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Study of Spatial and Topographical Variation of Rainfall in Kerman Province in Iran using GIS

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ABSTRACT

The present study has been conducted to find out the spatial and topographical (elevation) variation of rainfall in Kerman province in Iran using GIS. Totally twelve rain gauge stations rainfall data have been used for the study which is from 1381 to 1392 (based on the Persian calendar). The co-efficient of variation has been calculated from the rainfall data and its result has been interpolated using IDW technique to find out the spatial variation. The result of co-efficient of variation depicts that, 2.70 per cent area has been covered by very low variation, 29.14 per cent by low, 41.90 per cent by moderate, 24.70 per cent by high and 1.56 per cent by very high variation. Then the analysis of topographical variation with the rainfall shows the positive relationship, which illustrates higher amount of rainfall in high elevated areas compared to lower height.

Key Words: Co-efficient of Variation, GIS, Topography, Rainfall, Correlation

INTRODUCTION

Rainfall is a very vital natural resource which contributes the most important factor supporting life on earth. The density and quantum of rainfall at a specific place determines the environment and landscape of that region. This is the main source for agriculture, replenishing the groundwater table and quantum of drinking water. Excess rainfall leads to deluge while less rainfall leads to drought. The study of rainfall helps in anticipating danger and to avert it by planning and implementing preventive measures well before hazard

The amount rainfall varies specially as well as temporally, so this is essential to analysis the spatial temporal changes of rainfall distribution. The study of spatio-temporal analysis has been boomed after the invention of Geographical Information System (GIS), through which vast amount of data can be handled easily in short time with extreme accuracy of result (Agouris 2000, Alkan 2010, Singh 2013). Therefore the present study has been conducted to find out the spatial changes of rainfall and its relation with the topography in Kerman province in Iran using GIS. The estimation of rainfall variation can be possible using some statistical methods, among those the method co-efficient of variation is much popular, which already has been proved by several researchers (Anne 1996, Wong 2009, Lana 2009). The higher values in the result of co-efficient variation show higher variation of rainfall while low values represent the least variation. Therefore the current study has been adopted the co-efficient of variation statistical method to assess the spatial variation of rainfall and correlation analysis for relationship between rainfall and topography over the Kerman province.

STUDY AREA

The study area Kerman is one of 31 provinces of Iran, which is located in the southern part of the country (Map 1). Kerman shares its boundary with Yazd in the north, South Khorasan in the north east, Sistan and Baluchestan in the east and south east, Hormozgan in south and south west and Fars in North West. The province covers totally 182,984.25 km^2 of geographical area, which is equal to 11 per cent of the country. The geographical coordinate system of the province is from 32º 2' 57.64" latitude to 26º 0' 37.09" and longitude from 54º 23' 28.25" to 59º 30' 55.32".

METHODOLOGY

The rainfall data of the study area has been collected from the department of Meteorology in Kerman while province base map has been collected from the County office of Kerman. Totally twelve rain gauge stations' (Kerman, Bam, Sirjan, Shahr-E Babak, Jiroft, Baft, Rafsanjan, Anar, Kahnooj, Zarand, Shahdad and Lalezar,) rainfall data have been collected from the year 1381 to 1392, the spatial location of selected rain gauge stations as shown in map 1. The department of meteorology in Iran has been collecting and documenting the rainfall data based on the Persian calendar which is different

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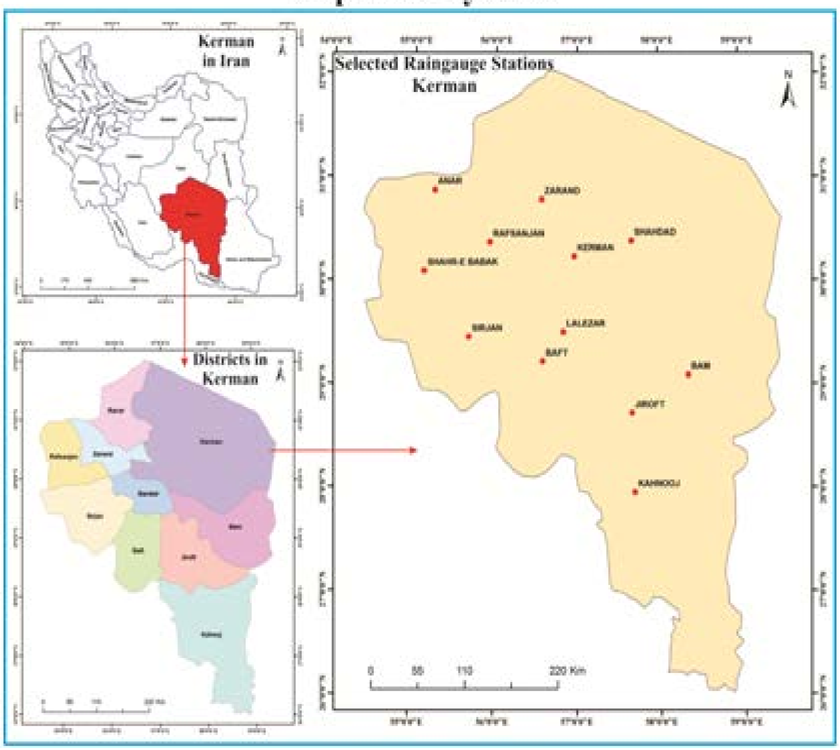
from the Gregorian calendar, so the present study has followed the Persian calendar for the analysis.

The collected rainfall data has been manipulated in Excel while geographical registration of base map and vector layer preparation has been done using ArcGIS 10.2. To find out the overall province rainfall distribution from the selected twelve rain gauge stations data, the interpolation method Inverse Weighted Distance (IDW) has been used. Then the spatial distribution of rainfall in each year has been classified into five groups spatially as very low, low, moderate, high and very high for the comparison of temporal changes. Finally the calculation of co-efficient of variation has been found from the collected rain gauge data, from which the spatial variation of rainfall in Kerman has been ascertained.

The Shuttle Radar Topographical Mission satellite imagery data has been obtained from the USGS website, and the errors in it has been corrected before the preparation of topographical map of Kerman. Then the finalized topographical data has been correlated with mean rainfall data of province in order to find out the relationship between the topography and the amount of rainfall.

Map 1: Study Area

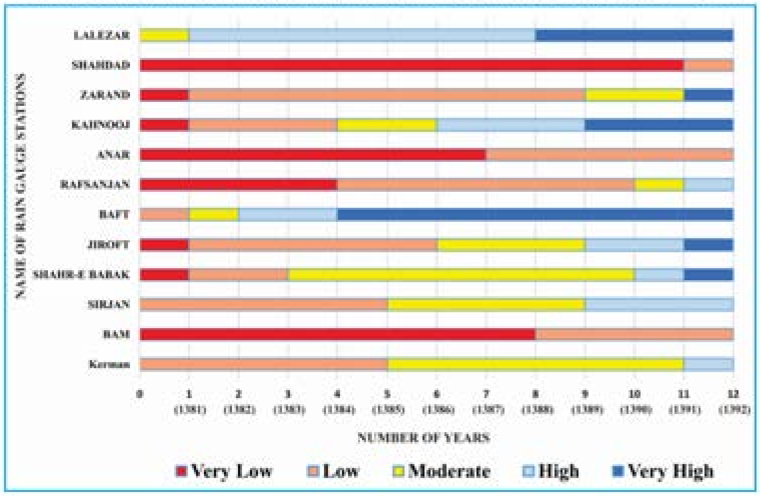


RESULT AND DISCUSSION

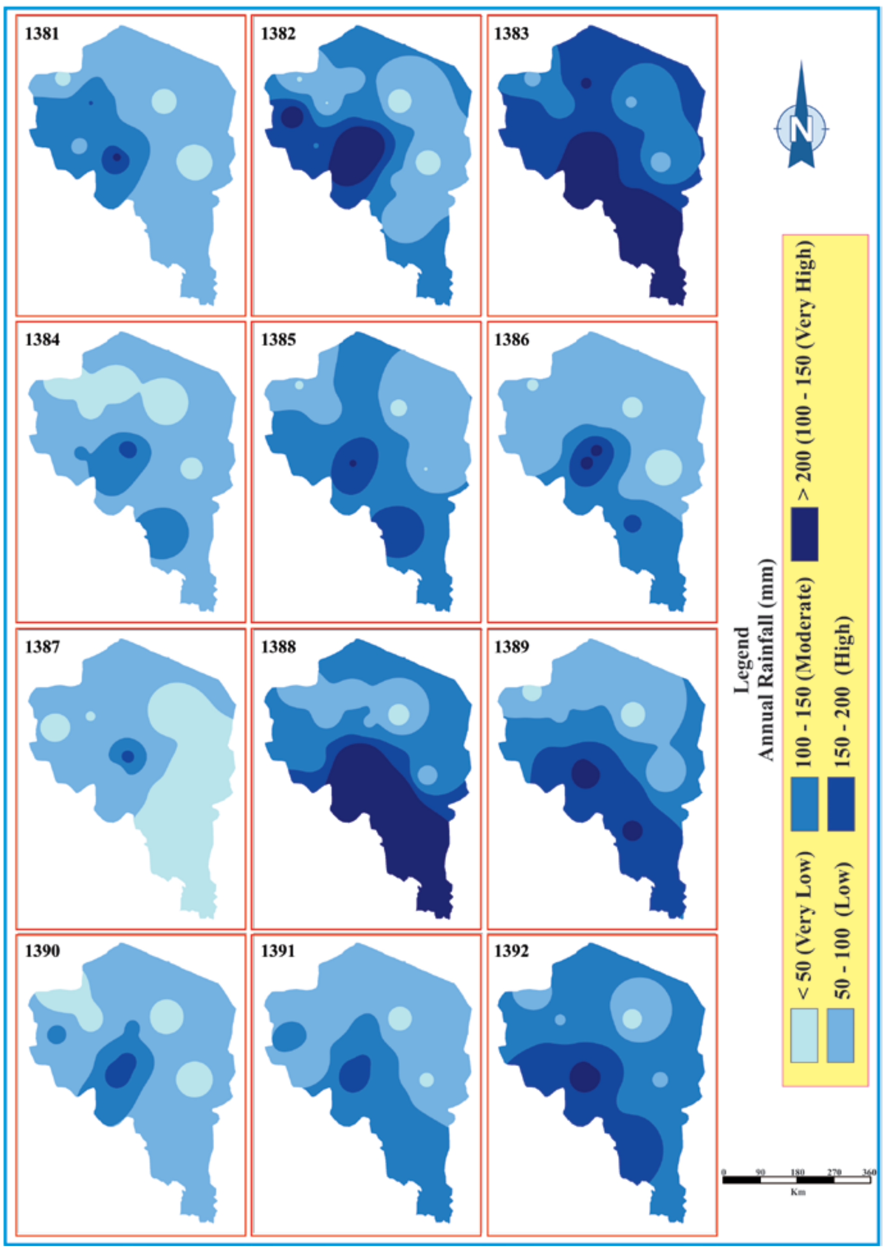
The analysis of collected twelve years rainfall data of twelve rain gauge stations shows that, the highest amount of rainfall has been received by Baft rain gauge station with the mean of 224.23 mm, while least amount 28.46 mm has been received by Shahdad (table 1). The year wise distribution of rainfall created using IDW interpolation method have been classified into five groups as shown in map 2. The result of rainfall distribution analysis shows that, southern and south western part of province have received higher amount of rainfall while northern and north eastern parts of the province have received least amount of rainfall. The clear changes in the spatial variation of rainfall can be observed in map 2.

The classified result of rainfall distribution as shown in fig 1 depicts that, the station Baft has received very high amount of rainfall in eight years, high in two years and moderate and low in one year respectively, from which it is clear that, the station Baft receives the highest amount of rainfall in the province. Next to Baft the station Lalezar has received Very high rainfall in four years, high in seven years and moderate in a year. The notable least amount of rainfall received station is Shahdad, which received very low amount of rainfall in eleven years and low in a year. Followed by Shahdad, the stations Bam and Anar also has received the least amount of rainfall in the province. The detailed report of each station variation can be seen in fig 1.

Fig 1: Frequency of Rainfall Classification - Kerman Province (1381 - 1392)



Map 2: Distribution of Rainfall in Kerman Province - (1381 - 1392)



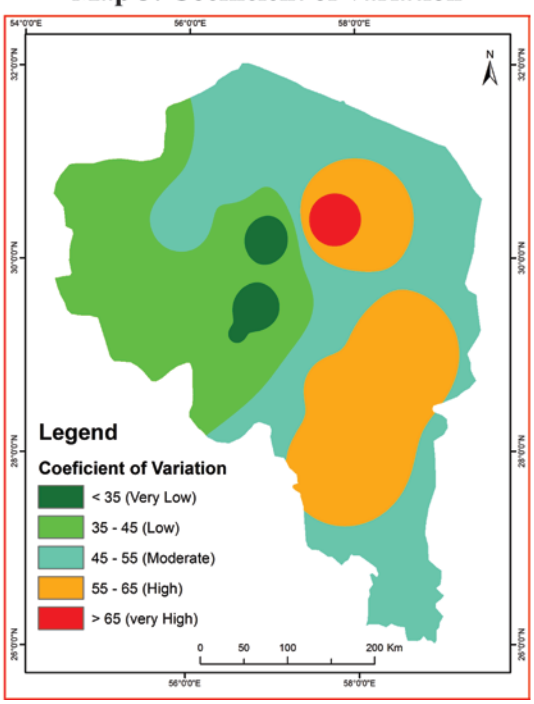
COEFFICIENT OF VARIATION

The coefficient of variation has been calculated to find out the spatial variation of rainfall in the province. The coefficient of variation (CV), which is the ratio of the standard deviation to the mean, was first introduced by Karl Pearson in 1896. This dimensionless relative measure of dispersion has widespread applications in many disciplines (Banik 2012). The result of coefficient of variation analysis has been inserted on the location rain gauge station and the IDW interpolation analysis has been formed to get the overall variation of province. The higher values in the CV result show the higher variation while low values show the low variation. In the present study the variation of rainfall ranges from 25.48 to 77. These values have been classified into five groups as very low (< 35), low (35 – 45), moderate (45-55), high (55-65) and very high (> 65). The result of spatial variation in rainfall (map 2) shows that, the station Shahdad and the regions around it have very high amount of variation, which hascovered 2848.75 km^2 geographical area, while the stations Bam, Jiroft, Kahnooj and its surrounding areas are having high variation that has covered 45195.50 km^2 area. The moderate amount of variation has covered large portion of the province (76663.50 km^2) including Rafsanjan, Zarand rain gauge stations and North, North East, South and central part of the province. The low variation of rainfall presents in the Sirjan, Shahr-e Babak, Anar rain gauge stations and its surrounding areas, which have covered 53330 km^2 area. The very low variation of rainfall has been presented in Baft, Lalezar, Kerman and its surrounding areas covering 4946.50 km^2.

Table 1. Coefficient of Variation			
S.No	Class	Area (Km^2)	Area (%)
1	< 35 (Very Low)	4946.50	2.70
2	35 - 45 (Low)	53330.00	29.14
3	45 - 55 (Moderate)	76663.50	41.90
4	55 - 65 (High)	45195.50	24.70
5	> 65 (very High)	2848.75	1.56
Total Area		182984.25	100.00

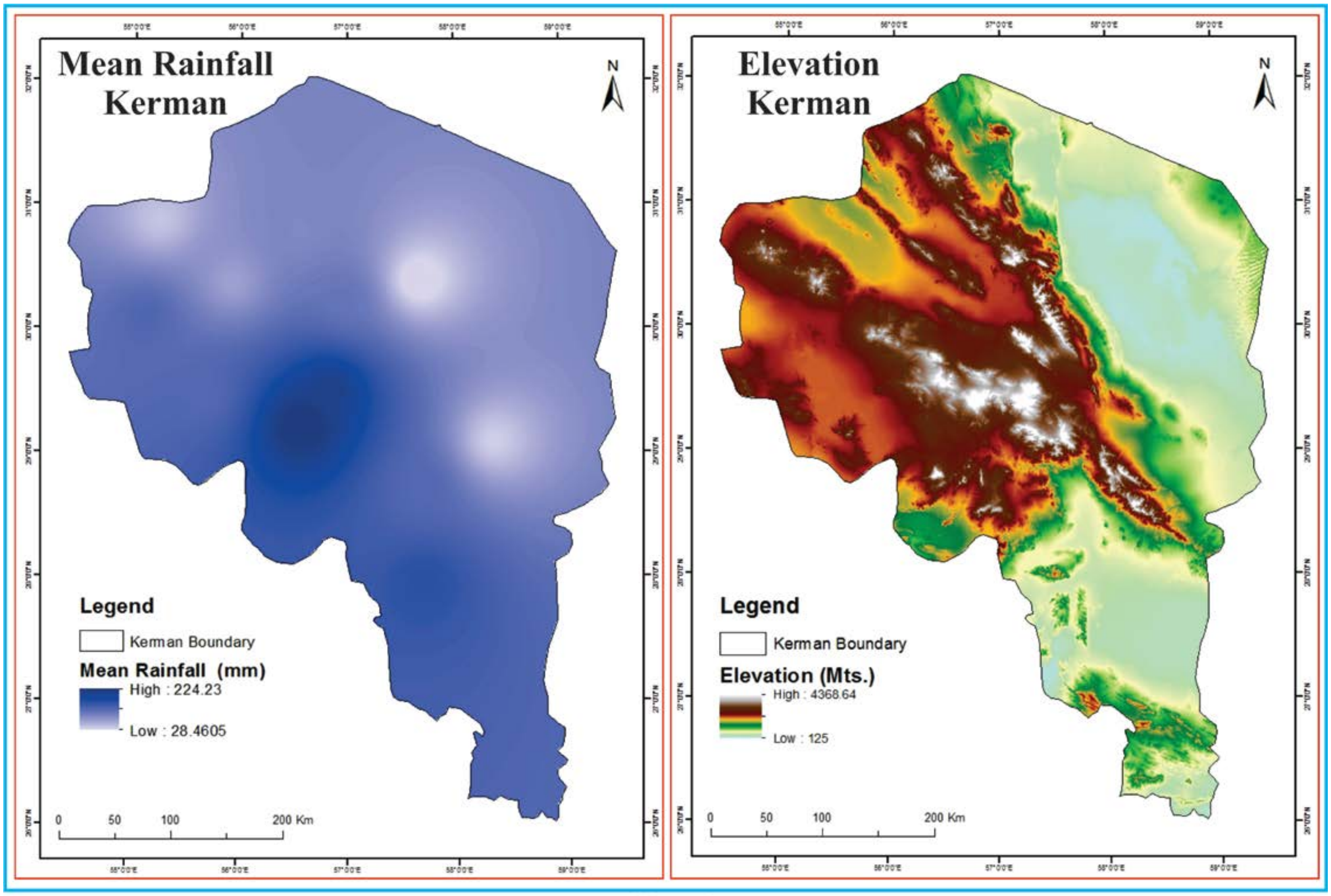
The holistic result describes that, vast area of the province has been covered by moderate variation (41.90 %) followed by low (29.14 %) and least amount of area has been covered by very high variation (1.56 %) followed by very low (2.70 %) while high variation has been covered by 24.70 per cent of area.

Map 3: Coefficient of Variation



CORRELATION OF RAINFALL AND ELEVATION

After the analysis of rainfall variation spatially, the correlation between mean rainfall and elevation has been carried out to assess the influence of topography in the rainfall. For this spatial distribution of mean rainfall data and topographical elevation (Digital Elevation Model) data has been used. The mean rainfall data shows that, the least amount of rainfall is 28.46 mm while highest is 224.23 mm (map 4), and the elevation map of the study area shows the least elevation is 125 mts. while highest is 4368.64 mts.



Map: 4

TABLE 2: RESULT OF STATISTICAL ANALYSIS				
Layers	Min	Max	Mean	STD
Elevation	125	4368.64	1327.53	781.44
Mean RF	28.46	224.23	108.72	30.7

COVARIANCE MATRIX		
Layers	Elevation	Mean RF
Elevation	341718.48	4433.91
Mean RF	4433.91	527.38

CORRELATION MATRIX		
Layers	Elevation	Mean RF
Elevation	1	0.33
Mean RF	0.33	1

The correlation analysis between mean rainfall and elevation has been done in ArcGIS using 'Band Collection Statistics' tool. The result of correlation analysis depicts the positive relationship between the mean rainfall and elevation with the value of 0.33. It clearly shows that, amount of rainfall is high at higher elevation compered to lower elevation.

CONCLUSION

The present study conducted to analysis the spatial and topographical variation of rainfall in Kerman provinces shows that, the rainfall varies spatially from region to region. The co-efficient of variation depicts that, the station Shahdad and the surroundings are having very high variation, which means the amount of rainfall received by this place is highly varied from year to year. The stations Bam, Jiroft, Kahnooj and its surrounding areas are having high variation, so any activity related to rainfall in these areas cannot be judged for the future. The moderate amount of rainfall variation covers large portion of the province including Rafsanjan, Zarand rain gauge stations and North, North East, South and central part of the province, where the average amount of past rainfall can be expected in the future. The low variation of rainfall presents in the Sirjan, Shahr-e Babak, Anar rain gauge stations and its surrounding areas, while very low variation is presented in Baft, Lalezar, which means the fluctuation of rainfall between each year is less, so these areas in the future would receive almost the same amount of rainfall that was received in the past, this would highly facilitate taking necessary steps for the future. The correlation of rainfall and elevation shows the positive correlation, which means, the elevated places in the province receive higher amount of rainfall than low elevation places. The result of correlation analysis helps to identify the suitable location for the activities related to rainfall.

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