Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/02/jls.htm
2015 Vol. 5 (S2), pp. 566-571/Afifi and Fuladipanah
Research Article

SUBSURFACE DAM SITE SELECTION USING GIS (CASE STUDY: CHAMSIAB PLAN, MASJEDSOLEYMAN, IRAN)

SamanAfifi and *Mehdi Fuladipanah
Department of Civil Engineering, Ramhormoz Branch, Islamic Azad University, Ramhormoz, Iran
**Author for Correspondence*

ABSTRACT
Using underground water due to its availability has been significant, but maintaining and protection of fresh with respect to increased consumption is very important challenge for authorities. Utilization of subsurface dams is one of the management solutions concerned with aquifers. In this paper, suitable site selection has been studied using GIS for subsurface dam in Chamasiab plan in Khuzestan province, Iran. The plan is located in semi-arid region with surface water crisis. Therefore, using underground water has vital role in the plan. For this purpose, feasibility study of construction site was done using GIS based n nine parameters as: topography, unsaturated zone, hydraulic conductivity, electric conductivity, specific yield, alluvium thickness, water table depth, hydraulic gradient, surface drainage density. A layer was dedicated for each parameter in GIS. After weighting of each parameter, suitable construction site was done using overlapping layers.

Keywords: *Subsurface Dam, GIS, Site Selection, Chamasiab Plan*

INTRODUCTION

Subsurface dam is a structure to protect and maintain of underground water which is constructed with impervious materials. This structure beside that can reserve water, can divert underground water direction which aquifers recharge and water table increasing are desired results of dams construction.
V or U shaped valleys are well suited locations to construct subsurface dams which morphological, geology, hydrological and geo-physical studies may facilitate recognition suitable sites. Respect to geological perspective, alluvial layers with thin thickness and impervious layers next to surface and underground stream in hydraulic gradient direction are the best conditions for feasibility of subsurface dams.
Compared to surface dams, low level construction technology, low cost, easy maintenance, short distance to the operation, lack of vaporization, no failure, and great reduction in water pollution are the benefits of subsurface dams. Subsurface dams can increase possibility of water resources up to 30 percent which is valuable amount in arid and semi-arid regions and can significant role in crisis conditions.
Different methods and researches have been developed for site selection of subsurface dams.
Saraf and Choudhury (1998), Gustafson (1993), Kamaraju *et al.,* (1996), Karanth (2001), and Kodituwakka (1996) developed using geographical information system to feasibility study of subsurface dam site selection.
Foster and Tuinhof (2004) showed that reservoir volume, dpth of bedrock, chemical qualification of soil, and permeability of materials have important role for site selection.
Forzieri *et al.,* (2008) and KheirkhahZarkesh *et al.,* (2008) have identified suitable areas for projects of constructing underground dam after doing field surveys and expert analysis using geographic information system.
Vanrompay (2003), Foster and Tuinhot (2004), Archwichai *et al.,* (2005), JanardhanaRaju *et al.,* (2005) have done their research about underground dams and how to construct them. KhierkhahZarkesh (2005), Sharifi (2007) and KhierkhahZarkesh *et al.,* (2008) have done some researches about prioritizing Flood flows using DSS and AHP process. As it clear, various parameters and conditions are effective and involved in dam site selection. In this research climate, geology, hydrology, hydrogeology and soil conditions of the plan were studied and calculated. After weighting each effective parameter in a specific layer in GIS, suitable site for subsurface dam construction in Chamasiab plan was determined.

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/02/jls.htm
2015 Vol. 5 (S2), pp. 566-571/Afifi and Fuladipanah
Research Article

MATERIALS AND METHODS

Chamasiab aquifer has been located between longitude 49°11'E to 49°16'E and latitude of 32°N to 32°03'N with mean elevation of 250 m. Its area is 19.31 km^2 which is located in Khuzestan province, Iran. Mean annual value of rainfall and temperature are 656.1 mm and 25 °C, respectively. Then, the plan has semi-arid climate.

Geological map of the plan is presented in figure 1. Mishan and Aghagary geological formation formed round the plan. Piezometric network of Chamasiab plan with three wells is presented in figure 2. These well are used to measure and data recording of underground water.

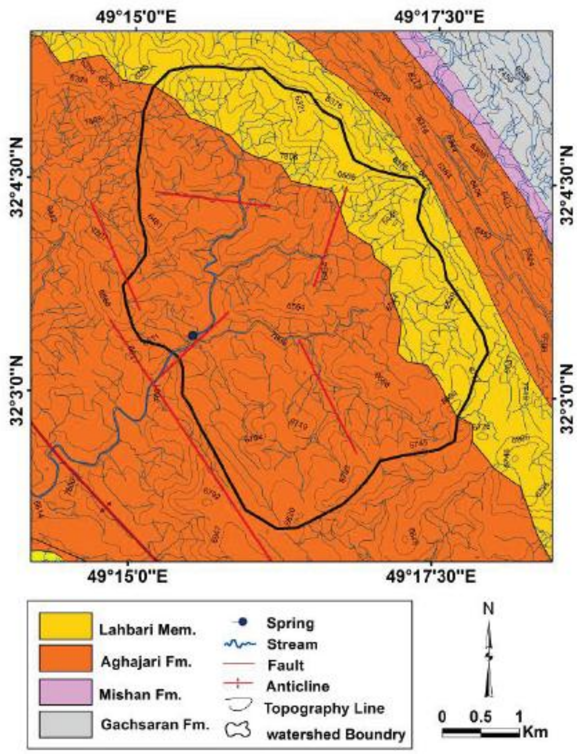

Figure 1: Geological map of Chamasiab aquifer

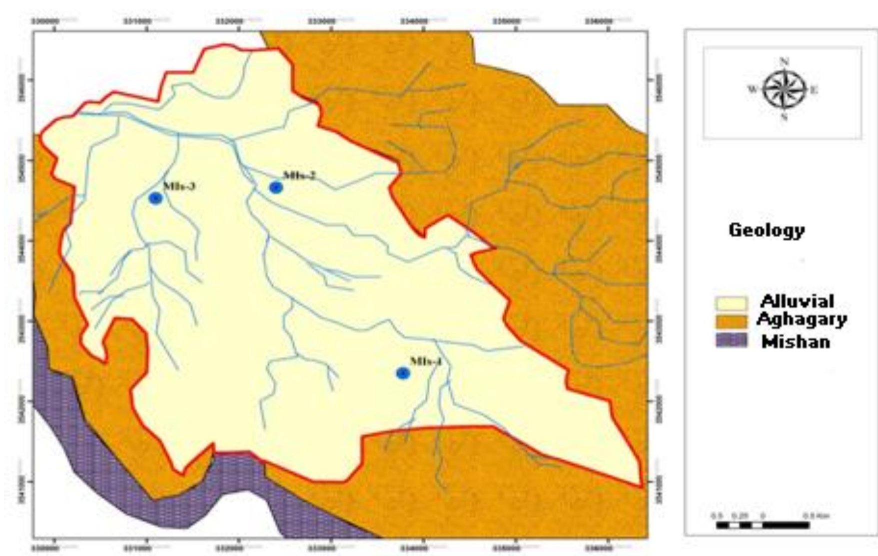

Figure 2: Piezometric well network of Chamasiab aquifer

Site Selection of Subsurface Dam

According to limitations of site location concern with subsurface dam, many parameters should be studied for plan zoning. This goal was done using GIS. The following parameters were selected for plan zoning.

Water Table Depth

Water table depth parameter is defining a depth that runoff must traverse to join underground water. With increasing water table depth, probability of water scope from dam reservoir. Of course, high water table depth decrease aquifer pollution probability. To create water table depth layer in GIS, recorded data from 1994 to 2013 (Figure 2) were used and were interpolated using Kriging method. Different water table depth weight is presented in table 1.

Hydraulic Conductivity

Hydraulic conductivity indicates ability of aquifer materials concern with water permittivity. Pumping test is the most acceptable method to determine hydraulic conductivity. This process was done using Mod flow software that the final result is presented in table 1. In this table, the different weight of hydraulic conductivity amount is determined.

Surface Drainage Density

This parameter illustrates surface stream densities which collect surface runoffs. To create this layer, a digital map of scale 1:25000 was used in GIS and analyzed in Spatial Analyst module. Simple options were applied for density type and appropriate radius, the layer of surface drainage density was created. The layer weighting was done which the final results are presented in table 1.

Hydraulic Gradient

This parameters indicates hydraulic head difference between two points of underground water at two certain distance. Flow velocity has direct relation with this parameter. Therefore to control water velocity behind the dam low hydraulic gradient is needed. Less than 5 percent is proposed. To create hydraulic gradient layer in GIS, recorded data from 1994 to 2013 (Figure 2) were used. Different slope of water table were calculated and categorized in different classes. Finally, weighing of hydraulic gradient layer was done (table 1).

Aquifer Storage Capability

The storage coefficient is the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer. This coefficient has inverse relation with head loss. In unconfined aquifers, storage coefficient is equal to specific yield or effective porosity. Specific yield layer was created using calibrated numerical model of Chamasiab plan which was weighted as table 1.

Topography

Topography map shows status of ups and downs which is used to create slop maps. More slop will decrease water infiltration. This layer was created using DGN geology maps of scale 1:25000 applying Microstation-V8 and GIS software which was weighted as table 1.

Unsaturated Zone

This layer affects aquifer recharge which it's constituent has important role. This layer was created using drilling logs and geo-physics information. Weighting zones are presented in table 1.

Salinity of Underground Water

Salinity indicates underground water quality which is described based on hydraulic conductivity. High salinity will cause worthless of subsurface dam construction. Using Reclassify module of GIS software to interpolate water qualification, the layer of this parameter was created which its weighing rage is presented in table 1.

Alluvial Thickness

The depth of alluvial and bedrock is equal. The Average thickness of alluvial with underground water stream in direction of hydraulic gradient is appropriate option for site selection of subsurface dam construction. This layer was created using geology map of Chamasiab plan and was weighted according to table 1.

Tale 1: Weighing of effective parameters in subsurface dam construction in Chamasiab aquifer

Depth to water table (m) W=2		**Hydraulic gradient (%) W=4**		**Surface drainage density (-) W=5**	
Range	Weight	Range	Weight	Range	Weight
4-8	9	0-0.25	9	0-0.004	1
8-12	8	0.25-0.45	6	0.004-0.008	2
12-16	7	>0.45	4	0.008-0.012	5
16-20	5			0.012-0.016	8
>20	2			>0.016	10
electrical conductivity (µmohs/cm) W=2		Specific yield (-) W=3		Alluvial thickness (m) W=4	
Range	Weight	Range	Weight	Range	Weight
0-500	10	<0.1	3	0-15	2
500-750	9	0.1-0.15	5	15-30	10
500-1000	7	0.15-0.2	8	30-40	8
1000-1500	6	>0.2	10	>40	3
1500-2000	3				
>2000	1				
Slope (%) W=3		Unsaturated depth (-) W=4		Hydraulic conductivity (m/day) W=4	
Range	Weight	Range	Weight	Range	Weight
0-2	10	Sand and gravel	10	4.5	4
2-4	9	Sand and silt	8	5	6
4-6	5	Sand, silt, clay	6	6	8
6-10	3	Sandy silt and clay	4	7.5	10
>10	1	Silt, clay	2		

RESULTS AND DISCUSSION

In this paper suitable site selection using weighting of effective parameters with application of GIS was done in Chamasiab plan, Khuzestan, Iran. Nine following parameters were selected to this goal: topography, unsaturated depth, hydraulic conductivity, electrical conductivity, specific yield, alluvial depth, depth to water table, hydraulic gradients, and surface drainage density. The amounts of these parameters were weighted in table 1, then optimum site was determined in GIS. Overlapping layer of each nine parameters determined suitable site. Table 2 shows the range of overlapping layer weighting. The range of 27-61 and 231-270 are the most adverse and the most favorable position of subsurface dam construction site, respectively. According to these ranges, two points in figure 3 indicates the most ideal condition for dam construction.

Table 2: Feasibility indices of subsurface dam construction in Chamaiab aquifer

Value	**Potential capacity**
Missing	27-61
Very low	61-95
Low	95-129
Average	129-163
High	163-197
Very high	197-231
Excellent	231-270

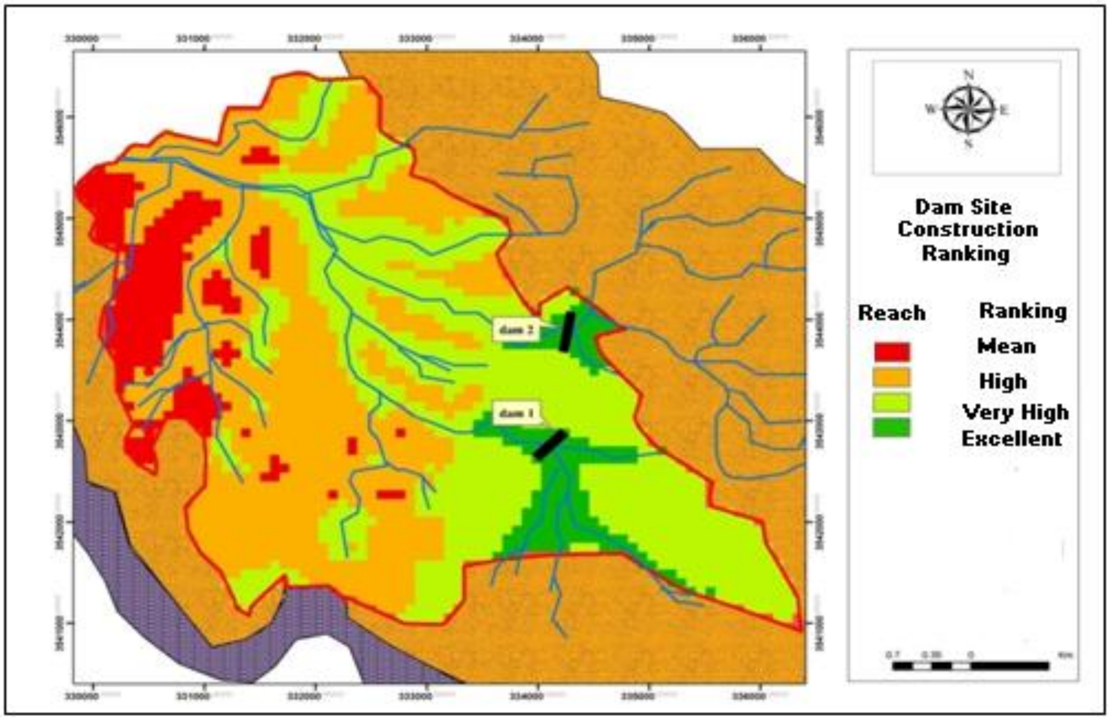

Figure 3: The locations of subsurface dam construction in Chamasiab aquifer

ACKNOWLEDGMENT
This paper has been extracted from research work. The authors would like to thanks Ramhormoz Branch, Islamic Azad University, Ramhormoz, Iran, for its kindly cooperation due to this research work.

REFERENCES
Archwichai L, Mantapan K and Srisuk K (2005). Approachability of subsurface dams in the Northeast Thailand. *International Conference on Geology, Geotechnology and Mineral of Indochina* 28-30.

Forzieri G, Gardenti M, Caparrini F and Castelli F (2008). A methodology for the pre-selection of suitable sites for surface and underground small dams in arid areas: A case study in the region of Kidal, Mali. *Journal of Physics and Chemistry of the Earth* **33** 74–85.

Foster S and Tuinhof A (2004). Subsurface dams to augment groundwater storage in basement terrain for human subGIStence-Brazilian and Kenyan experience, World Bank, Groundwater Management Advisory Team **5** 8.

Foster S and Tuinhof A (2004): Subsurface Dams to Augment Groundwater Storage in Basement Terrain for Human Subsistence Brazilian and Kenyan Experience World Bank Groundwater Management Advisory Team **5**.

Gustafson P (1993). Satellite Data and GIS as a Tool in Groundwater Exploration in a Semi-Arid Area, Ph.D. Thesis, Publ. A74, Chalmers University of Technology.

JanardhanaRaju N, Reddy TVK and Munirathnam P (2006). Subsurface dams to harvest rainwater_ a case study of the Swarnamukhi River basin, Southern India. *Hydrology Journal* **14** 526-531.

Kamaraju MVV *et al.*, (1996). Groundwater Potential Evaluation of West Godavari District, Andhra Pradesh State, India- A GIS Approach. *Groundwater* **34**(2) 318-325.

KheirkhahZarkesh M (2005). DSS for floodwater site selection in Iran, PhD Thesis, Wageningen University, ISBN: 90-8504-256-9 273.

KheirkhahZarkesh M, Salami H, Naseri HR and Davodi MH (2008). Suitable site selection for construction of groundwater dams using analytical hierarchy process (AHP), *In: 4th GIS International Conference along with ISPRS Workshop, National Cartography Center, Tehran, Iran, 6-7 Jan, 2008* **13**.

Saraf AK and Choudhury PR (1998). Integrated Remote Sensing and GIS for Groundwater Exploration and Identification of Artificial Recharge Sites. *International Journal of Remote Sensing* **19**(10) 1825-1841.
Sharifi MA (2007). Integrated planning and decision support systems: concepts, adoption and evaluation. *Asian Journal of Geoinformatics* **7**(4) 13-21.
Vanrompay L (2003). Report on the technical evaluation & impact assessment of subsurface dams (SSDs), TLDP Technical Report 14.