

## Effectiveness thresholds of rainfall intensity and slope gradient on erosion process in rainfed lands in Kalaleh region, Golestan Province

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### Abstract

The purpose of the present study was to evaluate the response thresholds of the main steps of erosion and sediment transport at plot scale in rainfed lands in Kalaleh region, Golestan province. The rainfall was simulated using Kamphorst simulator with plot dimensions of 25×25 cm considering rainfall intensities of 33, 64, 80 and 110 mm hr<sup>-1</sup> and three slope gradients of 6, 12 and 25% in four replications. Sediment concentration and soil loss were calculated by measuring runoff and sediment at the plot outlets and the results were analyzed in rainfall intensity and slope treatments. Based on the results of statistical analysis, the amount of sediment concentration increased with increasing rainfall intensity on all studied slopes. The main effect of rainfall intensity and slope gradient on sediment concentration and soil loss was significant ( $P \geq 0.05$ ), but their interaction effect was not significant. The results of determining subsets using Duncan test showed that sediment concentration had significant change between rainfall intensities of 33 and 64 mm hr<sup>-1</sup> and the slope gradient of 6 and 12%, while about soil loss, the subsets were 64 and 80 mm hr<sup>-1</sup> and the 12 and 25%, respectively. In other words, with consumption of the linear trends, the plot hydrological response threshold of sediment concentration (sediment detachment and entertainment) was about 50 mm hr<sup>-1</sup> of rainfall intensity and 9% of slope, while in case of soil loss (sediment transport) was at the higher rainfall intensities (about 72 mm hr<sup>-1</sup>) and higher slope gradients (about 18%).

**Keywords:** field capacity, rainfall simulator, rainfed land, sediment, soil loss.

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## Applying the management scenarios in prediction of groundwater level fluctuations by using the conceptual and mathematical MODFLOW model (Case study: Khezal-Nahavand Plain)

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### Abstract

Groundwater resources are the main source of water supply in many arid countries such as Iran. Because of uncontrolled increasing of the population, limitation of surface water resources and excessive extraction from aquifers, sharp drop in groundwater level in many plains such as Khezal plain located in Hamedan province was occurred. Khezal plain is important because of strategic crop farming and water supply for the region. So, needs serious qualitative and quantitative studies on its groundwater resources. In this study quantitative model of the aquifer was prepared with MODFLOW code. By the trial and error method the model was first calibrated in the both conditions: steady flow condition for October 2006 and unsteady flow condition from September 2006 to July 2007 then validated in October 2008. During the model calibration in steady condition, hydraulic conductivity of aquifer material and conductance coefficient of rivers bed and general head boundaries were optimized. On the other hand, specific yield and specific storage coefficients of the aquifer material were elevated through the model calibration in unsteady condition. After the model validation and confidence to the model result the water level fluctuations was predicted for one, three and 10 year later in two approaches: current conditions and applying the management scenario by 10% reduction in discharge of pumping wells. The results showed that, the most amount of ground water level drop occurs in the northeast area of the plain. The amounts of this water level drop were calculated 1.82, 3.6 and 8.2 m for one, three and 10 years later respectively. But with applying the management scenario, the amounts of water level drop were calculated 0.52, 2.7 and 7.07 m for the mentioned years.

**Keyword:** calibration, groundwater, Khezal plain, MODFLOW.

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## **Investigating spatiotemporal variations of precipitation and temperature over Iran under climate change condition considering AOGCM models and emission scenarios uncertainty**

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### **Abstract**

Climate change impacts on precipitation and temperature world-wide are not yet well understood (especially for precipitation), due to their complexity and regional variability. In this study In order to explicit the impact of climate change on Precipitation and temperature in Iran, 15 AOGCM whose greenhouse gases scenarios ran under A2, A1B and B1 were used. Monthly precipitation and temperature data were calculated for 21 synoptic stations for two future periods (2016-2045 and 2070-2099) under all of three scenarios. Result showed that increases in temperature during summer months are higher in comparison with the winter months for both future periods. All three emission scenarios predict same increase in temperature (approximately 1 to 1.5°C) for the first future period while A2 and B1 scenarios predict the highest and lowest increase in temperature over the period of 2070-2099, respectively. It is expected that mean temperature of Iran increases about 3.5°C for the areas close to Caspian Sea and central regions and 4.5°C for other regions under the A2 critical scenario. It is also found that precipitation amounts will be increased in Gilan province and also slightly in Ardabil Province under second future period while the precipitation amounts will be decreased in other regions. Generally, it can be concluded that annual precipitation volume of Iran will be decreased about 1.02 (0.25%) and 16.52 billion cubic meter (4.13%) for the first and second periods, respectively.

**Keywords:** climate change, emission scenarios, precipitation, temperature.

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## Spatial and temporal variations of groundwater salinity in Yazd Province using indicator kriging geostatistical method

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### Abstract

Yazd Province is one of the most arid regions of Iran and its agriculture particularly pistachio cultivation depends on groundwater resources. In the recent decades, natural factors (drought and severe evaporation) and human activities (over- exploitation of groundwater) caused a sharp decline in the quality and quantity of groundwater in this province. In the present study, the spatial and temporal variations in groundwater salinity (EC) were evaluated using geostatistical methods and ArcGIS software. For this purpose, ordinary kriging and indicator kriging were used to prepare zoning and probabilistic maps, respectively. Zoning and probabilistic maps showed an increase of groundwater salinity towards higher than 8 dS/m from 2003 to 2012. It was also found that groundwater of Ardakan, Bafgh, Taft, and Abarkouh cities has a very bad condition in terms of salinity and using it for pistachio orchards irrigation can reduce seriously the yield of this plant and its cultivation in the province will be questionable. So as to avoid lowering the quality of groundwater resources in the province, appropriate management measures such as well volumetric water gauge installation and banning both well water extraction and new well water allocation are required.

**Keywords:** electrical conductivity, GIS, trend analysis.

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## Evaluation the accuracy of ANFIS, SVM and GP models to modeling the river flow discharge

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### Abstract

Prediction the river flow discharge values are important in the surface water resources management. Find an appropriate model to accurately prediction of this parameter is one of the most important ways to simulation and prediction. In this study three ANFIS, SVM and GP models were evaluated and compared to modeling the monthly flow discharge of Nazloochoi River in Tapik hydrometric station that located in western of Urmia Lake based on precipitation of river basin. All the methods listed in M1 to M5 data flow patterns with a delay of 1 to 5 M6 to M10 and patterns of precipitation and discharge data combined with delays of one to five months were studied. To investigate the value of modeling's error three coefficient of determination, root mean square error and effectiveness criteria tests were used. The results of evaluation the accuracy and error values of models indicated that the combined pattern has better results only in SVM model and in GP and ANFIS models the ones series patterns presented the better results. Among the three studied models, ANFIS model with 4 and 5 delays input patterns presented the best results. Overall the results indicated that with adoption of ANFIS model to modeling the monthly river flow in Nazloochoi River, error values were decreased about 23% and 3%, respectively in GP and SVM models and accuracy of modeling compared to GP and SVM models were increased about 10% and 4%, respectively.

**Keyword:** flow discharge, genetic algorithm, support vector machine, Urmia Lake.

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## Land use optimization using combination of fuzzy linear programming and multi objective land allocation methods (Case study: Chelgerd Watershed)

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### Abstract

Over the past few decades, several models such as the LP model have been used for managing watersheds and determining optimal cultivation pattern for agricultural planning. Management and planning methods are the most important applied tools of management science for optimal allocating resources in order to gain the most profits in the different fields including natural resources, water resources. In this research, using optimization methods, a single objective fuzzy linear programming model was used to land use optimization and a multi objective optimization model for optimal allocation of resources. The results showed that the proposed combined model can be the base for correct management of resources and decrease the amount of soil erosion to 12%. Also, the results indicated that under optimized condition, the area allocated to dry farming lands will decrease about 59% and the area of rangelands, irrigated agricultures, gardens and forest plantation will increase about 1%, 9%, 94% and 229%, respectively. It is mentioned that the new produced model is a model which is compatible with social and economic condition of watershed and can apply for better use, conservation and rehabilitation of existent natural resources and can be introduce as model which is on the basis of environmental approach.

**Keywords:** fuzzy linear programming, multi objective land allocation, natural resources, optimization.

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## Potential detection of the groundwater resources using analytic network process in geographic information system (Case study: Basins leading to Tabriz Plain)

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### Abstract

Basins leading to Tabriz plain are part of the sub-basins of Urmia Lake basin, which is located in the east Azerbaijan province and in the north-western part of Iran. The area of this basin is 5397 km<sup>2</sup>, and Agriculture is one of the main sources of income for the people, which is dependent on groundwater and surface water resources. In this study, an attempt was made to investigate the basins leading to Tabriz plain in terms of potential detection of the groundwater resources using GIS. To achieve this aim, analytic network process and relationships between climate, hydrology, geology, topology, and environmental criteria were applied. Weights of criteria were calculated by analytic network method: geology (0.267), precipitation (0.208), stream density (0.130), vegetation cover (0.119), distance from stream (0.076), fault density (0.054), slope (0.042), distance from fault (0.034), elevation classes (0.028), aspect (0.019), and temperature (0.018). Finally, 5 potential classes including, very high, high, moderate, low, and very low were identified in the study area. The results of the study indicated that regions with high and very high potential often correspond with low elevations and alluvial large grain sediments of fourth era and fans. Also, low and very low potential regions respectively correspond with maximum heights (due to steep slope), and marl and shale regions (due to very low penetrance and high evaporation).

**Keywords:** Analytic Network Process, basins leading to Tabriz plain, Geographic Information System, groundwater, potential detection.

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## Forecasting of monthly rainfall using teleconnection climate indices using of artificial neural network and statical models (Case study: Sheshde and gharebolagh adjacent stations)

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### Abstract

Many of the meteorological variables such as precipitation strongly depend on the large scale atmospheric and ocean surface circulations. In the current study, the effect of climatic signals on the average monthly rainfall of the adjacent stations of Sheshdeh and Gharebolagh area was investigated during the statistical period twenty five years from 1985 to 2009. The regression and neural network models were used for simulation of precipitation. Then correlation of the climatic signals with precipitation was evaluated in different modes without and with delays of 3, 6, 9 and 12 months. Among twenty climate signals the most important of them include NINO1.2, NINO3 and WHWP with correlation coefficient in confidence level of 95%, (61, 45, and 33, respectively) were selected. Results showed that maximum correlation of climate indices via precipitation was associated with a delay of 6 months. The result of models simulation showed that the artificial neural network model has more accurate compare to other statistical models. This model is able to simulate the amount of precipitation according to the fluctuations with a correlation coefficient 66% and root mean square errors of 1.38. Finally, forecasting was done with coefficient of determination 44% for five years by artificial neural network. Therefore, according to the importance of precipitation and serious water crisis in the region, identifying the parameters affecting on precipitation and the long-term forecasts precipitation is necessary to manage the water resources.

**Keywords:** artificial neural networks, climate indices, monthly precipitation, pearson correlation analysis, statistical model.

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## Ten year prediction of groundwater level for the purpose of determining reasonable policies for exploitation from aquifer

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### Abstract

In recent decades, using water resources is increased for the sake of industrial, domestic and agricultural water consumptions by increase in urbanization and industrial development in Karaj region that fraction of groundwater resources is too much according to the recent drought years and reduced precipitation in Middle-East. These outcomes has caused groundwater level drop, reduced in aquifer storage and many springs and quants were deserted and dried up. Therefore, studying groundwater status accurately, groundwater level drop reasons, the consequences and presenting solutions to conservation and balancing groundwater are essential matter in this study area that all of them depends on determining reasonable policies for exploiting from the aquifer. Therefore, three scenarios entitled optimistic status, pessimistic status and continuing current exploitation status were defined to predict groundwater level of Karaj study area from water year 2014-15 until water year 2023-24 utilizing MATLAB interface. According to the results, 12.834 m, 17.019 m and 4.906 m water level drops were computed for continuing current exploitation status, pessimistic status and optimistic status, respectively.

**Keywords:** groundwater, groundwater level prediction, MODFLOW, Simulating.

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## Trend analysis of stream flow changing of Chamenjir watershed using non-parametric tests

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### Abstract

Trend analysis of changing stream flows of spring in Khorramabad city in three times span namely month, season and annual were investigated by statistical method. The data used include data from 4 springs were selected in 40-years period (1348-1388). In this study, the slope of the linear trend in the data sample estimates with using the TSA and then with using TFPW method the effect of coefficient of autocorrelation of data was eliminated, and discharge time series prewhitened, then trend changing of original and prewhitened time series with MK test were analyzed. Ultimately, trend analysis of changing of station of precipitation in annual were investigated by statistical method. The results of investigation in annual based on MK- TFPW presented. Also the results of this research show that at annual scale of stations no trend is significant at 10% level. So, decreasing of spring flow is due increase of pickup underground water.

**Keywords:** autocorrelation, Mann-Kendall test, prewhitening, spring, trend.

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## Estimation of crop actual evapotranspiration using SEBAL algorithm (Case study: Khoramdareh region at Zanjan province)

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### Abstract

Accurate estimation of crop evapotranspiration (ET<sub>c</sub>) plays an important role in improving the water use efficiency (WUE) and water management. Due to the presence of different types of coatings plant in large areas, the accurate calculation of the water requirements by conventional methods is elusive or impossible. Remote sensing methods are becoming attractive to estimate crop evapotranspiration, as they cover large areas and can provide accurate and reliable estimations. Present study estimates the actual evapotranspiration of corn and alfalfa cover at Khoramdareh region using remote sensing and meteorological data. Surface energy balance algorithm for land (SEBAL) and Landsat 8 images were utilized to determine actual evapotranspiration of corn and alfalfa covers. The obtained results were compared with the results of the PM-FAO56 model. The results showed that two models had good agreement with each other. Values of RMSE for the estimation of actual evapotranspiration of corn and alfalfa was found respectively, 0.92 and 1.25 mm/day. The determination coefficient ( $R^2$ ) for corn and alfalfa was respectively 0.89 and 0.83, respectively. The results showed that the SEBAL algorithm estimates the actual evapotranspiration of corn and alfalfa crop respectively less and more than PM-FAO56 model.

**Keywords:** crop water requirement, evapotranspiration, PM-FAO 56, remote sensing, SEBAL.

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## Determination of an optimized multi-sensor remote sensing index to promote real-time drought monitoring over the heterogeneous land covers

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### Abstract

In this article, new index, the Optimized Synthesized Drought Index (OSDI), is suggested for real-time monitoring of this phenomenon in areas with heterogeneous land covers. The precipitation, one of the important factors in drought, measured by ground stations and improved by TRMM satellite data. Each of the three normalized moisture indices, including Normalized Difference Vegetation Index (NDVI), Visible Short-Infrared Drought Index (VSDI), and the Surface Water Capacity Index (SWCI), individually enter to principal component analysis (PCA), with Precipitation Condition Index (PCI) and land surface temperature index (LST). The main components of these PCA are defined as Synthesized Drought Indices, called SDI1, SDI2, and SDI3. Then, the performance of three output indices is evaluated by using the Standardized Precipitation Index (SPI) in 1 and 3 month scale. Validation results indicate that the synthesized index of PCA on the normalized VSDI, LST and PCI, provides the best performance in real-time monitoring of drought. Index called (OSDI). Then, 42 Lands at 7 images were employed to evaluate the ability of suggested indices in heterogeneous land. The three normalized indices of NDVI, SWCI and VSDI, as the only effective factor in different performance of SDI1, SDI2 and OSDI, is produced by the spectral bands of Lands at 7 images and their performance in various lands covers were evaluated using SPI index. High correlation between normalized-VSDI and one-month-SPI has approved capability of OSDI in real-time monitoring of drought in heterogeneous areas. OSDI maps showed that in the provinces of Tehran and Qom of Iran, in 2008, 2009, and 2014, a severe drought has occurred in Central and South-East regions of Tehran, and also at central and northern parts of Qom.

**Keywords:** PCA, precipitation, remote sensing, synthesized drought index, temperature, vegetation.

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## Non-point source pollution modeling and critical area priority for environmental management of Tajan watershed

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### Abstract

Non-point pollution is an important factor in determining water quality and eutrophication of fresh water. The principle causes of this issue is high concentrations of nutrients in the water especially nitrogen and phosphorus. Change of land use particularly affected on water nitrate load. Therefore, understanding the correlations between land use and nitrate pollutant is a priority in order to assess pollutants loading and predicting the impact on surface water quality. The soil and water assessment tool (SWAT) were used to simulate nitrate loads in different land cover types in Tajan watershed. Annual nitrate of in output of Tajan watershed varied from 89350 kg to 31070 kg in period from 2001 to 2013. The contributing share of each land use/land cover (LULC) shows nitrate pollutant produced by grassland (5.7%) and forest (29%) are less than those produced by agricultural land (64%). Agricultural land was identified as the main source of nitrate pollution, and paddy fields and orchards had the most intensive soluble nitrate loss in springer and summer respectively Also, critical subwatersheds for management priority were characterized. The results of this study could be a useful guide in order to preserve and protect the ecosystem of Tajan watershed from more degradation and promote sustainable development in this region.

**Keywords:** critical area, land use, nitrate, Tajan watershed, SWAT model.

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## The effect of rainfall variability on Darakeh river flow rate during 1989-2012

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### Abstract

Rainfall and flow rate are of the most important climatic and hydrologic parameters whose investigation and determination of their behavior are of great importance in water resources management. One of the most suitable methods available for assessment of hydro-climatological conditions in the watershed is trend analysis which is used to examine the changes of a variable during time. Current study has been implemented in two parts. The first part of the study investigates the effect of rainfall changes on Darakeh river flow rate between 1989- 2012. To do this, monthly recorded data of rainfall from Haft Howz station (on Darakeh River) and methods such as graphical Mann-Kendall and linear regression tests were used. In addition, rainfall and river discharge anomalies were examined during the 24-year period. The results indicate that rainfall time series in Darakeh watershed has a positive and rising trend, though this trend is not significant. Also river flow rate increases with a slight slope during the studied time period and doesn't show a significant trend. Totally it can be concluded that except for some particular time periods, increase and decrease in the amount of rainfall and river flow rate has not been concordant. The second part predicts the future rainfall in the catchment using MRI-CGCM2.3.2a under A1B emission scenario for three time horizons (2030, 2060, and 2090). The overall results are representative of reduction in rainfall in Darake river basin in the future.

**Keywords:** climate model, linear regression, Mann-Kendall, rainfall prediction, river flow rate.

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## WEAP model calibration and validation in simulating the impact of irrigation systems change on the Ahar-Chai basin hydrological response

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### Abstract

In this study, application of WEAP model (soil moisture method) has been investigated for simulating hydrological behavior in Ahar-Chai basin. According to the development of pressurized irrigation systems in this basin, since 2005, two models were carried out for two periods, pre-pressurized period (1998-2006) and pressurized period (2006-2013). Irrigation method in first model was surface irrigation, and in second model was surface and pressurized irrigation. Tazekand (the basin outlet point) and Orang (upstream of the Satarkhan dam) hydrometric stations data were considered for calibration (4 year) and validation (4 year) for both models. The coefficient of determination, Nash-Sutcliffe Efficiency (NSE) and the Index of Agreement were used as statistical indices for calibration and validation of both models. The calibration of the indices for first model (1998 to 2001) in Orang station were determined 0.95, 0.82 and 0.98 respectively, and in Tazekand station were calculated 0.96, 0.80 and 0.97, respectively. The Calibration values of the indices in the second model (2006 to 2010) in Orang station were determined 0.95, 0.85 and 0.99 respectively, and in Tazekand station were determined 0.96, 0.83 and 0.98 respectively. The validation values of indices for first model (2002 to 2006) in Orang station were determined 0.98, 0.88 and 0.99, respectively, and in Tazekand station were calculated 0.96, 0.87 and 0.99, respectively. The validation values of the indices in the second model (2010 to 2013) in Orang station were determined 0.96, 0.86 and 0.99, respectively, and in Tazekand station were determined 0.97, 0.78 and 0.97, respectively.

**Keywords:** Ahar Chai basin, calibration, irrigation systems changes, soil moisture method, validation, WEAP model.

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