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Determinants of water security for rural households: Empirical evidence from Melani and Hamburg communities, Eastern Cape, South Africa

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Clean and safe water to drink is essential for human wellbeing. However, most people in rural areas still lack access to clean and safe water. This study estimated the determinants of the water security status for rural households from Melani-inland and Hamburg-coastal communities in the Eastern Cape Province, South Africa. The water poverty index (WPI) was used to calculate the water security status of households in the two communities, while the Tobit regression model was used to investigate the main factors affecting household water security status. The findings show that water security in the study areas is meagre, mainly due to the unavailability of water resources and the time that is taken to collect water. The Tobit regression results revealed that factors such as paying for water, type of toilet used, and time spent collecting water determine households' water security in the study areas. Therefore, the paper recommends policy options that improve: the affordability of water, access to non-water using flush toilets, and ensuring tap water is available at shorter distances.

Keywords: water security, water poverty index, Hamburg community, Melani community

Bepalers van watersekuriteit vir landelike huishoudings: Empiriese bewyse uit die Melani- en Hamburg-gemeenskappe, Oos-Kaap, Suid-Afrika: Skoon en veilige water om te drink is noodsaaklik vir die mens se welstand. Die meeste mense in landelike gebiede het egter steeds nie toegang tot skoon en veilige water nie. Hierdie studie het die bepalers van die watersekuriteitsstatus vir landelike huishoudings uit die Melani-binnelandse en Hamburgse kusgemeenskappe in die Oos-Kaap Provinsie, Suid-Afrika, beraam. Die Waterarmoede Indeks (WPI) is gebruik om die watersekuriteitsstatus van huishoudings in die twee gemeenskappe te bereken, terwyl die Tobit-regressiemodel gebruik is om die belangrikste faktore wat die huishoudelike watersekuriteitsstatus beïnvloed, te ondersoek. Die bevindings toon dat watersekuriteit in die studiegebiede verskraald is, hoofsaaklik as gevolg van die onbeskikbaarheid van waterbronne en die tyd wat daar geneem word om water in te samel. Die Tobit-regressie resultate het aan die lig gebring dat faktore soos die betaling vir water, die tipe toilet wat gebruik word, en die tyd wat spandeer word om water in te samel, huishoudings se watersekuriteit in die studiegebiede bepaal. Daarom beveel die artikel beleid aan wat die volgende verbeter: die bekostigbaarheid van water, toegang tot spoeltoilette wat nie met water werk nie, en om te verseker dat kraanwater op korter afstande beskikbaar is.

Sleutelwoorde: watersekuriteit, waterarmoede-indeks, Hamburg-gemeenskap, Melani-gemeenskap

Introduction

Clean and safe water to drink and sanitation are crucial to human health and wellbeing. The importance of water and sanitation has been stressed in the Agenda 2030 Sustainable Development Goals (Goal 6), emphasising the importance of the availability and sustainable management of water and sanitation for all (Akinyemi *et al.,* 2017). Currently, about 2.2 billion people in the world lack access to safe water, and it is estimated that by 2030, water demand will double (UN-Water, 2019). At the same time, the world population is expected to grow by three billion or more in the next 50 years, especially in developing countries (Jury and Vaux, 2005). To date, the majority of households in developing countries lack access to safe and clean drinking water for their livelihoods (Government of Canada, 2017). Unavailability of water at the household level in rural areas poses risks to human wellbeing as well as to sectors such as food security and farming, which use about 70% of the available freshwater (Mabhaudhi *et al.,* 2018; GC, 2017).

Depending on the context, the definition of water security can take various forms. From an agricultural perspective, it refers to input into production and food security, whilst from a water resources angle, it focuses on water scarcity and supply security. Policy in water security pertains to minimising vulnerability to hydrological variability, interdisciplinary linkages (food, energy, climate, economic and human security), and sustainable development, amongst others (Cook and Bakker, 2012). In developing indicators for water security, Jensen and Wu (2018) highlighted that water security indicators could be subdivided into indices such as resources, access, risks, and governance. Indicators for resources pertain to availability (water resource availability, water storage capacity), diversity (diversity of water supply), and quality (raw water quality). Access includes capacity (water supply capacity, water supply coverage), service sustainability (cost recovery of water utilities), and affordability (water tariff). Risks are flooding (flood frequency and flood damage) and public health risks (water access, sanitation, and water contamination incidents). Governance includes strategic planning (whether governments/institutions can supply water) and disaster management and regulation.

In the African context, and more specifically in rural areas, most households still lack access to safe and clean water to drink (Heijnen *et al.,* 2014; UNICEF and WHO, 2015). Rural Africa is lagging behind in the provision of safe drinking water to nearly 300 million of its people (Hope *et al*., 2020). Furthermore, there is a lack of analytical and diagnostic framework in assessing water security in Africa (Holmatov *et al.,* 2017). About 14 countries in Africa, including South Africa, lack access to adequate water, with 11 countries expected to be added to the list by 2025 (World Wide Fund, 2012). Even though in a study conducted in southern Africa, Holmatov *et al*. (2017) indicate that economic water security in the Southern African Development Community (SADC) is most outstanding for Seychelles and South Africa, and is lowest for Malawi and Madagascar, rural communities still lack access to clean water for their livelihoods.

Climate change, socioeconomic development, population growth, and ineffective management have been identified as affecting water security (Zawahri, 2017). About 80% of illnesses in Africa are associated with the unavailability of water and poor sanitation (Ahmad and Satter, 2010; GC, 2017). It therefore follows that clean and safe water to drink, and proper sanitation are essential needs in human health and wellbeing. Thus, improving access to clean and safe water to drink for rural communities will minimise water-related illnesses. WaterAid (2017) attest that improving access to clean and safe water is an essential component of an integrated approach to alleviate poverty, improve health, and lessen hunger. Even though the South African government recognises water as a vital resource to human wellbeing and is making efforts to provide clean and safe water to drink for households (DWA, 2004; Hardberger, 2005), approximately five million rural South Africans still lack access to clean and reliable potable water (StatsSA, 2016). Literature indicates that South Africa is a very water-scarce country with high pressure on limited water resources (Sershen *et al.,* 2016). It is one of the 49 driest countries in the world, and economic growth is being slowed down by inadequate access to drinking water and sanitation (Meissner *et al.,* 2018). According to Statistics South Africa (2016), only 44.4% of households have access to piped water inside their dwelling, 30% inside their yard, 15.5% to a point outside the yard, and 10% with no water access at all. In trying to ensure water security for all in South Africa, well-documented water legislation that stipulates the water movement concerning people and the environment has been made available (WWF-SA, 2017). The water legislation implies that efficient water-use and management of these limited water resources are urgent to promote sustainability (Njoko and Mudhara, 2017). Judging from the diverse water-related issues in South Africa, it is evident that water security is an urgent issue that the government needs to address (Soyapi, 2017). Several authors such as Ngarava *et al.* (2019), Meissner *et al*. (2018) and Rodda *et al.* (2016) have carried out studies on water security in South Africa, indicating mixed results on the level of water security.

Household socioeconomic characteristics have received little attention in terms of water security in South Africa (Sinyolo *et al.,* 2014). A few studies by Ngarava *et al.* (2019) and Sinyolo and Mudhara (2014) have tried to focus on the socioeconomic aspects of water security in South Africa. However, most of these studies were either homogeneous (Ngarava *et al.* 2019), focusing on the country as a whole, or focusing on certain areas. An example of the latter is a study by Meissner *et al.* (2018) which looked at Sekhukhune and eThekwini Local Municipalities. A study by Rodda *et al.* (2016) focuses on the local government decision-making level. A better understanding of how water security for households can be ensured is an area where empirical research studies are needed (Young *et al.,* 2019). Furthermore, Sinyolo *et al.* (2014) stated that there is limited scientific knowledge on the significant factors influencing water security, especially at the household level. Rhodes and Mckenzie (2018) attested that in order for the government to avoid the factors that cause water costs to increase, factors affecting a household's access to water first need to be understood.

To date in South Africa, limited emphasis has been placed on understanding the impact of socioeconomic factors on a household's water security (Rhodes and McKenzie, 2018). Few studies have tried to follow this route. Ngarava *et al.* (2019) took a gender perspective when looking at the water security status of female-headed households in South Africa. They found that there is dynamism in female-headed households in their exposure, sensitivity, and adaptive capacity to water insecurity. Women need access

to capacity-building and empowerment in wealth generation. This necessarily involves improvement in their water security status which can be achieved by improving their access to treated water and improving their infrastructure (Ngarava *et al,* 2019).

Sinyolo and Mudhara (2014) found that socio-economic factors such as age of farmer, off-farm income, training, location, and membership of associations were significant in increasing water security. Factors such as conflict were significant in decreasing water security. In a study by Sharaunga and Mudhara (2016) which focused on irrigation schemes, it was also found that factors such as age of farmer, access to land, and membership of associations reduced water security in South Africa.

Various factors have been identified from the literature as having a bearing on water security. These fall into physical/infrastructural, institutional and socioeconomic (Sharaunga and Mudhara, 2016) categories. Physical/infrastructural factors affecting water security include hydrological patterns, topographical features and artificial water storage and conveyance facilities. Institutional factors such as customary laws, statutory laws, and other forms of inequality disallow access to water. Socioeconomic factors include gender, income, societal position, culture, and tradition. However, according to Hinojosa *et al.* (2018), generalisations as to the determinants of water security are not ideal. Particular social and environmental factors as well as the perceptions regarding water security need to be changed.

In the Eastern Cape Province of South Africa, several scholars have found that rural communities face water insecurities due to climate change that has a considerable impact on rainfall distribution, streamflow, water quality, salt intrusion, and drought (Grecksch, 2015; Africa, 2012). As a result, rural communities in the Eastern Cape, which includes Hamburg, face substantial water shortages, causing residents to either draw water from local dams or limit themselves to one bath a week to save the available water (Jacob, 2018). According to a resident who runs an agency in Hamburg, the areas experienced water cuts 19 times in 2018 with no explanation from the municipality (Jacob, 2018). Hence, this study sought to ascertain the water security in two different Eastern Cape communities, namely Melani-inland and Hamburg-coastal. Meissner *et al.* (2018) carried out a similar study which focused on two different municipalities in South Africa (Sekhukhune, which is inland, drier, and a socioeconomically rural municipality, and eThekwini, which is coastal and urbanised). Furthermore, the study utilised a qualitative design, using key informant interviews and focus groups targeting community opinion leaders and decision-makers. This study will be different as it focuses on different municipalities as well as different micro household levels.

Research methodology

The study areas

This study was carried out in the Keiskamma catchment and the Keiskamma River's headwaters in the Eastern Cape, South Africa. The Keiskamma catchment and headwaters for the Keiskamma River are situated in the Eastern Cape Province of South Africa under the greater Amatola (Mhangara, Kakembo, and Lim, 2011). In catchment, two different communities were purposely selected based on their natural resource vulnerabilities, namely Melani-inland and Hamburg terrestrial communities.

Hamburg is a small rural area which falls under the Ngqushwa local municipality. Hamburg is located near the Keiskamma Estuary, where the Keiskamma river streams to the Indian Ocean (33° 17′ 26.88″ S, 27° 28′ 30″ E) (Martens, 2015). Hamburg is made up of communal, private, and state-owned land and is connected to the R72 road by a 14 km gravel road (Africa, 2012). The nearest urban area is that of Peddie, with the largest urban area being East London, which is 90 km away (Martens, 2015).

The study also focused on the Melani-inland community to explore the main drivers of water insecurity for rural households from a different setting to that of the Hamburg-coastal community. Melani is a village located approximately 12 km north of the town, Alice, in the Eastern Cape Province. The village is located in the Raymond Mhlaba Local Municipality (RMLM), previously known as Nkonkobe Local Municipality (NLM). The village is also situated along the Keiskamma River (32° 43′ 29″ S, 27° 07′ 35″ E). The local municipality covers 3 725 km^2 and is situated along the R63 surface road in the Amatole District Municipality (Ngcobo, 2017).

Theoretical framework

The study focused on the determinants of water security for households in rural areas. In this study, water security is defined as reliable, healthy, and maintainable water access by people and the communities to meet their daily needs (Reddy, 2002). According to McGarvey *et al.* (2008), the household's socioeconomic factors play a crucial role in improving the household's water access, such as having piped water, open wells, or good sanitation. Research indicates that the household's ability to pay for water also plays a critical role in some communities for better water delivery (Nocholas *et al.,* 2019). However, in most rural communities, households do not pay for water supply (Mothetha *et al.,* 2013; Nkuna and Ngorima, 2011). Therefore, the current study measures water security based on the total available water resources, access to water and sanitation resources, and the time taken to collect water.

In order to understand factors influencing water security, the Sustainable Livelihood Framework (SLF) was adopted. The framework is mostly used to help understand and analyse the challenges posed by underprivileged livelihoods (Carney, 1999). Several scholars suggest that the framework is a useful method to examine factors which might deprive the poor of making a better living for themselves (Donohue and Biggs, 2015; Carney, 1999). Scoones (2009) suggests that in order for livelihoods to be sustainable, poor households should be able to cope with shocks and stresses imposed by the environment and be in a position to maintain their assets while considering natural resources such as water. According to Donohue and Biggs (2015), the sustainable livelihoods approach implies that poverty is not just based on the shortfall of income, but also on the multi-dimensional concept, which includes aspects such as affordability of education and health care affordability. The framework also focuses on the household level and assets controlled by the household, which are influenced by external factors and shocks such as drought and climate change (Scoones, 1998).

The framework is useful to link socioeconomic and environmental concerns (Brocklesby and Fisher, 2003). Figure 1 summarises the sustainable livelihoods approach (Chambers and Conway, 1991).

Chambers and Conway (1991) suggest that households' livelihoods are formulated from financial, social, physical, human, and natural capital. Thus, financial capital is defined as the availability of stocks, including savings, pension, and wage income (Martens, 2015). Social capital is defined as the relationships and networks which enable people to co-operate. Physical capital is mainly the essential infrastructure humans depend on for their livelihoods, such as water supply and sanitation. Human capital is defined as the skills and ability of people to work to pursue different livelihood strategies, while natural capital is defined as the natural resources that sustain life (water). Therefore, water is one of the most crucial natural resources that help rural households maintain their livelihoods. Based on this background information, the sustainable livelihoods approach was used to link the socioeconomic factors influencing natural resources like water. In achieving this goal, the paper describes the water security status and investigates the factors influencing water security in the study area.

Sampling method and sample size

The study areas were purposely selected based on the vulnerability of the water resources in the area. According to the former Nkonkobe Municipality (2012), the Melani community has a population of 500 households, and Hamburg has a total population of 454 households (StatsSA, 2013), which makes a combination of 945 households. However, there might be a possibility of population growth or shrinkage between the indicated years to date. To obtain a 95% confidence level with a 5% error level, 283 households would be the lowest accepted number. Therefore, the study

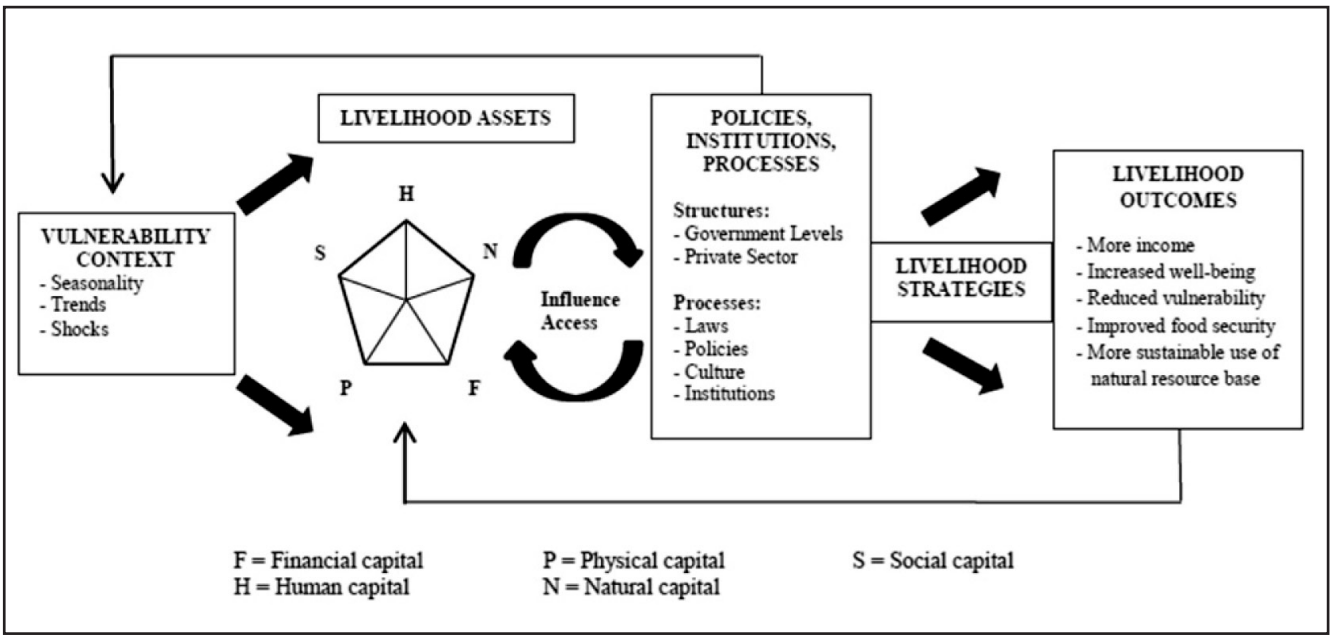

FIGURE 1: Sustainable livelihoods framework.
Source: Solesbury (2003)

randomly selected 283 households for direct questioning, making use of questionnaires. The study selected 141 households from Melani and 142 from Hamburg to make up a total of 283 households.

The sample size was derived from the formula below, following Israel (2013).

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where n is the sample size, N is the population size, and e is the level of precision. Thus, applying this formula with the known number of households and a margin of error of 5% is:

$$n = \frac{945}{1+945(0.05)^2} \quad (2)$$

= 283 households

Sources of data and methods of data collection

A cross-sectional research design was used to gather information from the 283 randomly selected households in the two study sites, namely the Hamburg-coastal area and Melani-inland area. Since the population was relatively homogeneous, the sample size was considered large enough to provide a dependable counterfactual. Quantitative data was used for this study. A semi-structured questionnaire was prepared for individual interviews. The questionnaire was pre-tested and modified accordingly before being administered to respondents. The actual primary data was then collected in June 2019 by five trained enumerators from both communities. The questionnaire was composed of information on the household head's basic characteristics such as gender, age, marital status, and education level. The questionnaire also included information on household access to water resources, access to piped water, time taken to collect water from the community water source, and access to sanitation.

Methods of data analysis

Measuring water security status

The study used the water poverty index (WPI) to calculate the level of water security for each respondent in the study areas. The household water security index is composed of the following variables:

- Water availability,
- Access to safe water,
- Clean sanitation, and
- Time taken to collect domestic water.

The WPI is given as follows: (Sullivan, 2002)

$$WPI = w_a A + w_s S + w_t (100 - T) \quad (3)$$

Where A: is the adjusted water availability (AWA) as a percentage. It is calculated on the basis of groundwater and surface water availability related to ecological water requirements and a basic human requirement and all other domestic demands as well as demands from agriculture; S: is household access to safe drinking water and sanitation (%); T: is the index (between 0 and 100) representing the time and effort required to collect water for household use. The final level of the WPI w_a, w_s *and* w_t comprises the weights given to each component of the index so that (w_a + w_s + w_t = 1).

Given that A, S, and T are all defined between 0 and 100 and between 1 and 0, in order to produce a WPI value between 0 and 100, the need therefore exists to modify the formula as follows:

$$WPI = \frac{1}{3}(w_a A + w_s S + w_t (100 - T)) \quad (4)$$

Following studies such as Sullivan 2002 and van der Vyver (2013) the linear index will be interpreted as follows: if WPI = 100, the household is water secure. Then if WPI = 0, this means the household is water insecure.

Tobit regression model

To identify factors influencing household water security status, the Tobit regression model was used. The water security index was then used as a dependent variable on the Tobit regression model to evaluate the factors that affect household water security status in the study areas.

The Tobit regression model was estimated as follows (Maziya *et al.*, 2017);

$$Y_I = \beta_\circ + \beta X_I + e_I \quad (5)$$

Where Y_I=WPI i:$\beta_\circ$ the constant term in the model; β = a vector of the variable coefficients; and e_I = error term. The Tobit regression model was considered appropriate as it takes account of the continuous but truncated nature of the dependent variable (min = 0; max = 100). The Akaike's Information Criterion (AIC) and the Bayesian Information Criterion (BIC) were used to compare the suitability of the model to simple linear regression.

Variables and literature review

TABLE 1: Variables used in the Tobit model

Variables	Description	Literature
Dependent variable WPI	Water poverty index (0 = water-poor, 100 = water secure)	Water poverty index (WPI) is a linear variable measured as a percentage between 0 and 100 of household's access to clean water to drink and sanitation, time taken to collect water, and water resources availability.
Independent variables Age of the household head	Number of years	Several studies argued that age distribution among households has a positive influence on water security (Schleich and Hillenbrand, 2009; Kenney *et al.*, 2008; Musolesi and Nosvelli, 2007). Several studies attested that older households in rural areas of southern Africa are more vulnerable to water insecurity, more especially those with a low income (Mudau, 2016; Geere *et al.*, 2010; Majuru, 2015). Other studies attested that older household heads are wiser and full of wisdom when handling water conflicts and challenges in the community (Sinyolo, 2013). The influence of household age is, therefore, not obvious, stressing the need for more studies on the topic.
Household size	Number of people in the household unit	Several studies have suggested that a larger household size presents a positive pressure on household water security through high demand (Schleich and Hillenbrand, 2009; Hoffmann *et al.*, 2006; Arbues *et al.*, 2004). These studies suggested that large households typically require more water to sustain their livelihoods (Dotse, 2016). An earlier study by Arouna and Dabbert (2010) noted that larger households might have labour advantages of collecting water from communal taps, especially in rural areas. Thus, considering this background, more studies across different geographical areas are required to advance knowledge on the influence of household size on water security.
Water infrastructure	Experienced issues of water infrastructure (leaking taps) (1 Yes, 0 No)	Water infrastructure is considered one of the significant issues impacting household water security (Alcamo *et al.*, 2000). South Africa has the best engineering infrastructure to transport water where needed; however, the infrastructure is slowly aging over time and needs to be reconsidered (Colvin *et al.*, 2016). Thus, infrastructure poses a negative implication on water security at the household level, especially in most rural communities.
Farming	Household involvement in farming activities	More water is consumed for farming purposes in rural areas, with about 70% of freshwater being used for irrigation in the food production process, leaving about 10% for home consumption and 20% for industries (United Nations, 2012). Other studies suggested that farming activities do not necessarily require clean water (Mzini and Winter, 2015). Therefore, based on the above uncertainties, the influence of farming on water security is not obvious.
Marital status	Married or otherwise	Marital status also contributes to the water security of households in one way or another. Therefore, a household headed by a married individual is likely to have access to more improved water sources than a household headed by an individual who never married (Irianti *et al.*, 2016). According to Irianti *et al.* (2016), the more households migrate, the less likely they are to be water-secure, and therefore married households are more committed and less likely to migrate. In contradiction, Adams *et al.* (2015) conducted a study on factors affecting water access in Ghana, which revealed that married households are less likely to be water-secure than households who never married. Therefore, based on the above uncertainties, the influence of the household head's marital status on water security is not apparent.

TABLE 1: Variables used in the Tobit model *(continued)*

Variables	Description	Literature
Race of the household head	Black or otherwise	In one way or another, the race also contributes to the factors that drive water security for households (WaterAid, 2020). According to Hendricks (2003), blacks are less likely to have access to water than whites. A study conducted by Brooks *et al.* (2017) revealed that, in most cases, white households are more likely to have water access than black households. The income inequalities might explain this as whites earn more income than blacks (Judin, 2019). Based on the low levels of income in rural areas, the study hypothesised that the household head's race would negatively influence water security.
Employment status of the household head	Employed or unemployed	Employment status is one of the main factors influencing water security. Employed household heads earn income and can afford to pay for water costs compared to unemployed household heads (Adams *et al.*, 2015). In contrast, Angoua *et al.* (2018) stated that fetching water is a domestic duty in rural areas, and households who are employed tend to neglect their domestic duties of fetching water, therefore limiting water security. Therefore, based on the above uncertainties, the influence of the employment of the household head on water security is not apparent.
Education status of the household head	No education at all, primary, secondary and tertiary	The education level of the household head is one of the main factors influencing water security. Adams *et al.* (2016) stated that educated households are more likely to be water-secure than those without education. Household heads with high education are more likely to understand the cost of using untreated water and therefore make efforts to improve their water quality (Adams et al., 2016). Based on the above information, the study hypothesised that the household head's education level, when high, positively influences water security.
Household paying for water	Paying for water or not	Households paying for water is one of the main factors influencing water security. Several researchers have claimed that households who are paying for water are usually more water secure than those who are not paying (Pinto *et al.*, 2018; Dlamini, 2015; Kujinga *et al.*, 2014). According to the World Bank (1993), in rural areas of developing countries, willingness to pay for water varies based on income and the existing supply characteristics. Therefore, based on the above information, the influence of paying for water on water security is not apparent.
Toilet used in the household	Using a pit toilet or flush toilet	The type of toilet used by a household also contributes to water security in one way or another. Households which own a flush toilet use more water than those who use pit toilets, increasing their water insecurity (Zaied, 2018). In contrast, the SFIAST (2019) argued that currently, there are dual flush toilets that save water, reducing the quantity of water used to flush. Therefore against this background information, the influence of flush toilets on water security is not apparent.
Time spent to collect water	The actual time taken to collect water in hours	Time spent collecting water by household members influences the household's water security in one way or another. Households who spend more time collecting water are more water-secure than those who do not (Lewis, 2016). In rural areas, water in taps is unreliable and needs households to collect from far sources (Tussupoca, 2016). Based on the above information, the study hypothesised that time spent collecting water by households has a negative influence on water security.

Results and discussion

Socioeconomic and demographic characteristics of the sampled households

Table 2 below presents descriptive statistics of the 283 surveyed households in the study. In relation to the respondent's socioeconomic characteristics, the household head's average age was 59 years, ranging from 25 to 96 years old in both communities. In both communities, females dominated in gender, as indicated by 74.6% of females in Hamburg and 66.7% in Melani. The majority of Hamburg households were married (61.3%), while only 45.4% of the sampled households in Melani were married and living in households whose average size is four members. The majority of the sampled households in Hamburg (43%) indicated that their household head had attained secondary education, while most households in Melani indicated that their household head had attained primary education (44.7%).

The majority of the sampled households in both communities revealed that they mostly depend on social grants as their source of income, as follows: Hamburg (76.8%) and Melani (84.4%). Although in Melani, the respondents said there was no dependence on agriculture as a source of income, respondents in Hamburg indicated that they use agriculture as a source of income (1.4%). In both communities, the respondents indicated high unemployment levels as follows: Hamburg (88%) and Melani (90.8%).

Water security status

Table 3 presents the WPI calculated for the two communities in the study area, namely, Hamburg and Melani communities. The results point out that in the Hamburg community, water availability is a meagre (17%); however, more people have access to clean and safe drinking water (86%), and less time is taken collecting water (28%). Results further indicate a WPI of 16, which implies a higher degree of water stress. These findings suggest high water insecurity mainly caused by reduced water availability. Therefore, priority for the Hamburg community should be on addressing water availability for purposes of increasing the WPI, which is currently very low. The results for the Melani community also indicate low water availability (24%), although slightly higher than the Hamburg community, with more people having access to clean drinking water (74%) and more time being taken to collect water (33%). Results also indicate a WPI of 15.7, which implies a higher degree of water stress. These findings suggest high water insecurity mainly caused by reduced water availability and more time taken to collect water. Therefore, priority for Melani community should be on addressing water availability and reduced time spent on water collection. Thus far, both communities have water poverty challenges mainly caused by reduced water availability and more time spent on water collection, especially for the Melani community. However, it is interesting to note that for a higher number of people from the two communities (Melani: 74%; Hamburg: 86%), although their water availability status is very low, the little water they have access to is generally clean and safe for drinking. Therefore, the water poverty challenge for the two communities is more of a technical and institutional nature (water availability and water proximity to residents). Assefa *et al*. (2018) looked at water stress for households using the WPI. Their results showed that a lack of institutional capacity, poor water infrastructure, and unreliable power supply are the major causes of poor household water security (Assefa *et al.*, 2018). Similar results were also observed earlier by Ogwang and Cho (2014), which indicated that resources like declining water availability per capita, access to bottlenecks, capacity, and water use are some of the major issues contributing to water poverty.

TABLE 2: Descriptive statistics of sampled households

Variable		Hamburg		Melani		Combined	
		Freq	*Percentage*	*Freq*	*Percentage*	*Freq*	*Percentage*
Gender	Male	36	25,4%	47	33,3%	83	29,3%
	Female	106	74,6%	94	66,7%	200	70,7%
Marital status	Unmarried	53	37,3%	77	54,6%	130	45,9%
	Married	87	61,3%	64	45,4%	153	54,1%
Education status	No formal education	26	18,3%	13	9,2%	39	13,8%
	Primary	45	31,7%	63	44,7%	108	38,2%
	Secondary	61	43%	53	37,6%	114	40,3%
	Tertiary	10	7%	12	8,5%	22	7,8%
Household source of income	Agriculture	2	1,4%	0	0%	2	0,7%
	Salary	9	6,3%	12	8,5%	21	7,4%
	Business	11	7,7%	5	3,5%	16	5,7%
	Social grant	109	76,8%	119	84,4%	228	80,6%
	Remittances	4	2,8%	1	0,7%	5	1,8%
	Other	7	4,9%	4	2,8%	11	3,9%
Employment status	Unemployed	125	88%	128	90,8%	253	89,4%
	Employed	17	12%	13	9,2%	30	10,6%
		Hamburg			**Melani**			**Gekombineer**		
		Min	*Max*	*Ave*	*Min*	*Max*	*Ave*	*Min*	*Max*	*Ave*
Age of the HH		25	93	59	25	96	59	25	96	59
Household size		1	13	4	1	12	4	1	13	4

Econometrics results

Determinants of water security status of households in the study area

Table 4 presents the results of the factors influencing water security status in the study area, which were estimated using a Tobit regression model. The water poverty index was used as the dependent variable on the Tobit regression model. Tobit regression was used because it has desirable characteristics of yielding consistent maximum likelihood estimates and accommodating the nature of the truncated dependent variable. The variance inflation factor (VIF) was used to test the severity of multi-collinearity between the independent variables, and the resulting values were less than 10. From the results, it can be deduced that multi-collinearity was not a problem as all VIF values were below 10. The results also show that the chi-square (p-value = 0.0001) was high and statistically significant for a log-likelihood ratio and Pseudo R^2 of 0.368. The low R squared could be justified because the variables used in the model do not fully explain water security as it is affected by several other variables not covered by this study.

For the Tobit regression model, the sign of the coefficient indicates the direction of the influence of the independent variable on the dependent variable. Thus, a positive value shows that an increase in that variable increases household's water security, holding other variables constant. A negative value implies that an increase in that variable decreases the household's water security, holding other variables constant.

The results indicate that factors such as paying for water, type of toilet used, and time spent collecting water all influence household's water security status in the study area. Time spent collecting water was significant at 1% while paying for water, and the type of toilet used were significant at 5%. Nine of the 12 independent variables used in the model were insignificant: age, household size, marital status, farming status, income source, education, water infrastructure, and race. One of the three significant independent variables had a negative sign, namely time spent collecting water. The negative sign indicates that an increase in the predictor variable will be associated with a decrease in the household's water security, therefore increasing water insecurity. Two predictor variables, namely type of toilet used and paying for water, had a positive sign implying an improvement in these independent variables will be associated with an increase in households' water security. As a result, this would lower water insecurity.

Paying for water was significant (p-value: 0.038) and had a positive relationship with the WPI. The results indicate that a unit change in a household's willingness to pay for water is associated with a decrease of 0.7767 units of household water security, holding all other independent variables constant. The results imply that households with the capacity to pay for water have lower chances of running out of water. This might be because households with the capacity to pay for water have access to different sources of purchased water; hence they are water-secure compared to households with limited ability to pay for water. Because

TABLE 3: Water poverty index for Melani and Hamburg communities

Community	Water availabillity (%)	Access to clean and safe drinking water (%)	Index of time spent in water collection	WPI
Weights	0.5	0,25	0,25	
Melani community	24	74	33	15.7
Hamburg community	17	86	28	16

Source: Field survey, 2019

TABLE 4: Determinants of water security status: Tobit regression model results

Variables	Estimated Co-ef	Std Err	*p* significance level
Age of the household head	0.00008	0.0123	0.994
Marital	0.3890	0.312	0.215
Household size	-0.0851	0.066	0.199
Paying for water	0.7767	0.371	0.038**
Employment status	-0.6819	0.737	0.356
Race of the household head	-2.9296	1.674	0.081
Type of toilet used	1.2644	0.624	0.044**
Water infrastructure	0.5168	0.309	0.096
Farming	0.3846	0.308	0.214
Time spent	-0.5081	0.114	0.000***
Education			
Primary	0.1577	0.463	0.734
Secondary	0.6709	0.357	0.062
Tertiary	0.2659	0.639	0.678
Constant	13.4737	0.891	0.000***

Note *** and ** show the level of significance at 1% and 5% levels, respectively.

water is an essential economic good requiring consumers to pay the costs, several scholars have claimed that households are willing to pay for water to increase water security in terms of reliability and sound quality water (Pinto *et al.*, 2018; Dlamini, 2015; Kujinga *et al.*, 2014). Mezgebo and Ewnetu (2015) attest that most households are willing to pay for water to improve the water supply. Mezgebo and Ewnetu (2015) further elaborate that households with better income, a short walking distance to the water source, and having a high level of education are mostly associated with households who are willing to pay for improved water supply.

The type of toilet used by the household was significant (p-value < 0.05) and had a positive relationship with the WPI. The results indicate that a positive unit change in the type of toilet used in the household (from using the outside toilet to using the flush toilet) is associated with an increase of 1.264 units of household water security, holding all other independent variables constant. This implies that the more households use flush toilets as against using outside pit toilets, the more their chances are of increasing their water security status. This might be because households with flush toilets have access to clean water for flushing and have access to clean sanitation. The Swiss Federal Institute of Aquatic Science and Technology (SFIAST) (2019) stated that currently, there are dual flush water-saving toilets that reduce the water used to flush. Thus, having access to a flush toilet does not necessarily decrease the water security of the household. The findings are also supported in UNEP (2002), which claimed that dual water-saving toilets exist and contain different flush volumes to reduce water use, and certain other toilets collect the urine separately and reuse it to flush and save water, therefore increasing water security (UNESCO-IHE, 2009). Larsen *et al.* (2001) attest that the source separating urine toilets has several benefits and saves about 80% of the water used to flush the toilets. Therefore, having flush toilets doesn't necessarily suggest that the household will be water insecure.

Time spent by the household collecting water had a significant (p-value < 0.1) and negative association with the WPI. A unit increase in time spent by the household collecting water is associated with an decrease of 0.5081 units of household water security, holding all other independent variables constant. The results indicate that the more time spent by households collecting water, the more likely they are to be water insecure. In the study area, water in community taps tends to be unavailable for long periods in a year, forcing households to walk long distances to rivers, dams, and boreholes in the community looking for water. Time taken to collect water forces households to reduce their water consumption as a saving mechanism which negatively compromise their water security. A comparable previous study by Tussupova (2016) noted that households in rural areas use public sources of water and have to walk long distances and spend much time collecting water to improve their water security status. Similar results were observed by Lewis (2016), who claimed that most rural households have to spend most of their days walking miles to meet their daily water needs, especially during dry seasons. The time taken to collect water in rural areas negatively impacts the poor and in most cases, becomes a substantial barrier to sustainable development and household water security (Greere and Cortobius, 2017). Therefore, the time used to fetch water by poor households in rural areas reduces the time for generating livelihoods such as finding work, increasing the levels of poverty for these households (Greere and Cortobius, 2017).

Conclusion

This study was designed to investigate household water security determinants in Hamburg-coastal and Melani-inland areas in the Eastern Cape Province of South Africa. Data were analysed using descriptive statistics, the water poverty index, and the Tobit regression model. The study concludes that water insecurity from the study area is a severe issue mainly caused by water resources' unavailability and the time taken to collect water. The paper concludes that to address water insecurity in the study areas, more focus should be on strategies to reduce household's time to collect water. The study further concludes that certain factors positively influence household water security (the type of toilet used and paying for water), while other factors negatively influence household water security (time spent collecting water). To enhance the level of water security in the study areas, there is a need to improve water infrastructure for water provision and the type of toilets used. Water infrastructure provision will also improve on time spent to collect water.

Recommendations

Based on the study findings, the paper recommends that to enhance the level of water security in the study area and similar areas, there is a need to improve water infrastructure for water provision and the type of toilets used. The provision of water infrastructure will also improve on time spent collecting water. It is also necessary to ensure that water is available at affordable prices in paying communities and that households can thus pay their water bills. The government should also make sure that households in rural areas have access to non-water using flush toilets, which will improve their water security. Lastly, the study recommends putting more effort into making sure that clean, available tap water is closer to households to minimise time spent in collecting water.

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