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Rainfall characteristics of Pampa river basin, Kerala: A time series analysis

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***Abstract*— Kerala, one of the smallest States of South India, is blessed with forty-four rivers. The holy river of Pampa is the third largest river in the State of Kerala, 176km long with a catchment area of 2235Sq.km. Recurring tropical monsoon floods during every season is one of the perennial problems experienced in this river basin. Substantial damages including loss of human life and properties and also total destruction of the crops due to frequent floods are common features of this river basin. Hence understanding general rainfall trend in the river basin and its underlying features are very vital in meaningfully understanding the flood phenomena and its socio-economic impacts. The present study evaluates the general trend of rainfall in the Pampa river basin, utilising the data collected from five gauging stations. The time series of monthly and annual rainfalls for the past three decades have been analysed using statistical techniques. Standard statistical criteria have been employed to identify the models in the analysis. Significant changes have been observed in the basin rainfall features – both seasonal and annual rainfall. The changing rainfall pattern observed in this study and their socio-economic impacts have been discussed.**

Key words – Rainfall; Time series analysis; Statistical trend analysis

I. INTRODUCTION

Kerala, the southernmost State of India, is known for its high level of socio-economic growth, commendable literacy level and improved health care standards. The rapid socio-economic transitions occurred in the State in the past few decades resulted in extensive urbanisation. The ecology of the State underwent radical changes consequent to these transitions. The massive ecological transitions had obvious impacts on the tropical monsoon fed rivers of the State also – which acted as the socio-cultural lifeline of the State. Hence, studies on the river basin characteristics form an intrinsic part of the review of the development scenario of the State.

While evaluating the performance of monsoon fed rivers, examining the rainfall characteristics is of immense importance. A few such regional studies have rendered unique and divergent features of the river performance [1, 2]. Further, a few regional rainfall analyses relevant to Kerala brought out significant micro level features that differ from the gross rainfall characteristics of the State [3, 4, 5]. However, most these studies primarily focussed on the northern regions of the State of Kerala like Palakad and Bharathappuzha basin. In this backdrop, in order to have a better understanding on the changes in the rainfall pattern in central region of the State, the rainfall characteristics of the Pampa River – flowing through the heart of the region- is examined in this paper. The rainfall trend on different spatial and temporal scales of Pampa River basin is reviewed with the help of past data processed statistically.

II. STUDY AREA

This study focuses the Basin of Pampa River, shown in Figure 1. This river, approximately 176km long, encompasses a basin area of about 2235sq.km. The basin stretches over four districts of the State viz., Idukki, Kottayam, Pathanamthitta and Alappuzha. The area extends over dense tropical monsoon forests, semi urbanized settlements, one famous pilgrim center – Sabarimala and also a rich agricultural (rice) bowl of Kerala, called Kuttanad. The study basin

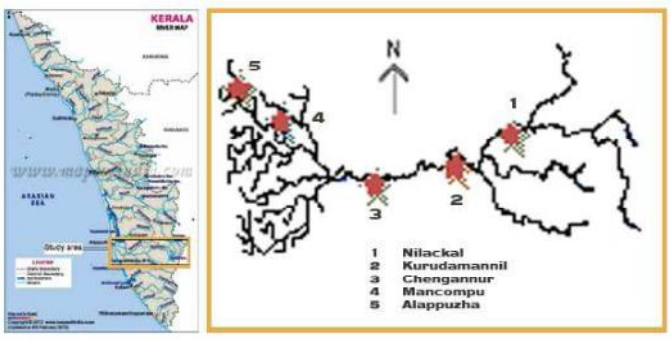

Fig.1 Study area and the rain gauge stations in Pampa river basin

lies between 76°23' to 77°20' East in longitude and 9°14' to 9°30' North in latitude. With humid tropical monsoon climate (average annual rainfall 3600mm with summer rains constituting about 10%) the basin experiences two distinct rainy seasons, South-West monsoon (June to September) contributing about 60% of the rainfall and North-East monsoon (October to December), providing about 30% of the rainfall. With a relative humidity of 70 to 90%, the study area experiences a temperature in the range of 21 to 36° C. The peak altitude of the basin is about 1677 m (at the origin of the river) and while flowing through a distance of about 176 km the river reaches the sea level and joins the Vembanad Lake and finally Arabian Sea. In this river basin there are only five rain gauge stations viz., Nilackal, Kurudamannil, Chengannur, Mancompu and Alappuzha. The particulars of these rain gauge stations are shown in table1.

Table 1. Particulars of rain gauge stations

Station numbers	Rain gauge station	Latitude	Longitude	Annual rainfall (mm)
1	Nilackal	9°23'	76°80'	3496
2	Kurudamannil	9°21'	76°44'	2941
3	Chengannur	9°19'	76°36'	2873
4	Mancompu	9°26'	76°31'	2804
5	Alappuzha	9°29'	76°20'	2890

III. DATA

Monthly rainfall data for the period from 1991 to 2013 for two downstream stations viz., Alappuzha, Mancompu and one mid-stream station (Chengannur) were collected from the Regional Centre of Indian Meteorological Department (IMD) at Thiruvananthapuram. However, in respect of the other two stations – Kurudamannil (a mid stream station) and Nilackal (upstream station)- the data were available only for a limited period from 2000 to 2012 with the Data Dissemination Centre, Department of Irrigation, Government of Kerala and the same was adopted for this study. The annual rainfall data for the State of Kerala for the whole period of analysis ie: 1991 to 2013 have been collected from the economic review reports available in website of the Planning Board, Government of Kerala. The data, for the purpose of analysis, have been grouped into the following four seasons corroborating with the IMD classification of seasonal rainfall. i) No-monsoon season: January to March ii) Pre-monsoon season: April to May iii) South-West monsoon season: June to September and iv) North-East monsoon season: October to December.

IV. METHODOLOGY AND ANALYSIS

The linear trend applicable for the data, over the period of study was analysed statistically. To have a gross idea on the general characteristics of rainfall in the basin, average annual rainfall data, taking all the five stations together have been initially used. The temporal change in the annual rainfall was compared with the annual rainfall of the State of Kerala for the period from 1991 to 2012. The graph showing the variation in the general rainfall pattern is given in fig 2.

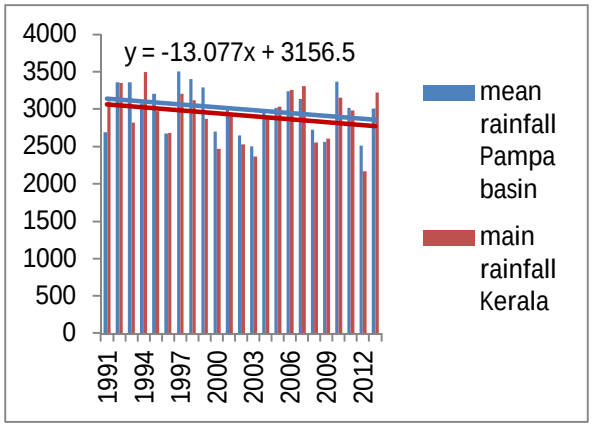

Fig.2. Comparison of rainfall of Pampa river basin and Kerala State

Further, the annual rainfall for the five individual rain gauge stations have been analysed in comparison with the rainfall pattern of the Kerala State. These are illustrated in figures 3 to 7. The statistical parameters relevant to the above trends are provided in table 2. The presence of trend in annual variations has been computed using SPSS10 using regression computations and the same have been utilized for analyses in the ensuing sections of this paper. To have a detailed examination on the rainfall trend during the seasons, climatological trend analyses of rainfall of all the five independent stations have been separately attempted for the four seasons distinctively. The pictorial representation of seasonal rainfall of all five rain gauge stations is provided in figures 8 to 12. The mean, maximum, minimum along with the standard deviation of these five stations also have been separately summarized in table 3.

Table 2. Statistical parameters of trend in annual rainfall in Pampa basin and Kerala

Sl. No	Station	Trend parameters for annual rainfall	
		Slope	Constant
1	Alappuzha	-20.6	3137
2	Chengannur	-63.1	3633
3	Mancompu	11.14	2780
4	Nilackal	70.07	3016
5	Kurudamannil	-42.05	3190
6	Kerala average	-13.18	3074

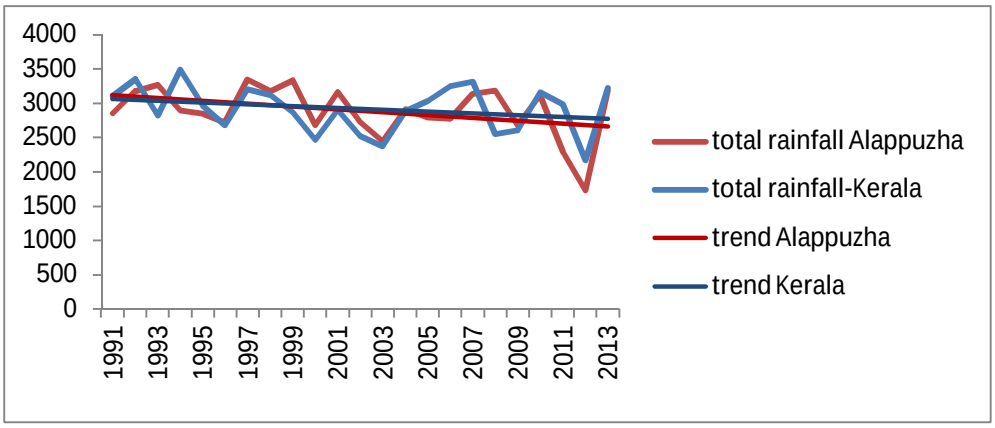

Fig 3. Comparison of annual rainfall of Alappuzha and average annual rainfall of Kerala

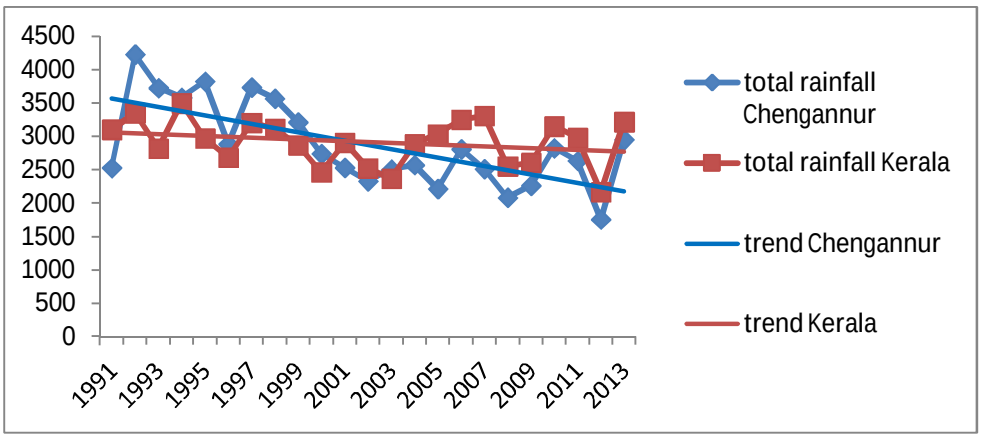

Fig 4. Comparison of annual rainfall of Chengannur and average annual rainfall of Kerala

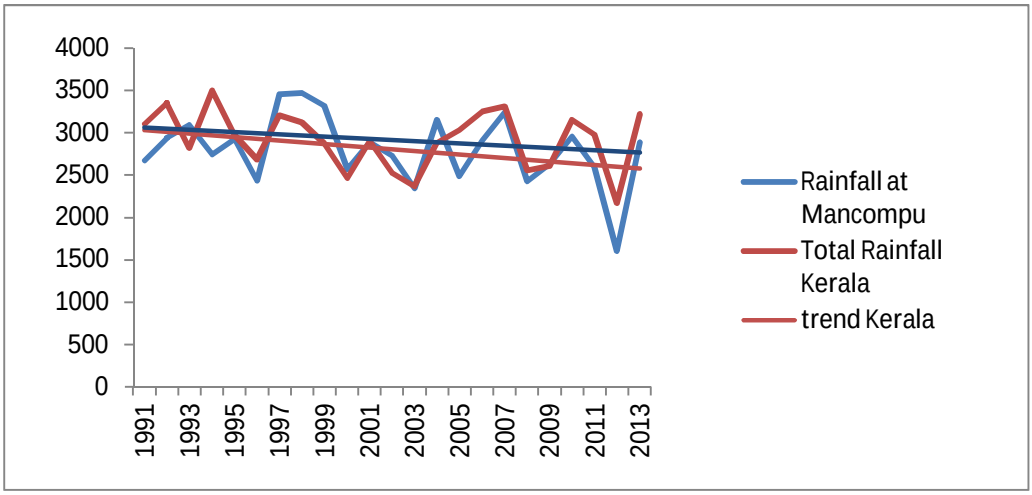

Fig 5. Comparison of annual rainfall of Mancompu and average annual rainfall of Kerala

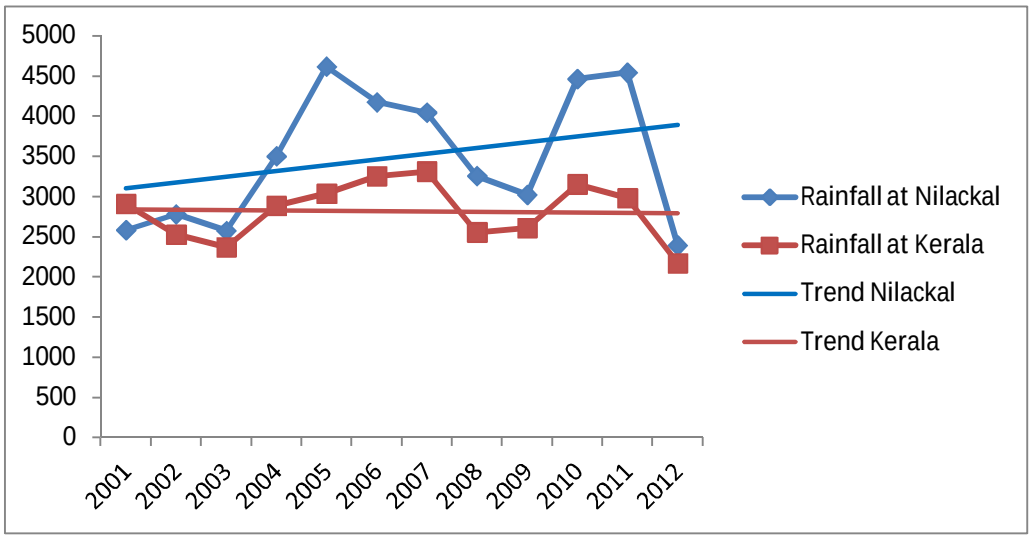

Fig 6. Comparison of annual rainfall of Nilackal and average annual rainfall of Kerala

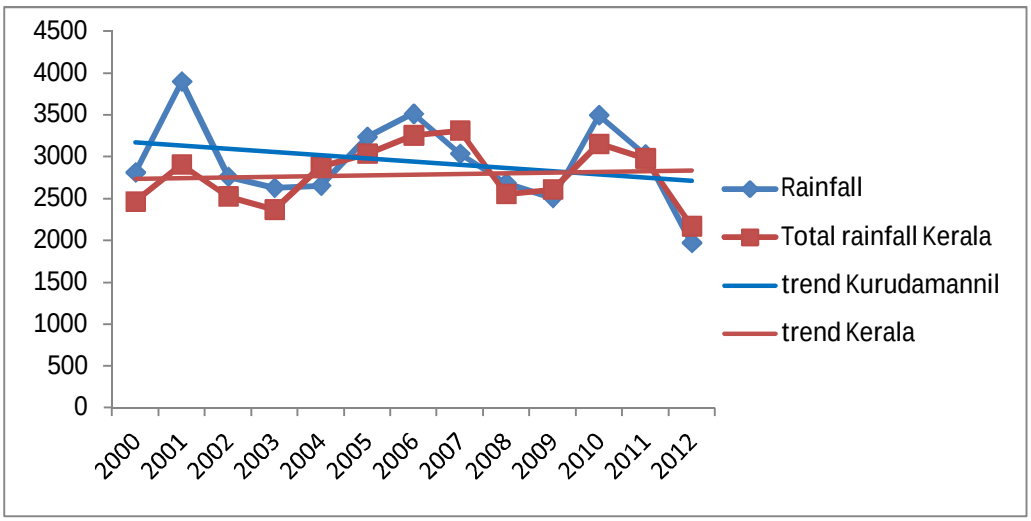

Fig 7. Comparison of annual rainfall of Kurudamannil and average annual rainfall of Kerala

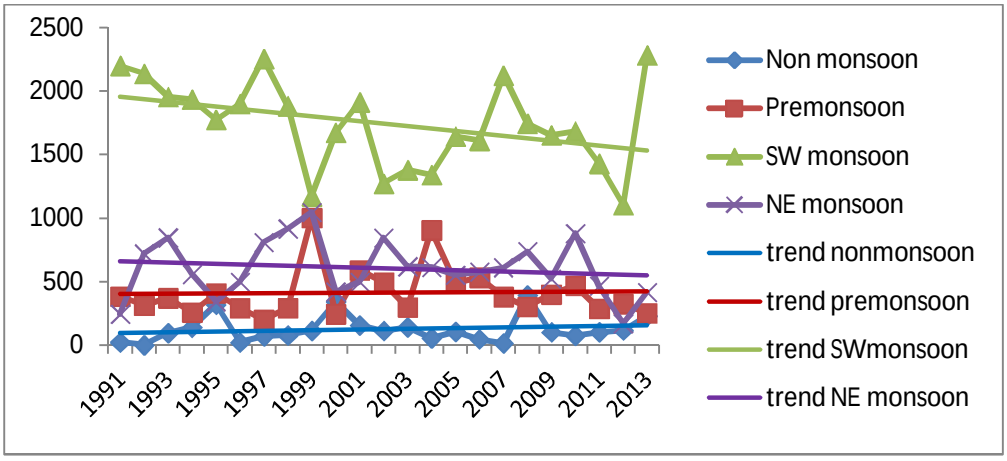

Fig 8. Seasonal rainfall at Alappuzha

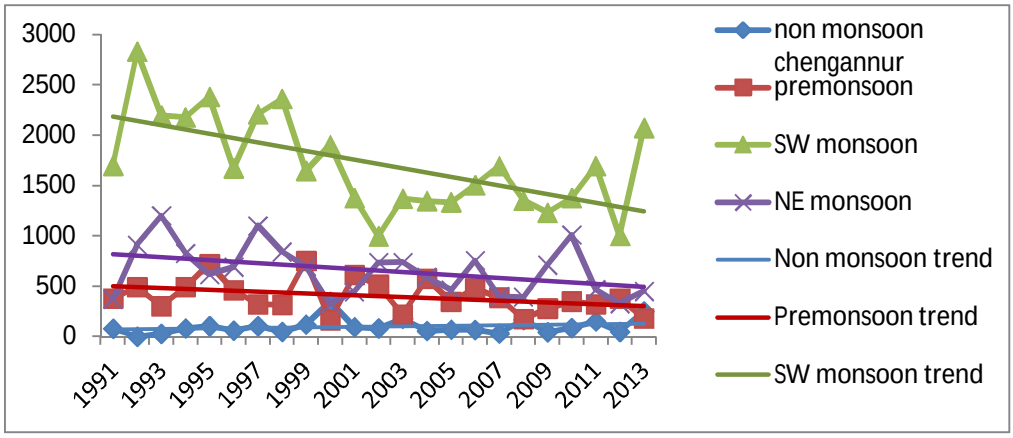

Fig 9. Seasonal rainfall at Chengannur

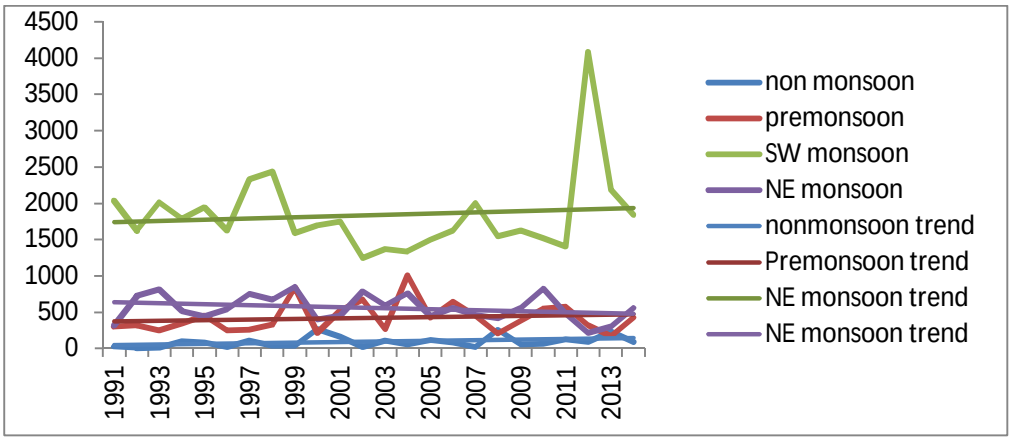

Fig 10. Seasonal rainfall at Mancompu

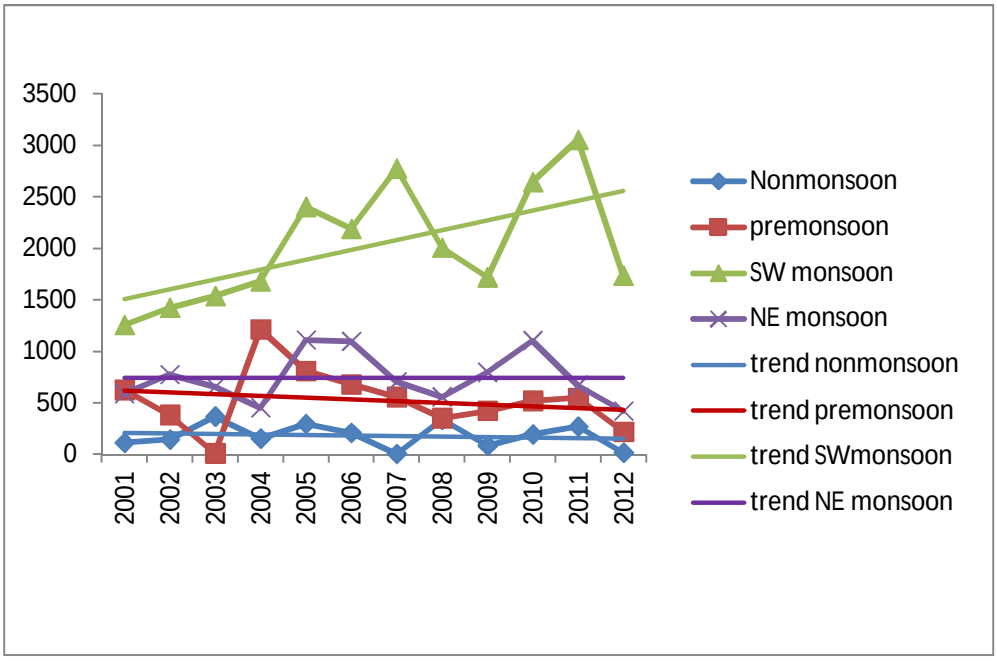

Fig 11. Seasonal rainfall at Nilackal

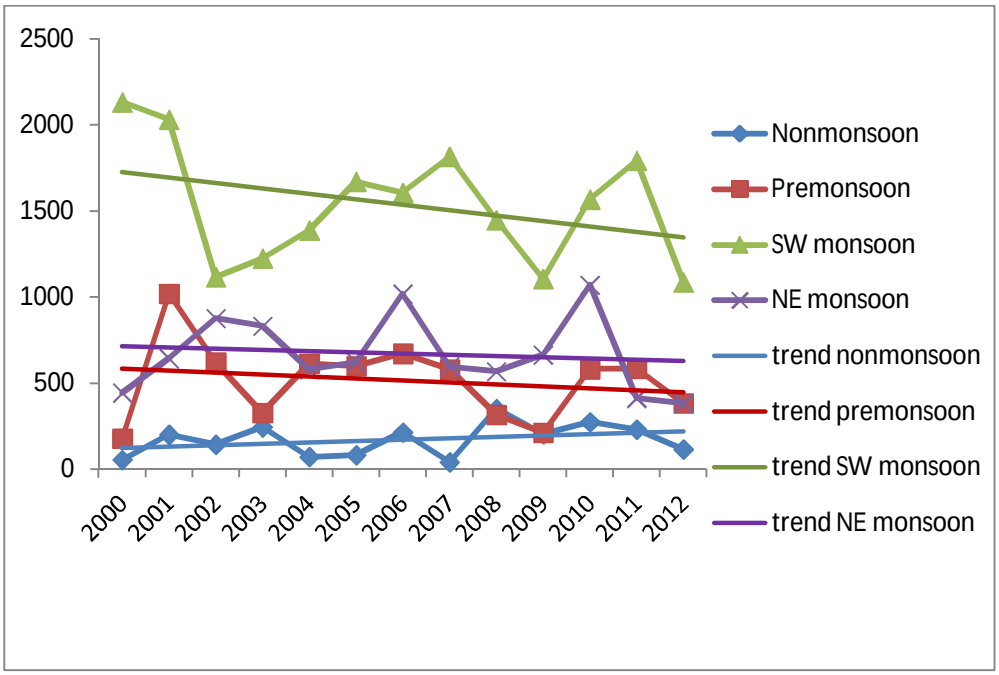

Fig 12. Seasonal rainfall at Kurudamannil

Table3. Summary of statistical properties of station-wise annual and seasonal rainfall

Annual/Seasonal	Mean	Maximum	Minimum	Standard Deviation
Alappuzha				
Annual	2890	3339.9	1725.7	378.5
No monsoon	138.2	396.5	3.1	104.1
Pre-monsoon	442.6	1002.8	201.6	198.2
S-W monsoon	1741.9	2281.6	1104.6	343.9
N-E monsoon	606.4	1046.2	173	220
Chengannur				
Annual	2872.8	4232.2	1759.3	638.1
No monsoon	100.7	346.8	0	77.5
Pre-monsoon	401.6	751.8	166.8	162.4
S-W monsoon	1714.7	2830.2	997.8	477.9
N-E monsoon	655.8	1200.2	325.2	249.9
Mancompu				
Annual	2804.2	3470.8	1603.1	415.3
No monsoon	92.3	268.4	4.5	76.9
Pre-monsoon	425.4	1006.5	168	212.6
S-W monsoon	1837.2	4081.7	1243.9	582.7
N-E monsoon	559.8	851.7	213.2	183.2
Nilackal				
Annual	3495.8	4617.1	2391.6	839.4
No monsoon	182.4	367.5	5.8	118.6
Pre-monsoon	528.7	1215	10	303.2
S-W monsoon	2034.7	3052.6	1254.5	576.9
N-E monsoon	745.4	1110.1	420.2	244
Kurudamannil				
Annual	2940.7	3899.3	1971.4	506.6
No monsoon	172.7	352.2	43.2	94.7
Pre-monsoon	515.5	1021.2	179.6	226.8
S-W monsoon	1537.3	2131.6	1086.4	348.6
N-E monsoon	670.8	1071	384.4	219.3

V. RESULTS AND CONCLUSIONS

A. General rainfall pattern

Recent significant trend analysis studies showed that monsoon as a whole is shrinking in India [6]. The annual rainfall at the Pampa river basin also, during the period under study showed a substantial shrinkage. However, it is significant to note that this river continually received a higher rainfall compared to that of the State of Kerala, throughout the period of study. A consistent decrement in the rainfall in the river basin, though corroborating with the rainfall trend of the state, is a matter of concern, primarily considering the major monsoon dependent agricultural pattern of the basin. The shrinking rainfall trend will have a major negative impact on the agricultural prospects mainly at Kuttanad, known as the rice bowl of Kerala located in this basin.

B. Station wise analysis

From the station wise trends provided in figures 9 to 13, it can be seen that the rain gauge station located at the upstream of the river – Nilackal – has a distinctive and unique pattern and trend, both in maximum and seasonal rainfall. Nilackal, during the period of study recorded a minimum of 2391.6mm and a maximum of 4617.1mm of annual rainfall, which is about 10% and 30% above the Kerala average respectively. Further, this station shows a higher positive trend during the Southwest monsoon alone while the rainfall during the other seasons remains more or less stable. This is a significant observation for a gauging station on the upstream of the river, which predominantly contributes to the recurring and severe monsoon floods in the Pampa river basin. This can be an important consideration while formulating flood mitigation measures for the basin. The rainfall pattern in the midstream and downstream stations remained more or less stable during the pre-monsoon and no-monsoon periods, whereas, during the Southwest monsoon and Northeast monsoon periods all these stations showed a homogeneous negative trend. The shrinking monsoon rainfall can have a major negative impact on the agro-ecological sustainability of the basin, which may converge quickly to a drought.

The high positive trend in monsoon rainfall of the upstream rain gauge station, read in conjunction with the severe negative trend of the downstream stations do not provide an overall prospective picture of the river performance. The overall trend can provide a significant decrease in the socio-agricultural dynamics of the basin in particular and the State in general. It is also worth to infer that in the upstream raingauge station, namely Nilackal, the South-West monsoon rainfall intensity alone has substantially increased whereas the mean annual rainfall pattern remained stable, which testifies that the rainfall intensity during the short spell of South-West monsoon alone was escalated showing a radical change in the climatic factors. The impacts of this perhaps require a closer hydrological examination. From the whole analysis it is clear, however, that the present trends are those of a shrinking monsoon and do not positively contribute to the basin development.

VI. CONCLUSIONS

This study examined the general rainfall pattern in the Pampa River basin using data from five rain gauge stations. Annual rainfalls as well as seasonal rainfalls at these five rain gauge stations have been analysed separately. The study revealed that while the trend of rainfall in the upstream station viz., Nilackal showed an increasing trend both in terms of annual and seasonal periods, the rainfall at this station remained always higher than the rainfall parameters for the State of Kerala. However, in respect of the other four stations the study observed significant decrementing trend in annual as well as seasonal rainfall. The decreasing trend in annual rainfall may have a serious influence on the agricultural production of this lower basin, which is known as the rice bowl of Kerala. Further, the seasonal incremental trend in the monsoon rainfall at the upstream station viz., Nilackal indicates increased flood hazards, which may require separate attention in hazard mitigation planning. As a whole the rainfall pattern of this basin does not show a promising and optimal trend.

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