Factors predicting the intention to accept treated wastewater reuse for non-potable uses amongst domestic and non-domestic respondents

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Water reuse projects can fail if the factors (social, technical, financial, etc) governing their implementation are not adequately addressed prior to implementation. This paper presents the findings of the analysis of questionnaires administered to potential domestic and non-domestic consumers in Capricorn and Vhembe (Limpopo Province) where wastewater reuse was being considered. The analysis examined the factors considered to predict the *intention* to accept wastewater reuse prior to implementation. Structural Equation Modelling (SEM) was employed to test several hypotheses addressing respondents' *intention* to accept wastewater reuse for non-potable end uses. In other words, SEM tested whether certain factors (e.g. trust, attitudes and control) measured *intention*. *Intention* was measured as a second order factor. For non-domestic respondents, the factors that predicted *intention* to accept wastewater reuse in order of significance were their *attitude towards wastewater reuse*, the degree of *control over the source of water and its application*, the respondents' *knowledge of the advantages of reuse* and the respondents' *trust in the service provider*. For domestic respondents, the factors were their *knowledge of the advantages of reuse*, the degree of *control over the source of water and its application, attitude towards wastewater reuse, trust in the service provider,* and the *subjective norms* of the respondents. *Physical quality satisfaction* (for both respondent categories) and *subjective norms* (for non-domestic respondents only) could not be assessed because a reliable scale was not formed. The above findings have implications for future wastewater reuse in South Africa, i.e. that decision-makers contemplating reuse for non-potable uses would profit from addressing the various factors predicting *intention* to accept reuse prior to implementation.

INTRODUCTION

The increasing demand for water in South Africa is driven by growing populations, the connection of previously un-served households to municipal water supply, growing industrial development, urban in-migration and a host of other factors. Consequently, water resources planners are continually looking for additional sources of water to supplement the limited resources available (Adewumi *et al* 2010). It was predicted that unless the water consumption patterns in South Africa change significantly, the country would not be able to meet the growing demand for water, and the problem could be extremely severe within 20–25 years (DWAF 2007). As shortages increase, allocation of water to irrigated agriculture, for example, may result in downstream urban areas facing water shortages, leading to water use restrictions and increased general discontent. It is thus within the context of freshwater constraints that the South African government is faced with the challenge of implementing sustainable alternatives, including wastewater reuse, for potable and/or non-potable requirements.

Wastewater reuse has become an attractive option for conserving and extending available water supplies. Other benefits of reuse include the decrease in the diversion of freshwater from sensitive ecosystems, replenishment of soil nutrients in agriculture due to irrigation, enhancement of groundwater recharge and delay in the future expansion of water supply infrastructure (Angelakis & Bontoux 2001; Joksimovic 2006).

Despite the benefits mentioned above, reuse should not be contemplated where there is non-compliance in treated wastewater effluent quality, crops to be irrigated have not been proven to be tolerant to the salts in the effluent, and there is no risk of salts from the effluent resulting in the deterioration of

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ground/surface water quality. Another major challenge affecting the implementation of reuse projects is public opinion. Opinion influences *intention* to accept, and *intention* influences behaviour. It is for this reason that community opinion towards wastewater reuse has been identified as a key component of reuse project success (Okun 2002; Po *et al* 2004). The majority of opinion surveys on water reuse that have been published in the literature have emanated from the USA, Australia, Western Europe and the Middle East. For the purpose of forming appropriate policy and strategy, and due to the large variations in culture, climate, water availability, economy, etc, opinion studies need to be developed or adapted for national and sometimes sub-national contexts (Friedler *et al* 2006). In view therefore of the significant impact public opinion has on water reuse, it is important that opinion be investigated prior to the implementation of wastewater reuse.

Several studies (including Nancarrow *et al* 2008; Nancarrow *et al* 2009; Nancarrow *et al* 2010; and Po *et al* 2005) suggest that public acceptance of reuse is a product of attitude, emotion, control over source of water, subjective norms (influence of people around you), knowledge of the scheme, associated risks, trust in the implementing authority, physical quality satisfaction, choice, specific use, source(s) of recycled water, cost, water scarcity and socio-demographic factors. Individually, or in combination, these factors have been investigated in various places where water reuse schemes have been implemented or are planned. For example, Wilson and Pfaff (2008) carried out research in Durban, South Africa, (and compared their findings with international experiences) to determine if there were groups with specific religious or philosophical objections to potable reuse of wastewater. They concluded that fundamental religious objections to potable wastewater reuse do not exist internationally and locally, but that people are generally not comfortable with the idea of potable reuse. Non-potable reuse of wastewater, on the other hand, is expected to be less uncomfortable, especially if this reuse involves minimum human contact (e.g. toilet flushing and irrigation). There is, however, currently no empirical research in South Africa confirming or debunking this supposition.

The research presented herein thus seeks to investigate the underlying factors that predict domestic and non-domestic respondents' *intention* to accept wastewater reuse for non-potable purposes. Domestic and non-domestic respondents are distinct water users, and are therefore investigated as separate respondents in this study. The investigation is achieved by employing the Structural Equation Model (SEM) to analyse the factors that are considered to predict *intention* to accept wastewater reuse for non-potable water requirements in two arid South African communities in Limpopo (Seshego, Sisulu and Ext 44 within the Capricorn District Municipality and the Vhembe District Municipality respectively) where wastewater reuse is being considered.

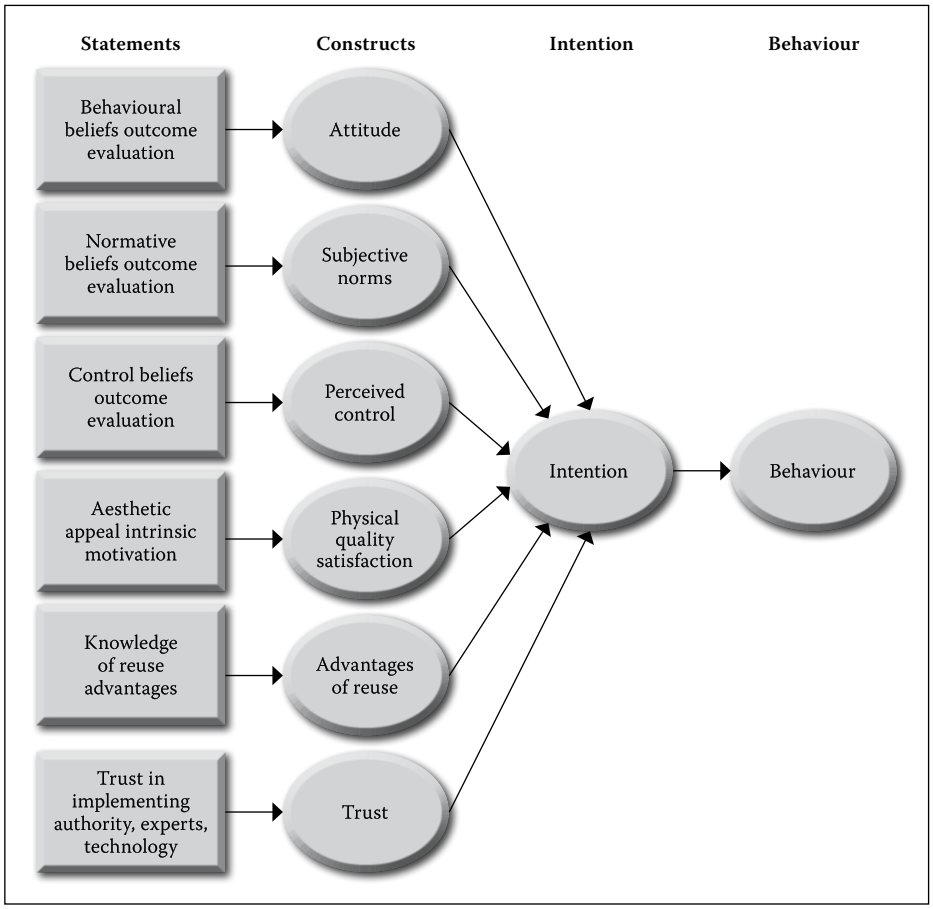

Figure 1 Hypothesised model predicting *intention* to accept, and behaviour towards wastewater reuse

BACKGROUND AND RESEARCH THEORY

This paper investigates the empirical relationships between *trust in the reuse implementing authority*, *knowledge of the advantages of reuse*, *physical quality satisfaction*, *perceived behavioural control*, *subjective norms* and *attitude*, as proposed by Ajzen (1985) and Po *et al* (2005), and the *intention to accept wastewater reuse* amongst potential non-domestic and domestic respondents in South Africa.

According to the Theory of Planned Behaviour (TPB) proposed by Ajzen (1985), an individual's *behaviour* is determined by the person's *intention* to engage in the behaviour. *Intentions* are in turn predicated on three factors (also known as constructs, belief based measures or latent/unobserved variables), i.e. *attitudes*, *subjective norms*, and *perceived behavioural control*. Definitions for these constructs are provided below:

- ***Attitude*** is a complex mental state involving feelings, values and disposition to act in certain ways. It measures overall positive or negative predisposition to behave in a certain way.
- ***Subjective norms*** are the beliefs about the normative expectations of others, and to comply with these expectations (also called normative beliefs). It measures the perception of how important people in the life of respondents would approve or disapprove of their performing a particular behaviour (i.e. social pressure).
- ***Perceived behavioural control*** is the belief about the presence of other factors that may facilitate or impede performance of the behaviour, and the perceived power of these factors (control beliefs). It measures the extent to which an individual has the capacity to perform the behaviour.

Based on the research conducted by Eiser *et al* (2002) which suggested the inclusion of the following constructs to Ajzen's (1985) TPB, i.e. (i) perceived risks and benefits, (ii) knowledge of the advantages of reuse, and (iii) trust in implementing authorities, experts and technology, Po *et al* (2005) proposed a hypothesised model comprising various constructs that influence the acceptance or rejection of recycled water for various

Table 1 Constructs measuring *intention* to accept wastewater reuse for non-potable water requirements and their respective hypotheses

Construct	Hypothesis
Advantages of reuse (ADV)	H1: Respondents' *knowledge of the advantages of wastewater reuse* has a positive effect on *intention* to accept wastewater reuse for non-potable water requirements.
Trust (TRU)	H2: Respondents' *trust* in the treated wastewater service provider has a positive effect on *intention* to accept wastewater reuse for non-potable water requirements.
Attitude (ATT)	H3: Respondents' positive *attitude* towards wastewater reuse will increase the *intention* to accept wastewater reuse for non-potable water requirements.
Control over source of water (CON)	H4: Respondents' *perceived control* over the source of water and its application has a positive effect on the *intention* to accept wastewater reuse for non-potable water requirements.
Subjective norms (SNO)	H5: Higher *subjective norms* associated with wastewater reuse for non-potable water requirements, has a positive effect on *intention* to accept wastewater reuse.
Physical quality satisfaction (PQS)	H6: The *aesthetically pleasing appearance* of recycled wastewater will have a positive effect on respondents' *intention* to accept wastewater reuse for non-potable water requirements.

uses. A derivative of this hypothesised model is presented in Figure 1. The six constructs shown in Figure 1 are hypothetical and therefore cannot be directly observed, but must instead be inferred from respondents' responses to questions/statements that statistically correlate with the constructs.

Hypotheses used in this study

In this study, the model predicting *intention* to accept or reject wastewater reuse was tied to a series of hypotheses discussed below:

***Knowledge of the advantages of reuse*:** The knowledge of the advantages of reuse has not been tested in the context of wastewater reuse for non-potable water requirements. This hypothesis postulates that if respondents have good knowledge of the advantages of wastewater reuse, this knowledge would enhance their *intention* to accept wastewater reuse for non-potable uses. Hence, the following hypothesis:

> H1: Respondents' *knowledge of the advantages of wastewater reuse* has a positive effect on *intention* to accept wastewater reuse for non-potable water requirements.

***Trust in the implementing authority*:** Prior research in Australia (Po *et al* 2005; Fielding *et al* 2009) identified trust in the Water Authority as a major determinant of the acceptance of recycled water. Also, a study conducted by Lin and Wang (2006) showed that trust had a positive effect on customers' loyalty and consumers' satisfaction. Eiser *et al* (2002), however, found that trust had a weak influence on consumers' food satisfaction. The following hypothesis was therefore developed for this study:

> H2: Respondents' *trust* in the treated wastewater service provider has a positive effect on *intention* to accept wastewater reuse for non-potable water requirements.

***Attitude*:** Attitude towards performing a particular behaviour is the degree to which an individual has a favourable or unfavourable assessment of the behaviour. TPB predicts that the more favourable an individual evaluates a particular behaviour, the more likely s/he will intend to perform that behaviour (Ajzen 1985). *Attitude* has been shown to be significant in predicting the *intention* to accept recycled water (Po *et al* 2005) and an organisation's *intention* to share knowledge (Bock & Kim 2002; Lin & Lee 2004). In this study *attitude* refers to the respondents' positive or negative disposition that will influence *intention* to accept wastewater reuse for non-potable water requirements. Thus, the following hypothesis was formulated:

> H3: Respondents' positive *attitude* towards wastewater reuse will increase the *intention* to accept wastewater reuse for non-potable water requirements.

***Perceived behavioural control*:** Perceived behavioural control refers to the presence or absence of requisite resources and opportunities to carry out certain behaviour. Chang (1998) reported that the perception of volitional control or perceived difficulty towards completion of an act will affect an individual's intent as well as the successful performance of that behaviour. His findings also showed that perceived behavioural control significantly influenced *intention*. Control over a source of water and its potential application(s) has not been tested within the context of perceptions towards wastewater reuse for non-potable water requirements in South Africa. Thus, the following hypothesis was formulated:

> H4: Respondents' *perceived control* over the source of water and its application has a positive effect on *intention* to accept wastewater reuse for non-potable water requirements.

***Subjective norms*:** The term *subjective norms* is closely related to social pressure. It measures the perception of how important people in the life of respondents would approve or disapprove of their performing a particular behaviour. Subjective norms have been found to affect knowledge sharing intentions among groups (Ruy *et al* 2003) and among senior managers (Lin & Lee 2004). Fielding *et al* (2009) and Po *et al* (2005) also reported that subjective norms significantly affected *intention* to accept recycled water. In this study, subjective norms about recycled water refers to how social pressure affects the *intention* of respondents to accept recycled water for non-potable water requirements. Hence, the following hypothesis:

> H5: Higher *subjective norms* associated with wastewater reuse for non-potable water requirements have a positive effect on respondents' *intention* to accept wastewater reuse.

***Aesthetic appearance*:** Hurlimann and McKay (2007) found out that the colour of recycled water was the most important attribute for consumers to accept recycled water for washing clothes. The following hypothesis was therefore formulated:

> H6: The *aesthetically pleasing appearance* of recycled wastewater will have a positive effect on respondents' *intention* to accept wastewater reuse for non-potable water requirements.

Table 1 summarises the hypotheses explained above.

RESEARCH METHODOLOGY

Questionnaire structure

Two questionnaires were developed and administered to a random sample of potential non-domestic (i.e. agricultural, commercial, educational and parks) and domestic non-potable water consumers. Non-domestic respondents were individuals representing their various institutions, while domestic respondents were representatives of various households. The questionnaire was subdivided into three parts: introduction, perceptions and respondents' personal data (domestic respondents only). The introductory part of the questionnaire clearly stated the aims of the project, which was to determine perceptions on the use of treated wastewater for non-potable purposes and the willingness to use dual water distribution systems. A concise definition of non-potable water was provided. The second section comprised statements (developed to test hypotheses H1–H6) aimed at measuring respondents' positive or negative perceptions towards wastewater reuse. Justifications for the statements used

in this section are provided below. The last section of the domestic questionnaire consisted of questions requiring demographic information such as gender, age, racial group, marital status, and academic qualification. Type of house and approximate monthly income data were requested from only domestic respondents.

Justification for the statements used to measure each construct

***Advantages of reuse (ADV)*:** The sentences below attempt to determine respondents' *knowledge of the advantages of wastewater reuse* and how this knowledge influences *intention* to accept reuse for non-potable water requirements:

i. ADV1 – *"The use of non-drinking water will reduce the amount of wastewater discharged to the environment"*: Treated wastewater is typically discharged into the environment (especially surface waters). By reusing treated wastewater therefore, the total volume of wastewater discharged into the environment is reduced.
ii. ADV2 – *"Non-drinking water use will reduce the depletion of groundwater and surface water resources"*: With increased wastewater reuse for non-potable water requirements, less fresh water is likely to be extracted from surface and ground waters. A reduction in the extraction of ground waters will reduce saline water intrusion in coastal areas, while a reduction in the extraction of surface waters will assist to maintain minimum environmental flows and mitigate negative and often irreversible ecosystem changes.
iii. ADV3 – "*The use of non-drinking water can save many South African communities from drought"*: The supply of treated wastewater for non-potable water requirements will mitigate the negative effects of a drought.
iv. ADV4 – "*There can be considerable savings of fertiliser on farms irrigated with recycled wastewater*": Nutrients in wastewater, such as nitrogen and phosphorus, nourish irrigated soil and consequently provide nourishment for plants, and therefore can readily replace organic fertilisers. Reuse should not be contemplated where plants or crops to be irrigated have not been proven to be tolerant to the salts in the effluent, and there is no risk of salts from the effluent resulting in the deterioration of ground/surface water quality.

***Trust in implementing authorities (TRU)*:** A respondent's *trust* in the provider of reclaimed water is measured by their responses to the statements below. The higher the level of *trust*, the more likely they will accept wastewater reuse. These statements assess *trust* in relation to the quality of the product or service rendered by the provider as perceived by the respondent. The statements include:

i. an overall statement TRU1 – *"This institution (I) will use non-drinking water if the quality can be proven to be satisfactory"*; and the following specific statements related to:
ii. disgust due to odour, colour, and suspended solids, TRU2 – "*This institution (I) will use non-drinking water if it is not disgusting or irritating"*;
iii. cloth-staining potential for domestic respondents, TRU3 – *"This institution (I) will use non-drinking water if it does not stain washing"* ; and
iv. public health and safety, TRU4 – *"This institution (I) trusts the municipality to provide non-drinking water that is safe and does not constitute a health risk."*

If reuse is implemented, reuse regulation and/or certification (such as the Green Drop Certification (DWAF 2009)) will likely improve respondents' *trust* in a service provider.

***Attitude (ATT)*:** The statements below attempt to assess a respondent's *attitude* towards wastewater reuse in the following ways:

i. The respondent's social obligation towards water which is a renewable, albeit finite and often abused resource, ATT1 – "*This institution is (I feel personally) obligated to do whatever I can to save water,*" and ATT2 – "*Water is a valuable resource that should be recycled."*
ii. The respondent's choice/preference with regard to wastewater reuse, ATT3 – "*This institution/I would prefer not to use non-drinking water,*" ATT4 – "*This institution/I would not use non-drinking water even in times of water shortages,*" and ATT5 (for non-domestic respondents) – "*This institution would only be prepared to use non-drinking water in times of water shortages.*"
iii. The respondent's willingness to be part of the solution and not easily apportion blame to government, ATT5 (for domestic respondents and ATT6 for non-domestic respondents) – "*The government is responsible for water shortages."*

***Control over source of water (CON)*:** The sentences below assess how acceptance of reuse is influenced by a respondent's *perceived control* over how water/wastewater is used/reused and how wastewater irrigated products are presented. The higher the *perceived control*, the more likely reuse will be accepted.

i. CON1 (for non-domestic respondents only) – *"Every household should be free to choose its source of water supply (e.g. groundwater, surface water and recycled wastewater)."*
ii. CON1 (for domestic respondents) – *"I have the right to know if fruits or vegetables are irrigated with recycled wastewater."*
iii. CON2 – "*Fruits and vegetables irrigated with non-drinking water (e.g. recycled wastewater) should be labelled in the supermarket."*
iv. CON3 (for domestic respondents) – *"I have the right to adequate drinking water supply."*

***Subjective norms (SNO)*:** The influence of others on a respondent's acceptance of wastewater reuse is measured by the following statements:

i. SNO1 – "*This institution (I) will use non-drinking water if other institutions (others) are using it."*
ii. SNO2 – "*Most institutions (people) who are close to our institution (me) will support the use of non-drinking water."*
iii. SNO3 (for domestic respondents only) – *"Non-drinking water use is an option for the poor or the rich?"* measures if respondents perceive that reuse is for a certain class of people.

***Physical quality satisfaction*:** Satisfaction with the *physical quality* of the reclaimed wastewater is most often the first determinant of a respondent's willingness to accept reuse. These statements address this construct:

i. PQS1 – "*This institution (I) will use non-drinking water if it is absolutely clear,*" and
ii. PQS2 – "*This institution (I) will use non-drinking water if it is colourless."*

Identification of potential non-domestic and domestic respondents

Two arid inland municipalities (Capricorn and Vhembe in the Province of Limpopo) were identified as suitable locations in South Africa to generate the data needed for the study. Limpopo is a water scarce province of South Africa while Capricorn and Vhembe contribute to South Africa's agricultural production in the areas of field crops (e.g. cereals and oil seeds) and horticultural crops (e.g. potatoes, vegetables, citrus and deciduous). Wastewater reuse has therefore been proposed to many of the agricultural holdings within these two municipalities, as it shows promise of reducing the current dependence on fresh water for most activities, and reducing the total bill paid monthly on drinking water. Of the total water requirement within the area, agriculture was estimated to use about 85%. In terms of households, there were 1 243 167 people

Table 2 Questionnaire responses in Capricorn and Vhembe, Limpopo Province

Potential consumers	Questionnaires administered	Questionnaires returned
Non-domestic	100	72 (72%)
Agricultural holdings	20	1
Commerce	20	17
Education (e.g. schools playgrounds /sport fields)	50	47
Public parks	10	7
Domestic	150	123 (83%)

living in 285 565 households in Capricorn in 2007, while Vhembe houses 1 240 035 people in 287 190 households (Statistics South Africa 2008). Use of recycled wastewater for some household non-potable water requirements such as toilet flushing, is also promising when considering the arid climate within the municipalities.

Sampling and data collection

Potential non-domestic respondents within agricultural holdings, commerce, education and public parks were randomly approached to participate in this exercise, and several (especially within agricultural holdings) declined to participate. This may have been due to the fear that if the public knew they were willing or remotely considering wastewater reuse, the sale of their products may suffer. In contrast, however, the questionnaire response rate from a random sample of potential domestic consumers was higher (83% in comparison to 72% for non-domestic respondents). Table 2 summarises the questionnaires administered and returned.

The questionnaires were physically administered to respondents, i.e. participants were individually approached and encouraged to participate in the survey. Participation was voluntary. The demographics for potential domestic respondents were 52 males and 71 females aged 18 to 65 years, with a mean age of 25.2 years (SD = 7.2). The majority of respondents were black (99%). In terms of marital status, 60.1% were single, 12.2% were married, 25.2 % were married with children and the remaining 1.6% were divorced or widowed. Most of the participants (69.5%) lived in Reconstruction and Development Programme houses, 19.8% in other houses, 4.9% in apartments, 4.1% in traditional houses and 1.7% in informal settlements. Household numbers varied from 2 to 10, with an average of 6 (SD = 5.2).

Measurement validation and analysis

As depicted in Figure 1, this study measured six constructs: *attitudes, subjective norms, perceived control over the source of water and its application, physical quality satisfaction, knowledge of the advantages of reuse* and *trust in the service provider*. The respondents were requested to rate how much they agreed or disagreed with each statement on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree).

Since the constructs were measured using multiple statements, it was necessary that the different statements used to assess the same construct should correlate with one another and exhibit high internal consistencies. This was achieved by determining the Cronbach's alpha (α) value (which varies from 0 to 1.0) amongst multiple statements measuring a construct. It is generally accepted that a Cronbach's alpha value above 0.70 is an indication of good internal consistency between items (Vicente & Reis 2008).

The analysis of the correlation between statements and their respective constructs was performed using SEM software called AMOS^{TM} 6.0. The basis for the SEM approach is that the existence of a causal relationship between two variables does not imply the existence of a correlation between them (Iriondo *et al* 2003). Hence, AMOS^{TM} 6.0 allows multiple relationships to be analysed simultaneously while maintaining statistical efficiency. AMOS^{TM} 6.0 uses the maximum likelihood (ML) method to estimate parameters. SEM in its general form consists of a measurement model and a structural equation model. The measurement model specifies the relationship between statements and constructs, while the structural equation model specifies the relationships between constructs, describes their effects (either negative or positive) and assigns the explained and unexplained variance. The SEM therefore simultaneously estimates and tests a series of hypothesised inter-related relationships between a set of constructs, each measured by one or more statements. *Intention* to accept wastewater reuse for non-potable water requirements was measured as a second order construct, and thus predicted using the six constructs (e.g. trust, attitudes and control) in the hypothesised model shown in Figure 1.

SEM has been used in diverse subject areas to confirm or disprove hypothesised models, e.g. to determine the properties of the latent factors underlying adolescent quality of life (Meuleners *et al* 2003); to test the prediction that overeating has a positive correlation with Body Mass Index (Davis *et al* 2006); to study the factors that condition reproductive success, seed emergence and plantlet survival in several plant species (Iriondo *et al* 2003); to identify travellers' attitudes, travel behaviour, and the causal relationships between a traveller's socioeconomic profile and his/her attitude towards travel (Shiftan *et al* 2008); to validate a data envelopment analysis (DEA) in the management of restaurants' menus (Reynolds & Taylor 2011); to identify factors affecting willingness to participate in electronic waste recycling (Nnorom *et al* 2009); to explore the relationship between road traffic noise and health (Fyhri & Klaeboe 2009); and to assess satisfaction with recycled water (Hurlimann *et al* 2008).

As shown in Table 2, 123 and 72 questionnaires were returned from various domestic and non-domestic respondents respectively. Although the use of SEM typically requires a sample size of between 200 and 400, smaller sample sizes have been analysed, e.g. Kahlor *et al* (2011 – 43 participants), Vissman *et al* (2011 – 25 participants), Bayer *et al* (2010 – 81 participants), Chan *et al* (2010 – 124 participants) and Sutherland (2010 – 23 participants). Thus, SEM was employed in the analysis of the returned questionnaires.

A two-step approach recommended by Anderson and Gerbing (1992) was adopted to evaluate whether the hypothesised model fitted the data. The first step involved a confirmatory factor analysis to estimate the measurement component of the constructs (Figure 1) in order to identify items of the same construct with high internal consistency. If the psychometric properties of the structure were deemed acceptable, the analysis proceeded to the second step, which involved the combination of the theoretical and measurement model (Huchting *et al* 2008).

RESULTS AND DISCUSSION

For potential non-domestic respondents, 20 statements in the questionnaire measuring the six constructs were subjected to item-to-total correlation and exploratory factor analysis. The item-to-total correlation is a correlation between a statement score and the sum of the remaining statements that form the scale. The test is performed to check whether any statement is inconsistent with the remaining statements. Once the number of correlated statements is determined,

exploratory factor analysis is performed to determine their factor loadings. Factor loadings are the correlation coefficients between the statements and the constructs. Factor loadings greater than 0.71 are typically regarded as excellent while less than 0.34 are regarded as very poor (Yongminga *et al* 2006). Four of the 20 statements with factor loadings of less than 0.34 (statements used to measure the *subjective norms* and *physical quality satisfaction* constructs) were excluded from subsequent analysis. Details of factor loadings for each statement are shown in Appendix 1. The retained 16 statements, which are grouped according to their respective constructs (Appendix 1), explained 81.32% of the variance of the *intention* to accept wastewater reuse (Table 4) and were therefore reliable for further analysis.

For potential domestic respondents, 20 statements measuring the six constructs were subjected to item-to-total correlation and exploratory factor analysis. Two statements measuring the *physical quality satisfaction* construct generated a factor loading of less than 0.34 and were excluded from subsequent analysis. The retained 18 statements, which are grouped according to their respective constructs (Appendix 2), explained 87.02% of the variance of the *intention* to accept wastewater reuse (Table 5) and were therefore reliable for further analysis. For these respondents, the details of factor loadings for each statement are shown in Appendix 2.

Following the exclusion of statements with factor loadings less than 0.34, good fits were obtained for both domestic and non-domestic respondents (Table 3).

Table 4 shows the composite reliabilities (i.e. Cronbach's alpha, α) and average variances extracted for the statements administered to potential non-domestic respondents. As earlier indicated, the composite reliabilities for PQS and SNO were below the threshold value of 0.70, and therefore only ADV, TRU, ATT and CON were employed in further analysis.

Table 5 shows the α and average variances extracted for the statements administered to potential domestic respondents. The composite reliability and variance for PQS was below the threshold value of 0.70 and therefore excluded in the further analysis.

Figure 2 shows a simplified schematic of standardised path coefficients, β, of the hypothesised model for potential non-domestic respondents comprising four constructs. As reported by Fielding *et al* (2009) and Po *et al* (2005), a strong contribution is represented by β values greater than 0.40, moderate contribution ranges from 0.20 to 0.40, and a weak contribution represents values below 0.20. All the paths specified were statistically significant with *p-values* less than 0.01. *Advantages of reuse* (β = 0.39) and *trust in service provider* (β = 0.21) were found to have a moderate contribution to respondents' *intention* to accept wastewater reuse. These constructs therefore moderately support hypotheses H1 and H2 respectively. *Attitude* (β = 0.60) and *control* (β = 0.59) have a strong contribution to respondents' *intention* to accept wastewater reuse, and therefore strongly supported hypotheses H3 and H4. Hypothesis H6 could not be tested because a reliable measure of *physical quality satisfaction* was not obtained. The same applied to Hypothesis H5 for *subjective norms*.

Figure 3 shows the schematic of the hypothesised model for potential domestic respondents comprising five constructs. All the paths specified were statistically significant with *p-values* less than 0.01. *Advantages of reuse* (β = 0.62), *trust in authority* (β = 0.44), *attitude* (β = 0.44) and *control* (β = 0.55) had strong contributions to respondents' *intention* to accept wastewater reuse. These constructs therefore strongly support hypotheses H1, H2, H3 and H4. *Subjective norms* (β = 0.33) had a moderate contribution to respondents' *intention* to accept wastewater reuse and therefore moderately support hypothesis H5.

Table 3 Goodness of fit for revised model

Fit index	Recommended value (Arbuckle 2005)	Non-domestic respondents	Domestic respondents
		Structural model	Structural model
$\frac{x^2}{df}$	≤ 3.00	2.60	2.30
AGFI	≥ 0.80	0.84	0.83
NFI	≥ 0.90	0.91	0.93
GFI	≥ 0.90	0.92	0.91
CFI	≥ 0.90	0.90	0.94
IFI	≥ 0.90	0.90	0.92
TLI	≥ 0.90	0.92	0.90
RMSEA	≤ 0.10	0.08	0.06

Table 4 Reliabilities and average variances extracted for potential non-domestic respondents

Constructs	No of items	Composite reliability (α)	Recommended value (Vicente & Reis 2008)	Average variance extracted (%)
Advantages of Reuse (ADV)	4	0.81	> 0.70	78
Trust (TRU)	4	0.82		80
Attitude (ATT)	6	0.78		86
Control over source of water (CON)	2	0.90		71
Physical quality satisfaction(PQS)	2	0.31		35*
Subjective norm (SNO)	2	0.42		48*
Intention to accept		0.85		81

* Constructs excluded from the computation of the average variance of the *intention* to accept wastewater reuse

Table 5 Reliabilities and average variances extracted for potential domestic respondents

Constructs	No of items	Composite reliability (α)	Recommended value (Vicente and Reis 2008)	Average variance extracted (%)
Advantages of reuse (ADV)	3	0.82	> 0.70	85
Trust (TRU)	4	0.73		77
Attitude (ATT)	5	0.68		84
Control over source of water (CON)	3	0.81		71
Physical quality satisfaction(PQS)	2	0.43		46*
Subjective norm (SNO)	3	0.85		75
Intention to accept		0.80		87

* Constructs excluded from the computation of the average variance for the *intention* to accept wastewater reuse

Hypothesis H6 could not be tested because a reliable measure of *physical quality satisfaction* was not obtained.

Implication of the results on planned wastewater reuse and future research

i. In order of significance, the constructs that influenced the *intention* to accept wastewater reuse amongst the surveyed non-domestic consumers were their *attitude towards wastewater reuse*, the degree of *control over the source of water and its application* within their institution, the *knowledge of the advantages of reuse* and *trust in the service provider*. The influence of *physical quality satisfaction* could not be assessed because a reliable scale was not formed. The same applied to *subjective norms*. For *subjective norms*, this may be due to the fact that different institutions use water for different end uses, and hence the use of wastewater for a specific purpose in one institution would likely have a limited effect, if any, on another institution choosing to or not to reuse wastewater for a different end use. From the results of the item-to-total correlation and exploratory factor analysis, the two statements which measured *physical quality satisfaction* were either inconsistent with each other, uncorrelated to the construct they were to measure, or both. In future research in this regard, the use of more than two statements to measure each construct may result in a more reliable scale.

ii. For the domestic respondents surveyed, the constructs (in order of significance) that influenced *intention* to accept wastewater reuse were their *knowledge of the advantages of reuse*, the degree of *control over the source of water and its application*, *attitude towards wastewater reuse*, *trust in the service provider* and the *subjective norms* of the respondents. Similar to the results obtained for non-domestic respondents, the influence of *physical quality satisfaction* could not be assessed, because a reliable scale measuring this construct did not emerge. Future research with effective measurement of this construct is required, because households are typically concerned about the physical appearance of the reclaimed wastewater. Hence, similar to the argument above for non-domestic respondents, the two statements which measured *physical quality satisfaction* were likely either inconsistent with each other, uncorrelated to the construct they were to measure, or both.

iii. A limitation of this study was the small size of surveyed agricultural sector respondents – a very important potential user of treated wastewater. This limitation impacts negatively on the application of the results obtained above to agricultural holdings in the surveyed area, and hence future research which surveys a larger number of agricultural respondents is recommended.

iv. For a holistic assessment of respondents' intention to accept reuse in locations contemplating wastewater reuse, it would be valuable to also survey and understand the religious and cultural perspectives of respondents (similar to the Wilson and Pfaff study (2008) conducted in Durban, South Africa.)

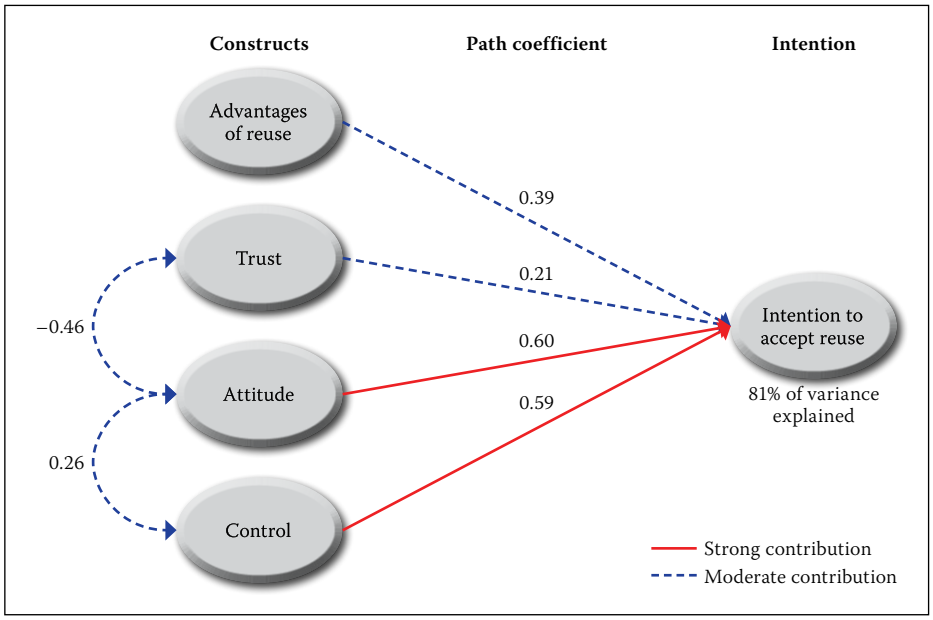

Figure 2 Simplified path coefficient of potential non-domestic respondents' perceptions in Capricorn and Vhembe, Limpopo Province

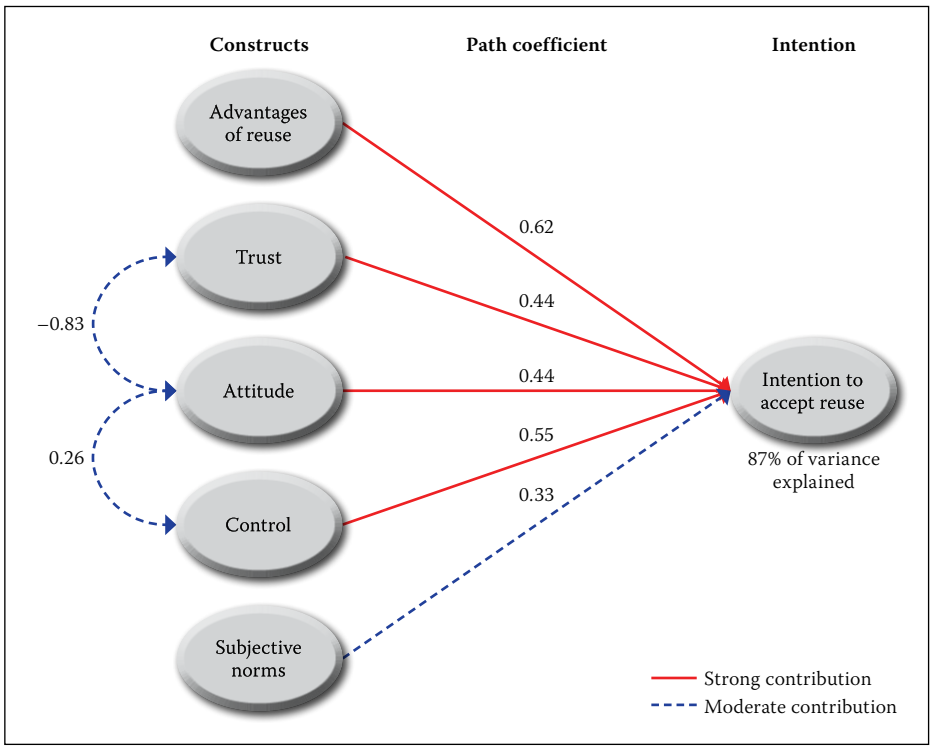

Figure 3 Simplified path coefficient of potential domestic respondents' perceptions in Capricorn and Vhembe, Limpopo Province

CONCLUSIONS

This paper presented a hypothesised model (adapted from Po *et al* 2005) which was used to predict *intention* to accept wastewater reuse for non-potable purposes amongst potential domestic and non-domestic consumers in two South African communities in the Limpopo Province. For the potential non-domestic consumers surveyed, *intention* to accept wastewater reuse was influenced by *attitude towards wastewater reuse*, the degree of *control over the source of water and its application*, the *knowledge of the advantages of reuse* and *trust in the service provider*. In order of significance for potential

domestic consumers surveyed, *knowledge of the advantages of reuse*, the degree of *control over the source of water and its application*, *attitude towards wastewater reuse*, *trust in the service provider* and the *subjective norms* of the respondents emerged as influences on the *intention* to accept wastewater reuse. Addressing these constructs would be valuable in determining whether wastewater reuse planning/implementation should proceed. Research to further interrogate this subject and the results presented herein was recommended in the previous section.

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REFERENCES

Adewumi, J R, Ilemobade, A A & Van Zyl, JE 2010. Treated wastewater reuse in South Africa: Overview, potential and challenges. *Resources, Conservation & Recycling,* 55 (2): 221–231.

Ajzen, I 1985. From intentions to actions: A theory of planned behaviour. In Kuhl, J and Beckmann, J (Eds), *Action Control: From Cognition to Behaviour*, Berlin: Springer, pp 11–39.

Anderson, J C & Gerbing, D W 1992. Assumptions and comparative strengths of the two-step approach. *Sociological Methods and Research*, 20: 321–333.

Angelakis, A N & Bontoux, L 2001. Wastewater reclamation in European countries. *Water Policy*, 3: 47–59.

Arbuckle, J L 2005. Amos™ 6.0 user's guide. Spring House, PA, USA.

Bayer, U C, Gollwitzer, P M & Achtziger, A 2010. Staying on track: Planned goal striving is protected from disruptive internal states. *Journal of Experimental Social Psychology*, 46: 505–514.

Bock, GW & Kim, YG 2002. Breaking the myths of rewards: An explanatory study of attitudes about knowledge sharing. *Information Resource Management Journal*, 15(2): 14–21.

Chan, D C N, Wu, A M S & Hung, E P W 2010. Invulnerability and the intention to drink and drive: An application of the theory of planned behaviour. *Accident Analysis and Prevention*, 42: 1549–1555.

Chang, M K 1998. Predicting unethical behaviour: A comparison of the theory of reasoned action and the theory of planned behaviour. *Journal of Business Ethics,* 17(12): 65–95.

Davis, C, Levitan, R D, Smith, M, Tweed, S & Curtis, C 2006. Associations among overeating, overweight, and attention deficit/hyperactivity disorder: A structural equation modelling approach. *Eating Behaviors,* 7: 266–274.

DWAF (Department of Water Affairs and Forestry) 2007. Overview of water resources availability and utilization in South Africa (author: Basson, M S), Pretoria: DWAF.

DWAF (Department of Water Affairs and Forestry) 2009. Green Drop Report. South African waste water quality management performance. Version 1. Available at: http://www.dwaf.gov.za/Documents/GreenDropReport2009_ver1_web.pdf

Eiser, R, Miles, S & Frewer, L J 2002. Trust, perceived risk and attitudes towards food technologies. *Journal of Applied Social Psychology,* 32(12): 2423–2433.

Fielding, K S, Price, J & Leviston, Z 2009. Community perceptions and acceptance of the indirect potable recycling scheme in South East Queensland. *Proceedings.* 7th IWA World Congress on Water Reclamation and Reuse, Brisbane, Australia, 20–25 September.

Friedler, E, Lahav, E, Jizhaki, H & Lahav, T 2006. Study of urban population attitudes towards various wastewater reuse options: Israel as a case study. *Journal of Environmental Management,* 81: 360–370.

Fyhri, A & Klaeboe, R 2009. Road traffic noise, sensitivity, annoyance and self-reported health – a structural equation model exercise. *Environment International,* 35: 91–97.

Huchting, K, Lac, A & Labrie, J W 2008. An application of the theory of planned behaviour to sorority alcohol consumption. *Addictive Behaviours,* 33: 538–351.

Hurlimann, A, Hemphill, E, McKay, J & Geursen, G 2008. Establishing components of community satisfaction with recycled water use through a structural equation model. *Journal of Environmental Management,* 88: 1221–1232.

Hurlimann, A & McKay, J 2007. Urban Australia using recycled water for domestic non-potable use – An evaluation of the attributes price, saltiness, colour and odour using conjoint analysis. *Journal of Environmental Management,* 83: 93–104.

Iriondo, J M, Albert, M J & Escudero, A 2003. Structural equation modelling: An alternative for assessing causal relationships in threatened plant populations. *Biological Conservation,* 113: 367–377.

Joksimovic, D 2006. Decision support system for planning of integrated water reuse project. PhD Thesis, University of Exeter, UK.

Kahlor, L, Mackert, M, Junker, D & Tyler, D 2011. Ensuring children eat a healthy diet: A theory-driven focus group study to inform communication aimed at parents. *Journal of Paediatric Nursing,* 26: 13–24.

Lin, H H & Lee, G G 2004. Perceptions of senior managers towards knowledge-sharing behaviour. *Journal of Management Decision,* 42(1): 108–25.

Lin, H H & Wang, Y S 2006. An examination of the determination of customer loyalty in mobile commerce contexts. *Information and Management,* 43: 271–282.

Meuleners, L B, Lee, A H, Binns, C W & Lower, A 2003. Quality of life for adolescents: Assessing measurement properties using structural equation modelling. *Quality of Life Research,* 12: 283–290.

Nancarrow, B E, Leviston, Z & Po, M 2008. What drives communities' decisions and behaviours in the reuse of wastewater. *Water Science and Technology,* 57(4): 485–491.

Nancarrow, B E, Leviston, Z & Tucker, DI 2009. Measuring the predictors of communities' behavioural decisions for potable reuse of wastewater. *Water Science and Technology,* 60(12): 3199–3209.

Nancarrow, B E, Porter, N B & Leviston, Z 2010. Predicting community acceptability of alternative urban water supply systems: A decision making model. *Urban Water Journal,* 7(3): 197–210.

Nnorom, I C, Ohakwe, O & Osibanjo, O 2009. Survey of willingness of residents to participate in electronic waste recycling in Nigeria. *Journal of Cleaner Production,* 17(18): 1629–1637.

Okun, D A 2002. Water reuse introduces the need to integrate both water supply and wastewater management at local regulatory levels. *Water Science and Technology*, 46(6–7): 273–280.

Po, M, Kaercher, J & Nancarrow, B E 2004. Literature review of factors influencing public perceptions of water reuse. Melbourne: CSIRO Land and Water.

Po, M, Nancarrow, B E, Leviston Z, Porter, N B, Syme, G J & Kaercher, J D 2005. Predicting community behaviour in relation to wastewater reuse: What drives decisions to accept or reject? Water for a Healthy Country National Research Flagship. Perth: CSIRO Land and Water.

Reynolds, D & Taylor, J 2011. Validating a DEA-based menu analysis model using structural equation modelling. *International Journal of Hospitality Management,* 30: 582–587.

Ruy, S, Ho, S H & Han, I 2003. Knowledge sharing behaviour of physicians in hospitals. *Expert Systems with Applications,* 25(1): 13–22.

Shiftan, Y, Outwater, M L & Zhou, Y 2008. Transit market research using structural equation modelling and attitudinal market segmentation. *Transport Policy*, 15: 186–195.

Statistics South Africa (SSA) 2008. Community Survey 2007: Statistical Release Basic Results: Municipalities. Pretoria: SSA.

Sutherland, L A 2010. Environmental grants and regulations in strategic farm business decision-making: A case of attitudinal behaviour in Scotland. *Land Use Policy*, 27: 415–423.

Taylor, S & Todd, P 1995. An integrated model of waste management behaviour: A test of household recycling and composting intentions. *Environment and Behaviour,* 27(5): 603–630.

Vicente, P & Reis, E 2008. Factors influencing households' participation in recycling. *Waste Management and Research,* 26: 140–146.

Vissman, A T, Hergenrather, K C, Rojas, G, Langfdon, S E, Wilkin, A M & Rhodes, S D 2011. Applying the theory of planned behaviour to explore HAART adherence among HIV-positive immigrant Latinos: Elicitation interview results. *Patient Education Counselling,* doi:10.1016/j.pec.2010.12.004.

Wilson, Z & Pfaff, B 2008. Religious, philosophical and environmentalist perspectives on potable wastewater reuse in Durban, South Africa. *Desalination,* 228: 1–9.

Yongminga, H, Peixuana, D, Junji, C & Posmentier, E S 2006. Multivariate analysis of heavy metal contamination in urban dusts of Xi'an, Central China. *Science of the Total Environment*, 355: 176–186.

Appendix 1 Factor loadings and internal consistency of statements for potential non-domestic respondents' questionnaire

Construct	Statement	Factor loading	Composite reliability, α
Advantages of reuse	1. The use of non-drinking water will reduce the amount of wastewater discharged to the environment, ADV1	0.80	0.81
	2. Non-drinking water use will reduce the depletion of groundwater and surface water resources, ADV2	0.60	
	3. The use of non-drinking water can save many South African communities from drought, ADV3	0.82	
	4. There can be considerable savings of fertiliser on farms irrigated with recycled wastewater, ADV4	0.53	
Trust in implementing authorities	1. This institution will use non-drinking water if the quality can be proven to be satisfactory, TRU1	0.57	0.82
	2. This institution will use non-drinking water if it is not disgusting or irritating, TRU2	0.69	
	3. This institution will use non-drinking water if it does not stain or cause corrosion, TRU3	0.81	
	4. This institution trusts the municipality to provide non-drinking water that is safe and does not constitute a health risk, TRU4	0.83	
Attitude	1. This institution is obligated to do whatever it can to save water, ATT1	0.57	0.78
	2. Water is a valuable resource that should be recycled, ATT2	0.52	
	3. This institution would prefer not to use non-drinking water, ATT3	0.70	
	4. This institution would never use non-drinking water, even in times of shortages, ATT4	0.61	
	5. This institution would only be prepared to use non-drinking water in times of water shortages, ATT5	0.58	
	6. The government is responsible for water shortages, ATT6	0.54	
Control over source of water	1. Every household should be free to choose their source of water supply (e.g. groundwater, surface water, recycled wastewater, etc), CON1	0.43	0.90
	2. Fruits and vegetables irrigated with non-drinking water (e.g. recycled wastewater) should be labelled in the supermarket, CON2	0.51	
Subjective norms	1. This institution will use non-drinking water if other institutions are using it, SNO1	0.22*	0.42
	2. Most institutions who are close to our institution will support the use of non-drinking water, SNO2	0.30*	
Physical quality satisfaction	1. This institution will use non-drinking water if it is absolutely clear, PQS1	0.15*	0.31
	2. This institution will use non-drinking water if it is colourless, PQS2	0.31*	

* Items excluded from further analysis

Appendix 2 Factor loadings and internal consistency of statements for potential domestic respondents' questionnaire

Construct	Statement	Factor loading	Composite reliability, α
Advantages of reuse	1. The use of non-drinking water will reduce the amount of wastewater discharged to the environment, ADV1	0.94	0.82
	2. Non-drinking water will reduce the depletion of groundwater and surface water resources, ADV2	0.81	
	3. The use of non-drinking water can save many South African communities from drought, ADV3	0.78	
Trust in implementing authorities	1. I will use non-drinking water if the quality can be proven to be satisfactory, TRU1	0.70	0.73
	2. I will use non-drinking water if it is not disgusting or irritating, TRU2	0.98	
	3. I will use non-drinking water if it does not stain washing, TRU3	0.94	
	4. I trust the municipality to provide non-drinking water that is safe and does not constitute a health risk, TRU4	0.96	
Attitude	1. I feel personally obligated to do whatever I can to save water, ATT1	0.51	0.68
	2. Water is a valuable resource that should be recycled, ATT2	0.52	
	3. I would prefer not to use non-drinking water, ATT3	0.60	
	4. I would only be prepared to use non-drinking water in times of water shortages, ATT4	0.47	
	5. The government is responsible for water shortages, ATT5	0.41	
Control over source of water	1. I have the right to know if fruits or vegetables are irrigated with recycled wastewater, CON1	0.98	0.81
	2. Fruits and vegetables irrigated with non-drinking water (e.g. recycled wastewater) should be labelled in the supermarket, CON2	0.80	
	3. I have the right to adequate drinking water supply, CON3	0.39	
Subjective norms	1. I will use non-drinking water if others are using it, SNO1	0.67	0.85
	2. Most people who are close to me will support the use of non-drinking water, SNO2	0.94	
	3. Non-drinking water use is an option for the poor or the rich, SNO3	0.58	
Physical quality satisfaction	1. I will use non-drinking water if it is absolutely clear, PQS1	0.24*	0.43
	2. I will use non-drinking water if it is colourless, PQS2	0.21*	

* Items excluded from further analysis