Moyses v4.0 (Modeller and Simulator for viSual impact asESsment

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1. Introduction

The use of energy from renewable sources has become especially important in energy policies in the last decades, due to economic, climatic and environmental reasons. Particularly, wind energy, with a growing European rate of a 35% [1] and solar energy are the most developed.

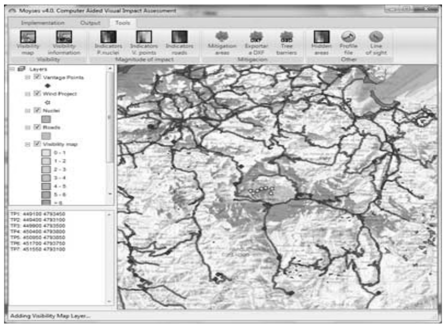

Image 1: Software tool Moyses v4.0

Visual Impact is one of the most controversial issues related to both types of energy. Sensitivity to landscape is one of the biggest obstacles to the development of this form of production, because of the difficulty in quantifying the visual effects that these structures have in a particular area. However, the magnitude of the impact caused by a wind farm, defined as the degree of visibility of the new structure, can be analysed quantitatively based on physical parameters as distance, number, arrangement, or topographical conditions.

Along with this and other criteria, the signing team has been developing an application named Moyses (MOdeller and Simulator for viSual impact AssESsment), for the automatic calculation of different issues related to Visibility Analysis (VA). Previous versions of this software have already been described [2, 3].

Moyses v4.0 has been generated to include new improvements oriented to asses wind farms, although readily transferable to other structures, as visual impact indicators, mitigation measures and automatic barrier location, line of sight tool, and calculation of areas with no visual impact. This communication is based on a recent work [4] which describes the tool widely, and a case study is performed to show how to make the mitigation measure of an impact, with graphical and numerical expression. This contribution provides an adaptation of the same methodology to measure the visibility of an observer moving along a road. In Section 2, a brief resume of the application is shown, and the results of quantifying a driver visibility on a wind farm near a highway are shown in Section 3.

2. Software Description

2.1. Initial Steps

As other existing applications – such as ArcGis, or more specific software such as WindPro, LSS or Envision - initial analysis is based on the automatized calculation of Zones of Visual Influence (ZVI) using a Digital Terrain Model (DTM). Curvature of the Earth and / or light refraction, important for long distance calculations, can be considered.

Visual inventory data in shapefile format is used to calculate the viewpoints for characterizing visual impact. This data set can include population centres, built areas, roads, vantage points, protected areas, etc., with alphanumeric attributes previously defined, as population data or number of users who travel a road sector, which are necessary to execute the additional tools. Once the application has loaded all the data provided and calculated ZVIs, Moyses provides a visibility map, the numerical calculation of the visibility area, population affected classified by distance, and the road area with visibility as the initial result.

2.2. Visual Impact Indicators

Several authors have proposed various methods for quantifying visual impact, using visual indicators with measurable characteristics. Spanish Method, proposed by Hurtado [5], and contrasted by Tsoutsos [6] has been implemented in this application. This process numerically quantifies the impact based on parameters of (i) general visibility, (ii) built-up area with visibility, (iii) relative position, (iv) distance and (v) population. All of them are, individually, important visibility information, and also the method integrates them into one, to give an idea of the overall effect.

Although the original paper applied the method only on urban areas, Moyses uses the procedure on different elements of the visual inventory, always taking into account the effect of each single indicator according to the input type. In addition, the application provides another set of indicators which contains (i) computation of the affected area, and in the case of roads, (ii) length with visibility to the wind farm, and (iii) travel times with visibility depending on the way type. All indicators are displayed both numerically and graphically.

2.2 Mitigation Measures

In case that the visual impact cannot be avoided, it is necessary to adopt techniques which allow an attenuation or mitigation. The location of visual barriers to minimise the impact is one of the most common actions.

A specific tool that automatically proposes the areas where visual impact can be attenuated or eliminated by a barrier with a given height has been implemented in Moyses. In order to arrange the calculation, DEM data, the polygon for which mitigation is going to be calculated and the project height are needed. The user will propose, through an interactive form, the barrier height and a distance range to locate it. It is also possible, if necessary, to load a new vector layer to include another constraint to locate the barrier, such as soil type, lack of equipment or facilities or other environmental or technical restrictions.

Results are displayed in the application map window as different pixel clusters, to indicate the different positions where the barriers that totally or partially mitigate the visual effect caused by the new structure can be located. Subsequently, Moyses can check the mitigation degree by modifying the DEM with the resulting barrier and recalculating the visibility map and the visual impact indicators.

2.3. Line of sight

This tool calculates the intervisibility between a point indicated interactively by the user and the structure being studied. In the case of a wind farm, Moyses calculates lines of sight to each existing turbine, and provides the measure of the visible part of each turbine in a new form. Also, it provides information on whether the windmill shape contrasts against the sky, against the terrain or against both.

The object contrast, or brightness and colour difference between the turbine and its background, is an important parameter which should be quantified. Moyses does not perform this type of calculation, but indicates the element of contrast.

2.4. Areas with no Visual Impact

This last tool has been developed with the objective of obtaining the overall pixels in a study area in which a structure of a given height can be located, which is not visible from a set of points selected by the user.

To run it, the user must select interactively on screen as many points as required, a structure length and the observer height. Moyses classifies the area according to the number of points that have no visibility, and provide a thematic map as a solution. This tool allows one to define suitable areas for the construction that minimises the impact on the previously defined points, as well as to define areas of special protection.

3. Visibility Analysis on Roads

A visibility analysis of a wind farm in a design stage for a highway has been developed using two different data sources: the road divided into sectors using a 100 m buffer around the axis, and the road defined by kilometre points (KP) equally spaced 1 km. Both polygons and KPs have their capacity stored, through data from the Spanish Ministry of Development [8]. All calculations are carried out with 50 m pixel terrain model.

Tabla I. Indicators sample for the road divided into sectors.

Name	Total área (m2)	Area with visibility (m2)	Lenght with visibility (m)	Time with visibility (s)	a	b	c	d	e	PA1
A-8-0045	166789,66	138991,38	1389,914	41,697	0.394	1,00	0,502	0,961	1,00	190.07
A-8-0046	297434,37	268361,84	2683,618	80,509	0.423	1,00	0,450	0,970	1,00	184.63

Tabla II. Indicators sample for the road defined by KPs.

Name	Total área (m2)	Area with visibility (m2)	Lenght with visibility (m)	Time with visibility (s)	a	b	c	d	e	PA1
A-8-083	2500.00	2500.00	1000.00	30.00	0.143	1,00	0,502	0,937	1,00	67.26
A-8-084	2500.00	2500.00	1000.00	30.00	0.571	1,00	0,450	0,957	1,00	245.90
A-8-085	2500.00	2500.00	1000.00	30.00	0.286	1,00	0,450	0,965	1,00	124.19

After performing the preliminary analysis, the indicators tool returns a results table with (i) area with visibility, (ii) length with visibility, (iii) estimated travel time with visibility and (iv) visual impact indicators of Spanish Method for each geometry tested. Indicator e is calculated based on the daily average intensity of vehicles, and it is at its' maximum in this case. An extract of the obtained indicators is shown in tables I and II, for a particular area of the highway, and for both definitions of sectors and KPs.

Once separately obtained the indicators for all sectors, Moyses provides a global computation in terms of area, length and travel times with visibility for the complete highway within the study area, obtaining a result of a 14% travel time with visibility using road sectors, and a 12% using KPs. The main route with visibility is oriented to the north-western area of the wind park, at an average distance of 11 km, as shown in figure 6

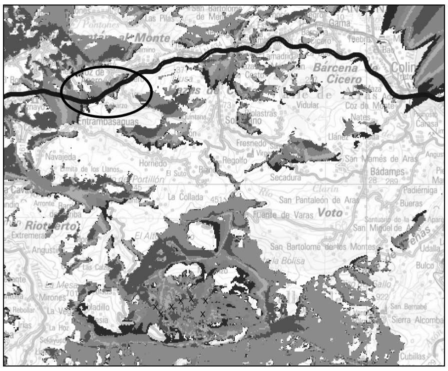

Image 6: main affected area

Image 7: mitigation results for polygon A-8-0045

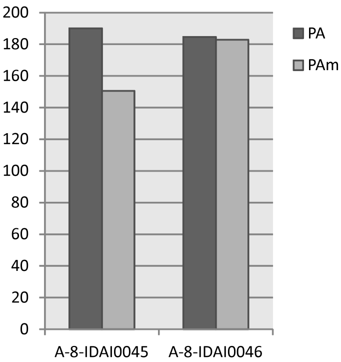

Image 8: improvement obtained

Knowing the area affected through the ZVIs and visual impact indicator tool, possible mitigation for the most affected sector, labelled as A-8-0045 is calculated, obtaining the result shown in Figure 7. The improvement is calculated for this location, and an attenuation of a 21% is obtained for this sector, with an additional gain of a 1% for the adjacent sector. Applying the same mitigation data to KPs, the mitigation for KP A-8-084, located in the sector A-8-0045, is 24.8%.

Tabla III. Indicadores para la carretera dividida en sectores tras la mitigación.

Name	Total área (m2)	Area affected (m2)	Lenght affected (m)	Time (s)	a	b	c	d	e	PA1
A-8-0045	166789,66	138991,38	1389,914	41,697	0,312	1,00	0,502	0,961	1,00	150.52
A-8-0046	297434,37	268361,84	2683,618	80,509	0,419	1,00	0,450	0,970	1,00	182.89

Tabla IV. Extracto de los indicadores para la carretera dividida en puntos kilométricos.

Name	Total área (m2)	Area with visibility (m2)	Lenght with visibility (m)	Time with visibility (s)	a	b	c	d	e	PA1
A-8-083	2500.00	2500.00	1000.00	30.00	0.143	1,00	0,502	0,937	1,00	67.26
A-8-084	2500.00	2500.00	1000.00	30.00	0,429	1,00	0,450	0,957	1,00	184.74
A-8-085	2500.00	2500.00	1000.00	30.00	0.286	1,00	0,450	0,965	1,00	124.19

Finally, the degree of visibility for KP A-8-084 is computed, using the line-of-sight tool, obtaining the results shown in figure 9. With the establishment of the mitigation barrier, visibility of one turbine is eliminated.

In this case, global length and travel time indicators do not vary, because it is a partial attenuation (fewer turbines are visible, but the full effect is not eliminated).

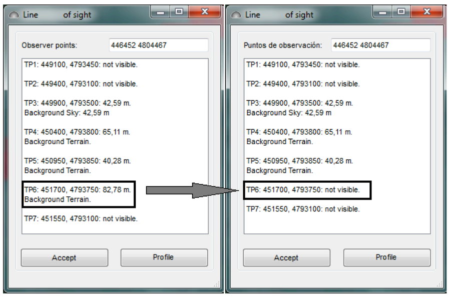

Image 9: mitigation results for polygon A-8-0045

Performing mitigation estimation for all sectors with visibility, and getting the new indicators for all of them make it possible to compute the overall effect for the complete road. Additionally, using the areas-with-no-visual-impact tool, defining areas where wind turbines could be located without being visible from these points is also possible.

4. Conclusions

Moyses software makes it possible to develop exhaustive studies of visibility, and contribute to visual impact studies in a much faster and automated way, also incorporating an acknowledged specific algorithm.

These tools (still in a process of improvement and development) provide the experts with a valuable assistance when performing the analysis of the visual effects that a structure causes on a given area. The software has been widely used in wind farm studies, but the tools are readily extrapolated to other kind of structures, such as solar farms, or even the additional infrastructure generated around the construction of wind farms, as access roads or distribution networks.

5. References

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