2012

Water conservation behavior in Australia

Sara Dolnicar
University of Wollongong, s.dolnicar@uq.edu.au

Anna Hurlimann
University of Melbourne

Bettina Grun
Johannes Kepler Universitat Linz, Austria, bettina@uow.edu.au

Water conservation behavior in Australia

Abstract

Ensuring a nation's long term water supply requires the use of both supply-sided approaches such as water augmentation through water recycling, and demand-sided approaches such as water conservation. Conservation behavior can only be increased if the key drivers of such behavior are understood. The aim of this study is to reveal the main drivers from a comprehensive pool of hypothesized factors. An empirical study was conducted with 3094 Australians. Data was analyzed using multivariate linear regression analysis and decision trees to determine which factors best predict self-reported water conservation behavior. Two key factors emerge: high level of pro-environmental behavior; and pro-actively seeking out information about water. A number of less influential factors are also revealed. Public communication strategy implications are derived.

1   **WATER CONSERVATION BEHAVIOR IN AUSTRALIA**

2

3   **Sara Dolnicar[a*,] Anna Hurlimann[b] and Bettina Grün[c]**

4   * Corresponding author

5   [a] Institute for Innovation in Business and Social Research,

6   School of Management & Marketing

7   University of Wollongong, Wollongong, NSW 2522, Australia

8   Phone: +61 2 4221 3862

9   Fax: +61 2 4221 4210

10   sara_dolnicar@uow.edu.au

11

12   [b] Faculty of Architecture Building and Planning

13   The University of Melbourne, Melbourne 3010, Australia

14   Phone: +61 3 8344 6976

15   Fax: +61 3 8344 5532

16   anna.hurlimann@unimelb.edu.au

17

18   [c] Institute for Innovation in Business and Social Research and

19   Department of Applied Statistics

20   Johannes Kepler Universität Linz, Altenbergerstraße 69, 4040 Linz, Austria

21   Phone: +43-732 2468-6829

22   Fax: +43-732 2468-6800

23   Bettina.Gruen@jku.at

24

25
26   **WATER CONSERVATION BEHAVIOR IN AUSTRALIA**

27

28

29   **Abstract**

30   Ensuring a nation's long term water supply requires the use of both supply-sided

31   approaches such as water augmentation through water recycling, and demand-sided

32   approaches such as water conservation. Conservation behavior can only be increased if the

33   key drivers of such behavior are understood. The aim of this study is to reveal the main

34   drivers from a comprehensive pool of hypothesized factors. An empirical study was

35   conducted with 3094 Australians. Data was analyzed using multivariate linear regression

36   analysis and decision trees to determine which factors best predict self-reported water

37   conservation behavior. Two key factors emerge: high level of pro-environmental behavior;

38   and pro-actively seeking out information about water. A number of less influential factors are

39   also revealed. Public communication strategy implications are derived.

40

41   Keywords: water conservation behavior, regression analysis, decision tree, pro-environmental

42   behavior, information seeking, Australia

43

1. Introduction

The conservation of water resources is a critical component of the effective and environmentally sustainable management of municipal water supplies. It is anticipated that climate change will decrease the reliability of water supplies, due to reductions in rainfall, and the increasing variability of rainfall events (Intergovernmental Panel on Climate Change, 2007). The conservation of water resources will therefore become increasingly imperative.

In Australia many locations felt the impact of changed climatic conditions on water resources: a 12 year drought affected many areas of the State of Victoria in South Eastern Australia. The drought was in line with worst case scenario models for climate change impacts on water resources (Government of Victoria, 2006), leading to mandated restrictions on the use of water for non-essential purposes (such as watering lawns and washing cars). Water restrictions are seen as a short term solution to balance supply and demand. The government has a policy position which seeks to limit restrictions to no more than 5% of the time (Government of Victoria, 2006, p.18). To achieve this aim, and secure the state's supply of water, the Victorian government is currently constructing the largest desalination plant in the southern hemisphere. Concurrently, the government is also encouraging the use of other water sources such as recycled wastewater for non-potable purposes. However, alternative water sources often come at high economic costs and significant greenhouse gas emissions (for a discussion see: Hurlimann, 2007; Schiffler, 2004).

Given the imperative of water conservation for environmental sustainability, efficient municipal water management, and climate change mitigation, it is critical to understand what factors contribute to water conservation behavior. Being aware of these factors will inform water managers, governments and public policy officers of how best to encourage water conserving behaviors, and thus reduce the need to augment existing water supplies. Despite

68 the importance of increasing water conserving behaviors, relatively limited research has been

69 conducted to date (Hurlimann, Dolnicar & Meyer 2009).

70   This paper seeks to address the gap by testing a comprehensive model of water

71 conservation behavior. Specifically, it responds to calls by authors of previous studies (e.g.

72 Corral-Verdugo & Frias-Armanta, 2006) for studies conducted with larger sample sizes of

73 respondents from geographically diverse regions in order to increase the generalizability of

74 findings. Furthermore, our study contributes by including a comparatively large set of

75 hypothesized explanatory variables.

76

77 **1.1 Attitudes towards water conservation and water conservation behavior**

78   A significant body of work on factors contributing to positive attitudes towards water

79 conservation exists. Factors include environmental awareness (Dickinson, 2001), information

80 (Bruvold and Smith, 1988; Sah and Heinen, 2001; UNESCAP et al., 2006), being female

81 (Lipchin et al., 2005), having experienced drought (Burton et al., 2007; Kideghesho et al.,

82 2007) and perceived cost benefits (Institute for Sustainable Futures, 2003).

83   However, it is known that attitudes do not necessarily translate into actual behavior

84 (including: Bagozzi, 1978). A number of studies find the association between positive

85 attitude towards water conservation and actual water conservation behavior to be weak:

86 Miller and Buys' (2008) residential study in Australia's South East Queensland finds that

87 most participants report feeling responsible for water conservation, but this attitude is not

88 reflected in their day-to-day water use behaviors. Similar conclusions are drawn by Aitken,

89 McMahon, Wearing & Finlayson (1994), Watson, Murphy, Kilfoyle & Moore (1999), De

90 Oliver (1999), and Gregory & Di Leo (2003).

91   Using actual water conservation behavior as a dependent variable is not trivial. Only a

92 limited number of studies have used actual or reported behaviors as the dependent variables.

93   A review of these studies (see Table 1) indicates that: beliefs regarding human-environment

94   interactions; attitudes about water in general; attitudes about water conservation; information

95   sources; knowledge about water-related issues; social norms relating to water; habits;

96   perception of water crisis and knowledge about climate change, have all been identified as

97   being associated with water conservation. In addition, a number of socio-demographic

98   variables also associated with water conservation have been identified, namely: age; income;

99   education; dwelling type; property value; number of residents in the household; and not

100   owning a garden.

101

102   --

103   Insert Table 1 here

104   --

105

106   Other studies have hypothesized, but not empirically tested, other factors which may

107   reduce water consumption. For example, Troy, Holloway and Nissen (2006) find that

108   domestic water consumption in the Australian Capital Territory fell 19% between 2001 and

109   2004. Reasons hypothesized to have contributed include education programs, a lengthy

110   drought, water restrictions and demand management initiatives.

111   The main limitation of previous work is that the number of explanatory variables

112   included in the studies tend to be low. Also, many studies rely on small sample sizes, or

113   samples from a limited geographical region; Corral-Verdugo and Frias-Armenta (2006)

114   explicitly state that replication studies with larger and geographically more representative

115   samples are required. We address these limitations in our research described below.

116

2. Materials and methods

2.1 Fieldwork administration

Data was collected in January 2009 using an Australian permission-based research-only internet panel. In total, 13,884 invitations were sent out, leading to a final sample size of 3094 respondents (22% response rate) of which 1,495 respondents were representative of the Australian population with quotas set for gender, age, state and education level. The remaining 1599 respondents were not representative; instead they were collected from specific locations because of their unique water situations (see Figure 1):

(1) Adelaide – where drinking water is sourced predominantly from the River Murray and water restrictions are common;

(2) Sydney – which has experienced periodic droughts over time;

(3) Brisbane – where a significant drought period in the 2000's provided impetus for a potable recycled water scheme to deliver recycled water to dams if the water storage levels deplete below 40% of capacity;

(4) Melbourne – where after a significant drought period in the 2000's, a large scale desalination plant is being constructed with significant public opposition;

(5) Perth – where significant decreases to inflows into water storages are being experienced and where various water infrastructure projects have been constructed or are currently under construction;

(6) Darwin – a tropical location where no water shortages have been experienced;

(7) The Mallee – a regional area in the State of Victoria which has a very low average rainfall, which experienced a significant drought period in the 2000's; and

(8) Toowoomba – a regional urban centre in the State of Queensland which experienced a significant drought in the 2000's and where the public voted against a potable recycled water system in a referendum.

6

142

143   --

144   Insert Figure 1 here

145   --

146

147   The present study does not require a representative sample because the aim is to

148   identify factors which affect water conservation. Rather, it is critical that there is sufficient

149   discrimination in variables hypothesized to play a role. This is ensured by the way the sample

150   was drawn.

151   The online data collection allowed controlling for non-response: respondents could

152   not proceed without having completed all questions on a page. As a consequence, missing

153   values due to oversight or unwillingness to answer did not occur.

154   Respondents have the following socio-demographic characteristics: the mean age is

155   44 years (standard deviation 16). The youngest respondent is 14 years and the oldest 87

156   years. About half of the respondents are female (53 percent) and 37 percent have a university

157   degree. Ten percent do not provide their annual income; eight percent state they have an

158   income of less than $20,000. Between 14 and 18 percent of respondents fall into the

159   following income groups: $21,000 to $40,000, $41,000 to $60,000, $60,000-$80,000,

160   $81,000-$100,000 and over $100,000.

161

162   *2.2 Questionnaire*

163   The behavior of interest (dependent variable) in this study is self-reported past water

164   conservation behavior, which was measured using the 17 items provided in Table 2. The final

165   water conservation variable is a summated score over all 17 binary items. A value of 17 thus

166   indicated the maximum, a value of 0 minimum water conservation behavior. The average is

167   12.5 (standard deviation 2.8). The survey was accompanied by a preamble advising that "It is

168   very important that you answer all questions honestly, even if you feel that a different answer

169   would appear to be more socially desirable. This is the only way that we can learn how

170   Australians really feel about environmental issues." The aim of this preamble was to facilitate

171   accurate reporting of behavior. Internet surveys have been found to increase honest

172   responses, given that respondents feel more anonymous (Babbie, 2008).

173

174   ---

175   Insert Table 2 here

176   ---

177

178   A number of variables were included as being potentially explanatory of people's

179   stated water conservation behavior. These include variables which have previously been

180   found to influence conservation behavior, and additional factors which the authors

181   hypothesized could potentially contribute:

182   *Environmental attitudes* were measured using the 15 item New Ecological Paradigm

183   (NEP) scale (Dunlap, Van Liere, Mertig & Jones, 2000), which, according to Bragg (1996), is

184   the most widely used instrument for measuring environmental attitudes. Response options

185   were Strongly agree (2), Mildly agree (1), Unsure (0), Mildly disagree (-1), and Strongly

186   disagree (-2). Item-level responses were added to the total NEP score.

187   *Environmental concern* was measured using six items developed by Berenguer,

188   Corraliza & Martin (2005) for general environmental concern. Five response options were

189   provided. Responses were added to give the overall value for environmental concern.

190   *Altruism* was measured using Clarke, Kotchen and Moore's (2003) nine item altruism

191   scale, which is based on Schwartz's (1970; 1977) norm-activation model. Five response

192   options were provided. The total altruism value is the sum over all nine altruism items.

193   *Pro-environmental behavior* was a summated value across respondents' answers to

194   the following question: "You will now see a list of behaviors. Please indicate how frequently

195   you carried out each of these behaviors at home in the last year?" Response options were

196   Always (coded as 4), Often (coded as 3), Rarely (coded as 1), Never, and Not applicable

197   (both coded as 0). This list was first used by Dolnicar and Leisch (2008) who compiled it

198   from a number of prior publications on pro-environmental behavior.

199   A *moral obligation* to behave in an environmentally friendly way has been shown to

200   be a good predictor of pro-environmental behavior. For example, Berenguer et al. (2005) find

201   moral obligation to be the best predictor of pro-environmental behavior, and Dolnicar and

202   Leisch (2008) find moral obligation to be a useful segmentation base to identify subgroups of

203   the population with distinct levels of pro-environmental behavior. We used the following

204   wording for the single item measure: "Do you consider yourself morally obliged to carry out

205   environmentally friendly behaviors?" Respondents answered with Yes (1) or No (0).

206   *Knowledge and perception* of (or attitudes to) recycled and desalinated water were

207   measured with 30 items developed by Dolnicar and Schäfer (2006) and subsequently used

208   also in Dolnicar and Schäfer (2009). Respondents answered with Yes (1) or No (0). The final

209   measure was derived by summing across all items.

210   *Active involvement in searching for information about water* was measured using a

211   single item asking respondents: "How much effort have you made this year to look for

212   information on water-related issues (water recycling, desalination, water conservation, rain

213   water etc.)?" Respondents had four response options: Absolutely no effort (coded as 0), A

214   small effort (1), A big effort (2), and A huge effort (3). Trumbo and O'Keefe (2005) found

215 information to be a significant factor with regard to explaining conservation behavior. They

216 measured 'information' as a three component variable, two components included 'seeking'

217 and 'attention'.

218   *Previous use of recycled / desalinated water* was measured using a single item

219 worded as follows: "Have you ever used recycled water / desalinated water?" Answer options

220 included Yes (1) and No (0).

221   *Experience with water restrictions* was measured by asking respondents "Have you

222 ever experienced water restrictions?" Answer options were Yes (1) and No (0).

223   *Perception of being limited by water restrictions* was measured by asking "To which

224 extent do you feel limited by water restrictions?" Answer options were: Not at all (0),

225 Slightly (1), and Strongly (2). For analysis, slightly and strongly were collapsed.

226   *People who influence* was computed as the sum over 14 items which listed different

227 social sources of influence, e.g. friends, partner, scientist etc. Answer options were Yes (1)

228 and No (0).

229   Finally, a number of socio-demographic questions were asked covering age, gender,

230 education, size of city, cultural background, feeling of belonging to the region, importance of

231 religion, their relocation intention if water supply could not be assured, whether or not water

232 restrictions in the past have led them to change their behavior, media use in general (to

233 measure 'exposure' to information about water issues – the third component of information

234 measured by Krumbo and O'Keefe 2005), and whether or not they have read, heard, or seen

235 any specific information about water recently.

236

237 *2.3 Analyses*

238   We conducted two analyses to gain an understanding of the factors that affect water

239 conservation behavior. First we conducted a regression analysis. All of the proposed

240   independent variables were assumed to affect conservation behavior. A multivariate linear

241   regression model was fitted using water conservation behavior as the metric dependent

242   variable. Variables were selected by omitting the variable with the largest p-value and then

243   comparing the two nested models – the one including this variable with the one without this

244   variable – using an F-test (backward selection). The selection process was stopped when all

245   p-values were larger than a pre-specified significance level of five percent. The final model

246   only contains variables which, if omitted, would significantly reduce the variance explained

247   by the fitted model.

248   The final model was analyzed with respect to (1) the variables included, (2) the

249   relative importance of each variable selected, and (3) the estimated coefficients for each of

250   the variables. To assess the relative importance of the variables, the "dominance" statistic, C,

251   is used to take into account the direct and indirect effects of the variable on the dependent

252   variable (see Budescu, 1993). The comparison of the dominance values of two variables

253   indicates that the variable with the higher dominance value is more useful in all subset

254   regressions and therefore has a higher relative importance. The linear regression analysis

255   assumes that no interaction effects between the explanatory variables occur and that they

256   influence the dependent variablein the same way regardless of the values of the other

257   explanatory variables.

258   Decision trees are an alternative model especially designed to detect interaction

259   effects and find groups of respondents with similar levels of conservation behavior (Breiman,

260   Friedman, Olshen & Stone, 1984). This analysis reflects the need to view people as a

261   heterogeneous group, rather than assuming that they all behave in the same way, which was

262   recently highlighted by the findings of Dolnicar and Grün (2008), that environmentally

263   friendly behavior differs both across different groups of people as well as within people

264   across context. Decision trees have the advantage that they (1) account for complicated

265   interactions between variables, (2) are easily interpretable, and (3) inherently perform

266   variable selection. This model is fitted to the data to gain complementary insights into those

267   gained by the regression model, and to verify if neglecting potential interaction effects

268   influences the results and conclusions drawn. Unbiased recursive partitioning (Hothorn,

269   Hornik & Zeileis, 2006) is used as the fitting method for this study's decision tree. The fitting

270   method recursively partitions the data into two subsets using binary splits. Each split is made

271   on the basis of one independent variable and leads to subgroups with similar conservation

272   behaviors. The method is therefore regarded as an a priori (Mazanec, 2000) or commonsense

273   segmentation (Dolnicar, 2004) of the respondents.

274   Recursive partitioning is an iterative method consisting of the following steps: (1)

275   determining whether or not a splitting variable exists which can improve the model fit and, if

276   so, (2) splitting respondents into sub-groups using this variable. Different recursive

277   partitioning procedures vary in the way they measure the dependency between each

278   explanatory variable and the dependent variable, as well as how the split is made. Unbiased

279   recursive partitioning applies conditional inference procedures for selecting the splitting

280   variable which gives unbiased variable selection results. Alternative procedures have the

281   drawback that variables with many possible splits, or variables with many missing values, are

282   systematically favored (Breiman et al., 1984). In addition, in unbiased recursive partitioning,

283   a natural stopping criterion for the procedure exists: the iterative process stops if the null

284   hypothesis that all explanatory variables are independent of the dependent variable cannot be

285   rejected at the pre-specified significance level of five percent. The considered splits are

286   binary, meaning that each step leads to the division of one sub-group into two new sub-

287   groups.

288

3. Results and discussion

289

290   The regression analysis explains 33 percent of the variance in the dependent variable,

291   conservation behavior. Results are provided in Table 3 including the regression coefficient

292   estimate, the standard error, and the *p*-value of the *t*-test if the regression coefficient is

293   significantly different from 0. The variables are ordered by importance. In addition the

294   generalized variance-inflation factors (GVIFs, Fox and Monette, 1992) are provided for each

295   variable. The GVIFs range from 1.0 to 2.0 for all variables included in the final regression

296   model indicating that multi-collinearity is not a problem. The metric variables were

297   standardized before regression analysis and their regression coefficients can be interpreted as

298   change in water conservation behavior if the explanatory variable changes by one standard

299   deviation. For binary variables, the coefficient indicates the change in water conservation

300   behavior if the answer is Yes instead of No. For categorical variables, the baseline category

301   included in the intercept is indicated in parentheses and the estimated coefficients for change

302   in water conservation behavior for the other categories when compared to the base category

303   are given in the table. For example, the water conservation behavior of respondents who state

304   that they watch non-commercial TV channels is 0.36 lower than for respondents who do not

305   watch TV.

306   Figure 2 contains standardized regression coefficients. All factors that positively

307   affect water conservation behavior plot to the right of the vertical axis and all factors that

308   affect behavior negatively plot to the left. The length of each bar indicates the extent of the

309   effect, which can be interpreted as how much the water conservation behavior changes in

310   standard deviations if the explanatory variable is increased by one standard deviation.

311   The dominance statistic indicates that general pro-environmental behavior is the best

312   predictor of water conservation behavior, followed by people's active involvement in

313   searching for information about water. Information seeking behavior was included in

13

314 Trumbo and O'Keefe's (2005) study which measured 'information' as a three component

315 variable: seeking, exposure and attention. They also found information to be a significant

316 factor with regard to explaining conservation behavior.

317   Furthermore, water conservation behavior is positively associated with: behavioral

318 change due to water restrictions experienced in the past; previous use of recycled water;

319 considering relocation if there was insufficient water in their area; feeling morally obliged to

320 behave in an environmentally friendly manner; susceptibility to influence from others; not

321 having a university degree; no previous use of desalinated water and not watching TV and/or

322 reading quality newspapers, which were defined as broadsheets distributed nationally.

323

324   ------------------------------------

325   Insert Table 3 and Figure 2 here

326   ------------------------------------

327

328   Figure 3 contains results of the recursive partitioning analysis. Recursive partitioning aims

329 to identify which variables best discriminate between segments of the population with

330 different levels of conservation behavior. These variables are shown as ellipses at the top part

331 of the chart. The final segments are shown at the bottom of Figure 3. As can be seen,

332 respondents have been split into 15 segments. Each of the segment plots at the bottom of

333 Figure 3 shows the distribution of water conservation behavior among members of this

334 segment. For example, Segment 1 on the far left, has a very low average level of water

335 conservation (6.4 on a scale of 17), as opposed to Segment 15 on the far right (14.6). The

336 recursive partition model explains 33 percent of the variance. The numbers of respondents in

337 each segment are, from left to right, 44, 23, 101, 262, 112, 165, 100, 473, 505, 263, 194, 316,

338 127, 43, and 366.

14

339   The top section of Figure 3 provides insight into which variables best discriminate

340   between those segments. As can be seen, pro-environmental behavior again emerges as the

341   most crucial explanatory variable. The top three splits all use this variable and separate out

342   those people with high (to the very right) and low (to the very left) water conservation

343   behavior scores.

344

345   ---------------------------------

346   Insert Figure 3 here

347   ---------------------------------

348

349   Among those respondents who demonstrate a very low level of pro-environmental

350   behavior (segments along the left branch), having made little effort in seeking out

351   information best describes the group with the lowest level of water conservation behavior.

352   The group with the highest level of conservation behavior is defined only by the variable of

353   pro-environmental behavior; no additional variables contribute to a further splitting of this

354   group. Other variables identified as discriminating between high and low conservation

355   behavior levels in the intermediate segments include: effort undertaken to search for water

356   information, extent of behavioral change due to water restrictions, and previous experience

357   with recycled water use. In addition, previous experience with water restrictions, as well as

358   the feeling of being limited by water restrictions, both emerge as good discriminating

359   variables in this model. Several variables included in the regression model, but with a rather

360   small influence, are not present in the decision tree. Of those variables not included in the

361   decision tree, only moral obligation emerges as an important factor in the regression model.

362   However, the proportion of respondents feeling morally obliged differs significantly over the

363   segments, as indicated by a χ^2-test (Deviance difference = 439, df = 14, p-value < 0.001).

15

364   Respondents assigned to segments in the right part of the tree are more likely to feel morally

365   obliged whereas the respondents in Segment 1 in the far left of the tree feel the least morally

366   obliged to behave in an environmentally friendly way.

367   Because recursive partitioning accounts for interaction effects between explanatory

368   variables the decision tree allows checking (1) if the additivity assumption of the main effects

369   of the explanatory variables in the regression is justified and (2) if some variables have a

370   different effect depending on other variables. The repeated inclusion of the variable pro-

371   environmental behavior indicates that the decision tree aims at approximating the linear

372   relationship between this variable and the dependent variable using a step function. This

373   means that the decision tree confirms the linear relationship between these two variables. In

374   addition the decision tree also indicates that for respondents who already have a very high

375   level of pro-environmental behavior no other variable is able to increase the water

376   conservation behavior. This indicates that the additivity assumption of the different

377   explanatory variables does only hold for respondents who do not have an extremely positive

378   pro-environmental behavior.

379

380   **4. Conclusions**

381   The aim of this research was to conduct a comprehensive empirical study that would

382   contribute to our understanding of the relative impact of different factors on people's (self-

383   reported past) water conservation behavior. We tested some explanatory variables which had

384   been shown in previous research to positively influence water conservation behavior. These

385   variable included: information (Dziegielewski, 1991; Watson et al., 1999; Hills et al., 2002;

386   Trumbo and O'Keefe, 2005); environmental attitudes measured using the New Ecological

387   Paradigm (Corral-Verdugo et al., 2003, 2006); and a range of demographic variables

388   including age (Clark and Finley, 2007; Miller and Buys, 2008); and education (Clark and

389 Finley, 2007). Additionally, we went beyond existing empirical research regarding water

390 conservation behaviors to include possible explanatory variables which had not yet been

391 tested.

392   A number of factors are strongly related to water conservation behavior, with the

393 strongest predictors of (self-reported) water conservation behavior being:

394   (1) General pro-environmental behavior. Water conservation is strongly related to pro-

395   environmental behavior; people are likely to engage in water conservation behavior

396   because they are interested in protecting the environment in general or conserving

397   limited natural resources. People who conserve water not only behave in an

398   environmentally friendly way, they also tend to feel morally obliged to behave in this

399   way.

400   (2) Efforts made to find information about water related matters. The fact that those who

401   conserve water also make a significantly greater effort to find information about water

402   indicates that they are proactively interested in water-related matters. They seek out

403   information and are likely to base their behavior on the information obtained.

404   While these two findings are very robust, they are not of particular practical use since

405 people who are already conscious about environmental issues and actively seek out water

406 related information do not need to be convinced in public information campaigns that they

407 should conserve more water. The only public policy implication that can be derived from the

408 above findings is that efforts should be made to increase the general level of environmental

409 awareness among the population.

410   Nonetheless, a number of other factors have emerged from this study as being

411 significantly associated with water conservation behavior. Some of these are very suitable for

412 informing the development of public information campaigns to increase water conservation,

413 specifically: previous experience of water restrictions; being limited by water restrictions;

414 and past changes in behavior due to water restrictions. These factors all lead to increased

415 water conservation behavior. A clear communication strategy can be derived from these

416 findings. Namely, messages should make the population aware of the negative personal

417 consequences they will experience in the case of insufficient water supplies, and should also

418 show people how, through communal efforts, they can avoid such consequences.

419 The significant association between media usage and water conservation behavior which

420 was revealed by the regression analysis also leads to practical recommendations about which

421 communication channels should and should not be used to communicate messages. Since

422 people who already engage in water conservation behaviors tend to watch less TV and read

423 more newspapers, TV would be a good communication channel for reaching those whose

424 water conservation behaviors could be improved. Newspapers are not a good choice except if

425 they are local newspapers, which tend to be read more by people with low levels of water

426 conservation behavior.

427 The main contribution of the present study was to simultaneously test for a wide range of

428 factors which may explain stated water conservation behavior. This has led to novel insights,

429 including the identification of factors which have only low potential to be useful in public

430 information campaigns which aim to increase water conservation behavior. Conversely,

431 insights have also been made in regards to identifying communication messages and

432 strategies most likely to attract the attention of the Australian population to encourage water

433 conservation behaviors. These may also be applicable to other developed nations. As

434 demonstrated in the introduction to this paper, achieving increased water conservation is

435 critical to ensuring the sustainable management of water resources and is particularly

436 paramount in light of changing climatic conditions.

437 The present study uses the predominant measure applied in the past in water conservation

438 studies, namely self-reported water conservation behavior (see Table 1). Future work

18

439   replicating this and other water conservation behavior studies with an actual behavior

440   measure as dependent variable, as opposed to the self-reported past behavior measure which

441   has been shown by Hamilton (1985) to be somewhat biased, is recommended.

447

448   **References**

449   Aitken, C., McMahon, T.A., Wearing, A.J., Finlayson, B.L., 1994. Residential water use:

450   Predicting and reducing consumption. Journal of Applied Social Psychology, 24, 136-

451   158.

452   Ajzen, I., 1985. From intentions to actions: A theory of planned behaviour. In J. Kuhl and J.

453   Beckman, (Eds.), Action-Control: From Cognition to Behaviour. Heidelberg: Springer,

454   pp. 11-39.

455   Babbie, E., 2008. The basics of social research. Belmont, California: Wadsworth Publishing.

456   Bagozzi, R.P., 1978. The construct validity of the affective, behavioral and cognitive

457   components of attitude by analysis of covariance structures. Multivariate Behavioral

458   Research, 13, 9-31.

459   Berenguer, J., Corraliza, J.A., Martin, R., 2005. Rural-urban differences in environmental

460   concern, attitudes, and actions. European Journal of Psychological Assessment, 21,

461   128-138.

462   Bragg, E.A., 1996. Towards ecological self: deep ecology meets constructionist self-theory.

463   Journal of Environmental Psychology, 16, 93-108.

464   Breiman, L., Friedman, J., Olshen, R.A., Stone, C.J., 1984. Classification and regression

465   trees. Monterey, California: Wadsworth & Brooks/Cole Advanced Books & Software.

466   Bruvold, W.H., Smith, B.R., 1988. Developing and assessing a model of residential water

467   conservation. Water Resources Bulletin, 24, 661-669.

468   Budescu, D.V., 1993. Dominance analysis: A new approach to the problem of relative

469   importance of predictors in multiple regression. Psychological Bulletin, 114, 542-551.

470   Burton, M., Marsh, S., Patterson, J., 2007. Community attitudes towards water management

471   in the Moore Catchment, Western Australia. Agricultural Systems, 92, 157-178.

21

472 Clarke, C. F., Kotchen, M. J., Moore, M. R., 2003. Internal and external influences on pro-

473   environmental behavior: Participation in a green electricity program. Journal of

474   Environmental Psychology, 23, 237-246.

475 Corral-Verdugo, V., Bechtel, R. B., Fraijo-Sing, B., 2003. Environmental beliefs and water

476   conservation: An empirical study. Journal of Environmental Psychology, 23, 247-257.

477 Corral-Verdugo, V., Frias-Armenta, M., 2006. Personal normative beliefs, antisocial

478   behavior, and residential water conservation. Environment and Behavior, 38, 406-421.

479 De Oliver, M., 1999. Attitudes and inaction: A case study of the manifest demographics of

480   urban water conservation. Environment and Behavior, 31, 372-394.

481 Dickinson, K., 2001. Urban water conservation: Consumer attitude, environmental policy

482   tools and the implications for sustainable development. Melbourne, Australia:

483   University of Melbourne.

484 Dolnicar, S., 2004. Beyond 'commonsense segmentation' – a systematics of segmentation

485   approaches in tourism. Journal of Travel Research, 42, 244-250.

486 Dolnicar S., Grün, B., 2008. Environmentally friendly behavior – can heterogeneity among

487   individuals and contexts / environments be harvested for improved sustainable

488   management? Environment and Behavior, 41, 693-714.

489 Dolnicar, S., Schäfer, A. I., 2006. Public perception of desalinated versus recycled water in

490   Australia. In Proceedings of the 1st Annual Desalination Symposium, Honolulu Hawaii,

491   7-9th May 2006. Denver: American Water Works Association.

492 Dolnicar, S., Schäfer, A. I., 2009. Desalinated versus recycled water: Public perceptions and

493   profiles of the accepters. Journal of Environmental Management, 90, 888-900.

494 Dolnicar, S., Leisch, F., 2008. An investigation of tourists' patterns of obligation to protect

495   the environment. Journal of Travel Research, 46, 381-391.

496   Dunlap, R. E., Van Liere, K. D., Mertig, A. G., Jones, R. E., 2000. Measuring endorsement of

497   the New Ecological Paradigm: A revised NEP scale. Journal of Social Issues, 56, 425-

498   442.

499   Dziegielewski, B., 1991. "The drought is real": Designing a successful water conservation

500   campaign. In Proceedings of the International Seminar on Efficient Use of Water,

501   Mexico City, October 1991. Mexico: International Water Research Association.

502   Fox, J., Monette, G., 1992. Generalized Collinearity Diagnostics. Journal of the American

503   Statistical Association, 87, 178-183.

504   Government of Victoria, 2006. Sustainable water strategy: Central Region action to 2055.

505   Melbourne, Australia: Department of Sustainability and Environment.

506   Gregory, G. D., Di Leo, M., 2003. Repeated behavior and environmental psychology: The

507   role of personal involvement and habit formation in explaining water consumption.

508   Journal of Applied Social Psychology, 33, 1261-1296.

509   Hamilton, L. C., 1985. Self-reported and actual savings in a water conservation campaign.

510   Environment and Behavior, 17, 315-326.

511   Hothorn, T., Hornik, K., Zeileis, A., 2006. Unbiased recursive partitioning: A conditional

512   inference framework. Journal of Computational and Graphical Statistics, 15, 651-674.

513   Hurlimann, A., 2007. Time for a water re-'vision'. Australasian Journal of Environmental

514   Management, 14, 11-18.

515   Hurlimann, A., and Dolnicar, S., 2011. Voluntary relocation - an exploration of Australian

516   attitudes in the context of drought, recycled and desalinated water. Global

517   Environmental Change, 21, 1084-1094.

518   Hurlimann, A., Dolnicar, S., Meyer, P., 2009. Understanding behaviour to inform water

519   supply management in developed nations - A review of Literature, conceptual model

520   and research agenda. Journal of Environmental Management, 91, 47-56.

521   Institute for Sustainable Futures, 2003. Urban water demand forecasting and demand

522   management: research needs review and recommendations. Melbourne, Australia:

523   Institute for Sustainable Futures, and University of Technology, Sydney.

524   Intergovernmental Panel on Climate Change, 2007. Climate change 2007: Impacts,

525   adaptation and vulnerability. Contribution of Working Group II to the Fourth

526   Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge:

527   Intergovernmental Panel on Climate Change.

528   Kideghesho, J. R., Roskaft, E., Kaltenborn, B. P., 2007. Factors influencing conservation

529   attitudes of local people in Western Serengeti, Tanzania. Biodiversity and

530   Conservation, 16, 2213-2230.

531   Lipchin, C. D., Antonius, R., Roishmawi, K., Afanah, A., Orthofer, R., Trottier, J., 2005.

532   Public perceptions and attitudes towards the declining water level of the Dead Sea

533   Basin: A multi-cultural analysis. In S. Schoenfeld (Ed.), Palestinian and Israeli

534   environmental narratives. Toronto: Centre for International and Security Studies, York

535   University.

536   Mazanec, J. A., 2000. Market segmentation. In J. Jafari (Ed.), Encyclopedia of Tourism (pp.

537   125-126). London: Routledge.

538   Miller, E., Buys, L., 2008. The impact of social capital on residential-affecting behaviours in

539   a drought-prone Australian community. Society & Natural Resources, 21, 244-257.

540   Russell, S., Fielding, K., 2010. "Water demand management research: a psychological

541   perspective" Water Resources Research, 46, WO5302.

542   Sah, J. P., Heinen, J. T., 2001. Wetland resource use and conservation attitudes among

543   indigenous and migrant peoples in Ghodaghodi Lake area, Nepal. Environmental

544   Conservation, 28, 345-365.

545 Schiffler, M., 2004. Perspectives and challenges for desalination in the 21st century.

546 Desalination, 165, 1-9.

547 Schwartz, S. H., 1970. Elicitation of moral obligation and self-sacrificing behavior. Journal of

548 Personality and Social Psychology, 15, 283-293.

549 Schwartz, S. H., 1979. Normative influences on altruism. In L. Berkowitz (Ed.), Advances in

550 experimental social psychology (Vol. 10, pp. 221-279). New York: Academic Press.

551 Troy, P., Holloway, D., Nissen, K., 2006. Domestic water consumption in the ACT.

552 Canberra: Australian National University College of Science.

553 Trumbo, C. W., & O'Keefe, G. J., 2005. Intention to conserve water: Environmental values,

554 reasoned action, and information effects across time. Society & Natural Resources, 18,

555 573-585.

556 UNESCAP, UNESCO, and Tehran Province and Tehran City Water and Wastewater

557 Companies, 2006. Tehran water conservation demonstration project at the Nasim

558 residential complex. Retrieved June 15, 2010 from

559 http://www.unescap.org/esd/water/conservation/2005/Brochure.pdf.

560 Watson, R., Murphy, M., Kilfoyle, F., Moore, S., 1999. An opportunistic field experiment in

561 community water conservation. Population and Environment, 20, 545-560.

562

Table 1: Factors found to influence water conservation behaviors in select past research

Factor which positively influences water conservation	Study	Behavior measurement A= actual; S = self-reported; E = estimated; I = stated intention	Format tested S = single variable; M = multiple variable
Involvement in water consumption decisions	Gregory & Di Leo (2003)	A	M
Information	Trumbo & O'Keefe (2005)	S	M
	Dziegielewski (1991)	S	S
	Watson et al. (1999)	S	M
	Hills et al. (2002)	A	S
Positive attitude to water conservation	Syme et al. (2004)	E	M
	Murphy et al. (1991)	S	M
	Moore et al. (1994)	S	M
	Cameron and Wright (1990)	S	M
Ecological beliefs about water (e.g. is a limited resource – using the New Ecological Paradigm Scale)	Corral-Verdugo et al. (2003)	S	M
	Corral-Verdugo et al. (2006)	S	M
Media interventions	Moore et al. (1994)	S	M
Behavioral intention	Murphy et al. (1991)	S	M
	Watson et al. (1999)	S	M
	Moore et al. (1994)	S	M
Knowledge of water conservation related issues	Murphy et al. (1991)	S	M
	Gregory & Di Leo (2003)	A	M
	Moore et al. (1994)	S	M
	Hamilton (1985)	A	S
Social norms regarding water conservation	Trumbo & O'Keefe (2005)	S	M
	Corral-Verdugo et al. (2003)	S	M
	Corral-Verdugo et al. (2006)	S	M
	Lam (1999)	I	M
	Clark and Finley (2007)	I	M
Beliefs regarding human-environment interactions	Corral-Verdugo et al. (2008)	S	M
Perception / concern of / about water crisis / drought	Bruvold (1979)	S	M
	Lam (2006)	S	M
	Clark and Finley (2007)	I	M
Awareness about climate change	Clark and Finley (2007)	I	M
Habits: fostering low water use	Gregory & Di Leo (2003)	A	M
DEMOGRAPHIC FACTORS			
Age: older respondents	Miller & Buys (2008)	S	M
	Clark and Finley (2007)		
Income: lower income respondents	Miller & Buys (2008)	S	M
	Gregory & Di Leo (2003)	A	M
	Corral-Verdugo et al. (2003)	S	M
Education: lower	Clark and Finley (2007)	I	M
Not owning a garden	Clark and Finley (2007)	I	M

Living in a detached dwelling	Miller & Buys (2008)	S	M
	Clark and Finley (2007)	I	M
Net annual property value (negative)	Aitken et al. (1991)	A	M
	Aitken et al. (1994)	A	M
Number of residents per household (negative)	Aitken et al. (1991)	A	M
	Aitken et al. (1994)	A	M

564 Note: references included in the table are not in the reference list. They are included in the
565 supplementary material available online.

Table 2: Water conservation items used to construct the dependent variable (water conservation behavior)

I collect water from shower/sink/bath for use elsewhere
I take shorter showers
I make sure that taps do not drip
I strictly adhere to water restrictions
I collect water when it rains (not in a rainwater tank)
I have a dual flush toilet
I rarely water the garden
I recycle grey water from the washing machine for garden / outdoor use
I recycle grey water from the shower for garden / outdoor use
I minimize toilet flushing where possible
I use water efficient showerheads
I use water efficient taps
I only use the washing machine when it is full
I only use the dishwasher when it is full
I do not wash my car with water
I use minimal water for cleaning
I do not hose my driveway

585 **Table 3: Summary of the final linear regression model including information on the**

586 **dominance C and the generalized VIF (GVIF) for each variable and the regression**

587 **coefficient estimates (Estimate) with corresponding standard errors (Std.Error) and *p*-**

588 **values of *t*-tests.**

|	Dominance C (%)	GVIF	Estimate	Std. Error	*p*-value
Intercept	–	-	12.14	0.43	< 0.001
Pro-environmental behavior (Stronger)	58.2	1.5	1.19	0.05	< 0.001
Active involvement in searching for information about water (Higher)	19.2	1.3	0.39	0.05	< 0.001
Moral obligation	7.3	1.2			
– Yes			0.34	0.13	0.007
Behavioral change due to water restrictions	6.3	1.0			
– Yes			0.79	0.12	< 0.001
Previous use of recycled water	3.5	1.1			
– Yes			0.38	0.09	< 0.001
Extent of influence of others (Stronger)	1.8	1.1	0.08	0.04	0.046
Likelihood of relocation (Higher)	1.3	1.0	0.12	0.04	0.003
Education level	0.9	1.1			
– University degree			-0.35	0.09	< 0.001
Previous use of desalinated water	0.8	1.1			
– Yes			-0.53	0.12	< 0.001
Watch TV (Don't watch)	0.4	1.1			
– Private / commercial			-0.36	0.41	0.370
– State / non-commercial			-0.65	0.41	0.117
Read Newspaper (Quality)	0.4	1.1			
– Local			-0.21	0.09	0.015
– None			-0.05	0.18	0.773

589 Explained variance: $R^2 = 0.33$

590 Watch TV: Respondents indicated if (1) they don't watch TV or their favorite TV channel is

591 (2) a private / commercial channel or (3) a state / non-commercial channel.

592 Read Newspaper: Respondents indicated if their favorite newspaper is (1) a quality

593 newspaper or (2) a local newspaper or (3) if they do not read newspapers.
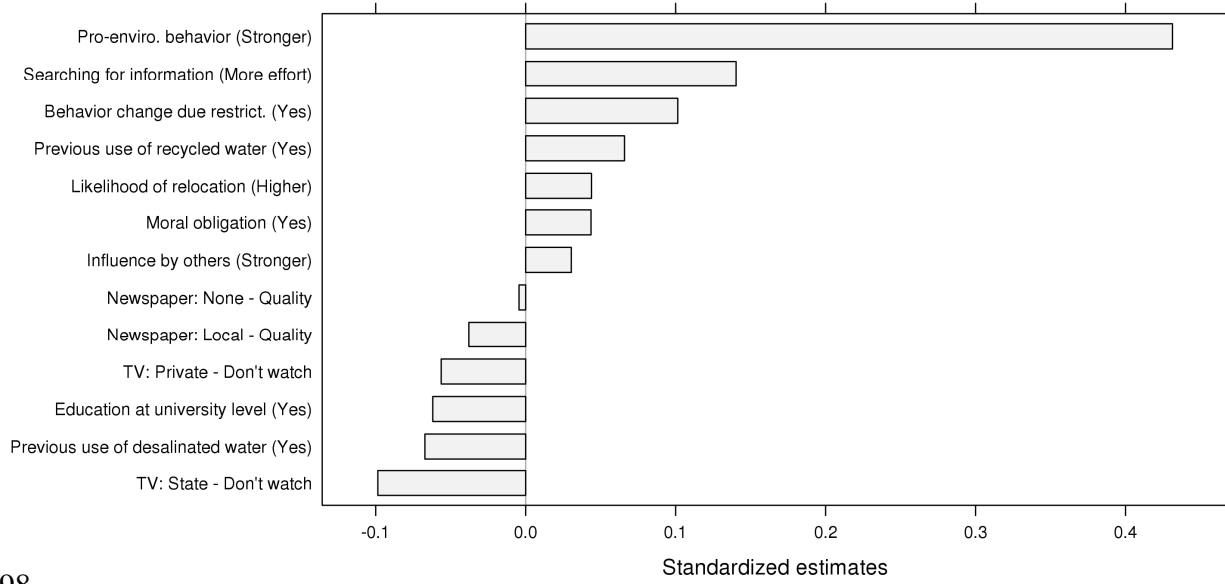
29

594 **Figure 1: Map of Australia indicating the locations of study**
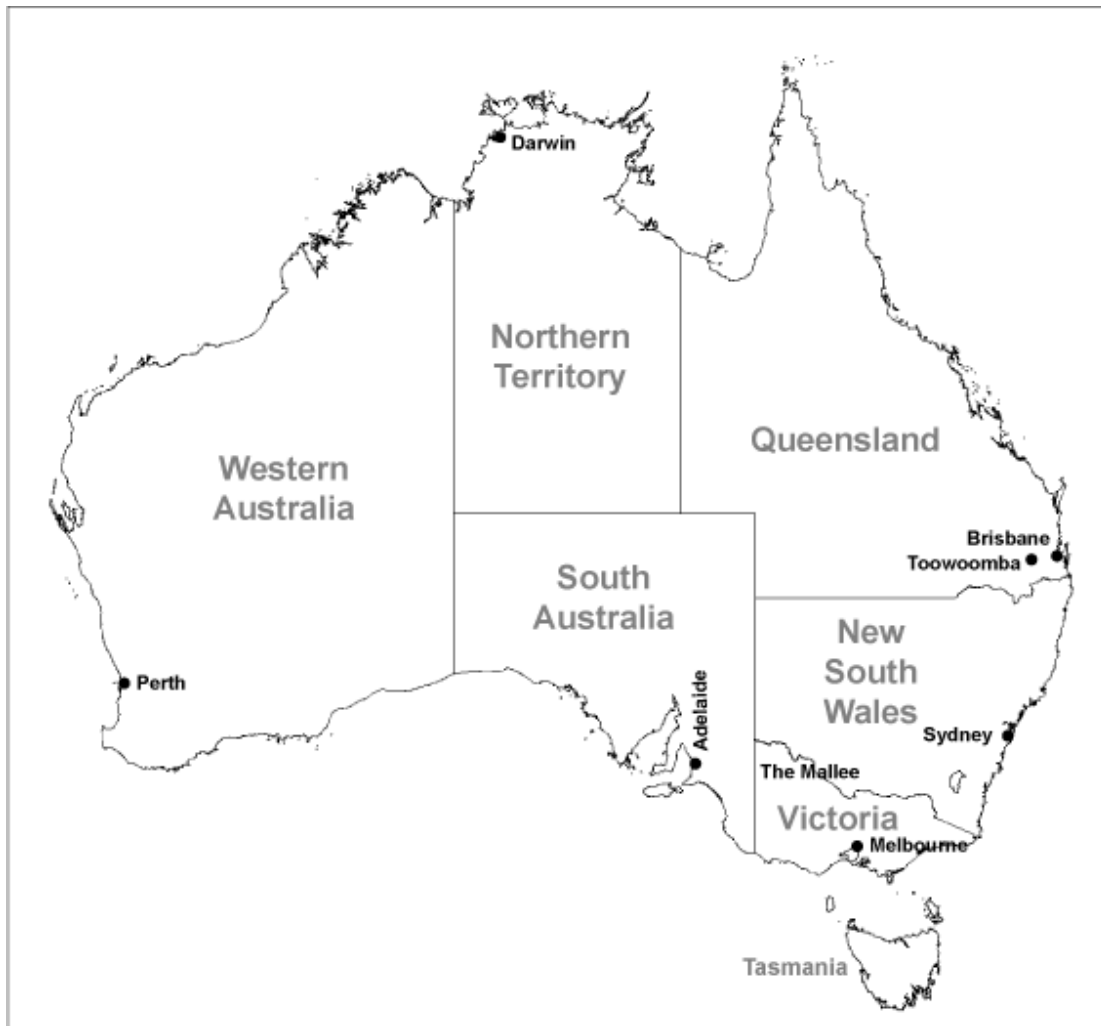
595

596   Source: Hurlimann and Dolnicar (2011). Reproduced by permission of Global Environmental Change, Elsevier

597   Figure 2: Standardized regression coefficients for the water conservation behavior model

598

599   Figure 3: Recursive partitioning results for water conservation behavior

600

601   Low water conservation   High water conservation

602   Explained variance: 0.33

603