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GEO-PORTAL IMPLEMENTATION WITH A COMBINED APPROACH OF AHP AND SWOT

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ABSTRACT

In order to achieve the goals of sustainable development, reliable and more quality spatial data is required in the decision-making and planning process. In other words, the existence of an appropriate infrastructure of spatial data is necessary for the sustainable development of the community. Recently, the creation of a Spatial Data Infrastructure (SDI) is in the program of many states at various national, provincial and local levels. SDI can be defined from a variety of perspectives; however, the geoportal design and implementation play a key role as a platform for providing spatial services. In this regard, various software exists as a geoportal platform, which is a necessity to choose an appropriate software tool among them. To achieve this goal, a set of related software products should be investigated and compared. Then, the criteria that are important from the perspective of the user and the developer are selected for software comparison, and ultimately software packages which support SDI (for geo-portal) are selected. In this regard, attempts to select one software with emphasis on environmental activities among four open source software for geo-portal implementation. In this article, the combination of AHP and SWOT is used to achieve this goal with an emphasis on environmental activities. Therefore, the criteria are first weighed using the AHP method, then, the SWOT method is used to select the appropriate software based on identifying strengths, weaknesses, opportunities, and threats.

Contribution/Originality: This study contributes to the existing literature that helps organization to choose the best software according to their internal and external factor which exist in their factory. This study uses new estimation methodology for choosing the best open source software for geoportal. Different organs can use it according to the criteria that important for choosing the best software and implementation of geoportal.

1. INTRODUCTION

Data which are collected from the environment is transformed into information, and then this information is converted into knowledge, and finally, decision-making and planning are done based on this information. Scientific studies, on the other hand, suggest that 80% of the data are inherently spatial or spatial in nature, which is required by organizations in their various management, planning, implementation and even day-to-day operations [1]. Therefore, in the present age, the importance of spatial data is not unobtrusive for anyone, because spatial data and related technologies generate spatial knowledge and, consequently, improved decision-making and coordinated planning. Spatial knowledge has a direct and significant impact on the economic, social and environmental

development of countries. In other words, spatial data are considered as one of the sustainable development infrastructures of countries. Achieving sustainable development is the main goal of many societies and countries around the world. Although many perspectives and definitions are mentioned for sustainable development, they all refer to almost a single point: "balanced and comprehensive development in the economic, social and environmental sectors"[2].

Recently, the evolution of Geospatial Information Systems (GIS) has created the technology of spatial data infrastructure for the optimal use of spatial data in an interactive environment. According to the definition of the GSDI[1], SDI[2] is the concept of a related set of technologies, policies and organizational hierarchies that facilitate the availability and accessibility of data and spatial processing in a shared environment [3].

Since organizations and companies produce and consume geographic information tend to use the best of spatial information, there is a need for appropriate documentation to search, evaluate, and use with existing spatial data sets for most manufacturers. Data and user communities have become an important priority, as this is the first important step in building a data infrastructure [4]. For example, environmental spatial data exists at different servers in different departments, consequently, all of this information should be read from different servers and made available to users.

SDI is also referred to as a kind of GIS environment, in which two requirements are met: 1) Work in the Web environment, and 2) Compliance with spatial standards [5].

Today, SDI is an appropriate and integrated structure for coordinating activities related to spatial information [6] as well as increasing awareness of the existence, status or quality of data; as a result, more and more appropriate use of which are enabled by different users in a distributed and interactive environment [7]. SDI has been defined and interpreted by different communities in diverse ways. These different perceptions have been shaped based on the background and specific problems of each country, organization, or society as a whole. SDI has been shaped by the view which specialists have in relation to SDI [8]. However, the goal of infrastructure development is the same in all societies: ease of access to information in such a way as to meet the needs of organizations, offices, citizens, businesses, and in general societies [9].

Indeed, SDI creates coherent spatial databases by integrating and spatial data generated in production organizations to improve the decision-makers and system planner. The goals of SDI are 1) attracting the participation of devices in creating and maintaining this database, 2) providing users with easy access to this database, as well as 3) using its data at different stages of decision making and planning [10]. Therefore, data organizations must provide themselves with web-based spatial services to create such a facility. Geoportal is considered as one of the main pillars of the formation of SDI, which is the gateway to the input of the spatial data, Users or organizations access spatial information of the other organization by using a geo-portal.

Geoportals are a special type of portal that is developed to provide users with access to spatial data and services. In other words, the geoportal is a web site used as an entry point for searching data and spatial services. Creating a geoportal as the gateway to entering spatial information is one of the most important parts of spatial information infrastructure; therefore, in this article, several available open source geo-portal software are compared, and the best one is chosen based on the AHP-SWOT method.

The rapid pace of the growing technology has made system developers not spend much time on designing and producing their own software products, and put their product in the first place at the earliest possible time. Because it will soon be necessary to revise the product and make changes to it by considering the new technological possibilities. Such a product development cycle requires that software products always include program code and

[1] Global Spatial Data Infrastructure Association

[2] Spatial Data Infrastructure

documentation, which can be continually reviewed during operation (even if there is no access to the original product programmers) [11].

The use of open source software to improve the level of software, and solve problems is better than commercial software. Today, many open source software are available for a variety of purposes. For example, there are various software tools for building spatial services, service catalogs and geo-portals for SDI, which are provided free of charge to users. These software can also change the custom shape by changing the programming of the applications.

In this paper, Geonode, Esri Geoportal, GeoNetwork, and Easy SDI software were selected to create geoportal in Iran. These software are good open source ones which are used in different countries such as Australia, the Netherlands, the United States and etc [12]. Nevertheless, the best option should be chosen according to the criteria and capabilities of each software according to the country's requirements. Individuals and organizations choose and use software based on their learning and abilities. However, the right choice will lead to the optimal access to spatial information and the formation of a spatial information infrastructure faster and better. So selecting an appropriate software is very influential for implementation of the process of national SDI formation.

Choosing appropriate software to implement geoportal with an emphasis on environmental criteria has some advantages. It makes the developer to access to spatial data and to create a framework for the proper use of spatial data for better decision-making and management in the environment.it also a time conserving for proper utilization of environmental resources. Creating geo-portals and accessing spatial services is crucial to preventing re-work, unnecessarily time and costs consuming. In addition, using spatial data is very important to conduct projects, planning, and managing.

In the following, we first study the research on the AHP (Analytical Hierarchy Process) model and its integration with the SWOT (Strength, Weakness, Opportunity, and Threat analysis) matrix, which is a tool for decision-making management. Then a systematic decision has been made for systematic analysis of the internal and external environments of the organization [13]. In the next section, the theoretical formulation of the hierarchical analysis model, the SWOT matrix, and the method of implementing the research are devoted. In the last part, the findings and the results of the model implementation in the selection of appropriate software have been investigated, and the conclusion is derived from the research.

2. BACKGROUND RESEARCH

Yousefi, et al. [14] used a Fuzzy-AHP model to select the appropriate site for industrial waste disposal in Salafchegan's special economic zone. In this research, the combination of fuzzy and AHP models was used to optimize the selection of suitable industrial waste disposal sites, which would increase the accuracy of the model and ensure the reliability of the results. After selecting and preparing a map of the effective parameters, weighing was carried out using the AHP method, and experts' opinions. With respect to their effective factors and their AHP weights, the mapping of the membership functions of each factor was prepared and fuzzy integration using the AND operator. In this way, the areas which are completely inappropriate for disposal of industrial wastes are recognized as well as the areas were perfectly suitable for it in Salafchegan province of Qom province [14].

AbdulReza [15] used the AHP method to select the optimal process for sewage treatment. In this paper, the process of AHP is based on expert knowledge, which was used to select the best process of anaerobic treatment of wastewater in industrial settlements. This method is used for making multi-criteria decisions in order to obtain scientific and acceptable results. Anaerobic treatment processes include UASB, an anaerobic reactor with the upstream flow (UAFB), anaerobic buffer reactor (ABR), anaerobic contact process, and anaerobic lagoon. These options were weighted according to technical, economic, environmental and managerial criteria, and the relevant criteria were weighed, and the results were then evaluated by using Expert Choice software [15].

Sedigheh and Ranjbar [16] combined SWOT Matrix with analysis techniques hierarchical, network, and fuzzy TOPSIS[3]. This combination can determine ambiguity and uncertainty in the strategic decision-making process. It also determines the degree of importance of the strengths, weaknesses of the organization, as well as the opportunities and threats of the organization. In addition, it can rank the strategies developed in terms of the impact of the strategic factors of the SWOT on the organization's success. As a result, it provides insight into the strategic management team of the organization regarding the organization's capabilities in exploiting its environment to achieve a competitive advantage [16].

In 2015, Tavana and his colleagues found that an accurate assessment of decision criteria improves the quality of a company and its activities. As a result, relevant criteria and sub-criteria were identified using SWOT analysis. Then, the AHP method was used to evaluate relative weights among the relevant criteria. Finally, these local weights were used to assign global weight to each criterion, and make a proper decision to promote the company [17].

In 2012, Sukran Seker and his colleague used SWOT analysis as a method for analyzing the power consumption of a company in Turkey, which recognized strategies based on SWOT factors. The hierarchical analysis method is used to support the decision-making status, which was identified by using the SWOT method. Therefore, the SWOT matrix became a hierarchical structure, and the model was analyzed with hierarchical process [18].

In 2017, Zeynel Abidin Polet and his colleagues determined the benefits and weaknesses of the land and cadaster management system in Turkey. They also determined its opportunities and threats due to the external environment factors obtained by the SWOT matrix. Then, the information about the land and cadastral management system in Turkey was assigned to continuous AHP by using this matrix. Therefore, the SWOT provides the main scheme in which decision making analysis is done, and AHP helps in analyzing SWOT implementation; as a result, different strategic decisions can be prioritized [19].

In 2012, Kerem Toker and colleagues stated in a paper that SWOT is a common tool that identifies the strengths and weaknesses (internal factors) of a company, as well as opportunities and threats (External factors) of the market environment. In this research, the lack of decision making in ranking for SWOT factors has led to the prediction of SWOT analysis with the multivariate decision-making process called AHP. The AHP method uses a two-way comparison of factors to evaluate them using a specific value calculation. The purpose of using the combined method is to improve the quantitative part of strategic planning [20]. In 2006, Chang and Huang used hierarchical analyzes to determine the importance of internal and external assessment indicators and calculated the concession of container ports in East Asia through an average weighted method [21].

To date, many types of research have been done on the implementation of the AHP and SWOT for decision making, planning, and management. The combination of these two methods is more visible in cross-border research. In Iran, each of these methods has been used separately in various researches. A better result can be obtained by combining these two methods. As a result, in this research, we have tried to combine these two methods to make a good choice by considering different criteria and their weighing. As choosing the right software, considering their problems, threats, and strengths, is much better and more accurate, the right choice is very beneficial to advance the goals.

3. METHOD

In this section, four open source software programs are dedicated to choosing the appropriate software. Firstly, the theoretical framework of the research is described. Then the method of doing the research is explained. Next selected criteria have been introduced for evaluating the appropriate software for implementation of geo-portal.

[3] Technique for order preference by similarity to an ideal solution (TOPSIS)

Then, the method of weighting the criteria and choosing the appropriate option is presented through the method of AHP and SWOT.

3.1. Theoretical Framework of Research

Hierarchy process analysis is one of the most comprehensive systems designed for decision making with multiple criteria. This technique makes it possible to formulate the problem in a hierarchical manner. It is also possible to consider different quantitative and qualitative criteria in the problem. This process involves various options in decision making, and it is possible to analyze the sensitivity of criteria and sub-criteria. Hierarchy process analysis is also based on a paired comparison that facilitates judgments and calculations. It also indicates the degree of compatibility and incompatibility of the decision [22].

The AHP model was first introduced by Thomas. L Saaty, an Iraqi ambassador in the late 1970s (Thomas L. Saaty) [23]. However, today, this model is one of the most effective models in various dimensional planning. In the case of different criteria in decision making, we need to weigh the criteria for which AHP is used for this purpose. AHP is a flexible, powerful, and simple method used to make decisions in situations which conflicting criteria make choosing between options difficult [24]. This model begins with the identification and prioritization of decision elements. These elements include goals, criteria and possible options. The process of identifying these elements and linking them together ultimately leads to the creation of a hierarchical structure.

In the hierarchical process, elements of each level are compared in comparison to their respective element at the higher level, and their weights are calculated. We call these weights as the relative weights. Then, the final weight of each option is determined by combining relative weights. The binary comparison method is a basic method for testing the AHP model. This method reduces the conceptual complexity of decision making, because only two components are considered at each time, which consists of three main steps: a) the production of a dual comparison matrix; b) the calculation of the weight of the criteria; and c) the estimation of the agreement ratio [25].

To create a dual matrix, values from 1 to 9 were used to determine the relative priority of two criteria Table 1 [22]. In this way, these criteria are compared two by two to determine the coefficient of importance (weight) of the criteria. This matrix is called a "binary comparison matrix of criteria". The elements of this matrix are all positive, and they are according to the principle of "inverse conditions" in the process of analyzing the hierarchy (if the importance of element i related to element j is k, the importance of the element j related to element i is equal to 1/k) [26].

Table-1. The 9th L Saaty Scale for Binary Comparison of Options [27].

Description	Importance
Equal importance	1
Equal to Medium Importance	2
Mediocrity importance	3
Medium to strong importance	4
Strong importance	5
Strong to very strong importance	6
Very strong importance	7
Highly strong to extremely powerful importance	8
Super strong importance	9

Source: [23].

In the next steps, the weight of the criteria is calculated, then the degree of compatibility of the criteria with each other is investigated. All these steps are calculated using the Expert Choice software. Finally, the weight of each software is calculated based on each criterion by comparing the binary of each software with each of the criteria. As a result, the final weight of each option is obtained according to the relative calculated weights.

One of the strengths of the hierarchical model is the combination with other models such as SWOT. SWOT is an abbreviation for strengths, weaknesses, opportunities, and threats. The SWOT analysis is one of the strategic tools, which adapt the strengths and weaknesses of the system with the opportunities and threats of onsite the system. A systematic analytical SWOT is provided to identify these factors and develop a long-term plan to create the best match among them. This model is long-term planning that not only minimizes the weaknesses and threats, but also maximizes the opportunities and strengths. SWOT model is useful for all systems, organizations, all levels of industry, and etc. To propose solutions for survival and interaction with environmental factors; as a result, SWOT is ultimately beneficial to prepare long-term plans [28].

The information obtained from the analysis can be displayed systematically within a matrix Table 2. The combinations of four elements of the matrix help to determine the four types of planning strategies. With SO strategies, new environmental opportunities can be heavily invested. With WO strategies, the advantages lied in opportunities can be used to overcome the weaknesses. Through ST strategies, environmental threats can be eliminated by using maximum strengths. Finally, by using WT strategies threats we can be eliminated and weaknesses are minimized.

Table-2. SWOT matrix.

Strength Factors	Strengths (S)	Weaknesses (W)
Opportunities (O)	aggressive strategy	Conservative strategy
Threats (T)	Competitive strategy	Defensive strategy

Source: [21].

3.2. Methods of Doing Research

In this article, eight criteria are selected for software analysis, their advantages, and disadvantages. These criteria are as:

1. Collaboration with other software
2. Support for various metadata items according to the needs of the environment (such as scale)
3. Compliance with the spatial standard in the provision of services (interoperability)
4. The possibility of providing spatial services (WFS and WPS)
5. Development capability
6. Defining user access levels (appropriate management).
7. Easy to use
8. Extent of use

These criteria are evaluated for selecting the appropriate software. Initially, the weaknesses and strengths of the internal factors, and the threats and opportunities of external factors are determined based on the criteria selected in the SWOT matrix. These factors are presented in Table 3.

Table-3. Internal and external factors of the SWOT model.

Internal factor		External factor	
Strengths (S)	**Weaknesses(W)**	**Opportunities(O)**	**Threats(T)**
1.Compliance with spatial standards 2. Support for metadata items 3. Ability to provide spatial service 4. Define hierarchy to facilitate entry of items	1. Inappropriate programming language 2. Inappropriate management 3. Not having the ability to collaborate with other software 4. Inability to search advanced (based on metadata items)	1.Easy to use 2. Development capability 3. Extent of use 4. Service-oriented architecture	1. Insecurity 2.Vulnerability 3. Failure to support the software 4. Failure to support Persian language

The strategies are determined by identifying these factors. After identifying all the weaknesses, strengths, threats and opportunities, the Internal Factor Rating Matrix (IFE[4]) and the Factor Factoring Matrix (EFE[5]) are formed. The strengths and weaknesses are analyzed in the IFE matrix, and the opportunities and threats are also analyzed in the EFE matrix.

IFE and EFE tables are designed for any software which is capable of displaying and searching spatial data through the Web. At first, the weight of each criterion was determined using the AHP method. In this method, the importance of each criterion is presented for choosing the appropriate software based on weighting the criteria. The weighting process is done based on research and studies. In Table 4, the weight of the criteria is presented for internal factors. Then each of the columns was normalized Table 5. Finally, the weight of the criteria was obtained using a mathematical average of each row.

Table-4. Matrix 8 * 8 Comparison of criteria.

Criteria	F1	F2	F3	F4	F5	F6	F7	F8
F1	1	2	1/3	3	2	1/3	1/4	1/2
F2	1/2	1	1/3	2	2	1/2	1/3	1/3
F3	3	3	1	4	3	2	2	2
F4	1/3	1/2	1/4	1	1/2	1/3	1/4	1/5
F5	1/2	1/2	1/3	2	1	1/4	1/3	1/4
F6	3	2	1/2	3	4	1	1/2	1/2
F7	4	3	1/2	4	3	2	1	1/2
F8	2	2	1/2	5	4	2	2	1

Table-5. Normalization Matrix.

Criteria	F1	F2	F3	F4	F5	F6	F7	F8
F1	0.06	0.13	0.08	0.12	0.10	0.03	0.03	0.09
F2	0.03	0.06	0.08	0.08	0.10	0.05	0.05	0.06
F3	0.20	0.20	0.26	0.16	0.15	0.23	0.30	0.37
F4	0.02	0.03	0.06	0.04	0.02	0.03	0.03	0.03
F5	0.03	0.03	0.08	0.08	0.05	0.02	0.05	0.04
F6	0.20	0.13	0.13	0.12	0.20	0.11	0.07	0.09
F7	0.27	0.20	0.13	0.16	0.15	0.23	0.15	0.09
F8	0.13	0.20	0.13	0.20	0.20	0.23	0.30	0.18

The weight of each criterion was obtained by averaging the value of each row for internal and external factors, which shown in Table 6.

Table-6. Standard weight (for internal factors).

Criteria	Weight
F1: Inappropriate programming language	0.055
F2: Inappropriate management of users	0.043
F3 Not having the ability to collaborate with other software	0.115
F4: Inability to search advanced (based on metadata items)	0.028
F5: Compliance with spatial standards	0.222
F6: Support for metadata items	0.156
F7: The ability to provide spatial services	0.311
F8: Define hierarchy to facilitate entry of items	0.07

4. RESULTS

Selecting an inappropriate software to implement geo-portal can be very destructive because searching for a spatial service will not be easy. Hence users cannot easily use them, and good management cannot be done on them.

[6] Internal Factor Evaluation

[7] External Factor Evaluation

Therefore, selecting the appropriate software for implementing geo-portal is very important; a good choice can be done by considering the criteria mentioned before.

In order to select the appropriate software, AHP and SWOT were used. The results of weighting the criteria show that GeoNetwork software is the appropriate software with each of the mentioned methods. By using Expert Choice software, criteria are compared in relation to the importance and superiority of each other. Finally, the weight of each criterion is normalized and averaged. The inconsistency rate is also 0.10. An inconsistency rate is an indicator in which value indicates inconsistencies and possible inconsistencies in the paired matrix [29].

Each of the selected criteria is weighted by the AHP method. In order to evaluate the criteria, a comparative method is used, in which two criteria are compared with each other, and they derive different values based on their importance and also according to the goal of analysis.

After determining the weight of the criteria for each factor, a score of one to four is allocated based on the degree of compliance of the system with opportunities and threats, or weaknesses and strengths. Score 1 to 4 respectively indicates the basic weakness, weakness, strength, and very high strength factor in relation to the desired criteria.

Table 7 shows the internal factors. The coefficient of importance each factor was multiplied by the weight of that factor obtained by the AHP method. Weighing value is obtained, which is between 1 and 4 with the sum of scores. For the Geo Network software, the internal factors obtained 3.50 which is shown in Table 7.

Table-7. IFE Table.

IFE	Internal Strategic Factors	Weight	Current status rating	Weighted score
Weakness	1. Inappropriate programming language	0.055	1	0.055
	2. Inappropriate management of users	0.043	1	0.043
	3. Do not interact with other software	0.115	1	0.115
	4. No advanced searchability (based on metadata items)	0.028	1	0.028
Powers	1. Adhere to spatial standards	0.222	4	0.888
	2. Support metadata items	0.156	3	0.468
	3. The possibility of providing spatial services	0.311	4	1.244
	4. Define hierarchy to facilitate the entry of items	0.070	3	0.21
		1		3.05

Then, the external factors strategy table is also provided for each software. The weighted score for external factors of Geo Network software was 2.56. By comparing the weighing scores of software with each other, GeoNet software is superior to Geonode, Esri Geoportal, and Easy SDI software.

5. DISCUSSION AND CONCLUSION

Appropriate software for geo-portal implementation that users can search for their data is very important. Users need to have the right tools to search for their spatial data, know the available data and content. They also must know spatial data quality access to data and provide orders for processing data and etc. A user who searches for a particular data or services connects to a geoportal and introduces his or her subject to the system. The geoportal also finds services that contain searchable topics, and after finding the desired data, the user can access it through the data service provided by the data owner. By choosing open source software, one can implement a geo-portal which is suitable for searching and accessing spatial services. In choosing the appropriate software for geo-portal implementation, various parameters must be considered. These parameters and criteria are presented in the research methodology section. In order to choose the appropriate software based on these parameters, a combination of two methods AHP and SWOT is used. As seen, the Geo Network software was selected as a suitable software for geo-portal implementation. Weighing the criteria using the AHP method, and applying the weights to

the internal and external factors of the SWOT matrix, the highest scores for this software were awarded. Environmental parameters are among the most important parts of each country and should be given special attention. Everything that is necessary for the survival of humans depends on the environment; the environment is a human being and it is the most important aspect of life because the health of mankind and any other species are directly related to the health of the environment [24]. Therefore, a suitable geo-portal is designed and implemented with the emphasis on modeling environmental data. The geoportal is equipped with web-based spatial services and organizations which are responsible for environmental affairs. This can help to achieve national SDI. There is also better and more forward-thinking management and planning in order to maintain the environment. The geoportal is the gateway to entering spatial information, which has to be implemented with respect to several elements such as services, the creation of a platform for ordering, managing users, and so on. As a result, geo-portal is one of the requirements for the formation of SDI, and all organizations will place their generated spatial services within a geo-portal to become part of the spatial information infrastructure. For example, the environmental organization produces its own spatial data such as protected areas, wildlife refuges, hunting grounds, national parks, green spaces, and so on. By creating a site for environmental layers, all of these layers were categorized and provided with the provision of web-based spatial services. As a result, environmental data are integrated based on the needs of the users and the levels of their access, so the user can provide their data by a local portal. It should be noted that by creating a geoportal at the national level, all available spatial services produced by different organizations can be known. In this way, an organization generally generates an appropriate portal using appropriate open source software (based on the results of this research Geo Network software) to locate spatial services produced by other organizations, so that all users search this portal and can access to spatial data.

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