Land Cover Classification of Anzali Wetland Using Fusion of Sentinel 1 and ALOS/PALSAR 2 Images

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Abstract

Anzali Wetland in Iran, as one of the most valuable wetlands registered in the Ramsar Convention is being destroyed by environmental factors and human activities. In the last two decades, among various satellite images, radar images have played a special role in wetland monitoring. Radar is an all-weather sensor and it is sensitive to surface roughness and moisture. They serve as a valuable source for quick and accurate monitoring of wetlands. However, similarities in backscattering coefficients of different wetland classes and relatively difficult processing – in comparison to optical images- are the most important factors that limit their application. In this study, the capabilities of SAR images in the classification of Anzali wetland and the three main land use classes around the wetland (i.e., agricultural lands, reeds, and built-up areas) were evaluated. Two radar images, Advanced Land Observing Satellite/Phased Array L-band Synthetic Aperture Radar (ALOS/PALSAR) and Sentinel 1 captured in 2018 were used. The texture parameters of the two images have been extracted. The images and their extracted texture layers have been fused by the feature-level method and further classified by the random forest method. The overall accuracy of feature-level fusion is equal to 75% and the kappa coefficient is equal to 0.62. The evaluation results related to producer and user accuracy are 100% and 83.33%, respectively, show the high capability of radar images in the classification and detection of wetlands. However, some errors have been observed in the separation of agricultural lands, reeds, and built-up areas.

Keywords: Anzali wetland, radar images, feature-level fusion, remote sensing, classification

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Identification of Flooded Areas Using Time Series Statistical Calculations and Based on Integrating Radar and Optical Data

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Abstract

Natural hazards have always had devastating effects on human life, of which the flood is one of the most serious one. Therefore, providing rapid flood identification methods for crisis management is highly necessary. The purpose of this study is to provide a method with proper accuracy and speed in preparing flood maps. In this study, two time series of Sentinel-1 and Landsat-8 data were used to prepare a flood intensity map by integrating statistical calculation and index extraction. The proposed algorithm is that first the map of permanent water surfaces is automatically prepared by optical images over a period of 5 years. Then, to determine the flood intensity in different regions, statistical calculations are used on the time series of radar images, and finally, using the Normalized Difference Flood Index, which can quickly identify the flood, the final flood map is obtained. The proposed approach has been implemented following the occurrence of the flood of 1398 in two regions of Golestan and Khuzestan, which have different geographical conditions. Assessments performed with the help of ground truth maps and confusion matrices, and in addition, McNemar test was used for more complete analysis. The implementation of the algorithm in the Google-earth-engine environment showed that this method, in addition to having high accuracy, allows the use of hundreds of images without the need for special hardware. The overall accuracy in a period of time in Golestan and Khuzestan was 91.84 and 97.36, which indicates the high generalizability of the algorithm in regions with different extent.

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Simulation of Salinity Expansion Upstream of Qazvin Saltmarsh Interception Drain in Conditions of Ground Water Overexploitation

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Abstract

A large part of Iran suffers from salinity which threatens sustainable agriculture and food security. Overexploitation of groundwater, where fresh and saline aquifers are adjacent to each other increases saline water hydraulic gradient and solute transport toward fresh aquifer and increases salinity. In Qazvin saltmarsh salinity is expanding toward upstream lands under the mentioned mechanism. An interception drain has been constructed in area in order to drive out saline water and control salinity. The purpose of this study is to assess interception drain ability in controlling salinity and the effect of hydraulic gradient increase and decrease on salinity expansion toward upstream lands. First using observed data, the HYDRUS-2D model was calibrated and validated. Then the effect of increasing and decreasing upstream input flow (10%, 20%, 30%) on drain operation in 5-, 10-, 15- and 20-year intervals was simulated in six treatments. According to results at all time intervals, the greater the upstream inflow, the more solutes are leached out of area by interception drain. The simulation results also showed that the initial soil salinity at the drain floor decreased about 16.1 ds/m after 20 years. As upstream input flow decreases 10%, 20% and 30% this amount (16.1 ds/m) decreases 11%, 17% and 25% respectively. While increasing upstream input flow increases this amount (16.1 ds/m) 22%, 28% and 40%. Therefore, overexploitation from upstream aquifer reduces the inflow to the area and prevents further salinity reduction

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Development of DRASTIC Model Using Artificial Intelligence on the Potential of Aquifer Contamination in Semi-arid Regions

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Abstract

Due to rapid economic growth and over-exploitation of groundwater, nitrate contamination in groundwater has become very serious. The main purpose of this study is to develop a DRASTIC model to identify the vulnerability of groundwater to nitrate contamination. Therefore, the standard DRASTIC model was presented considering the land use factor (DRASTIC-LU model) to demonstrate the vulnerability of groundwater. The novelty of the present study is the development of DRASTIC and DRASTIC-LU models by a support vector machine (SVM) to prevent the error of overlap and index methods. For implementation and validation of the models, 21 samples of observation wells were collected in Birjand plain aquifer. RMSE values for DRASTIC, DRASTIC-LU, DRASTIC+SVM, and DRASTIC-LU+SVM models were calculated to be 0.821, 0.743, 0.612, and 0.490, respectively, which was found that the hybrid models using SVM shows a better correlation between the amount of vulnerability and nitrate contamination. It was also found that the DRASTIC-LU+SVM model has a higher accuracy for assessing the vulnerability of groundwater to nitrate.

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Investigation of Effective Variables in Participatory Planning in Floods Management in Human Settlements
(Case study: Latian River Basin)

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Abstract

Flood is defined as one of the most dangerous kinds of natural disasters which have caused massive damages, deaths, and economic conflicts on the Latian river basin. Participatory planning is one of the recent planning approaches that has been utilized by planners in a variety of fields such as urban planning, urbanism, environmental planning, and crisis management through the last decades. In this study, with the consideration of the recent investigations over this river basin, region specifications, habitants, and conditions of the Latian river basin, the effective variables of participatory planning were selected. Economic, social, governmental, cultural, and environmental variables were chosen as effective variables in participatory planning in flood management. These variables were then compared with each other, for which the Analytic hierarchy process (AHP) method was used to compare and rank the variables because due to the multiplicity of expert opinions and the complete stability, it is possible to calculate the weight of each variable using the data normalization method. After analyzing the data, which are the results of the opinions of 21 experts, it can be concluded that the economic variable with the highest weight is in the highest rank compared to other variables, the governmental variable is placed after the economic variable in the second rank, the social and cultural variable is in the third place after the governmental variable, and the environmental variable is in the fourth place after the social and cultural variable.

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Estimation of Environmental Flow Indicators in the Downstream of Golestan and Voshmgir Dams

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Abstract

Due to the importance of rivers in water supply, it is crucial to understand the flow condition and river regime. The streamflow of the rivers is affected by dam construction, climate change, flow diversion, bypass and urban development, which cause various problems, such as drought, streamflow reduction and environmental issues. Therefore, the purpose of this study is to estimate 34 environmental flow indicators in the downstream of Golestan and Voshmgir dams using the IHA software version 7.1. To do this, Gonbad and Ghazaghli hydrometric stations in the downstream of Golestan Dam and Agh Ghala hydrometric station were considered to analyze the effect of Golestan and Voshmgir dams, respectively. In order to investigate the climate change situation in the study area, the trend of climatic variables including precipitation, temperature and evapotranspiration were also evaluated using Mann-Kendall test and Sen's slope at confidence levels of 1 and 5%. According to the results of the trend test, the changes in climatic variables have often been in an increasing trend in precipitation and temperature and a significant increasing or decreasing trend in evapotranspiration. The results also showed that peak discharge of high current pulses rates in Gonbad, Ghazaghli and Agh Ghala hydrometric stations are 28, 38 and 30.5 m^3/s with a frequency of zero-, two- and one-day in the period after the construction of dams, respectively. The peak discharge indicator of small floods in Gonbad, Ghazaghli and Agh Ghala hydrometric stations are 46, 107 and 149.8 m^3/s with a frequency of zero-day, respectively, Golestan and Voshmgir dams have been caused a decreasing trend in this indicator due to self-regularity of the dams. Finally, according to the large Flood indicators, it can be concluded that in Gonbad and Ghazaghli stations, peak discharge of the large floods indicator with a flow rate of zero m^3/s has a decreasing trend and in Agh Ghala station with a flow rate of 274 m^3/s shows a decreasing trend. Finally, the self-regulatory effect of Golestan and Voshmgir dams have caused low monthly changes and large and small floods and in the most months of the year, the flow discharge is lower in the periods after the construction of the dams. The results of this analysis can be used in the decision-making on sustainable water resources management issues for future watershed management plans.

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Hydrogeochemical Study of Groundwater Resources in Bostanabad Plain Using Multivariate Statistical Methods

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Abstract

Shortage of surface water resources and excessive exploitation of groundwater resources in Bostanabad plain has caused a sharp decline in groundwater level and thus reduced its quality. The purpose of this study is to investigate the concentrations of major, minor and trace elements in groundwater resources with statistical methods. Therefore, 33 samples were collected for chemical analysis of major and minor ions and metalloid and heavy metals from spring and wells in the region. Physicochemical parameters of the samples were investigated using cluster and discriminant analysis and Pearson correlation coefficient. Using cluster analysis, it was found that the samples are located in two clusters; cluster 1 belongs to the samples collected from East and Northeast of the area and is affected by Miocene evaporitic formations of the region, while cluster 2 is mainly related to the samples which are impacted from alluvial tuffs of the Sahand volcanic Mountain. Na, Mg, NO_3, PO_4 and SiO_2 parameters were determined in 5 steps as the most appropriate parameter to predict clustering. Increasing salinity will be effective in increasing the mobility and release of manganese. The correlation between calcium, arsenic and iron showed that the sorption of arsenic to the surface of iron hydroxide increases in the presence of calcium. The relation between iron and manganese will be strong due to the common sensitivity to changes in oxidation-reduction potential, similar geochemical properties as well as the simultaneous presence of iron and manganese (hydro) oxides in the upper layer of soil.

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The Evaluation and Assessment of Bank Erosion Risk Using BANCS Model: a Case Study in Northern Iran, Waz River, Mazandaran

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Abstract

The erosion phenomenon and sediment transport are the most important hydrodynamic processes that effect watersheds, rivers, coasts, ports, dams, bridges, roads, farms, and civil facilities. Waz is one of the main rivers on the northern slope of Alborz in the Mazandaran province. This river has a morphological dynamic behavior and affected by various factors including geology, slope, land-use, and the condition of hydraulic flow. The aim of this study was to assess the bank of Waz River stability using BANCS model, which includes NBS and BEHI indexes. To assess the rate of bank erosion in the Waz River, in a three-kilometer interval, eight cross-sections were selected using field impression and mapping the parameters e.g. side height and angle, bank-full width, bank-full average depth, the maximum average-depth of bank in bank-full, the curvature radius, and bank material based on NBS and BEHI models. Regarding the results for each cross-section based on bank erosion risk index, near bank shear stress and comparing with field surveys, the banks with more risk of bank erosion and more stable banks were determined. Besides, comparing the results obtained from BEHI and NBS models with field surveys showed more efficiency of BEHI model for the Waz River. According to the results from BEHI model in all cross-sections, there is a high risk of erosion in both bank's side. Thus, the left side of bank in cross-sections 3, 5, and 6 and the right side of bank in cross-sections 1, 4, and 7 have had a high rate of erosion. The right side of bank in cross-sections 2, 3, and 6 and the left side of bank in cross-sections 1 and 6 have had a low rate of erosion. The rate of erosion in other cross-sections were moderate.

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Determining the Thresholds of Sustainable Use of Rangeland Ecosystems by Combining Remote Sensing Techniques and Meteorological Indices (Case Study: the Karaj River Watershed)

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Abstract

Despite the need to determine the threshold of sustainable use of rangeland ecosystems, especially in drought conditions, no significant progress has been made in recent years, and still, time-consuming and costly sampling of species production in a period of 5 to 10 years is used. In this study, to determine and monitor the threshold of sustainable use of rangeland ecosystem, the satellite index and meteorological drought index has been used, while the satellite index was determined by field measurement of canopy cover in a one-year period 2018-2019 in part of the basin of the Karaj River watershed. In this regard, in 3-, 6-, 9-, and 12-month time steps, and the maximum satellite index (NDVI) during the growth period in the target years was determined over a period of 20 years. The results showed that there is a correlation coefficient of about 60% between satellite index and plant density, and in the normal years the satellite index has a correlation coefficient of about 70% with the index of meteorological drought and 9-month cumulative rainfall leading to the period of maximum growth. Using the permitted harvest coefficients, the operating thresholds for the allowable range of the satellite index were determined, and eventually, the value of satellite index (NDVI) for the sustainable exploitation of the rangeland was proposed as (0.07459 ± 0.00908) and (0.16597±0.01702) for wet and dry years respectively.

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Investigation of the Effect of Climate Change under Emission Scenarios on Intensity-Duration-Frequency Curves of Precipitation in Zahedan Synoptic Station Using Fractal Theory

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Abstract

Rainfall intensity-duration-frequency (IDF) curves are used to plan, design and operate water resources projects or to protect various engineering projects against floods. Curves created from past climates cannot be valid for the future climates unless they are updated with future climatic trends. The purpose of this study is to investigate the effect of climate change on IDF curves in Zahedan Synoptic Station. First, the fractal behavior of precipitation at the station was investigated and the results showed that the maximum intensity of precipitation follows the mono-fractal behavior. Theoretical error was calculated by the method of relative difference (RD) and the results showed that the errors are within the allowable range, then the curves are extracted for the base period (1982 to 2019) and for the return period of 2, 5, 10, 50, 100 and 200 years. Further, future precipitation data (2021 to 2055) were predicted using HadGEM2-ES general circulation model, from the CMIP5 models series, under the RCP4.5 and RCP8.5 emission scenarios, and using LARS-WG statistical downscaling model. Based on the future data, IDF curves for the future were extracted employing the fractal theory. Comparison of base and future period curves showed that the average maximum rainfall intensity in different durations and return periods increased by 22.9% under RCP4.5 scenario and decreased by 11.1% under RCP8.5 scenario.

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Prioritization of Talar Watershed Flood Risk Potential in GIS Environment

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Abstract

Talar watershed with various land use, hydrological and vegetation characteristics is located in Mazandaran province. In recent years, numerous devastating floods have occurred in this basin. In this study, flooding prioritization of Talar sub-basins under different hydrological and physiographic conditions were compared with an area of 189613.6/ha in agricultural, residential, rangeland and forest land-uses. First, the basin is divided into six sub-basins, including Shirgah, Karmozd, Drasleh, Polusfid, Arjangrudbar and Chashem, and for each sub-basin, geometric, climatic, permeability and physiographic parameters such as area, perimeter, length of main channel, length and slope of basin, time of concentration, CN, discharge, etc. have been calculated using GIS software. Time of concentration with methods of Branci Bay Williams, Johnson, Pilgrim-McDremat, Kirpich, California, Chow, Spey, Ventura was evaluated based on the characteristics of the basin but the Bransi-Williams method with 19.2 hours TC, showed the most suitable method for all the basins. Based on the SCS method, the share of each sub-basin was determined in the flood of output from the whole basin. The results of the maximum stannous flood peak also showed that Polsefid with a flow of 380 cubic meters per second had the highest flow during the statistical period (1986-2019). Sub-basins are divided into three groups with high, medium and low flood potential in terms of similarity of flood potential, erosion, vegetation, and effects of human impact. The results showed that the highest amount of flooding in each of the sub-basins includes the sub-basin of Chashm with 29.19%, in Draseleh with 23.25% and finally shirgah with 16.76%.

Experimental Study of Two-Phase Air-water flows Properties in Hydraulic Jumps on Vegetated Rough Bed

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Abstract

Hydraulic jump is a complex three-dimensional phenomenon which is frequently observed in open channel flows such as rivers. The hydraulic resistance of vegetation plays a major role in the hydrodynamics of rivers with extensive natural floodplains. Vegetation penetrates the flow field and creates resistant force and, consequently, energy dissipation. In this study, the effect of vegetation density and height on flow in a hydraulic jump and parameters related to two-phase Air-water flow are examined using cylindrical elements made of galvanized iron with a homogeneous diameter of 7 mm as vegetation. Thus, neither the effects of plant diversity nor flexibility have been considered. For this purpose, four forms of rough bed were used in two modes of staggered and collocated grid roughness with two heights of 1.5 and 3 cm, and the results were compared with data on smooth bed as a reference. Experiments were conducted in a horizontal rectangular flume with a width of 30 cm, in the range of upstream Froude numbers between 1.5 Fr1 5.5. Air-water flow measurements were conducted with a dual-tip conductivity probe, which was designed, developed and calibrated in this research. The results of this study showed that the presence of vegetation increases aeration by increasing the void fraction in a jump roller. On the other hand, increasing the resistant force and shear stress in the bed reduces conjugate depths and roller length. This increase and decrease depend on the upstream Froude numbers, height and density of vegetation.

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Optimizing of Sampling Wells by a Spatiotemporal Approach in the Groundwater Level Monitoring Network
(Case Study: the Sarab Plain)

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Abstract

Optimizing the sampling wells in the groundwater monitoring network is important in terms of reducing maintenance costs and improving efficiency and increasing the speed of data updating. Statistical methods (such as kriging) or principal component analysis (PCA) are commonly used to identify significant wells. In geostatistical methods, optimization is performed according to the location of the samples but the temporal information of the wells is not taken into account. In the PCA method, indicator wells are determined in terms of temporal information of wells in the vicinity of monitoring stations. In this research, an approach based on a combination of these two methods is presented to consider the spatiotemporal information of wells and it is used to reduce the number of piezometric wells of the Sarab plain aquifer. The present study was conducted by obtaining data from 47 wells related to the first aquifer of Sarab plain in 1397 in three main stages: 1- Exploratory spatial data analysis (ESDA), 2- Determining the priority of wells based on temporal information of the wells in the neighborhood by PCA method, 3- Investigating the surface accuracy changes by kriging method assuming the removal of wells with low temporal priority. The results showed that 9 wells of the Sarab plain (19%) have relative importance less than 0.3. By removing these wells and evaluating the RMSE error in the deleted points, the value of these wells can be calculated with 46 cm error through spatial autocorrelation information. Therefore, the removed wells do not enter much spatial information into the monitoring network, and by removing them, it is possible to increase the accuracy of measuring the water level in other wells and save time and cost with the same initial accuracy.

Keywords: Groundwater, sampling wells, Geostatistic, principal components analysis, the Sarab plain

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Investigation of the Phenomenon of Subsidence due to the Decrease of Groundwater Level in the City of Urmia Using the Zoning of Changes in the Distribution of Soil Layers

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Abstract

In the present study, the phenomenon of land subsidence in the Urmia plain (west of Lake Urmia) has been investigated. In the study area, 53 observation wells were used to study the changes in groundwater depth. The groundwater depth of the plain varies between 1 and 50 meters and decreases from west to east. In the northwest of the plain in the Nooshinshahr lands, the number of isothermal curves is 50 meters, which decreases to the east of the water table depth. Examining the information obtained from periodic subsidence visits, a number of piezometers were observed in the margins of the eastern margin of the Urmia aquifer, which led to the protrusion of the pipe and its fittings. The trend of subsidence at 18 piezometers was studied. Subsidence values in Urmia plain vary from 5 to 17 cm. Most subsidence has occurred in the north and northwest of the plain, which in terms of granulation, has a higher percentage of fine sediments. In the area of Chai shrine to Shahrchay, it decreases and reaches 5 cm in the Jarchilo well. The amount of subsidence between Shahrchay to Barandozchay Rivers has increased significantly towards Lake Urmia and varies between 6 cm to 13 cm. These changes are due to two main reasons, one is a sharp drop in the water table (uncontrolled withdrawals) and the other is the compaction of fine-grained sediments due to a drop in the water table and a decrease in hydrostatic pressure and weight gain of high sediments.

Keywords: Land Subsidence, Decrease of Groundwater Levels, Piezometers, the Urmia Plain.

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Investigation of Alluvial Sediment's Seed Bank and Its Comparison with Vegetation Along Beshar River

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Abstract

This study has tried to introduce the flora, biology and chorology of vegetation along the Beshar River, on the Kohgilouyeh va Boyerahmad province, and its sediment seed bank to determine the role of the river in transferring seeds and the importance of alluvial sediments in maintaining and storing plant seeds. For this purpose, a floristic list of vegetation along the Beshar River on Dehno, Mokhtar, Darohan, Kabgian, and Rudashti areas was prepared by field surveys. Then, to determine status of the seed bank using the seedling generation method, the sediments along the river was sampled and transferred to the greenhouse for germination. The results showed that there were 32 and 25 plant species in the vegetation along the river and sediment seed bank, respectively. Among the identified species, 20 species are shared between the vegetation along the river and the sediment seed bank, while 5 species including *Alyssum dasycarpum*, *Chenopodium botrys*, *Erodium cicutarium*, *Medicago rigidula*, and *Aeluropus littoralis* are present only in the sediment seed bank. According to the results, hemicryptophytes, therophytes, and geophytes along the river are 50%, 48.87% and 3.12%, respectively. In sediment seed bank, 36% of the species are hemicryptophytes and 64% of the species are trophites. The analysis of variance shows that there is a significant difference between sediment seed bank in different areas of the river in terms of number of seedlings grown. The comparison of the mean, also, indicates the existence of a significant difference between the seed bank of sediments in all areas except Kabgian and Dehno. Since the rivers with significant sediment load indicate the unfavorable condition of the upstream lands and the destruction of vegetation, the seed bank of alluvial sediments of these rivers is small which shows the poorness of the soil seed bank of the watershed. Therefore, determining the status of the seed bank of river sediments can play a key role in understanding the status of the watershed management.

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Drought Monitoring in Tehran Province Using TRMM Satellite Data

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Abstract

Drought is a climatic phenomenon that affects different parts of the environment during its continuation. Most drought assessment systems are mainly based on rainfall data. However, short statistical period of data, insufficient density of stations and poor quality of ground rainfall data, reduces the ability to show the spatial pattern of drought. Therefore, the current paper aims at monitoring drought in Tehran province using rainfall network data. Thus, monthly precipitation data of six synoptic stations in Tehran province and monthly precipitation data of TRMM satellite with spatial resolution of .25 × .25 degrees during the period (1998-2019) have been used. The results show that the output of the 12-month SPI index for TRMM points is in good agreement with synoptic stations and the drought characteristics at different stations are consistent with different points of the TRMM network. In 36% of the study period, the rainfall in the province is in normal range and in 64% the rainfall is not normal. In all parts of the province, the frequency of dry and wet periods is equal and each of which is 31.8%. In terms of severity, most precipitation anomalies in Tehran province are mild and moderate, so that the frequency of mild drought is 18%, moderate drought is 9% and severe drought is about 4.5%. Extremely severe drought has not occurred in any part of the province in the last 22 years. Also, 2001, 2008, 2013 and 2014 are the most severe periods of widespread severe drought in the province, with most areas suffering from moderate to severe droughts.

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Estimation of Water Consumption in the Agricultural Area of Iran and Evaluation of the Results Obtained from the WaPOR Product With Ground Data

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Abstract

In this study, Iran's water consumption has been estimated in all province of Iran using the actual evapotranspiration product WaPOR which is developed by FAO. To consider the plains which have the main agricultural water consumption of Iran, the amount of water consumed was estimated for every province in the year 2010 to 2016, then the slope of changes in agricultural water consumption was determined for every one of them separately. The volume of water consumption in the agricultural area of Khuzestan, Tehran and Gilan provinces have the highest increasing trend in the period 2010 to 2016, respectively, and in the other words, they have positive slope changes. Hormozgan and Kermanshah provinces also had the largest decrease in the amount of water consumed in the agricultural area. The results of this 7-year statistical period illustrate that water consumption of agricultural and the volume of irrigation have been increasing in Iran since 2013. To evaluate the accuracy of WaPOR product, its values were compared with evapotranspiration from SEBAL algorithm and Lysimeter station statistics in the Miandoab plain. The results present that in most areas, the evapotranspiration values of SEBAL algorithm are higher than the WaPOR, which reaches its maximum value by moving to an altitude of 2000 meters. The actual evapotranspiration values of the lysimeter of Tabriz University were in good agreement with the calculated values of the SEBAL algorithm, also the volume of water consumed calculated with WaPOR is less than the actual value.

Keywords: Iran, Agricultural Consumption, SEBAL, Evapotranspiration, WaPOR

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Analysis of Water Resources Management Strategies by TOPSIS Method Based on Water Footprint of Agricultural Products in Dez Basin

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Abstract

Lack of water, energy and food (WEF) resources due to rapid population growth, climate change, ecosystem imbalances and economic diversity are the biggest challenges for the world today. In this paper the optimal management of WEF resources is investigated with the nexus approach and using the concept of water footprint in the Dez basin located in the Khuzestan province. To do this, the water footprint of major horticultural crops cultivated are calculated in this basin. Also, in order to provide strategic solutions in the optimal management of water resources with regard to the three components of WEF, the TOPSIS analytical method has been used. The results show that the highest index of water footprint of crops was related to mung bean, rice, sugarcane and rapeseed, respectively, which were equal to 4945, 2671, 1462 and 1227 cubic meters per ton, respectively. Finally, according to the analysis and priority of effective strategies on WEF resources management by TOPSIS method, five criteria are identified: optimal collection and extraction of WEF resources, changing irrigation patterns and implementation of low-demand methods, agricultural water resources quotas, development of risk management and crisis to prevent the loss of quantity and quality of WEF resources in order to improve agricultural products, recycling and reuse of water by emphasizing the replacement of effluents for agricultural use and green space by using new methods for water extraction. They are ranked first to fifth as important and effective strategies.

Keywords: Water resources management, TOPSIS method, water footprint, agricultural products

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Evaluation of Gene Expression Model in Spatial Prediction of Groundwater Salinity and Its Comparison with Geostatistical Models (Case study: the Mashhad Plain)

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Abstract

Groundwater is an important source of exploitation in arid and semi-arid regions. Therefore, in order to maintain groundwater quality and its optimal management, it is important to know their spatial and temporal distribution, and their monitoring and zoning should be considered as an important principle in the country's water resources planning. The aim of the present study was to zone the electrical conductivity of groundwater in the Mashhad plain aquifer using 5 methods of reverse distance (IDW), local estimator (GPI), general estimator (LPI), kriging and cokriging and also evaluating the gene expression programming model in predicting this parameter, using spatial data. For the present study, data from 122 observation wells in the aquifer area of Mashhad plain were used. To compare the methods used, three squared evaluation criteria were the mean square error (RMSE), the mean absolute value of the error (MAE) and the Nash Sutcliffe criterion (NSE). The semi-variable plot in GS + showed that the electrical conductivity data fit best in the spherical model. The results of the present study showed that among the mentioned methods, the gene expression programming model with RMSE=275.54 µmos/cm, MAE=223.15 µmos/cm and NSE=0.94 and then the cokriging method with RMSE=573.59 µmos/cm, MAE=319.73 µmos/cm and NSE=0.72 from the highest accuracy and local estimator method (GPI) with RMSE=996.11 µmos/cm, MAE=755.56 µmos/cm and NSE=0.16 had the lowest accuracy.

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Potential Detection of Mineral Water Springs Using Statistical Models a (Case Study of Vazroud Watershed, Mazandaran)

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Abstract

Determining the potential of mineral springs is one of the most important and essential issues in water resources management in humid regions of Iran. In this study, the potential map of the spring for the management and planning of groundwater resources was performed using statistical models of frequency ratio (FR) and weight of evidence (WOE) in the Vazrood Watershed of Mazandaran province. For this purpose, 57 springs were identified randomly in the calibration (34) and validation (23) phases. In the implementation of both models, the effective factors that were used in spring potential include: slope percentage and aspect, hypsometry, plan and profile, geology, land use, topographic wetness index, distance from fault, fault density, drainage density, distance from the river and distance from the road. The ROC curve was also used to validate the models. The results showed that the accuracy of the FR model was 84.4% and the accuracy of the WOE model was 77.2%. These results indicate a very good accuracy of these two models in determining the potential areas of springs in the Vazrood Watershed. According to the results, the accuracy of the FR model is also higher than the WOE model. Finally, 39.7% and 34.9% of Vazroud watershed in high and very high classes in terms of spring potential are in two models of WOE and FR models, respectively. Finally, the potential maps of the springs can be used to provide the basic infrastructure to clean the springs from human damage and the entry of investors to build spring factory and ultimately the prosperity of the local economy of the Watershed residents of Vazroud.

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