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Research Paper

Understanding social preferences for land use in wastewater treatment plant buffer zones

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ABSTRACT

This study explores community preferences regarding alternative land uses in wastewater treatment plant buffer zones in Western Australia. The study uses the choice experiment method, and is the first study to apply this method to the context of wastewater treatment plant buffer zone management. In the study there are two information conditions and four land use options. In the first information condition different land use options were presented using text and tables only. In the second information condition land use options were presented visually as maps alongside the text and table information. A between-subject design is used to test how the presentation of information influences people's preferences for different land use options. For both information conditions the most preferred land use option is nature conservation. Presenting visual information was found to reduce the tendency of respondents to select the status quo option, and was also associated with evidence of increased use of information for decision making. Comparing the value of the optimal land use mix to current real world buffer zone land uses identified the possibility of material welfare gains from reallocating land in buffer zones towards nature based land uses.

1. Introduction

Urban growth and the intensification of urban land use is a common global trend. Consequently, water utilities are under increasing pressure to better manage the impacts of their activities and infrastructure, such as odor from wastewater treatment plants, on surrounding land use (Genius, Menegaki, & Tsagarakis, 2012). While wastewater treatment plants are essential infrastructure for enabling urbanization, they emit odor which can negatively impact the amenity value of nearby residents (Craven, Gardner, & Bartlett, 1996). Globally, the emission of odor from treatment plants and associated infrastructure such as pumping stations is a major public concern (Kaye & Jiang, 2000; Lebrero, Bouchy, Stuetz, & Munoz, 2011; Nicell, 2009). In many places the number of complaints about odor from treatment plants has increased due to higher expectations by the general public, and stricter environmental regulations (Lebrero et al., 2011). There is also the possibility that as population increases and the volume of wastewater treated grows, both the amount and spatial extent of odor generated will increase, which may then intrude into residential and commercial areas.

To mitigate the risk of odor impacting residents that live close to treatment plants water utilities can: invest in new technology and infrastructure; relocate treatment plants; purchase the land surrounding the treatment plant to create a buffer zone; and seek planning restrictions on uses of land owned by others within a buffer zone. A buffer zone is defined as the land between the boundary of a treatment plant or pumping station and the boundary of the area where there could be a negative impact from odor emissions. Where a buffer zone is created, there is a need for land use planning restrictions within the buffer zone to avoid incompatible land uses. In practice, land use controls, which typically take the form of zoning restrictions, have been applied with mixed results (Water Corporation, 2014a).

Depending on the treatment plant type and population serviced, in Australia odor buffer zones typically occupy between 80 and 700 ha with an average area of around 147 ha[1] (Consulting Environmental Engineers (CEE), 2009). Whether or not a buffer zone is a cost effective solution to odor management depends, in part, on the total community value of the land allocated to the buffer zone. For example, if the land in

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[1] There are around 2468 wastewater treatment plants in Australia (Water Corporation Database, Pers. Comm.). By taking an average area of 147 ha per treatment plant the estimated total area of land within buffer zones in Australia would be around 362,796 ha

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the buffer zone also provides local amenity or recreation benefits, these benefits can be included in the total economic assessment of different odor management options. To understand the extent to which buffer zones are a cost effective management strategy it is therefore necessary to understand community preferences for different land uses within buffer zones.

Non-market valuation techniques are often used to capture community preferences when there is no existing market (Rambonilaza & Dachary-Bernard, 2007; Scarpa, Thiene, & Hensher, 2012). While there are many non-market valuation studies of urban land-use planning (e.g., Rambonilaza and Dachary-Bernard (2007), Strazzera, Cherchi, and Ferrini (2010), and Vecchiato and Tempesta (2013)) a survey of the literature has failed to identify any non-market valuation studies on community land use preferences for treatment plant buffer zones. To address this knowledge gap we conducted a non-market valuation study of community's preferences for buffer zone land use options, where the specific technique used is the choice experiment method.

Choice experiments are based on the proposition that goods and services can be described in terms of attributes, and attribute levels. In a choice experiment, survey respondents are presented with a series of alternatives, called choice sets, and asked to choose their most preferred option. From the choice experiment data it is possible to identify people's preferences for different attributes (such as different land use options), and it is also possible to calculate the trade-offs people are willing to make among different attributes and attribute levels (Holmes, Adamowicz, & Carlsson, 2017; Lancaster, 1966; McFadden, 1986; Train, 2009). The approach has been used extensively in the environmental economics literature to identify values held for non-market goods (e.g., Adamowicz, Boxall, Williams, & Louviere, 1998; Bennett & Blamey, 2001; Carson & Czajkowski, 2014).

A finding in the urban planning literature is that people respond differently to urban planning options when information is presented visually rather than in a text only format (Allen, Regenbrecht, & Abbott, 2011; Howard & Gaborit, 2007). In the choice experiment literature, the role of visual information has been explored to some extent (e.g., Arnberger & Eder, 2011; Davies, Laing, & Scott, 2002; Hanley, Wright, & Adamowicz, 1998; Matthews, Scarpa, & Marsh, 2017; Patterson, Darbani, Rezaei, Zacharias, & Yazdizadeh, 2017; Scarpa, Campbell, & Hutchinson, 2007). Some studies find that presenting information in a visual format enhances realism, and thereby strengthens the validity of survey results (Dijkstra, Roelen, & Timmermans, 1996). Further, Bateman, Day, Jones, and Jude (2009) argue that the visual form could increase the evaluability of choice options and so reduce judgment error and reliance on heuristics while making choices. In a recent study that used a virtual environment, Matthews et al. (2017) found support for the view that providing visual information reduces choice error variance. However, not all studies find that providing visual information adds to study effectiveness. For example, both Arentze, Borgers, Timmermans, and DelMistro (2003) and Patterson et al. (2017) find no statistically significant impacts associated with providing visual information in choice experiments; and Vriens, Loosschilder, Rosbergen, and Wittink (1998) find mixed effects. Our paper adds to this growing body of literature that examines the impact of providing visual information in an urban land planning context.

We are not aware of any study that has looked at the impact of visual information in the context of choice experiments for buffer zone management, and as such, in this study we have implemented a between-subject choice experiment design where one group of respondents were presented with text, table information, and maps on various land use scenarios and the second group of respondents were presented with text and table format information only.

This study addresses two broad research questions: 1) Does presenting information in a visual format impact people's preferences and choices of various land use options?; and 2) What are the preferences for different land use options within the buffer zone of a wastewater treatment plant?

The choice experiment was conducted in metropolitan and regional Western Australia. There are 113 wastewater treatment plants and 1161 pumping stations in Western Australia that are operated by the main water utility, the Water Corporation, serving more than 2.4 million people. The size of the total land area contained within buffer zones is therefore large. For example, the total odor buffer area of the treatment plants alone covers 16,634 ha (of which 22% is owned by Water Corporation). The scale of investment in treatment plant odor mitigation is also substantial. Understanding the community's preferences for buffer zone land use options will assist buffer zone planning and management in Western Australia, and improving the alignment between community preferences for land uses in buffer zones and actual land use practice has the potential to deliver a substantial overall community benefit.

2. Materials and methods

2.1. Questionnaire development

The questionnaires were developed in several stages. First, a series of consultation meetings were held with experts from Water Corporation (2014–2015). These meetings were conducted to identify the list of relevant attributes and design the first draft of the questionnaire. Next, in March 2015, a focus group discussion was held to test the preliminary questionnaire. Internal testing within UWA and Water Corporation then took place in April–May 2015. The final stage of the development process was the release of a pilot of the questionnaire in June 2015. Based on this process four potential buffer zone land use options were identified as attributes: nature conservation areas, sporting and recreation areas, commercial/industrial area, and agricultural and horticulture areas. For individual land uses the following descriptions were provided to the respondents:

- Nature conservation areas are managed to protect native plants and animals and provide some access for passive recreation activities e.g. access to walk trails. Many buffers zones contain or are located near nature corridors which are intended to connect remnant bushland and wetlands. The buffer zone allows native animals to move from one area of bushland to another.
- Agriculture and horticulture areas could include - aquaculture, vineyards, orchards and market gardens, plant nurseries and greenhouses, and fodder production or pasture (including turf farms).
- Sporting and recreation areas provide spaces for organized sport and informal play and exercise, relaxation, and social interaction. They could include - grassed ovals and playing fields for sport e.g. football, soccer, rugby, cricket, and athletics; gardens and open parklands, community gardens, corridor links; and community use facilities e.g. playgrounds.
- Commercial/industrial areas within the wastewater treatment plant buffer zone could include – renewable energy e.g. biogas, waste to energy, solar and wind farms; warehouses; transport depots; general and light industry e.g. manufacturing, assembly or repairs; and waste transfer and recovery e.g. transfer stations, enclosed composting.

For each of the land uses four different levels were developed. The different levels of expansion or reduction in each particular land use considered in the study are detailed in Table 1, and the status quo land uses were selected based on advice from industry experts. To help respondents visualize the buffer zone, Fig. 1 was developed to represent the status quo land uses as described in Table 1. In Fig. 1, the dimensions and areas are generally representative of the average areas of treatment plant sites, buffer zones, and land uses. All participants saw the land use map shown in Fig. 1. A video containing information on potential uses of resources from wastewater treatment plants was also shown to all participants (Water Corporation, 2014b).