

The Importance of Monitoring at Irrigation Areas and GIS Applications: Water Table in Particular

Aynur Fayrap^{a*}, Şerife Pınar Güvel^b

^aState Hydraulic Works Operation and Maintenance Department, Ankara, Turkey

^bState Hydraulic Works 6th Regional Directorate, Adana, Turkey

*E-mail address: aynurf@dsi.gov.tr

Received date: October 2016

Accepted date: November 2016

Abstract

Monitoring studies are inevitable in terms of ensuring the sustainability of irrigation, creating of awareness related to environmental impact, interfering and taking of measures if necessary besides efficient using water in irrigation applying. Furthermore, monitoring and evaluation studies are very important from the point of providing a basis for scientific researches on scenarios of climate change, drought, sea level rise in coastal areas by creating numerical analysis models of irrigation operation works. The one of the most important activities of irrigation operation phase is monitoring water table. The objective of this study is to assess the change of water table depth and groundwater salinity for the years 2003, 2008 and 2013. In this study, the data obtained from water table monitoring works in an irrigation project operated is evaluated by using Geographic Information Systems which provide efficient and rapid assessment and recommendations are presented.

Keywords: Water Management, Watertable, Monitoring and Evaluation, GIS.

1. Introduction

Water resources are indispensable for sustainability of life and the need to ensure food safety increases with rapid population growth in the world. The reliable and efficient planning and management of water resources have great importance. Monitoring activities, carried out after putting into operation irrigation projects after completing construction works by high investment costs, are essential to achieve the expected performance and sustainability of these projects. In many countries, the main reason why expected benefits from irrigation projects can not be achieved is the failure to monitor and assess regularly that provides clear and explicit determination of this project [1]. With monitoring works, which is part of project management, by providing backward flow of information to project managers and operators at all levels, with target assessments for effectively and efficiently carrying out project performance, more learning and problem-solving process is carried out [2]. Information system for monitoring and evaluation of an irrigation project includes four parts; analysis of water use efficiency, agricultural activities, environmental problems and socio-economic situation [3-4]. For sustainable irrigation increasing the amount of product obtained per unit area, potential environmental impacts must be kept under control, measures must be taken and should be altered if necessary. Monitoring and evaluation of spatial distribution of water table depth and groundwater salinity in irrigation projects in the operating phase, have great importance in terms of water management and environmental impact [5-6]. Water table situation can be viewed and analysed best by drawing water table maps. Water table maps are surface maps created by combining equivalent observation values of water table wells that are pointly marked on topographic maps [7]. In large areas, because of monitoring groundwater flow, water table depth, parameters as hydraulic

gradient and salinity leads to more labor and time by using traditional methods, determining spatial and time-dependent changes by using Geographic information systems (GIS) ensures more efficient and faster evaluation [8]. GIS provides probabilistic techniques for determining and estimating value of surface patterns on measurement areas [9]. In this study, it is aimed to evaluate spatial and temporal changes at water table depth and quality in Hatay-Yarseli Irrigation Projects area located at Amik Plain in 2003, 2008 and 2013 water years preparing EC maps and water table depth maps by using GIS.

2. Material and Method

Hatay Yarseli Irrigation Project is located in Asi River Basin in Hatay in southern part of Turkey. The location of Hatay Yarseli Irrigation Project in Turkey is shown in Figure 1. The water resource of Yarseli Irrigation Project is Yarseli Reservoir that irrigation has 7300 ha gross and 6800 ha net irrigation area. Yarseli Dam was built for irrigation purpose on Beyazçay stream in Hatay in Asi River Basin. Yarseli Dam, irrigation channels, pump stations and irrigation plants are planned in Hatay Yarseli Irrigation Project. The important water resources of the project is Asi River and Beyazçay Stream. In the project area, there are Mediterranean climate features. The months of winter are mild and rainy, summer is hot and dry. The slope varies between 1-5% in the irrigation area. No important problem in terms of drainage were determined with the assessment of field studies within Hatay-Yarseli Project planning studies, but water table was found to be 100 cm at 213 hectares represented by two water table wells located in coastal side of Asi River. The crop pattern has been identified as cotton, wheat, vegetables, rice, potatoes and maize for project area in planning studies [10].

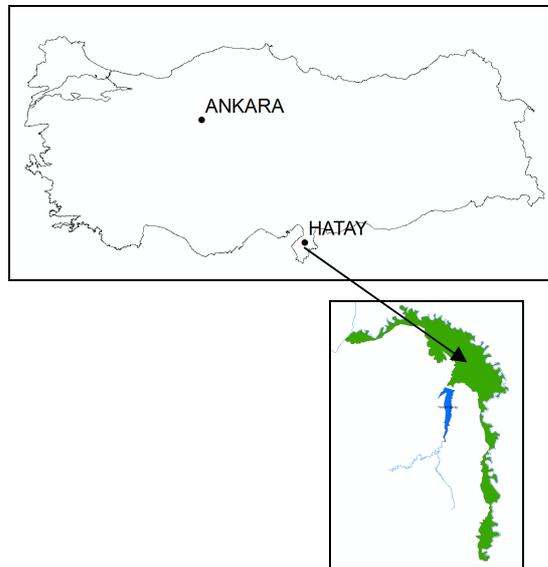


Fig. 1. The location of Hatay-Yarseli irrigation projects area

Critical highest and critical lowest depth maps of water table, water table depth maps in August are drawn in order to assess the status of water table in the research area, water table salinity maps are drawn by using observed salinity values of groundwater wells in order to determine quantitative distribution of salinity. Water table maps are compared to determine spatial and temporal changes in

the project area with five years interval in 2003, 2008 and 2013 years. Critical highest depth maps of water table are drawn by using the highest water table values in each observation wells. The maps drawn by using the lowest water table values in each observation wells are the critical lowest depth maps of water table. Water table depth maps in August, which is the intensive irrigation month, are drawn by using water table observation results. Groundwater salinity maps are drawn by using electrical conductivity values (EC $\times 10^{-6}$ 25 °C) of water samples taken from monitoring wells according to analysis reports. Water table maps and numerical analysis are prepared by using Geographic Information System (GIS) technology. ArcGIS software is used in GIS studies. The locations and data records of 35 observation wells are associated with Hatay-Yarseli Irrigation Project area by using GIS technology to evaluate water table, and spatial and temporal changes in five-years periods are discussed in by using GIS. In this context, geographic analysis of water table depth and salinity data set is evaluated and the results are investigated.

3. Results and discussion

3.1. Groundwater salinity (EC)

The quality of water table is an important indicator in determining the drainage problem. Also there is the necessity of determining the quality of the water table in terms of salinity tolerance of plants to root crops as far as the water table rises cases. EC value is between 0-2000 micromhos/cm in total project area in 2003 and in 2008. EC value is over 2000 micromhos/cm at % 4.2 of total project area in 2013 (Figure 2a, b, c).

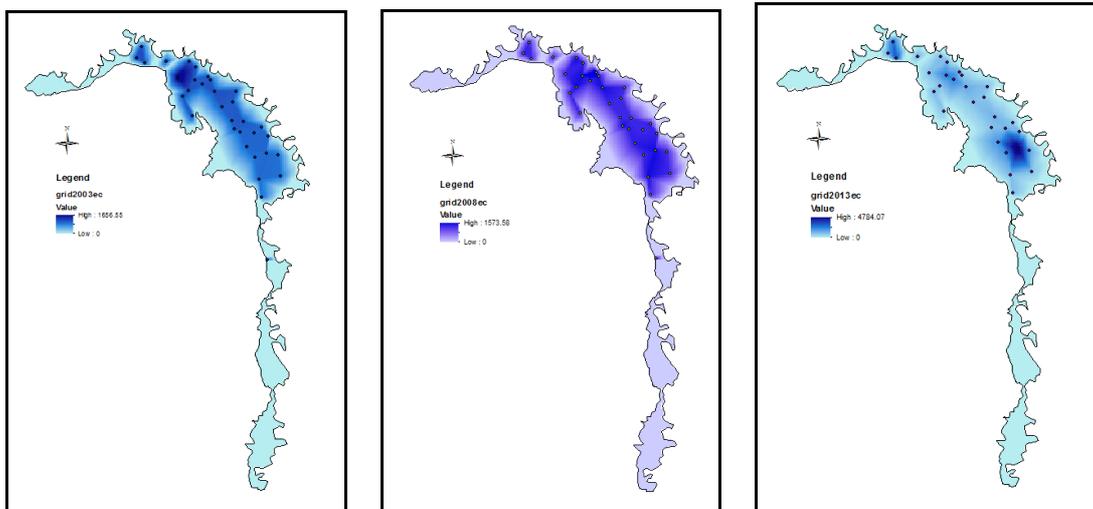


Fig. 2. Water table salinity maps in the years 2003(a), 2008(b) and 2013(c) respectively at the irrigation area

3.2. Critical highest depth map of water table

The area where the water table is between 0-2 m in the irrigation area on this map which indicates water table that rises to the highest level in a year has the most extensive drainage problems. Critical highest depth maps of water table shown in Figure 3a., b. and c. prepared by using GIS are evaluated as;

In 2003; in parts of %96 (6504,6 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %4 (242,2 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of % 0,1 (8 ha) of analyzed irrigation area, water table depth was found in 100-150 cm. It is

determined that there is no area in critical highest depth map that the water table depth is deeper than 150 cm (Figure 3a).

In 2008; in parts of %64 (4348,6 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %28 (1906,2 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %5 (339,7 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %2 (121,7 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %1 (38,6 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 3b).

In 2013; in parts of %99 (6680,2 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %1 (74,6 ha) of analyzed irrigation area, water table depth was found in 50-100 cm. It is determined that there is no area in critical highest depth map that the water table depth is deeper than 100 cm (Figure 3c).

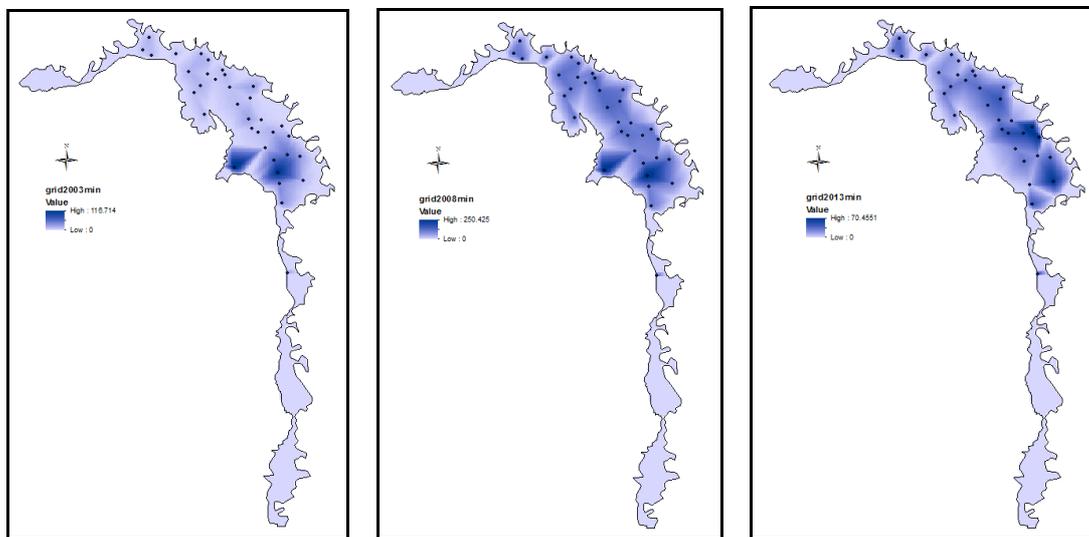


Fig. 3. Critical highest depth maps of water table in the years 2003(a), 2008(b) and 2013(c) respectively at the irrigation area

3.3. Water table depth map in August

The map of the most intensive month of irrigation is drawn to determine how the water table affected from irrigation. This map is drawn for August which is the most intensive month of irrigation in Yarseli Irrigation Project (Figure 4a,b,c).

In 2003; in parts of %52 (3525,5 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %11 (769,1 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %12 (774,8 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %14'ü (926,89 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %11 (758,51 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 4a).

In 2008; in parts of %52 (3549,4 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %10 (671,5 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %10 (665,4 ha) of analyzed irrigation area, water table depth was found in 100-150

cm, in parts of %11 (724,2 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %17 (1144,7 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 4b).

In 2013; in parts of %58 (3892,7 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %15 (997,9 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %14 (951,1 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %8 (572,8 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %5 (340,3 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 4c).

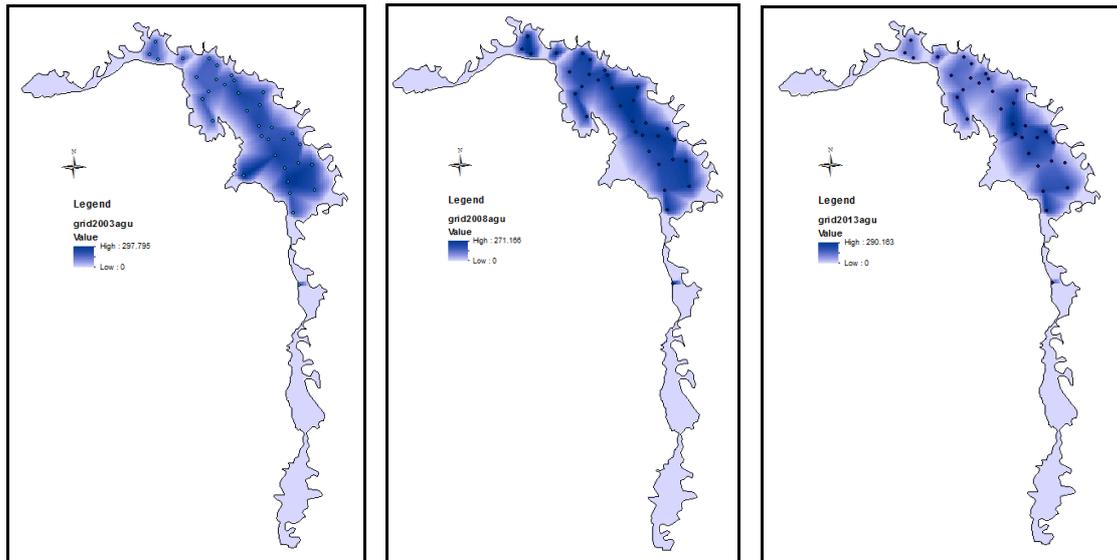


Fig. 4. Water table depth maps in August in the years 2003(a), 2008(b) and 2013(c) respectively at the irrigation area

3.4. Critical lowest depth map of water table

The map drawn by using the lowest water table depth value of each observation well according to annual measurement results indicates the maximum fall of water table level in a year (Figure 5a,b,c). In this map, the area where the water table is between 0-1 m shows the water table is in roots in all of the year. These areas are also the farm (subsurface) areas that need implementation of drainage methods.

In 2003; in parts of %51 (3433,1 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %10 (676,9 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %10 (680,9 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %13 (859,3 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %16 (1073,7 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 5a).

In 2008; in parts of %50 (3347,3 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %9 (608,3 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of %9 (629,5 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %10 (657,4 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in

parts of %22 (1510,4 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 5b).

In 2013; in parts of %52 (3535,8 ha) of analyzed irrigation area, water table depth was found in 0-50 cm, in parts of %10 (638,6 ha) of analyzed irrigation area, water table depth was found in 50-100 cm, in parts of % 9 (614,1 ha) of analyzed irrigation area, water table depth was found in 100-150 cm, in parts of %12 (818,3 ha) of analyzed irrigation area, water table depth was found in 150-200 cm, in parts of %17 (1137,4 ha) of analyzed irrigation area, water table depth was found in 200-300 cm (Figure 5c).

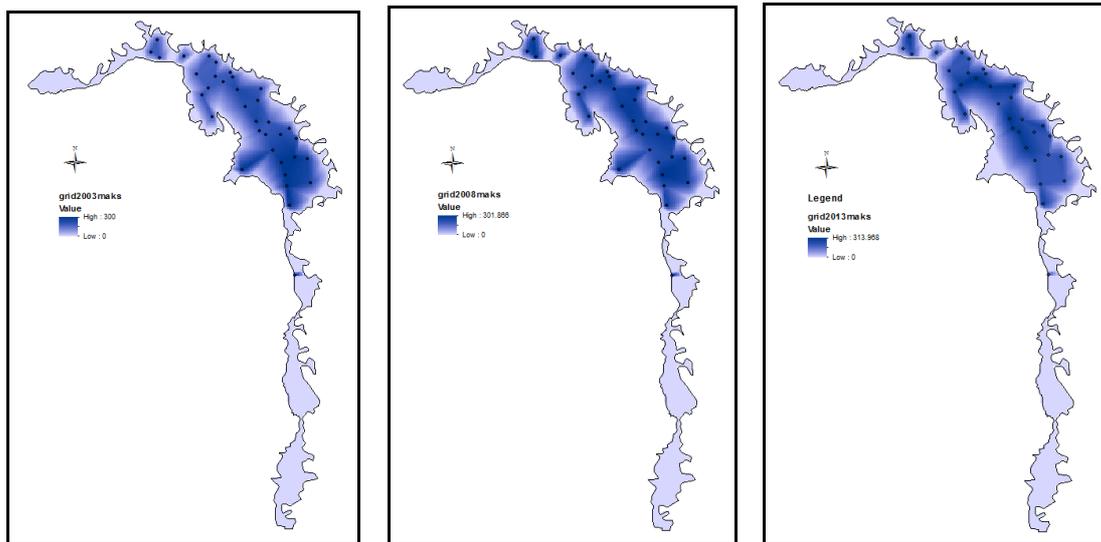


Fig. 5. Critical lowest depth maps of water table in the years 2003(a), 2008(b) and 2013(c) respectively at the irrigation area

4. Conclusions and recommendations

By using Geographic Information Systems (GIS) in evaluation of monitoring activities, the reliability of the results increases beside the easy use of mapping data obtained from observation points. In addition, long-term storage of data and evaluation, ensuring easy accessibility to save time and labor are other advantages of GIS.

It is possible to evaluate spatial and temporal distribution of water table and groundwater salinity in irrigation areas that are in the operational phase, preparing water table maps by using GIS and to examine the two criteria together. Both maintenance and repair activities, and measures taken for drainage are performed according to the results of this evaluation.

In this study, water table monitoring studies and the change of water table depth and groundwater salinity in five year period in 2003, 2008 and 2013 in Yarseli Irrigation Project is evaluated.

In 2003, water table depth in all irrigation area is less than 2 m according to critical highest water table map. In August, it is seen that water table depth is closer than 50 cm to soil surface at %52 of irrigation area according to water table maps of August. The results indicate that there are drainage problems in irrigation project. The lowest water table depth values between 0-1 m is the %61 of irrigated area according to critical lowest water table depth map and it shows that farm drainage system functions largely discredited or maintenance and cleaning works were not enough.

Groundwater salinity value is less than 2000 micromhos/cm and relaxes possible threats related to herbal and soil structure.

In 2008, water table depth in % 99 of irrigation area is less than 2 m according to critical highest water table map. In August, it is seen that as in 2003 water table depth is closer than 50 cm to soil surface at %52 of irrigation area according to water table maps of August. The lowest water table depth values between 0-1 m is the %59 of irrigated area according to critical lowest water table depth map. We see that groundwater salinity didn't cause any problem. In case of unsalted water table, the purpose of the project is only the removal of drainage water in root crops. Drainage water can be used for irrigation in these conditions.

In 2013, water table depth in all irrigation area is less than 2 m according to critical highest water table map, it is seen that water table depth is closer than 50 cm to soil surface at %58 of irrigation area according to water table maps of August. The lowest water table depth values between 0-1 m is the %62 of irrigated area according to critical lowest water table depth map. It was determined that groundwater salinity is greater than 2000 micromhos/cm in % 4,2 of analyzed area in 2013. Compared to last years in 2013 according to critical highest and lowest water table depth maps, there is an increase where ground water level remains high, this increase is also seen in salinity maps. According to water table depth map in August, which indicates how water table level impressed from irrigation, the increase in the area where water table depth between 0-50 cm is %6 compared to 2003, and compared to 2008.

References

- [1] Değirmenci H. ve Büyükcangaz H., Sulama Projelerinin İzleme ve Değerlendirilmesinde Amaca Yönelik Proje Planlama (Aypp) Yaklaşımı. *Atatürk Üniv. Ziraat Fak. Derg.* 34(1) 77-83, 2003.
- [2] Anonymous, The Evaluation of Aid Projects and Programmes. The Overseas Development Administration, London, 1984.
- [3] Rieser, A., Situative Monitoring and Evaluation in Irrigation. DVWK Bulletin, Situation-Specific Management in Irrigation, International Irrigation Symposium 1989, Verlag Paul Parey, Hamburg/Berlin, p. 235-262, 1989.
- [4] Jurriens, M., Monitoring of Irrigation Systems Operation. Advances in Planning, Design and Management of Irrigation Systems related to Sustainable Land Use. Proceedings of an International Conference, 14-17 September 1992, Leuven, Belgium, p. 515-523, 1993.
- [5] Gündoğdu K.S., Sulama Proje Alanlarındaki Taban Suyu Derinliğinin Jeostatistiksel Yöntemlerle Değerlendirilmesi. *Uludağ. Üniv. Zir. Fak. Derg.*, 18(2):85-95, 2004.
- [6] DSİ, Tabansuyu İzleme Rehberi, DSİ Genel Müdürlüğü İşletme ve Bakım Dairesi Başkanlığı, Ankara, 2005.
- [7] Mahajan, G., Evaluation and Development of Groundwater. ISBN 978-81-313-0339 9:70-75, 2008.
- [8] Çetin M., Diker K., Assessing drainage problem areas by GIS: A case study in the eastern Mediterranean region of Turkey. *Irrig. And Drain.* 52, 343-353, 2003
- [9] Sarma, D.D., Geostatistics and Applications in Earth Sciences. Capital Publishing Company, New Delhi, 2nd Edition, pp 205, 2007.
- [10] DSİ, Hatay-Yarseli Projesi Yapılabilirlik Raporu, DSİ Genel Müdürlüğü 6.Bölge Müdürlüğü, Adana, 1980.