
10 Enhancing socio-ecological interactions to achieve sustainable decentralised sanitation systems

Why people are not using technical solutions

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10.1 INTRODUCTION

Universal access to water, sanitation, and hygiene (WASH) in many peri-urban and rural villages has not yet been achieved. Various technical solutions are available to solve the problem, but end-user acceptance of sanitation solutions is the main unsolved problem. Education and demonstrations to ensure the sustainable use of the given technology seldom succeed. Almost a third of the children in South Africa live under the “food poverty line” (that only allows enough for basic nutrition and no other essentials), and almost half live under the “lower bound poverty line” (that allows enough for essentials such as clothing but only if some nutritional costs are sacrificed). In the Limpopo Province, more than 30% of the population experienced hunger in 2013. The prevalence of stunting among boys and girls zero to three years of age was 26.9% and 25.9%, respectively (Said-Mohamed et al., 2015). According to the Mopani District Municipality (2019), 74% of households in the Mopani municipal area earn less than R1 100 per month. There is reason to think that poverty and hunger have worsened due to COVID-19. Modelled results from 44 African countries indicate that the expected rapid population growth will be the main cause of food insecurity and undernourishment throughout Africa. The effects of climate change were considered insignificant compared to the effect of population growth.

Universal access to WASH in the communal tenure villages in Limpopo, both peri-urban and rural, is still far from being achieved. The number of households with access to free basic sanitation is 1,360, and the number of backlogs is 63 times more,

at 86,388 (Mopani District Municipality, 2019). Rural households generally undertake their on-site arrangements, such as pit toilets. Several risks are associated with these pit toilets, including flooding, groundwater pollution, basic hygiene, the community's health and the safety of young children. The pit toilets require labour-intensive maintenance, and space becomes a problem each time one toilet is filled, and residents have to build another, especially in peri-urban areas where stands are small (Van Vuuren, 2014). The water supply is mostly insufficient (below 25 litres per person per day) because of the lack of pipeline reticulation and the widespread nature of the households in rural villages (Mopani District Municipality, 2019).

A circular economy, where waste products become resources that are used, can potentially solve many of these problems in rural and peri-urban communities and may result in significant improvements. Human excreta contains nutrients needed for food production and can be used to produce biogas for cooking or other energy needs. It is unclear whether these communities will be open to such possibilities. Still, as opposed to modern cultures' current linear take-make-dispose pathways, the African perspectives of cycles may be more open to adapting to circular economic practices. A new Water Research Commission project (van Niekerk et al., 2022) was initiated in April 2022 to investigate the potential of introducing DSPs of using human excreta as a resource for other important things household practices such as food and energy production. The development phase will be done in one rural and one peri-urban community in the Limpopo Province.

Many technologies are available for decentralised sanitation systems that can potentially be used in the service of rural and peri-urban communities in South Africa. Many of these technologies have been tested in previous projects, and some, like the pour-flush toilets, were relatively successful (Pillay and Bhagwan, 2021; Van Vuuren, 2014; Water Research Commission, 2014). However, in many cases, the reason for different solutions' successes or failures is unclear. Previous studies have engaged with the end users to determine their willingness to use different sanitation solutions. Still, as far as we know, there has not been a culture-driven approach to designing sanitation solutions. There have been thorough analyses of cultural and religious aspects and thought patterns of the end users that did not follow through to involve end users in the development of solutions. It seems as if the cultural information was not integrated into the solutions in, for example, studies by Taing et al. (2014) and Akpabio and Takara (2014). Technical concepts imported from another region without considering the complexity of the socio-cultural context have too often failed. Education and demonstrations to ensure the sustainable use of the given technology seldom succeed.

In African traditions, cultural, social and religious patterns are integrated. Modernisation typically delegates religious beliefs to the private life of individuals, separately from the larger social networks. All these patterns are in flux and can be expected to differ from one community to the other. Still, one can also expect that some trends are similar in certain communities, which makes it easier to transfer a solution that works in one community to a similar community with a few adjustments.

Decentralised sanitation and smallholder farming (SHF) have many characteristics of complex socio-ecological systems (SES), with many different actors and interconnected subsystems. This chapter explores the complex systems theory and how

it can be applied to develop new ways of successfully integrating a DSP in a WEF framework. This WEF framework will define the requirements, opportunities and goals of the DSPs to be developed that will produce food and/or energy and healthy water resources.

10.2 METHODOLOGY

A literature review was conducted to collate existing knowledge on the African cultural and religious thought patterns on sanitation, food production, cooking and eating patterns and energy use and to better understand sanitation problems and practices such as open defecation. Reliable peer-reviewed publications, books, and other sources the authors were familiar with were perused. Further literature searches were undertaken by following citations and publications of known authors and using search words such as decentralised sanitation, sanitation in Africa and open defecation. Reports published by the WRC and the Pollution Research Group in KwaZulu-Natal were found on their respective websites. A literature review was also undertaken on the more recent advances in the complex systems theory. Interviews were conducted with people from the Mafarane village in Limpopo to determine their thoughts and feelings regarding sanitation in their communities.

10.2.1 THE COMPLEX SYSTEMS THEORY

Cilliers (2008) hesitated to define the complex systems theory because it is not simple enough to apply fixed characteristics. Nor is there a prescribed methodology to apply the complex systems theory. What is needed is for a scientist to develop a feeling and a certain attitude to engage with these systems (Cilliers, 2008; Preiser, 2019). Understanding complex systems theory in terms of how it differs from the traditional scientific methodology is more useful.

Complex versus complicated systems and holistic versus reductionist approaches. The reductionist approach is to comprehend a unified entity in terms of its components. Complicated systems, e.g., a computer, can be disassembled into their components and reassembled to operate in a specific way. To understand complicated systems, the reductionist approach can be used, where the components of a larger system can be studied to determine linear cause-and-effect relationships without the ‘interference’ of the rest of the system. Reductionism produces isolated technologies that operate in predictable ways (van Rooyen et al., 2020). The scientific method typically follows the reductionist approach because it is designed to study the components of a system to learn something about the system as a whole. However, the reductionist approach is inappropriate for complex systems (Cilliers, 2008). Suppose the isolated technologies that are produced through the reductionist approach are implemented in a context where they have to function within a larger, complex system. In that case, this larger system often interferes with the intended cause-and-effect relationships.

On the other hand, complex systems comprise several factors – things and thoughts – that interact and combine to produce unpredictable and even highly surprising outcomes. Emergence, defined as new system arrangements and behaviours,

is a typical property of complex systems that occurs when the whole system has different and nonreducible properties to the properties of the system's components (Preiser, 2019; van Rooyen et al., 2020). Considering all these factors and their interactions requires a holistic approach in contrast to the reductionist approach.

Context and intervention. Complex systems are open systems, meaning the boundary between the system and its environment is unclear. Changing the context of a system will also change the system itself (Preiser, 2019). When explaining complexity theories, Jean Boulton stated that the emphasis should be on the context, not the intervention (Boulton, 2019). The complex systems theory perspective also requires that we bring social systems and ecological systems together in a way that they are “not just overlapping and interdependent, but inseparable. This perspective emphasizes that people, economies, societies, and cultures shape and are in turn shaped by ecosystems” (Reyers et al., 2018).

Scale: An SES is typically a dynamic cross-scale system where global decisions impact local conditions and emergence on local scales, impacting global conditions (Reyers et al., 2018). This creates difficulties when implementing sustainable solutions. Effective interventions depend on selecting the most appropriate scale to focus on without neglecting the interactions between the chosen scale and the scales above and below it.

Other relevant properties of complex systems: Characteristics of a SES that are relevant for our project include multiple perspectives, inter-relationships and communication, feedback loops; ideas emerging from the interactions, and continuous adaptation to change. Relationships are especially important in complex systems, and linear thinking, i.e., predictable cause-and-effect outcomes, should not be expected (Preiser, 2019). Development is done through an iterative process until a suitable solution emerges.

10.3 TRADITIONAL AFRICAN CULTURES AND THE WATER-ENERGY-FOOD NEXUS

In African traditional cultures, real life, well-being and moral values cannot be treated outside the spiritual, political, social and religious worldviews, and matters related to water and sanitation are better understood from the perspective of ‘subjective’ rather than ‘objective’ worldviews (Douglas, 2003). These worldviews, to a bigger or lesser degree, form the undertone that influences the life choices of the African people. The Nigerian Bishop and International Chairman of the Organization of African Instituted Churches, Daniel Okoh, said to Öhlmann et al. (2019):

People from Sub-Saharan Africa ... are highly religious... So, for Africa, because of the religious nature, you will always find a way of using it to get the ... commitment of the people to the project, whatever it is. If it is water, it must be explained spiritually. If it is [an] agricultural project, it must be explained spiritually.... Honestly, if you do not do that, you will lose it.

Culture can be seen as a strategy to deal with the world in which people live and a way of associating with and interacting with each other and nature. Cultural aspects include practices consisting of behaviour patterns, the meaning people

give to these patterns of behaviour and the associated feelings. We can discuss “patterns of culture” (Benedict, 1989). A practice is a subdivision of culture, an established way of doing certain things. Practices also have patterns and must fit into the larger cultural, social and ecological patterns. Our cars, for example, fit well into our cultural and social patterns but not the larger ecology. Practices, like cultures, are constantly changing, sometimes faster, sometimes slower. They emerge from the ongoing interaction and combination of multiple things and thoughts, such as traditions, modern technologies, ecological conditions, political and economic events, etc.

Water, energy and food are relevant topics in the African context, and it is necessary to understand these topics’ cultural and religious context. In the following sections, we will give attention to African cultural patterns regarding energy, agriculture, food, cooking, cuisine, and sanitation.

10.3.1 ENERGY

In 2013, K. J. Wessels and a group of researchers reported that over 80% of households across sub-Saharan Africa (SSA) rely on biomass as their primary energy source. They calculated that at current levels of fuelwood consumption, biomass in many parts of the Limpopo region would be exhausted within 13 years. It further showed that it would require a 15% annual reduction in consumption for eight years to a level of 20% of households using fuelwood before the use of biomass would reach sustainable levels. They concluded that the severity of dwindling fuelwood reserves in African savannahs underscored the importance of providing affordable energy for rural communities (Wessels et al., 2013).

The rich significance of sitting and living around the fire for traditional family life shows how domestic energy use is integrated into household practices. However, there is a tendency to replace sitting around the fire with sitting in front of the TV. If that happens, the wood stove can potentially be replaced by biogas, depending on how the household as a system changes.

Decentralised sanitation is relevant for energy use in two ways: (i) saving energy to build and maintain centralised sanitation and treat wastewater, and (ii) the possibility to generate biogas from sewage through anaerobic digestion (AD). According to Msibi and Kornelius (2017), you need waste from approximately 205 chickens, 8 cows, 20 pigs, or 63 people to feed a 2,500 L/day biodigester, which is generally enough energy to satisfy the cooking requirements of one household. Therefore, biogas production is not feasible on a household scale. Msibi and Kornelius (2017) calculated that one non-sewered household generates enough greywater to feed on a 2,500 L/day biodigester, and the use of greywater is recommended. The use of biogas digestion is currently limited by a lack of supporting policies, unsuitable climates, limited support from the private sector, installation, operation and maintenance costs of the digesters, lack of technical knowledge and limited water availability (Msibi and Kornelius, 2017). In certain areas, the lack of feedstock for the digester may also be a limiting factor. According to Meegoda et al. (2018), if a biodigester is overloaded, it could cause acidification and stop the microbial breakdown process. A biodigester needs fairly intensive management.

According to Lin et al. (2018), AD is economically more profitable than composting on a larger scale, while composting is more profitable on a smaller scale.

10.3.2 FOOD AND AGRICULTURE

10.3.2.1 Agriculture in the traditional African culture

In traditional African cultures, food production is regarded as being closely related to the fertility of people and the land. In this tradition, fertility is essentially a religious concept. Fertility is a manifestation of a mysterious life force. It depends on the relation with the ancestors and, ultimately, more remotely, on God. The modern approach requires harmony between forces and not control over nature in search of progress and a better future. In Chapter 3 of the recent book edited by Matholeni et al. (2020), Georgina Kwanima Boateng writes:

Earth, therefore, is a woman and her fertility is revered because it is the source of sustenance and reproduction. The spiritual connection between Asaase Yaa (Mother Earth) and women in Africa cannot be overemphasised.

It is a long-standing tradition. Fifty years ago, Mother Earth was described as a dominant motif throughout modern African literature (Cartey, 1969). It is also a dominant motif in local cultures, specifically in agriculture. In 1938, Jomo Kenyatta, who later became the first president of Kenya, wrote:

In Gikuyu life, the earth is so visibly the mother of all things animate, and the generations are so closely linked together by their common participation in the land, that agricultural ritual, and reverence for ancestral spirits, must naturally play the foremost part in religious ceremonial. Communion with the ancestral spirits is perpetuated through contact with the soil in which the ancestors of the tribe lie buried.... the earth is the most sacred thing above all that dwell in or on it... Ceremonies are performed to cause the rain to fall, to purify and bless the seeds, and again to purify the crops.

(Kenyatta, 1985)

Rain is regarded in Zulu tradition as fertilisation of the earth by the sky, as a husband fertilises his wife. The earth cannot bear fruit if the rain does not work on it with water (Berglund, 1976). Berglund (1976) describes a ritual in Zulu culture to make the field fertile. The ritual contains many male and female symbols to ensure fertility. When Berglund asked a diviner about it, the diviner said that the field is “the mother from whom we eat.” A male could not perform the ritual because “Men do not sow. They slaughter the animals when there is to be meat. But they do not sow.”

10.3.2.2 Food in the traditional African context

When integrating decentralised sanitation with SHF practices, eating patterns are as important as sanitation patterns. The eating pattern, and where applicable, the market, will determine what food can be produced and what not.

In his study of the history of food and cuisine in Africa, James McCann (2010) emphasises two things: (i) African cooking and cuisines have formed over history

and have expressed agility in keeping up with changing times, and (ii) food is deeply embedded in the culture. McCann (2010) frequently refers to the dynamism of African foods over the years. There is a rich variety of cuisines across different regions of the continent.

Contact with world regions like the Indian Ocean rim (from at least the first century CE) and the Atlantic world (after 1500) brought many more challenges and opportunities that African cooks built into their stews, porridges, and breads.

This included the use of food that was borrowed from other continents, such as maize, bananas and spices. In different regions, different influences from elsewhere have combined with local cultures so that, in each place, some type of cooking has emerged that involves the layering of ideas, daily rituals of eating, ingredients, and methods of assembling foods for both public and private meals.

Cuisine is a product of history, and a meal is a conjuncture of time, place, and particular ingredients. Globally, cooking and cuisine can be seen as a creative composition at the heart of all cultural expressions of ourselves. Food, like dress, music, and art, carries deeper structures of cultural identity that form a marker of group coherence and solidarity—food helps define who we are.

(McCann, 2010)

In African cultures, the most important rule/concern at any ceremony is the amount of food you prepare; one ought not to disappoint guests or starve them (Phasha et al., 2020). However, the emphasis on the agility of African cuisine indicates that the beliefs and taboos around food have not been as strict as it is, for example, in the Jewish religion.

Some traditions may have a negative impact if viewed from the outside, especially concerning the health and well-being of women. Traditional food taboos often have a bearing on the relationship between men and women. Lung'aho (2021) states that in SSA, pregnant women are forbidden from eating protein-rich foods such as eggs and snails for several reasons, including the fear that the child may develop bad habits. In some cultures, men eat before women and children. And boys may eat before girls. Africa's cooks were women, but they often served food to the men and children first and got to eat at the end when everyone else had had their fill. If food is scarce, a mother may sacrifice the food left after serving the men to the children. Community education and socio-behavioural change are needed to give equal priority to the nutrition of all family members.

Similarly, Chakona and Shackleton (2019) documented food taboos and beliefs among pregnant isiXhosa women. They found that cultural beliefs and food taboos followed by some pregnant women influence their food consumption, which impacts the health of mothers and children during pregnancy and immediately afterwards. Overall, 37% of the women reported one or more food practices shaped by local cultural taboos or beliefs. The most commonly avoided foods were meat products, fish, potatoes, fruits, beans, eggs, butternut and pumpkin, rich in essential micronutrients, protein and carbohydrates. Most foods were avoided for reasons associated with pregnancy outcome and labour and to avoid an undesirable body form for the baby.

10.3.3 SANITATION IN THE TRADITIONAL AFRICAN CONTEXT

10.3.3.1 Human excreta and the concept of impurity

Distinct cultures have different attitudes towards toilet systems and the treatment of human excreta. Our cultures and contexts structure the basic instinctive repulsion towards excreta into attitudes and treatment patterns (Warner et al., 2008). Each context is different, but certain trends are widely spread across SSA, such as a lack of proper sanitation for many and the impact of modernity, which conflicts with the spiritual forces operating in material things in African cultures.

The conflict between the secular worldview of modernity and the religious nature of African traditions is also relevant in the search for sustainable sanitation solutions. The meaning associated with such concepts as dirt, pollution, hygiene and disease evolves in relation to local cultural experiences, with special forms of values and risks. However, the ambivalence characterising such meanings underlies the sanitation and hygiene challenges. It leads to a disconnect between inner convictions and overt actions. In most reports across SSA, local knowledge and the equation of cleanliness with godliness and beauty sharply contrast with actual physical sanitation and hygiene practices and behaviours in many contexts and forms. Mphahlele (1962) blames the missionaries:

What do those missionaries think? It all began when those desperate ladies taught us how to brush our teeth, wash with soap, and sleep with windows open to let in the fresh air - early to bed, early to rise, cleanliness is next to godliness.

Monnig (1978) emphasises the central role of “impurity,” which is one of “a great variety of supernatural forces (that) may cause unfortunate events.” However, these supernatural forces often act with and within natural causes. They do not necessarily preclude a person from treating an unfortunate event, such as sickness, naturally and supernaturally. A Sepedi word used to describe impurity is *ditšhila*, but the word is broadly used for excreta and also means sin. Literally, *ditšhila* means dirt, but it may be better translated as an impurity, and more particularly, ritual impurity. Conditions of impurity include:

A woman giving birth, as well as the unborn child, the placenta and the hut where the birth has taken place... children who are born unnaturally, i.e., twins, malformed children, children who are born with teeth... The condition of *ditšhila* is closely connected with the critical changes of life, particularly with its beginning and its end... The impurity requires ritual cleansing.

(Monnig, 1978)

During informal discussions with rural communities in Limpopo, people said that women and men are not meant to share the same toilet in the Tsonga traditions. It is a taboo, more specifically related to brides and grooms. It is seen as unclean and spiritually compromising to share as women need to sit, and men do not. However, sharing toilets between men and women in rural areas is no longer much of an issue, although separate toilets are still preferred. Mostly, people do not have enough money or resources to continue this practice. There is a belief that the bad odours in pit latrines are linked to bad spirits and that sharing toilets is spiritually compromising.

In his book *Bantu Heritage*, Junod (1938) does not refer to sanitation. On p. 93, it is said: “Bantu women have a strong sense of modesty, which is unfortunately deteriorating. They always take great care to choose a special place for bathing and the men who dare to approach this place are booed.”

However, according to Berglund (1976), when healing is needed, faeces are often associated with the evil that has caused the illness. A prominent theme in the book *Zulu Thought-Patterns and Symbolism* (Berglund, 1976) is that of cleansing from evil by physically ejecting something from the body, like spittle, vomit and emetics (p. 292) and blowing out of medicines (p. 352). *Ukuhlanza* (to clean)

... refers to vomiting and expulsion of faeces after an emetic or purge... All bodily excess, particularly faeces, which is vile, must be disposed of outside the homestead and, preferably, be buried. ‘This thing is vile. A home is good. They do not agree. That is why it must be concealed somewhere at a distance from the homestead.’ Zulu accepts this disposal of something vile as normal.... Evil which, on the other hand, is not expelled normally, must be cast out through acts such as enemas and vomiting. Today castor oil and a large number of other purges are obtainable in chemist shops and made use of extensively. There are Zulu who ‘cleanse the stomach from poison’ regularly every week, even more frequently, sometimes making use of both laxatives and enemas. In cases of sickness, disregarding the type, enemas, laxatives and vomiting are often automatically administered to the patient, especially if the sickness causes a rise in temperature. ‘If the sick person is hot (i.e., runs a temperature) it is certain that there is a great medicine (i.e., sorcery) inside (him/her). Where does the medicine enter? Is it not through the mouth? So, it is in the stomach. That is why there must be vomiting and enemas. These things remove the poison which causes the sickness.’

(Berglund, 1976, pp. 328–329)

‘Cleaning the baby out’ by intestinal washes is believed to cool the child down and protect it by purging harmful evil influences.

(van Andel et al., 2015)

10.3.3.2 Open defecation

There are many reasons why open defecation is still practised. These include convenience, unavailable toilet facilities, poorly constructed and private toilets, water scarcity, a lack of toilet paper, and children not being trained to use toilets. Traditional beliefs and practices can promote open defecation. For example, some believe it is cleaner (Dittmer, 2009).

In SSA, there are cultural restrictions regarding human excreta and toilet use. Some of these beliefs concerning the location and type of a toilet facility have also increased open defecation practices in some places, for example:

- Excreta from different people should not be put on top of each other, which is what would happen in a communal pit latrine.
- Storing faeces underground is unacceptable in some cultures, as it is believed to pollute the soil where the ancestors are buried.
- In some cases, people fear using a communal pit latrine because witch doctors using excreta for harmful purposes will then know where to find it. This can be a more serious problem for women in their menstrual cycle

because blood is considered a powerful substance in witchcraft (Akpabio and Takara, 2014), which is further discussed in the next section.

10.3.3.3 Gender and generational considerations

Cases of treating children's faeces and other waste products with a tolerance have been widely reported; linked not only with the idea of inoffensiveness of child excreta, but such tolerance also carries spiritual implications for parents and potential parents. Every material element of child hygiene (sputum, faeces, urine and other child waste products) entails potential blessing, depending on how it is handled.

(Akpabio and Takara, 2014)

The literature reports on many cultural restrictions to women and their management of menstrual hygiene because menstruation is considered to be connected to evil spirits and curses (see discussion on the impurity in **Section 4.3.1**). During menstruation, women and girls are considered 'impure.' Women and girls need proper, hygienic facilities, privacy and water for washing their hands, bodies and clothes that were used. Where disposable pads are used, they need a disposal system. These requirements are seldom discussed in SSA because of the contempt with which the topic is considered. Women are often ashamed of their condition and hide their used cloths in unhygienic places, exposing them to diseases (Hickling and Hutton, 2014).

Similar thought patterns have been revealed during informal discussions with communities in the Limpopo Province. According to these people, women must dispose of all the sanitary essentials straight inside the toilet to avoid witchcraft being done to them, which correlates with what Akpabio and Takara (2014) said (refer to **Section 4.3.2**). Disposing of sanitary essentials in bins both in homesteads and public spaces is still seriously frowned upon. Women are expected to wash, burn or bury what they cannot dispose of in their toilets. For younger women, this is a cause of great embarrassment and also leads to unhygienic practices of resisting going to the toilet and disposing of sanitary essentials in inappropriate ways to try and hide these essentials from view. Few toilet systems are robust enough to handle objects like sanitary pads. Toilets from which the content is to be reused will not get rid of these items in the way these people expect. So, such beliefs will have important implications for the uptake of decentralised sanitation solutions.

Furthermore, current sanitation systems also make women more vulnerable because they may be attacked when they go out to use the toilet at night. Women often do not drink water to avoid having to go out at night, which can again cause health problems (Warner et al., 2008). Women must consider their safety when deciding where and when to defecate, and open defecation in between shrubs may feel like the safer option. Defecating before sunrise or after sunset may provide them with more privacy, but that may not be in favour of their safety.

However, in responding to this issue, just as with other issues, we must consider local cultures. In his book, *A Short History of African Philosophy*, Hallen (2009) argues that one reason for the unmeant negative impact of Western efforts to improve the quality of life in Africa is that the conceptual frameworks used to "understand"

African society have their origin in Western culture. This applies to concepts such as community, family and gender. For example, African female scholars such as Oyeronke Oyewumi, Ifi Amadiume and Nkiru Nzegwu.

at various points and in the strongest terms reject 'feminism' as a Western-based and Western-oriented movement that has yet to demonstrate that it is prepared to reject the misrepresentations of African societies by Western scholarship and is prepared to learn from rather than dictate to the non-Western world.

Hallen continues:

Western feminists strengthen the gendering of society in individualistic terms, while traditional African cultures put the community first, and give male and female equal and interdependent roles in the community, which makes it possible not to gender society. Amadiume, for example, blames Western feminists that their imposed systems erode all positive aspects of historical gains, "...leaving us impoverished, naked to abuse, and objects of pity to Western aid rescue missions".

(Quoted by Hallen (2009))

These women protest against people from outside who impose their own ideas in their context. It highlights the importance of approaching people with a learning attitude rather than an authoritarian attitude when undertaking development projects.

10.3.3.4 Environmental, socio-economic and behavioural considerations

According to van Oel (2002), things to consider when selecting the best options for the improvement of sanitation (environmental, economic and social) can be summarised:

1. Geological subsurface considerations.
2. Access to water.
3. Affordability by the recipient community for capital as well as for maintenance costs.
4. Future upgrading must be considered.
5. The recipient community must be fully involved in the choice of a system.
6. To stimulate real involvement, the community must be trained to do the development work themselves wherever possible.
7. The local authority must have the institutional structure necessary for the operation and maintenance of the system.
8. A system must operate despite misuse by unsophisticated users and should require as little maintenance as possible (van Oel, 2002).

We generally agree with van Oel (2002) but would formulate two statements (5 and 7) differently. In our approach, we emphasise the design of a sanitation practice, which incorporates a technical tool or system, with the recipient community rather than just involving them in choosing a system (as mentioned under nr 5). In cases where the local authority does not have the institutional capacity to operate and maintain toilet systems, the statement under nr 7 is not feasible. Taing et al. (2014) have shown that poor maintenance is due to a lack of responsible people in situations where several

households share one toilet. Therefore, the household should be able to construct and maintain its own toilet system. If the household owns the toilet and they can maintain it, there is a fair chance that they will take responsibility for it.

In general, in communal tenure villages in Limpopo, around 12% of the households have no sanitation structures and practice open defecation, either in their own yards or in the surrounding veld; a large proportion has pit latrines (around 56%), and some have ventilated improved pits. The use of toilet paper for anal cleansing is rare (~5%), with most people using newspaper (74%) and stones (21%). Water for hygiene and sanitation is unavailable, and people do not regularly wash their hands after using their toilets. Cleaning of the toilets and top structures is also not done regularly due to water scarcity. In addition, there is a tendency for the pit latrines to fill up as the sandy-loam structure and depth of the soil can lead to the liquid not draining away fast enough (van Oel, 2002).

In a study conducted in Mohlaletse village (Sekhukhune District Municipality), the following conclusions were reached through a community-based process. People needed individual household solutions. Dry sanitation options, such as ventilated improved pit latrines (VIP) and urine diversion dehydration toilets (UDDT), are the most suitable. In this respect, approximately 65% of participants are aware of the fertilisation potential of human excreta and are prepared to consider sanitation options where human excreta are used for fertilisation. For households that use toilet paper for anal cleansing and have a groundwater tap on their plot, two other systems are also adequate (the pour-flush toilet and the aqua-privy with soak-away) (van Oel, 2002).

A survey in a different and more recent study in the rural Makhwane village (also in the Sekhukhune District Municipality) showed a situation much unchanged from 2002. An additional hygiene challenge noted within the community was the fact that children under the age of 12 in most of the households (62%) were not allowed to use the toilet. This practice was attributed to the lack of improved sanitation facilities; parents feared their children were at risk of falling into and drowning in outside toilets, such as pit latrines (Budeli et al., 2020).

Besides the hygiene challenges, major sanitation issues were observed across the village. Approximately 41% of the households in the community did not have toilets installed in their yards, and 86% of the households use the open field as an alternative for a sanitation facility, while the remaining 13% share sanitation facilities with their neighbours. The findings show that 60% of householders safely dispose of their solid waste (e.g., diapers) in the pit latrines, while 6% dispose of soiled diapers in the streams, 9% in the field, 37% in a separate pit and 11% burn them. Only 25% of households use reusable diapers. Households using reusable diapers generally dispose of the faecal matter by soaking the soiled fabric diapers in water and discarding the wastewater in an open field (Budeli et al., 2020).

The literature often acknowledges that people living in rural and peri-urban areas desire full waterborne sanitation (Pillay and Bhagwan, 2021; Van Vuuren, 2014; Water Research Commission, 2014). Out of 275 households in dense settlements in eThekweni, Ekurhuleni and the City of Tshwane, approximately 70% indicated that they preferred waterborne sanitation in their homes (Martin and Pansegrouw, 2009). However, Martin and Pansegrouw (2009) did indicate that these people were willing

to consider other options when they became aware of the costs associated with these flush toilets. It is not only in terms of sanitation that lower-income households aspire to have the things available to people in urban areas. Van Niekerk (2008) observed that poor households closer to the cities planted lawns and flower gardens instead of vegetables, in contrast to communities in more rural areas who often produce vegetables and maize in their gardens. Therefore, one must deal with these feelings of low-income households being inferior to those in urban areas.

10.4 DISCUSSION

10.4.1 POOR UPTAKE OF SOLUTIONS

Social acceptability is repeatedly mentioned as one of the most important problems in implementing decentralised sanitation systems (Martin and Pansegrouw, 2009; Odindo et al., 2016; Taing et al., 2014). One of the largest studies on user perception of UDDTs showed that UDDTs installed since 2001 are still mostly in use. Out of 15,983 households, 85% indicated that all members and 8% that some members in the household use the UDDTs. However, user satisfaction was low, with 70% unsatisfied with the UDDTs. The reasons for the unhappiness of the users were bad odours from the toilet (27%), lack of privacy from doors that do not close properly (22%), poor quality of materials used and construction workmanship (12%), the urine pipe not being connected correctly (12%), etc. (Roma et al., 2013). Key findings of another study looking at qualitative and quantitative indicators of the perceptions of UDDTs showed:

1. Although 97% of recipients use UDDTs, 95% of interviewees did not consider these toilets a permanent sanitation solution for their households and were waiting for waterborne sewage.
2. Most participants reported not identifying with the UDDT benefits, such as using urine as a fertiliser.
3. The participants felt that the UDDT was not sensitive to their comfort since one must always be mindful if your urine or faecal matter is going to the right place.
4. The fear of allowing children between two and five years to use the UDDT toilet was a highly discussed issue. Most participants reported that they discouraged their children from using the UDDT, and they practised open defecation instead.
5. Among users, 80% were not maintaining the UDDT properly. The findings reveal that females mainly clean the UDDTs in the household, including emptying the toilet. A small proportion of respondents reported that older females do the task of emptying the toilet because being in contact with faecal matter will bring bad luck to younger females.
6. The older generation preferred the VIP toilet because they are accustomed to it, it requires less responsibility from the user, and the user does not have to empty it, and

7. The doors, back cover, and seats were reported to be items that easily break, which made people feel that they were given cheap *toilets that were not customised to their reality* (Mkhize et al., 2017).

Personal conversations with community members indicated the following complaints regarding their current sanitation (VIP latrines):

1. People in the communities see VIP latrines as an inferior service because it compromises their dignity, the toilets have bad odour and lots of flies, which affects mostly women, and they fill up very quickly.
2. Community members also feel like the government is undermining them because they come from rural areas, and the government is more concerned about supporting urban populations. They are told that waterborne sewage is impossible and expensive, but they see flush toilets in the cities and towns. The government also refers to the VIPs that they provide as standard basic services, and thus, people believe there should be better, more permanent options available. Still, the officials choose not to assist them with these.
3. Women are expected to keep the toilets clean, even though this is an almost impossible task with pit latrines, as none of the surfaces can be properly disinfected. There is a strong belief that many women's infections are related to using these unsanitary toilets.
4. The fact that access to water for cleaning, rinsing, and hygiene is extremely limited and very often not unavailable at or close to the toilets is a further contributing factor to unsanitary conditions.
5. Most people prefer their toddlers not to use the toilet because they have accidentally fallen inside the pit latrines and are dying. Parents are then blamed for being irresponsible. In addition, the pedestals are not appropriate for small children. It means that toddlers and small children, more often than not, defecate in the open. Some people use small buckets as latrines for the smaller children.

Roma et al. (2013) concluded that successfully implementing the UDDTs depends on education and establishing the economic return from using urine excreta for agricultural purposes. We agree that reusing urine and excreta may be important for successfully implementing decentralised sanitation. However, instead of educating people, we believe in co-developing a practice with the end users, i.e., one must change the technology to fit into the socio-ecological context instead of changing the people to fit the requirements of the technology.

10.4.2 APPLYING THE PRINCIPLES OF THE COMPLEX SYSTEMS THEORY IN THE SHF CONTEXT

Application of the complex systems theory may seem arbitrary and uncertain, but some proven approaches can be used. The following general principles should be

applied in the development of the Decentralised Sanitation Practice in the WEF nexus (DSP-WEF):

- Firstly, as Cilliers (2008) mentioned, it is important to engage with the SHFs with a learning attitude and not preconceived ideas of the solutions. The eventual integrated sanitation-with-small-holder-farming practice(s) must emerge from the interaction between the different role players. This aligns with the fact that relationships are important in complex systems. Understanding problems and potential solutions could not originate from a single person's perspective but should involve the perspectives of as many different parties as possible. The viewpoints of the SHFs themselves are especially critical in assessing problems and developing solutions. Together, all role players must develop a common vision. Limited interaction between the different role players during the development phase would prevent learning and the emergence of more beneficial outcomes (van Rooyen et al., 2017). This approach can be called transdisciplinary research, in which SHFs, relevant NGOs and government officials, markets and scientists, etc., put their heads together to solve an everyday problem. The co-development process should be done through an iterative process of conceptualising, testing, and adapting until the most suitable solution is found.
- As discussed in **Section 3**, it is important to develop solutions at the correct scale in a complex system. One disadvantage of a larger scale project, e.g., sewerage systems, is that the individual households depend on the larger system and good management. Small-scale solutions give the household more control to solve their own problems. Solutions at various scales (from single households to smaller and larger combinations of local households) should be tested during future development to better understand the needs and requirements of the target communities.
- We agree with Boulton (2019) that the focus should be on context rather than interventions. The context is shaped by its history and the existing economic, social, ecological, political and other issues. However, we would formulate it slightly differently: our emphasis is on how the eventual solution emerges from the interaction of all aspects, including the context and the intervention. The focus should be on how the relevant role players experience the intervention, contextual factors, and what meaning they give to it. Attending to how people experience something and what meaning they give to it is called a phenomenological approach (Aydin, 2007). Thus, the emphasis must be on how technical interventions are integrated into and become embedded in the SHF practices, which are embedded in the wider context.
- Complexity can either be (i) observed and analysed or (ii) one can “participate in and creatively co-construct the phenomenological experiences of everyday instances and encounters of a messy, complex reality” (Preiser, 2019). We follow this second approach, not disregarding the first.

10.4.3 ADDRESSING BEHAVIOURAL AND CULTURAL THOUGHT PATTERNS IN THIS STUDY

Problems such as safety risks and environmental pollution of sanitation in rural and peri-urban areas should be addressed. More invisible problems, such as religious and cultural thought patterns and how they affect sanitation and other topics related to the WEF nexus, are just as important to understand and must be central to the approach followed during future research. One problem continuously identified in the literature is the ambition of low-income communities to have lifestyles similar to higher-income urban communities. It indicates that the root of the problems extends to a much deeper socio-economic condition of inequality in the country. It also highlights that the more wasteful practices in urban communities must be addressed to improve the quality of life in rural and peri-urban areas.

It is uncertain to what extent traditional thought patterns and symbolism play a role in the target community of this project and to what extent modern ways of thinking have been acquired. Modern technology has been introduced, and the relationship with the land has been modernised. Still, it is uncertain what has remained of the traditional, cultural and religious thought patterns, what influence it will have in sanitation development projects and how it should be taken up in the practices that emerge out of the various interactions that should occur during a development project. The relevant stakeholders and role players must determine the answer to this question in each local context. The information on cultural thought patterns from the literature is, however, important for the following reasons:

1. It provides a theoretical framework that should be tested in each community.
2. It creates an awareness of the potential perspectives of the SHFs.
3. It creates respect for the culture and behaviour of the people.

From the literature, we can derive that traditionally, human excreta are seen as vile, something that has to be concealed somewhere at a distance from the homestead. Sickness is both a natural and/or a spiritual matter. It can be caused by evil through witchcraft or jealousy, but it often has a physical presence in the body that can be cleansed out by being expelled from the body. Laxatives and enemas can help to cleanse the body. Fieldwork is needed in any community where solutions are being developed to determine to what extent human excreta is experienced as an impurity in normal circumstances and if any rituals are involved in normal daily affairs. If human excreta is seen as impure and associated with evil, the question is how participants can be motivated to consider it a resource.

An interesting aspect of impurity (*ditšhila*) in African cultures is that it is closely connected with the critical changes of life, particularly with its beginning and its end. Life is often seen cyclically; when you are born, you come from the world of the ancestors, and when you die, you return to them. In modern African literature, birth and death are often taken up in the cycle of life so that life comes from death as a plant grows from a seed buried in the ground. The seed has to die for the plant to grow. That implies that impurity is also taken up in the circle of life. Could this

thought pattern contribute to developing a circular agricultural pattern in which human excreta are taken up in the agricultural practice?

10.5 CONCLUSIONS

Nutrition and sanitation are two areas that can be linked in a circular economy. In both areas, there seem to be particular concerns regarding the health and safety of women and children. Ecological impacts are also concerned with current sanitation and energy consumption practices. Many projects have attempted to develop decentralised sanitation systems in rural and peri-urban communities to solve these problems. However, these technologies have often not been accepted by the end users. This could be due to the less obvious importance of cultural and religious thought patterns, how they influence the people's behaviours and their acceptance of the proposed solutions.

What is needed is a careful assessment of the cultures and the relevant feelings and thoughts of the low-income communities that need the solutions. Such an assessment will require the scientist to form a relationship with the end-user and involve them in developing the solution. Such an approach aligns with the complex systems theory, which guides how the development process should be undertaken.

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