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GEOGRAPHIC MODELING TO SUPPORT DECISIONS IN THE IDENTIFICATION OF ALTERNATIVE SOURCES

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1. INTRODUCTION

Demand for renewable energy sources has been stepped up to meet the growing global demand for sustainably produced electricity, as fossil fuels (oil, gas and coal) are responsible for two-thirds of global greenhouse gas emissions (GHG), which can lead to sudden and irreversible changes in the planet's climate (ELOY, 2009 and ONUDI, 2013).

Energy efficiency, the development of renewable energies and waste residues valorization are elements of a strategy to reduce global warming problem coupled with territorial management. But for an assertive decision to be made, in relation to the definition of areas and spaces in which to be implemented projects of alternative sources, it is necessary to compile variables that are also pertinent to economic, environmental, social and financial issues, linked to data and spatially distributed Earth information.

Geographic Information Systems (GIS) are designed to support the collection, management, analysis, modeling and visualization of georeferenced data to solve planning and management problems (MENDES, 2013) indispensable as a decision-making tool for implementing alternative projects.

The main objective of this work is to present a method developed in GIS in order to identify the most appropriate places to install energy generation projects by renewable sources. Specifically: define the cartographic and/or meteorological products to extract the information to identify the potential generator; produce a conceptual model using Object Modeling Technique for Geographic Applications (OMT-G) and a logical/physical model in ModelBuilder (ESRI's ArcGIS technology) to identify areas and apply the models produced.

2. RENEWABLE ENERGIES

Renewable energies are those that use the forces of nature to generate energy without damaging the environment, such as production from the speed and constancy of wind (wind), solar gradients or small format hydroelectric (ELOY, 2009).

Hydroelectric energy is the main ally in clean, autochthonous and inexhaustible generation, constituting one of the main sources of electricity (ONUDI, 2013), but there is a risk related to its size. In Brazil, however, the Small Hydroelectric Power Plants (SHP) are considered renewable when their plants have at most one flooded area up to 1.3 km^2 and a drop height between 3 and 10 m in height, in addition to an installed power between 1.1 MW and 30 MW.

Wind energy is also considered to be renewable, widely available, clean, with low environmental impact and in 2009 had the highest growth potential in the world. Usually the windiest areas are the highlands and the large free areas without barriers. With the current technology, the installation of a turbine is interesting when the site is subject only to winds with average daily speed over 3.6 m/s, persistent and regular, and with low turbulence intensities (ELOY, 2009).

Solar energy is an inexhaustible, free and non-polluting source (ELOY, 2009), depending on latitude, season and atmospheric conditions such as cloudiness and relative humidity. It is the equipment used in this capture that determines what type of energy to be obtained (solar thermal or photovoltaic). With 2300 to 3000 hours of sunshine per year, Portugal is in a privileged position for the use of solar energy.

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3. GEOGRAPHIC MODELING

Geographic modeling is the process of generating additional elements from existing data sets. It can encompass several universes such as conceptual, physical and logical.

Conceptual modeling of geographic data is a representation and simplified organization of geographic reality elements involving content description, structure and operations. A conceptual schema can describe graphical and semantic data (HUBNER, 2009). According to Lisboa Filho et al. (2000) among the better known conceptual models for geographic data are those of object-oriented formalism (OO).

OMT-G is a modeling technique for the OO formalism (CRAVEIRO, 2004) that adds primitives to the Unified Modeling Language (UML) class diagram to model the geometry and topology of spatial data, offering aggregation, specialization / Generalization, network, and spatial associations (BORGES, 2002). It is based on three main concepts: classes, relationships and spatial integrity constraints (BORGES et al, 2005). Classes can be conventional or georeferenced that have subclasses and semiology that identify them and represent the data groups, which can be continuous, discrete and non-spatial.

The logical design implies the transformation of the conceptual schema into a data schema compatible with the type of model used. In this phase the mapping of the concepts of abstraction used in the conceptual scheme into data representation elements of the chosen model is carried out (LISBOA FILHO and IOCHPE, 2001, LAGO, 2006). In physical design the physical implementation aspects (data types, file storage structures, access paths, partitioning, grouping, etc.) are defined, based on the model to be used, allowing the designer to plan aspects related to efficiency (LISBOA FILHO and IOCHPE, 2001).

For ArcGIS users there is the option to develop the entire logical/physical design with the ModelBuilder tool which is a visual programming language for the construction of geoprocessing workflows. According to Cosme (2012) ModelBuilder is an instrument that, much more than allowing the design of the model, tests the procedure, validating it and allowing its operationalization, and can be considered a graphic programming tool that brings together Geoprocessing functions and allows the elaboration of models (processes) that can be used on multiple occasions. According to Silva (2015) ModelBuilder functions as a component of ArcGIS software and allows the creation of models (simplified and manageable representation of reality) from flows that join a sequence of tools necessarily present in the ArcToolbox and database, and allows you to create both workflows and new tools. Its purpose is to process large amounts of data in sequence.

4. METHOD

To develop the proposed method, it was necessary to carry out researches in different bibliographic and documentary sources in order to gather subsidies to structure it, as well as to geographically and conceptually delimit it. The methodological procedures are described below:

Definition of electrical energy matrices by renewable sources: solar, wind and small hydro power (SHP);

Definition of cartographic and/or meteorological information and products: Digital Elevation Models (DME); Land use and land cover data; Roughness of territory; Weather/climate data;

Development of the conceptual model: drawing/class diagram that described and fixed the rules for the constructed structure, by performing the behavioral analysis of the attributes of the geographical and conventional variables of the real world and its representation in the form of classes of objects and their respective relationships. Domains were assigned to the data types and spatial and non-spatial relationships were established between object classes, taking into account the different concepts used by the OMT-G model. This structure aimed to determine the flow to be followed to map areas with potential for power generation, ie, flows were defined for the different sources studied, with classes and relationships, where classes were obtained through operations indicative of the potential isolated by source, be it hydric, wind or solar;

Development of the logical/physical model: three methodological flows already modeled conceptually in the OMT-G for ModelBuilder were reproduced. The construction of this model followed the sequence of the conceptual model. In this way, the methodological flow was produced to identify areas with potential for power generation by water source (SHP), whose defined parameters were considered to indicate the possible ideal locations to insert a 150 m wide bus with a water fall height of 10 m. The other sites were considered without potential, although it is possible to identify potentials with different heights and bus widths. Next, the flow was developed for wind potential where wind velocities less than 3.6 m/s were considered null. With the exception of semantic data related to the wind source that required previous modeling in specific wind simulation software and resulted in a geographic class of point called "wind speed synthesized" used as input data in ModelBuilder, the entire construction followed the model described conceptually. After this step, the production of the methodological flow was started to identify areas with solar potential, either photovoltaic or thermal. The areas with the highest solar potential per aspect were indicated, as well as potential were assigned, considering the different Hemispheres for regions located in medium latitudes (tropical regions between 30º and 55º of latitude both north and south);

Application in the study area: the physical / logical model produced was applied in the study area: Central South region of Continental Portugal. The region had all the necessary premises to apply the method, from the beginning to the end of the flow, mainly, had meteorological stations with data made available through the Internet. In the end, it was possible to identify areas with potential to generate energy from hydro, wind and solar sources.

5. RESULTS

Model development and its application allowed to present results in three different sides: the conceptual model; the logical/physical model; and the implementation of its application in the area of study in the form of maps.

Maps that identified areas with potential to generate energy by defined renewable sources (hydro, wind and solar) were produced as results. A total of 17 sites with potential for installation of projects to generate energy through the hydroelectric source were identified (SHP with a 150 m bus and a drop height of 10 m). These 17 sites considered appropriate are shown in Figure 1.

Regarding the wind potential, it was possible to verify that the minimum wind speed identified in the study area was 2,095 m/s in the Municipality of Santarém and the maximum was 5.821 m/s in the Municipality of Beja, close to the border with Spain. Regions in the Municipalities of Beja, Sagres and Portalegre corresponded in this study to the highest verified wind potential, with values between 5.266 and 5.821 m/s. In approximately 48% of the study area, however, no wind potential was identified, since the areas have wind velocities below 3.6 m/s or some type of restriction. See Figure 2.

Regarding solar energy, the result of the relative global solar potential, taking into account the aspect, is presented in Figure 3, where it can be verified that 12% of the areas do not have solar potential. In the rest of the area, solar potential was identified between low and excellent throughout the region, approximately 88% of the area, with estimated radiations between 2.855 and 4.152 kwh/m^2 (daily average for the year 2015). In order to investigate the solar potential, no restrictions were taken into account, assuming that solar thermal and / or photovoltaic installations can be used in urban environments (roofs), as well as in reservoirs.

FIGURE 1
Water Potencial

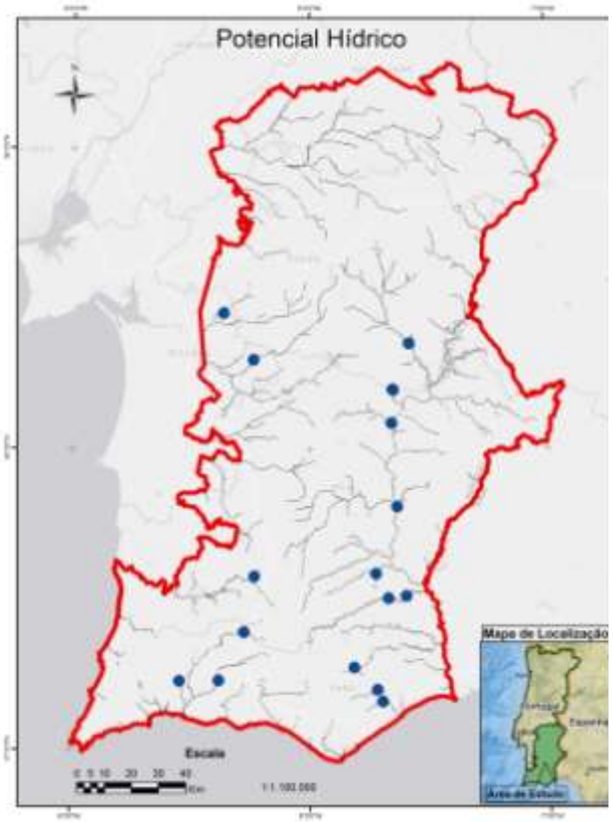


FIGURE 2
Wind Potencial

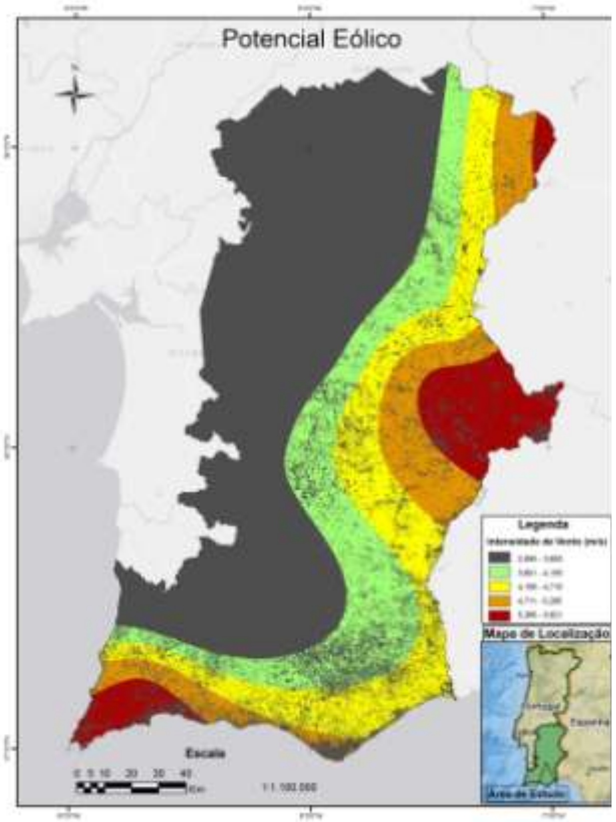
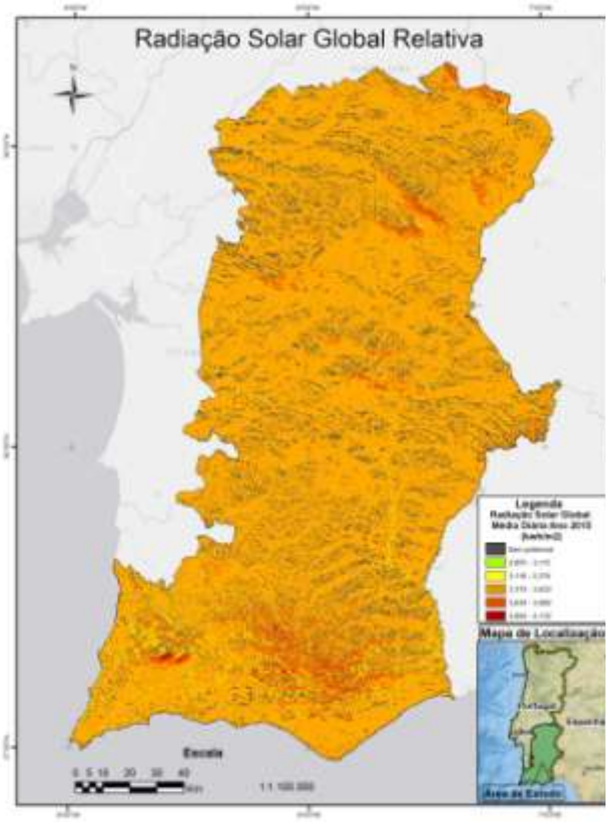


FIGURE 3
Relative global solar radiation – Daily average for 2015



6. CONCLUSIONS AND RECOMENDATIONS

It is concluded that all the objectives were reached, since the cartographic and/or meteorological information and products necessary to the development of the model were defined; a conceptual model was developed that established a methodological flow in order to provide the identification of areas to generate electric energy by renewable sources of water, wind and solar, independent of implementation software; a logical/physical model was implemented in ModelBuilder that resulted in the identification of possible areas to generate electrical energy by the aforementioned sources, regardless of prior definition of areas; and the logical/physical model was applied in a study area for validation in the Central South region of Continental Portugal and the resulting maps presented satisfactory results, pointing out the respective potentials to the matrices surveyed. Through the analysis, the hydroelectric potential of the region was considered low, medium the wind potential and high the solar potential.

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