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Identifying barriers to installing above-ground rainwater tanks in urban households in Aotearoa New Zealand: a segmentation approach

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ABSTRACT

Urbanisation poses numerous challenges to fresh water biodiversity, and installation of above-ground rainwater tanks on private properties is one important tool for addressing these challenges. In this paper, we used an online survey targeting a representative sample of 1291 urban residents to investigate their underlying capabilities, opportunities, and motivations for installation of above-ground rainwater tanks on their properties. Only 221 (17%) of the 1,291 respondents already had an above-ground rainwater tank installed on their property. By segmenting on behavioural variables, we found that those urban residents who currently did not have a water tank on their property were not homogeneous. We identified three audience segments, 'Supportive' (19%), 'Receptive' (59%) and 'Reluctant' (22%), each with their own unique driver and barrier combination to rainwater tank installation. Suitable leverage points and behaviour change tools (e.g. education, enablement, incentivisation) and message framing (environmental, community, or functional benefits) are identified for each segment.

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Introduction

Management of fresh water habitats and biodiversity within urban environments has become an increasingly important challenge (Capodaglio, Ghilardi, and Boguniewicz-Zablocka 2016; United Nations 2019). Like many countries around the world, urban land use in Aotearoa New Zealand is increasing as the population both grows and urbanises (Statistics New Zealand 2020). The resulting increase in population density and changing consumption patterns have led to heightened demand for fresh water resources. This increased demand has led to problems such as the over-extraction of groundwater, strained surface water sources, and heightened vulnerability to water scarcity in the face of climate change, whilst simultaneously contributing to water pollution, degradation of aquatic ecosystems and loss of biodiversity (Chakravarthy, Charters, and Cochrane 2019; Gadd et al. 2020; McGrane 2016). These challenges necessitate innovative and sustainable approaches to urban water management to ensure the long-term availability of clean, reliable fresh water supplies while conserving and maintaining fresh water biodiversity.

Various strategies have been implemented to mitigate the strain on conventional water sources and diminish the environmental footprint of urban water systems. These strategies encompass a three-fold approach: reducing water consumption, reusing water, and mitigating water pollution. Initiatives to reduce water consumption, such as water-efficient

technologies and public awareness campaigns, aim to curtail excessive water use (e.g. Millock and Nauges 2010; Seyranian, Sinatra, and Polikoff 2015). Water reuse systems, like greywater recycling and wastewater treatment for non-potable purposes, represent another promising path toward sustainability (Dixon, Butler, and Fewkes 1999; Yoonus and Al-Ghamdi 2020). Concurrently, strategies to decrease water pollution, including improved stormwater management and wastewater treatment, seek to protect and restore urban waterbodies (Barbosa, Fernandes, and David 2012; Crini and Lichtfouse 2019).

Rainwater harvesting

Rainwater harvesting systems, including above-ground rainwater tanks, are important contributors to sustainable urban water use (Amos, Rahman, and Gathenya 2018; Kolavani and Kolavani 2020; Wurthmann 2019). Rainwater harvesting systems capture and store rainwater for both potable and non-potable purposes, thereby potentially reducing the demand for fresh water and mitigating the strain on the centralised water supply systems (Campisano et al. 2017; Delaney and Fam 2015; Sharma et al. 2012, 2016). Hence, rainwater harvesting contributes to both water conservation and water pollution reduction goals through decreased chemical use, decreased run-off peak flow, reduced soil erosion, and flood mitigation in urban basins (Ashley, Gersonius, and Horton 2020; Brown et al. 2016; Burns, Ladson, and Fletcher

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2015; Campisano and Modica 2015; de Sá Silva et al. 2022; Palla, Gnecco, and La Barbera 2017; Zhang et al. 2012).

Despite the potential benefits of rainwater harvesting such as rainwater tanks, numerous barriers hinder their widespread adoption in urban areas. These barriers include regulatory constraints and complexities, technical and logistical issues inhibiting their effectiveness, water quality, space and aesthetics, and the costs associated with initial set up and the ongoing operating and maintenance. In addition, within urban resident populations, values, attitudes, beliefs knowledge, skills, and motivations about fresh water and rainwater tanks can also impact the likelihood that tanks will be purchased and installed (Addo, Thoms, and Parsons 2018; Bond and Worzala 2011; Brown et al. 2016; Campisano et al. 2017; de Sá Silva et al. 2022; Gao et al. 2018; Leidl, Farahbakhsh, and FitzGibbon 2010; Mankad, Fielding, and Tapsuwan 2015; Parsons et al. 2010; Schirmer and Dyer 2018). A comprehensive understanding of these and other barriers in Aotearoa New Zealand is crucial for designing effective policies and interventions to encourage the installation of rainwater tanks and, consequently, promote sustainable water management and improve fresh water habitats in urban areas in this country.

Human behavioural insights

Recognising that urban residents are not homogeneous, population segmentation based on demographic, psychographic, and/or behavioural variables gives a deeper understanding of the unique drivers and barriers that each subgroup faces. This knowledge enables the creation of interventions that are more personalised, relevant, and resonant with the intended audience (Hine et al. 2014, 2017; Rundle-Thiele, Dietrich, and Kubacki 2017), and allows for the allocation of limited resources more efficiently as interventions can be directed towards the segments of the population that are most likely to benefit from them (Slater, Kelly, and Thackeray 2006). Although previous studies have identified a range of psycho-social factors (i.e. barriers and drivers) to rainwater harvesting and rainwater tanks adoption in urban areas, to our knowledge none has used a segmentation approach to provide the foundation for targeted behaviour change interventions.

As noted by Michie et al. (2014), the behavioural science literature has produced over 83 behaviour change theories and an unwieldy number of determinants. The Behaviour Change Wheel (BCW) framework (Michie, Atkins, and West 2014) offers a comprehensive and systematic approach to understanding behaviour change, combining insights from multiple behaviour change theories and models, and providing a well-rounded perspective on the psychological, environmental, and social factors influencing human behaviour (Michie, van Stralen, and West 2011). The BCW is underpinned by the COM-B model, a framework to understand Behaviour as a function of Capability, Opportunity and Motivation, which integrates the highly disparate behavioural science literature into a single manageable

framework that enables the identification of the behavioural drivers and barriers that are most relevant to the issue being investigated (e.g. McLeod et al. 2015). The COM-B model emphasises the importance of considering three essential components of behaviour. 'Capability' comprises an individual's psychological and physical ability/self-efficacy to perform the desired behaviour, including having suitable insight, knowledge, and skills. 'Opportunity' explains factors external to the individual that permit or prohibit a behaviour, such as the physical environment and social surroundings. 'Motivation' describes the cognitive processes that vitalize and guide behaviour. These processes may involve reflective motivation (which entails rational decision-making and/or appraisals) and automatic motivation (which entails emotional and impulse responses).

By identifying which elements of the COM-B model are most relevant, practitioners can make informed decisions about which behaviour change techniques are likely to be effective in each context so interventions can be tailored to target the root causes of a behaviour and lead to lasting and meaningful behaviour change in individuals and communities. For example, if a capability-type factor is identified, then an appropriate intervention should aim to educate, train, or support. If an opportunity-type factor is identified, in contrast, then the best intervention would aim to enable, facilitate, prompt, or restrict. A motivation-type factor requires an intervention aimed to persuade, demonstrate, incentivise, or coerce (McLeod et al. 2015; Michie, Atkins, and West 2014). Practitioners then use the COM-B model alongside the BCW framework to design the best-suited intervention for the target context and population. The BCW framework has been used to explore water conservation behaviours (Addo, Thoms, and Parsons 2018; Hine, Driver, and McLeod 2018) but has not been applied specifically to rainwater tank installation.

This study

The aims of this study were:

- (1) To identify potential barriers to rainwater tank installation in urban areas in Aotearoa New Zealand,
- (2) Determine the relative importance of these barriers alongside demographic variables, environmental concern, and community values in influencing current rainwater tank installation and future intentions to install rainwater tanks.
- (3) Segment urban residents using these barrier factors to identify key leverage points that may be useful for informing the development of targeted behaviour change interventions to encourage the installation of rainwater tanks.

Materials and methods

Study participants

A community survey was administered by a market research firm to an online research panel. The market research firm

used interlocking quotas to ensure that the sample was representative of the general urban population in Aotearoa New Zealand by age, gender, and location. Potential respondents had to be over 18 years of age, own their own home, and reside in localities where the population exceeds 5000 people. The questionnaire was reviewed in accordance with the ethical review process of Manaaki Whenua – Landcare Research (application no. 2223/04).

Survey structure

The community survey consisted of 20 questions. The first block of questions collected information about the participants – demographics (age, education, gender and location) and socio-psychological dimensions (Environmental concern, Connectedness to Nature, National Environmental Identity and Sense of Community). The second block of questions asked about their current behaviour with respect to above-ground rainwater tank installation and their perceived barriers. These questions are described below.

Measures

Socio-structural questions

Demographics were included in the analyses as possible covariates of the three selected behaviours. Measures included age, level of education, and gender.

Socio-psychological dimensions were assessed using a range of psychometric measures. Unless otherwise specified, all measure items were rated on a 7-point Likert-type scale anchored at 1 = strongly disagree and 7 = strongly agree. Further details of each item are described in the supplementary material (Table S1).

- **Environmental Concern:** Concern for the consequences of environmental problems on the biosphere, oneself, and other people was assessed using the measure developed by Schultz (2001) and validated in New Zealand samples by Milfont, Duckitt, and Cameron (2006). This inventory comprises four items for each of the concern types, biospheric, egoistic, and altruistic.
- **Connectedness to Nature:** A measure of individuals' emotional feelings towards nature was assessed using the measure developed by Mayer and Frantz (2004). It consisted of 14 items.
- **National Environmental Identity:** Environmentalism and a 'clean-and-green' attitude have been found to be core components of being a 'true' New Zealander (Milfont et al. 2020). Five items captured two aspects of this dimension, national identity (Van Bavel et al. 2022) and national environmental identity (items generated based on the New Zealand's biological heritage project website: <https://bioheritage.nz/goals/stategic-objective/environmental-stewardship/>).
- **Sense of Community:** The Brief Sense of Community Scale developed by Peterson, Speer, and McMillan (2008) was used to assess the dimensions of needs fulfillment, group

membership, influence, and shared emotional connection with an individual's community. It consisted of eight items.

Behaviour measures

Respondents were asked whether they currently have an above-ground rainwater tank installed at their home (0 = no and 1 = yes). Willingness to install an above-ground rainwater tank in the next 12 months was assessed using a 7-point Likert-type scale with 1 = highly likely and 7 = highly unlikely. Also, willingness to make a financial contribution to an organisation that helps homeowners install above-ground rainwater tanks on private properties in the next 12 months was assessed using this same 7-point scale.

Respondents were asked to rate their agreement with sixteen questions pertaining to potential barriers of rainwater tank installation. These barriers were identified from previous studies (Addo, Thoms, and Parsons 2018; Bond and Worzala 2011; Brown et al. 2016; Leidl, Farahbakhsh, and FitzGibbon 2010; Mankad, Fielding, and Tapsuwan 2015; Parsons et al. 2010; Schirmer and Dyer 2018) and are detailed in Table 1. They cover an individual's capability (i.e. knowledge and skills), physical and social opportunity, and motivation to install an above-ground rainwater tank (Michie, Atkins, and West 2014). Responses to all items used a 7-point Likert-type scale anchored at 1 = strongly disagree and 7 = strongly agree.

Quantitative data analysis

Internal consistency of the multi-item socio-psychological scales (Environmental Concern, Connectedness to Nature, National Environmental Identity, and Sense of Community) were examined with the Cronbach's Alpha Test (Tavakol and Dennick 2011). Comparisons of demographic and the socio-psychological variables between respondents who already had an above-ground rainwater tank installed and those who did not were conducted using either a MANOVA or Pearson's chi-squared test in IBM SPSS Version 29. A Latent Profile Analysis (LPA) was conducted to classify residents into homogeneous segments based on their responses to consolidated barrier factors.

We firstly conducted the LPA to identify the optimal number of latent profiles using the barrier factors. The relative model fit was assessed using Bayesian information criteria (BIC; Schwartz 1978), relative entropy (Ramaswamy et al. 1993), and the Lo – Mendell – Rubin likelihood ratio test (LMR; Lo, Mendell, and Rubin 2001). A significant p value from the LMR test ($p = 0.05$) indicated that the given profile solution fitted the data significantly better than the solution with one fewer profile. The LPA was conducted in Mplus 8.9 (Muthén and Muthén 2017). We then evaluated the quality of the LPA to ensure that our identified profiles were meaningful and not simply artifacts of the observed variables used to define them. To accomplish this, we examined the degree to which the latent profiles associated with other observed variables that were not used to define the profiles, including demographics (age, gender, education level) and all four socio-

Table 1. Description of the 16 barrier items for installing an above-ground rainwater tank.

Barrier item	Source
<i>Capability (4 items)</i>	Bond and Worzala (2011); Mankad, Fielding, and Tapsuwan (2015); Schirmer and Dyer (2018)
1. I am not aware of the environmental benefits of installing a rainwater tank	
2. I know how to install a rainwater tank (reverse score)	Addo, Thoms, and Parsons (2018); Parsons et al. (2010)
3. I am not sure how to safely use the water that is stored in a rainwater tank	Leidl, Farahbakhsh, and FitzGibbon (2010)
4. I do not have the physical ability to install a rainwater tank	Addo, Thoms, and Parsons (2018)
<i>Physical Opportunity (4 items)</i>	Mankad, Fielding, and Tapsuwan (2015)
1. My yard does not have enough space for a rainwater tank	
2. Installing a rainwater tank is too costly	Addo, Thoms, and Parsons (2018); Bond and Worzala (2011); Brown et al. (2016); Leidl, Farahbakhsh, and FitzGibbon (2010); Mankad, Fielding, and Tapsuwan (2015); Parsons et al. (2010)
3. Organising a plumber to install a rainwater tank is difficult	Addo, Thoms, and Parsons (2018); Mankad, Fielding, and Tapsuwan (2015)
4. Council regulations do not make it easy to install a rainwater tank	Brown et al. (2016); Leidl, Farahbakhsh, and FitzGibbon (2010); Mankad, Fielding, and Tapsuwan (2015); Parsons et al. (2010)
<i>Social Opportunity (4 items)</i>	Mankad, Fielding, and Tapsuwan (2015)
1. I do not know anyone who has installed a rainwater tank	
2. My local Council does not encourage installing a rainwater tank	Addo, Thoms, and Parsons (2018); Brown et al. (2016); Leidl, Farahbakhsh, and FitzGibbon (2010)
3. My local community encourages installing a rainwater tank (reverse score)	Addo, Thoms, and Parsons (2018); Leidl, Farahbakhsh, and FitzGibbon (2010)
4. People like me do not have rainwater tanks	Mankad, Fielding, and Tapsuwan (2015); Schirmer and Dyer (2018)
<i>Motivation (4 items)</i>	Addo, Thoms, and Parsons (2018); Bond and Worzala (2011); Mankad, Fielding, and Tapsuwan (2015)
1. Installing a rainwater tank is too much effort	
2. Installing a rainwater tank seems like a waste of money	Brown et al. (2016); Parsons et al. (2010)
3. There are no benefits to me for installing a rainwater tank	Bond and Worzala (2011); Brown et al. (2016); Mankad, Fielding, and Tapsuwan (2015)
4. Consuming water stored in a rainwater tank can be a health risk	Leidl, Farahbakhsh, and FitzGibbon (2010)

psychological variables. The relationship between the profiles and our distal outcome of future intentions to install a rainwater tank were examined to determine whether the identified profiles were predictive of adoption, and hence useful for practitioners to target in behaviour change interventions. Analyses for these comparisons were conducted using either MANOVA or Pearson's chi-squared test in IBM SPSS Version 29.

Results

Participants

Complete responses were received from 1,291 urban residents from urban areas with population >5000 across Aotearoa New Zealand (Auckland 395, Northland/Bay of Plenty/Gisborne regions 131, Waikato 115, Hawkes Bay/Taranaki/Manawatu Wanganui regions 162, Wellington 146, Canterbury 199, Rest of South Island 143). The average age of respondents was 49.3 years (± 17.2) and range from 18 to 90 years. There were 745 female (58%) respondents, 541 male (42%) respondents, and 5 respondents who identified as non-binary. One hundred respondents (8%) had completed a higher tertiary degree, 486 (38%) had completed an undergraduate degree, 272 (21%) had a trade or technical qualification, 371 (29%) had completed secondary education, and 62 (5%) stipulated no qualifications or were unsure.

Internal reliability of scales

All multi-item scales reflected a good internal consistency greater than 0.80 (Table S1). Scale scores for each of these themes were computed by averaging the items which were then used for subsequent analysis.

Tank installation

Only 221 (17%) of the 1,291 respondents already had an above-ground rainwater tank installed on their property. These respondents had a significantly stronger sense of community and connectedness to nature than respondents without a rainwater tank, on average (Table 2). There was no difference between the three environmental concern types, national identity, or national environmental identity for the two groups. There was also no difference between the ages ($F = 2.75$, $p = .10$, $\eta^2 = .00$) or education level ($\chi^2 = 1.89$, $df = 4$, $p = .76$, $r = .02$) of the two groups. Of the respondents who did not already have a rainwater tank, 200 (19%) were willing to install one in the next 12 months, 467 (43%) were somewhat willing, 226 (20%) were slightly willing, and 197 (18%) were not at all willing.

Audience segmentation

To develop the most effective targeted engagement interventions, it is not only important to understand why urban residents are willing or not to install above-ground

Table 2. Comparison of socio-psychological variables between respondents with and without an above-ground rainwater tank.

	With tank (n = 221)		No tank (n = 1070)		F	p value	η^2
	Mean	SD	Mean	SD			
Environmental Concern	5.45	1.32	5.32	1.25	2.00	.16	.00
Egoistic	5.80	1.15	5.83	1.10	.14	.70	.00
Biospheric	5.81	1.13	5.83	1.09	.09	.76	.00
Altruistic							
Connect to Nature	4.81	.75	4.62	.81	9.58	<.01	.01
National Identity	5.87	1.24	5.85	1.30	.08	.78	.00
National Env. Identity	5.74	.98	5.65	1.06	1.22	.27	.00
Sense of Community	4.63	1.27	4.04	1.23	41.82	<.001	.03

rainwater tanks, but also if these reasons are similar across all residents. We used LPA to identify segments of urban residents with similar COM barrier profiles for above-ground rainwater tank installation. This analysis was restricted to the 1070 respondents who did not already have an above-

ground rainwater tank on their property. As can be seen in Table 3, the 4-profile solution had a lower BIC value and higher entropy value; however, the LMR test indicated that the 3-segment fitted the data significantly better and that retaining any additional segments did not significantly improve the fit. The results of this analysis suggested that a three-segment solution was the most parsimonious and had the best fit to the data. Thus, our sample could be divided into three segments based on their barriers to installing an above-ground rainwater tank on their property.

To validate our LPA solution, we examined the degree to which membership in the identified segments associated with the other observed variables that were not used to define them as well as respondents' intentions to install a water tank on their property. Notable, there was a significant difference with the willingness to install

Table 3. Model fit indices for the latent profile analysis solutions.

Segment solution	BIC	Entropy	LMR
2	65046.33	.78	<.001
3	64620.07	.79	<.001
4	64425.87	.80	.10
5	64346.88	.81	.27
6	64183.05	.83	.22
7	64062.77	.85	.15
8	64093.21	.85	.75

BIC – Bayesian information criterion; LMR – Lo–Mendell–Rubin likelihood ratio test.

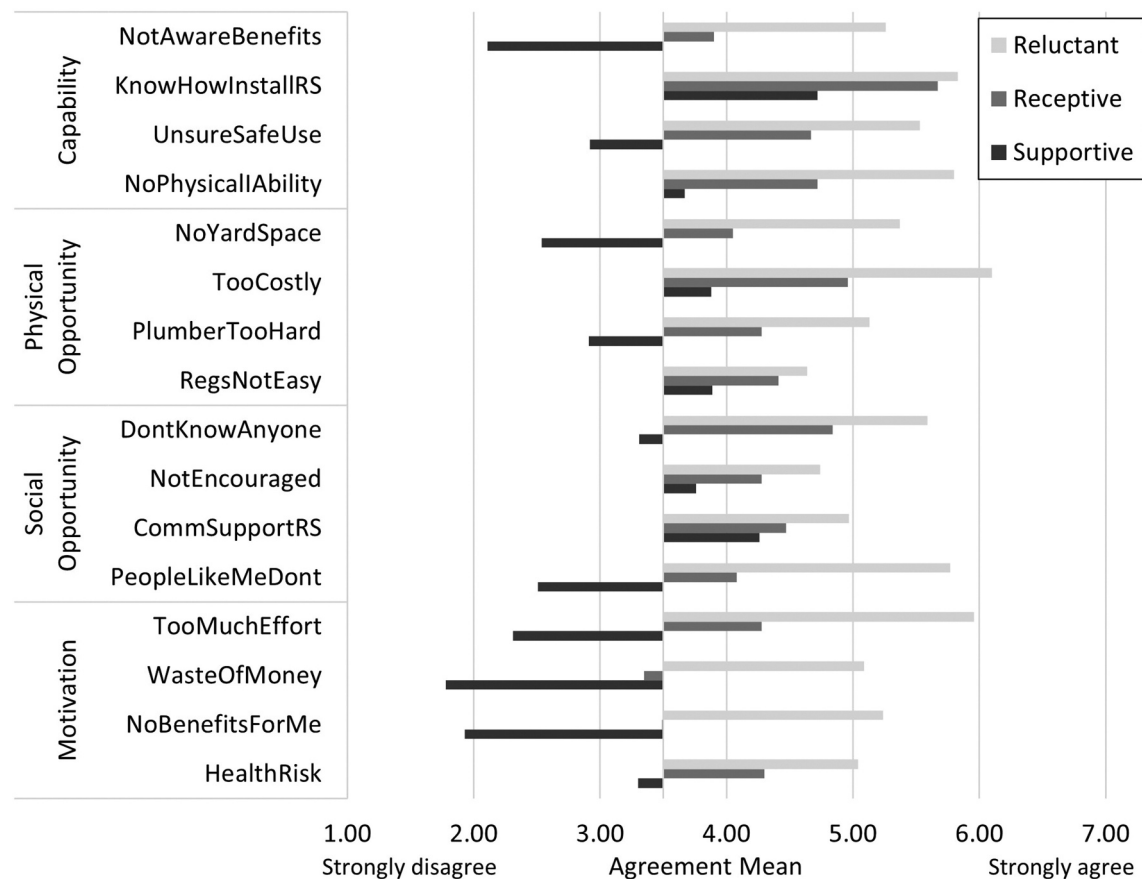
**Figure 1.** Agreement with the COM barrier items (1= strongly disagree and 7 = strongly agree) for each of the three identified profiles – 'supportive', 'receptive', and 'reluctant'.

Table 4. Differences between COM barrier items to install an above-ground rainwater tank across the three identified segments.

COM Barrier items	Supportive (n = 205)	Receptive (n = 631)	Reluctant (n = 234)	Profile differences		
	Mean	Mean	Mean	F	p	η^2
Not aware of environmental benefits	2.11 ^a	3.90 ^b	5.26 ^c	229.14	<.001	.30
Know how to install rainwater tank (RS)	4.72 ^a	5.67 ^b	5.83 ^b	26.23	<.001	.05
Unsure how to safely use stored water	2.92 ^a	4.67 ^b	5.53 ^c	152.43	<.001	.22
Do not have physical ability to install	3.67 ^a	4.72 ^b	5.80 ^c	74.62	<.001	.12
My yard does not have enough space	2.54 ^a	4.05 ^b	5.37 ^c	117.94	<.001	.18
Installing a rainwater tank is too costly	3.88 ^a	4.96 ^b	6.10 ^c	165.59	<.001	.24
Organising a plumber is too difficult	2.91 ^a	4.28 ^b	5.13 ^c	125.65	<.001	.19
Regulations do not make it easy	3.89 ^a	4.41 ^b	4.64 ^b	22.04	<.001	.04
Do not know anyone who has installed	3.31 ^a	4.84 ^b	5.59 ^c	74.95	<.001	.12
Council doesn't encourage installation	3.76 ^a	4.28 ^b	4.74 ^c	29.23	<.001	.05
Community encourages installation (RS)	4.26 ^a	4.47 ^a	4.97 ^b	16.14	<.001	.03
People like me do not have a tank	2.51 ^a	4.08 ^b	5.77 ^c	247.69	<.001	.32
Installing a tank is too much effort	2.31 ^a	4.28 ^b	5.96 ^c	574.77	<.001	.52
Installation a waste of money	1.78 ^a	3.35 ^b	5.09 ^c	354.92	<.001	.40
No benefits to me for installation	1.93 ^a	3.49 ^b	5.24 ^c	301.18	<.001	.36
Consuming stored water is a health risk	3.30 ^a	4.30 ^b	5.04 ^c	76.22	<.001	.13

Means with different superscripts (in rows) differ significantly at $p < .05$ Tukey HSD. η^2 (partial eta squared) indicates effect size.

Table 5. Differences between age, willingness to install an above-ground rainwater tank, and socio-psychological dimensions across the three identified segments.

All participants	Supportive (n = 205)	Receptive (n = 631)	Reluctant (n = 234)	Profile differences		
	Mean	Mean	Mean	F	p	η^2
Age	52.88 ^b	48.57 ^a	49.65 ^{ab}	4.99	<.01	.01
Environmental Concern	5.43	5.28	5.32	3.65	.31	.00
Egoistic	6.04 ^b	5.80 ^a	5.71 ^a	13.13	.004	.01
Biospheric	6.04 ^b	5.82 ^a	5.70 ^a	13.35	.004	.01
Altruistic						
Connectedness to Nature	4.87 ^b	4.58 ^a	4.51 ^a	12.51	<.001	.02
NZ National Identity	6.16 ^b	5.74 ^a	5.85 ^a	7.89	<.001	.02
National Env. Identity	6.01 ^b	5.57 ^a	5.57 ^a	14.56	<.001	.03
Sense of Community	4.29 ^c	4.02 ^b	3.89 ^a	8.25	<.001	.02
Future willingness	5.10 ^c	3.78 ^b	2.42 ^a	141.94	<.001	.21

Mean scores for future willingness: 1 = not at all willing, 7 = extremely willing. Means with different superscripts (in rows) differ significantly at $p < .05$ Tukey HSD. η^2 (partial eta squared) indicates effect size.

a rainwater tank, so we named our three segments to reflect the willingness and extent of barriers preventing rainwater tank installation – 'supportive' ($n = 205$), 'receptive' ($n = 631$) and 'reluctant' ($n = 234$). These are shown in Figure 1, Table 4, and described below. Members in the 'supportive' segment were the most willing to install a rainwater tank and members in the 'reluctant' segment the least willing (Table 5).

We found significant differences between the three segments and all the measured socio-psychological variables except egoistic environmental concern (MANOVA results: Wilk's $\lambda = .96$, $F(14, 2122) = 3.61$, $p < .001$, $\eta^2 = .02$), with the 'supportive' segment consistently scoring significantly higher on these variables (Table 5). There was also a statistical difference in age between segments, with members in the 'supportive' segment being older, while members in the 'receptive'

segment being the youngest (Table 5). No differences were observed between segments regarding gender ($X^2(2) = 5.01$, $p = .08$, $r = -.01$) or education level ($X^2(8) = 9.09$, $p = .34$, $r = -.01$).

Members in the 'supportive' profile ($n = 205$) tended to be older and were the most willing to install an above-ground rainwater tank in the future. On average, they scored the highest across all psychometric scales, indicating they have a strong environmental identity and sense of community. Knowledge on how to install an above-ground rainwater tank was their main barrier, followed by the social opportunity barriers of lack of community and Council (i.e. local government) support, as well as the physical opportunity barriers of cost and difficult regulations.

Members in the 'receptive' profile ($n = 631$) were somewhat willing to install an above-ground rainwater tank in the future. On average, they scored lower than the 'supportive' profile

across all psychometric scales, indicating they have moderate environmental identity and sense of community. Members tended to be younger than members in the other profiles and were somewhat aware of the environmental and personal benefits of installing a rainwater tank. The highest-rated barriers for members of this group included their capability to install a rainwater tank, their physical and social opportunity, and their perceptions that it was too much effort and a health risk.

Finally, members in the 'reluctant' profile ($n = 234$) were the least willing to install an above-ground rainwater tank in the future. On average, they scored the lowest on all psychometric scales, indicating they were the least environmentally and community-minded group. Members were not aware of either the environmental or personal benefits of installing a rainwater tank and had relatively strong agreement with all the COM barriers. In particular, they believed that installing a water tank was too costly, required too much effort, and was a waste of money. They did not know anyone else who had a rainwater tank and believed that people like them did not need one.

Discussion

Above-ground rainwater tanks are an important tool for achieving sustainable urban water use as well as mitigating stormwater run-off problems in urban areas (Burns, Ladson, and Fletcher 2015; de Sá Silva et al. 2022; Palla, Gnecco, and La Barbera 2017). Considering that the behaviours of urban residents are a fundamental part of promoting rainwater tank installation, we engaged with urban homeowners in Aotearoa New Zealand to understand the underlying determinants of above-ground rainwater tank installation and identified potential target audiences. We discuss our main findings and the practical implications of these results below, including how this information can be used to develop more impactful interventions to achieve meaningful change in water conservation and stormwater run-off behaviour to improve natural waterway habitats and biodiversity in urban areas.

Barriers to installing above-ground rainwater tanks

In this study, we engaged with urban residents to understand the underlying barriers and drivers of above-ground rainwater tank installation. To our knowledge, this study is the first to adopt the Behaviour Change Wheel (BCW) and associated Capability-Opportunity-Motivation-Behaviour (COM-B) model (Michie, Atkins, and West 2014; Michie, van Stralen, and West 2011) to identify specific driver and barrier factors relating to rainwater tank installation. Although initially designed to modify health-related behaviour, this framework has proven useful for pro-environmental behaviours such as household water conservation (Addo, Thoms, and Parsons 2018; Hine, Driver, and McLeod 2018), encouraging cycling (Dalton, Burke, and Jones 2022), litter reduction (Kolodko et al. 2021), recycling (Allison et al. 2022), green consumerism (Sundaraja et al. 2021), and wildlife protection (McLeod, Hine, and Driver 2019).

We found that 17% of urban residents across Aotearoa New Zealand had an above-ground rainwater tank already

installed on their property. For those residents who did not already have a rainwater tank installed, we identified a range of barriers, encompassing their awareness of fresh water issues and knowledge about the benefits of rainwater tanks, adoption skills, regulatory complications, set up and maintenance costs, and community support. There is a mixed approach by local government in Aotearoa New Zealand to rainwater harvesting. Although some Councils, e.g. Wellington, have developed initiatives to encourage householders to install rainwater tanks to increase post-disaster resilience (Stewart et al. 2016), to our knowledge only a small proportion of Councils encourage and support residents to install above-ground rainwater tanks to supplement the centralised water supply systems for activities such as toilet flushing and outdoor use (Kvigstad 2022; Marshall 2020). Different studies have shown that, in urban catchments, the extensive installation of rainwater tanks could efficiently support reducing the frequency and peak of stormwater flooding (Campisano and Modica 2015; Palla, Gnecco, and La Barbera 2017; Zhang et al. 2012), which could be a useful mitigation strategy when considering the increasing risk of flooding in urban areas across Aotearoa New Zealand (Ministry for the Environment 2008).

Practical implications of audience segmentation

Although behaviour change research on pro-environmental behaviours dates back over 40 years, there has been less research on which strategies work best in which circumstances (Schultz 2014; van Valkengoed, Abrahamse, and Steg 2022). A key strength of the BCW is that it provides a useful framework for linking identified causes of behaviour (from the COM-B analysis) to the best behaviour change tool for the job, thus avoiding the 'it seemed like a good idea at the time' notion (Michie, Atkins, and West 2014). Moreover, by considering the diverse characteristics and needs of the target audience through segmentation, relevant behaviour change interventions can be further tweaked to resonate with the intended audience, maximising their impact and helping to achieve more long-lasting and meaningful change.

We identified three separate segments within our urban resident sample: 'supportive', 'receptive', and 'reluctant'. Members of the 'supportive' segment were willing to install an above-ground rainwater tank and were the most capable and motivated to do so. The main barriers for this group included perceived regulatory difficulties, the cost of installation (physical opportunity barriers), and community and Council support (social opportunity barriers). Interventions targeting this segment should aim to enable and support residents by working with Councils to make it easier to understand and comply with installation regulations as well as actively promoting installation and providing personal subsidies and/or incentives to lower the costs. Given that members of this segment showed higher environmental and community identities, interventions aimed at encouraging installation could also frame the communications in terms of these members' values (Lakoff 2010; Wallen and Kyle 2018). These messages could be endorsed and championed by influential community organisations

and individuals who these older residents associate with and trust (Cialdini 2009) to promote and reinforce a community norm of rainwater tank installation (Cialdini et al. 2006; Schultz et al. 2007).

The 'receptive' segment was somewhat willing to install an above-ground rainwater tank. Since more survey respondents fell into this segment than other groups, it would be a priority to target (Kneebone, Smith, and Fielding 2017; McKenzie-Mohr 2011). Members in this profile identified barriers across all COM items. Like the 'supportive' segment, members were impeded by perceived regulatory difficulties and cost and community support, but they also identified capabilities (uncertainty how to install a rainwater tank and the safe use of the water), personal norms (no-one they knew had installed a water tank), motivation (too much effort and perception of health risk), and additional physical opportunities (plumber too hard to organise and no yard space) as barriers. Interventions to tackle the capability barriers would need to instruct and increase understanding of the procedure to install above-ground rainwater tanks and the safe use of the stored water using information channels frequented by this younger age group. It would be beneficial to work with local suppliers and plumbers to provide easy access to details about the availability and costs of tank installation as well as increasing the range of tanks to accommodate different backyard spaces (McKenzie-Mohr 2011). Tackling the personal norm and motivation barriers interventions would depend on credible local sources to promote rainwater tank installation, to provide a demonstration of tank installation and use, and to share feedback of like-people's experiences (Larson et al. 2013; Schultz 1999). They should adopt messages framed around environmental and community values (Lakoff 2010) and draw attention to discrepancies between values and current behaviour (cognitive dissonance) to create discomfort (Dickerson et al. 1992; Osbaldiston and Schott 2012). Written or verbal commitments that are linked to values and outcomes (e.g. environmental identity and improving fresh water biodiversity across urban areas) may provide further motivation (Lokhorst et al. 2013; McKenzie-Mohr 2011).

Finally, members of the 'reluctant' segment are the least willing of the resident groups to install an above-ground rainwater tank. They would be the toughest group to encourage to participate, and considering their relatively small size, the least priority group to attempt to persuade (Kneebone, Smith, and Fielding 2017; McKenzie-Mohr 2011). Members of this profile were not aware of either the personal or environmental benefits of installing an above-ground rainwater tank on their property. Urban residents have been found to be more motivated by functional benefits than environmental benefits with respect to private property changes (Brown et al. 2016; Gao et al. 2018). As such, initial interventions with this group should educate, persuade, and encourage, promoting awareness on the personal benefits as well as the community and environmental benefits. This awareness campaign could then be followed by a range of interventions targeting the other barrier factors as described above.

Limitations and future research

This research provides the foundation for further work aimed at developing more effective urban fresh water management communication and behaviour change interventions promoting the installation of above-ground rainwater tanks. The BCW framework, associated COM-B model, and segmentation analysis provides practical, intuitive tools for engagement specialists to increase their understanding of behaviour in context and design interventions that are most likely to be effective. However, there are practical challenges associated with identifying and targeting members from each of the identified profile groups. Engagement specialists would need to engage and collaborate with community leaders and representatives to seek their insights in identifying these segments and involve them in the development of interventions to ensure relevance, accessibility, sensitivity and inclusivity (Michie, Atkins, and West 2014).

An important next step is to develop and evaluate intervention strategies specifically designed to address the needs of each profile. More specifically, there is a need to improve our understanding of the relevant COM factors for urban contexts, which behaviour change tools are most effective for encouraging participation, under what conditions, and the effectiveness of different communication channels. It is all too often the case that scientifically credible evidence about the effectiveness of a particular intervention has not been collected. The effectiveness of behaviour change interventions should be rigorously evaluated against program goals using scientifically robust methods such as treatment and control groups, random assignment, and the use of appropriate statistical tests to determine whether the intervention made a difference and worked as intended (Murnane and Willett 2010).

Conclusion

Urbanisation poses numerous challenges to fresh water habitats and biodiversity, and the installation of above-ground rainwater tanks on private properties is one important tool for addressing these challenges. In this paper, we investigated the underlying capabilities, opportunities, and motivations for urban residents' installation of above-ground rainwater tanks on their properties. By segmenting on behavioural variables, we found that urban residents were not homogeneous, identifying three audience segments, each with their own unique drivers and barriers combination. The identification of these audience segments will allow the creation of interventions that are more personalised, relevant, and resonant with the intended audiences.

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Data availability statement

The data that support the findings of this study are available from the corresponding author [LJM] upon reasonable request.

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