Understanding Landscape Visualisation for Visual Impact Assessments

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Summary: With modern planning policy and the shift to neighbourhood planning through the localism bill understanding the potential visual impacts that may arise from a development is more relevant now than ever before. Whether for 200m high wind turbine developments or to understand how visible a drain culvert will be within a park both planners and developers want to understand where the visibility will be. As part of an environmental statement and in standalone landscape and visual impact assessments, landscape architecture companies undertake analysis of their designs to ensure they understand the potential effects and therefore to inform mitigation strategies.

KEYWORDS: Landscape Visualisation, Zone of Theoretical Visibility, ZTV, Viewshed, Wind Farm LVIA.

1. Introduction

As a well-established tool within most modern GIS, viewshed analysis is often demonstrated as one of the easiest and useful planning and design aids with a GIS. The concept of highlighting areas from which new, or old, objects can be seen and then overlaying this onto mapping is one that most people can understand. In fact for most large planning applications the inclusion of some visual analysis is seen as paramount and the ability to use viewshed analysis often prevents the need for large numbers of photomontages. However the technical aspects behind creating viewsheds are not always as simple as a few clicks of buttons. Instead the design might call for a raised / lowered landform, or questions might be raised as to whether surface models or bare ground assessments should be undertaken. A issue often then arises as most GIS users are introduced to the tools and the outputs without a full understanding of results and how they should be interpreted or even how the inputs need to change in different circumstances. With more bodies, both academic and commercial, adopting GIS for viewshed analysis these accidental misinterpretations are becoming increasingly common. These interpretations are then further compounded by published guidance documents which adopt specific calculations that differ from those built into the commercially available GIS tools making the outputs incorrect to those accepted by the planning bodies. Even without issues of reliability and correct interpretation the GIS analyst is also now faced with questions arising from the commonality of having to interpret multiple viewsheds and how together they cause an “impact” on an area. So what pitfalls should viewshed users ensure are missed? What are some examples of how the guidelines differ from common viewshed tools? And in what ways can other GIS techniques allow for the easier interpretation of multiple viewshed analysis?

2. Following published guidance

In parallel to the development and adoption of GIS there has been numerous papers published which deal with viewshed analysis, indeed the majority of generic GIS guides even explains the viewshed tool and its key concepts. With the publication of papers such as Riggs P D and Dean D J (2007) discussions on issues with viewshed analysis move one stage further but these documents are not as readily recommended to most analysts and so the conclusions are often unheeded. Instead the often publicised viewshed works tend to focus on the implementation of the viewshed and how it aids design. In both Sparkes A and Kidner D (1996) and Foley R (2003) the examples of viewshed analysis on proposed wind farm developments are made. These developments lend themselves to the tools within viewshed analysis as they tend to contain extremely tall “point” features that have a controversial visual impact and a large study area (often over 30km radii from the proposed developments). To standardise the implementation of viewshed analysis in wind farm planning in 2007 there was the publication of the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document (University of Newcastle, 2002). This has helped to develop and standardise best practices within the Wind Farm industry and within most planning authorities has become accepted best practice for the production of all computer generated visualisation techniques (both viewshed and wire framed figures).

3. Understanding errors / differences

With the publishing of guidance for viewshed analysis the GIS specialist then has to become aware of how the algorithms their chosen GIS software differs from the base versions used by the governing body. Although a majority of GIS programmes offer viewshed analysis papers such as Fisher P F (1993) highlight that the outputs can differ completely. Even once the professional has stated which software was used to create a viewshed differences can arise from the extra factors implemented onto the model. As an example the earth curvature model published within the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document (University of Newcastle, 2002) is shown as Equation 1 whilst the curvature and diffraction model within ArcGIS is highlighted by Equation 2.

$$h = \frac{C^2 (1 - 2k)}{2r} \tag{1}$$

c : distance to the object in metres
k : is the refraction coefficient (0.075)
r : the radius of the Earth in metres (6,376,000)

$$Z_{actual} = Z_{surface} - \left\{ \frac{Dist^2}{Diam_{earth}} \right\} + \left\{ R_{refr} * \left\{ \frac{Dist^2}{Diam_{earth}} \right\} \right\} \tag{2}$$

Dist : The planimetric distance between the observation feature and the observed location.
Diam : The diameter of the earth (12,740,000 meters)
R_{refr} : The refractivity coefficient of light (0.13).

As both of these equations differ in their representation of both the earths size and refraction due to atmospheric issues and on the exact equation the results are therefore different. Although for a small site with a study area of a few kilometers the curvature of the earth will have minimal affect as the study area increases the effect is increased exponentially. Exploring Table 1 highlights how by a 35km study radius the curve alone would mask a 80m (or 70m) object. Table 1 also highlights however that the difference between the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document and that built into ESRI’s ArcGIS product becomes fairly important (with a discrepancy between the two of over 10m at 35km from the site).

Table 1. Earth Curvature Differences

Distance to development (km)	*SNH Vertical Correction (m)*	*ESRI Vertical Correction (m)*
5	1.669	1.452
10	6.675	5.808
15	15.019	13.069
20	26.700	23.234
25	41.719	36.303
30	60.705	52.276
35	81.769	71.154

As the viewshed tool within ArcGIS does not allow manipulation of their earth curvature calculation, the creation of a curved surface to which all terrain maps are draped has been the solution to ensure that outputs are to the guidance standards. Additional to this the creation of this curved surface has allowed the export of curved XYZ files to be used in the production of wireframes allowing the photomontages to be a more accurate version of the final development.

Although these mathematical errors occur depending on the software or guidance adopted the greater error with viewshed analysis is with the lack of acknowledgement of the false positive within digital surface viewsheds. When working with a digital surface model the GIS is unaware of the "obstructions" in views (for example a building or woodland) until after it has assessed visibility as if the viewer was standing on top of the obstruction (see Figure 1).

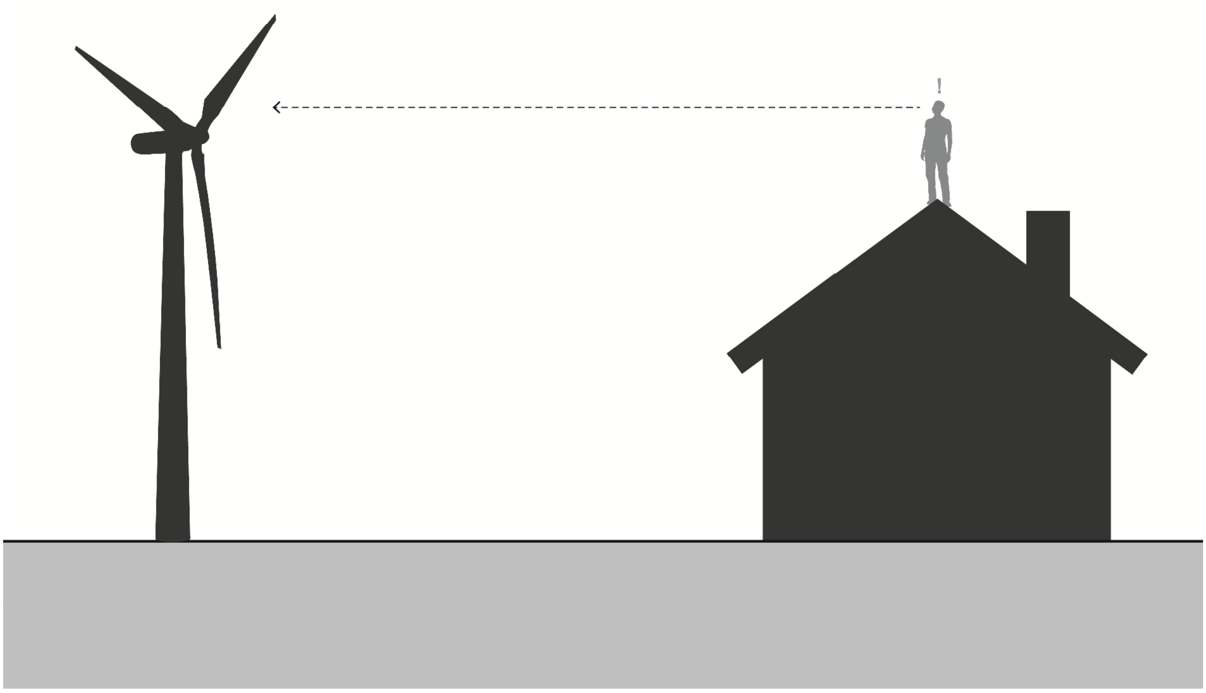


Figure 1. Visibility caused by a surface model viewshed

Obviously from a visual perspective both roof tops and the tops of trees are not likely locations from which the development is visible and instead Figure 2 shows how it should be a negative viewshed response instead of a positive.

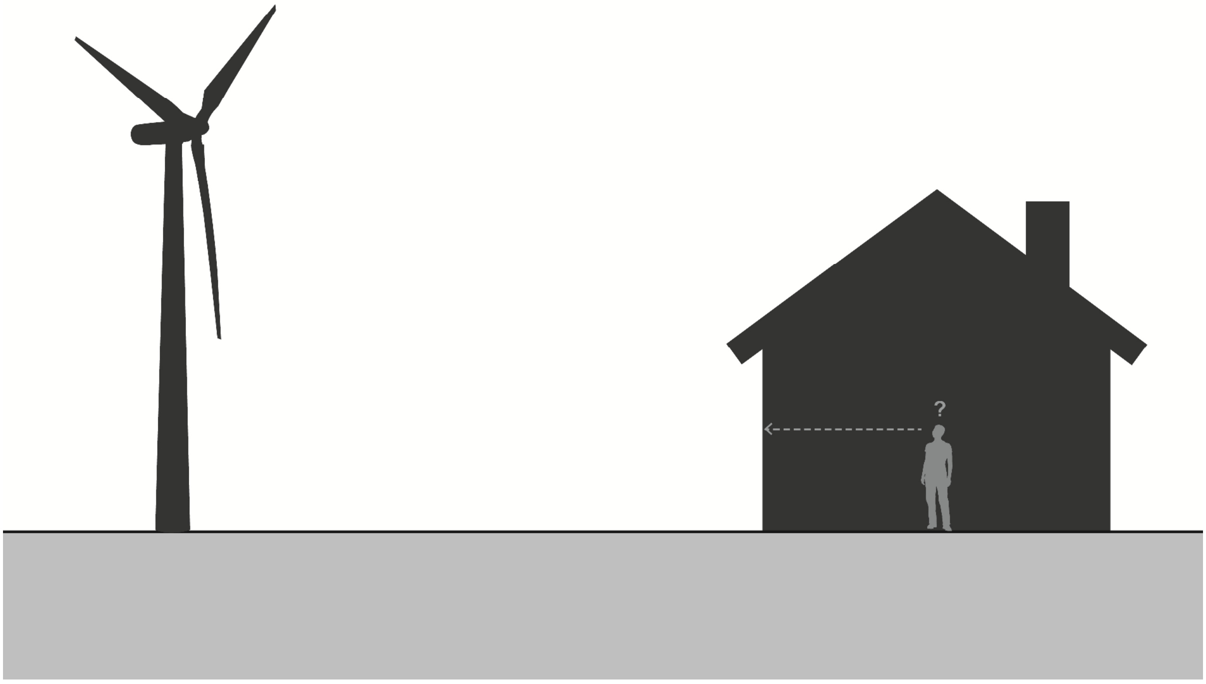


Figure 2. Actual visibility

To enable this, the GIS analyst must therefore be aware of the “False” positives from a surface model viewshed and remove them by questioning surface and bare ground terrain to ascertain where they exist.

4. Moving viewshed analysis forward

With viewshed analysis common practice within planning applications and users having an understanding of how the tool actually works it becomes possible to find other applications to undertake viewshed work. Although most analysis ends with the production of a plan which provides a yes/no answer to whether a development is visible or not further analytical techniques can give the developer far greater details. For example using the positive results of a viewshed as point locations to run a “reverse” viewshed (with the observer and object attributes switched) it is possible to create a zonal plan showing areas of high visual impact compared to the areas of low visual impact within a development boundary. This tool can then be modified further by ranking different landscapes so that the views from protected landscapes (such as national parks) are more important than those of brownfield sites. Figure 03 shows a reverse viewshed analysis of Peterborough cathedral with the lighter grey areas having a greater visibility and this decreasing to areas of black with no visibility of the Cathedral.

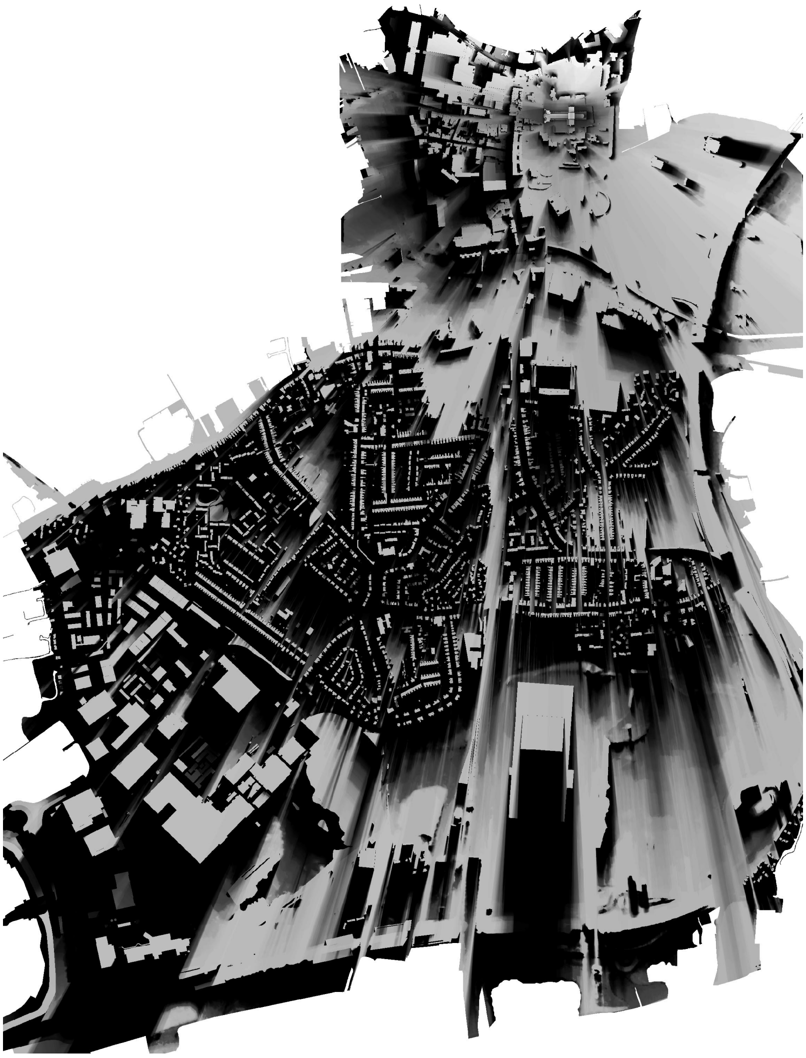
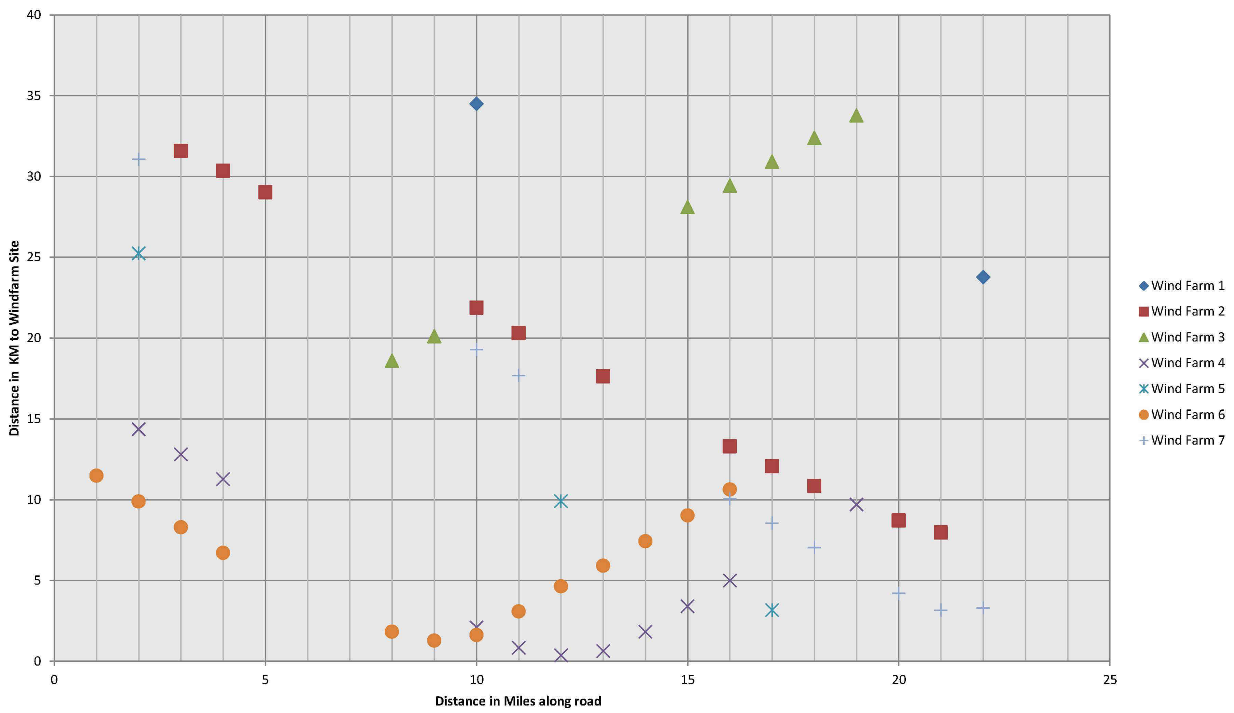


Figure 3. Reverse viewshed of Peterborough Cathedral

Another under used method for using viewshed analysis is to understand the impact of height by applying numerous points at the same location but different heights to get a gradient viewshed to understand at which height the object becomes visible to different locations (for example will the observer only see the wind turbines blades or can they see ¾ of the towers as well). With Viewshed analysis also being adopted to understand cumulative impacts from numerous wind farm developments in a small area it also becomes apparent that overlaying numerous viewsheds to understand impact is not always the most feasible analysis. Instead through processing the viewsheds into yes/no information and interpolating this onto points of distance to the turbine and distance along linear features (the often used example is roads) it is possible to graphically show the visibility of different sites as the observer would travel along the road (Figure 4 is one such graph).



Currently this tool has been developed for use on wind farm cumulative impact assessment but with a little modification it could have use within any linear visual projects (for example the visibility of tourism sites along the royal mile, or the visibility of standing stones along the avenue on Salisbury plain).

2. Acknowledgements

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4. Biography

David current role is as the GIS Manager for one of the largest landscape architecture firms in the UK (LDA Design) whilst also undertaking an MSc in GIS from Southampton University. David's role includes working across GIS platforms whilst developing spatial analysis, theoretical visibility and master planning solutions.