Assessing and quantifying residential garden privacy on proposed residential development.

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Summary

This paper proposes through a case study, a Geographic Information System (GIS) visibility analysis approach to assessing and quantifying garden privacy on proposed residential development. Using a Digital Terrain Model (DTM) and information extracted from the proposed architectural drawings, the study combined the probable and cumulative viewshed methods to describe with confidence the degree of visual exposure of the proposed gardens in the study area.

KEYWORDS: viewshed analysis; visual amenity; development management; visual exposure, visibility analysis.

1. Introduction

The ability to employ computational methods in assessing and quantifying privacy levels of residential gardens could help improve the planning application decision making process. Local Planning Authorities (LPAs) often put privacy in the same bracket as quantitative aspects such as overshadowing and access to daylight and sunlight when making planning decisions (Grant et al., 2008). These quantitative aspects can usually be predicted or measured using established methods, such as the Building Research Establishment's 25 and 45 degree tests (Littlefair, 2011). When it comes to privacy in the residential garden, the main criteria found in literature that attempts to measure it is the use of distance between buildings (Ansary and Shalabyb, 2014). However, there are no established methods that categorise these distances in reference to visibility (Shach-Pinsly et al., 2011).

Most LPAs publish Planning Documents to provide detail on policies governing residential garden privacy. However, some are written using vague terms that require some form of value judgement or discretion, while others are written using codified terms in the form of prescriptive space standards (Grant et al., 2008) resulting in a 'one cap fits all' approach. This paper argues that privacy in the residential garden should be assessed based on visual exposure as described by Rahim (2015), rather than the use of discretion or distances between buildings.

The paper proposes a GIS based method which assesses visual exposure on a quantifiable scale of visibility to improve the planning applications decision process. The study combined the probable and cumulative viewshed methods through a case study, to describe with confidence the degree of visual exposure of the proposed gardens in the study area.

1.1. Study area

The study area (**Figure 1**) is located at 1°7'22"W, 53°10'19"N in Newark and Sherwood District (NSD), Nottinghamshire. The site is approximately 30,733m² and had planning permission approved in June 2019 for the development of 107 dwellings ranging from 2 to 5 bedrooms.

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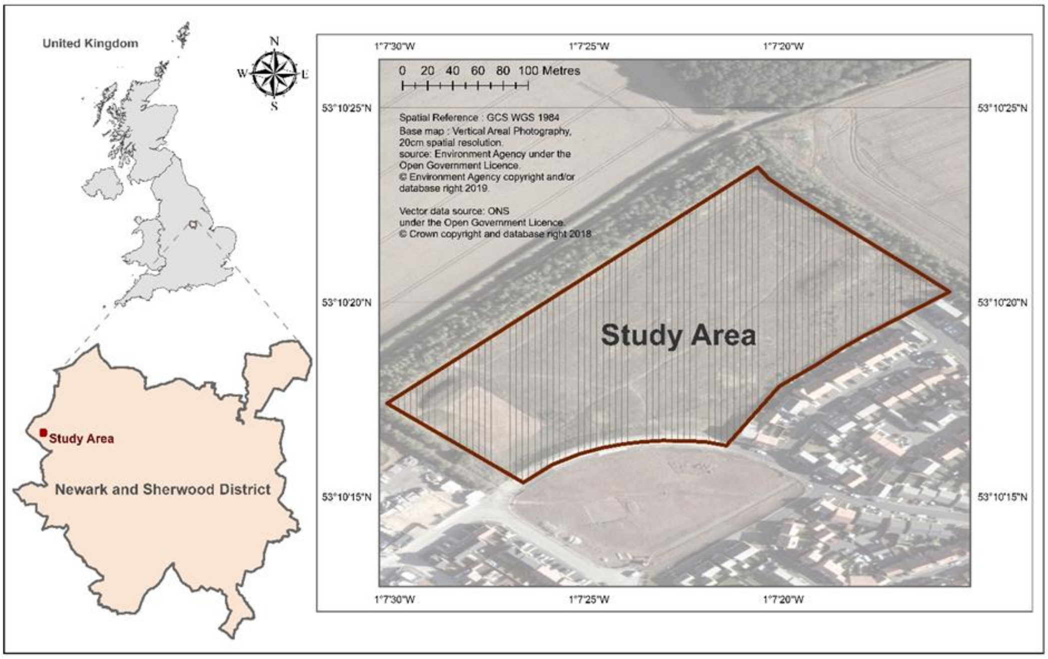

Figure 1. Study Area.

1.2. Cumulative and Probable Viewsheds

Viewsheds (represented in raster format) are computed by generating Lines of Sight (LoS) between a viewpoint and the cells of a Digital Elevation Model or DEM (Nutsford et al., 2015). A target cell is invisible if the DEM is above the LoS, otherwise it is visible (Kim et al., 2004). When multiple viewsheds are added up into a single result, it is known as a cumulative viewshed. This allows the possibility to determine the Visual Magnitude which represents the number of viewpoints visible from a location (Llobera, 2003).

The probable viewshed determines the probability of visibility at a location, taking into account the effects of errors and uncertainties in the DEM used to generate the viewshed (Murphy et al. 2018). According to Fisher (1994), probable viewsheds are computed by using Monte Carlo simulation to generate alternative DEMs based on the root mean square error of the original DEM. By summing up the viewsheds derived from each DEM using Equation 1, it is possible to determine the probability of each cell being visible.

$$p_{(Xij)} = \frac{\sum_{k=1}^{n} X_{ijk}}{n} \tag{1}$$

$P_{(Xij)}$= Probability of visibility of a cell at row *i* and column *j*

X_{ijk}= Cell value at row *i* and column *j* at realisation *k*

k = Realisation where *k* is from 1 to n (number of realisation)

Combining the cumulative and probable viewshed methods demonstrates the degree of visibility while accounting for the errors and uncertainties in the DEM.

2. Data and Methods

The two fundamental datasets required for viewshed analysis are: (1) the surface to be considered for visibility and (2) the observer locations. To generate a Digital Surface Model (DSM) and observer locations for the study area, the following data were sourced from Environment Agency and NSD Council:

Table 1 Data requirements

Data	Purpose
LiDAR composite DTM	To provide elevation information of the study area.
Proposed Architectural Drawings.	To extract location and/or height, information for all proposed buildings, windows, finished floor levels, gardens and fences.
Vertical Aerial Photograph	For the purpose of georeferencing or spatial adjustment
Site Boundary coordinates	To be used as additional control points for georeferencing or spatial adjustment

2.1. DSM generation

To generate the DSM, the location of windows, fences and buildings were captured from the proposed architectural drawings and attributed with their respective height information. The latter two were then converted into raster data then merged with the DTM into a single surface as described in **Figure 2**. The attributed window data represented the observer locations.

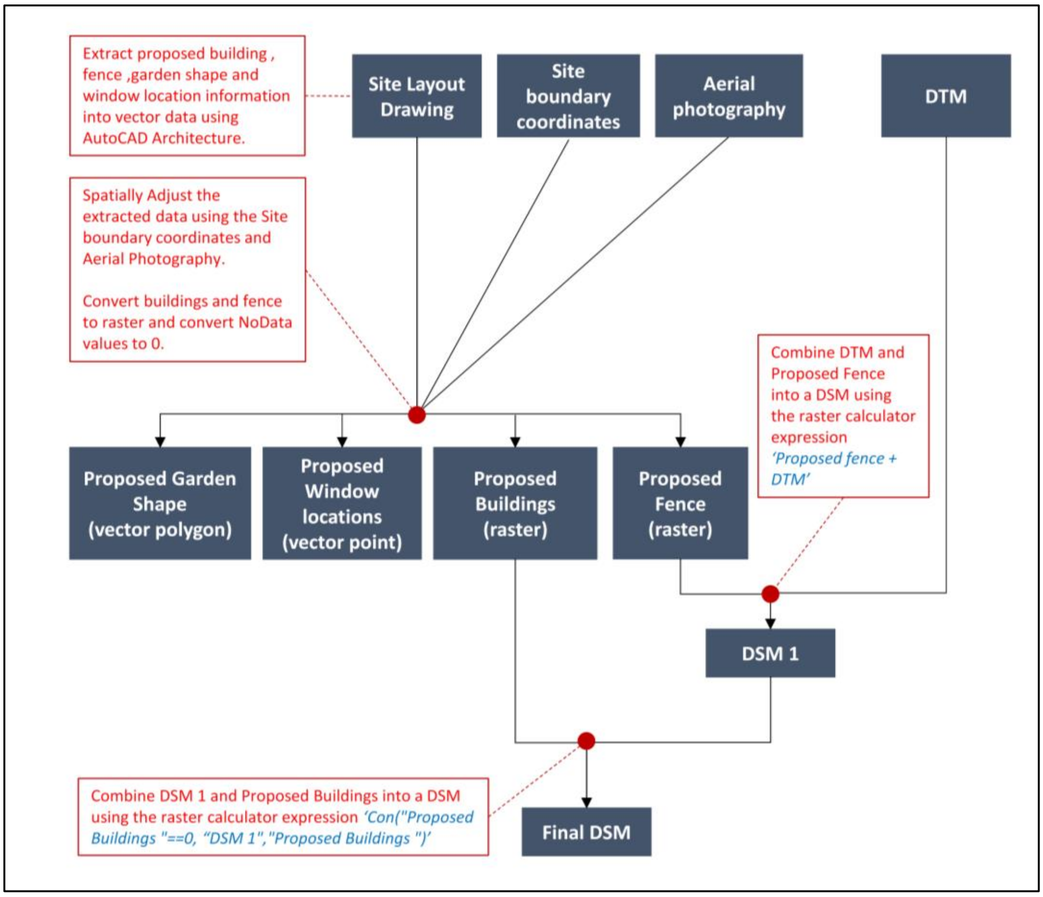

Figure 2. DSM Generation process.

2.2. Visibility computation

The visibility computation employed a Monte Carlo simulation of the errors in the proposed DSM as described by Fisher (1994) to derive alternative DSMs from which a probable cumulative viewshed of the study area was derived (**Figure 3**). Based on the assumption that the errors in the proposed DSM follow a normal distribution, 19 random raster files were generated from the proposed DSM. According to Hope (1968), a minimum of 19 realisations are required to achieve results with a statistical significance of 0.05. Each random raster was combined with the proposed DSM to generate a 19 alternative DSMs. Using the proposed window location data as viewpoints, cumulative viewsheds were computed from each of the alternative DSM (Including the Proposed DSM). The resulting 20 cumulative viewsheds were then summed together using Equation 1. The outcome was a probable cumulative viewshed which described with confidence the degree to which locations on the study area are visible by taking into account the errors in the proposed DSM. Due to the repetitive nature of this process, a toolbox created by Rášová (2017) for computing probable viewsheds was modified to incorporate cumulative viewsheds.

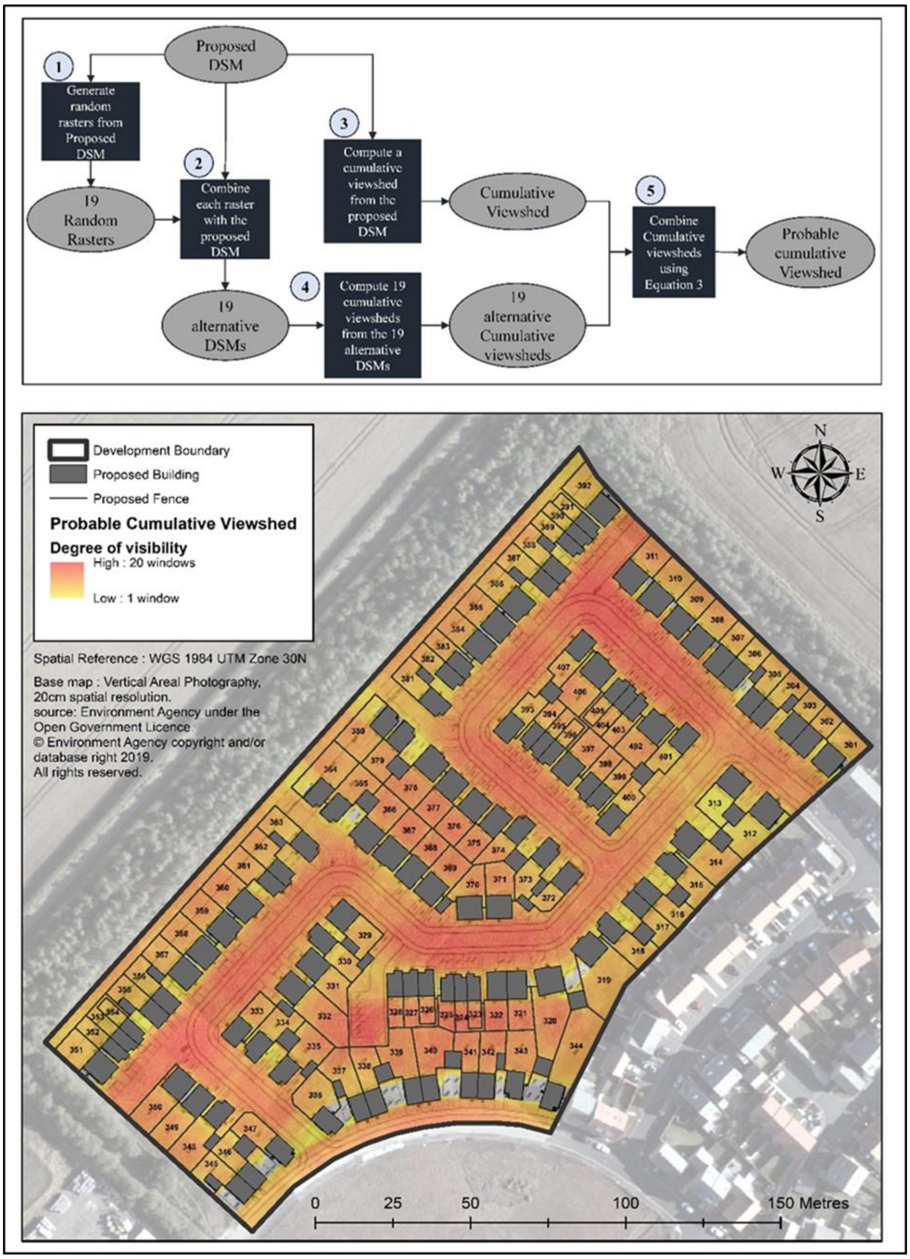

Figure 3. Probable cumulative viewshed of the Study Area.

2.3. Quantifying and ranking visibility

To quantifying visibility on the study area, the mean visual magnitude of cells of the generated probable cumulative viewshed for each proposed garden was computed (Equation 2). This was termed the privacy score and represented the average number of windows overlooking the garden space in question.

$$\bar{X}V_m = \frac{\sum(x)}{n} \tag{2}$$

$\bar{X}V_{(m)}$= Mean visual magnitude (privacy score)
x = Visual magnitude value of a cell on the probable cumulative viewshed.
n = Total number of cells on the area in question.

3. Results and Discussion

Plot 313 on the study area was identified as the least impacted while plots 324 and 325 were the most impacted (**Figure 4**).

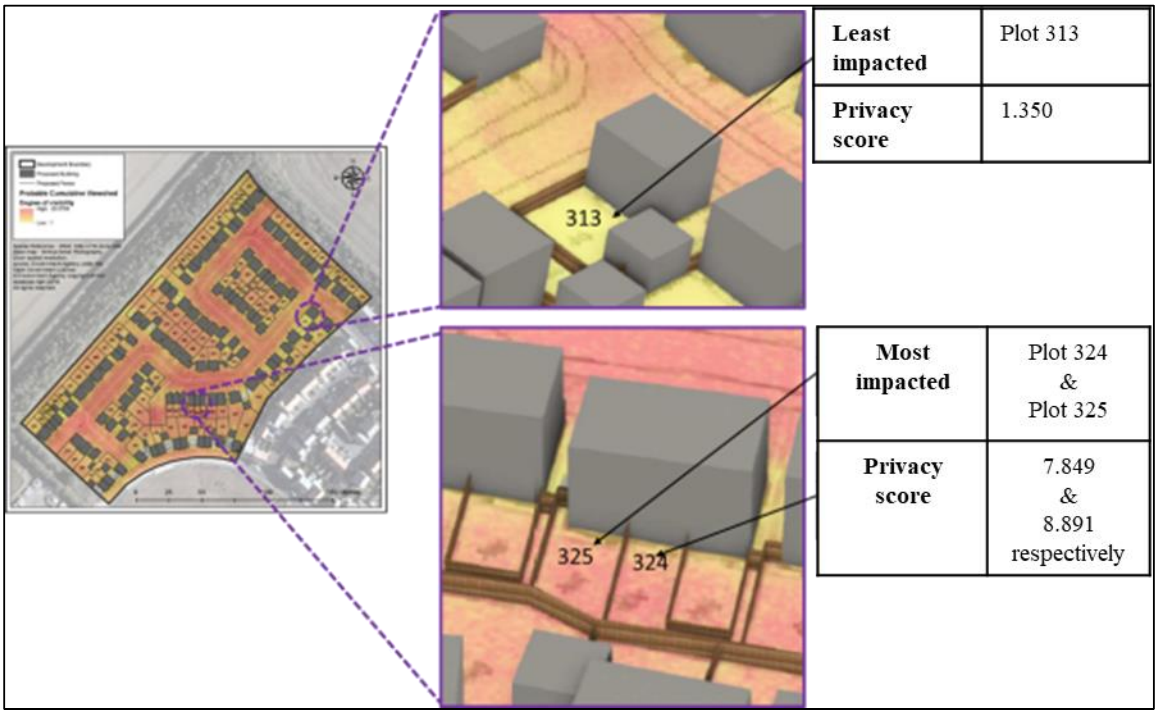

Figure 4. Case study results.

The GIS based method presented in the case study demonstrates the variation in visual exposure across the site. This method could be helpful in understanding not only areas that are impacted but the degree to which they are impacted. Basing decisions on visibility analysis rather than space standards will allow LPAs to define how much visual exposure of gardens will be deemed unacceptable. This will ensure consistency in the decision making process.

4. Conclusion

This paper does not express an opinion on the planning judgement to approve the development on the study area, its intention is to demonstrate how the decision making process could be better supported with the GIS based method. Given the fact that the assessment of garden privacy is based on actual visual exposure of the garden space, the GIS based method is recommended as a better alternative to existing methods.

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Biographies

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