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# Predicting and understanding home garden water use

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**Abstract**

There is now substantial literature describing the importance of home gardens for a variety of quality of life variables such as avoidance of stress, recreation and personal and social identity. From a water resource management perspective it is reasonable to hypothesise that those households that gain the most personal benefits from their gardens will use more water. Consideration of the relationship between quality of life and external water use needs to be made if policies in relation to demand management, supply reliability and restrictions are to reflect community values adequately. In this study, estimates were made of external water use, the total water use outside home (e.g. on lawns, gardens, or swimming pools) for 397 households in detached housing in Perth, WA. Measurements were made of a variety of socio-demographic variables which may affect water use. These included income, block size, swimming pool ownership and so on. In addition five latent attitudinal or quality of life variables were measured. These were the importance of garden and natural space for personal lifestyle satisfaction, interest in gardening, attitudes towards the garden as a source of recreation, attitudes to water conservation and a social desirability scale. External water use was modelled using structural equations with the latent variables. The expected socio-demographic variables such as block size or swimming pool ownership were found to influence water use. Lifestyle, garden interest and garden recreation activities were found to be related but all had a direct influence on external water use. Attitudes towards water conservation unlike previous studies also directly affected external usage. It appeared that the interaction between attitudinal and socio-demographic influences were minimal on external water use. The significance of these findings for evaluating the performance of water utilities on the social dimension of sustainability is discussed. Finally, the need for appropriate specificity in attitudinal and water use measurement in demand prediction studies is highlighted.


*Keywords:* External water use; Water conservation; Social desirability; Quality of life

## 1. Introduction

Water conservation in urban areas is an issue of increasing importance to urban utilities. Significant amounts of water are used on gardens. For example in Perth, WA, the external water use, or the total amount of water people used outside their home (e.g. on lawns, gardens or swimming pools) accounts for 56% of total domestic usage. Almost all of this water is used for watering lawn and garden (Loh and Coghlan, 2003). Even for multi-residential households (e.g. duplexes, triplexes, townhouses/units), the main water use is outside the home watering lawns and gardens. Despite this, external water use is often considered the most expendable. It is often targeted by the application of restrictions during water shortages and is regularly one of the main components of media based campaigns to save water. A questionnaire based price elasticity

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study (Thomas and Syme, 1988) has also shown that external use was likely to be substantially more sensitive to price changes than indoor use.

Perth (WA) residents have been shown to be reasonably tolerant of moderate restrictions on external water use (Syme et al., 1989; Nancarrow et al., 2002). The apparent flexibility in external water use however, does not mean that access to water for gardens is not an important issue. There have been many benefits demonstrated for the maintenance of a good garden. Gardens provide significant recreation and psychological benefits (Halkett, 1978; Constantine, 1981; Kaplan and Kaplan, 1990), economic returns (Syme et al., 1980), sense of place (Sime, 1993) and play an important function in terms of one's relationships with family and friends (Bhatti and Church, 2000). Home gardens are also seen as an extension of an individual's psychological home (Sigmon et al., 2002) and to some extent can reflect 'fashion' in terms of current trends in social presentation or the community's relationship with nature (e.g. Bhatti, 1999).

Whether and how such functions relate to water use in the garden is however a moot point. If they do it is reasonable to consider quality of life as part of planning for reliability in water supply for gardening. As Bhatti (1999) pointed out, despite the tendency for higher density living the role of gardening and gardens in community life in countries such as Great Britain has expanded rather than contracted in recent times. The continued development of suburban estates with detached housing in Australia and other developed countries also reflects a long lasting attachment to gardens.

Despite the social significance of gardens, no studies have examined the relationship between household attitudes towards garden and gardening, and their external water consumption. Studies in the past correlated garden based attitudes with the total household water consumption, instead of external water use only. The results of these studies have been inconsistent. For example, Syme et al. (1990/1991) in their Perth study found that there were significant correlations between the attitudes of husbands and wives towards their garden and the overall annual water consumption for their household. In particular, families who regarded their garden as making a greater contribution to the resale value of their house tended to use more water over the year. And so did families who enjoyed the recreational amenity of their garden more. These relationships were however not found in an earlier study (Syme et al., 1980). The discrepancies may have been because the earlier study was conducted during a drought, only one member of the household was interviewed and an alternative water tariff system was in force. Nevertheless, Aitken et al. (1994) in their Melbourne study also found that attitudes towards water use were poor predictors of household water use when measured twice a week for 2.5 months over winter. Aitken et al. (1994) acknowledged that the lack of correlation might have been because their water measurements were undertaken during winter months when garden watering was minimal. Similar to other studies, Aitken et al. (1994) also failed to make the distinction between internal versus external water use attitudes, or internal and external water consumption.

Overall it could be postulated that the inconsistent results in determining the relationship between household water use and their attitudes toward garden could be due to the inappropriate use of total household water consumption figures. This is, of course, understandable given the lack of credible estimates of household external consumption available to the researchers. Such an estimate has recently become available in Perth. Water consumption inside the home in Perth has been found to be relatively stable across seasonal variations (Water Authority of Western Australia, 1987; Loh and Coghlan, 2003), different socio-economic groups (i.e. high, medium and low income groups) and housing types (i.e. single and multi-residential households) (Loh and Coghlan, 2003). The variations in internal water consumption were often dependent upon the household size and appliance ownership, rather than household attitudes.

Because of the seasonal consistency of internal water use and the conduct of the Domestic Water Use Study (DWUS) by the Water Corporation of Western Australia and Australian Research Centre for Water in Society (ARCWIS, 2002) over a period of 16 months from the summer of 1998 to the end of summer in 2000, an opportunity to gain an accurate estimate of external water use of a sample of 720 homeowners or renters in Perth occurred. The present study examines the implications of household attitudes towards garden and gardening, and lifestyle preferences for external water consumption. The research also examines other

socio-demographic factors that may influence the external water consumption.

The DWUS study incorporated three questionnaires which were administered at different times. The 'appliance' questionnaire, which included both household and demographic data was administered when the respondents were first recruited prior to the first summer of 1998/1999. At the conclusion of the first summer, the respondents were asked to complete a 'community attitudinal' questionnaire which was repeated again the same time the following year.

The attitudinal and life style questions were repeat or improved measures used in the Syme et al. (1990/1991) study and new measures specifically targeted at external water use. These included scales of attitudes towards water conservation, interest in gardening as an activity and attitudes towards the garden as a recreational resource. The lifestyle questions asked the respondents about the importance of green areas and gardens to their preferred lifestyle and how often garden-based leisure, gardening activities and irrigation activities were undertaken and how enjoyable they were. Lifestyle issues were rounded off with questions about how much time was spent in the garden for leisure, whether gardening was seen as work or leisure and whether a gardener was employed. A social desirability scale was also included to examine possible response biases from respondents who may want to appear to have socially acceptable attitudes. In addition, householders' water use habits and ownership or access to outdoor water consuming appliances were also asked.

All these variables along with the household data were used in a structural equation modelling approach including latent variables to predict external water consumption. In broad terms it was hypothesised that the more positive attitudes towards gardening and the greater perceived contribution the respondent's garden had to lifestyle the more water would be used externally.

## 2. Method

### 2.1. Sampling

Out of the 720 detached household sampled in the DWUS study in Perth (ARCWIS, 2002), only 593 households who had their monthly water consumption recorded were used in the present study. These households served as the main sample in the study and were randomly chosen from the suburbs they lived in. The suburbs were selected based on Australian Bureau of Statistics Collection Districts and stratified by income. In total, 60 suburbs were used: 15 from low income, 30 from medium income and 15 from high income groups. All dwellings were detached houses on their own blocks.

To ensure the representativeness of the samples obtained, the interviewers were instructed to call at every second house of their allocated suburb at least three times of the day before they could dismiss the potential participating household. Further attempts were made to ensure that there were equal numbers of male and female respondents. The questionnaire was administered on a door to door basis and conducted as a personal interview.

### 2.2. Questionnaire contents

The variety of attitudinal and lifestyle variables that were included in the questionnaire is outlined in the introduction. The variables that are related to external water use, and showed sufficient reliability and variability were included in the formal modelling as shown in Table 1. The key social variables are: (1) *lifestyle*: the importance of green space in the home and neighbourhood; (2) *garden recreation*: the importance of the garden as a source of leisure and entertainment for friends; (3) *garden interest*: the enjoyment of gardening as an activity; (4) *attitudes towards water conservation*: attitudes towards water conservation; (5) *social desirability*: the tendency to express great and possibly exaggerated concern about water related issues to please the researchers.

Other variables that were included in the modelling exercise are shown in Table 2. All of these variables are self-evident except perhaps the garden rating scale. This was a simple rating of the interviewer from one meaning the garden was basically unkempt through to three which indicated that the garden was highly maintained.

### 2.3. Measurement of external water use

The external water uses were not recorded directly. The overall consumption of each house was measured

Table 1
Summary of latent attitudinal variables of interest and their designed questions

| Latent variable | Manifest variable | Question |
|---|---|---|
| Life style (1 = not at all important to 5 = most important) | | How important are the following to the preferred lifestyle of you and your family |
| | IMP1 | Large areas of lawn in your garden |
| | IMP3 | Neighbourhood parks and gardens |
| | IMP6 | Large areas of garden beds |
| | IMP9 | A green home environment |
| Garden recreation (1 = strongly agree to 5 = strongly disagree) | | Please tell me how much you agree or disagree with the following statements |
| | ATT1 | I enjoy showing friends around the garden |
| | ATT5 | I never entertain friends in the garden |
| | ATT12 | I hardly ever use the garden for recreation |
| | ATT21 | All our family makes a lot of use of the garden |
| | ATT22 | The garden is an important place for my leisure activities |
| Garden interest (1 = strongly agree to 5 = strongly disagree) | | Please tell me how much you agree or disagree with the following statements |
| | ATT7 | I get great satisfaction from working in the garden |
| | ATT10 | Gardening is a valuable way to spend time |
| | ATT14 | Gardening is a pleasant break from the household work and routine |
| | ATT23 | I do not like gardening |
| Conservation attitude (1 = strongly agree to 5 = strongly disagree) | | Please tell me how much you agree or disagree with the following statements |
| | ATT9 | The price of water restricts what I want to do in the garden |
| | ATT13 | Individuals should take responsibility for the environment around them |
| | ATT16 | I do not have time to conserve water |
| | ATT20 | Stormwater is a valuable resource that should be reused |
| | ATT24 | I really have not thought much about cutting down our use of water |
| Social desirability (1 = strongly agree to 5 = strongly disagree) | | Please tell me how much you agree or disagree with the following statements |
| | RATT2 | Domestic water conservation is the most important concern in my life |
| | RATT6 | The most enjoyable activity in my life is helping to protect our waterways |
| | RATT28 | I would rather "go without" than do some thing that degrades the environment |
| | RATT31 | I never do anything that would be harmful to our waterways |
| | RATT36 | I have never wasted a drop of water |

Table 2
Other variables of interest and their designed questions

| Variables | Question |
|---|---|
| Lawntech (1 = no lawn to 3 = fully automatic) | How do you water your lawns? |
| Garden (1 = unkempt to 3 = highly maintained) | Garden rating |
| Own (1 = own and 2 = rent) | Do you own or rent this property? |
| Block ($m^2$) | How big is your block? |
| Education (1 = some or all of primary school to 5 = completed tertiary qualification) | What is your highest level of education? |
| Income (1 = less than Au$ 22,000 to 5 = more than Au$ 72,000) | What is your gross household income? |
| Swimpool (1 = yes and 2 = no) | Do you own a swimming pool? |

monthly from December 1998 to April 2000. Examinations of Perth water consumption data has revealed that winter water use contained very little external water usage and that internal usage was relatively constant throughout the year (Water Authority of Western Australia, 1987; Loh and Coghlan, 2003). This is not surprising as most of Perth's rainfall occurs in the winter months of June–August. Basically, no watering is needed for garden beds in winter. We therefore estimated external water use in the following way:

$$\begin{aligned}&\text{the external water use in summer}\\&\quad = \text{the total water use in summer}\\&\qquad (\text{December, January and February, } 1998/1999)\\&\qquad -\text{the total water use in winter}\\&\qquad (\text{June, July and August, } 1999).\end{aligned} \tag{1}$$

The results of the first post-summer attitudinal survey, with the exception of social desirability scale were used for modelling as these were the closest proximity in time to the records of summer water consumption used in the study. The social desirability scale was measured only at the second attitudinal survey but was included in the modelling as it could be an influential factor of external water use and/or the reported conservation attitudes.

## 3. Model and results

### 3.1. Exploratory analysis

Only households without garden bores (or wells) ($N = 397$) were included in the exploratory analysis in an attempt to examine the relationship between variables. This is because bore owners often relied more on their own bore water and used little scheme water for watering purposes.

As a preliminary analysis of the data, the correlation and multiple linear regression of the external water use on all proposed "predictor" variables (e.g. importance variables (IMP) and attitude variables (ATT and RATT)) were conducted. The results indicated reasonably high correlations in the responses to the attitudinal scales such as the garden recreation and garden interest. The amount of variance in the external water use that can be accounted by these variables was also found to be high (48.69%) in comparison to other studies which used total water consumption figures.

### 3.2. Structural Equation Model with latent variables

The relationship between external water use and the "predictor" variables was investigated using a Structural Equation Model with latent variables. This technique is widely used in psychology and other social sciences, although its properties are not clear when the model structure is complicated (e.g. Bollen, 1989; Lohmöller, 1989). There were three main reasons for using this methodology in this study.

Firstly, from the modelling perspective, if collinearities (i.e. high correlations between variables) are present in multiple linear regression models, the estimates of regression coefficients may be unstable and the estimated variance can be unacceptably large; see, for example, Stone and Brooks (1990) and Denham (1995). This is true for this study as the questionnaires were designed in the way that variables within groups are highly correlated. One statistical solution for this problem is to construct a new set of regressors having lower dimension. These new variables are derived from the original regressors and are called latent variables.

Secondly in practice, especially in social sciences including psychology, the variables of interest are frequently not observed directly and become latent variables. Instead, many phenomena relating to the variable of interest can be observed. For example, "conservation attitude to water" is a variable of interest but is not directly measurable. Many questions about water can be asked and conclusions can be drawn about the "conservation attitude to water". Direct use of the observed variables (answers to the questions) in analysis leads to difficulties in explanation of the results. Therefore, it was decided that Structural Equation Models with latent variables were more appropriate for the study.

Finally, under conditions of measurement error, traditional techniques such as analysis of variance (ANOVA) or moderated multiple regression may not be able to estimate the true values of model parameters. That is, the parameter estimates might be biased. The present paper employed Covariance based Structural Equation Model, which deals with the variance–covariance matrix written as a function of

all observed variables and in the estimation procedure compares with the theoretical variance–covariance matrix written as a function of the model parameters.

### 3.3. Results

Factor based Maximum Likelihood Estimation using variance–covariance matrix was employed in the current model. The computing was carried out in AMOS 4.0 (SmallWater Co., 1999). The Bayesian information criterion (BIC) was used for model selection. Note that the fitting errors tend to decrease as the number of model parameters increases. BIC as well as other information criteria penalizes the residual sum of squares by a function of the number of free model parameters so that the model does not become overfitted or underfitted. Unlike traditional statistical hypothesis testing, BIC will select the model with smallest criterion value.

A number of external water use models were tried and the model with smallest BIC (1219.567) was selected as the final model. The model fit is presented in Fig. 1.

In demographic terms it can be seen that (1) owner-occupied properties tend to have a better garden; (2) owner-occupied households tend to use more water (a negative correlation between the external water use and the house ownership); (3) large block sizes use more water; (4) higher income households tend to use more water; (5) better rated gardens consume more water; (6) households with a swimming pool tend to use more water; and (7) households with more sophisticated lawn watering systems tend to use more water. All these relationships are perhaps predictable and perhaps apart from the garden rating scale and lawn reticulation have been demonstrated elsewhere. The significant finding is that these variables seemed to have minimal interactions with the psychologically

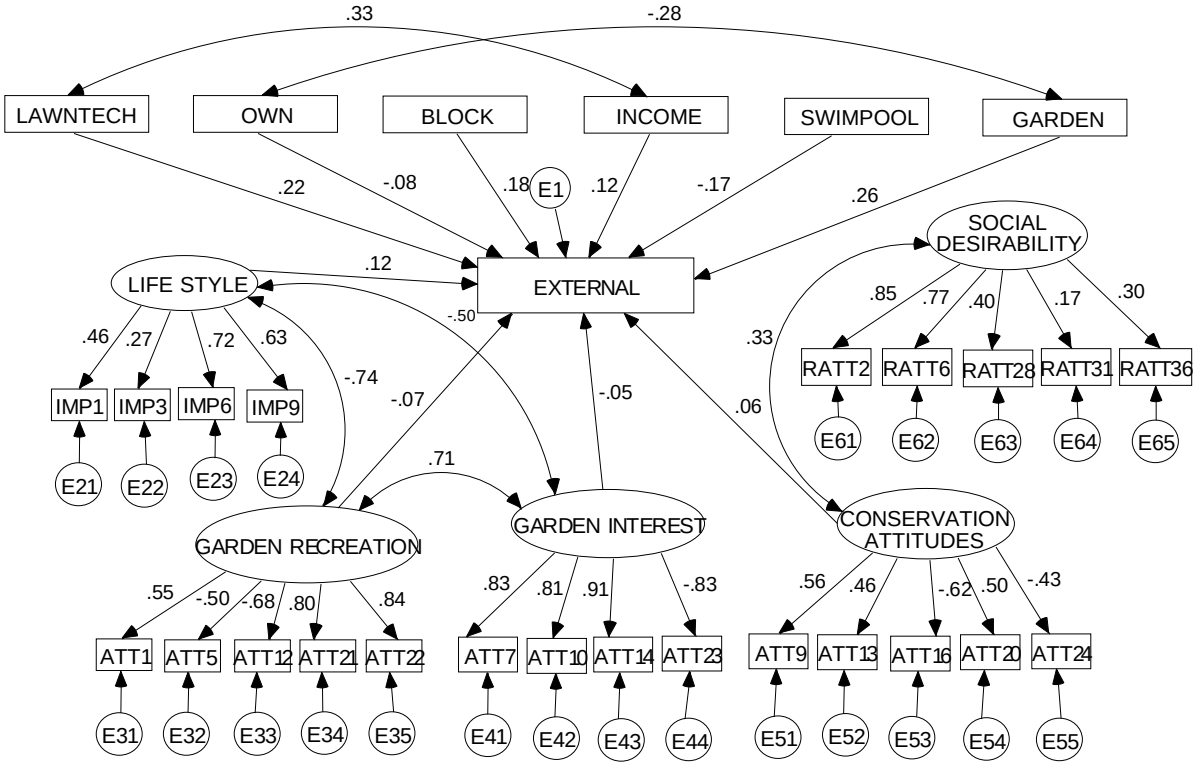


Fig. 1. Model structure and results of Structural Equation Model with latent variables: the best model with standardised partial correlation coefficients.

based or "quality of life" variables in their influence on external water usage.

For the latent psychological variables, we have shown that the three interrelated factors, "lifestyle" requirement, garden recreation and garden interest all have an impact on external water use. It is noteworthy that higher interests in gardening and garden recreation are associated with more external water being used. In contrast to earlier findings, there was a significant pathway between water conservation attitudes and external water consumption. The so-called social desirability variable had a direct influence on the conservation latent scores but not on external water use.

## 4. Discussion

This study began with the premise that gardens and gardening were significant contributors to the urban lifestyle and as such were likely to be important determinants of external water use. The study supported our hypothesis. Lifestyle, leisure and an enjoyment of gardening were interrelated and all contributed significantly to external water use. Specifically, households who enjoyed a 'green' environment, displayed high interest in garden and gardening, used more water externally.

Irrigation has long been found to be the major component of external water use (Stone, 1996; Water Corporation, 2001). Consistent with this, lawn reticulation systems were shown to contribute a significant proportion of variance to external usage. Surprisingly though households with more sophisticated lawn reticulation systems were found in the present study to have used more water externally. The reason for this is not really apparent from the data collected but it may indicate a tendency to set timing devices for longer periods or more frequently than other irrigation modes. This poses a significant challenge to the standard promotion of reducing water usage by installing automatic reticulation systems in Australia. As the ownership of automatic reticulation systems has raised rapidly over the past years, it will be crucial for the water agencies to introduce educational programs to ensure the systems are used appropriately and that water efficiency outside the home is achieved.

The use of structural equation modelling in the present study has provided a useful opportunity to look at the possible interactions between household attitudes and their socio-demographic data and the significance of these variables. Overall, household attitudes appeared to be as important as the socio-demographic variables in determining external water usage, and the interactions between them were minimal. Consistent with this, Syme et al. (2001) also found a negligible interaction between block size and garden interest. It can therefore be inferred from the present findings that restrictions and drought management policies are associated with measurable and important social outcomes. It is important that these customer benefits are considered as part of water utilities decision making processes when considering reliability and future sources issues.

As an example it is feasible to calculate a "social elasticity" ratio for water use much in the same way as price elasticity analyses. This would enable an assessment as to how much a loss in access to external water quantities would affect satisfaction in the garden environment. While the significance of such a calculation may require careful interpretation because of the cross sectional nature of this study, and the fact that behavioural change can accommodate to maintaining some benefits, it would provide food for debate in setting a utility's level of service in the restrictions or drought response areas.

The performance of water providers in contributing to long term sustainability is now considered in terms of the triple bottom line: economic; environmental and social (e.g. McKay and Bjornlund, 2001). Economic analyses have been standard practice for some time. It is now also considered good practice to include the effects of water supply infrastructure on the natural environment in assessing utility's sustainability. But if the social dimension of sustainability is considered, the contribution of external water use to urban quality of life also needs to be monitored. This study shows that such monitoring is possible.

In terms of predicting, it is worth noting that attitudes towards water conservation did on this occasion independently predict external consumption. This contrasts with earlier studies that attempted to predict total household consumption. Past studies may have failed to account for the actual effects of household attitudes on external water consumption because of the inclusion of internal water use figures in their measurement which are often inelastic and dependent

largely on household size (Loh and Coghlan, 2003). An additional reason for this may well relate to the fact that both the water use and conservation attitudes were more targeted and specific than in earlier studies (Heberlein and Black, 1976).

Finally, it is interesting also that the social desirability scale influenced the conservation attitudes but not external water use directly. This may indicate that although the statements in this scale relating to water were extreme they may reflect a genuine concern about water and its management by the general community. This is reinforced by the often demonstrated dominant role of water in the urban landscape and the imagery associated with water. Nancarrow et al. (1996/7) for example have demonstrated repeatedly that there are a cluster of water users who think of water mostly in terms of its conservation. Regardless, these findings demonstrate the need for accurate water use measures and targeted attitudinal measurement if attitude behaviour investigations are to be useful in this area.

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