



Technology of geographical information systems applied to the licensing of nuclear sector installations

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ABSTRACT

The nuclear licensing process involves the preparation of several documents such as Site Report (SR), Preliminary Safety Analysis Report (PSAR), Final Safety Analysis Report (FSAR), Physical Protection Plans, Radiation Protection Plans and Emergency Plans that be must submitted to the National Nuclear Energy Commission (CNEN) for approval. This work presents an analysis and a guide for the use of Geoprocessing tools in the updating of environmental studies necessary to update the Site Report (SR) of the Nuclear Technology Development Center (CDTN). The main objective was to present a tool to support the administrative process, using Geoprocessing techniques and their applications for data analysis and integration, supporting the development of methodologies to optimize the monitoring processes and nuclear licensing. To achieve the objective, we searched for and obtained available data of high reliability in various institutions using a methodological flowchart for data acquisition and treatment. The study developed was using the ArcMap 10.2 application from ArcGis, especially the Model Builder analytic tool. This tool allowed the construction of a (macro) schema of the methodology from the applied GIS tools, which presents as advantages the efficiency and optimization of the execution time of the procedures in situations where it is necessary to apply the same routine of tasks, besides the fact of being editable, which offers possibilities for adaptations and improvements.

Keywords: Geoprocessing 1, Licensing 2, Model Builder 3.

1. INTRODUCTION

According to Sobrinho over the last few years, the development of the environmental issue has been evolving, based on an increasingly strict legislation and a more energetic performance of the oversight bodies [15]. In this scenario, licensing of nuclear installations is intended to ensure that the location, construction and operation of nuclear, radioactive and storage and disposal facilities for radioactive materials do not involve undue risks to workers, the general public and the environment.

Federal law No. 7.781 de 1989 , which rewrites articles 2, 10 and 19 [2], provides that the government shall exercise the monopoly through CNEN. Article 2 defines the Competencies, covering a broad spectrum related to the nuclear issue, such as : policy formulation, regulation, guarding of radioactive waste, provision of services, scientific research and production and sale of materials and equipment.

According to safety standards CNEN-NE-1.04 [3] nuclear licensing is a process by which the National Nuclear Energy Commission (CNEN) regulatory agency, radioprotection and nuclear safety board, through evaluations and verification of Conditions, grants, modifies, limits, extends, suspends or revokes a license, authorization for the construction or operation of a nuclear installation.

Composed of a set of processes and requirements, it is applied to the activities related to the location of the enterprise, the descriptive design of items important to safety, construction, operation, modifications and decommissioning, as well as acquisition and movement and control radiation sources [4,5].

In an interpretation of the current nuclear law , expressed in the safety standards CNEN NE 1.04, CNEN NN 6.02, CNEN NE 1.13 and CNEN 8.02 [3,4,5], it is possible to observe that the studies and reports that accompany the administrative acts in the nuclear licensing processes are complex and comprehensive about maintaining nuclear safety and quality of the environment. Being conditions for the approval of the licenses, involving the preparation of documents, such as Site Report (SR), Preliminary Safety Analysis Report (PSAR), Final Safety Analysis Report (FSAR), Physical Protection Plans, Radiological Protection Plans and Emergency Plans, which be must submitted to the CNEN for approval.

Among the reports required during the nuclear licensing process, the Site Report (SR) is one of the most important, with constant updating of detailed items during licensing. It is the document in which the applicant needs to demonstrate if the site chosen for the construction of the facility meets the requirements of the safety standards, containing all the data and information that allow analyzing the feasibility of the proposed site for construction, and is of extreme importance to the other Government Acts involved in nuclear licensing processes.

The SR should cover aspects such as characteristics of use of neighborhoods, distribution of the local population, access roads and distances to population centers. A preliminary analysis of the installation's potential influence on the environment must be presented, as well as a pre-operational environmental monitoring program, with scenarios of its normal operation or in the event of an accident.

This paper presents part of the study carried out for CDTN aiming to demonstrate the strength of the methodology used. It was semi-automated the elaboration of the map with distribution of the population for demographic studies. For the SR of CDTN this map is a fundamental factor for population analysis in view of the great population dynamics that occurs around this Center. Circumferences considered as distance from the center were determined with the intention of defining together with the data made available in the 2010 census the zones of floating population, zone of low population and centers of population according to values estimated by IBGE 2010. The sectoral distribution of the resident population within a radius of 0 to 15 km from the CDTN site was defined based on the demographic census and the objectivity of the study.

The potential applications of geotechnologies in the various stages of nuclear licensing are numerous, one of the most important being the optimization of the specific studies required in the viability analysis of the site where the project will be established. Thus, the aspects included in SR are fully favored with the use of technological innovations, since they efficiently enable the obtention and treatment of a large amount of data and the dissemination of clear and reliable information.

According to Rosa, geotechnologies are the set of technologies for collecting, organizing, processing, analyzing and providing information with geographic reference and are composed of hardware and software solutions, which together constitute powerful tools for decision making, once that enable an integrated analysis of the various geoenvironmental attributes [13].

One of the most important information technologies is the Geographic Information System (GIS), which allows complex analysis, integrating data from several sources and creating georeferenced databases. It also enables the automation of the production of cartographic documents.

A GIS consists of a set of computational tools used in geoprocessing, which involves collecting and processing data obtained from field surveys to efficiently store, update and retrieve data [6].

Nevertheless, a GIS is not only composed of software, but also by applied methodologies, data to be collected and processed, and specific hardware of high performance in data processing. In order to work with GIS in a broad way, it is fundamental to plan the design of the system based on user expectations and technical knowledge regarding system specifications and studies to be developed [12].

Thus, this set of technologies alone can hardly be useful if not worked in a consistent, solid and viable way, seeking to maximize the potential of the technologies. Studies using GIS increasingly use modeling tools, such as those available in Environmental Systems Research Institute (ESRI) technology. For example, the work by Petta et al. where they sought to develop a system to evaluate and monitor the radiation level measurements in a radon oil installation [11]. The aforementioned study focused on the elaboration of a GIS, with the purpose of evaluating and, consequently, monitoring the measurements of radiation levels in the oil installations of Canto do Amaro (Mossoró-RN).

Oliveira et al. developed two works which made it possible to express the great help provided by geotechnologies [9]. In the first work, the Geoprocessing tools and the possibilities inherent to the Geographic Information Systems (GIS) technology were used, as an instrument to verify the correlation between the radiometric gamma anomalies and the lithologies present in the study area in question, (UTM Caldas) Poços de Caldas, MG, in his next work, an evaluation of the results obtained with the application of surface water quality indexes, and spatialization with the Toxic Substances (CT) around the UTM / Caldas, was presented.

Using Model Builder / ArcGis it is proposed to semi-automate the tools of analysis, spatial statistics and projections and transformations. The use of Model Builder and the tools of ArcGis 10.2.1 provide agility, efficiency and semi-automation of the processes of selection of areas, in addition to reducing the analyst's working time.

Model Builder is a visual programming language for building geoprocessing workflows. The models automate and document their spatial analysis and data management processes, where the model is represented by a diagram that connects the process sequences and geoprocessing tools, using the output of one process as input to another process.

Models created in Model Builder enable anytime it is necessary to make changes, weights or add new data, this can be done through the existing model without having to rebuild all the processes.

Based on this assumption, a self-explanatory guide was developed to present the tools and the applicability of geoprocessing in the preparation of the maps that make up the reports of the CDTN.

2. METHODOLOGY

The methodology consisted in elaborating a sequence of procedures and guidelines indicating the availability, treatment and contribution of geoenvironmental information and geotechnological tools necessary for the preparation of reports related to the licensing of CDTN nuclear installations. The Nuclear Technology Development Center (CDTN) is one of the Research Units of the National Nuclear Energy Commission (CNEN), an autarchy linked to the Ministry of Science, Technology and Innovation (MCTI). Located on the university campus of the Federal University of Minas Gerais (UFMG), in the Pampulha neighborhood, in Belo Horizonte, the CDTN operates in research and development, teaching (postgraduate) and providing services in the nuclear area and in related areas. Figure 1 shows a scheme of the main activities planned as necessary for a good application of geotechnologies in the licensing reports, specifically the Site Report (SR).

To construct the flowchart, as an auxiliary tool in data processing, it was elaborated a preliminary study in order to establish the difficulties commonly encountered when working with geotechnology in research centers with the characteristics of CDTN.

The methodological flowchart shown in Figure 1 represents schematically the main steps for a good execution of the geoprocessing tools in order to assist the SR studies and illustrates how to proceed to collect data and gather the information necessary to work with each topic addressed in this report.

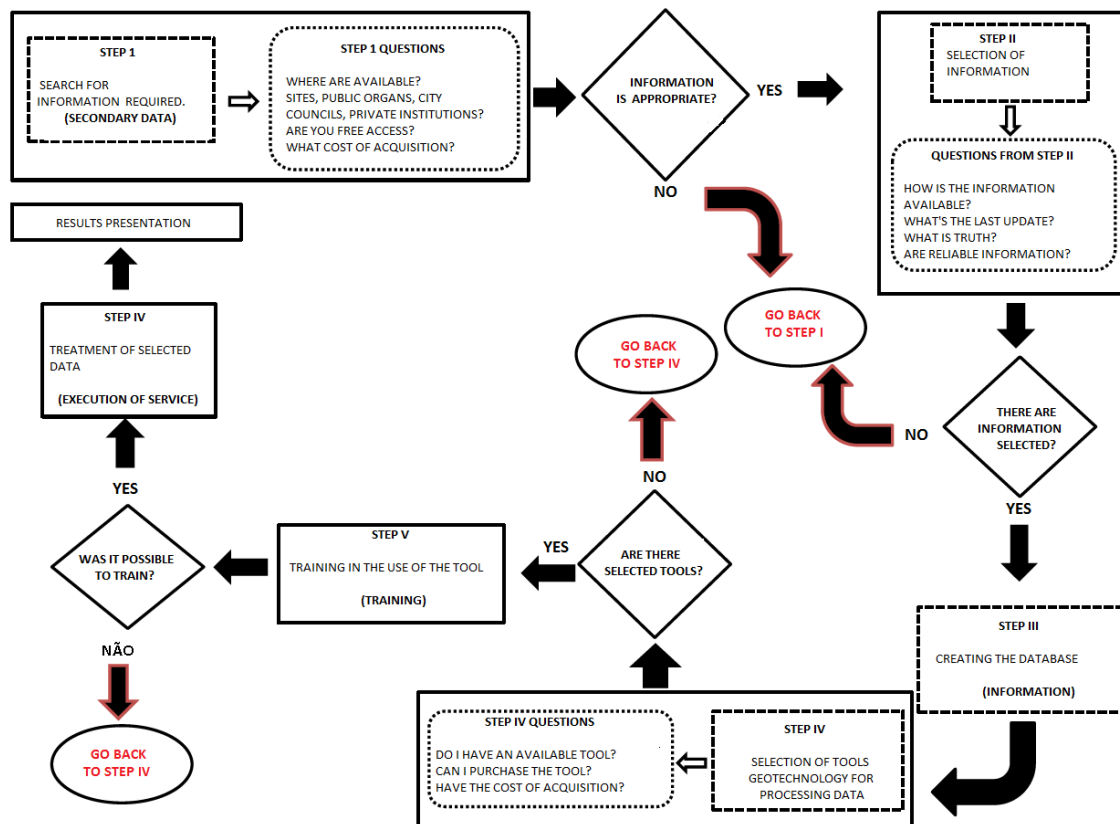


Figure 1: Methodological flowchart

The flowchart presented in Figure 1 was extremely applicable in the search, treatment and application of environmental data and the choice of the tool with the greatest potential for the execution of the work.

For this work, the sites used to obtain the necessary geoinformation in the elaboration of a cartographic database, it took into consideration carefully the source data, the criteria for download and the formats available to support the updating of parts of the Location of CDTN were:

- Mineral Resources Research Company (CPRM).
- Economic Development Company of Minas Gerais (CODEMIG).
- United States Geological Survey (USGS).
- National Water Agency (ANA).
- Brazilian Institute of Geography and Statistics (IBGE).

The structure of ArcGIS software and its ArcMap application was adopted in planning the activities and post-processing the results. During the integrated analysis of the data, repetitive operations were optimized using a modeling tool (Model Builder - ArcGIS), so the analysis process became semi-automated.

All the information selected for this study was worked with ArcGis 10.2.1 / ESRI software (ARCMAP™, 2013) and its toolbox (ArcToolbox) [1]. Inside the ArcToolbox, where the model was created employing the Model Builder routine, inserting the tools mentioned below, in order to semi automate the study. The flowchart shown in Figure 2 and the map completed during the process (Figure 3) are made available at the end of this topic.

1. Analysis Tools

- Extract
- Clip
- Select
- Overlay
- Erase
- Intersect
- Union
- Proximity
- Buffer

2. Spatial Statistics Tools

- Utilities
- Calculate Areas

3. Projections and Transformations

- Feature

Projected Coordinate Systems

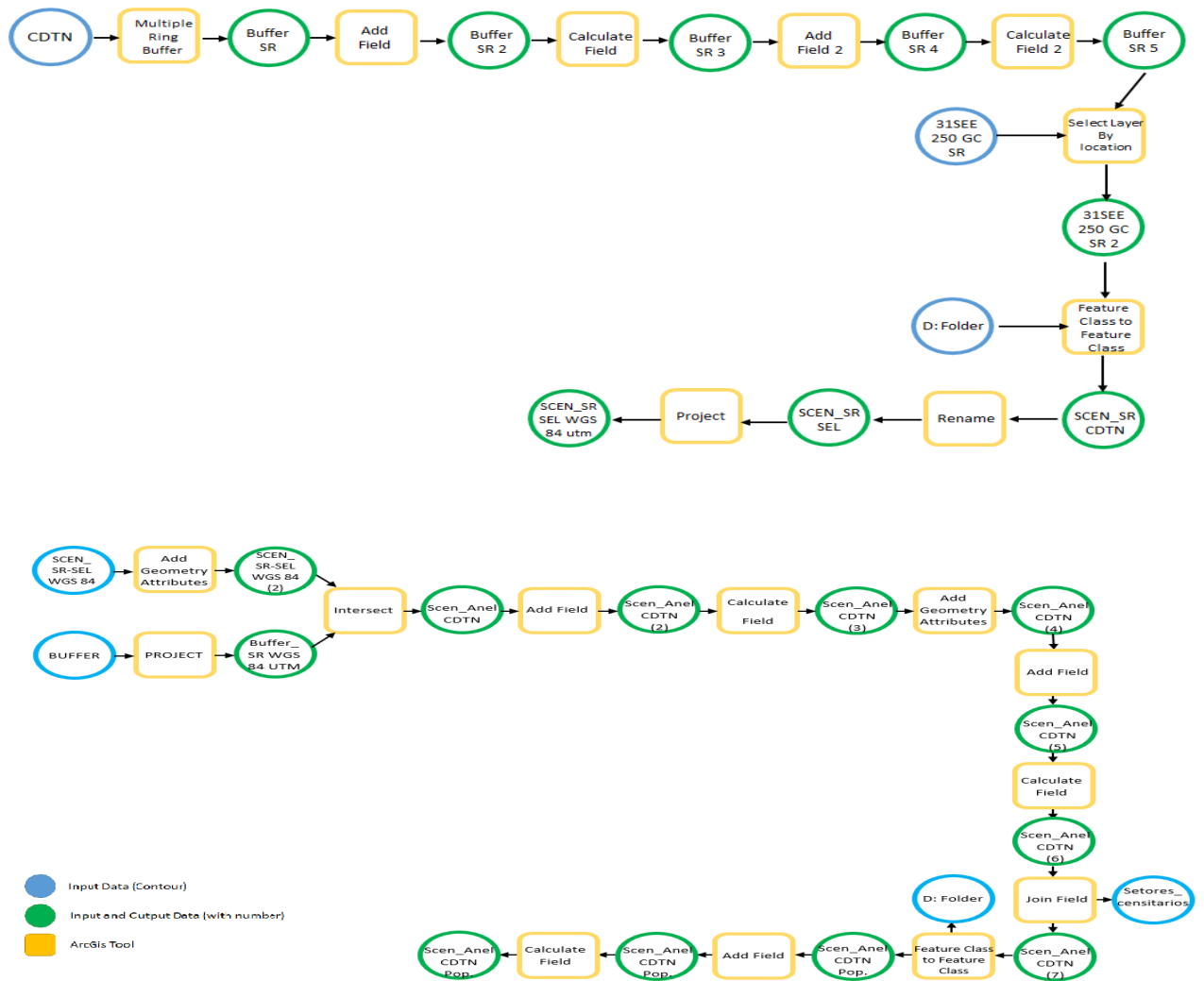


Figure 2: Population density map execution workflow

3. RESULTS AND DISCUSSION

Using the Geoprocessing resources shown in the figure 2, concentric circles with numerical parameters of 1, 5, 10 and 15 km were drawn, punctuated from the CDTN Meteorological Station (EMET). This procedure showed that in addition to the municipality of Belo Horizonte, some other municipalities in the RMBH are also included in the area of interest established by the RL. The demographic map, figure 3, has the main purpose of supporting studies to identify critical groups, based on the integration with results of atmospheric dispersion models of pollutants.

This type of map is also used to: delimit the exclusion area; know the population distribution and trends; characterize the existence of green areas and spaces not yet urbanized or of urban expansion, and; portray land use and occupation.

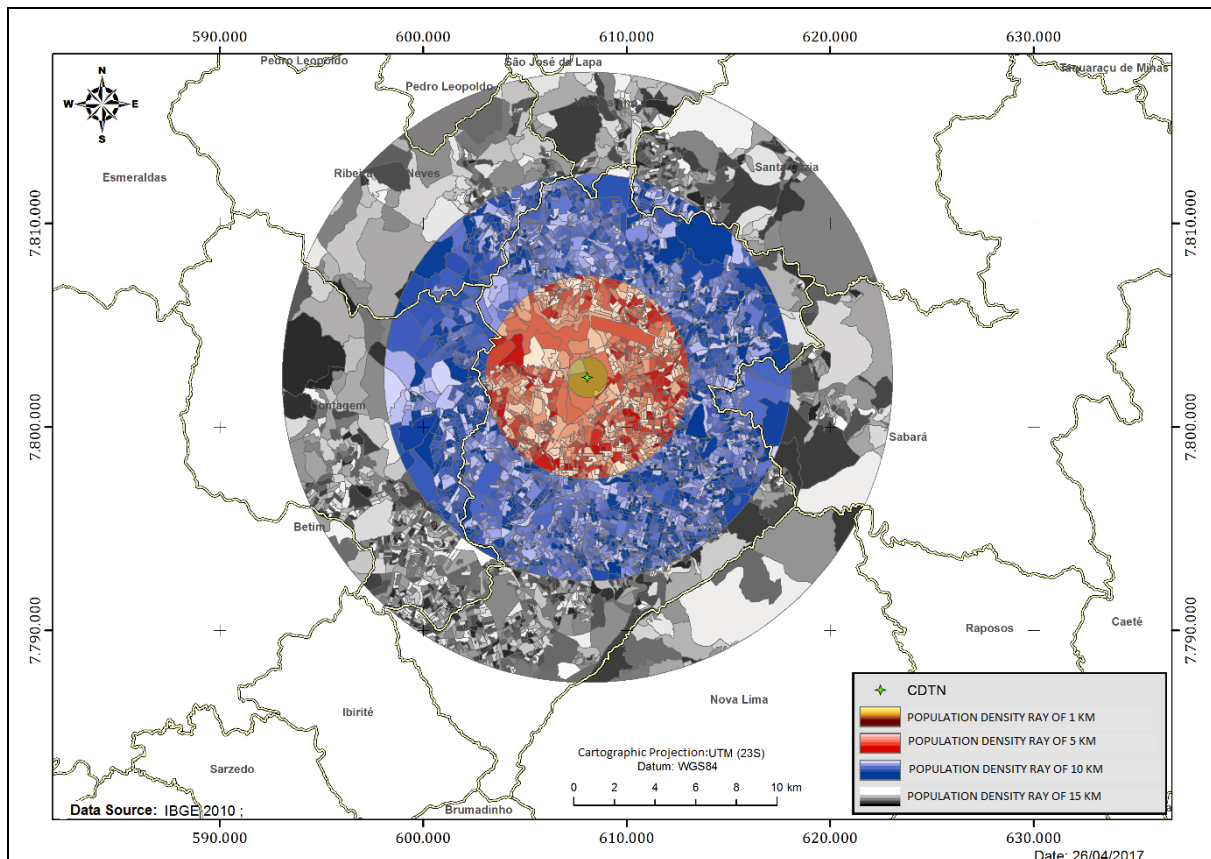


Figure 3: Population distribution in radius of 0 to 15 Km.

4. CONCLUSIONS

The presented methodology, which involves the use of ArcGIS software and its Model Builder / ArcMap tool, made it possible to obtain a semi-automated process, which aims to speed up the execution of activities that generate the necessary information in the stages of preparing a Location Report, in addition to improve the quality of the results; mainly in procedures for updating this report. It was possible to visualize, through the application of the functions present in the software, the potential of geotechnologies and their impacts on the quality of the results obtained.

The agility in creating, testing and adjusting models in order to reproduce reality in the best possible way stands out. Once the model of the geographical situation is assembled, semi-automation makes it possible to carry out studies of different scenarios, which can generate subsidies for more agile interventions.

5. ACKNOWLEDGMENTS

To the Nuclear Technology Development Center for the opportunity for technical improvement, for the efforts made and resources made available. To, the Brazilian Nuclear Energy Commission for the grant and to CNPq and FAPEMIG boards for the resources provided for the execution of this project, which otherwise would have been unlike to be developed.

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