# Total and Cumulative Viewshed: An application in the Genil River Valley

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## ABSTRACT

*This paper shows two different applications of the viewshed tool included in current GIS packages (this one used here has been ArcGis 8.2). The aim is to explore the visual landscape of the Genil river valley (Andalusia, Spain) during the 2nd Iron Age.*
*One of the applications is a total viewshed. In order to assess the cultural importance of total visual values, a correlation to one of the cultural landscape variables (intervisibility of sites) has been done.*
*The other application is a cumulative viewshed from single sites. Its cumulative nature comes from the fact of understanding the site as a group of several viewpoints.*
*Some other important aspects involved in this kind of calculations (e.g. suitable visibility radius, reciprocity of view) are discussed as well.*
*The work is part of the author's PhD Project.*

## 1. INTRODUCTION

Total and cumulative are two ways to represent viewshed and to explore visual landscapes.
Although both kinds of calculation are cumulative (since they are obtained from several viewpoints), the main difference between them lies in the nature of approach. In the total viewshed, observers are anonymous points regularly distributed over the whole digital terrain model (DTM). In the case of cumulative analysis, the viewpoints have been determined according to a cultural meaning.
In this paper these two different calculations will be shown in an archaeological context. The area and period of my interest, as in previous works on viewshed (Zamora 2002, 2004, forthcoming a, b and c), is the Genil river valley (Southern Spain), along the river's stretch shared by the present-day provinces of Cordoba and Seville. The landscape is a sedimentary basin (60 km long per 45 km wide), an open valley of mild topographical shapes, mostly composed of hills. Some of these hills hold 2nd Iron Age sites on their tops, which makes a suitable area for visibility studies.
A group of 28 sites from the Late Iberian period, many of them hillforts, are the archaeological features considered in this work.

## 2. TOTAL VIEWSHED

### 2.1. AIM

A total viewshed has been carried out in order to analyse the potential visual structure of topography. Since both offset A and B have been equally elevated, the total viewshed shows not just how many times a location can be seen but also how many other observers the location can see.
Since total viewshed values refer to the natural structure of just one landscape variable (topography), it is not ensured that they have a cultural meaning. In order to assess the cultural importance (if any) of sites' visual value from total viewshed, a correlation to one of the cultural landscape variables (intervisibility of sites) has been done.

### 2.2. TECHNICAL SPECIFICATIONS

In theory, in a total viewshed all locations in the landscape are considered as observers. However, due to the amount of hours required for computation, it is highly recommended to make some kind of selection among potential viewpoints. In this case, the observers layers is a regular point mesh with intervals of 1'1 km between points, which means a density of almost one viewpoint per square kilometre.
The observer's height has been set in 2 m, this is the height of a person plus the hypothetical help of a rock or a tree. The problem of non reciprocity of view (Fraser, 1983; Wheatly and Gillings, 2000, 2002) has been overcome elevating 2 m offset B as well. Therefore, reciprocity of view has been inferred[1].

1 **Although an observers' distance of 1'1 km may seem poor, several tests (not showed here) have proven that usign more accurate**

Although total viewshed is an abstract calculation, the radius should be defined by some kind of cultural parameter. In cases of long distance radius and specially when using unlimited radius, high elevations will be extremely favoured in terms of amount of times seen (van Leusen, 2002, 2004; Mapples, 2004).
In this study, that cultural parameter has been the maximum distance for visual communication between sites. The task of choosing a proper distance for visual communication is very complex. The concept involves several parameters (kind of visual sign, among other aspects). The conditions of current research for visual communication do not permit the identification of visual signs in use during the Iberian period. However, the archaeological record has shown that the recognized maximum distance between watchtowers was 10 km (Bernabeu *et al.*, 1987; Bonet and Mata, 1991; Díes Cusí, 1991). Thus, the chosen radius is 10 km long. This choice does not totally avoid the radius effect (van Leusen, 2002, 2004), because it is still a long distance radius. If the visual target were people or any other short distance target, shorter radius would be more appropriate.

## 2.3. ANALYSIS

Table 1 shows data from total viewshed. The first column shows intervals of times seen. The next three columns refer to the whole DTM, and the last three columns refer to sites. For example, the frecuency column for sites (second row) means that there are 4 sites holding values between 26 and 50 times seen (or able to see); the percentage column for DTM (thrid row) indicates that 8'9% of DTM's cells have a visual value between 51 and 75.
The visual value of each archaeological site has been obtained just clicking cell by cell on the site's group of cells (the site and its very close surroundings), and choosing the highest cell value.
The analysis of these data reveals that the 97% of DTM's cells hold values below 75 times seen, while just the 35% of sites are included in those intervals. In other words, 18 of a total of 28 sites, which is the 64%, are included in the group of DTM's cells that hold the 2% highest visibility values.
For the DTM's cells the mean visual value is 24 times seen. However, the mean for sites is 84, which is very representative of their advantageous place in the total visual landscape.
Sites are located in the most visible/able to see places.

Table 1

| | DTM | | | Sites | | |
|---|---|---|---|---|---|---|
| Times seen | Frequency | % | Cumulative % | Frequency | % | Cumulative % |
| 1-25 | 289927 | 62,8 | 62,8 | 0 | 0 | 0 |
| 26-50 | 119349 | 25,8 | 88,6 | 4 | 14,2 | 14,2 |
| 51-75 | 41247 | 8,9 | 97,5 | 6 | 21,4 | 35,6 |
| 76-100 | 9510 | 2 | 99,5 | 12 | 42,8 | 78,4 |
| 101-125 | 1074 | 0,2 | 99,7 | 4 | 14,2 | 92,6 |
| 126-150 | 139 | 0,03 | 99,73 | 1 | 3,5 | 96,1 |
| 151-174 | 14 | 0,003 | 99,733 | 1 | 3,5 | 99,6 |
| | 461260 | 99,7 | | 28 | 99,6 | |

In order to make a proper assessment of the importance of this property, it is convenient to relate it to other landscape variables. In this case the variable has been intervisibility of sites.
For this task, two rankings for sites have been stablished: one ranking includes the sites' visual values from the total viewshed, and the other one refers to the number of sites that every site has in line of sight (LOS).
The intervisibility value for each site has been obtained from its particular viewshed, and not from the line of sight tool, since viewshed permits to consider not just a single point but a wider area as observer, which is a more realistic approach.
Table 2 shows these two rankings, the sites' visual value and the number of sites in line of sight.
The statistical analysis has been a simple correlation coefficient between both series of values.

**parameters (observers' interval 500 m; both offset, A and B, 8 m, which is the average height of a large iberian citywall, 6-7 m (Moret, 1996, p. 95) plus the height of a person) produces similar results. However, this statement refers just to this particular study, since the same can be not true for other geographical areas.**

Table 2

| Archaeological Sites | Visual Value (Times seen) | Num. of Sites in LOS |
|---|---|---|
| Anzur | 170 | 5 |
| Balas | 135 | 8 |
| Atalaya | 124 | 3 |
| Guijo | 117 | 5 |
| Cabezas | 106 | 1 |
| Gaseosas | 105 | 4 |
| Castellares | 100 | 5 |
| Quebradas | 99 | 5 |
| Moranilla | 97 | 4 |
| Casariche | 92 | 4 |
| Cabezuelas | 91 | 6 |
| Santaella | 90 | 4 |
| Canterones | 90 | 1 |
| Alhonoz | 88 | 4 |
| Estepa | 82 | 1 |
| San Antón | 82 | 7 |
| Cosmes | 79 | 5 |
| Sotillo Gallego | 77 | 5 |
| Caramolos | 71 | 3 |
| Zayuelas | 70 | 6 |
| Castillejo Santa. | 66 | 3 |
| Zorro | 62 | 6 |
| Castillejo Ecija | 58 | 6 |
| Salinas | 57 | 7 |
| Puerto Rubio | 44 | 3 |
| Ecija | 42 | 2 |
| Morana | 41 | 2 |
| Mestas | 29 | 4 |

## 2.4 RESULTS

The correlation coefficient between both variables is 0'1, which means there is no correlation.
For Iberian sites (Late period) in the Genil river valley, higher visual value does not mean better intervisibility.

## 3. CUMULATIVE VIEWSHED

Unlike visual analysis from several sites, the cumulative viewshed done here is an application just to a single site.
The thing that makes cumulative the viewshed from just one site is the fact that the observer is understood like a group of points over the site's whole surface.

### 3.1. *AIM*

The aim is analysing the intensity of view from the site (and from the visual field to the site as well, in the cases where reciprocity of view applies). The cumulative viewshed will permit to know how often a particular area is seen.

## 3.2. TECHNICAL SPECIFICATIONS

Since the main interest of this procedure is its methodological approach, the only one technical specification I would like to stress is the fact of considering a unique feature (a site) as a group of independent viewpoints.

## 3.3. ANALYSIS

The cumulative viewshed from all these viewpoints shows which areas are more times seen while walking throughout the site, this is, it includes some kind of observer's movement possibility.
For seeing the areas with low cumulative value the observer needs to locate in more particular places. However, seeing areas of high cumulative value is much easier in terms of observer's location.
The cumulative viewshed offers a more refined image of the visual field than the binary one (Fig. 1).
One of the archaeological applications of this approach is to identify the visual link of each site to a particular geographical area. This appreciation is probably the first one that the archaeologist perceives while "digging" visibility in the field, and it is shown in the viewshed obtained from cumulative calculation.
Since I am considering viewpoints over the whole site's surface, I am ignoring the height of the city walls and other constructions, which certainly blocked the view fom the site's inside to the outside.
Figue 2 shows a comparison between the cumulative viewshed from the whole site's surface and the viewshed just from the city walls. Although the calculation from the whole site has a stronger intensity of colours, this is due to the greater amount of viewpoints. In this example both results are proporcionally similar. In both cases the view to the South-West is more intensive than to the South-East.

## 3.4 RESULTS

When we place this viewshed in its regional context, since the analysed site is located in the western part of the basin, the high cumulative values place in the basin's outside. Therefore, in general terms, the site is visually more conected to the adjacent basin than to the Genil river valley.

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## FIGURES

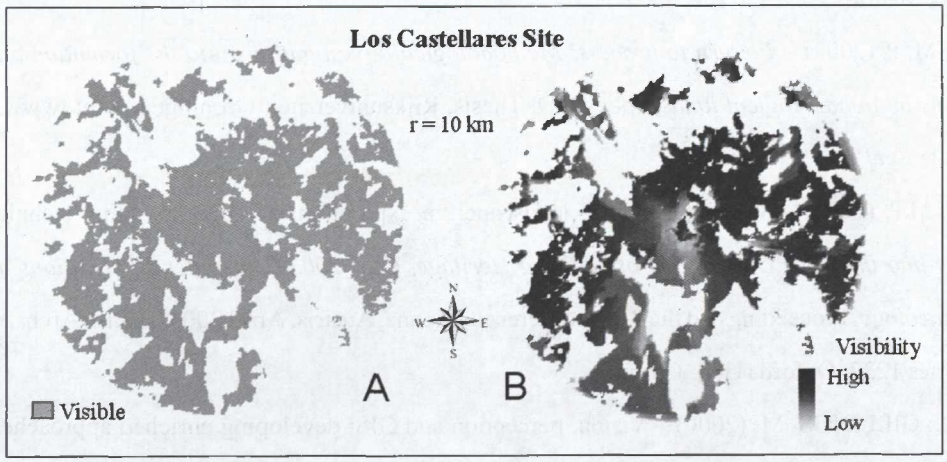


Fig. 1 – Los Castellares Site. Binary viewshed (A) and cumulative one (B).

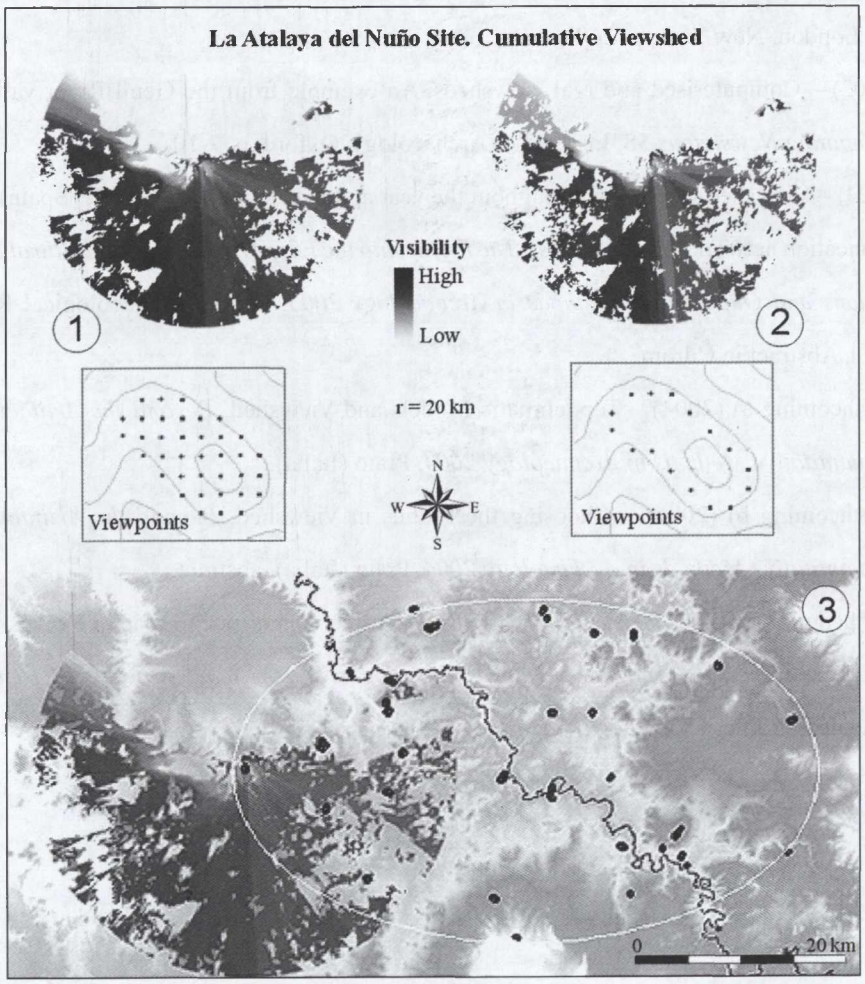


Fig. 2 – La Atalaya del Nuño Site. 1. Cumulative viewshed from the site's whole area. 2. Cumulative viewshed from the city walls. 3. Cumulative viewshed placed in the regional context. The white ellipse indicates the Genil basin.