

## Investigation of Climate Change Occurrence and its Impact on Wheat Growth (Case Study: Fars Province)

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### Abstract

The purpose of this study is to predict climate change and investigate the effect of climate change on Growth Day-days and total days of wheat growth in the Fars province. For this purpose, the climate data of three synoptic stations of Shiraz, Lar and Abadeh in Fars province and the data of two models HADGEM2-ES and EC-EART were scaled under RCP45 and RCP85 scenarios. LARS-WG statistical model was used for downscaling. The results showed that the LARS-WG model has appropriate accuracy in downscaling of Fars province climate, minimum and maximum temperature parameters. The minimum and maximum temperatures of all three stations of Shiraz, Lar and Abadeh increased under both RCP45 and RCP85 scenarios. The increase in the minimum temperature of the base period (1980–2015) in the Fars province relative to the period (2021–2040) for the RCP45 and RCP85 scenarios are 1.43 and 1.65 ° C, respectively. The maximum increase in base temperature over this period for the RCP45 and RCP85 scenarios are 1.51 and 1.66 ° C, respectively. The amount of changes in the rainfall of the baseline period increased by 2.93% and 1.95% for the RCP45 and RCP85 scenarios, respectively. Then, using ADP equation, the number of day-index under two temperature thresholds of 4 and 25 ° C for the basic and future time interval (2021-2040) was calculated and the results showed the degree of days of wheat growth period (GDD) and total days' number. The growth period (DAP) had an increasing and decreasing trend compared to the baseline period.

**Keywords:** Climate Change, RCP Scenarios, Downscaling, GDD, ADP, Fars Province.

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## Investigating the Effect of Climate Change on Water Flow and Water Balance of Latyan Dam Watershed Using SWAT Model

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### Abstract

The climate change can be a major threat to biodiversity and ecosystem integrity. Therefore, prediction of hydrological behavior of watersheds for conservation and reconstruction of ecosystems is necessary. Latyan dam watershed as one of the mountainous basins of the country with an area of approximately 710 km<sup>2</sup> is located northeast of Tehran and west of Damavand city. In this research, to evaluate the run-off and water balance caused by climate change, the SWAT semi-distributed hydrologic model has been used based on the data collected in the years 1988-2014. Given the high precision of the CMIP5 series models, the outputs of these models were introduced into the model under the two scenarios RCP 2.6 and RCP8.5 for the near future using the climate LARS-WG model. The result of stimulation for 2021-2050 showed that mean temperature increases by 0.75 C° for the RCP 2.6 optimistic scenario and 1.45 C° for the RCP 8.5 pessimistic scenario. In addition, rainfall was reduced by 2 % in RCP 8.5 and 5 % in RCP 2.6. The result for water flow showed that high level of water flow decreases by 2.4 cubic meters per second in May and increases by 1.49 in April. The water flow in RCP 8.5 scenario for May and June was greatly reduced, which can negatively affect the level of water in dam until the start of rainfall. Average evapotranspiration was increased by 3 mm in the optimistic scenario and 8mm in the pessimistic scenario which negatively affects the accessible water resource. Reduction of rainfall was predicted for the two scenarios. The results of the research emphasize the necessity of applying appropriate policies for adaptation of ecosystem based climate change in the management of the Latyan catchment area.

**Keywords:** LARS-WG, Latyan Dam, RCP, SUFI2, Water Balance.

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## **Risk Assessment of Water Resources Development Plans Using the Fault Tree Analysis Method (Case Study: District 4 of Mokran and Bandar Abbas)**

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### **Abstract**

Nowadays, the improper distribution of rainfall and the decline in precipitation, in addition to the population growth, resulted in water consumption and demand have made society dependent on the use of water resources development plans. Also, one of the long-term goals of the country's water strategy is to strike a balance between the amount of water demand and existing water resources, bearing in mind the social, economic, and environmental considerations. Therefore, risk analysis of water resource development plans based on sustainable development indicators is necessary. In the present study, for the first time, the Fault Tree Analysis (FTA) technique was employed in order to assess the risk of water resource development projects under the framework of sustainable development. After determining the top event, factors leading to its occurrence, including the failure of social, economic, environmental and water resources indices were identified. The proposed model was presented as a case study for water resources development plans of the "district 4 of Mokran to Bandar Abbas City". After calculating the area performance in Vensim, the probability of failure of the Sustainable Development Indicators was estimated based on Vensim output and used as input to the proposed Fault Tree. The results showed that the failure probability of the best, worst and existing condition scenarios were 38%, 90% and 50%, respectively. Finally, due to the calculated high risk, the base events were ranked based on their contribution on the top event occurrence. The ranking results showed that the most effective base events in the best scenario are social failure and economic failure and in the worst case scenario are economic and social failures, respectively.

**Keywords:** Sustainable Development, Fault Tree Analysis, Water Resources Development Plans, Mokran, Vensim.

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## Prioritization of Sub-watersheds from Flooding Viewpoint using the Hec-Hms Model in Upstream of Shiraz Khoshk River

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### Abstract

Flood is among the complex and destructive natural phenomena that causes heavy damage every year. River routing and spatial situation of the sub-catchments are effective factors on floods in catchment outlets. Hence, for performing the flood control projects in upstream parts of catchments, their effects on flood should be investigated. In this research, the priority of the sub-watersheds was considered for flood occurrence in the Chenar -Soukhteh watershed using the HEC-HMS model. After providing the data needed for flood hydrographs, the SCS hydrological simulation methods was used. Prioritization of the sub-catchments for flooding was done by utilizing the HEC-HMS model. Model calibration was done by sensitive parameters including initial losses, curve number and lag time. In order to evaluate the effects of flooding, two indicators of physical criteria such as flux peak flow and flow volume were considered in each step. By applying the repetitive method for individual removal of sub-catchment, flood hydrographs corresponding to its precipitation were calculated for each sub-catchment. Then, with successive elimination of sub-catchment, the effect of each one in the production of flood output was obtained. The results showed that in events that were calibrated in medium CN conditions, sub-catchment 5 had the first priority in terms of flooding, while in the case of wet-calibrated CN, sub-catchment 6 has the first priority.

**Keywords:** prioritization, HEC-HMS Model, Flooding, Chenar-Soukhteh.

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## **Analysis and Identification of Key Factors and Drivers Affecting Integrated Water Resources Management based on Futures Studies Approach (Case Study of Tabriz County)**

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### **Abstract**

The system of water resources is influenced by several factors affecting a particular geographical environment or in a wider space. Sometimes, these effects are such that, the conditions for access to healthy water resources and performances of water resource planning and management are faced with massive problems. The goal of water resource planning and management is to match the socio-economic system demand of water with the supply of the water system through administrative control and management, without damaging sustainability of ecosystem. This can be achieved by identifying effective and influential factors, both from water supply side, and demand side of the various sectors of the society. Therefore, in the present study, it was attempted to identify key factors and drivers affecting the future of water resources of Tabriz County till the 2041 vision based on the Integrated Water Resources Management. Meanwhile, to apply appropriate policy strategies, some 46 primary factors were identified by the panel of experts by using the resource review and Delphi method. In order to determine the key factors and effective drivers in this system, 15 factors were introduced using the cross impact matrix. The final findings indicate that environmental and economic factors have the largest share as the main actors in this collection and will play a more effective role in the future of water resources and it is expected that driver affecting County water resources to be one comprising environmental and economic components.

**Keywords:** Integrated Water Resources Management (IWRM), Cross-Impact Matrix, Driving forces.

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## The Efficiency of an Ensemble Frequency Ratio-Support Vector Machine Model in the Detection of Flood-Prone Areas of the Kalat Basin

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### Abstract

Flooding hurts the environment, economy, human communities, and industry. Therefore, comprehensive knowledge on flood probability modeling is essential to identify sensitive areas and to improve flood management systems. Advanced floods models usage has been grown dramatically today. That's why several researchers have integrated some models obtaining acceptable results for identifying flood-prone areas. Since numerous high-risk floods have occurred in the Kalat Basin and no advanced techniques have been used to estimate flood probability, so the Frequency Ratio-Support Vector Machine (FR-SVM) ensemble model was selected for flood modeling. Accuracy and efficiency evaluation, consequently, has been compared with the standalone SVM model. By investigation, 73 floods points were recorded according to recent 2018 end-month floods, and 15 conditioning factors including annual precipitation, geology, land use/land cover, slope length, river distance, analytical hill shading, elevation, convergence index, profile and plan curvatures, slope, stream power index, topographic roughness index, topographic wetness index and valley depth were considered. Models were evaluated by various precision criteria such as kappa coefficient, root means square errors, receiver operating characteristics and precision-recall curve. The FR-SVM model with a precision-recall curve of 0.8862 showed high accuracy and performance than SVM. These results can be used to manage flood-prone areas and other natural resource applications.

**Keywords:** Flood probability modeling, Support vector machine, Frequency ratio, Ensemble model, Kalat Basin.

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## Forecasting of Groundwater Fluctuations Using Time Series and GMS Models (Case Study: Rafsanjan Plain)

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### Abstract

Awareness of precipitation changes as an important hydrological component in water resources is essential to provide appropriate management and management approaches for proper utilization of groundwater in arid and semi-arid regions, caused by the lack of rainfall in these areas. Regarding the importance of the subject, in this study, the prediction of fluctuations in groundwater level was influenced by stochastic models in the Rafsanjan plain. Future precipitation was projected using the ARIMA model in EViews9 software for 2017-2023, then groundwater drainage was simulated using the groundwater model system (GMS) during the base period (2003-2016) and results from the ARIMA model for the upcoming period. The results of groundwater drainage simulation showed that in the whole region, groundwater abatement occurred in the upcoming period relative to the base period, and the most groundwater losses occurred in the southwest of the plain, and an annual increase of approximately 130 million cubic meters Groundwater resources are made. In general, groundwater has the highest level (upper level) at the beginning of the period and the lowest level (lowest level) at the end of the statistical period. After modeling the groundwater level for the base period, rainfall prediction from the ARIMA model was applied to the groundwater model with the assumption that the aquifer was operationally constant. The results showed that the aquifer volume deficit was 1021.09 million cubic meters in the final model year (2023). Also, the changes in the level of the aquifer in the Rafsanjan Plain from 2003 to 2023 indicate that, given the estimated rainfall from the ARIMA model, it can be admitted that an average of 1 meter annual waterfall will occur in this plain.

**Keywords:** Rafsanjan Plain, Groundwater, ARIMA Model, GMS Model.

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## **Evaluation of River Bank Stability against Erosion and Management Practices of Taleghan River Bank Using LIN Method**

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### **Abstract**

Erosion and sediment transport are the important hydrodynamic processes in drainage basins that can affect many hydraulic and hydrologic systems such as rivers, beaches, ports, dams, bridges, roads, and farms. One of the most important sediment sources in Iran drainage basin is bank channel erosion that causes on-site and off-site effects. Therefore, investigating of channel/river band instability is necessary for engineering activities to stabilize the riverbank against bank erosion. Thus, the main objectives of this study were to investigate the instability coefficient of the Taleghan River and to find the engineering solution for its stabilization by using the Lin model. In view of this, all required parameters comprising slope, shear stress, slope angle, and satiability coefficient of grain are measured using filed study and Google earth imagery. Finally, bank satiability coefficient and effective rock size for revetment besides the riverbank is obtained in the study area. According to the results, the highest amount of bank erosion and consequently (0.0002,0.0001), the lowest stability coefficient and the largest stone at the threshold (0.33, 0.48) and effective on revetment are related to the 4th section. The lowest amount of erosion, as a result, the highest range of stability coefficient (0.002,0.017) and smallest stone at the threshold (0.75, 0.95) and effective on revetment is related to the 1st section. The main reason could be the size of the grain size on the side, the slope of the basin, slope aside and bank full discharge width. Depending on the location of the area, the best way to prevent bank erosion is to create rip rap on the sides of the high erosion.

**Keywords:** Stability factor, LIN model, Taleghan river, bank erosion, size of the rock.

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## Potential Evaluation of Bioenergy Production from Maize Crop Based on Water Footprint Approach

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### Abstract

The development of energy supply from biomass to reduce greenhouse gas emissions has led to a focus on producing important crops from energy perspective which culminated in water consumption increase. Therefore, in this study for analyzing the water and bioenergy nexus, an index called water footprint was used. In this regard, information about maize in the plains of the Khuzestan province was collected. Based on the calculations, it was found that the water footprint of maize crop in the province has an average of 3355.6 m<sup>3</sup>/ton and the biomass water footprint is equal to 214.9 m<sup>3</sup>/ton. Moreover, in the study of water footprint of maize biomass, it was found that the highest and the lowest water footprints devoted to Behbahan plain (27.1 m<sup>3</sup>/GJ) and Abbas Abad plain (10 m<sup>3</sup>/GJ), respectively. Accordingly, Khuzestan province with an average of 13 m<sup>3</sup>/GJ, has a better condition in terms of water consumption in compared to countries such as Zimbabwe, Brazil and the United States, with a water footprint of 200, 39 and 18 m<sup>3</sup>/GJ, respectively. Mapping the biomass energy production potential with the water footprint approach also showed that water footprint in southeastern plains of the province (especially Behbahan, Omidieh, and Hendijan) are in the interval between 12 up to 27.1 m<sup>3</sup>/GJ and have low priority for biomass production. In contrast, the northern and eastern plains (especially Abbas Abad, Andimeshk, Sidon and Qaleh Tal) with bioenergy water footprints of 10 to 10.9 m<sup>3</sup>/GJ have high priority to the use of maize biomass for energy production.

**Keywords:** Biomass, Greenhouse gases, Khuzestan, Maize.

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## Investigating Water Body Changes Using Remote Sensing Water Indices and Google Earth Engine: Case Study of Poldokhtar Wetlands, Lorestan Province

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### Abstract

Wetlands are the most important natural ecosystems on the earth, and assessing changes in them is one of the essential necessities in the natural resource management of this valuable natural ecosystem. The aim of this study is to investigate water body changes using remote sensing water indices and Google Earth Engine (GEE) in the study area of Poldokhtar wetlands, Lorestan province. Remote sensing water indices includes AWEInsh, AWEIsh, NDWI, mNDWI, NDWI plus VI, mNDWI plus VI and LSWI plus VI that were used TM, ETM+ and OLI Landsat satellite images, and Google Earth Engine were applied Landsat Water Product data. The results demonstrated temporo-spatial distribution of water body changes in the study area and they were compared to real data indicating AWEIsh and AWEInsh with overall accuracy of 99.39 and 99.19 and Kappa coefficient of 0.94 and 0.91 were the best water indices among all in enhancing water bodies. Furthermore, GEE results showed overall accuracy of 87 and kappa Coefficient of 0.86. These results indicate that water indices and GEE are useful tools in detection of increasing and decreasing trends in water bodies that can assist planner and policy-makers in protecting and managing natural resources in the study area.

**Keywords:** Remote sensing water indices, Google Earth Engine, Wetlands, Water body, Poldokhtar, Lorestan.

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## Comprehensive Risk Assessment of Sarkhoon Aquifer Salinization Using a Combination of Machine Learning Models

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### Abstract

Risk assessment of aquifer salinization is of great importance especially in regions near the coast. In this study, it was attempted to develop a comprehensive framework for salinity risk assessment for Sarkhoon aquifer, Hormozgan province by combining the aquifer vulnerability potential model and machine learning algorithms. In the first step, the input layers required for the generation of the aquifer vulnerability potential map were prepared based on DRASTIC model and combined. Then, the map of salinization hazard occurrence probability was obtained by using three machine learning models of Random Forest, Extreme Gradient Boosting (XGBoost), and Bayesian Additive Regression Trees (BART) by considering 12 factors affecting groundwater including topographic wetness, soil, vegetation and other factors. Prior to modeling, a collinearity test was performed on the data and it was observed that there was no collinearity between the models' input parameters. Evaluation of the modeling performance with the receiver operating characteristic (ROC) curve indicated that all three algorithms had very good accuracies with area under curve (AUC) values higher than 90%. Thus, all three models were combined based on their AUC values to produce a united map for the probability of salinization hazard occurrence. Finally, the map of salinization risk was generated based on the values for the vulnerability, salinity and hazard occurrence probability. The obtained risk map showed that the eastern part of the aquifer has very high salinization risk which is due to the high concentration of agricultural land in this part of the plain. The results of this study revealed that achieving a reliable map for assessing aquifer salinization risk is possible by combining machine learning models.

**Keywords:** Groundwater, Salinization hazard, Random Forest, DRASTIC index, Vulnerability potential.

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## Wetland Management Strategies with Emphasis on Water Resources Using, SWOT and WASPAS Models

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### Abstract

Sustainable management of wetlands, in terms of their terrestrial and aquatic ecosystems composition and characteristics, requires scientific and multi-disciplinary approaches. The purpose of this study was to develop Jazmourian wetland management strategies using multi-criteria decision-making models. This study was an evaluation-analytical study that collected library and documentary data as well as field data. In this study, first, using DPSIR framework, the criteria were developed according to the theoretical framework and then WASPAS method was used to prioritize wetland conservation and restoration management strategies. Then, The Quantitative Strategic Matrix Planning method was used to extract strategies and determine the direction of water resources management strategies. Following on from the IFE and EFE matrices, the internal factors accounted for 0.254 and the external factors of 0.213 which indicates a high aggressive approach to profitability. Results from the WASPAS model for measuring and analyzing hierarchical management strategies indicate that, respectively, conservation of indigenous vegetation units with a weight of 0.403, is the highest priority and at the top of hierarchical analysis, and then public participation in management. Watercourse with weight of 0.373, construction of small dams instead of large dams with weight of 0.321, creation of employment in services and handicrafts with weight of 0.291, cultivation of economically viable plants with weight of 0.223, organizing drilling wells with weight of 0.222, use of treated wastewater for irrigation with weight of 0.221, expanding use of new irrigation systems with weight of 0.220, determination of cost The actual weight of 0.204 in agriculture, greenhouse cultivation and development under cultivation 0.193 and ultimately, the solution is cementing, cover and intubation of streams with weight of 0.146 is the lowest priority.

**Keywords:** Strategic Environmental Assessment, Prioritization, Quantitative Strategic Planning Matrix, DPSIR Model.

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## **Vulnerability of Shazand Plain Subsidence Caused by Groundwater Level Reduction Using Weighting Model and Its Validation Analysis Using Radar Interferometry**

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### **Abstract**

In this research, the factors affecting land subsidence in the Shazand plain have been investigated using a weighting model. In the ALPRIFT model, seven effective parameters, aquifer environment, land use, pumping, feeding, aquifer thickness, distance from fault and groundwater loss were rated and classified according to expert opinion. By combining these parameters in ArcGIS environment, the vulnerability map was evaluated. The index ranged from 87 to 170. Then, for optimization and adaptation, seven layers effective on fuzzy subsidence were prepared and the final map was prepared. Then the final map of the subsidence potential was prepared using the AHP method. Vulnerability of lowland subsidence was obtained by integrating layers in Arc GIS for a period of 2016-2017. InSAR satellite map was used to validate this model. Fuzzy and AHP methods were combined with weighting model to improve the results and optimize the weights applied. The results show that all three methods have almost the same correlation with satellite data and fuzzy method shows the highest correlation with satellite data and actual subsidence. Based on this model, the north and northwest regions are subject to subsidence. It should be noted that the Shazand refinery is located in a high subsidence potential area and management plans should be put in place to control the subsidence.

**Keywords:** Subsidence Potential, InSAR Satellite Map, Weighting Model, Shazand Plain.

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## **The Impact of Agricultural Water Pricing on Sustainability of Its Resources (Case Study: Kohgiluyeh and Boyerahmad Province)**

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### **Abstract**

The largest consumption of water is in agricultural and irrigation sectors, which accounts for about 70 percent of the world's total fresh water consumption, and because of rapid population growth, increased urbanization and climate change, water resources are scarce worldwide. In the present study, the potential impacts of water pricing on increasing efficiency, improving fairness and equity in water allocation and sustainability of surface and groundwater will be reviewed. The required data were collected through questionnaires and face-to-face interviews with farmers in different areas where farmers pay for irrigation costs in the area. The results showed that for productive farms, out of 139 farms, 14 farms were fully efficient in water use and the amount of extra water consumed for these farms was equal to zero. Of the 112 ranchers, only 19 ranchers had fully efficient water use and no additional water use and have not consumed excess water. The results of the Sustainability Index showed that if farmers and ranchers were more efficient in their water use and reduce water loss, their sustainability index would increase. The results of the VAR model indicate the equilibrium vector, which indicates the long-run equilibrium relationship between pricing policy and agricultural output. In other words, the results clearly indicate that water pricing policy has increased agricultural production in the studied units.

**Keywords:** Water Pricing, Data Envelopment Analysis, Water Sustainability, VAR Model.

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## Vertical Distribution of Microbial Pollution (Case study: Sabalan Dam)

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### Abstract

The main purpose of the research is to investigate the relationship between pathogenic micro-organisms (total coliforms (TC) and fecal coliforms (FC)) with physical and chemical parameters of water in different depths of reservoirs. Samples were taken from different depths of the dam reservoir in June, July and August, when the water was in maximum temperature, pH, TC, FC, electrical conductivity (EC), pressure (P), Total phosphorus (TP), total dissolved solids (TDS), dissolved oxygen (DO) and temperature (T) were measured. Preliminary results showed that pH, DO and T parameters decreased with increasing depth in the water column, while EC, TDS and TP increased. The results obtained from multivariate statistical analysis methods revealed that TC and FC were affected by P and TDS changes. By moving from the surface to the bottom of the dam reservoir, the distribution of the coliforms decreased, which is unbalanced, and no specific pattern of coliform distribution can be considered. Based on the analysis of the relationships, it was found that 58% of total coliform and 59% of fecal coliform changes were predictable if the total soluble and pressurized solids were quantified. Also, by Pearson correlation analysis, it was determined that total coliform and fecal coliform, in none of the four levels, were correlated with total soluble solids and pressure parameters, and none of these parameters had a significant direct effect on them. As a result, fecal coliform and total coliform are directly related to T, Do and pH and inversely related to EC, TDS, and strain.

**Keywords:** Quality protection, Total coliforms, Fecal coliforms, Biological stratification, Dam reservoir.

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## Investigation of Uncertainties in a Rainfall-Runoff Conceptual Model for Simulation of Basin using Bayesian Method

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### Abstract

Taleghan River is among the most important rivers in Iran due to its flow to Taleghan Dam, supplying drinking water to this region in addition to being one of the sources for northwestern part of the city of Tehran. Long-term river discharge data are needed to design hydroelectric power stations and manage water resources. With the existing monitoring stations being scattered and not providing sufficient hydrological data for the basin, we employ rainfall-runoff models which are popular tools for expanding hydrological data over time and space. In this paper, the feasibility of applying a conceptual rainfall-runoff model called HYMOD to a part of Taleghan River Basin is investigated. The generalized probability estimation method was used for model calibration and uncertainty analysis. The results show that the observed discharges are satisfactorily consistent with the observations, indicating that the hydrological model is working well and applying HYMOD to estimate long time series of river discharge in the study area is turning reasonable results.

**Keywords:** Taleghanrood catchment, HYMOD, uncertainty, River discharge, Rainfall-Runoff Bayesian method.

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## Analysis of Hydrological Drought Severity, Duration and Magnitude Using Copula Functions (Case study: Bandar-Sedij and Kol-Mehran Watershed)

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### Abstract

The drought characteristics are often highly correlated. But, the univariate drought analysis is not a proper approach since it doesn't involve the dependence structure of drought characteristics. Therefore, the multivariate drought analysis is used since it considers the dependence structure of drought characteristics in the model. The aim of this study is to analyze multivariate hydrological drought in the Mehran and Sedij basins. For this reason, the empirical copula was used to compute the cumulative distribution function of the run-off and the joint deficit index. Then, the drought severity, duration and magnitude were extracted and several theoretical copulas belongs to the Archimedean and Elliptical families were fitted to obtain the trivariate distribution of drought variables. Results of the JDI and SPI-12 evaluation in the study area represented that the JDI is a proper index of monitoring hydrological drought and provides a more precise estimation than the SPI-12. Further, results of joint return period indicated that the joint trivariate return period is larger than the conditional trivariate return period. So that, the joint or conditional probability with high or low return periods is important in predicting drought events. Because the under-estimation or over-estimation of drought risk have serious impact on environmental resources, soil moisture and water quality. Generally, the multi-dimensional copulas are useful approaches in evaluating the complicated and non-linear relationship of variables and constructing a comprehensive index for evaluating drought condition.

**Keywords:** Hydrological drought, Copula function, drought characteristics, joint deficit index.

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## **Flood Spatial Location Detection by Combining AHP and Fuzzy Models Using WLC Method in GIS (Case Study: Khorramabad Watershed)**

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### **Abstract**

Locating suitable areas for constructing flood and water infiltration in underground trips with the purpose of storing runoffs and increasing groundwater reserves for providing required water for various purposes and also, the control of damages caused by floods, shows the importance and high necessity of these studies in order to protect natural and human resources. In this study, it has been attempted to provide appropriate locations for the flood distribution in Khorramabad watershed. For this purpose parameters such as land use, altitude, drainage density, geology, distance from residential areas, distance from river, distance from road, slope, soil categories, soil texture, electrical conductivity and unsaturated thickness was prepared and examined in the environment of ArcGIS 10.5. At first, the parameters were analyzed using fuzzy method between zero and one and then using the Expert Choice hierarchical analysis of paired comparison of variables were classified as quantitative classification and then using software based on analytic hierarchy process, the weight of each criterion was obtained. The most effective criteria in this study were the parameters of distance from residential areas, land use and unsaturated thickness. Finally, using ArcGIS10.5 the techniques and combined with linear-weighted combination, the location for flood propagation was determined. The results showed that according to the final map of flood spreading, 13.99% of Khorramabad watershed, appropriate desirability and 26.04% of the average desirability for constructing the constructs with the aim of spreading floods. These areas can be considered in planning the necessary actions to broadcast floods in this area.

**Keywords:** AHP Method, Flood Control, Fuzzy Model, GIS, Location.

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## Development Bayesian Model for Forecasting Groundwater Quality Index (Case Study: Zanjan Plain)

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### Abstract

Determining and forecasting groundwater quality can be a primary step for managing aquifer sustainability. This study investigates and forecasts groundwater quality in Zanjan Aquifer. In the previous studies, the GWQI index is a simple weighting based on expert opinions. Thus, in the developing a new index (C-GWQI), for weighting, the Shannon entropy method and the COPRAS multi-criteria decision-making technique were used. In this research, COPRAS Multi Criteria Decision Making Technique was utilized to develop the new index (C-GWQI). By defining two permissible and desirable points of drinking water according to the WHO standard, aquifer quality was classified into three ranges including, desirable, permissible and non-permissible for drinking water. The results showed that in all periods of time, groundwater quality is lower in urban areas than in other areas. However, in most of the wells surveyed, the water quality was evaluated in desirable range for drinking. The developed index was forecasted using the Bayesian network model under eight structural strategies and the best-case strategy was selected according to mean absolute relative error (MARE) and correlation coefficient (R). The best strategy was forecasted next month's groundwater quality with MARE of training and test respectively of 1.932% and 0.992%. This strategy was able to forecast the following month with good accuracy with predictor parameters such as return water, discharge, precipitation, temperature, and quality of this month. The results of this study can assist managers to better conserve and manage the aquifer.

**Keywords:** Bayesian network, COPRAS, groundwater quality, Zanjan Aquifer.

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## Determination of Optimal Operation Policy of Reservoir with Nonlinear Model to Reduce Reservoir Water Losses

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### Abstract

The purpose of this study is to evaluate the evaporation and seepage losses in different dams' reservoirs operation policies. In the present study, in order to assess water losses, water supply deficiency and reservoir efficiency indices from 2012 to 2018 were analyzed. First, the operation policy of the Generalized Reduction Gradient (GRG) was formulated, then the mentioned indices for the generalized reduction gradient, the current operation and the proposed rule curve were estimated and compared. The Seep/w numerical model calibrated using vibrating wire piezometers to accurately estimate the seepage value. The results showed that the GRG improved the annual seepage, evaporation and deficiency indices by 67.86%, 54.24% and 67.68%, respectively. Moreover, the improvement of the reliability, reversibility, vulnerability and flexibility indices were 368.95%, 110.26%, 67.68% and 4750.40%, respectively. This policy also improved the annual evaporation deficiency indices by 15.88% and 41.86% respectively, compared to the current operation policy. The improvement of this policy in terms of reliability, reversibility, vulnerability and flexibility indices obtained 25.54%, 30.34%, 41.86% and 125.15%, respectively. Interestingly, this policy had an 18.65% growth in comparison to the current operation policy. Therefore, the GRG optimization policy is optimally effective in improving deficiency, evaporation losses, and reservoir's flexibility indices. This approach is recommended to be used for the assessment of reduction in evaporation and seepage losses and deficiency of water supply and also for the enhancement of reservoir performance for other reservoirs.

**Keywords:** Evaporation, Seepage, Pishin Dam, Generalized Reduced gradient operation policy, Rule curve.

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