Rainfall Analysis at District Level For Crop Planning In North Karnataka

A Case Study Of Dharwad district

ABSTRACT

North Karnataka comprises thirteen districts that possess different rainfall patterns, soil types and cropping systems. The dynamic nature of climate necessitates assessment of climate variability and local level long range forecasts for adoption of suitable cropping systems in tropical regions. Long period data of rainfall from 1951 to 2018 (68 years) over the thirteen districts were subjected to serial correlation techniques to identify important lag years with significant serial correlation coefficient (SCC) for annual rainfall, and for seasonal and monthly rainfall for Dharwad district as a pilot study. Significant SCCs were identified in these series to develop auto-regression models. These models assessed through hindcast indicated that, except the adjacently located districts of Bagalkot, Kalaburgi and Yadgir, significant association existed between the other districts indicating the possibility of ahead of season forecast of rainfall for these districts. Significant association was also noticed between actual and hindcast values of seasonal and monthly rainfall in Dharwad district and therefore, have potential for selection of crops and cropping systems for the district well in advance. Thus, the results can be well adopted for crop planning well in advance at district level for better results and adoption. In particular, the seasonal and monthly forecast models as indicated for Dharwad district can be of immense help to advise the cropping systems/patterns for the ensuing the *Kharif* and the *Rabi* crops.

Key words: Correlogram, Auto-regression models, rainfall variability, crop planning

INTRODUCTION

Adoption of cropping patterns over a region essentially depends on the interannual and intra seasonal variations of rainfall, either directly on rainfed crops and indirectly in terms of available water for surface irrigation in irrigated crops. North Karnataka comprises thirteen administrative districts distributed over four agroclimatic regions, viz., North Eastern Transition Zone, North Eastern Dry Zone, Northern Dry Zone and North Transition Zone, and parts of the Hill and Coastal zones and two meteorological subdivisions namely North Interior Karnataka and Coastal Karnataka. Rainfall varies considerably over space and time over this region. The region is affected greatly by the southwest monsoon currents over the coastal and hilly (Uttara Kannada) and the submontane (Haveri, Dharwad and Belagavi) districts. Parts of these submontane districts are in the rain shadow region for the Western Ghats and too far away to the northeast monsoon currents to be greatly affected by it. Thus, the monsoon periods have variable but important influences on the crops in the drier regions of north Karnataka. Since the underlying soils are also different, multiple types of cropping systems have been adopted in the region. Paddy, sorghum, pearl millet, redgram, cotton and sugarcane are the major crops grown in North Karnataka. While recognising the importance of the dynamics of the atmosphere and weather patterns that cause variations in intraseasonal rainfall results in seasonal and annual rainfall every year, it is also required to assess the interannual rainfall fluctuations over smaller areas over a long period of time in order to draw adoptable inferences for agriculture. The analysis and interpretation in the paper is aimed towards this. Venkatesh (1998) analysed the seasonal and annual rainfall variability pattern at Bijapur and indicated an increase in rainfall over the years. Venkatesh (2003) analysed eleven year moving averages of actual and estimated values from auto regression models to compute the monthly and seasonal rainfall series of Bijapur district and compared with actual.

Venkatesh and Guled (2005) suggested crops and cropping patterns for different monthly rainfall situations for Bijapur district.

The results of the present study attempt to provide additional input for crop planning in Dharwad district as the case study for use in tandem with the national and regional long range forecasts issued by the India Meteorological Department.

DATA AND METHODOLOGY

The station-wise 68 years (1951-2018) of daily rainfall data for seventy-nine taluks of the north Karnataka were collected from the AICRP on Agrometeorology, RARS, Vijayapura and the Directorate of Economics and Statistics. The entire data was transformed into taluk wise daily rainfall data by averaging data of all the stations that come under individual taluks, which were further transformed into the monthly, seasonal and annual rainfall data.

Serial or Auto-Correlation (Anonymous, 1966) refers to the relationship, between the successive values of a given variable. Correlograms were constructed for annual rainfall time series for individual districts. The lag years with significant correlation are identified. Accordingly, the data of the significantly related series was used to develop multiple regression forecast models to obtain the rainfall for any given year (Lag 0) using step wise regression analysis performed through SPSS software. The developed models were used to hindcast the rainfall for each district. The correlation analysis was performed between actual and hindcast data.

Information is provided about what type of cropping pattern needs to be performed based on the forecast rainfall for individual district, keeping in view the Package of practices of UAS Dharwad (Anonymous, 2020).

RESULTS AND DISCUSSION

Annual rainfall:

Serial correlation coefficients at different lag periods in the form of correlogram were constructed for annual rainfall of districts of the north Karnataka. Example for five districts of the north Karnataka, namely Ballari, Bagalkot, Gadag, Koppal, Vijayapura districts is presented in Fig. 1. The information on significant SCCs of annual rainfall for all districts is summarized in Table 1.

In case of Ballari district, annual rainfall has negatively significant serial correlation (SCC) at lags of 14 and 23 years (L14 and L23), while Bagalkot district has significant a positive SCC at a lag of 21 years (L21). Gadag district has significant positive SCC at lag of 13, 18 and 21 years (L13, L18 and L21) and a negatively significant SCC at a lag of 15 years (L15). In Koppal district, positive SCC was noticed at lag of 9 and 13 years (L9 and L13) and negative significant SCC at lag of 7 and 20 years (L7 and L20), whereas in Vijayapura district, it showed a positive significant serial correlation at 10 years lag (L10) and a negative significant SCC at a lag of 19 years (L19).

In case of Kalaburgi district (Table 1), positive SCC at lag 6, 9, 11, 12 and 20 years (L6, L9, L11, L12 and L20) and negative significant SCC at lag of 4 and 16 years (L4 and L16) were noticed. In Yadgir district, a positive significant SCC at 11 years lag (L11) is seen. In Raichur district, a positive significant serial correlation at a lag of 19 years (L19) and a negative significant serial correlation at a lag of 10 year (L10). In Bidar district, a positively significant SCC at 20 years lag (L20) and negatively significant SCC at lag of 4, 16 and 22 years (L4, L16 and L22) were noticed. In Dharwad district, positive significant serial correlations at lags 1, 2, 13 and 14 years (L1, L2, L13 and L14) and a negatively significant SCC at a lag of 22 year (L22) were noticed for annual rainfall. Belagavi district had positively significant SCC at lags 1, 13, 14 and 17 years (L1, L13, L14 and L17) and negatively significant SCC at lags 6, 7, 10, and 20 years (L6, L7, L10 and L20). In Haveri

district, a positively significant SCC at 21 years lag (L21) and a negatively significant at 19 years lag (L19) were noticed. Uttara Kannada district had a positively significant serial correlation at a lag of 15 years (L15) and a negatively significant serial correlation at a lag of 9 years (L9).

Seasonal and monthly rainfall for Dharwad district:

Significant SCC for seasonal and monthly rainfall for Dharwad district is summarized in Table 2. It is noticed that the southwest monsoon has only one positive significant SCC at a lag of 1 year (L1) and two negative significant SCC at lags 22 and 23 years (L22 and L23). In northeast monsoon season, positive significant SCC was noticed at lags 13 and 16 years (L13 and L16) and negative significant serial correlations at lags 7 and 19 years (L7 and L19). The *Kharif* season had only one positive significant serial correlation at 1 year lag (L1) and one negative significant serial correlation at 7 year lag (L7). In the *Rabi* season, two positive significant serial correlations at lags 13 and 19 years (L13 and L19) and one negative significant serial correlation at a lag of 20 year (L20) were identified.

In case of the monthly rainfall (Table 2), June rainfall had three negative significant SCC at lags 3, 10 and 22 years (L3, L10 and L22) were noticed. July rainfall showed two positive significant SCC at lags 1 and 14 years (L1 and L14), August rainfall showed only a single negative significant SCC at a lag of 20 year (L20), while September rainfall had two positive significant SCC at lags 5 and 19 years (L5 and L19) and three negative significant SCC at lag 3, 22 and 23 years (L3, L22 and L23). For October there only negative significant SCC at lags 7, 19 and 22 years (L7, L19 and L22) was identified.

Development of forecast models:

The data corresponding to the significant lag years were considered further for multiple regression analysis to develop auto-regression models for annual rainfall for individual districts and the monthly and seasonal rainfall for Dharwad district, and the models are presented in Table 3 for annual rainfall in all districts and Table 4 for seasonal and monthly rainfall in Dharwad district. It is noticed that the models for annual rainfall in Belagavi, Bidar, Dharwad, Raichur and Vijayapura districts showed high significance at 1 per cent level and in case of Ballari, Gadag, Haveri, Koppal, Yadgir and Uttara Kannada districts the significance was at 5 per cent level. However, the model results were not significant for Bagalkot and Kalaburgi districts.

Amongst the seasonal auto-regression rainfall models for Dharwad district, those of *Kharif* season, southwest monsoon season and the northeast monsoon season rainfall showed significance at 1 per cent level, while the *Rabi* season model showed significance at 5 per cent level. On a monthly basis, the models of August and September showed significance at 1 per cent level, while those of July and October rainfall showed significance at 5 per cent level. On the other hand, the model developed for June did not show any significance. This indicates that is difficult to the forecast rainfall for June, which is the onset of the monsoon for Dharwad. These types of inadequacies need to be considered while advising the farmers. In such cases, the ENSO-IOD influences district rainfall (Venkatesh et al, 2019a and 2019b) can be given due weightage to help the farmers.

Hindcasting of rainfall series and comparison with actuals

The developed models were used to re-calculate (hindcast) rainfall for the years 1951 to 2017. The hindcast series was compared with the data through the correlation analysis. The results are presented in Table 5 for annual rainfall of all districts. The significant positive correlation existed in Ballari, Gadag, Koppal and Haveri districts and was highly significant

positive correlation existed for Belagavi, Dharwad, Bidar, Raichur and Vijayapur districts (Table 5). There was no significance correlation between the clusters of Bagalkot, Yadgir and Kalaburgi districts, and hence the procedure cannot be used for these districts. However, the corresponding models can be successfully used for ahead of the year forecast of annual rainfall for all the other districts.

From the results of seasonal and monthly rainfall in Dharwad district (Table 6), correlation coefficient between hindcast and actual rainfall was highly significant for seasonal rainfall and significant for monthly rainfall (Table 6). Hence, there is ample scope to use these models to provide ahead of the season forecast in Dharwad district, monthly and seasonal scales, which are important for crop planning.

Even though the relationships were significant, the magnitude of the correlations was smaller in Tables 5 and 6. Hence, the results can be used qualitatively in terms of normal, below-normal and above-normal conditions. Keeping the above factors in view, every year the models can be used to estimate seasonal and monthly rainfall before the start of the season to guide the farmers.

Crop planning strategies in Dharwad district

The monthly and seasonal rainfall prediction models can be used for crop planning strategies. When the model predicted low rainfall in the Kharif season and high rainfall in the Rabi seasons, then planning can be made to adopt drought tolerant crops like maize, bajra, sorghum cultivars to be grown in the Kharif season, whereas moisture loving, pest resistance varieties can be preferred in the Rabi season. Information from the Package of Practices of UAS Dharwad (Anonymous, 2020) was collected for suitably selecting crops and varieties suitable for respective rainfall situations are detailed below, and the same are given in the succeeding tables.

If below normal rainfall is predicted for October, then selection of sorghum drought resistant genotypes like SPV-2217, RSV-1098, CSV.29R and CSV.26R could be adopted and also crops recommended for delayed sowing like safflower and chickpeas varieties can be avoided and crop varieties that have early sowing-window and drought resistant varieties likeAnnigeri-1 and JJ-11 in chickpeas and A-300, A-2 and NARE-6 in safflower crop can be preferred on a larger scale.

On the other hand, depending on the forecast of (Anonymous, 2016) low rainfall in different months, short duration and mid-season drought resistant redgram varieties, JC-11 and BSMR-736 and Maize varieties, CSH-14, CSH-16 and CSH-30 are recommended for sowing conditions in June and June- July, Maize variety Hema and Sunflower variety CBSH1 recommended for sowing in August suggested for late Kharif season. In the Rabi season, drought resistant and pest resistant Maize variety, DSH-4 and Nithyashree can be recommended for sowing in September and October, Sunhemp variety Annigeri-1, A-300, Sorghum variety CSH-1, M35-1 and wilt resistant Chickpeas variety BRG-5 were recommended for late sown conditions suggested for low rainfall forecast in October for Dharwad district. Thus, the results can be well adopted for crop planning well in advance at district level for better results and adoption. In particular, the seasonal and monthly forecast models can be of immense help to advise the cropping systems/patterns for ensuing in the *Rabi* crops.

List 1 : Crop planning strategies in Dharwad district, India

Rainfall situation forecast		Crops	Varieties
Kharif	Rabi		
Below normal	Normal/above normal	Maize	Hema (hybrid)

Normal/above normal	**Below normal**	Rabi Jowar	CSH-10

Kharif Rainfall situation forecast			Crops	Varieties	
June	July	August			
Below normal	Normal/above normal	**Below normal**	Maize+Redgram	Hema (hybrid)	BSMR-736
			Maize	Hema (hybrid)	
Normal/above normal	**Below normal**	Normal/above normal	Sunflower+Chickpea	CBSH-1	JJ-11 Annigeri-1
			Fallow- Rabi Sorghum	CSH-14, CSH-16, CSH-30 Composite	
			Little millet	C0-2 PRC-3	
			Field Bean	H.A-3/4	

Rabi Rainfall situation forecast		Crops	Varieties
September	October		
Below normal	Normal/above normal	Sunhemp	Anniger-1 A-300
		Maize	Nithyashree (hybrid)
Normal/above normal	**Below normal**	Rabi sorghum	CSH-10, M35-1
		Chickpea	BRG-5 Annigeri-1 JJ-11

CONCLUSION:

Making available ahead of year forecast of annual rainfall, seasonal and monthly rainfall is of great importance for farmers. Our attempt at using the established serial correlation and autoregression models at spatially microlevel like district level has brought out good results. A comparison between actual and estimated values for hindcasting showed

good results. Even suggestions on qualitative terms like below normal, normal and above normal in districts other than these three districts. Adopting the procedure for Dharwad district, suggested that is possible to estimate the seasonal and monthly rainfall ahead of the season. This has considerable opportunity for ahead of season rainfall forecast and therefore, crop planning for the district. We have suggested crops and genotypes that can be taken up in different situations of seasonal and monthly rainfall forecast, and the same can be extended to other districts in north Karnataka.

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Table.1Significance of SCC at different Lag years for Annual rainfall in different districts of the north Karnataka

Districts	Lag years																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Bagalkot																					P		
Ballari														N									N
Belagavi	P					N	N			N			P	P			P			N			
Bidar				N												N				P		N	
Dharwad	P	P											P	P								N	
Gadag													P		N			P			P		
Haveri																			N		P		
Kalaburgi				N		P			P		P	P				N				P			
Koppal							N		P				P							N			
Raichur										N									P				
Uttara Kannada									N						P								
Vijayapura										P									N				
Yadgir											P												
P- Positive significant SCC; N- Negative significant SCC																							

Table.2Significance of SCC at different Lag years for Seasonal and monthly rainfall for Dharwad district

Seasons / Months	Lag years																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
SWMS	P																					N	N
NEMS							N						P			P			N				
Kharif	P						N																
Rabi													P						P	N			
June			N							N												N	
July	P													P									
August																				N			
September			N		P														P			N	N
October							N												N			N	
P- Positive significant SCC; N- Negative significant SCC																							

Table.3 Auto-regression models forecast of district wise annual rainfall in north Karnataka

District	Model Developed	R^2
Bagalkot	P= -0.432 (L7) + 670.04	**0.21**
Ballari	P= -0.318 (L23) + 649.24	**0.35***
Belagavi	P= -0.523 (L7) + 1500.35	**0.50****
Bidar	P= -0.549 (L4) -0.237 (L22) + 1660.1	**0.61****
Dharwad	P= 0.457 (L1)-0.277 (L6) +614.4	**0.56****
Gadag	P= -0.343 (L15) + 830.06	**0.31***
Haveri	P= 0.188 (L19) +0.208 (L21) +738.77	**0.30***
Koppal	P= -0.378 (L7) +894.215	**0.36***
Kalaburgi	P= 0.11 (L1) + 0.234 (L19) +467.71	**0.24**
Raichur	P= 0.421 (L19) + 376.786	**0.41****
Vijayapura	P= 0.432 (L11) - 0.365 (L22) + 613.962	**0.48****
Uttara Kannada	P= 0.258 (L15) + 2463.63	**0.28***
Yadgiri	P= 0.339 (L1) + 555.429	**0.35***

**Significant at 1% level *Significant at 5% level

Table.4 Auto-regression models for monthly and seasonal rainfall at Dharwad

Month	Model Developed	R^2=
June	P= -0.271 (L10) + 146.71	**0.29**
July	P= 0.307 (L1) + 99.88	**0.31***
August	P= -0.314 (L20) + 147.45	**0.55****
September	P= 0.284 (L19) + 78.42	**0.57****
October	P= -0.415 (L7) + 140.56	**0.42***
Kharif	P= 0.360 (L1) + 241.07	**0.68****
Rabi	P= 0.326 (L19) + 0.313 (L13) + 64.67	**0.36***
SWMS	P = 0.471 (L1) + 252.47	**0.47****
NEMS	P=-0.296(L7)+0.243(L19)+0.264(L16)+180.84	**0.58****

**Significant at 1% level *Significant at 5% level

Table.5 Correlation coefficient between actual and hindcasted values of district wise annual rainfall in the north Karnataka

District	Correlation coefficient
Bagalkot	**0.18**
Ballari	**0.37***
Belagavi	**0.50****
Bidar	**0.61****
Dharwad	**0.57****
Gadag	**0.29***
Haveri	**0.30***
Kalaburgi	**0.14**
Koppal	**0.29***
Raichur	**0.44****
Uttara Kannada	**0.31***
Vijayapura	**0.46****
Yadgir	**0.24**

**Significant at 1% level *Significant at 5% level

Table.6 Correlation coefficient between actual and hindcasted monthly and seasonal rainfall in Dharwad district

Months/Seasons	Correlation coefficient
June	**0.30***
July	**0.29***
August	**0.33***
September	**0.31***
October	**0.27***
Kharif	**0.34****
Rabi	**0.42****
SWMS	**0.45****
NEMS	**0.34***

**Significant at 1% level *Significant at 5% level

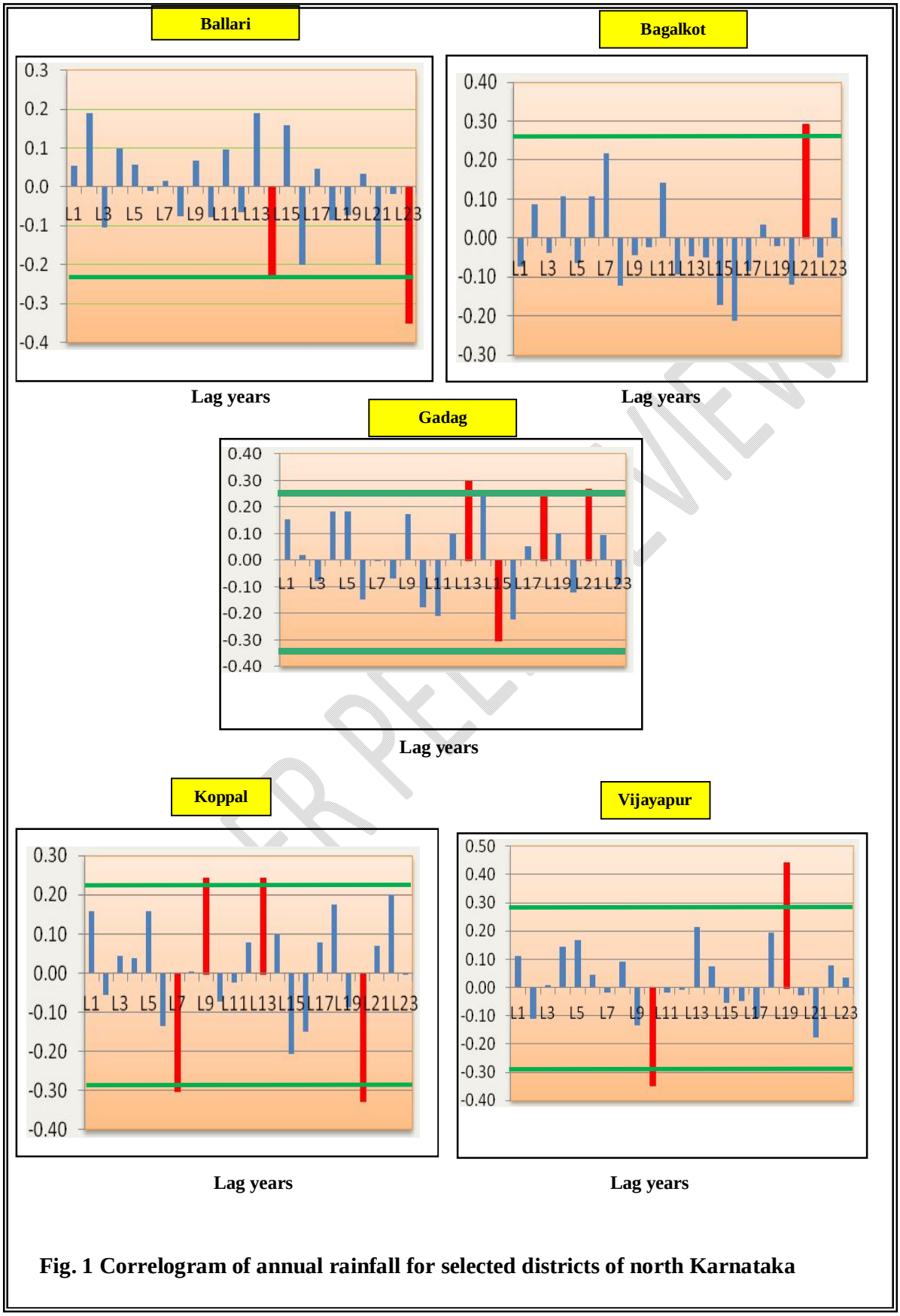

Fig. 1 Correlogram of annual rainfall for selected districts of north Karnataka