MAPPING FLASH FLOODS IN IRAQ BY USING GIS

ALI RAHEEM AL-NASSAR[1], HUSSAIN KADHIM[2]

1DEPARTMENT OF ATMOSPHERIC SCIENCES, COLLEGE OF SCIENCE, MUSTANSIRIYAH UNIVERSITY, BAGHDAD, IRAQ; ALIRAHEEM@UOMUSTANSIRIYAH.EDU.IQ

2MINISTRY OF TRANSPORTATION GENERAL COMPANY FOR PORTS OF IRAQ, IRAQ; HUSSAINKADHIM86@GMAIL.COM

Outline

1.Introduction

Over the past five decades, economic losses related to hydro-meteorological hazards have increased, but the human toll has fallen dramatically. This is thanks to scientific advances in forecasting
Over the last three decades, many world regions have suffered from water crises and drought .The Middle East and Northern Africa region can be considered as the most water-scarce region of the world ,These countries, including Iraq, Turkey, Iran and Syria .

The complete understanding of the range and rainfall amounts received in a certain location, can provide the designers, planners and decision makers useful guides prepare for and deal with the consequences of precipitation anomalies

Iraq is located between latitude (29.5°- 37.22°N) and longitude (38.45°- 48.45°E).

Rainfall in Iraq is characterized by an unorganized distribution of both spatial and temporal. The annual, seasonal and monthly mean rainfall varies considerably with years. The rainfall year in Iraq is from 1 October to 31 May.

This study aims to investigate flash floods in Iraq by plotting the cartographic maps by using synoptic and dynamical analysis of meteorological reanalysis data.

2. Data and methodology

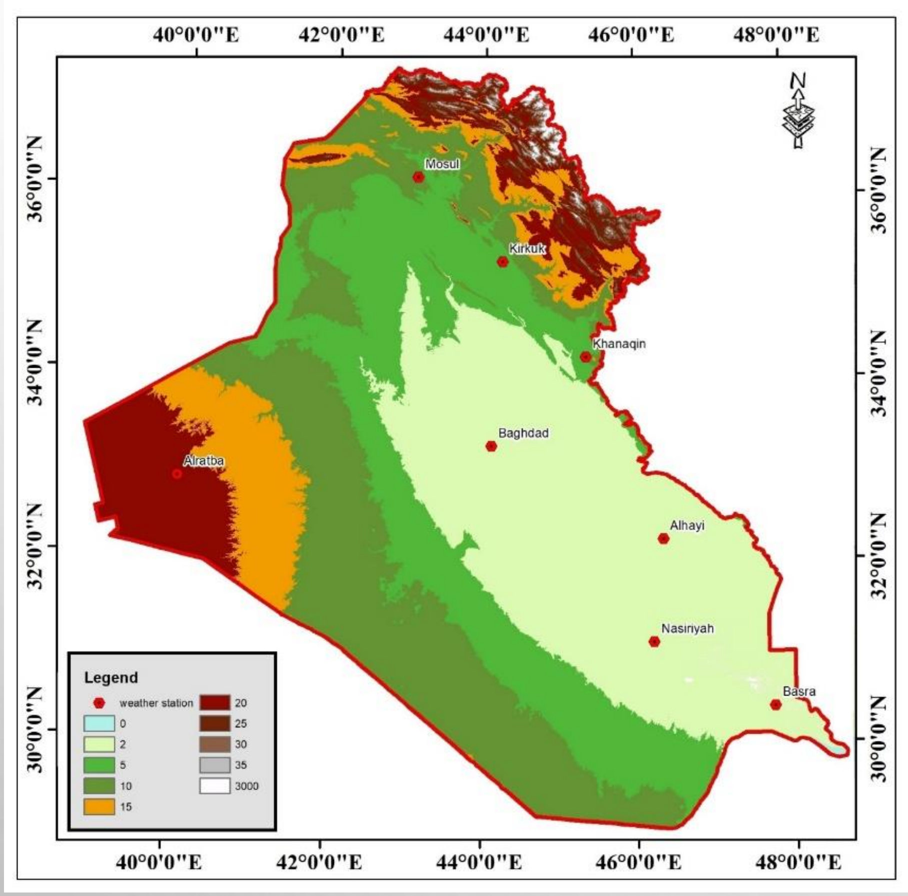


Figure 1, Physical map of Iraq according to topography and its location. It shows the location of meteorological stations that used in this study

Table 1. Meteorological Stations in Iraq

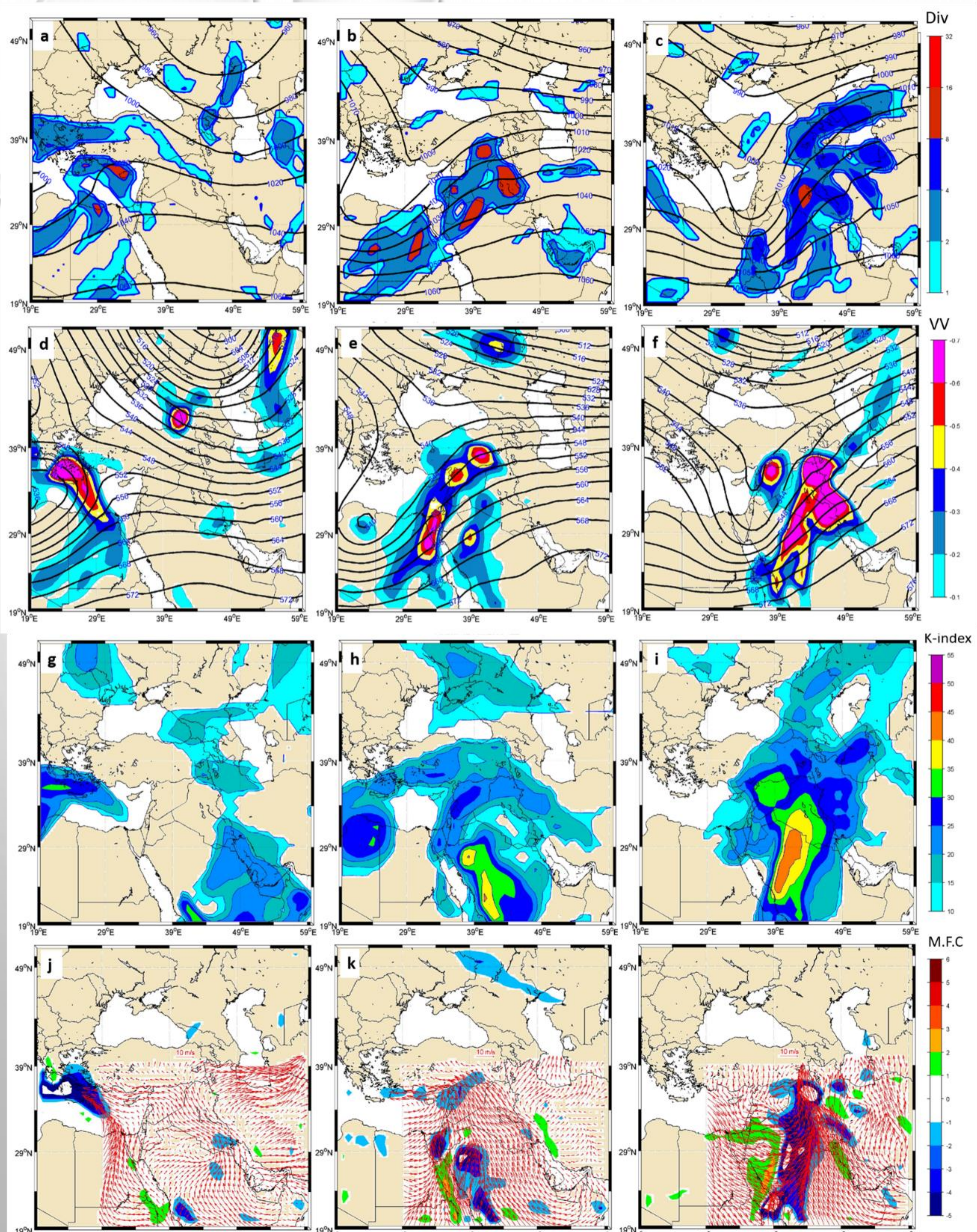
	stations	longitude	Latitude	Elevation (m)
1	Mosul	43.09°	36.19°	223
2	Kirkuk	44.24°	35.28°	331
3	Khanaqin	45.39°	34.35°	185
4	Baghdad	44.24°	33.18°	34
5	Rutba	40.17°	33.02°	615
6	Hai	46.14°	32.08°	15
7	Nasiriya	46.14°	31.01°	3
8	Basrah	47.47°	30.31°	2.40

3.Results and discussion

https://www.alhurra.com/

https://ar.nasiriyah.org/post/11465

https://www.alsumaria.tv/



3. Results and discussion

3.1 Synoptic and dynamic analysis of the heavy rain that fell in Basra Station on January 24, 2017.

3.2: Flash flood modeling

3.2.1: The first model:

Table 2: The highest rainfall for selected stations (2017-2007)

stations	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Average
Mosul	48.3	52.7	27.3	46.6	52.1	62.4	75.3	66.3	64.7	44.7	27.1	51.59
Kirkuk	60.6	24.7	41.2	52.3	44.7	44.4	117.2	45.3	58.9	72.4	25.2	53.35
Khanaqin	—	—	—	—	—	29.5	58.7	37.5	3.3	1.5	4.4	22.48
Baghdad	24.6	14.5	15.1	17.4	29.1	67.5	89.9	17.8	84.9	29.6	23.9	36.25
Rutba	19.9	17.3	7	41	47.2	22.5	40.6	24.1	13	8	8	22.6
Hai	13.70	21.8	23.101	20.2	30.80	23.7	32	33.80	60.3	43.60	18	29.18
Nasiriya	75.8	20.4	18.5	14.7	11.6	40.3	68.4	60.7	22.8	20.5	4.8	32.59
Basrah	40.3	18	27.8	7.7	12.2	26.2	29.6	58.5	41.6	25.6	54.3	31.07

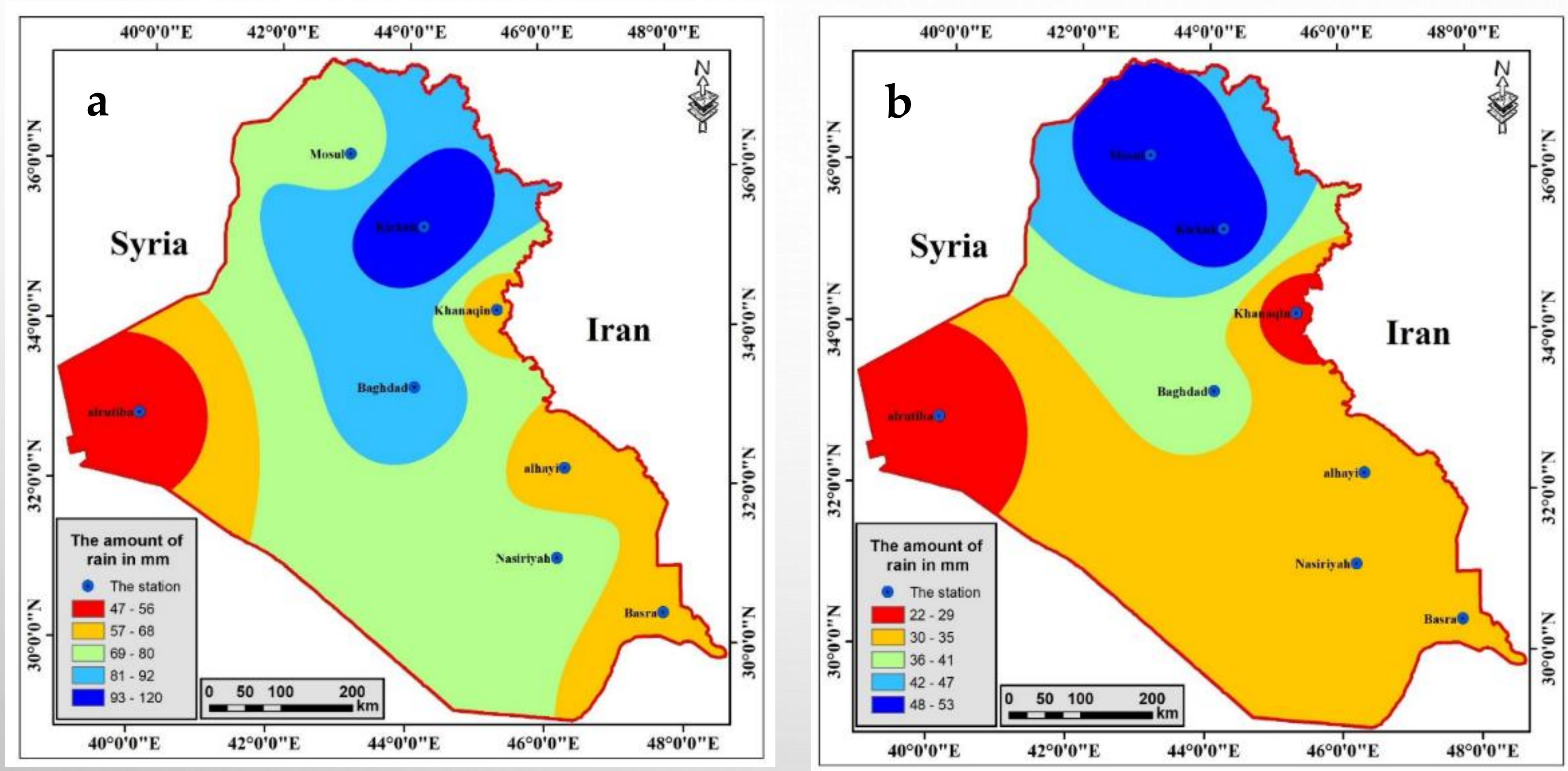


Figure 3. (a)The highest rainfall that fell during single rainstorm.
(b) The average of the highest rainfall that fell during single rainstorm.

3.2.2: The second model

Table 3 average with the highest number of rainy days and rainfall records and the correlation coefficient between the rainy days and the rainfall amounts.

stations		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Avg.	r*
Mosul	Days	5	6	4	7	7	6	6	9	4	6	5	5.91	0.37
	rain(mm	48.3	32.9	48	35.302	52.10	10	33.1	66.3	38	44.7	27.1	39.62	
Kirkuk	Days	5	6	5	5	7	4	7	9	6	6	5	5.91	0.27
	rain(mm)	60.6	24.3	14.6	47	32.9	24.6	117.2	38.6	40.8	10.1	25.2	39.63	
Khanaqin	Days	——	——	——	——	——	6	5	8	4	2	3	4.67	0.15
	rain(mm)	——	——	——	——	——	4.3	58.7	7.2	1	1.5	4.4	12.85	
Baghdad	Days	4	3	4	4	5	3	6	7	5	6	4	4.64	0.07
	rain(mm)	6.7	3	11	13.6	6.1	35	16.1	16.7	84.9	10.9	9.7	19.43	
Rutba	Days	2	3	2	4	5	6	4	3	3	2	3	3.36	0.41
	rain(mm)	19.9	15.8	0.01	11.8	6.3	22.5	21	7	6.2	8	0.6	10.83	
Hai	Days	4	3	3	2	3	4	7	8	5	4	3	4.18	0.46
	rain(mm)	13.7	20	23.1	10.4	1.4	8.8	17.8	33.8	22.9	43.6	1.9	17.95	
Nasiriya	Days	4	2	4	3	3	3	6	5	4	5	3	3.82	0.34
	rain(mm)	75.8	20.4	1.5	2.4	9.5	40.3	45.9	60.7	4.5	2.6	4.8	24.4	
Basrah	Days	3	2	2	3	3	3	6	2	3	2	4	3	0.46
	rain(mm)	40.3	15.7	27.8	6.4	4.3	13.8	6.1	58.5	16.8	25.6	21.4	21.52	

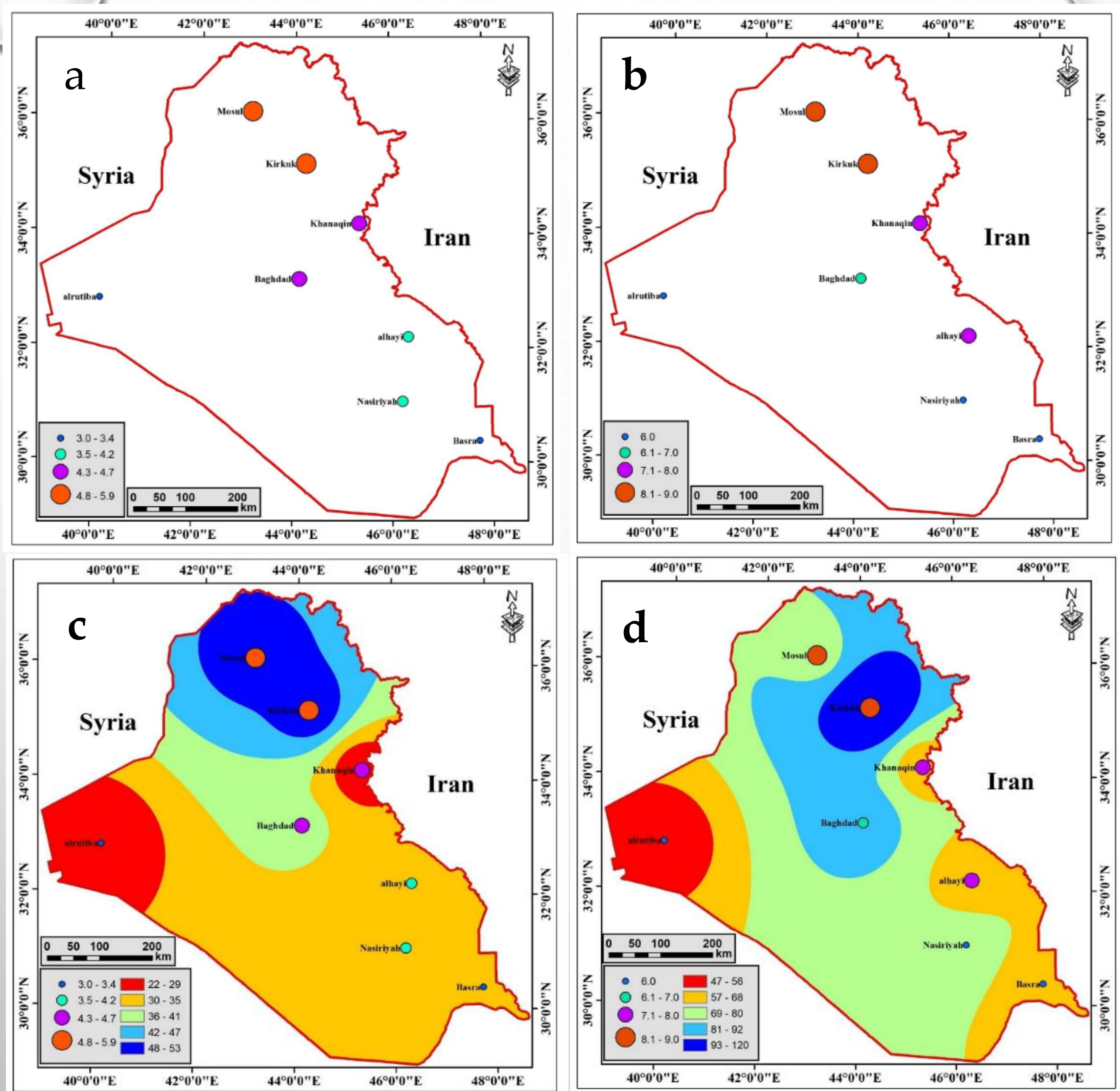


Figure 4.

(a)The average of the highest number of rainy days. (b) The highest number of rainy days. (c) The average of the highest number of rainy days with rain. (d) The highest number of rainy days with rain.

3.2.3: The third model

Table 4. The average with highest frequency of rainstorms and their amounts in the selected stations (2007-2017) and the correlation coefficient between the highest frequency of rainstorms and their amounts:

stations		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Avg.	r*
Mosul	Frequency	9	5	8	6	6	8	6	7	7	6	6	6.73	-0.12
	Rain(mm)	26.2	0.804	28.10	56.003	118.80	50.8	35.9	53.9	22.804	42.201	50.1	44.15	
Kirkuk	Frequency	5	5	6	6	5	7	6	7	6	6	8	6.09	0.51
	Rain(mm)	34.3	49.001	54.50	29.20	71.80	52.4	40.30	80.20	37.4	88.7	95.1	57.54	
Khanaqin	Frequency	—	—	—	—	—	4	6	7	5	4	3	4.83	0.24
	Rain(mm)	—	—	—	—	—	35.1	21	15.5	6.4	3.4	2.3	13.95	
Baghdad	Frequency	4	5	7	5	5	5	6	5	5	5	7	5.36	0.02
	Rain(mm)	32.2	23.703	11.40	5.50	25.10	83.20	70.80	35.80	28.20	30.30	42.00	35.29	
Rutba	Frequency	5	3	5	4	6	6	7	5	5	3	5	4.91	0.12
	Rain(mm)	16.3	10.5	0.70	24.50	20.80	0.20	13.91	36.50	13.60	0.001	11.00	13.46	
Hai	Frequency	5	5	5	6	5	6	6	5	5	5	6	5.36	0.01
	Rain(mm)	3.304	45.304	6.40	26.20	50.10	32.1	51.50	46.90	56.90	35.20	31.2	35.01	
Nasiriya	Frequency	5	3	4	5	6	5	6	5	6	5	8	5.27	0.15
	Rain(mm)	9.202	1.401	7.10	29.20	19.90	19.30	7.80	83.05	36.10	11.6	19	22.15	
Basrah	Frequency	5	4	6	6	5	5	3	3	5	3	6	4.64	-0.06
	Rain(mm)	46.703	31.6	39.60	17.50	22.4	28.90	40.20	60	43.80	26.1	64.10	38.27	

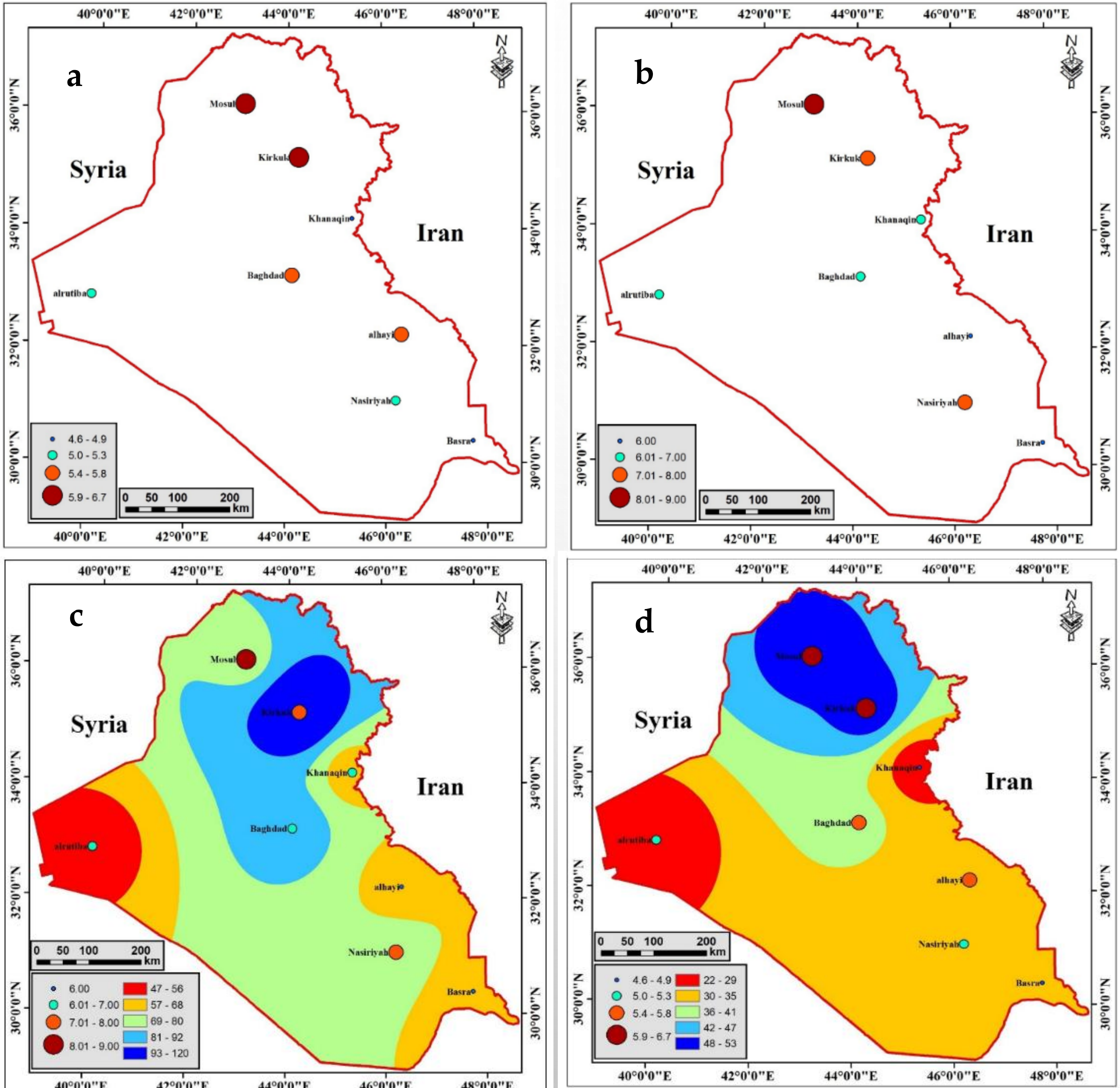


Figure 5.
(a)The average of the highest frequency of rainstorms per month.

(b) The highest frequency of rainstorms per month.

(c) The average of the highest frequency of rainstorms per month with rain.

(d) The highest frequency of rainstorms per month with rain.

3.2.4: The Fourth Model

Table 5. The total annual rainstorms with the annual rainfall amount in the selected stations (2007-2017) and the correlation coefficient between the total annual rainstorms and the annual rainfall amount

stations		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Avg.	r*
Mosul	Rainstorms	40	30	32	35	41	39	33	36	36	35	28	35	0.23
	Rainfall(mm)	193.8	216.31	223.81	240.61	294.71	278.61	455.51	340.81	288.809	216.00	145.10	263.1	
Kirkuk	Rainstorms	27	27	32	27	35	34	29	37	40	26	31	31.36	0.28
	Rainfall(mm)	173.1	134.91	225.81	267.21	221.81	292.105	394.30	319.00	315.50	321.50	204.50	260.89	
Khanaqin	Rainstorms	—	—	—	—	—	26	23	28	20	15	8	20	0.81
	Rainfall(mm)	—	—	—	—	—	116.4	169.35	170.3	14.9	4.9	10.1	80.99	
Baghdad	Rainstorms	20	22	33	27	27	26	27	32	29	27	30	27.27	-0.002
	Rainfall(mm)	99.21	59.11	67.52	92.51	96.02	184.42	296.72	107.52	190.92	104.52	71.82	124.58	
Rutba	Rainstorms	12	15	24	26	29	29	33	30	17	3	21	21.73	0.7
	Rainfall(mm)	58.40	72.90	23.31	109.01	87.92	73.01	135.21	157.61	41.90	10.30	21.81	71.95	
Hai	Rainstorms	21	26	27	22	24	28	27	30	28	21	21	25	0.64
	Rainfall(mm)	64.51	87.62	85.32	80.30	120.31	81.20	156.81	188.61	194.61	123.51	43.10	111.45	
Nasiriya	Rainstorms	22	17	29	20	28	24	28	31	28	24	28	25.36	0.4
	Rainfall(mm)	112.51	65.50	56.91	57.61	85.11	116.22	174.22	219.72	93.22	68.3	29.7	98.1	
Basrah	Rainstorms	23	13	29	16	21	22	14	5	19	19	17	18	0.5
	Rainfall(mm)	139.21	67.10	89.81	57.007	65.30	115.30	48.31	60.5	131.50	86.90	128.20	89.93	

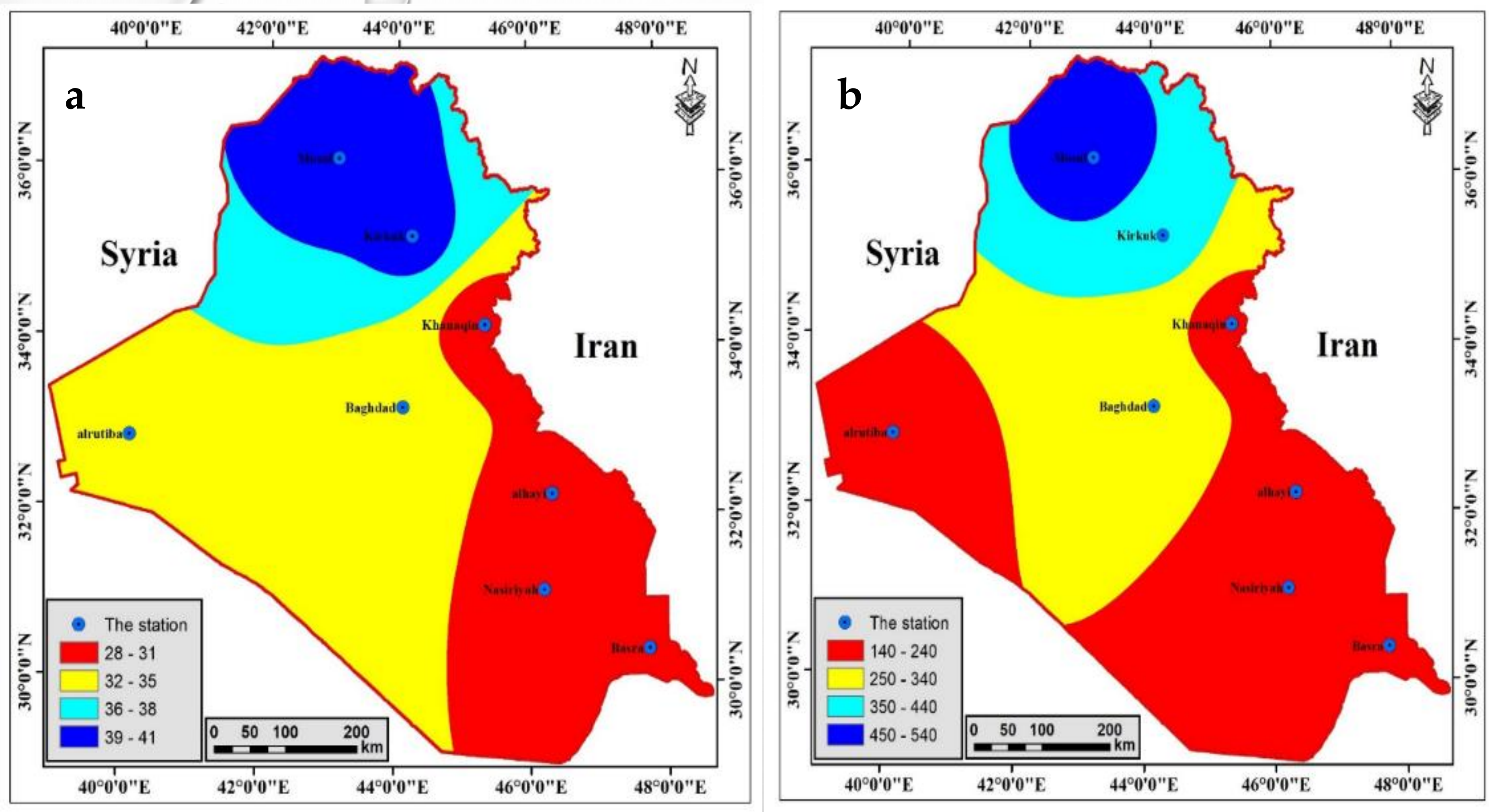


Figure 6. (a)The highest total annual rainstorms (2007-2017).
(b) The highest total annual rainfall (2007-2017).

Conclusions

The results of the statistical analysis showed that the length of the duration of the rainstorm is not a significant factor in the formation of the flash floods, because the length of the rainstorm duration does not necessarily lead to an increase in the amount of rainfall, except in the case of its association with the strength of the rainstorm intensity (the amount of precipitation/unit time), Therefore, this model is canceled from relying on its results as one of the models that determine the locations of the effective flash floods.

The results of the statistical analysis showed that the increase in the frequency of rainstorms does not necessarily lead to an increase in the intensity of the flash floods, because this increase in the number of iterations may increase the probability of rainstorms that do not lead to the formation of flash floods to cause damages or stop the daily life of humans.

The increase in (the amount of precipitation/unit time) leads to an increase in the risk of flash floods, because it reduces the chance of Infiltration, evaporation, runoff entering a storm drain or rivers.

We also have assessed the synoptic conditions of one of the highest flash flood events, in Basra city taking place December 23–24, 2017. The upper (250 hPa) and middle (500 hPa) atmospheric conditions present an upper-level trough leading to this episode.
Southern Iraq (Basra city) was affected by the divergence of horizontal wind and associated with upwards motions. Simultaneously, the low-level atmosphere, experiencing the convergence of humidity from the Red Sea and the Persian Gulf.

References

[1] Buchwaldt, R.;Encyclopedia of Natural Hazards, Bobrowsky,P.T, Springer Netherlands,Simon Fraser University Canada, 2013,324.

[2] NOAA, National weather service, Flood and flash flood definitions,National Oceanic and Atmospheric Administration. Available at: https://www.weather.gov/mrx/flood_and_flash, 24-06-2021.

[3] Al-Nassar, A.R. ; Pelegrí, J.L. ; Sangrà, P. ; Alarcon, M. and Jansa, A. Cut-off low systems over Iraq: Contribution to annual precipitation and synoptic analysis of extreme events. International Journal of Climatology, 2020.40(2), pp.908-926

[4] Aboud Al-Kinani, M.N.; Al-shamry, M.K. Synoptic analysis of floodwaters affecting East Wasit Governorate and its impacts on infrastructure and agricultural land, Journal of the College of Education, Wasit University, 2019, 4 ,4, DOI: https://doi.org/10.31185/eduj.Vol4.Iss4.966.

[5] Abdul-Jabbar,A.M.; Khtan ,A.Predicted the Cumulative Annual Rainfall in Iraq using SDSM Moda, Al-Mustansiriyah Journal of Science, 2021,32,2,.DOI: http://doi.org/10.23851/mjs.v32i2.97

[6] Al Nassar,A.R.T. Dynamics of Cyclones and Precipitation over the Middle East, Ph.D. Degree, Universitat Politècnica de Catalunya. Departament de Física, Spain, 25-09-2018.

[7] Vahidnia, M.H.; Alesheikh, A.A.; Alimohammadi,A.; Hosseinali, F. A GIS-based neurofuzzy procedure for integrating knowledge and data in landslide susceptibility mapping. Computers & Geosciences,2010, 36, 9: 1101–1114.

[8] Alaghmand, S.; Bin-Abdullah, R.; Abustan, I.; Vosoogh, B. GIS-based River Flood Hazard Mapping in Urban Area: A Case Study in Kayu Ara River Basin, Malaysia. International Journal of Engineering & Technology, 2010, 2, 488–500.

[9] Wang,Y.; Li, Z.; Tang, Z.; Zeng, G. A GIS-based spatial multi-criteria approach for flood risk assessment in the Dongting Lake Region, Hunan, Central China. Water Resources Management, 2011, 25, 13, 3465–3484.

[10] Patel, D.P.; Srivastava, P.K. Flood hazards mitigation analysis using remote sensing and GIS: Correspondence with town planning scheme. Water Resources Management, 2013, 27, 7, 2353–2368.

[11] Jaafari, A.; Najafi, A.; Pourghasemi, H.R.; Rezaeian, J.; Sattarian, A. A GIS-based frequency ratio and index of entropy models for landslide susceptibility assessment in the Caspian forest, northern Iran. International Journal of Environmental Science and Technology, 2014,11, 4,

[12] Aldescu, G.C. The necessity of flood risk maps on Timis river. IOP Conference Series: Earth and Environmental Science, 2008,4. IOP Publishing.
[13] Koehler, K.A.; Volckens, J. Prospects and pitfalls of occupational hazard mapping: 'between these lines there be dragons', Annals of Occupational Hygiene, 2011,55, 8, 829–840.
[14] Fernández, D.S.; Lutz, M.A. Urban flood hazard zoning in Tucumán Province, Argentina, using GIS and Multi Criteria Decision Analysis. Engineering Geology, 2010,111, 1–4, 90–98.
[15] Sowmya, K.; John, C.M.; Shrivasthava, N.K. Urban flood vulnerability zoning of Cochin City, southwest coast of India, using Remote Sensing and GIS. Natural Hazards, 2015,75, 2, 1271–1286.
[16] Gerl, T.; Bochow, M.; Kreibich, H. Flood Damage Modeling on the basis of Urban Structure Mapping Using High-Resolution Remote Sensing Data. Water, 2014, 6, 8, 2367–2393.
[17] Emmanouloudis, D.; Myronidis, D.; Ioannou, K. Assessment of flood risk in Thasos Island with the combined use of multicriteria analysis AHP and geographical information system. Innovative Applications Information Agricultural Environment, 2008 2, 103–115.
[18] Sinha, R.; Bapalu, G.; Singh, L.; Rath, B. Flood risk analysis in the Kosi river basin, north Bihar using multi-parametric approach of analytical hierarchy process (AHP). Journal of the Indian Society of Remote Sensing, 2008,36, 4, 335–349.
[19] Meyer, V.; Scheuer, S.; Haase, D. A multicriteria approach for flood risk mapping exemplified at the Mulde river, Germany. Natural Hazards, 2009, 48, 1, 17–39.
[20] Chen, Y-R.; Yeh, C-H.; Yu, B. Integrated application of the analytic hierarchy process and the geographic information system for flood risk assessment and flood plain management in Taiwan. Natural Hazards, 2011,59, 3, 1261–1276.
[21] Tehrany, M.S.; Pradhan, B.; Jebur, M.N.; Neamah, M. Flood susceptibility mapping using a novel ensemble weights-of-evidence and support vector machine models in GIS. Journal of Hydrology, 2014,512, 332–343.

THANK YOU FOR LISTENING