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GIS Supported Analysis of Environmental Impact Assessment in Dam Projects: Pamukluk Dam Example

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Abstract

Application of Geographical Information System (GIS) to Environmental Impact Assessment (EIA) of dam projects was investigated. By using data obtained from digitizing of related maps, the Spatial Impact Assessment Method (SIAM) was applied in order to be utilized in EIA studies. For this pupose, environmental impact indexes were calculated for the study areas, absolute, short, intermediary and extended protection zones determined according to the maximum water level of dam reservoir and irrigation areas. Calculated environmental impact indexes were -1.5, 0.73, -1.81, -0.22, 0.96 and 1.22, respectively. Environmental impact assessment results showed that the most affected area was found to be short protection zone. The reason of this condition is able to explain as existing of population density in this area.

Keywords: GIS, EIA, SIAM, Pamukluk Dam, Water pollution and control regulation

Baraj Projelerinin Çevresel Etki Değerlendirilmesinin CBS Destekli Analizi: Pamukluk Barajı Örneği

Öz

Coğrafi Bilgi Sisteminin (CBS) baraj projelerinin Çevresel Etki Değerlendirmesine (ÇED) uygulanması araştırılmıştır. İlgili haritaların sayısallaştırılmasından elde edilen verileri kullanarak, ÇED çalışmalarında kullanılmak üzere Mekansal Etki Değerlendirmesi Metodu uygulanmıştır. Bu maksatla, baraj rezervuar maksimum su seviyesine göre belirlenen mutlak, kısa, orta ve uzun mesafeli koruma bölgeleri ve sulama alanları altında kalan alanlar için çevresel etki endeksleri hesaplanmıştır. Hesaplanan çevresel etki endeksleri sırasıyla -1,5, 0,73, -1,81, -0,22, 0,96 ve 1,22 olarak elde edilmiştir. Çevresel etki değerlendirme sonuçları, en fazla etkilenen alanın kısa mesafeli koruma bölgesi olduğunu göstermiştir. Bu durumun nedeni, bu alandaki nüfus yoğunluğunun varlığı ile açıklanabilir

Anahtar Kelimeler: CBS, ÇED, Mekansal etki değerlendirme, Pamukluk Barajı, Su kirliliği kontrolü yönetmeliği

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1. INTRODUCTION

Every objects and every happening events on the world have a place, that is a geographical position. The groundwater and surface water resources, the forests, the land types, the mines, the geologic formations, the wetlands, the dry lands, the deserts, the atmospheric phenomenas, the plant covers, the domestic or wild animals, the usage of field, the archeological sites, the settlements, their pollutions, their social, economical, and cultural situations, the environmental pollution, the transportation network as highways and railways, the traffic accidents, the fires, the factories, the production bazaars, the groundwork associations as water, canalization, electric, telephone network are all related to geographical position. Collecting, evaluating, analyzing, planning, mapping of such different circumstances and events, updating them according to the new situations and producing solutions for problems can be possible by managing the information faultlessly and generating information systems. In the stages told above, GIS, which collect information, classify, decrease the process of deciding by using various analysis and questioning techniques, become a part of activities.

EIA is an aid system to decisionmaking and to the minimization or elimination of environmental impacts at an early planning stage. The EIA process is potentially a basis for negotiations between the developer, public interest groups and the planning regulator. There are many techniques used in EIA, such as matrices, checklists, overlay maps, and networks [1].

Besides the produced information on the earth, also the amount of the information obtained from satellites is increasing day by day. According to the researches and statistics, the yearly obtained datas double every year. So, there is a heavy information accretion and traffic around us. The bigness and congestion of the obtained informations mass make easy the informations becoming complicated. Therefore these datas must be managed with an organized manner. The need for informations management has revealed the concept of information systems in parallel with the developments of information technologies.

It is an incontestable reality that GIS has become an important mean in solving many problems fast and effectively. As we discuss the usage of GIS in the solution of environmental problems in this context, we can easily see how strong and successful it is.

At the results of the works which have started in 1980 and continued up today, many researchers have agreed on that in the studies of GIS is a useful mean in EIA and they have anticipated that its utilization will rapidly become widespread [2]. The researches have shown that GIS is a tool which will be used in the EIA processes of the elimination, content, description of project, determining and evaluating of effects, comparison of alternatives, developing the preventions, the presentation of report, keeping and checking after EIA.

In the EIA works, the effectively and widespreadly utilization of GIS is essential for getting the benefits obtained from the usage of GIS. But despite of these lots of advantages, the usage of GIS is not common. The main reason of that is the need of investment, time and qualified man power for the GIS technology. After providing these main requirements, the quality and formats of the datas being stocked in the platform of GIS are very important. Because of many datas still being on pappers, there are great problems in the data transfer to the platform of GIS.

GIS is a tool which is used for collecting spacial datas for a specific aim, stocking, presenting for usage in case of necessity, transformation and displaying [3]. Because of many spacial natures of environmental impact, it is used as a frame for combining all processes in all EIA's stages from making thematic information, stocking and displaying to impact assessment and evaluating them as a decision making aids [4].

At the same time, GIS provides the usage of a simple processing group (overlay, classification, interpolation, collecting of spacial information) which provides the further information supporting of the impact assessment. For example the impacts of the usage of agricultural lands, the ecological injuries of vulnerable areas, the changing of water flow and the attainable changes can be primarily anticipated with the collected information in GIS and the crossing of the thematic datas in the project place. The support functions, except for the presentation of GIS's results, have been researched less. But there are still the examples of evaluation of simplified impact and visalization methodologies based on GIS. A majority of these approaches is used for producing impact maps by crossing of the main information with the project characteristic and impacts, the spacial describing of the impacts and their evaluations. Eddy [5] has especially emphasized the advantages of using GIS in EIA for the data management, overlay and its analyses, trend analyses, the data groups source for mathematical impact models, habitat and aesthetic analyses and public application.

The anticipation of impacts greatness is generally made by the application of simulation models. The obtained result is usually a map of environmental component value (for example a concentration of air pollutant) in any points of work place. So the extensions of environmental impacts can be anticipated according to the spacial dispersion of the environment quality values obtained for every evaluated alternative [6].

Recently the importance and potential of usage of GIS has been accepted by integrating a spacial approach to the economical evaluation of environment, that is the preparation of "economical value maps" [7,8]. Such an approach increases the practical application of cost-benefit analysis and so it has got a very strong potential for developing the economical evaluation role in EIA. GIS can provide good function of information technology for EIA, based on its strong ability on processing spatial data and attribute data. The applications of GIS in establishing environmental information database, selecting sites for projects, making environmental thematic map and combining with environmental model to predict environmental impact [9].

Artunes at al. [10], have presented a new approach in the impact evaluation based on the assumption that the importance of environmental impact is linked to the spacial dispersion of the impacts and impacted environment besides the other headlines of environmental impact importance. The information which is generated by using GIS in the estimated levels and impacts characterization of EIA, is used in the evaluation of impact importance by calculating a group of impact indexes. The impact indexes for every environmental components (air pollution, water resources, biological resources) have been calculated based on the spacial dispersion of impacts. This work, which is made by Artunes at all., presents a new impact evaluation method "Spatial Impact Assessment Methodology" (SIAM) which aims to make the evaluation of impact importance more productive by presenting accessibly the spacial dispersion of environmental impacts. So this method is based on spacial importance evaluation of impacts with the support of GIS by using the obtained information in the process of EIA.

In this study, application of GIS to Environmental Impact Assessment (EIA) was investigated. For this purpose, the maps of the dam planned by General Directorate of State Hydraulic Works (DSI) on Pamukluk Stream and its surrounding area were digitized. By using data obtained from digitizing, the SIAM was applied in order to be utilized in EIA studies.

2. MATERIALS AND METHODS

2.1. Materials

In this study, the impact values were obtained with the aim of EIA, for the purpose of using it in the Environmental Impact Assessment of Pamukluk Dam planned by DSI. The purposes of Pamukluk Dam are domestic water supply for Mersin and Tarsus cities, irrigation water supply for agricultural area (18 600 hectar) and electricity generation.

MapInfo Professional 7,5 SCP Evaluation and Vertical Mapper 1.51 programs were predominantly used for both preparation of the workplace model and analyzing in a numerical situation and getting the results. MapInfo Professional 7,5 SCP Evaluation program is usually used in the stages of making layers, digitization, data entry, analyzing and making a three dimentinoal model of area by using Vertical Mapper 1.51 various interpolations. In the applications of Map Basic which takes place in MapInfo Professional 7,5 SCP Evaluation, overlay applications were used. The study area is on East Mediterranean Region and in Mersin Province's boundaries. It is bounded by Berdan dam reservoir lake on east, Tece stream on west, Mersin and Tarsus cities on south. On north the study area border extends to 240 m elevation. The Pamukluk Dam will be built 120 m height from thalweg on Pamukluk stream which is a reach of Berdan River on 33 km northeast of Mersin. The study area has generally a slope land view and it consists of complicated slope lands. There are surface rocks and altitude problems and there are altitudes between 150 and 350 m elevations. The study area is shown on the Figure 1.

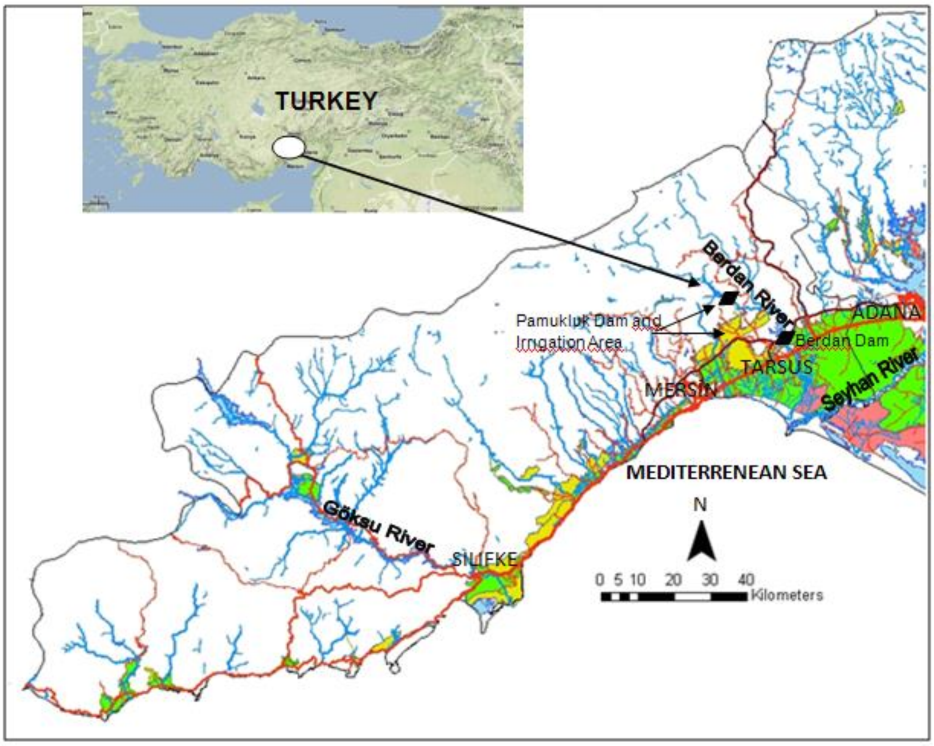

Figure 1. Study area

2.2 Method

The maps, which take place in computers by being scanned, were attached to MapInfo Professional 7.5 SCP Evaluation program as a leader in the created layers that was as a base to be used, with the help of coordinates which were the corners of maps based on real world coordinates. The reference points were adjusted with the help of coordinates on 1/25000 scaled maps corners used as a base and the margin of error was decreased. The dealt maps have a scale of 1/25000 and because there are contour lines, water resources, settlements, partial plant pattern and roads on these maps, the digitization was made one by one for these attributions and layers was made for each one. Because the contour lines have a 10 m sensitivity on 1/25000 scaled maps, the established layer was made with a 10 m sensitivity. As based on legends of maps used for base, the other layers was classified relatively. For each different water elevation, a seperate layer was made by taking the planned dam normal and maximum water elevations from the report prepared by DSI.

2.3. The Application of SIAM in the EIA Study of Pamukluk Dam

The precollected information is commented and integrated to support the decision- making on the stage of EIA evaluation. Because the impact anticipation results of various environmental components are given in different units, it is very difficult to anticipate this information conjugately and evaluate the alternatives. In the EIA

applications a general impact magnitude scale (for example, from a very important negative impact,-5; to very important positive impact, +5) is generally described to cope with this difficulty.

As seen on the Figure 2, the application of SIAM to Pamukluk Dam EIA was made in three steps. These steps are: specifying the content and impact (Environmental components, indicators selection, the definitions of analysis levels and specifying the related study areas), estimating the impacts and classification of environmental descriptives and the calculation of impact indicator and indexes.

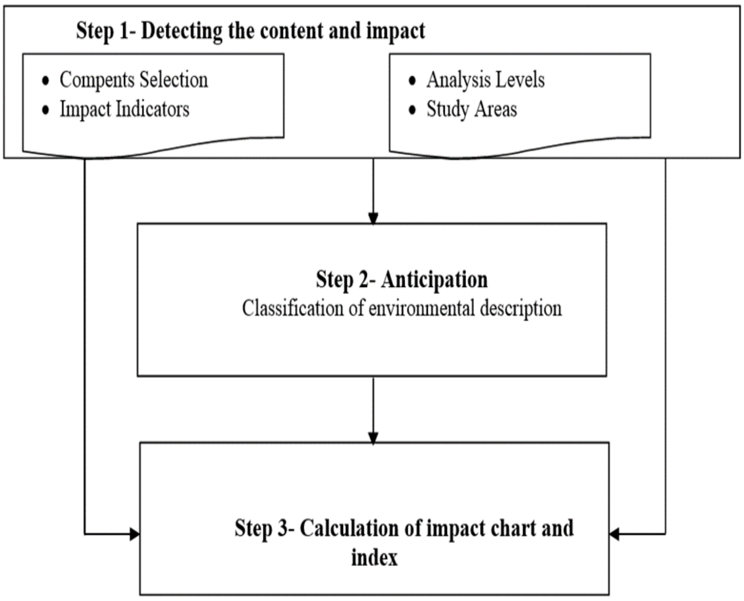

Figure 2. Steps of SIAM’s Application

Step 1: Detecting the Content and Impact

The impact indicators are used to measure the impacts of each component. So for each component at least one impact indicator must be described. The described indicators, on the level of EIA’s scope stating, must be addressed to all units related to impact evaluation, especially to professionals, job owner and general public. The used impact indicators are related to the project type and the characteristic properties of affected area. As the environmental impacts of the dam, which will be built on Pamukluk river, is examined, it can be possible to make a distinction for impact indicators. This distinction can be seen on the Figure 3. But because the datas of study area were constricted, two of the components shown on Figure 3 and the indicators related to these were examined and SIAM was tried to be applied related to these components.

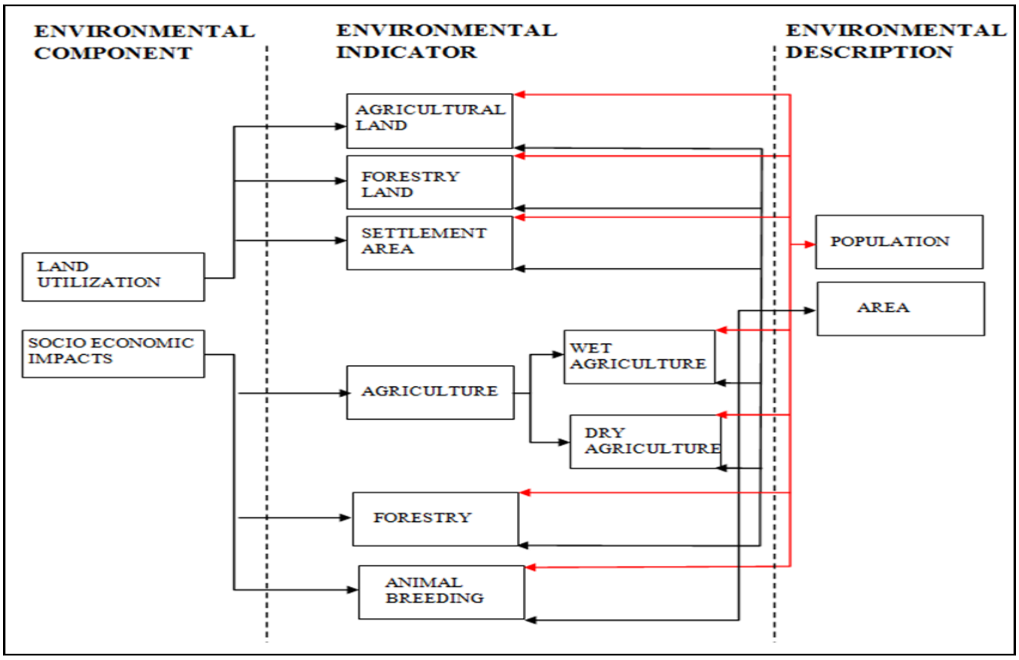

Figure 3. Impact indicators of Pamukluk Dam

The area which is regarded in the SIAM application and the calculation of impact indicators was called as study area. There are not many detailed analysis and standart methods in the existing literature. But the selection of study area is directly related to the results of EIA process. According to Mostert [11], the prefered study area has subjective point of views. While the project owners and authorities prefer generally small work areas in the EIA process, various environmental groups prefer bigger study areas.

The study areas of the dam planned to be built on Pamukluk stream were specified as close neigbour areas which are directly impacted by the project that was the impact analysis on the projects local scale. One of the reasons for putting such a limitation was that the numerical platform, which was obtained by producing the project area data, was attained from the work area and the maps covering its close environment. The other and more important matter is that because it is assurance of drinking and potable water which takes place among the projects aims, they are arrangements and applications belonging to Absolute, Short Distance, Middle Distance and Long Distance Protection Areas which take place in the fourth part of Water Pollution and Control Regulation (WPCR) published on the "Turkish Republic Official Gazette" of numbered 26786 and dated 13rd February 2008 [12], that is in the Basics and Bans Related to Water Quality. On the Figure 3, the protection areas of Pamukluk Dam reservoir prepared with buffer analysis are shown.

Step 2: The Anticipation and Classification of Environmental Descriptives

The anticipation level results of SIAM assume that the environmental descriptives for each project alternatives are presented with the maps which show the expected spacial dispersion. In this study, "environmental descriptives" describe the environment properties which are affected by the planned project. The obtained results from impact anticipation must be classified according to general evaluation scale based on criterias specified by some resources such as environmental quality regulations, resource evaluation guides, dose-reaction relations, known impacts, pressed literature and experts.

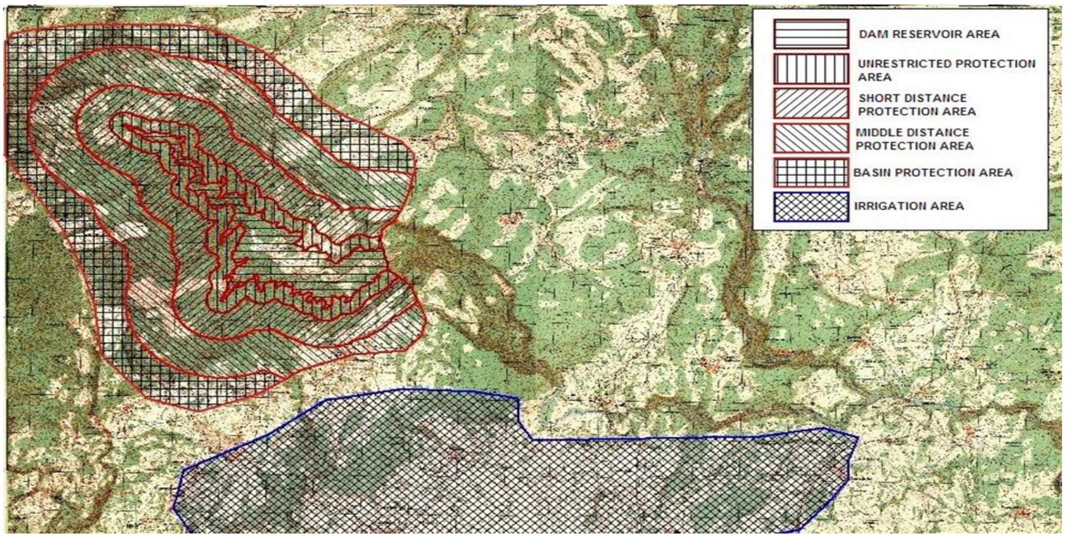

Fig. 4. Protection areas in dam reservoir

Some analysis with a GIS based must be done to specify the plant pattern which was in the study boundaries shown in the Figure 4 and to take the areas of this plants pattern. With these analysis the estimating of the acreages, which were in the protection areas specified in both dam reservoir and The Basics and Principles Related to Water Quality, has almost no error. The village headmen was contacted for specifying the settlements in the project area of Pamukluk Dam and the population, and taken the information of final situations of the villages. The villages which are directly affected by the project and other information about these villages are shown in the Table 1.

Table 1. The population of settlement site and study areas

Name of Settelement	Population (Person)			Study Area of Population (%)		
	Total	Woman	Man	Agriculture	Animal breeding	Forestry
Karain	321	147	165	27	40	33
Sarıkavak	1190	517	673	50	39	11
Kesecik	249	130	119	30	50	20
Belen	842	428	414	50	40	10
Tepetaşpınar	230	113	117	90	10	-
Kaklıktaş	347	160	187	80	20	-
Çakırlı	876	459	417	95	5	-
Karadiken	680	363	317	95	5	-
Ulaşlı	1422	681	741	95	5	-
İbişim	584	303	281	95	5	-
Pirömerli	412	198	214	50	40	10
Karadirlik	782	388	394	80	20	-

The population, which will be directly and indirectly affected by Pamukluk Dam project made by benefitting from the villages population belonging to layer of settlements obtained from the base map, was specified as a result of overlay analysis. The population densities were considered in the determining of the affected population and it was benefited from the informations in the settlement layers for the calculation of population density. But, while specifying especially the protection areas, it was seen that either complete or one part of the settlement was in the specified protection area. Moreover, while one part of a settlement was in the protection area, the other part was in another protection area. However while the population, which is affected by the protection area is being specified, only the population which takes place in the settlement in the boundary of protection area must be calculated. As regarding this factor, the areal greatness of the settlements affected by the project was specified with the help of the settlements layer prepared before. Then the settlement areas, which take place in each protection area and irrigation area, was found by benefiting from the maps prepared with the help of overlay analysis. The population density of he settlements having areas and the populations in the protection and irrigation areas are shown in the Table 2.

Table 2. The population of settlement site and study areas

Name of Settlement	Population (person)	Area Km^2	Pop. density person km	Population Density of Protection Areas				Population in Protection Area			
				700 m	1000 m	Basin Protect	Irrigation	700 m	1000 m	Basin Protect	Irrigation
Karain	321	0.214	1497	0	0	0.214	0	0	0	321	0
Sarıkavak	1190	0.967	1231	0	0.395	0.521	0	0	486	641	0
Kesecik	249	0.098	2529	0	0	0.098	0	0	0	249	0
Belen	842	0.683	1232	0.051	0.247	0.008	0	63	305	10	0
Tepetaşpınar	230	0.292	788	0	0	0	0.090	0	0	0	71
Kaklıktaş	347	0.217	1601	0	0	0	0.128	0	0	0	205
Çakırlı	876	0.211	4154	0	0	0	0.211	0	0	0	876
Karadiken	680	0.327	2083	0	0	0	0.327	0	0	0	680
Ulaşlı	1422	0.209	6804	0	0	0	0.209	0	0	0	1422
İbişim	584	0.192	3040	0	0	0	0.072	0	0	0	219
Pirömerli	412	0.223	1846	0	0.014	0.128	0	0	26	236	0
Karadirlik	782	0.414	1888	0	0	0	0.270	0	0	0	510

Step 3: Calculating of Impact Chart and Index

In the situation of making project, the environmental components are dealt as land use and social impacts, agriculture, forest and settlement for the land use as impact indicators, the sectors with which people continue living, that is as animal breeding, agriculture and forestry. The area loss and affected population are specified as environmental descriptive.

In this situation, the impact index for j alternative is;

$$EI_j = w_a \sum_{i=1}^{n} \left(Q_i \frac{I_{a,i,j} - I_{a,i,0}}{IT_a} \right) + w_p \sum_{i=1}^{n} \left(Q_i \frac{I_{p,i,j} - I_{p,i,0}}{IT_p} \right) \quad (1)$$

Calculated with this statement. Here $w_a + w_p = 1$; w_a: the given weight for area indicator, w_p: the given weight for population indicator, Q_i: i class in the environment quality fan for environmental descriptive, $I_{a,i,0}$: in the study area, in the situation of there is no project, the effected area in i environment quality class , $I_{a,i,j}$: in the study area, j is in the situation of the project alternative , i is in the environmental quality class, the effected area, IT_a: total work area, $I_{p,i,0}$: in the work are, the situation of there is no project, i is in the environment quality class, effected population, $I_{p,i,j}$: in the work area , j is in the situation of the project alternative, i is the effected population in the environmental quality class, IT_p: total population in the study area, n: is the number of class which is evaluated in the adapted environment quality scala.

The obtained information from the application of this method (SIAM) gives impact index, the magnitıde of impacts (environmental quality maps are described with the impacted area and the magnitude of habitat) and their importance (environmental sensitivity is described by considering the distribution of population and resource importance maps) at the same time. In this study, the obtained environmental impact indexes for Pamukluk Dam are shown in the Table 3.

Table 3. Environmental impact index for Pamukluk Dam

IMPACTS	INDICATOR	INDICATOR VALUE					
		IMPACT AREA MAGNITUDE					
		0 m	300 m	700 m	1000 m	Basin Protection Area	Irrigation Area
Population Impacted by Area Decrement	Forestry	-4	-4	-1	0	0	0
	Animal Brending	-4	-4	-4	0	0	0
	Farming	-5	-5	-2	-2	0	0
	Settlement Area	-5	-5	-5	-3	0	0
Population Impacted by Irrigation	Irrigated Agriculture Farmers	0	0	1	1	1	0
	Water Demandıng Farmers	0	0	2	5	5	5
	Forestry Makers	0	0	1	2	2	0
	Animal Breeders	0	0	0	2	2	1
Land Impacted by Area Decrement	Agricultural Land (Wet)	-5	-4	-2	-2	0	0
	Agricultural Land (Waterless)	-5	-4	-1	-1	0	0
	Forestry Land	-5	3	2	2	0	0
Land Impacted by Irrigation	Agricultural Land (Wet)	0	0	1	1	1	1
	Agricultural Land (Waterless)	0	0	4	4	5	5
	Forestry Land	0	0	1	1	1	1

3. RESULTS AND DISCUSIONS

After applying a range of digitization techniques to maps with 1/25000 scale used as base, the digital maps of work area were obtained. With the help of these digital maps, it was very easy to control the study area.

Both the existing features of the specific protection areas and the features of these areas after finishing of the project was benefited from SIAM according to the specified attributes with digital maps. The environment components be effected the dam construction were classified into two groups. These classified components were handled as population and land. There is no settlement in the region which is down the reservoir area of Pamukluk Dam and in 300 m that is in the boundaries of absolute protection area. So there is no effect in the areas of 0 m and 300 m. When the values of basin protection and irrigation areas columns are examined, because the indicator values of forestry, animal breeding, agriculture and settlements which will be effected by the loss of area are 0 (means having no effect), it is not thought that there will be positive or negative situations in these regions. The most important environmental indicator which is affected by the loss of area is 700 m that is with the short distance protection area it is 1000 m that is the settlements which take place in the middle distance protection areas are drawn attention. The main reason for becoming prominent of the negative effect here is that the indicator values of these two areas are negatively high because of the activities in the border of 700 and 1000 m, that is because the indicator value of population in the settlements which are affected by the loss of area is -5 at 700 m and -3 at 1000 m, the negative effects in these areas appear. Besides being a population density in the boundaries of these two protection areas causes the negative effects. Because the region which is down to the reservoir area of Pamukluk Dam, that is 0 m, is completely in the dam reservoir, this place has no benefit for the population which will be affected by the irrigation. Besides during the describing of the 300 m absolute protection area and 70 m short distance protection area, it is stated that making activities in these regions is completely forbidden. So, because these regions protect their existing situations, it is seen that they are affected a bit positively.

As the SIAM values of lands which are affected by the loss of area, because the agricultural land in the reservoir area of Pamukluk Dam, that is 0 m, is not so much and the existing agricultural land will be under the water of dam reservoir lake, the effect in this region is known as negative. But the forest lands in the same region are so much and completely all this area will be under the dam lake, specifying the affect indicators as -5 effects negatively the SIAM value here more than the other areas. As the 700 and 1000 m protection areas are handled, because the agricultural lands in the regions are in the boundaries of protection areas, it causes a loss of agriculture area by being negatively affected as a result of the indicator values which are given depending on the not applying the agriculture freely according to the situation before project. Besides because the activities in the same regions are forbidden and various impressions on the forest lands are removed, the forest lands here are positively affected.

As we look at the indicator values of the lands which are affected by the irrigation, it is seen that 700 m, 1000 m, the basin protection area and irrigation areas are positively affected. Because 0 m is under the dam reservoir lake and it is not allowed to make any activities in 300 m, the indicator values for the land affected by the irrigation is given as 0. The SIAM value of the land which is affected by the irrigation depending on these indicator values was found as 0 (for 0 and 300 m). As the 1000 m protection area is handled, because there is no great change in the agriculture lands which make irrigated farming in the existing situation and despite of the high indicator values in the agriculture lands which need water, the applied activity restrictions in the 1000 m protection areas have neither changed the SIAM values nor changed positively on a small scale.

In this study, the digital maps obtained by using the GIS technology, were used in two stages to be used in SIAM. One of these two stages is a stage of data producing for the application of SIAM, the second stage is a stage of displaying the SIAM values on impact areas by transferring the results obtained from the produced datas for SIAM to GIS platform.

Making the maps related to the obtaining the data in SIAM was specified in consequence of overlay analysis. Both the areas and the population densities were obtained by superposing the study areas with the population and area information which were specified as environmental descriptive to each other one by one.

The totals of SIAM values were appointed to those areas as impacted value. In the result of the SIAM, the total of the obtained values for each contagion area formed the impact value for this area. After obtaining this impact value, the thematic map of the contagion areas was formed. The thematic maps formed according to the impact situation, were constituted in the boundaries of both the protection areas and the irrigation areas, and the totals of SIAM values were appointed as a impacted value for each of the area.

For the application of SIAM, both digital maps and methods of analysis provided by GIS technologies were tried to be used. With the help of the maps the essential area and population greatness for SIAM were specified. The regions impacted situation was executed by using the obtained values from maps with the impact greatness which was specified within the context of SIAM. The impacts were examined and evaluated by seperating the area around the dam reservoir lake into the area under the dam lake, absolute, short distance, middle distance, basin (long distance) protection areas and irrigation area as impacted areas. As a result of the evaluations, the area effected worstly, was found as the 70 m border with -1,81 impact value, that is, the short distance protection area. After this area, the area affected worstly was found as the area with -1,50 impact value, that is, the area under the dam reservoir lake. Despite of the fact that the area under the dam reservoir lake is normally thought to be affected badly by the project, its impact value was lower than the short distance protection area. As examining these reasons, because there is no settlement area under the dam reservoir lake, there is no impact depending on the population in the dam lake area. The impacted values were found in order of; the middle distance protection area with -0,22 impacted value, the absolute protection area with 0,73 impacted value, the basin protection area with 0,96 contagion value and irrigation area with 1,22 impacted value. The impact matrix obtained by using SIAM is given in the Table 4.

Table 4. Impact matrix obtained by using SIAM

IMPACTS	INDICATORS	IMPACT AREA BOUNDARIES						IMPACT AREA BOUNDARIES						IMPACT AREA BOUNDARIES					
		0 m	300 m	700 m	1000 m	Bas. Pro.	Irri. Are.	0 m	300 m	700 m	1000 m	Bas. Pro.	Irri. Are.	0 m	300 m	700 m	1000 m	Bas. Pro.	Irri. Are.
Population Impacted by Area Decrement (Person)	Forestry	0	0	6	87	251	0	-4	-4	-1	0	0	0	0,00	0,00	0,00	-0,04	0,00	0,00
	Animal Breeding	0	0	25	322	601	310	-4	-4	-4	0	0	0	0,00	0,00	-0,56	0,00	0,00	0,00
	Farming	0	0	31	409	605	3673	-5	-5	-2	-2	0	0	0,00	0,00	-0,35	-0,35	0,00	0,00
	Settlement Area	0	0	63	817	1457	3982	-5	-5	-5	-3	0	0	0,00	0,00	-1,75	-1,05	0,00	0,00
Population Impacted by Irrigation (Person)	Irrigated Agriculture Farmers	0	0	9	123	181	1102	0	0	1	1	1	0	0,00	0,00	0,03	0,03	0,02	0,00
	Water Demanding Farmers	0	0	22	286	423	2571	0	0	2	5	5	5	0,00	0,00	0,12	0,30	0,25	0,55
	Forestry Makers	0	0	6	87	251	0	0	0	1	2	2	0	0,00	0,00	0,02	0,04	0,06	0,00
	Animal Breeders	0	0	25	322	601	310	0	0	0	2	2	1	0,00	0,00	0,00	0,13	0,14	0,01
Land Impacted by Area Decrement (km^2)	Agriculture Land (Wet)	1,1	0,5	0,0	0,0	0,0	0,7	-5	-4	-2	-2	0	0	-0,32	-0,10	0,00	0,00	0,00	0,00
	Agriculture Land (Waterless)	0,0	0,0	2,1	5,3	7,1	27,6	-5	-4	-1	-1	0	0	0,00	0,00	-0,05	-0,08	0,00	0,00
	Forestry Land	4,1	6,2	11,7	15,3	9,4	13,1	-5	3	2	2	0	0	-1,80	0,83	0,51	0,45	0,00	0,00
Land Impacted by Irrigation (km^2)	Agriculture Land (Wet)	1,1	0,5	0,0	0,0	0,0	0,7	0	0	1	1	1	1	0,00	0,00	0,00	0,00	0,00	0,00
	Agriculture Land (Waterless)	0,0	0,0	2,1	5,3	7,1	27,6	0	0	4	4	5	5	0,00	0,00	0,11	0,19	0,39	0,60
	Forestry Land	4,1	6,2	11,7	15,3	9,4	13,1	0	0	1	1	1	1	0,00	0,00	0,15	0,13	0,10	0,06
								Total Effects of Area						**-1,50**	**0,73**	**-1,81**	**-0,22**	**0,96**	**1,22**

In the Table 4, in the situation of building Pamukluk Dam with gathering the total effects of areas, it was seen that the effect of dam to near abroad was -0,62. One of the important reasons for finding this value can be explained as a population density in the protection areas. Furthermore, only near abroad of the project was regarded and the impact values were specified by using the greatnesses in there while evaluating the project. In case of counting in the far and great areas effected by the dam to the SIAM model, the impacted value will positively increase. As looking at the main reason for doing this project, it can be seen that they are potable water supply, irrigation and electricity generation. As we discuss especially the potable water supply and electricity generation among these aims, the contagion value, as told before, will positively increase, when the areas which are effected by these aims, are evaluated in greater scale not in a local basis. Besides, a three dimensional land model of Pamukluk River and the near surroundings was made at the end of the study. With the established model, the evaluations on the project become visually apparent. Looking at the project area from different angles become more comfortable by the help of using the digital maps prepared as especially the areas under the maximum and minimum water elevations, the protection areas, the settlement areas and the water sources. Evaluating and presenting the impacts on three dimensional model is used as a more effective mean in the presentation stage which is a very important stage in EIA procedure. In the Figure 5, the impact values are shown on the map. Besides in the Figures of 6 and 7, two of the three dimensional maps are shown.

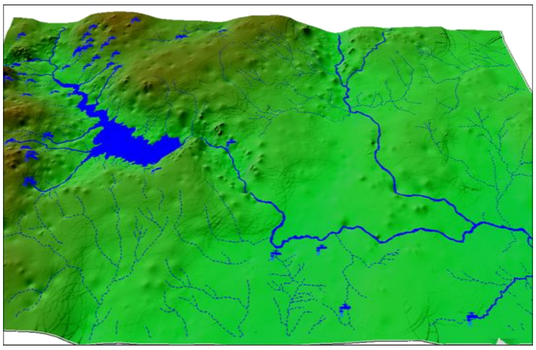

Figure 5. Impacted areas and ımpact magnitude of Pamukluk Dam

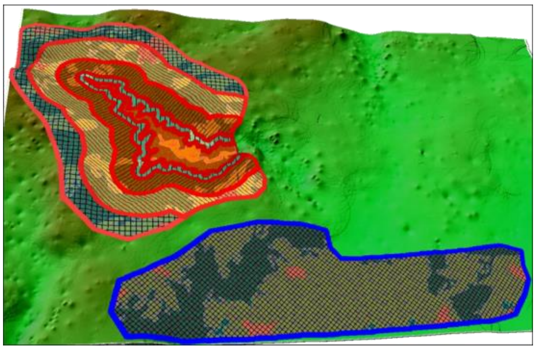

Figure 6. Three dimentional presentation of water resources

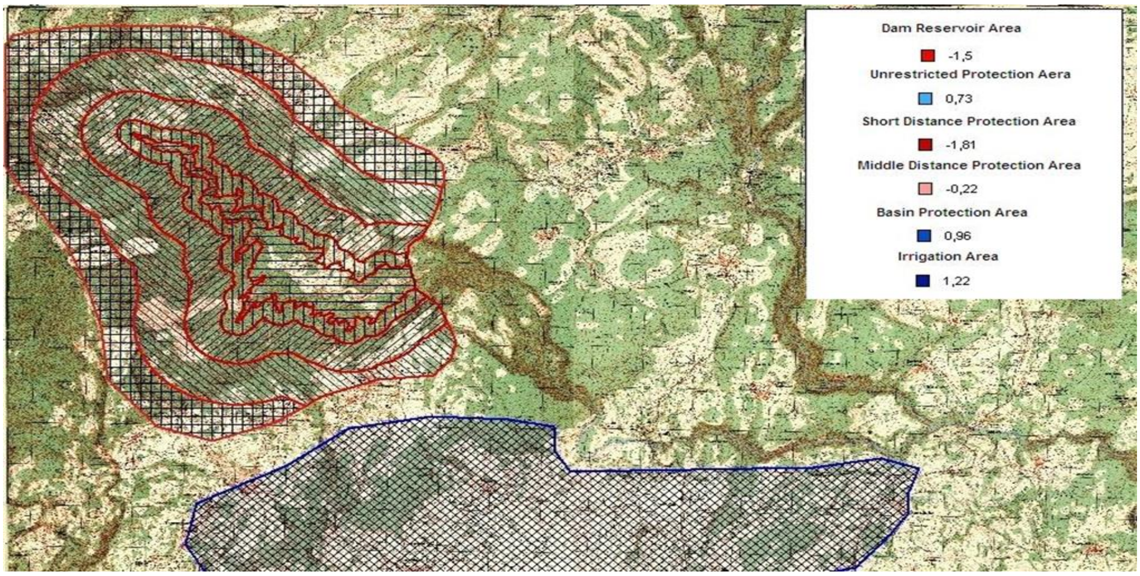

Figure 7. Impacted areas from SIAM results

4. CONCLUSIONS

In this study, the application of Geographic Information Systems (GIS) in the studies of Environmental Impact Assessment (EIA) was examined. Within the scope of this analysis, the maps of the dam, planned to be built on Pamukluk River by State Hydraulic Works (DSI) and the near surroundings was digitized and at the end of the digitization process the Spacial Impact Assessment Methodology (SIAM) was applied to be used in EIA works by benefiting from the obtained data. From the SIAM, the area under the dam reservoir lake specified in the study area; absolute, short distance, middle distance and basin protection areas and the environmental impact values of irrigation area were determined. Basing on these results all the data on the project area can be evaluated in consequence of a good and expert teams study and it can be used in the works of monitoring and evaluating after the project. The project impacts can be clearly specified by monitoring the changes which happen in the time interval of todays situation and the economical life of the project and it can be used as a guide in the alike projects.

After the water resources which feed the dam reservoir lake in the project area and the datas belonging to these sources are completely collected on the basin area, an evaluation can be made in terms of both hydrologic and pollution. When the maps and climatic values, which are related to the lands usage classes belonging to this region are obtained, the potential erosion regions in this area can be determined. The water quality collected in the dam reservoir lake can be monitored. The changes in the quality can be correctly observed. Besides the works, oriented to the amelioration of the water quality, can be made at the top level thanks to the produced maps.

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