

Property owners' uptake of stormwater source controls: A case study of a low-density upmarket residential estate in Pretoria, South Africa

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Abstract

An integrated approach to Water Sensitive Urban Design and Sustainable Drainage Systems requires community involvement. Mooikloof is a low-density upmarket residential estate with one-hectare properties and large detached houses, but with no stormwater infrastructure, offering a unique case study of uptake of source controls. Using the Theory of Planned Behaviour and an online survey, we examined property owners' current and intended uptake of rainwater harvesting, green roofing, permeable paving and retention ponds, and factors influencing uptake. Owners showed noticeable levels of uptake of certain controls, influenced foremost by positive attitudes and peer pressure with site hydrology also playing a role. Some owners may need assistance to implement certain controls, whereas others may need incentivising or behavioural nudging towards uptake. We conclude with recommendations for further research and the practical implementation of source controls on site or individual residential properties in similar contexts.

Keywords: water sensitive urban design; sustainable drainage systems; stormwater source controls; theory of planned behaviour; perceived behavioural control

Introduction

Water Sensitive Urban Design (WSUD) can be defined as “the integration of urban planning with the management, protection and conservation of the urban water cycle” (Sharma et al. 2016, 2). The objectives of WSUD include flood mitigation, water quality improvement, water conservation, and water-related environmental and recreational opportunities. Sustainable Drainage Systems (SuDS) is a component of WSUD focusing on stormwater management. SuDS, a term used in South Africa and the UK amongst other countries, is also known as Low Impact Development (LID) or Low Impact Urban Design and Development (LIUDD) in New Zealand and North America, or as Alternative Techniques (ATs) in France (*Techniques Alternatives* (TAs) in French), or as Best Management Practices (BMPs) in Sweden. The term BMPs has,

however, largely been replaced with Stormwater Control Measures (SCMs) (Fletcher et al. 2015). The terms ‘green infrastructure’ and ‘non-point source control’ are also used in the US. SuDS provides sustainable alternatives to the conventional rapid disposal of stormwater. The objectives of SuDS include managing stormwater runoff effectively, promoting amenity, and preserving biodiversity. SuDS have various options arranged in a treatment train, including source, local, and regional controls. Source or at-source controls manage stormwater on site or as close as possible to its source, and includes rainwater harvesting, green roofing, permeable paving, and soakaways (Armitage et al. 2014). Source controls are therefore associated with structural or non-structural small-scale best management practices to maintain pre-development hydrological conditions, minimise excessive runoff, and to use stormwater as a resource for sustainable development.

Stormwater source controls require community involvement for these to be implemented sustainably on site or on individual residential properties (Nancarrow, Porter and Leviston 2010). In fact, about half of runoff from urban areas comes from private properties (Brown et al. 2016). Yet, the implementation of these controls is arguably more of a social and institutional rather than a technological challenge (Armitage et al. 2014; Dobbie, Farrelly and Brown 2017), it being neither easy nor necessarily acceptable to communities (Donofrio et al. 2009). Moreover, cluster and higher-density residential settings are not always conducive for the wider scope of different controls. While uptake of rainwater harvesting has received attention in South African studies (Dobrowksy et al. 2014; Baiyegunhi 2015; Fisher-Jeffes et al. 2017), comparable studies of uptake of other source controls such as green roofing and permeable paving are more limited. More systematic theory-driven research is needed that focuses on actual and intended uptake of various source controls in feasible

settings, rather than research that focuses on hypothetical scenarios or settings in which the implementation of source controls is not as feasible (Mankad and Tapsuwan 2011).

Mooikloof is a low-density upmarket residential estate on the eastern edge of Pretoria, South Africa. It includes approximately 500 one-hectare properties of which approximately 400 were built-up with large detached houses at the time of this study. Mooikloof is unusual as it has no municipal stormwater infrastructure. It therefore offers a unique case study of uptake of source controls, considering that property owners must somehow manage or at least accommodate stormwater runoff. Owners have the space and economic means to do so, arguably more so than in most other residential settings where uptake is usually too low to determine the effect of independent variables. Despite the responsibility on owners to manage stormwater, neither the municipality nor estate management impose any regulations or requirements on them. Also, no water restrictions that may have influenced uptake of source controls were in place at the time of this study. Figures 1 and 2 show examples from Mooikloof of stormwater management on residential properties.

Figure 1. Example of a stormwater channel directing runoff from a street onto a residential property.



Figure 2. Example of a stormwater retention pond on a residential property.



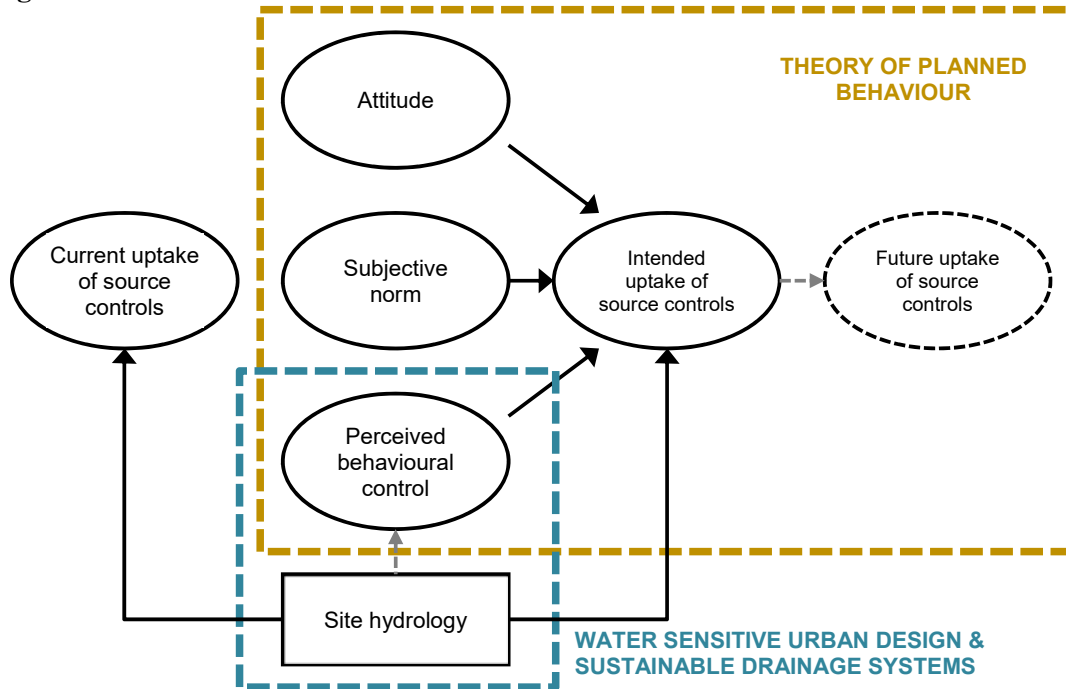
The aim of this article is to examine property owners' uptake of stormwater source controls, and the factors influencing uptake, to better understand the practical implementation of source controls on site or individual residential properties. Source controls included (1) rainwater harvesting, (2) green roofing, (3) permeable paving, and (4) retention ponds, as identified from the SuDS options in the WSUD framework and guidelines for South Africa (Armitage et al. 2014). Although 'retention ponds' is a regional rather than a source control in terms of the treatment train, it serves as a near-source control in this study as it is implemented on individual residential properties throughout the estate. We subsequently present the theoretical framework, research design and methods for the study, followed by the findings and conclusion. The article offers a conceptual and methodological framework for further research on property owners' uptake of stormwater source controls. Recommendations are therefore provided for further research, as well as the practical implementation of source control on site or on individual residential properties in settings lacking stormwater infrastructure.

Theoretical framework

Uptake of stormwater source controls is essentially about pro-environmental behaviour, and the Theory of Planned Behaviour (TPB) is well validated and widely used in the study of this behaviour (Chao 2012), especially household water conservation (Fielding et al. 2012). The TPB is basically a three-factor model of behaviour involving attitude, subjective norm, and perceived behavioural control. According to the TPB, if a person has a positive attitude towards a behaviour, such as harvesting rainwater, and feels both peer-pressured (subjective norm) and able (perceived behavioural control) to harvest rainwater, they are likely to form a strong intention and will probably do so in future (Ajzen 2011). The effect of attitude, norm, and behavioural control in household water conservation through rainwater harvesting is well-established (Parsons et al. 2010;

Ward et al. 2013; Mason, Arwood and Shires 2018). Behavioural control as influenced by financial incentives can be a strong predictor of household uptake of stormwater source controls (Brown et al. 2016). The TPB is therefore useful to study uptake of source controls as the construct of behavioural control can be used to better understand how property owners' ability to implement source controls is influenced by various practical considerations. Figure 3 shows how the TPB was applied to this study.

Figure 3. Theoretical framework.



Note: Adapted from Ajzen (2011).

We adapted the original TPB by differentiating between current and intended uptake of stormwater source controls. Thus, we first determined the proportion of owners currently using source controls, then, of those not currently using source controls, determined their attitude, norm, behavioural control, and intention to use these source controls in future. According to the TPB, background factors influence intention

indirectly by influencing behavioural control beliefs. Behavioural control beliefs therefore mediate the effect of background factors (Ajzen 2020).

In terms of background, we hypothesised that site hydrology may influence current and intended uptake directly and not via behavioural control beliefs. We hypothesised that: (1) the extent of roof coverage would influence rainwater harvesting and green roofing (i.e., the greater the proportion of roof coverage on the property, the more likely owners would consider rainwater harvesting or green roofing), and (2) the extent of stormwater runoff would influence permeable paving and stormwater retention ponds. These hypotheses have rarely, if ever, been examined in the literature, and as such these are exploratory hypotheses. While a consultation with a landscape architect from the University of Pretoria's Department of Architecture suggested the importance of assessing site hydrology before implementing stormwater source controls, we were interested whether site hydrology may also influence actual and intended uptake by property owners. A better understanding of the role of site hydrology may lead to a better understanding of how to practically implement source controls on site and on individual residential properties. Webster (2015) argues that urban planning requires a stronger knowledge base informed by theoretical models from the social sciences that help explain "constrained decision-making" by actors such as households. Uptake of source controls can be regarded as constrained decision-making considering that uptake is likely to be influenced by various factors, especially physical factors such as site hydrology and layout, as well as building design.

Research design and methods

We conducted an online survey amongst property owners in Mooikloof. First, we introduced the study and arranged access with the estate manager's office at the Mooikloof Owners' Association. After receiving inputs from the estate manager and the

consulted landscape architect regarding the context and site hydrology, we designed and programmed a questionnaire on Qualtrix. The questionnaire was piloted with stakeholders and two owners, after which it was finalised. The owners insisted that questions be minimised to maximise participation. The Research Ethics Committee of the University of Pretoria's Faculty of Engineering, Built Environment, and Information Technology granted ethical clearance (EBIT/61/2017). Clearance involved informed consent, voluntary participation by owners older than 18 years, and for responses to remain anonymous. No incentives were offered for participation.

The estate manager's office emailed a cover note, an informed consent tick box, and a link to the questionnaire to all property owners in their database, totalling approximately 400 recipients. Apart from informed consent, owners had to confirm that they were living on the property at the time of the survey, and were given two weeks to respond. Towards the end of the second week, owners were reminded and given another week to respond. A total of 73 owners responded ($N = 73$), yielding a response rate of approximately 18%, which is around the norm for online surveys (Andrews, Nonnecke and Preece 2003).

Data were exported to, cleaned, and analysed in IBM SPSS Statistics (Version 27). Considering the small sample, data analysis was limited to bivariate analyses for categorical data using the Chi-Square Likelihood Ratio (for tables meeting minimum expected frequencies) and the Fisher-Freeman-Halton Exact Test (for tables not meeting minimum expected frequencies). Effect sizes were calculated using Cramér's V (for nominal \times ordinal tables) and Gamma (for ordinal \times ordinal tables) ($\alpha = 0.05$).

Findings

We first explain how site hydrology and the TPB constructs were operationalised in the questionnaire. Thereafter we present findings in terms of current and intended uptake of

stormwater source controls, the association between site hydrology and current and intended uptake, and the association between attitude, norm, behavioural control and intended uptake. Table 1 shows site hydrology with corresponding questionnaire items.

Table 1. Site hydrology with corresponding questionnaire items.

Site hydrology	Questions	Answer categories
Proportion of roof coverage	<i>Please provide a rough breakdown (out of 100) of the proportion of coverage on your property of each of the following:</i>	Roof <i>Impermeable paving (i.e., paving through which water cannot seep)</i> <i>Permeable paving (i.e., paving through which water can seep)</i> <i>Swimming pool</i> <i>Lawn (i.e., short grass)</i> <i>Garden (i.e., area of the plot with plants for aesthetic value)</i> <i>Natural/indigenous vegetation</i> <i>Other (Please specify)</i>
Extent of stormwater runoff on property	<i>Does your property receive storm-water runoff from the streets?</i> <i>Does your property receive storm-water run-off from adjoining properties?</i>	<i>Yes, to the extent that it must be managed</i> <i>Yes, but not to the extent that it must be managed</i> <i>No</i> <i>Not sure</i>

As indicated earlier, site hydrology, including the extent of roof coverage and stormwater runoff, was hypothesised to influence uptake of source controls. Roof coverage was converted into a three-category ordinal variable with scores either below, within, or above the 95% confidence interval for the mean. Stormwater responses were consolidated into a single three-category ordinal variable with categories ‘Not sure/None that must be managed’, ‘From streets *or* adjoining properties’, and ‘From streets *and* adjoining properties’. Respondents were also asked about existing water-saving behaviour, i.e., if they used any of the following: constant flow regulators, smart metering, water-saving shower heads, dual flush toilets, eco-settings on appliances, and

Table 2. Stormwater source controls with corresponding Theory of Planned Behaviour constructs (continued next page).

Description of source control measure / Filter question	Attitude	Subjective norm	Perceived behavioural control	Intention
<p>‘Rainwater harvesting’ refers to the collection of rainwater from roofs into storage tanks. For example, JoJo Tanks. <i>Do you currently make use of rainwater harvesting on your property? Yes / No →</i></p>	<p><i>Harvesting rainwater on my property in the near future would be good for the environment. (A)</i></p>	<p><i>My family and friends would approve of me harvesting rainwater in the near future. (SN)</i></p>	<p><i>I have the <u>technical knowhow</u> or could find the technical knowhow to put up storage tanks in the near future. (PBC1)</i> <i>I have the <u>financial means</u>, or could find the financial means to put up storage tanks in the near future. (PBC2)</i></p>	<p><i>I will consider harvesting rainwater on my property within the next three years.</i></p>
<p>‘Green roofing’ refers to the growing of plants and vegetation on a roof. The vegetated surface typically retains some of the rainwater and provides temperature insulation. <i>Do you currently make use of green roofing on your property? Yes / No →</i></p>	<p><i>Putting up green roofing on my property in the near future would be good for the environment. (A)</i></p>	<p><i>My family and friends would approve of me putting up green roofing in the near future. (SN)</i></p>	<p><i>I have the <u>technical knowhow</u>, or could find the technical knowhow to put up green roofing in the near future. (PBC1)</i> <i>I have the <u>financial means</u>, or could find the financial means to put up green roofing in the near future. (PBC2)</i></p>	<p><i>I will consider putting up green roofing on my property within the next three years.</i></p>

Table 2. Stormwater source controls with corresponding Theory of Planned Behaviour constructs (continued from previous page).

Description of source control measure / Filter question	Attitude	Subjective norm	Perceived behavioural control	Intention
<p>‘Permeable paving’ refers to sustainable materials and techniques that allows water to seep through the paving into the ground. In addition to reducing run-off it also filters pollutants from the water. <i>Do you currently make use of permeable paving on your property? Yes / No →</i></p>	<p><i>Putting in permeable paving in the near future would be convenient for me. (A)</i></p>	<p><i>Most of the other owners in Mooikloof Equestrian Estate would consider putting in permeable paving in the near future. (SN)</i></p>	<p><i>I have the <u>technical knowhow</u>, or could find the technical knowhow to put in permeable paving in the near future. (PBC1)</i> <i>I have the <u>financial means</u>, or could find the financial means to put in permeable paving in the near future. (PBC2)</i></p>	<p><i>I will consider putting in permeable paving on my property within the next three years.</i></p>
<p>‘Stormwater retention ponds’ refers to landscaping at the lower end of a property that retains rainwater runoff either from the property itself, the street or adjacent properties. <i>Do you currently make use of a stormwater retention pond on your property? Yes / No →</i></p>	<p><i>Putting in a stormwater retention pond on my property in the near future would be good for the environment. (A)</i></p>	<p><i>My family and friends would approve of me putting in a stormwater retention pond in the near future. (SN)</i></p>	<p><i>I have the <u>technical knowhow</u>, or could find the technical knowhow to put in a stormwater retention pond in the near future. (PBC1)</i> <i>I have the <u>financial means</u>, or could find the financial means to put in a stormwater retention pond in the near future. (PBC2)</i></p>	<p><i>I will consider putting in a stormwater retention pond on my property within the next three years.</i></p>

timed sprinklers. Table 2 shows stormwater source controls with corresponding TPB constructs.

Table 2 first shows how each source control was defined for respondents, followed by the respective filter question that captured current uptake. Only respondents who answered ‘no’ to current uptake received the questions on attitude, norm, behavioural control, and intention. Each of the four TPB constructs were measured using the normative statements in Table 2 followed by five-point Likert scales ranging from ‘Disagree completely’, ‘Disagree’, ‘Neither agree nor disagree’, ‘Agree’, to ‘Agree completely’. Considering the small sample, each of these were collapsed into a three-category ordinal variable ranging from ‘Disagree (completely)’, ‘Neither agree nor disagree’, to ‘Agree (completely)’. Table 3 shows current and intended uptake of stormwater source controls.

Table 3. Current and intended uptake of stormwater source controls.

Source control measure	Current uptake of source control as a proportion of responses excluding missing cases (N = 64)		Intended uptake (‘Agree’ / ‘Strongly agree’) as a proportion of respondents not currently taking up source control	
	N	%	N	%
Rainwater harvesting	18	28.1	35	76.1
Green roofing	1	1.6	13	20.6
Permeable paving	28	43.8	7	19.4
Stormwater retention ponds	19	29.7	10	22.7

Table 3 shows noticeable levels of current uptake of permeable paving, and to a lesser extent retention ponds and rainwater harvesting. Despite the upmarket context, green roofing is negligible. Contrary to other studies highlighting the reinforcing nature of pro-environmental behaviour (see, e.g., Amodeo and Francis [2019]), existing water-saving behaviour (i.e., using constant flow-regulators, smart metering, eco-settings on appliances, etc.) had no positive effect on current uptake ($\gamma = -.124$; $p = 0.486$). More than half of those who did not harvest rainwater at the time of the survey, intended to do

so within the next three years. A noticeable proportion intended to take up green roofing, which is arguably the more challenging of the five to implement. Moreover, if a roof has not been constructed with green roofing in mind, future implementation is unlikely, and intention may therefore be inflated. Social sciences methodology indeed suggests that respondents tend to inflate pro-environmental behaviour, although this is usually in the presence of fieldworkers whereas the anonymous online survey may have helped to mitigate social desirability bias. Table 4 shows the association between site hydrology and current and intended uptake of stormwater source controls.

Table 4 shows that the strongest effects of site hydrology on current uptake involved the effect of stormwater runoff on retention ponds, followed by the effect of roof coverage on rainwater harvesting. The more stormwater runoff and roof coverage, the more likely owners used retention ponds and rainwater harvesting respectively. The proportion of roof coverage had some effect on green roofing, though this was statistically not significant, also bearing in mind the small number of responses for green roofing. Site hydrology therefore appeared to have little effect on green roofing and permeable paving, at least in terms of the conditions measured in this study.

A different picture emerged for intended uptake. The strongest positive effects of site hydrology involved the effect of roof coverage on green roofing and rainwater harvesting, even though the latter was not statistically significant. The more roof coverage, the more likely owners intended to use green roofing or harvest rainwater within the next three years. Stormwater runoff now appeared to have little meaningful effect on retention ponds, and less so on permeable paving. Roof coverage therefore appears to affect both current and intended uptake of rainwater harvesting and intended uptake of green roofing, while stormwater runoff appears to effect current uptake of retention ponds, but out of necessity, i.e., to avoid possible flooding or erosion on or

Table 4. Association between site hydrology and current and intended uptake of stormwater source controls.

Site hydrology by corresponding source control	Current uptake		Intended uptake	
	Chi-Square (Likelihood ratio) / Fisher-Freeman-Halton Exact Test	Cramér's <i>V</i> (Approximate sig.)	Fisher-Freeman-Halton Exact Test	Gamma (Approximate sig.)
Proportion of roof coverage × Rainwater harvesting	$\chi^2 (2, 64) = 5.757, p = 0.059^*$	.307; $p = 0.049^{**}$	N = 46; $p = 0.690$	.423; $p = 0.121$
Proportion of roof coverage × Green roofing	N = 64; $p = 0.203$	.250; $p = 0.136$	N = 63; $p = 0.037^{**}$	.530; $p = 0.003^{***}$
Extent of stormwater runoff × Permeable paving	N = 64; $p = 0.927$	.068; $p = 0.862$	N = 36; $p = 0.836$	.058; $p = 0.840$
Extent of stormwater runoff × Stormwater retention ponds	N = 64; $p = 0.001^{***}$	.450; $p = 0.002^{***}$	N = 44; $p = 1.000$	.182; $p = 0.536$

Note: Significant at the *0.1, **0.05, and ***0.01 levels respectively.

downstream from the property. Owners currently without retention ponds are unlikely to consider these irrespective of the extent of runoff on their properties, probably because of current runoff not posing any risk of flooding or erosion, or flooding and erosion being mitigated by topography, vegetation, or other controls such as soakaways or wetlands. Table 5 shows the association between attitude, norm, behavioural control, and intended uptake of stormwater source controls.

Table 5. Association between attitude, norm, behavioural control and intended uptake of stormwater source controls.

Source controls by corresponding attitude, norm, and behavioural control		Fisher-Freeman-Halton Exact Test	Gamma (Approximate sig.)
Rainwater harvesting	A	N = 46; $p < 0.001$ ***	1.000; $p = 0.003$ ***
	SN	N = 46; $p < 0.001$ ***	.988; $p = 0.023$ **
	PBC1	N = 46; $p = 0.887$	.065; $p = 0.847$
	PBC2	N = 46; $p = 0.438$	.278; $p = 0.384$
Green roofing	A	N = 63; $p = 0.004$ ***	.558; $p = 0.001$ ***
	SN	N = 63; $p < 0.001$ ***	.744; $p < 0.001$ ***
	PBC1	N = 63; $p = 0.036$ **	.498; $p = 0.012$ **
	PBC2	N = 63; $p = 0.016$ **	.470; $p = 0.006$ ***
Permeable paving	A	N = 36; $p = 0.008$ ***	.634; $p = 0.001$ ***
	SN	N = 36; $p < 0.001$ ***	.771; $p < 0.001$ ***
	PBC1	N = 36; $p = 0.412$	.297; $p = 0.220$
	PBC2	N = 36; $p = 0.013$ **	.560; $p = 0.009$ ***
Stormwater retention ponds	A	N = 44; $p < 0.001$ ***	.802; $p < 0.001$ ***
	SN	N = 44; $p < 0.001$ ***	.775; $p < 0.001$ ***
	PBC1	N = 44; $p = 0.087$ *	.341; $p = 0.111$
	PBC2	N = 44; $p = 0.259$	.101; $p = 0.649$

Note: Significant at the *0.1, **0.05, and ***0.01 levels respectively.

Attitude and norm had strong and statistically significant effects on intended uptake of all four source controls. Clearly, the more positive and pressured owners felt to use a source control, the more likely they intended to do so. The effects of behavioural control are mixed. As indicated earlier, behavioural control was measured in terms of having or being able to find the technical knowhow (PBC1) and financial means (PBC2) to implement a source control. Behavioural control in terms of technical

knowhow was weak to moderate and statistically not significant for three of the four controls. It was, however, strong, and statistically significant for green roofing.

Behavioural control in terms of financial means was weak to moderate and statistically not significant for rainwater harvesting and retention ponds, but moderate to strong and statistically significant for green roofing and permeable paving.

Owners' intentions to use stormwater source controls are foremost driven by positive attitudes and peer pressure. Green roofing also depends on both technical knowhow and financial means, but permeable paving appears to depend on financial means only, and rainwater harvesting and retention ponds on neither. Thus, despite positive attitudes and peer pressure, some owners intend to use a measure, but may only be able to do so under different circumstances, while some owners may be able to do so, but they simply do not intend to.

Conclusion and recommendations

Using the TPB and an online survey, we examined property owners' current and intended uptake of stormwater source controls and the factors influencing uptake in a low-density upmarket residential estate. Owners showed noticeable levels of current uptake of permeable paving and retention ponds, and intended uptake of rainwater harvesting and even green roofing, suggesting that further research using the TPB to better understand the practical implementation of source controls on site or individual residential properties, as well as planning and designing for source controls, are worthwhile. Intended uptake is influenced foremost by positive attitudes and peer pressure, but site hydrology also plays a role with certain source controls. Some owners may need assistance to implement certain source controls, whereas others may need incentivising or behavioural nudging towards uptake. We conclude with recommendations for further research and the practical implementation of source

controls on site or on individual residential properties in settings lacking stormwater infrastructure.

In terms of research, the study shows support for the TPB, but the measurement of site hydrology requires refinement, particularly in terms of how it may be mediated through perceived behavioural control, i.e., owners' ability to implement stormwater source controls in terms of various practical considerations. Roof coverage appears to predict rainwater harvesting and green roofing. Stormwater runoff appears to predict retention ponds, but not permeable paving. Depending on context, additional site hydrology factors can be identified for rainwater harvesting, green roofing and retention ponds, but different factors should probably be identified for permeable paving.

According to the original TPB, perceived behavioural control may mediate the effect of site hydrology on uptake, though in this study behavioural control was measured in terms of technical knowhow and financial means. Behavioural control can therefore also be measured in relation to site hydrology, for example, the extent to which respondents feel they have enough roof coverage or suitable gutters and downpipes to enable rainwater harvesting. We included only three of the four source controls identified as SuDS options in the WSUD framework and guidelines for South Africa, and we recommend the inclusion of soakaways in future research in addition to rainwater harvesting, green roofing and permeable paving.

Our sample size limited us to bivariate analyses. Random door-to-door sampling, though more difficult, may increase response rates and sample sizes (De Leeuw 2012), which in turn may enable multivariate analyses such as regression or structural equation modelling. Ideally, each of the TPB constructs should be measured with about three to five items to enable factor and reliability analyses. The five-point Likert scale violates the assumption of normality, whereas wider semantic differential

scales may broaden statistical options. Finally, asking respondents to provide a breakdown of property coverage led to some survey fatigue. Limiting response categories to a maximum of five may reduce fatigue.

In terms of implementation, planners, architects, and managing agencies can do more to help implement stormwater source controls on site or on individual residential properties in a sustainable manner. Layout planning can ensure that stormwater runoff is distributed more equally across properties, while site planning can ensure that boreholes, retention ponds, and permeable paving are optimally located on properties. Architects can draft building codes and design houses to better facilitate rainwater harvesting and green roofing. Attitudes and norms strongly predicted intended uptake of source controls, suggesting that managing agencies can award prizes and display innovative solutions in circulars. Some owners, though they intend to implement source controls, may need technical support or financial incentives in the form of a proportional reduction in rates or levies for example (see, e.g., Brown et al. [2016]). Others, though they can implement source controls, may need behavioural nudging in the form of awareness campaigns, awards, or other forms of recognition or incentivising.

Acknowledgements

The authors would like to thank: the landscape architect from the University of Pretoria's Department of Architecture for proposing the questionnaire items around site hydrology; the management at the Mooikloof Owners' Association for permitting and facilitating the online survey; the owners who piloted the questionnaire; the owners who participated in the survey, and the two reviewers whose comments helped to improve the article.

Disclosure statement

No potential conflict of interest was reported by the authors.

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