: none"> - coping (open defecation “hotspots”; “flying toilets”) - navigate (ask neighbours; use at work) - navigate (long-term investment for a toilet) 	<ul style="list-style-type: none"> - navigate (perceived temporary use of culturally unfit novel artefacts) 	<ul style="list-style-type: none"> - navigate (perceived temporary use of culturally unfit artefacts)
Socio-cultural	- coping (excluded)	- less options to choose from	- no strategies necessary,

barriers	- navigate (accompany each other to open defecation hotspots)	- coping (open defecation; flying toilet) - navigate (ask friends; use at work; walk further to other toilets; accompany each other) - contravene (illegal access by breaking public toilet doors; misbehaving by using more than paid for; dumping faecal waste from container-based options in drainages)	one option at home
Capabilities (have money)	- navigate (long-term investment for a toilet; joining a toilet management group)	- navigate (more options to consider including expensive one; joining toilet management groups)	- no strategies necessary, one option at home - no motivation for long-term investments
Inability (No money)	N/A	- coping (open defecation; flying toilets) - navigate (use dirtier and less unhealthy options; ask friends; use at work) - negotiate (use on credit) - contravene (illegal access by breaking public toilet doors; misbehaving by using more than paid for)	- no strategies necessary, one stable option at home

For individuals whose spatial extension in relation to toilet access leans closer to “detached”, where varieties of fragmented service options do exist, Table 3 shows that using diverse response strategies is common. There are high degrees of precarities and, despite many alternatives, aligning the practice preconditions requires a lot of effort and even luck. For example, when the cheaper toilet is not functioning because of toilet blockage, finding an alternative would mean either going to the nearer but more expensive option or one that is farther but cheaper, or in-house coping so as to be able to take care of more urgent domestic obligations like childcare. A majority also prefer the more hygienic toilet options, but would frequently use the cheaper and less hygienic when they lack money. At night, they use whichever toilet is open. With availability of several but fragmented service arrangements, introduction of *Jitegemee*, *Banza* and *Fresh Life* is understood as useful complimentary (R2, R3, S8, B3, FGD4, LL1).

For individuals whose oscillations in relation to toilet access lean closer to “adjacent”, they have what can be considered a “main service option”. A toilet in the home gives a sense of secure access as oscillations in domestic space has minimal influence to access. Payments for services are often included in the rent, and the use by a small number of people implies fewer challenges in operation and maintenance. In Table 3 we have shown that people in this category also involve themselves with response strategies – of which most are targeted at improving quality of already available service options. For example, shared toilet users negotiate among themselves about maintenance of

toilet facilities. An illustrative example is that of one respondent who has taken-over everyday maintenance of a number of shared toilets, and in return receives privileged access to one of the toilets for private use by her family only (R1)

Table 3 shows that, for individuals whose oscillations in relation to toilets lean closer to “limited”, coping seems to be the most commonly applied response strategy. Interestingly, people in this category seem to develop, over time, common locations where open defecation is done – the “hotspots” (FGDs 1 and 4). The women would accompany each other to these open locations. This way, despite it being a non-desired response strategy, coping has developed qualities that can categorize it as an access option, with distinct recognizable elements, rather than a response. People have an understanding about how, where and under what circumstances open defecation is done. The same phenomenon is identified for the “flying toilet” whereby just by its terminology many informal dwellers have a similar understanding of how to perform the practice. For this group, domestic spaces can be altered in two ways: by introducing new service offerings and by long-term navigating strategies like investing in toilet structures or joining toilet management groups.

Two general observations, related to response strategies, are worth mentioning: daily sanitation response strategies can become stable or long-term strategies, and secondly their benefits spill over to other domestic activity-domains. First, people negotiate with neighbours to invest together to construct new toilets. They also navigate and negotiate to gain membership to a shared/public toilet group, and as well negotiate with service providers for flat-rate monthly payments by families, instead of the regular pay-per-use. Second, the socially desirable response strategies become useful beyond only toileting. For example, joining a toilet management group means the members carry out other group activities like savings, which contribute to the domain of earning a living or establishment of home improvement “merry-go-round” initiatives.

5. Discussion: Agency of users in anchoring novel service offerings in oscillating domestic spaces

Our conceptualization of the “oscillating domestic space” has enabled us to understand practices in a way that captures the tensions between individual rational preferences, everyday obligations, contextual factors, and wider cultural and economic structural factors. We suggest that this provides a more encompassing alternative to conventional perspectives that either place too much focus on individual rational choice or determinist structural accounts. Analysing the way practices occur in time-space proved useful for understanding how rationales are shaped and how choices are arrived at, daily, as people undertake domestic tasks in contexts of poverty and with highly dynamic practice

preconditions. Our analysis enables us to challenge some of the conventional ways that users are understood and their roles prescribed in innovation processes, and to also give new explanations to why seemingly superior service offerings fail to embed in informal settlements. Two explanations are given:

First, new service offerings are often developed with a narrow view of users - informal settlement dwellers as passive consumers. This is because the context and conditions under which the users have to make daily choices and decisions is not adequately understood. When service providers interview users about their perceptions, preferences and willingness to pay, the inquiry does not result in a dialogue on degree of complexity, competing needs and obligations, and the range of considerations for users when they make actual choices. When novel service offerings are introduced, they often only fit partially with the realities. We suggest that a fruitful approach is to consider the introduction of an innovation as a situation that pushes people to reflect on a wide range of constraints, opportunities, and priorities in the entire domestic space. How informal settlement dwellers respond to the quickly changing contexts and conditions for practices illustrates that they are entrepreneurial and reflexive actors struggling to provide themselves with basic necessities.

As a consequence, novel service offerings are often appropriated by users in Nairobi's informal settlements as useful "add-ons", rather than permanent replacement of a previously used alternative. A complete shift to new options is perceived as risky. Majority are not ready to abandon a seemingly "inferior" option that has proved meaningful and useful in specific situations of oscillating domestic space. The use of the *Jitegemee* container-based option exemplifies this point. It was introduced as an in-house family-solution, envisioned by the innovators and providers as an ecologically-superior and a more decent alternative to replace open defecation practices. However, among users, the novel solution was perceived as an "add-on" and was used in specific but limited situations – as a full-time solution for children and an emergency option for female adults on certain occasions – while only the men completely abandoned it. The *Jitegemee* was appropriated, by users, differently from what the providers had envisioned. Further, open defecation practices still persisted. We argue that these differentiated perspectives and logics between users and providers explain many failures of seemingly superior novel options to become embedded in people's daily lives.

In view of a preference for creating a diverse portfolio of alternatives by users, one reason the service providers withdrew *Jitegemee* was the perception that a partial uptake was a failure, leading them to withdraw their offerings. Their desired outcome, to substitute, may require a long time to create legitimacy (that the offering can deal with all sorts of oscillating domestic space conditions). It will also require a significant rearrangement of interlinked domestic practices. Not only does

substitution require that users make considerable effort and expend resources to bundle together a new practice with existing ones, it may also be impossible due to local preconditions (such as lack of infrastructures – roads, water, housing and electricity) that are influenced by challenging external factors. For users who consider fully substituting new service options, the perceived advantage may be outweighed by the range of obligations, priorities, logistics and risks that must be considered.

The case of *Jitegemee* also shows why it is problematic to assume that practices are based on conformity, and neatly-mirrored norms, values, or beliefs. There can be significant difference between what people do and what they see as appropriate, desired, or good. Sometimes, novel service-offerings are accepted even though they are perceived as socio-culturally unfit. One female interview respondent explained that, of the *Jitegemee* toilet, she and her neighbours only later questioned and laughed at the idea that they had accepted and used it for a while, despite perceiving it not to fit to their socio-cultural norms. They stopped using the *Jitegemee* once other more fitting alternatives (better public toilet) became available.

Second point why seemingly superior innovations fail to embed is a lack of a clear distinguishing between “acceptance” and “embedding”. When new innovation are introduced, the two as steps require different approaches. Acceptance is indeed an important first step for introducing novel service offerings, but the attribution of positive meaning is not enough for new practices to embed. Thus, introducing a novel service offering should not be perceived as a one-time event – a radical change, e.g. convincing potential users that *Jitegemee* is an ecologically superior and convenient alternative. Providers should consider supporting the factors for embedding, for example by making other practice preconditions more stable and reliable, e.g. providing a consistent disposal location for wastes from *Jitegemee*, and adapting the logistics for disposal to fit to other domestic activities.

Making systemic and multi-dimensional considerations when introducing a new service offerings can indeed be very complex endeavour. A possible approach is to view embedding as a process that requires continuous calibrating of service offerings in response to users’ experience of a new service offering in their daily lives. In fact, may not even be possible to foresee how a new technology or service will be embedded. Users thus have to be more actively involved in the design processes and all subsequent steps. This view is shared with scholars on rural development (Korten, 1980) and grassroots innovations (Seyfang & Smith, 2007). For example, Learning Process approaches from development studies highlight how development projects that are more successful often have a “fit” in terms of tasks, context, and organizational variables (Korten, 1980, p. 496), and concurrent development and adjustment of programs and organizations to be useful.

From our analysis, it is worth highlighting the feedback effects the introduction of novel service offerings could have on the wider community context (domestic space). Service providers may present a solution for a problem in one activity-domain, but create new social and technical problems. Some interview respondents indicated that the introduction of the *Jitegemee* may have increased dumping of faecal waste into the open drainages. The requirement to make payments for every disposal of waste from *Jitegemee* into a public toilet was reported as a disincentive. Economic precarity still persists for the users – whenever they lack money they unwillingly result in dumping. An increase of the *Jitegemee* toilet may provide a useful alternative to individual beneficiaries but also increase unhygienic faecal waste disposal, affecting entire communities and wider environments.

Socially, introduction of novel service offerings leads to reorganization of social relations – which risks creating opportunity that marginalizes some community members. For example, introduction of shared toilets in one of the study locations required the formation of a new management group, whereby new access requirements excluded those who were unable to meet them. Caution is required on how novel service offerings influence micro-politics and intra-community social dynamics, often providing opportunities for social differentiation, exclusions, conflicts and tensions.

6. Conclusion

Introducing more socially, economically and ecologically robust service offerings requires a good understanding of context where users have to manage their daily lives. This paper presents an analytical framework, *oscillating domestic space*, built on insights from practice theory, to identify how inhabitants of informal settlements establish ways of carrying out domestic tasks. The framework gives a middle-ground perspective between under-socialized accounts that see users as isolated rational actors, and over-socialized accounts, which expect highly routinized behaviour prescribed by cultural and economic structures. Additionally, by focusing on the time-spaces of performing practices, the framework proved useful for understanding how rationales are shaped and how choices are arrived at daily, as people undertake domestic tasks in contexts of poverty and with highly dynamic and uncertain practice preconditions. Our findings indicate how critical it is that innovators and providers in developing cities understand better the everyday life strategies of informal dwellers in order to align their own perspectives to realities on the ground, to better design their interventions, and to provide relevant support at the fitting time.

Conceptually, by focusing on the Global South, a comparatively more complex context to analyse practices, compared to the Global North (where the main body of empirical work in transition studies

originates), we contribute new insights regarding how time-space dimensions of practices can be operationalized, specifically when large uncertainties exist as to where, when and how practices are performed. Shove et al. (2012, p. 95) acknowledges that preconditions and contexts for practice are ever-growing in complexity and that uncertainties and fragmentation is a concern for the future, also in OECD contexts. For example, prospects towards sustainable systems are seen to favour heterogeneity (i.e. decentralizing water, energy and sewerage systems) and more user involvements (i.e. car sharing, co-production of energy, and sustainable consumption). Informal settlements present a context of discovery to understand processes involved in building, maintaining and transforming potential future complexity-laden socio-technical systems. This paper complements recent theorizing about splintered regimes, see Van Welie et al. (Resubmitted), which provides a new way of seeing and understanding co-existing socio-technical regimes. Importantly, the consideration of both user and provider practices in understanding how splintered regimes are reproduced supports the argument we make that the demand-side perspectives are important to understand sectoral transformations. We also reflect that a context with unmet needs, fragmented services, and negative outcomes and feedbacks in basically all aspects of daily life can also create a form of 'lock-in' that is hard to escape – as the persistence of open defecation is explained, despite several seemingly superior alternatives being introduced.

The robustness of our conceptualization of the oscillating domestic space needs to be further tested through analyses of other urban basic service systems like water, energy and solid waste management, where similarities are discussed in terms of heterogeneity of co-existing service offerings and uncertainties of practice preconditions (Marshall & Farahbakhsh, 2013; Parrot, Sotamenou, & Dia, 2009; Peloso & Morinville, 2014; Singh, Wang, Mendoza, & Ackom, 2015). This can also be extended to the Global North to analyse processes of decentralization and user-led sustainable consumption. Furthermore, this study can be a starting point for future statistically representative analyses applying such previously undefined analytical elements, and help formulate timely directions for further transitions research in both the Global North and South.

7. References

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Appendix

Appendix 1: List of interview respondents (for anonymity only first names are given)

Informal settlement inhabitants				
Code	Neighbourhood	Age (range)	Toilet category	Occupation
	Mathare-Bondeni			
B1	Lucy	51-60	Adjacent	Social worker
B2	Immaculate	31-40	Adjacent	Intermittent jobs (political campaigning; data collection; clothes business)
B3	Josphine	41-50	Detached	Runs an unregistered local bar
B4	Mary	51-60	Detached	Unemployed
B5	Esther A	21-30	Detached	Runs a local shop
B6	Everlyne	41-50	Detached	Runs an unregistered local bar
B7	Harriet (Case 3)	51-60	Adjacent	Local peanut business
B8	Violet	31-40	Detached	Local vegetable business
B9	Mercy	21-30	Adjacent	Intermittent jobs (hawking either tea or clothes)
B10	Esther B	61-70	Limited	Runs an unregistered local bar
FGD 1	10 participants	Adults		
	Kahawa-Soweto			
S1	Agnes	41-50	Detached	Intermittent jobs (hawking & cultivating)
S2	Jane	50-60	Detached	Unemployed (dependant on children)
S3	Wambui	31-40	Detached (no pay)	Runs a local restaurant
S4	Anastacia	51-60	Detached (no pay)	Field project officer for a local NGO
S5	Esther	41-50	Detached	Clothes business in the city
S6	Dorothy	31-40	Detached (no pay)	Farming and intermittent house cleaning and cultivating jobs
S7	Leah	31-40	Detached	Hawking & Community Health Volunteer
S8	Penina	41-50	Detached	Local fruits and vegetables distributor, and intermittent cultivating jobs
S9	Rose	41-50	Detached	Local charcoal seller
S10	Gladys (Case 1)	41-50	Limited	Intermittent jobs (hawking, cultivating, house-cleaning)
FGD 2	10 participants	Adults		

FGD 3	10 participants	Teenagers		
	Mukuru-Rorie			
R1	Janet	21-30	Adjacent	Industry part-time casual jobs
R2	Naomi	31-40	Limited	Community Health Volunteer
R3	Dorice	31-40	Detached	Field project officer for an NGO
R4	Rose	31-40	Detached	Community Health Volunteer
R5	Anne	41-50	Detached	Local street-food vendor
R6	Caroline	31-40	Detached	Unemployed
R7	Elizabeth	21-30	Detached	Unemployed
R8	Josphine	41-50	Detached	Unemployed (unwell from effects of industry jobs)
R9	Dorcas	41-50	Detached	Local vegetable business
R10	Caroline (Case 2)	31-40	Detached	Intermittent jobs (hawking, house-cleaning)
FGD 4	8 participants	Adults		
FGD 5	10 participants	Adults		
Local experts and informants				
NGO rep.	NGO representatives (1-22)			
CHEO	Community Health Extension officers (1-3)			
LL	Local community groups leaders (1-9)			
MI	Local male inhabitants (1-3)			