Article

Analyzing precipitation predictions in Iran

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Abstract: In this study, critical areas of Iran were determined using 50-year rainfall data and ARIMA model. For this purpose, annual rainfall data of 112 different synoptic stations in Iran were gathered. To summarize, it could be concluded that: ARIMA model was an appropriate tool to forecast annual rainfall. According to obtained results from relative error (RE) between observed and forecasted values, five stations include IRANSHAHR, SIRJAN, NAEIN, ZAHEDAN, and KISH, were in critical condition. Therefore, in these areas due to lack of accurate forecasting, agriculture water management and crop pattern presenting must be done very carefully. As the figure 1 in 65% from forecasted annual rainfalls by ARIMA model amount of relative error was less than 0.1 (10%). These areas were in the safe range. 35% of forecasting had a relative error between 0.1-0.2 (10-20%) and these areas were in the alarm range. Finally only 5% of all ARIMA forecasting occurred in the critical range. This showed a high ability of ARIMA model in annual rainfall forecasting. At 45 stations accrued rainfalls with amounts of less than half of average in the 50-year period. Therefore, in these 45 areas, chance of drought is more than other areas of Iran.

Keywords: Iran; precipitation; water

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1. Introduction

Forecasting of annual rainfall is significantly important in water resources management and crop pattern design. In this study, ARIMA model forecasted annual rainfall in 112 different synoptic stations in Iran and critical areas were determined. After publishing the paper of Box and Jenkins, Box-Jenkins models became one general time series model of hydrological forecasting. These models include Auto Regressive Integrated Moving Average (ARIMA), Auto Regressive Moving Average (ARMA), Auto Regressive (AR), and Moving Average (MA). Access to basic information requires integration from the series (for a continuous series) or calculating all of differences the series (for a continuous series). Since the constant of integration in derivation or differences deleted, the probability of using these amount or middle amount in this process is not possible. Therefore, ARIMA models are non-static and cannot be used to reconstruct the missing data. However, these models are very useful for forecasting changes in a process [1]. Models of time series analysis (Box-Jenkins models) and drought periods study in various fields of hydrology and rainfall forecasting in irrigation schedule are widely applied, which some of them will be described in the following.

Mishra and Singh [2] did a review about drought modeling. Smakhtin and Hughes [3] described a new software package for automated estimation, display, and analyses of various drought indices–continuous functions of precipitation that allow quantitative assessment of meteorological drought events to be made. Yurekli and Kurunc [4] simulated agricultural drought periods based on daily rainfall and crop water consumption. Constituted monthly time series of drought durations of each hydrologic homogeneous section was simulated using ARIMA model. No linear trend was observed for the time series except one section. In general, the predicted data from the selected best models for the time series of each section represented the actual data of that section. Serinaldi and Kilsby [5] presented a modular class of multisite monthly rainfall generators for water resource management and impact studies. The results of the case study point out that the model can capture several characteristics of the rainfall series. In particular, it enables the simulation of low and high rainfall scenarios more extreme than those observed as well as the reproduction of the distribution of the annual accumulated rainfall, and of the relationship between the rainfall and circulation indices such as North Atlantic Oscillation (NAO) and Sea Surface Temperature (SST), thus making the framework well-suited for sensitivity analysis under alternative climate scenarios and additional forcing variables. Luc et al. [6] studied an application of artificial neural networks for rainfall forecasting successfully. Wei et al. [7] using weather satellite imagery forecasted rainfall in Taiwan. Andrieu et al. [8] studied Adaptation and application of a quantitative rainfall forecasting model in a mountainous region. This work shows that a limit on forecast lead-time may be related to the response time of the precipitating cloud system. Burlando et al. [9] using ARMA models forecasted short-term rainfall. Hourly rainfall from two gaging stations in Colorado, USA, and from several stations in Central Italy been used. Results showed that the event-based estimation approach yields better forecasts. Hu et al. (2006) studied rainfall, mosquito density and the transmission of Ross River virus using a time-series forecasting model. Their results showed that both rainfall and mosquito density were strong predictors of the Ross River virus transmission in simple models. Ramírez et al. (2005) used artificial neural network technique for rainfall forecasting applied to the São Paulo region. The results showed that ANN forecasts were superior to the ones obtained by the linear regression model thus revealing a great potential for an operational suite. Han et al. [10] forecasted drought based on the remote sensing data using ARIMA model successfully. Chattopadhyay and Chattopadhyay [11] compared ARIMA and ARNN models using Univariate modelling of summer-monsoon rainfall time series. Anctil et al. [12] survived impact of the length of observed records on the performance of ANN and of conceptual parsimonious rainfall-runoff forecasting models. The results showed that best performance about evenly for 3- and 5-year training sets, but multiple-layer perceptrons (MLPs) did better whenever the training set was dominated by wet weather. The MLPs continued to improve for input vectors of 9 years and more, which was not the case of the conceptual model. Jia and Culver [13] using bootstrapped artificial neural networks suggested that even a small set of periodic instantaneous observations of stage from a staff gauge, which can easily be collected by volunteers, can be a useful data set for effective hydrological modeling. M. Baareh et al. [14] used the artificial neural network and Auto-Regression (AR) models to the river flow forecasting problem. A comparative study of both ANN and the AR conventional model networks indicated that the artificial neural networks performed better than the AR model. They showed that ANN models can be used to train and forecast the daily flows of the Black Water River near Dendron in Virginia and the Gila River near Clifton in Arizona. Xiong and M. O'connor [15] used four different error-forecast updating models, autoregressive (AR), autoregressive-threshold (AR-TS), fuzzy autoregressive-threshold (FU-AR-TS), and artificial neural network (ANN) to the real-time river flow forecasting. They found that all of these four updating models are very successful in improving the flow forecast accuracy. Chenoweth et al. [16] estimated the ARMA model parameters using neural networks. Their results showed that the ability of neural networks to accurately identify the order of an ARMA model was much lower than reported by previous researchers, and is especially low for time series with fewer than 100 observations. Using forecasting of hydrologic time series with ridge regression in feature space, Yu and Liong [17] showed that the training speed in data mining method was very much faster than ARIMA model. See and Abrahart [18] used of data fusion for hydrological forecasting. Their results showed that using of data fusion methodologies for ANN, fuzzy logic, and ARMA models accuracy of forecasting would increase. Using hybrid approaches, Srinivas and Srinivasan [19] improved the accuracy of AR model parameters for annual streamflows. Using the Fourier coefficients, Ludlow and Enders [20] estimated the ARMA model parameters with a relatively good accuracy. Chenoweth et al. [21] estimated the ARMA model parameters using the Hilbert coefficients. Their results showed that the Hilbert coefficients are considered a useful tool for estimating ARMA model parameters. Balaguer et al. [22] used the method of time delay neural network (TDNN) and ARMA model to forecast asking for help in support centers for crisis management. The obtained correlation results for TDNN model and ARMA were 0.88 and 0.97, respectively. This study confirmed the superiority of ARMA model to the TDNN. Toth et al. [23] used the artificial neural network and ARMA models to forecast rainfall. The results show the success of both short-term rainfall-forecasting models for forecast floods in real time. Mohammadi et al. [24] forecast Karaj reservoir inflow using data of melting snow and artificial neural network and ARMA methods, and regression analysis. 60% of inflow in dam happens between Aprils until June, so forecasting the inflow in this season is very important for dam's performance. The highest inflows were in the spring due to the snow melt caused by draining in threshold winter. The results showed that artificial neural network has lower significant errors as compared with other methods. Mohammadi et al. [25] in other research estimated parameters of an ARMA model for river flow forecasting using goal programming. Their results showed that the goal programming is a precise and effective method for estimating ARMA model parameters for forecasting inflow. Valipour et al. [26] estimated parameters of ARMA and ARIMA models and compare their ability for inflow forecasting. By comparing root mean square error of the model, it was determined that ARIMA model can forecast inflow to the Dez reservoir from 12 months ago with lower error than the ARMA model. Valipour [27] studied number of required observation data for rainfall forecasting according to the climate conditions. By comparing R2 of the models, it was determined that time series models were better appropriate to rainfall forecasting in semi-arid climate. Numbers of required observation data for forecasting of one next year were 60 rainfall data in semi-arid climate.

Therefore, considering the above mentioned performed researches, we can know the efficacy of ARIMA model in forecasting field and hydrologic sampling. Effect of annual rainfall forecasting has not been done in previous researches for agriculture water management and critical areas determining. This study aims to forecast annual rainfall using ARIMA model and determine areas that chance of drought in those is more than other areas of Iran.

2. Materials and Methods

In this study to forecasting of annual rainfall used from 112 synoptic stations data in Iran. In order to rainfall forecasting at the annual scale, rainfall data period from 1951-2000 has been gathered. Actually, the used data involved 5600 data (all stations). In this study, ARIMA model were used for forecast annual rainfall. In each station 250 structure of ARIMA model were used. For this purpose used MINITAB software to run of all ARIMA structures. In this research used from 49 years data (1951-1999) for calibration of ARIMA model and forecasted amount of annual rainfall for year 2000. Finally, by two methods critical areas of Iran for water management were specified and used relative error to compare stations. In first method, areas that amount of their relative error were more than 20% were introduced as critical areas. In second method, areas that amount of their rainfall in some years were less than half of average rainfalls in 50 years periods were specified as areas that chance of drought in these were more that other areas.

3. Results and Discussion

Tables 1 to 5 shows obtained relative error for 112 different stations with stations information and best structures of ARIMA models. Figure 1 represents ability of ARIMA model in annual rainfall forecasting. Figures 2 and 3 shows critical areas of Iran for agriculture water management according to first and second methods, respectively.

After running 28000 ARIMA structures for all stations, according to obtained results from relative error in tables 1 to 5, five stations include IRANSHAHR, SIRJAN, NAEIN, ZAHEDAN, and KISH, were in critical condition. In these areas due to very low rainfalls in 2000, ARIMA model do not give a good forecasting and relative error was more than 20%. Therefore, in these areas due to lack of accurate forecasting, agriculture water management and crop pattern presenting must be done very carefully. As the figure 1 in 65% from forecasted annual rainfalls by ARIMA model amount of relative error was less than 0.1 (10%). These areas were in the safe range. 35% of forecasting had a relative error between 0.1-0.2 (10-20%) and these areas were in the alarm range. Finally only 5% of all ARIMA forecasting occurred in the critical range. This showed a high ability of ARIMA model in annual rainfall forecasting.

In addition five areas marked in the first method, can be determined 45 areas as critical areas of Iran due to occurred amount of their rainfall in some years were less than half of average rainfalls in 50 years periods. In these areas because observed very low rainfall in some cases, drought in the coming years is not unexpected. Thus, how agriculture water management should be performed with high accuracy and proposed crop pattern to be applied with adequate safety factors else there is the possibility of being trapped in periods of drought. To support of sustainable agriculture and management of required water can be prevented from future damage.

Table 1: Obtained relative error for 112 different stations with stations information and best structures of ARIMA models (0-3%)

Station	Code	Altitude	Longitude	Elevation (m)	Actual rainfall (mm/year)	Forecasted rainfall (mm/year)	Relative error (%)	Best model
MESHKINSHAR	40705	38 23 N	47 40 E	1568.5	289.4	289.0	0.1	ARIMA(1,0,0)
BABOLSAR	40736	36 43 N	52 39 E	-21.0	968.4	964.5	0.4	ARIMA(5,1,3)
RAMHORMOZ	40813	31 16 N	49 36 E	150.5	292.8	291.4	0.5	ARIMA(4,1,0)
TORBATE JAM	40806	35 15 N	60 35 E	950.4	111.6	111.0	0.6	ARIMA(1,3,0)
ABADAN	40831	30 22 N	48 15 E	6.6	155.5	156.7	0.8	ARIMA(5,1,0)
MAKOO	40701	39 20 N	44 26 E	1411.3	185.7	184.2	0.8	ARIMA(0,0,2)
SHOSHTAR	99446	32 3 N	48 50 E	67.0	296.3	298.7	0.8	ARIMA(1,1,0)
ZANJAN	40729	36 41 N	48 29 E	1663.0	309.7	312.7	1.0	ARIMA(5,1,0)
NOUSHAHR	40734	36 39 N	51 30 E	-20.9	1227.2	1239.4	1.0	ARIMA(1,1,0)
ARDESTAN	40799	33 23 N	52 23 E	1252.4	129.2	130.5	1.0	ARIMA(5,1,1)
ALIGOODARZ	40783	33 24 N	49 41 E	2034.0	415.1	409.1	1.4	ARIMA(1,1,3)
KANGAVAR	40771	34 30 N	48 0 E	1460.0	346.8	352.0	1.5	ARIMA(1,1,0)
SHIRAZ	40848	29 36 N	52 32 E	1488.0	358.0	351.7	1.8	ARIMA(4,1,0)
KARAJ	40752	35 55 N	50 54 E	1312.5	240.0	244.3	1.8	ARIMA(1,1,0)
ARAK	40769	34 6 N	49 46 E	1708.0	343.7	337.5	1.8	ARIMA(5,1,0)
BOJNURD	4	37	57		309.1	301.6	2.4	ARIMA(

	0723	28 N	19 E	1091.0				3,3,4)
KHOY	4 0703	38 33 N	44 58 E	1103.0	207.1	212.2	2.5	ARIMA(4,1,0)
YASOUJ	4 0836	30 40 N	51 35 E	1837.0	619.5	635.2	2.5	ARIMA(0,0,2)
YAZD	4 0821	31 54 N	54 24 E	1230.2	44.9	46.1	2.6	ARIMA(1,1,0)
OROOMIEH	4 0712	37 32 N	45 5 E	1313.0	230.6	236.7	2.6	ARIMA(5,1,1)
KERMAN	4 0841	30 15 N	56 58 E	1753.8	86.9	89.2	2.6	ARIMA(0,0,1)
ILAM	4 0780	33 38 N	46 25 E	1363.4	504.0	489.3	2.9	ARIMA(5,1,2)
BOROOJEN	9 9459	31 57 N	51 18 E	2197.0	175.1	180.4	3.0	ARIMA(5,1,0)

Table 2: Obtained relative error for 112 different stations with stations information and best structures of ARIMA models (3.1-5.5%)

Station	Code	Altitude	Longitude	Elevation (m)	Actual rainfall (mm/year)	Forecasted rainfall (mm/year)	Relative error (%)	Best model
GORGAN	4 0738	36 51 N	54 16 E	13.3	579.0	561.0	3.1	ARIMA(1,1,0)
AHWAZ	4 0811	31 20 N	48 40 E	22.5	234.8	227.4	3.1	ARIMA(1,0,1)
SARDASHT	4 0725	36 9 N	45 30 E	1670.0	689.1	712.0	3.3	ARIMA(1,1,0)
KHORRAMABAD	4 0782	33 29 N	48 22 E	1125.0	423.8	438.6	3.5	ARIMA(5,1,2)
SARAKHS	4 0741	36 32 N	61 10 E	235.0	99.3	95.8	3.6	ARIMA(5,3,2)
TABRIZ	4 0706	38 5 N	46 17 E	1361.0	205.0	197.6	3.6	ARIMA(5,1,0)
KHALKHAL	4 0717	37 38 N	48 31 E	1796.0	340.7	353.1	3.6	ARIMA(5,1,1)
GHOOCHAN	4 0740	37 4 N	58 30 E	1287.0	271.5	281.4	3.6	ARIMA(4,1,0)

BANDAR ANZALI	4 0718	37 28 N	49 28 E	-26.2	2009.8	1934.1	3.8	ARIMA(5,1,4)
BIJAR	4 0748	35 53 N	47 37 E	1883.4	309.4	321.3	3.9	ARIMA(5,1,4)
ABADEH	4 0818	31 11 N	52 40 E	2030.0	95.1	99.2	4.3	ARIMA(5,1,1)
MALAYER	4 0775	34 17 N	48 49 E	1725.0	327.4	313.4	4.3	ARIMA(4,1,0)
SAVEH	9 9372	35 3 N	50 20 E	1108.0	239.2	228.4	4.5	ARIMA(1,2,0)
KERMANSHAH	4 0766	34 17 N	47 7 E	1322.0	352.4	335.8	4.7	ARIMA(1,1,0)
SHAHROUD	4 0739	36 25 N	54 57 E	1345.3	166.9	158.9	4.8	ARIMA(1,1,0)
MASJED SOLEYMAN	4 0812	31 56 N	49 17 E	320.5	372.2	390.4	4.9	ARIMA(1,1,0)
ESLAMABAD GHARB	4 0779	34 8 N	46 26 E	1346.0	354.4	336.3	5.1	ARIMA(4,1,2)
SABZEVAR	4 0743	36 12 N	57 43 E	977.6	147.4	155.2	5.3	ARIMA(3,1,3)
SEMNAN	4 0757	35 33 N	53 23 E	1171.0	140.5	148.0	5.4	ARIMA(1,1,0)
GHAZVIN	4 0731	36 15 N	50 0 E	1278.3	311.0	294.2	5.4	ARIMA(1,1,0)
GHORVEH	4 0772	35 10 N	47 48 E	1906.0	317.3	334.6	5.5	ARIMA(1,1,0)
SANANDAJ	4 0747	35 20 N	47 0 E	1373.4	329.5	311.5	5.5	ARIMA(1,1,0)

Table 3: Obtained relative error for 112 different stations with stations information and best structures of ARIMA models (5.6-9.1%)

Station	Code	Altitude	Longitude	Elevation (m)	Actual rainfall (mm/year)	Forecasted rainfall (mm/year)	Relative error (%)	Best model
ABALI	4	35	51		440.9	416.1	5.6	ARIMA

	0755	45 N	53 E	2465.2				(0,0,2)
DOGONBADAN	4 0835	30 26 N	50 46 E	699.5	336.5	316.5	5.9	ARIMA (1,3,0)
KASHMAR	4 0763	35 12 N	58 28 E	1109.7	145.7	154.4	5.9	ARIMA (5,1,0)
TEHRAN	4 0754	35 41 N	51 19 E	1190.8	195.6	183.9	6.0	ARIMA (5,1,1)
KHORRAMDAREH	4 0730	36 11 N	49 11 E	1575.0	247.9	262.8	6.0	ARIMA 4,1,0)
MARIVAN	4 0750	35 31 N	46 12 E	1287.0	741.5	694.3	6.4	ARIMA (1,1,0)
GARMSAR	4 0758	35 12 N	52 16 E	825.2	115.1	122.8	6.7	ARIMA (1,1,0)
NEYSHABOOR	4 0746	36 16 N	58 48 E	1213.0	15.8	16.9	6.7	ARIMA (1,1,0)
IZEH	9 9455	31 51 N	49 52 E	767.0	600.6	641.5	6.8	ARIMA (5,1,0)
KASHAN	4 0785	33 59 N	51 27 E	982.3	136.9	146.5	7.0	ARIMA (4,1,0)
SHAHRE KORD	4 0798	32 20 N	50 51 E	2061.4	242.6	260.0	7.2	ARIMA (1,1,0)
NATANZ	9 9421	33 32 N	51 54 E	1684.9	194.1	208.5	7.4	ARIMA (1,1,0)
BEHBAHAN	4 0834	30 36 N	50 14 E	313.0	188.1	202.2	7.5	ARIMA (0,0,1)
BAFGH	4 0820	31 36 N	55 26 E	991.4	32.2	34.7	7.6	ARIMA (3,1,0)
MARAGHEH	4 0713	37 24 N	46 16 E	1477.7	175.5	189.0	7.7	ARIMA (1,1,0)
MANJIL	4 0720	36 44 N	49 24 E	333.0	196.9	212.1	7.7	ARIMA (1,3,0)
TAKAB	4 0728	36 23 N	47 7 E	1765.0	296.5	272.8	8.0	ARIMA (3,1,2)

GHAEN	40793	33 43 N	59 10 E	1432.0	124.3	134.4	8.1	ARIMA (0,0,1)
BIRJAND	40809	32 52 N	59 12 E	1491.0	94.1	86.4	8.2	ARIMA (0,0,2)
FASSA	40859	28 58 N	53 41 E	1288.3	243.7	264.3	8.5	ARIMA (1,1,0)
KAHNOUJ	40877	27 58 N	57 42 E	469.7	241.3	262.8	8.9	ARIMA (1,5,0)
BUSHEHR	40858	28 59 N	50 50 E	19.6	263.3	287.2	9.1	ARIMA (1,0,1)
GONBADE GHABOOS	99240	37 15 N	55 10 E	37.2	514.7	467.7	9.1	ARIMA (1,1,0)

Table 4: Obtained relative error for 112 different stations with stations information and best structures of ARIMA models (9.2-13%)

Station	Code	Altitude	Longitude	Elevation (m)	Actual rainfall (mm/year)	Forecasted rainfall (mm/year)	Relative error (%)	Best model
TABASS	40791	33 36 N	56 55 E	711.0	61.2	66.9	9.2	ARIMA(1,0,0)
BANDAR DAIER	40872	27 50 N	51 56 E	4.0	203.7	183.8	9.8	ARIMA(1,1,0)
JOLFA	40702	38 45 N	45 40 E	736.2	129.2	141.8	9.8	ARIMA(0,0,1)
ZABOL	40829	31 2 N	61 29 E	489.2	26.8	29.4	9.9	ARIMA(0,0,1)
SARAB	40710	37 56 N	47 32 E	1682.0	200.8	220.8	9.9	ARIMA(1,1,0)
GONABAD	40778	34 21 N	58 41 E	1056.0	99.3	89.2	10.1	ARIMA(5,1,0)
MASHHAD	40745	36 16 N	59 38 E	999.2	168.9	151.6	10.3	ARIMA(0,0,3)
FERDOUS	40792	34 1 N	58 10 E	1293.0	101.0	90.4	10.5	ARIMA(5,0,4)
GHOM	40770	34 42 N	50 51 E	877.4	175.1	156.1	10.9	ARIMA(1,0,0)
BOSTAN	4	31	48 0	7.8	206.2	228.9	11.0	ARIMA(

	0810	43 N	E					3,1,1)
MIANEH	4 0716	37 27 N	47 42 E	1110.0	274.6	243.6	11.3	ARIMA(1,1,0)
MAHABAD	4 0726	36 46 N	45 43 E	1385.0	313.3	277.5	11.4	ARIMA(4,1,0)
CHAHBAHAR	4 0898	25 17 N	60 37 E	8.0	44.4	49.6	11.7	ARIMA(2,0,0)
ESFAHAN	4 0800	32 37 N	51 40 E	1550.4	88.1	77.8	11.7	ARIMA(0,0,2)
BANDAR MAHSHAHR	4 0832	30 33 N	49 9 E	6.2	146.2	128.9	11.8	ARIMA(0,0,2)
SAR POL ZOHAB	4 0765	34 27 N	45 52 E	545.0	379.5	333.6	12.1	ARIMA(1,1,0)
BAM	4 0854	29 6 N	58 21 E	1066.9	47.7	53.5	12.1	ARIMA(5,1,1)
GOLPAIGAN	9 9417	33 28 N	50 17 E	1870.0	184.1	206.9	12.4	ARIMA(1,0,0)
MINAB	4 0876	27 7 N	57 6 E	27.0	199.0	224.0	12.6	ARIMA(1,2,0)
JASK	4 0893	25 38 N	57 46 E	4.8	16.4	18.5	12.7	ARIMA(1,3,2)
PIRANSHAHR	4 0724	36 40 N	45 8 E	1455.0	577.2	503.4	12.8	ARIMA(3,0,3)
ARDEBIL	4 0708	38 15 N	48 17 E	1332.0	302.8	264.0	12.8	ARIMA(4,1,1)

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١٦١ Table 5: Obtained relative error for 112 different stations with stations information and best structures of ARIMA models (>13%)

Station	C ode	Alt itude	Long itude	Eleva tion (m)	Actual rainfall (mm/year)	Forecasted rainfall (mm/year)	Relative error (%)	Best model
RAVANSAR	4 0764	34 43 N	46 40 E	1362.7	399.4	451.6	13.1	ARIMA (5,1,0)
DEHLORAN	4 0796	32 41 N	47 16 E	232.0	205.5	232.7	13.2	ARIMA (1,0,0)
LAR	4	27	54		102.1	116.4	14.0	ARIMA

	0873	41 N	17 E	792.0				(1,0,0)
	4	31	50					ARIMA
LORDEGAN	0814	31 N	49 E	1580.0	466.4	533.9	14.5	(3,1,0)
	4	28	61					ARIMA
KHASH	0870	13 N	12 E	1394.0	40.0	45.8	14.5	(5,1,0)
	4	36	50					ARIMA
RAMSAR	0732	54 N	40 E	-20.0	802.8	920.0	14.6	(1,1,0)
BANDAR	4	27	56					ARIMA
ABASS	0875	13 N	22 E	10.0	213.6	245.3	14.8	(5,1,0)
	4	32	50 7					ARIMA
KOOHRANG	0797	26 N	E	2285.0	1077.9	1238.5	14.9	(1,3,0)
	4	34	48					ARIMA
HAMEDAN	0768	51 N	32 E	1749.0	318.9	271.4	14.9	(1,1,0)
	4	32	48					ARIMA
DEZFUL	0795	24 N	23 E	143.0	429.7	494.9	15.2	(4,1,0)
	9	30	55					ARIMA
RAFSANJAN	9502	25 N	54 E	1580.9	52.5	44.5	15.2	(3,1,0)
	4	37	49					ARIMA
RASHT	0719	12 N	39 E	36.7	1438.3	1211.7	15.8	(2,1,0)
	4	31	51					ARIMA
SHAHREZA	0815	59 N	50 E	1845.2	98.2	115.3	17.4	(2,1,0)
TORBATE	4	35	59					ARIMA
HEYDARIEH	0762	16 N	13 E	1450.8	220.2	259.3	17.8	(2,5,3)
BANDAR	4	26	54					ARIMA
LENGEH	0883	35 N	50 E	14.2	132.1	157.0	18.9	(1,1,0)
	4	38	47 4					ARIMA
AHAR	0704	26 N	E	1390.5	243.5	289.6	18.9	(5,1,0)
	4	25	54					ARIMA
ABOMOOSA	0890	50 N	50 E	6.6	52.2	62.6	19.8	(5,1,0)
	4	26	53					ARIMA
KISH	0882	30 N	59 E	30.0	113.3	136.7	20.7	(1,0,0)
	4	29	60					ARIMA
ZAHEDAN	0856	28 N	53 E	1370.0	40.7	49.9	22.6	(0,0,2)
NAEIN	4	32	53 5		66.2	91.6	38.3	ARIMA

	0801	51 N	E	1549.0				(5,1,0)
	4	29	55					ARIMA
SIRJAN	0851	28 N	41 E	1739.4	66.7	98.9	48.2	(3,1,3)
	4	27	60					ARIMA
IRANSHAHR	0879	12 N	42 E	591.1	20.0	33.3	66.4	(0,0,3)

Figure 1: 1: Ability of ARIMA model in rainfall forecasting according to the relative error

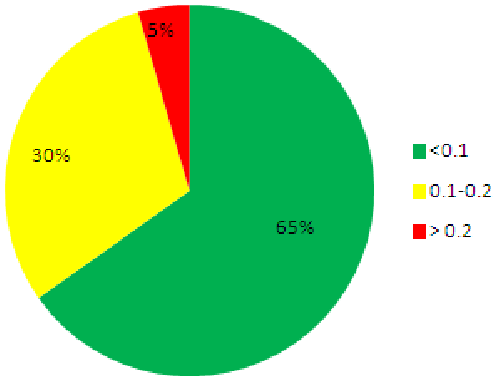


Figure 2: Critical areas of Iran for agriculture water management according to first method

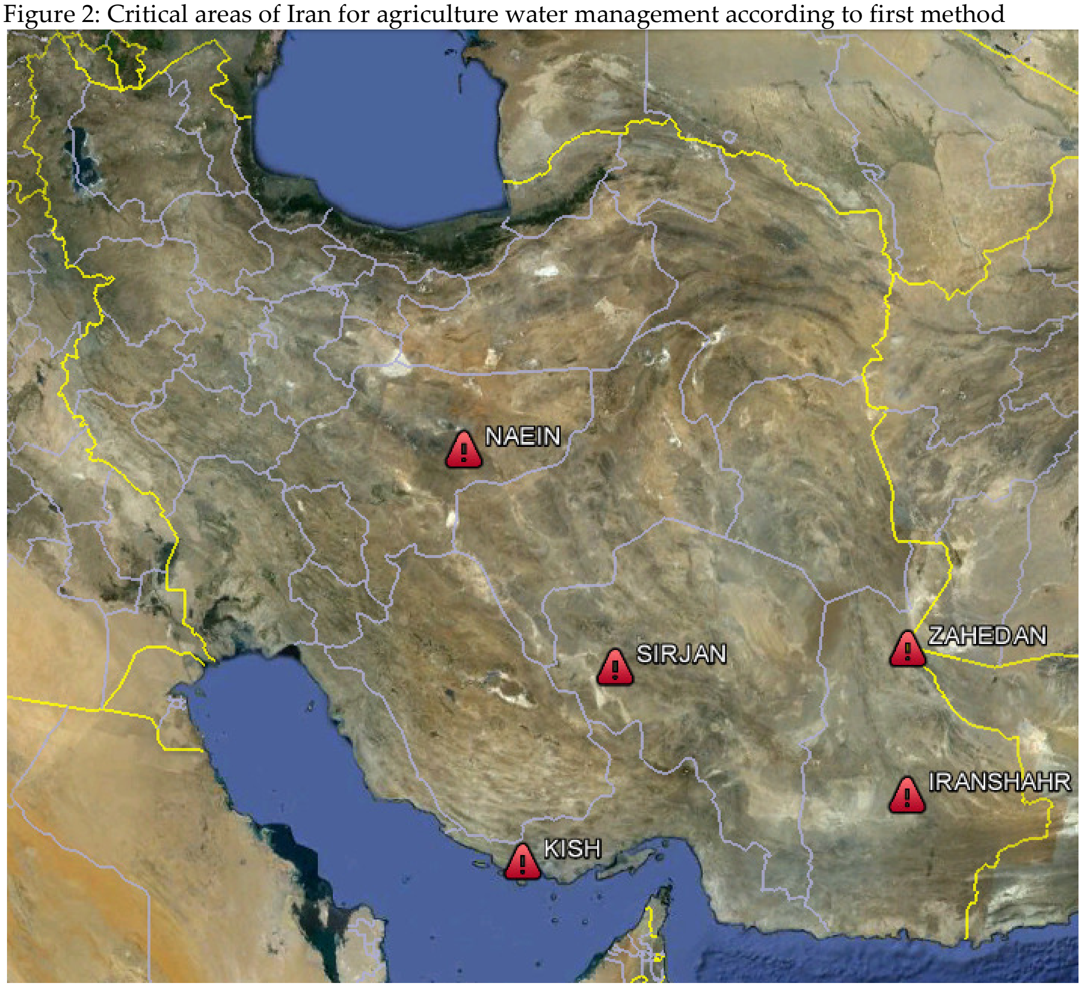
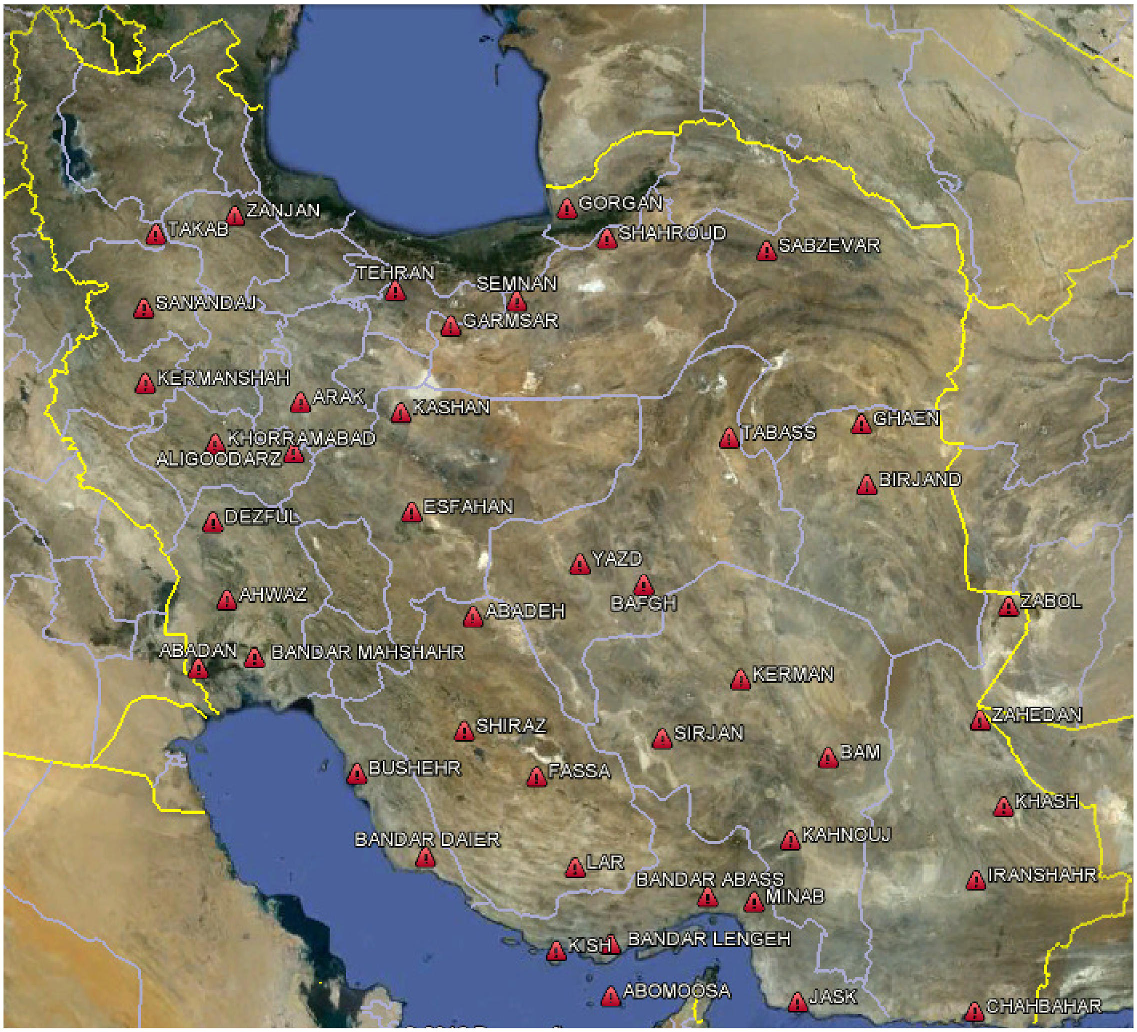


Figure 3: Critical areas of Iran for agriculture water management according to second method



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