Using 3D Virtual GeoDesigns for Exploring the Economic Value of Alternative Green Infrastructure Options

Sigrid HEHL-LANGE, Lewis GILL, John HENNEBERRY, Berna KESKIN, Eckart LANGE, Ian Caleb MELL and Ed MORGAN

1 Introduction

Green spaces and green infrastructure are perceived as important factors promoting quality of life in cities and towns. The provision of green infrastructure does however have attached costs for planning, realisation and maintenance. The VALUE research project (‘Valuing Attractive Landscapes in the Urban Economy’), funded by the EU Interreg IVB programme, aims to establish an economic value for investments in green infrastructure. The Sheffield case study undertaken by VALUE focussed on a number of green investments along the River Don in The Wicker on Blonk Street.

The investments are including a new footbridge over the River Don and walkways along the river to facilitate access and movement for pedestrians and cyclists, further sluice gates to react to flooding events caused by extreme weather and the planting of new trees along the river. These investment projects were developed and realized by the South Yorkshire Forest Partnership (SYFP) utilising VALUE funding. The VALUE investments in Blonk Street were completed in 2011 (see Fig. 2). Further actions to prevent flooding through river channel modifications were also delivered. These resources were not funded through VALUE and are not considered elements of the VALUE investment.

2 Methodology

Stated preference techniques are a common method of undertaking economic valuations of non-market resources, such as environmental goods (BATEMAN et al. 2002, LAING et al. 2005). A stated preference technique was developed to underpin a quantitative survey used to estimate the Willingness-to-Pay (WTP) of residents, commuters, business owners and employees for alternative green infrastructure development scenarios in a case study site at the Wicker in Sheffield, UK.

2.1 Quantitative Survey

The economic evaluation undertaken for the Sheffield VALUE investment utilised a contingent valuation (CV) experiment methodology. In the CV survey visual cue cards showing 3D computer-generated images conveying the nature of the proposed investment on Blonk Street were used. Based on computer-generated images the WTP of different user and interest groups for the different options were assessed in a survey. It is considered within the research literature that cue cards showing multiple-choice responses, Likert
Scales and 3D visualisations offer broader scope and choice to the researcher than maps and provide more robust data for analysis (CROMPTON 2001). This is compared to the use of structured written statements outlining the investments proposed (LINDSEY 1994).

The WTP elicitation question was framed as a regular monthly increased payment in rent or mortgage. In the questionnaire the average cost per month of rent/mortgage for a two-bedroom apartment in the case study area was stated. The respondents were then asked: If you were living in the area and it had the characteristics shown in the image, how much extra would you be willing to pay in rent/mortgage each month to have this view? Respondents were therefore provided with the opportunity to state a specific payment. Alternatively they were also able to express the following options: nothing, I would not pay, refused, don’t know. ‘Nothing’ was classified as genuine zero. The three other options were identified as protest zero (BERNATH & ROSCHEWITZ 2008).

An on-site survey was conducted by Ipsos-Mori, a social research company, over a six-week period in August and September 2011 using a face-to-face interview technique. In total 1939 people were asked to participate in the study and 510 responses were achieved, representing a response rate of 26%.

### 2.2 Qualitative Survey

As a follow-up to the quantitative survey, qualitative workshops were organized and held in November 2011. The sessions each lasted 1-1.5 hours. In these sessions we used PowerPoint presentations with static and dynamic visualisations on a large screen and additional real time visualisations. The venue was a seminar room in a University building. Participants were recruited through the quantitative survey conducted in summer 2011 by asking respondents at the end of the questionnaire if they would have an interest in attending follow up workshops investigating green infrastructure. 186 people gave us their name and telephone number of which 25 people declared that they would have the time and interest to participate. One of the workshops was held on a Saturday morning, two others were held in the evening on weekdays.

Several people are required to facilitate the visualisation workshop (HEHL-LANGE & LANGE 2005, SCHROTH et al. 2011). In this case one person acted as moderator and also represented the hosting institution, another person acted as the computer facilitator presenting all the visualisations, two additional people were used to take minutes and document the workshop by taking photos and finally there were the invited participants. For the preparation of a visualisation workshop considerable more time than for a conventional workshop was required (SCHROTH 2009). This reflects the time needed to prepare the visual inputs of the workshop including taking views from each computer model for static representations, preparing pre-recorded animations as walkthroughs and identifying how to present the real time interactive visualisation. Sufficient time was also needed to set up the hardware and to verify that all the visualisations ran properly. Seating was U-shaped around a table oriented towards the screen. Lighting had to be dark enough to see the projected landscape visualisations but bright enough for participants, while watching them, to fill out a questionnaire with the same core questions as were used in the quantitative survey. Brighter lighting also supports the discussions among the participants (SCHROTH 2009). Two Info sheets, one with information about the VALUE project and one reflecting the URSULA project, which also contained a consent form were distributed at the beginning of the
workshop. As a warm-up exercise, participants were shown firstly all images in random order, an animation (pre-recorded flythrough) and a demonstration of what could be expected in the real time navigation. We used in each workshop in addition to the status quo a different alternative scenario, once ‘Past’, once ‘Sheffield City Council’ and once ‘Streets’. It would have been too time consuming to show each group all the scenarios. Because of time constraints, only the facilitator could navigate through the real time landscape models. Instead of the 8 to 9 expected participants per workshop only a total of 10 participants took part in the three workshop events.

2.3 3D Visualisation

The 3D visualisations used in the surveys were part of the URSULA (Urban Rivers and Sustainable Living Agendas) project, a joint research project utilising the same case study site in Sheffield. Its goal is to provide innovations, tools and supporting evidence for the redevelopment of urban river corridors to create places where people want to live and work, now and in the future. A virtual landscape model of the case study site was modelled for the status quo (Fig. 2) alongside three different future scenarios. The ‘Sheffield City Council’ model (Fig. 3) represents the planning proposal of the Sheffield City Council. There are two further scenarios ‘Streets’ (Fig. 4) and ‘Floods’. The scenario ‘Floods’ was not used in the surveys of Blonk Street but instead a model representing the past (Fig. 1), before the VALUE investments – the new footbridge and the walkways – were built. Visualisations of future scenarios are helpful, as in this way people can share the same vision (LANGE et al. 2008, LANGE & HEHL-LANGE 2010).

Within the URSULA case study site the virtual landscape model was built using different software. Simmetry3d, a real-time visualisation software, which runs on a PC was used for the interactive landscape visualisation. Within Simmetry3d interactive walkthroughs at eye-level are possible based on the technologies used in the computer game industry (MORGAN et al. 2009). Simmetry3d has excellent compatibility for importing GIS data, image data, and for importing data from the other software used in the URSULA project: SketchUp and LENNÉ3D. From vector GIS data building footprints were used as the basis for manually constructing building models in SketchUp. Also, in SketchUp the perspective corrected photographs were draped as textures onto the building volumes. Building models were also built from photographs using the “PhotoMatch” feature in SketchUp (MORGAN et al. 2009). The site plans of alternative scenarios were drawn by the URSULA design team conventionally by pen on paper. In SketchUp these two-dimensional site layout plans were digitized by hand, assigned with land usage and the buildings were extruded up into three dimensions by creating massing models, with floor areas modelled. Simmetry3d has its own modelling tool and library for vegetation; the focus is on trees but not on shrubs and perennials. As the software LENNÉ3D has very realistic species specific tree and plant models, Simmetry3d has built-in compatibility for importing LENNÉ3D vegetation. In the URSULA virtual landscape model vegetation of both software packages are used. The virtual model of the Sheffield-Wicker site consists of a digital terrain model (DTM) provided by the Environment Agency with a horizontal resolution of 0.5 m and a height accuracy of 0.25 m on which an aerial photo of 0.2 m resolution from Cities Revealed was draped within Simmetry3d. All built form like building footprint, roads, paths and river channels and land usage date were imported as GIS vector data from Ordnance Survey MasterMap. All these data were available through licensing agreements through the University.
Fig. 1: Past, before the VALUE investments

Fig. 2: Status quo, with the VALUE investments

Fig. 3: Scenario, ‘Sheffield City Council’ with the VALUE investment and additional greener investment
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3 Results

The analysis of the quantitative survey shows that preference and WTP are clearly linked with greener investments options (see Fig. 6). To find out respondents’ preference and opinion about green infrastructure they had to give answers to the statements ‘I like the look of this image’ and ‘I think there is enough greenery in this image’. Therefore respondents had to check a box on a five-point rating scale from ‘I strongly agree’ to ‘I strongly disagree’ in the questionnaire. When the scenarios are compared the level of vegetation with which they agree appears to have the biggest impact. Interestingly respondents were satisfied the most with the ‘Past’, before the VALUE investments and were willing to pay £ 10.81, e.g. the most.

In the qualitative survey the questions about preference and greenery had to be adapted, that they were equally valid for the static as well for the dynamic visualisations. Instead of ‘I
like the look of this image’ we used ‘I like the urban river landscape’. And for the vegetation we wrote simply ‘I think there is enough greenery’. 

As there were only a limited number of participants in the workshops a quantitative analysis was not possible. But there is the same tendency, that the ’Past’, indicates a higher preference against the two other options. For the Status quo, which was the only model evaluated by all 10 respondents, we can suggest that preference is rated higher when they watched the pre-recorded animations, and event better when they experienced the real-time navigation. One of the respondents was willing to pay £ 25 for the ’Past’, equally in case of an image, an animation or the real time navigation. In the qualitative survey there are more protest zero than genuine zero in the WTP answers.

In the discussions of the three workshops it was clear that the majority of participants preferred more natural and wild vegetation. In general their opinion was, the more green the better. This can help to explain the preferences for the ‘Past’ alternative, where the river channel is fairly unmanaged and shows a high proportion of spontaneous vegetation with mostly willows combined with invasive species growing at the river banks. Consequently the Status quo, showing the VALUE investments – the new footbridge and the walkways – was the least preferred option. Most of the spontaneous vegetation and invasive plant species such as Japanese Knotweed (Fallopia japonica) and Himalayan Balsam (Impatiens glandulifera) in the riverbed was recently taken out by the River Stewardship Company (WILD et al. 2008). Another reason that was explored in the discussions was that although the new footbridge was completed it was still closed for the public. This meant that the new footbridge was at the time of our surveys visually available but not physically accessible. Walkers and cyclists therefore gained no additional benefits from the investment. The new walkways along the river are presently not in an attractive state as on the other side of the
River Don new buildings are under construction. One participant also argued that the new footbridge blocks the view.

Two participants only evaluated the Scenario ‘Sheffield City Council’. In addition to the three models used for the quantitative research we also integrated for the qualitative survey a fourth model, the Scenario ‘Streets’, to enquire whether the VALUE investment would profit more from natural wild vegetation. The scenario ‘Streets’ has like the ‘Past’ spontaneous vegetation in the riverbed. The explanations provided by five respondents who evaluated the Scenario ‘Streets’ were similar to the result of the scenario ‘Past’. The one respondent who was willing to pay £25 for the ‘Past’ was equally willing to pay the same amount for the scenario ‘Streets’. This respondent reported that she used to live in a house with no view at all. Now their house has a gorgeous view. When a council officer came to allocate the tax band for her house, he also commented on the view. And our participant said: You will not charge me for this view. For her it was clear that there is a direct relationship between the quality of the view and WTP.

4 Conclusions

The greener the landscape models are, the higher they are rated by respondents for preference and WTP values. The workshop data suggests, that those visualisation models that contain a greater proportion of natural unmanaged vegetation are considered by respondents to have higher ecological benefits. What was not tested was a scenario with equally the same amount of green as in the ‘Past’ and ‘Streets’ but with a lot of new formally planted and managed trees instead of the spontaneous vegetation.

The dynamic visualisations were appreciated very much by the participants and were deemed helpful to the discussions. Danahy (2001) emphasizes the importance of peripheral vision for person’s visual experience in the landscape. Also the results of the evaluation were in some cases higher with the dynamic visualisations.

The selection of the people for the workshops seems to be random, however it is a very selective process. We only had people who are very interested in the site; some came from far away on their own cost. Because of the limited number of participants and the bias in the sample more general conclusions are not supported by this study.

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