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Temperature, Rainfall, and Rainfall Recharge of the Kakodonga River Basin, India

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Abstract: ***The Kakodonga river basin covered an area is about 1,113 km^2. The aim of this paper to analyses the temperature and rainfall characteristics that is average temperature, rainfall, rainfall intensity, rainfall variability and rainfall ratio of the Kakodonga river basin. The daily temperature and rainfall data for a period of 30 years is collected, converted and computed to monthly, seasonal and annual basis for eleven rain-gauge stations. The average maximum temperature is 28.5^{0}C and minimum temperature is 18.4^{0}C of the basin. The average rainfall of the basin is 1766mm and total surface of water resources are 1,965,558,000m^3. The average annual recharge of the basin is 327mm. The total ground water resources of the basin have been estimated to be 363,951,000m^3. In the present paper an attempt to study of rainfall analysis of seasonal, annual and rainfall recharge of the Kakodonga river basin. The data can be used for sustainable management and optimum utilizes the resources for sustainable development and other hydrological studies in future. The present study helpful to estimates the future flood zones and to avoid floods to construct the nalla bunds, small ponds, percolation ponds, stone wall, contour trenching, check dams, plantation and afforestation.***

Key words: Rainfall, Rainfall intensity, Rainfall variability, Rainfall ratio, Rainfall recharge, Temperature

1. Introduction

India is a developing country where agriculture is the main economic activity. With increasing population and decreasing per capita availability of water there is a need for careful planning and utilization of water resources. Water plays a crucial role in the optimum utilization and conservation of water. The study on water resources planning and development has been developed for the river basins (Akhter *et al*, 2013). The surface water resources of a region has to be carefully evaluated by a systematic study of the distribution of rainfall data collected from the available rain gauge stations over a period of time (Nayak, 2011; Jakhar, 2011). Of all the climatic parameters rainfall is an important input, which controls the total cropped area under rained conditions. The timely accuracy of the rainfall is important for crop growth. Any serious departure from the normal rainfall leads to a great stress. Moisture is an important factor in all the crop produced areas. The normal rainfall is necessary for successful crop production. The surface water resources evaluation is an important aspect in understanding the nature of vegetation and the peculiarities in its variations for planning and development of agriculture (Subash *et al*, 2012). Water resources are important study of water input in the form of rainfall and water loss in the form evaporation and evapotranspiration (Patel, 2009). It is a part of Applied Climatology (Singh and Gurjar, 2011) used for identification of water surplus and water deficit zones in a region or basin. It plays an important role in development of agriculture, hydrology and especially for water resources management. It is well established that water supply to a region is primarily through precipitation and water loss is entirely due to evaporation and evapotranspiration.

Sharma and Sharma (2010) remarked that land use and precipitation significantly affect the ground water recharge (GWR) and the sediment yields and heavy rainfall and the anthropogenic intervention are important factors affecting GWR in the NE region. Sharma and Thakur (2007) expressed their views that the quantitative estimation of water balance is essential in land and water resources development not only for economic appraisal of the project but also for assessing the reliability and sustained availability of water needs in the long run. Singh and Sharma (2010) and Nanaware *et al* (2009) discussed that periodic assessment of groundwater resources should be given top priority on the behalf of water resource managers. Ground water regulatory measures need to be imposed in severely over exploited area through pro active approach. Water resource development and management should be carried out on watershed, being a hydrological unit, integrating both surface and sub-surface water availability, closely in turn tied with land use practices, this is the notion highlighted by Das (2013). Sharma and Dubey (2013) describe rainfall analysis and planning of water harvesting and irrigation in semi arid region. Rainfall analyses for crop planning in Uttarakhand illustrated by Tripathi (2009).

The Kakodonga River originates in Naga Hills near Lio Longidun village of Wokha district of Nagaland state and it flows north western direction in Assam before joining the Gelabil River, Gelabil River, Bhogdoi River, and Dhanshiri river finally discharge to the Brahmaputra. The major tributaries of the Kakodonga River are 1. Ghiladhari, 2. Chelcheli nalla, 3. Bajalkate nalla, 4. Soriipani nalla, 5. Kasojan, 6. Dholi river. The maximum altitude is 760m above MSL. It is located near Bhandri village of Wokha district of Nagaland and southeastern part of the basin. The minimum altitude of the basin is 80m above MSL. It is located near Darikamari village of Assam state. The land use of the Kakodonga basin has been identified are cultivated land under wet conditions through bore wells, tank and canal irrigations. They are found mostly in valley fill soils and fluvial plains. The major soils of the Kakodonga basin are alfisols, entisols, inseptisols, and mountain soils.

The study comprises an area of about 1,113sq. km., and a geographically located between 26^0 15'10"N to 26^0 44'48"N latitude and 93^0 59'10"E to 94^0 21'45"E longitude in Survey of India Topographic sheets. The Kakodonga river basin is one of the important southern sub-tributaries of mighty River Brahmaputra (Fig.1). The river originates from Naga Hills and flow in the course of Assam. It is situated in the parts of Jorhat and Golaghat districts of Assam and Wokha district of Nagaland. A small portion of the basin is covered by Naga Hills in south and most of part belongs to Brahmaputra plain. The majority of the watershed covered an agricultural land, mainly tea gardens and paddy fields. During the rainy season the river inundate the low lying areas and causes heavy loss to property, lives and agriculture crops. Due to flood, river has more siltation and also change direction of flow.

2.Methods and Materials

1) For the preparation of base map and other thematic maps and survey of India topographic sheets 1:50,000 on scale as mentioned above and IRS P6 LISS III imagery (23.5mt resolution), 2010 have been consulted. All the topographic sheets and imageries are geo-referenced. Digitization and all the mapping works are done in GIS environment using Arc GIS and ERDAS Software. The monthly temperature and rainfall data over a period of 30 years are collected from eleven rain-gauge stations. They are well distributed in and around the Kakodonga river basin to analyze the rainfall data. The water resources of the basin are studied by analyzing rainfall data on monthly, seasonal, and annual basis. The surface water resources of the basin are also worked out based on mean annual rainfall and geographical area of the basin. The statistical methods adopted by Bhargava (1977) are used for the analysis of annual mean rainfall, rainfall intensity, rainfall variability and rainfall ratio.
2) .According to Radhakrishna *et al* (1974) Method the rainfall recharge of the basin is 10% of the annual rainfall, U. S. Geological Method (1962) the annual rainfall recharge of the basin is 15% of the annual rainfall, Seghals' (1970) has worked out the ground water recharge as $G = 2.5 (P-16)^{0.5}$ where precipitation is in inches and according to Krishna Rao (1970) method the annual recharge R = 0.20 (P-400) when precipitation is between 400mm to 600mm, R = 0.25 (P-400) when precipitation is 600 to 1000mm and R = 0.35 (P-600) when precipitation is above 1000mm. Based on rainfall recharge and specific yield data the ground water resources of the basin are also worked out.

3.Results and Discussion

3.1 Temperature

The average monthly temperature in Kakodonga river basin varies from a maximum of 33.6^0 C in July of Sycota rain-gauge station to a minimum of 9.1^0C in January month of Sycota rain-gauge station (Table 2 and 3). The average monthly maximum temperatures are less than 30^0C in January, February, March, April, October, November and December months. The average monthly maximum temperatures are above 30^0C in May, June, July, August and September months. The mean maximum temperature varies from 31.5^0C in July and August months to a mean minimum of 29.1^0 C in December month. The mean maximum temperatures are above 22.5^0Cin January month. The minimum average temperature in January is 9.7^0C. the mean maximum annual temperature is 28.5^0C. The mean minimum annual temperature is 18.4^0C.

The mean annual temperature in Kakodonga river basin varies from a maximum of 29.80^0 C in Honowal rain-gauge station to a minimum of 17.15^0 C in Wokha rain-gauge station (Table 4). The average monthly maximum temperatures are less than the average maximum and minimum temperatures vary from maximum of 38.97^0 C in Honowal station and minimum of 34.91^0 C in Wokha station. The mean maximum annual temperature is 28.5^0 C. The mean minimum annual temperature is 18.4^0 C.

3.2 Mean Rainfall analysis

The analysis of the mean rainfall of the Kakodonga river basin, it is shows that less than 100mm of rainfall in November, December, January, February and March months (Table.1 & Figure.2). The mean rainfall shows in the months of April, May and October varies from 100mm to 250mm. In the months of June, July, August and September rainfall ranges from 250mm to 500mm. The Garanga rain gauge station shows very less rainfall that is 3mm in December month, and maximum mean rainfall found Negheriting (569mm) rain gauge station in the month of July.

3.3 The Seasonal and Annual analysis of rainfall of the Kakodonga river basin

3.3.1 Winter

The mean seasonal rainfall during winter season varies from 23mm in Garanga station to a maximum of 99mm in Negheriting station (Table.6). The average winter precipitation of the basin is 62mm. The spatial distribution shows that the precipitation is less than 30mm in southwestern part of the basin (Fig.5). It ranges from 30mm to 70mm in central and northeastern parts of the basin. The rainfall intensity ranges from 6mm / a rainy day in Garanga station to a maximum of 16mm / a rainy day in Wokha station. The average rainfall intensity is 12mm / a rainy day. The spatial distribution shows that it varies from 10mm / a rainy day in southwestern part to a maximum of 15mm / a rainy day in northeastern, northwestern and southeastern parts of the basin. The rainfall variability value increases from 261% in Wokha station to a maximum of 669% in Garanga station. The spatial distribution shows that rainfall variability during this month is about 300% in northeastern and southeastern parts of the basin. It exceeds 650% in southwestern part of the basin. The rainfall ratio values increase from 684% in Sycota station to a maximum of 2082% in Borholla station. The spatial distribution shows that the rainfall ratio ranges from 800% in northeastern part to a maximum of 2000% in central and southeastern parts of the basin.

3.3.2 Pre-monsoon

In pre-monsoon season of the rainfall values varies from a minimum of 170mm in Garanga station to a maximum of

901mm in Negheriting station (Table.7). The average precipitation value of the basin is 473mm. The spatial distribution shows that the precipitation value increases from 180mm in southwestern to 480mm central and northeastern part of the basin (Fig.6). The rainfall intensity ranges from 15mm / a rainy day in Garanga station to a maximum of 43mm / a rainy day in Wokha and Negheriting station. The average rainfall intensity is 30mm / a rainy day. The spatial distribution shows that in the pre-monsoon season the rainfall intensity is less than 15mm / a rainy day in central part of the basin. It exceeds 40mm / a rainy day in northwestern and southeastern parts of the basin. The rainfall variability ranges from 122% in Wokha station to a maximum of 419% in Garanga station. The spatial distribution shows that the variability is less than 150% in northwestern and southeastern parts of the basin. It exceeds 400% in central part of the basin. The rainfall ratio during this season varies from 485% in Golaghat station to a maximum of 1459% in Borholla station. The spatial distribution of rainfall ratio minimum in the basin is 600% in western and northeastern parts of the basin. The maximum of 1300% is found in central parts of the basin.

3.3.3 Monsoon

The mean seasonal precipitation during monsoon varies from 303mm in Garanga station to a maximum of 1511mm in Negheriting station (Table.8). The average precipitation of the basin is 873mm. The spatial distribution shows that the precipitation is less than 400mm in central part of the basin (Fig.7). It ranges from 400mm to 900mm in central to northeastern parts of the basin. It exceeds more than 1300mm in northwestern parts of the basin. The rainfall intensity ranges from 20mm / a rainy day in Garanga station to a maximum of 63mm / a rainy day in Negheriting station. The average rainfall intensity is 39mm / a rainy day. The spatial distribution shows that the rainfall intensity is less than 20mm / a rainy day in central part of the basin. It increases from 30mm to 40mm / a rain day southeastern parts of the basin. It exceeds 60mm / a rainy day in northwestern part of the basin. The rainfall variability ranges from 61% in Golaghat station to a maximum of 392% in Garanga station. The spatial distribution shows that it is about 100% northeastern, northwestern and western parts of the basin. It exceeds 350% in southwestern part of the basin. The rainfall ratio value of a minimum of 173% is found in Golaghat station and a maximum of 1150% is found in Garanga station. The spatial distribution shows that the rainfall ratio is less than 300% in southeastern part of the basin. It exceeds 1000% in southwestern part of the basin. It ranges from 300% to 1000% in southeastern to southwestern parts of the basin.

3.3.4 Post-monsoon

In this post-monsoon the precipitation values vary from a minimum of 180mm in Garanga station to a maximum of 656mm in Negheriting station (Table.9). The average precipitation value of the basin is 356mm. The spatial distribution shows that the precipitation value increases from 200mm in southwestern part of the basin to 350mm in the southeastern and northeastern parts of the basin (Fig.8). The rainfall intensity varies from 15mm / a rainy day in Garanga station to a maximum of 36mm / a rainy day in Negheriting station. The average rainfall intensity is 29mm / a rainy day. The spatial distribution shows that in the post-monsoon season the rainfall intensity increases from 16mm / a rainy day in southwestern to southeastern and northeastern parts and 30mm / a rainy day in central part of the basin. The rainfall variability ranges from 164% in Golaghat station to a maximum of 543% in Garanga station. The spatial distribution shows that it is about 200% in central and northeastern parts of the basin. It exceeds 500% in southeastern parts of the basin. The rainfall ratio ranges from a minimum of 588% in Titabor station to a maximum of 1918% in Garanga station. The spatial distribution shows that the value is less than 600% in northern part of the basin. It exceeds 1900% in southeastern parts of the basin.

The seasonal analysis of the mean rainfall depict that the basin received the maximum rainfall of 873mm in monsoon season. In winter period the mean average rainfall is 62mm. During pre-monsoon period rainfall is 473mm and in post-monsoon period it is 356mm. The seasonal analysis of rainfall intensity indicates that in winter period it is less than 12mm / a rainy day. During pre-monsoon and post-monsoon periods it varies from 30mm to 29mm / a rainy day. It exceeds 39mm / a rainy day in monsoon period. The rainfall ratio values are above 363% during winter period. During pre-monsoon and post-monsoon period it varies from 211% to 236%. In monsoon period the rainfall variability is less than 127%. The rainfall ratio values are above 1204% in winter period. The ratio values vary from 800% to 700% in pre-monsoon and post-monsoon periods. During monsoon period there is greater stability it is 433%.

3.3.5 The Annual analysis of rainfall of the Kakodonga river basin

The mean annual precipitation varies from 676mm in Garanga station to a maximum of 3168mm in Negheriting station (Table.10). The average annual precipitation of the basin is 1766mm. The spatial distribution of the precipitation is less than 600mm in south and western parts of the basin (Fig.9). It ranges from 600mm to 3000mm in west and northwestern parts of the basin. The rainfall intensity ranges from a minimum of 55mm / a rainy day in Garanga station to a maximum of 140mm / a rainy day in Wokha station. The average rainfall intensity is 110.6mm / a rainy day. The spatial distribution shows that the rainfall intensity is about 50 mm / a rainy day in western part and 100mm / a rainy day in northwestern parts of the basin. The rainfall variability varies from 638% in Wokha station to a maximum of 2023% in Garanga station. The spatial distribution shows that the rainfall variability is about 500% in southeastern part of the basin. It exceeds 2000% in western part of the basin. The rainfall ratio ranges from 2000% in Golaghat station to a maximum of 6062% in Garanga station. The spatial distribution shows that it ranges from 2000% in western part to a maximum of 6000% above in southwestern part of the basin

3.4. The rainfall recharge of the Kakodonga river basin has been worked out using Radhakrishna *et al.*, Method (1974), U. S. Geological Method (1962), Seghal Method (1970) and Krishna Rao (1970) Method:

According to Radhakrishna *et al.*, (1974) method the rainfall recharge of an area or basin is 10% of the rainfall. The

rainfall recharge varies from a minimum of 68mm in Garanga station to a maximum of 317mm in Negheriting station (Table.11 & Fig.10). The average of annual rainfall recharge is 177mm. According U. S. Geological method (1962) the annual rainfall recharge of an area or a basin is 15% of the annual rainfall. According to this method the minimum annual recharge of 101mm is found in Garanga station and the maximum recharge of 475mm is found in Negheriting station. The annual recharge of the basin is 265 mm. The Seghal's (1973) has worked out ground water recharge as $G = 2.5 (P-16)^{0.5}$ where precipitation is in inches. According to this method the annual rainfall recharge are relatively high. They vary from a minimum of 69mm in Garanga station to a maximum of 899mm in Negheriting station. The average annual recharge of the basin is 412mm. According to Krishna Rao (1970) method the annual recharge R = 0.20 (P-400) when precipitation is between 400 mm to 600mm, R = 0.25 (P-400) when precipitation is 600 to 1000mm and R = 0.35 (P-600) when precipitation is 1000mm and above 2000mm. The annual recharge varies from a minimum of 207 mm in Garanga station to a maximum of 662mm in Negheriting station. The annual recharge of the basin is 453mm. The average of the four methods is worked out for each station in the Kakodonga river basin. The average annual recharge varies from a minimum of 111mm in Garanga station to a maximum of 588mm in Negheriting station. The average rainfall recharge of the basin is 327mm. Rainfall recharged is total geographical area × mean annual recharge = 363,951,000 m^3

4.Conclusion

The present study area of the basin is about 1,113sq.km. The basin has six stream orders in the basin and overall drainage network shows dendritic pattern. The average maximum temperature is 28.5^0C and minimum temperature is 18.4^0C of the basin. The average rainfall of the basin is 1766mm and total surface of water resources are 1,965,558,000m^3. The average annual recharge of the basin is 327mm. The total ground water resources of the basin have been estimated to be 363,951,000m^3. The analysis of water resources of the Kakodonga river basin, it is found that the basin receives less than 100mm of rainfall in November, December, January, February and March, but in month of March Negheriting rain gauge station is more than 100mm rainfall of the basin. The maximum mean rainfall shows in the months of April, May, and October varies from 100mm to 250mm, but in Negheriting rain gauge station shows more than 250mm rainfall in above months. In the months of June, July, August and September rainfall ranges from 250mm to 500mm except the Garanga rain gauge station. The Garanga rain gauge station shows very less rainfall in all the months and maximum mean rainfall found Negheriting rain gauges station. The analysis of seasonal mean rainfall indicated that the basin receives maximum rainfall of 873mm in Monsoon period, 473mm in Pre-monsoon period, 356mm in Post-monsoon period and 62mm in Winter period. In the present paper an attempt to study of rainfall analysis of seasonal, annual and rainfall recharge of the Kakodonga river basin. The data can be used for sustainable management and optimum utilizes the resources for sustainable development and other hydrological studies in future. The present study helpful to estimates the future flood zones and to avoid floods to construct the nalla bunds, small ponds, percolation ponds, stone wall, contour trenching, check dams, plantation and afforestation.

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Figures and Tables

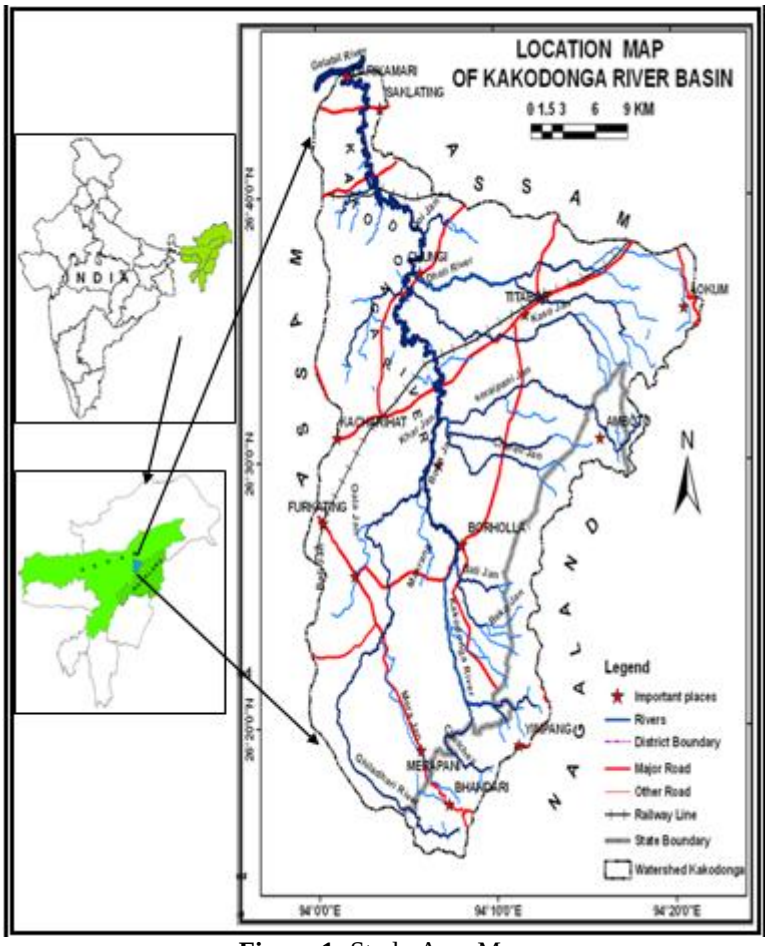

Figure 1: Study Area Map

Table 1: Mean rainfall (1983-2013) of the Kakodonga river basin

S.No.	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Jorhat	16	38	69	161	223	259	334	295	218	110	22	9
2	Garanga or Wokha TE	10	9	20	72	78	93	130	80	107	63	10	3
3	Wokha	14	35	89	154	277	388	389	311	245	131	26	13
4	Golaghat	13	32	76	167	168	215	291	224	164	95	10	3
5	Kamarbund	16	35	77	153	215	239	286	284	217	112	30	12
6	Honowal	20	45	71	213	252	287	344	314	261	110	31	14
7	Titabor	20	42	63	161	224	261	346	304	234	113	18	13
8	Borholla	32	34	91	159	243	247	275	305	181	103	19	8
9	Negheriting	24	58	192	302	408	493	569	450	407	223	26	17
10	Sycota	13	29	48	125	190	169	271	237	134	81	18	8
11	Khumtai	13	30	64	175	229	284	312	318	267	116	20	8

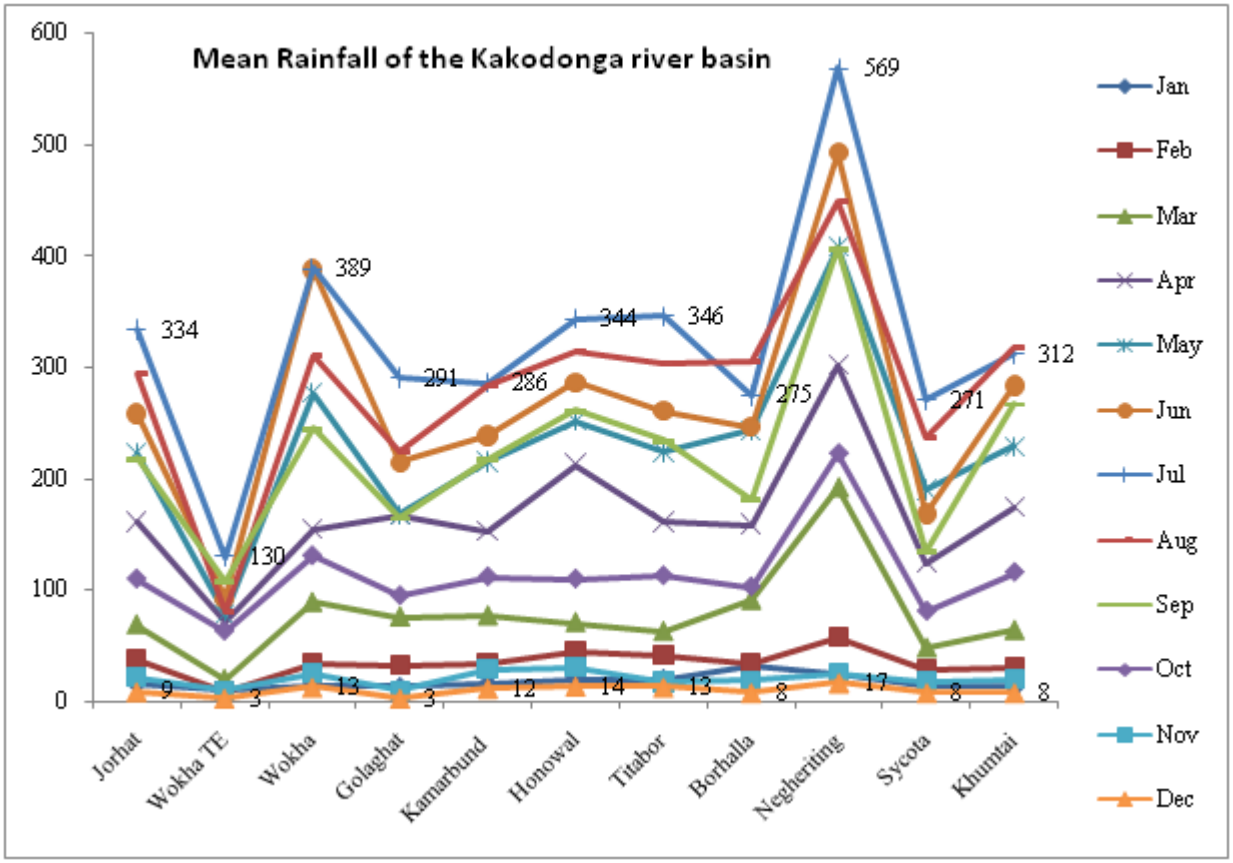

Figure 2: Mean Rainfall of the Kakodonga river basin

Table 2: Mean Maximum temperature in ^{0}C (1983-2013) of the Kakodonga river basin

S. No.	*Station*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1	Jorhat	22.6	24.5	27.1	28.3	30.6	31.7	31.9	32.3	31.5	30.1	27.4	26.6
2	Garanga or Wokha TE	22.3	24.2	27.5	28.5	29.3	30.0	30.1	30.3	30.0	29.2	26.8	23.5
3	Wokha	21.4	23.0	26.0	27.0	28.2	28.7	28.5	28.9	28.7	27.9	25.4	22.3
4	Golaghat	22.5	24.5	27.6	28.6	29.6	30.1	30.2	30.5	30.1	29.3	26.9	23.6
5	Kamarbund	22.4	24.2	26.9	28.2	30.8	31.9	32.2	30.3	31.9	30.2	27.2	25.4
6	Honowal	23.5	26.3	28.8	29.6	32.1	33.2	33.6	33.9	33.1	30.8	28.1	24.7
7	Titabor	22.8	25.6	27.4	29.4	31.0	32.2	32.4	32.4	32.2	30.2	27.1	24.3
8	Borholla	22.2	25.4	27.1	29.4	30.9	32.1	32.4	32.4	32.1	30.4	26.9	24.1
9	Negheriting	22.5	24.4	27.0	28.2	30.5	31.7	31.6	32.1	31.3	30.0	27.2	26.5
10	Sycota	23.2	26.1	28.9	29.5	32.2	33.2	33.6	33.2	32.9	30.8	28.2	24.8
11	Khumtai	22.4	24.4	27.6	28.6	29.5	30.0	30.2	30.3	30.1	29.2	26.8	23.5

Source: Compiled by the Author

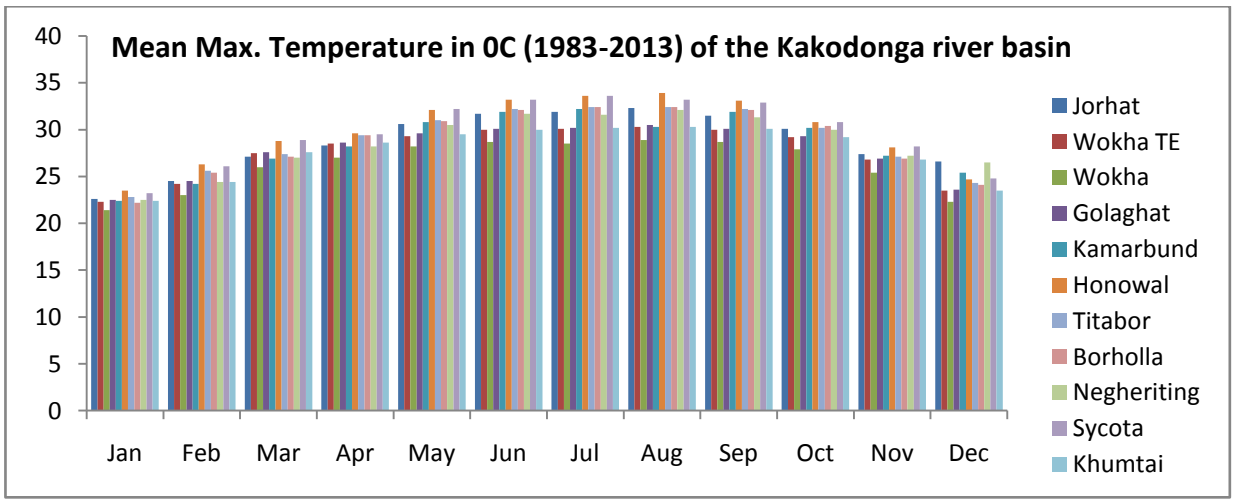

Figure.3

Table: 3 Mean Minimum temperature in ^{0}C (1983-2013) of the Kakodonga river basin

S. No.	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Jorhat	10.2	12.2	16.0	19.3	22.6	24.6	25.2	25.3	24.3	21.3	15.9	11.7
2	Garanga	10.0	12.4	15.6	18.5	20.8	23.3	23.6	23.7	22.9	20.5	16.1	12.1
3	Wokha	9.3	11.5	14.5	17.2	19.7	21.9	22.3	22.3	21.7	19.3	14.9	11.2
4	Golaghat	10.4	12.8	15.9	18.7	20.9	23.3	23.7	23.8	23.1	20.6	16.1	12.2
5	Kamarbund	9.9	10.0	15.8	19.1	22.6	24.6	25.0	25.0	24.3	21.4	15.7	11.4
6	Honowal	9.2	11.4	14.7	18.9	22.0	23.5	24.2	24.0	23.4	20.8	16.2	11.6
7	Titabor	9.5	12.3	15.3	19.6	22.6	24.4	24.5	24.7	24.3	21.6	15.8	11.2
8	Borholla	9.2	12.1	15.1	19.3	22.6	24.5	24.4	24.6	24.2	21.5	15.7	11.0
9	Negheriting	10.0	12.1	15.9	19.2	22.5	24.6	25.1	25.1	24.1	21.2	15.8	11.6
10	Sycota	9.1	11.1	14.9	18.9	21.9	23.4	24.1	24.2	23.5	20.9	16.1	11.8
11	Khumtai	10.3	12.5	15.8	18.4	20.5	23.2	23.7	23.6	22.9	20.4	16.0	12.1

Source: Compiled by the Author

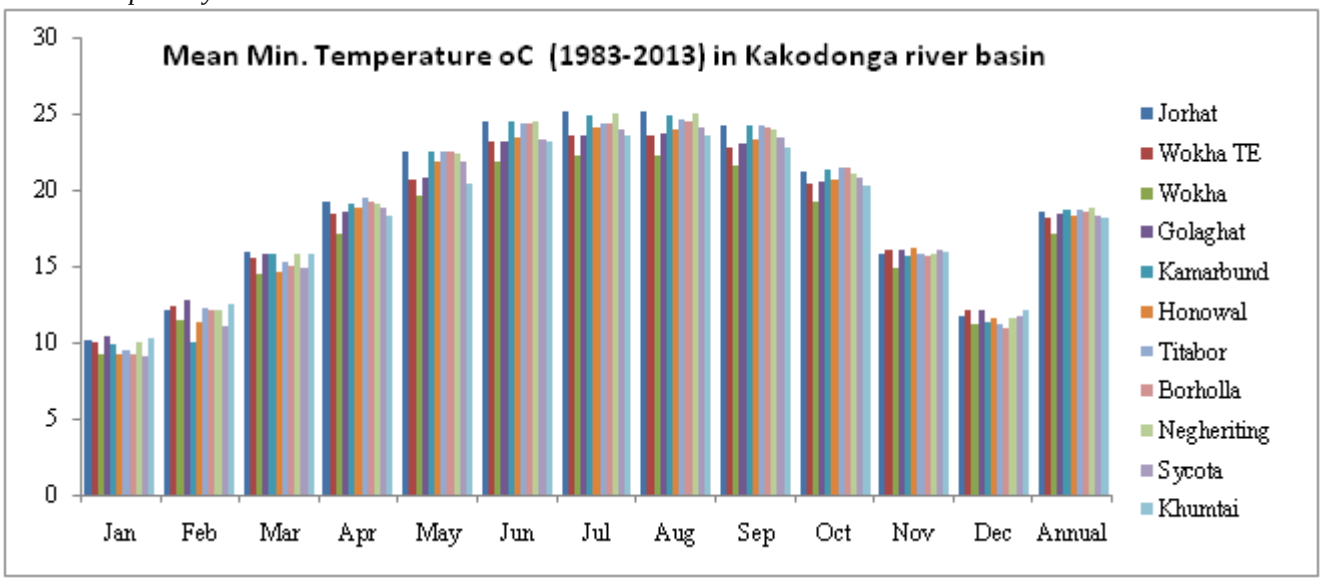

Figure 4

Table 4: Mean annual temperature in ^{0}C (1983-2013) of the Kakodonga river basin

S. No	Month	Mean Temperature in ^{0}C		
		Max.	Min.	Average
1	Jorhat	29.55	18.61	33.39
2	Garanga or Wokha TE	27.64	18.28	32.1
3	Wokha	26.33	17.15	30.32
4	Golaghat	27.80	18.46	32.36
5	Kamarbund	28.46	18.74	32.97
6	Honowal	29.80	18.33	33.23
7	Titabor	28.90	18.81	33.26
8	Borholla	28.77	18.67	33.06
9	Negheriting	28.60	18.94	33.24
10	Sycota	29.72	18.34	33.2
11	Khumtai	27.72	18.28	32.14

Source: Compiled by the Author

Table 5: Season Wise Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin

Seasons	Mean Rainfall in mm	Rainfall Intensity in mm/ a rainy day	Rainfall Variability in %	Rainfall Ratio in %
Winter	687	136	3993	13249
Pre-monsoon	5208	333	2324	8855
Monsoon	9605	432	1394	4760
Post-monsoon	3921	315	2591	8610

Source: Compiled by the Author

Table 6: Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin (Winter)

S. No.	Station	Mean rainfall in mm	Rainfall intensity in mm / a rainy day	Rainfall variability in %	Rainfall ratio in %
1	Jorhat	63	14	324	1001
2	Garanga	23	6	669	1635
3	Wokha	62	16	261	870

4	Golaghat	48	9	271	977
5	Kamarbund	63	14	351	1245
6	Honowal	79	14	282	1024
7	Titabor	75	13	308	1191
8	Borholla	74	15	474	2082
9	Negheriting	99	14	356	1080
10	Sycota	50	12	266	684
11	Khumtai	51	9	431	1460

Source: Compiled by the Author

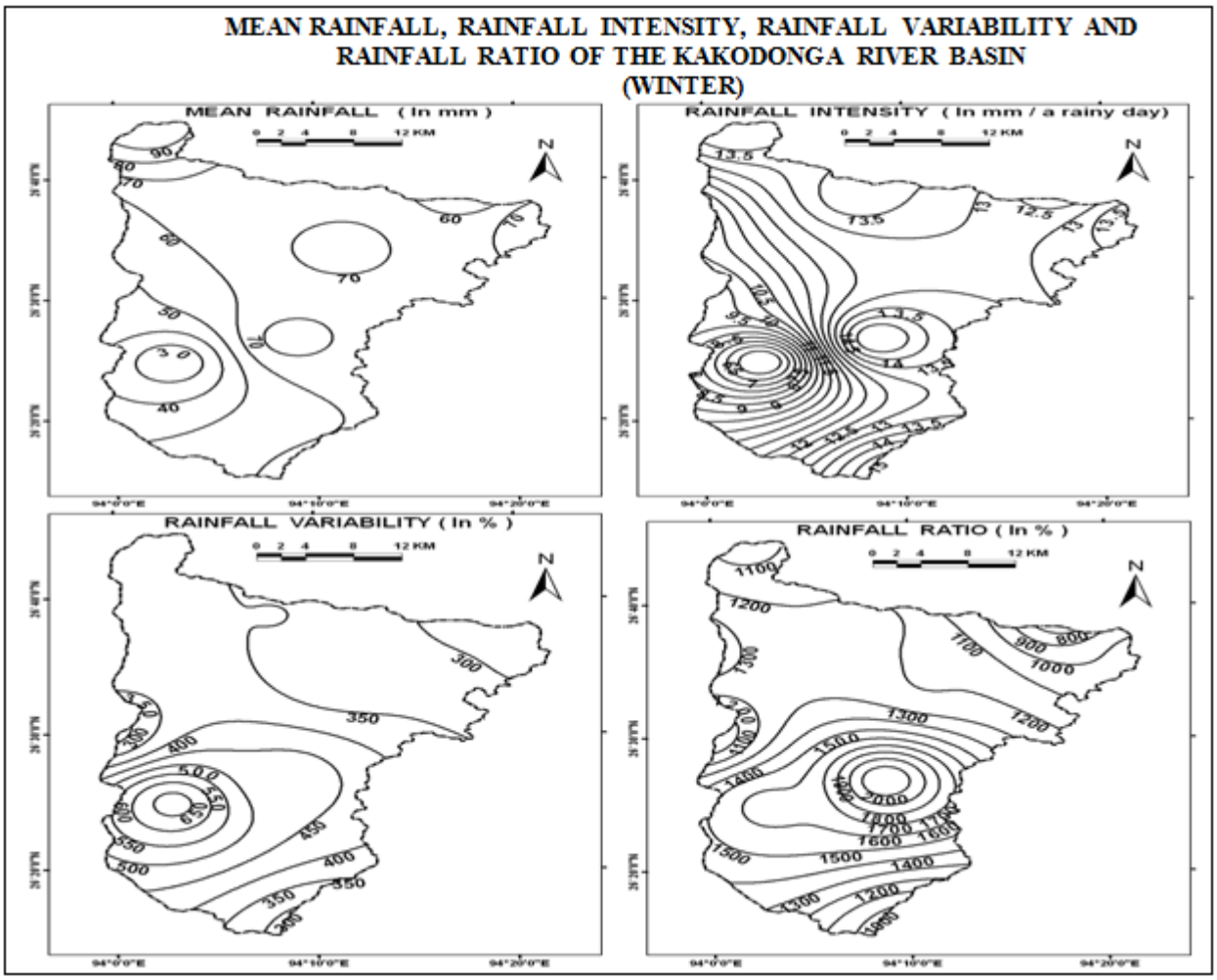

Figure 5

Table 7: Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin (Pre-monsoon)

S. No.	*Station*	*Mean rainfall in mm*	*Rainfall intensity in mm / a rainy day*	*Rainfall variability in %*	*Rainfall ratio in %*
1	Jorhat	453	29	163	645
2	Garanga	170	15	419	1359
3	Wokha	520	43	122	989
4	Golaghat	411	29	152	485
5	Kamarbund	445	29	180	591
6	Honowal	536	29	158	540
7	Titabor	449	28	179	698
8	Borholla	492	32	355	1459
9	Negheriting	901	43	248	900
10	Sycota	363	26	190	590
11	Khumtai	467	30	158	599

Source: Compiled by the Author

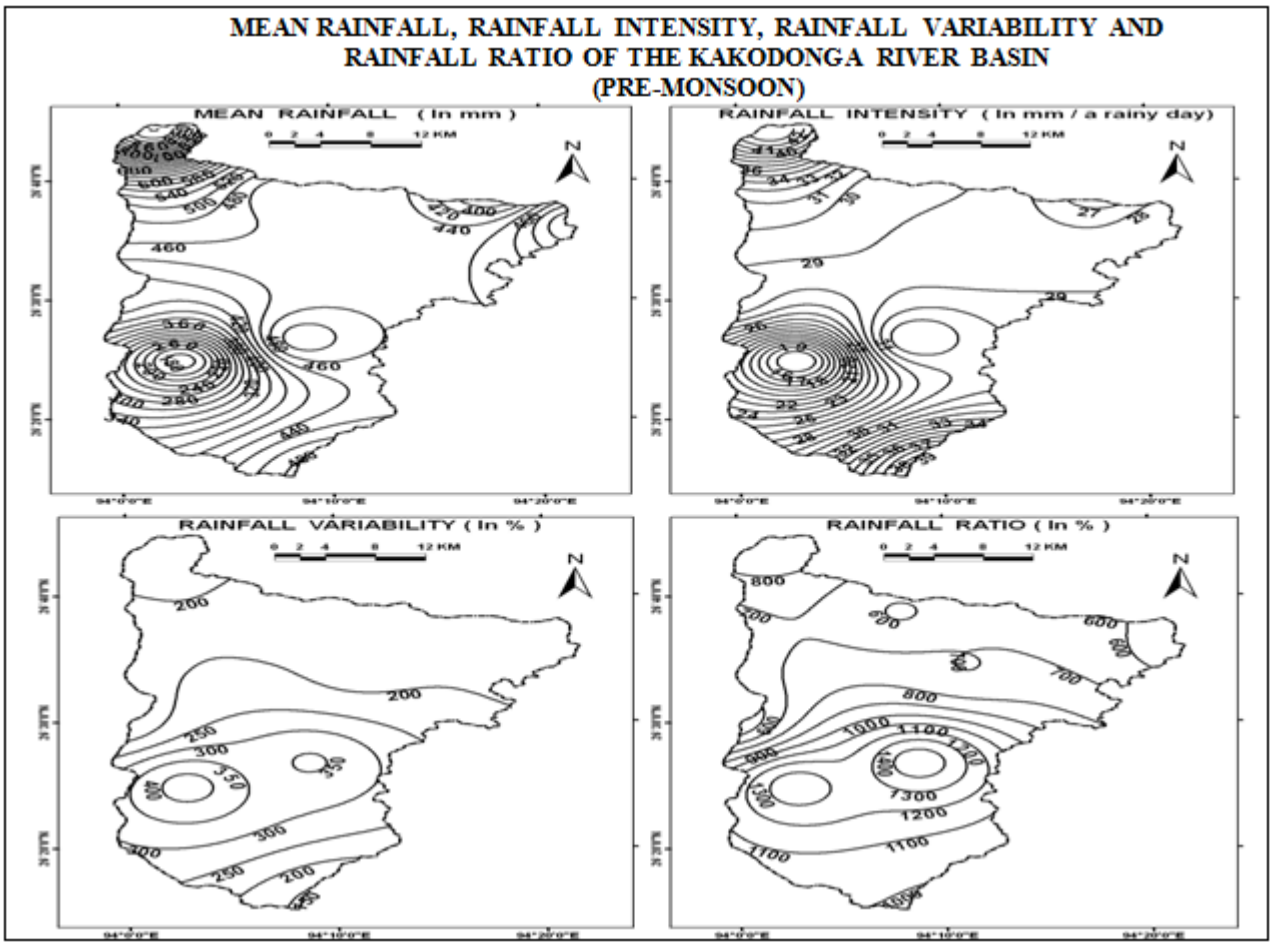

Figure 6

Table 8: Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin (Monsoon)

S. No.	Station	Mean rainfall in mm	Rainfall intensity in mm / a rainy day	Rainfall variability in %	Rainfall ratio in %
1	Jorhat	888	40	88	337
2	Garanga	303	20	392	1150
3	Wokha	1088	47	70	259
4	Golaghat	730	35	61	173
5	Kamarbund	809	36	97	349
6	Honowal	946	40	92	336
7	Titabor	912	40	102	401
8	Borholla	828	39	126	490
9	Negheriting	1511	63	98	350
10	Sycota	677	33	146	454
11	Khumtai	913	40	122	462

Source: Compiled by the Author

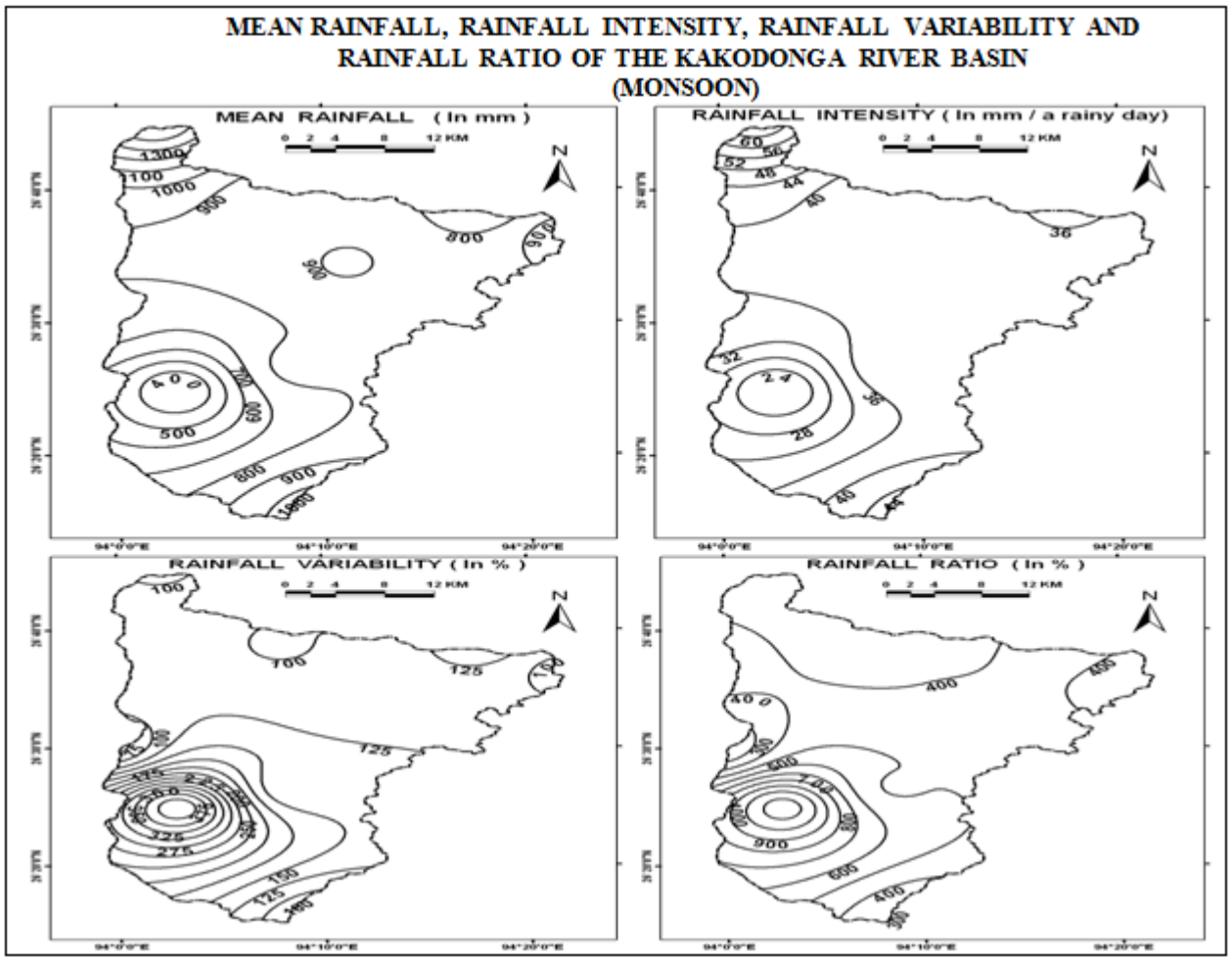

Figure 7

Table 9: Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin (Post-monsoon)

S. No.	*Station*	*Mean rainfall in mm*	*Rainfall intensity in mm / a rainy day*	*Rainfall variability in %*	*Rainfall ratio in %*
1	Jorhat	350	32	206	695
2	Garanga	180	15	543	1918
3	Wokha	402	34	185	734
4	Golaghat	269	24	164	509
5	Kamarbund	360	31	248	612
6	Honowal	403	33	181	640
7	Titabor	364	29	190	588
8	Borholla	302	31	199	722
9	Negheriting	656	36	216	710
10	Sycota	233	27	213	674
11	Khumtai	403	23	246	808

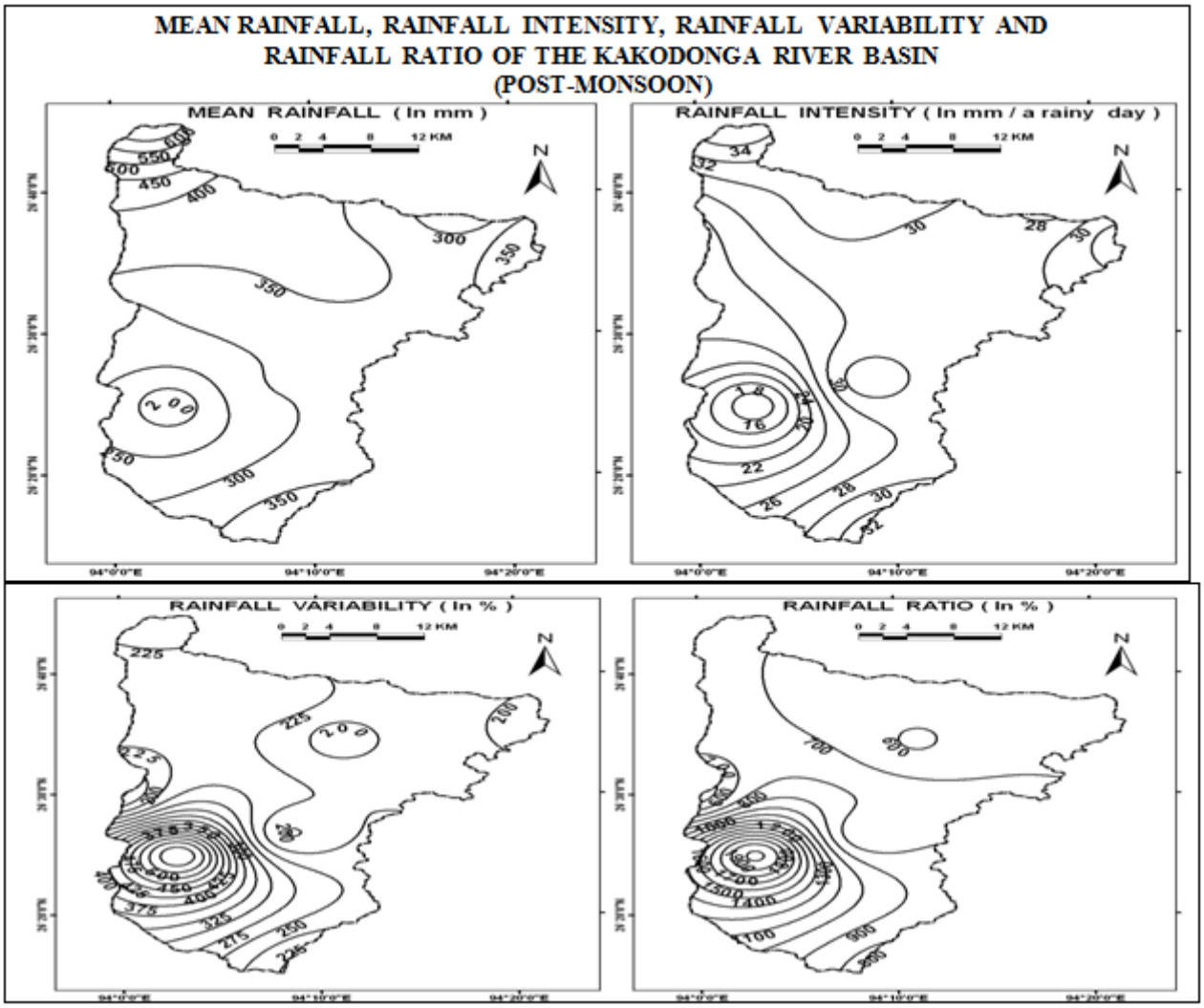

Figure 8

Table 10: Mean rainfall, Rainfall intensity, Rainfall variability and Rainfall ratio of the Kakodonga river basin (Annual)

S. No.	Station	Mean rainfall in mm	Rainfall intensity in mm / a rainy day	Rainfall variability in %	Rainfall ratio in %
1	Jorhat	1754	115	782	2677
2	Garanga	676	55	2023	6062
3	Wokha	2072	140	638	2852
4	Golaghat	1458	97	648	2144
5	Kamarbund	1678	110	876	2797
6	Honowal	1964	116	713	2539
7	Titabor	1799	110	779	2878
8	Borholla	1697	117	1154	4753
9	Negheriting	3168	156	918	3040
10	Sycota	1322	98	815	2402
11	Khumtai	1835	102	957	3329

Source: Compiled by the Author

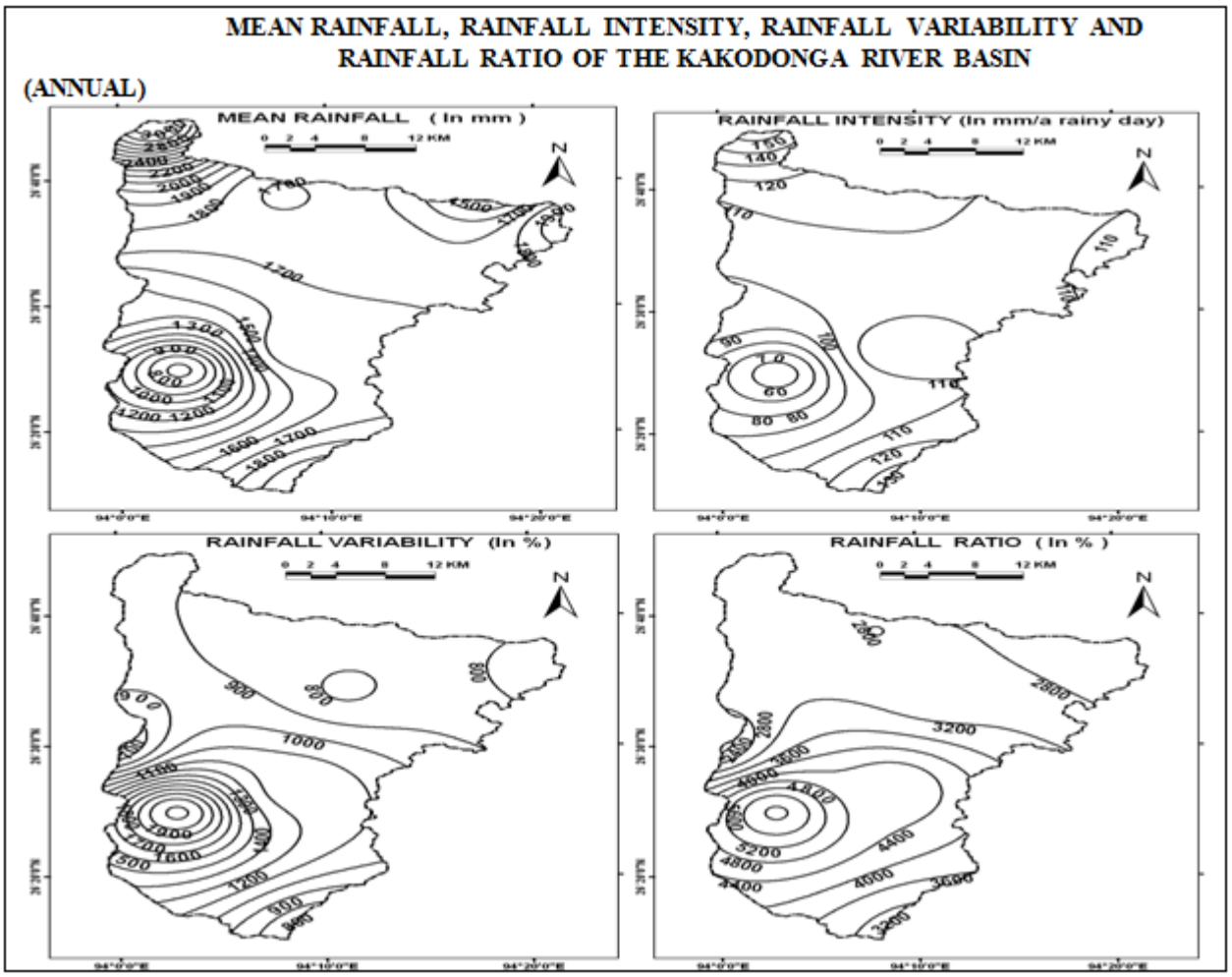

Figure 9

Table 11: Annual rainfall recharge of the Kakodonga river basin (All values in mm)

Sl. No.	*Station*	*Average Annual Rainfall in mm*	*Radha krishna et al Method (1974)*	*U.S. Geological Method (1962)*	*Seghal's Method (1973)*	*Krishna Rao Method (1970)*	*Average Recharge in mm*
1	Jorhat	1754	175	263	404	463	326
2	Garanga	676	68	101	69	207	111
3	Wokha	2072	207	311	515	514	387
4	Golaghat	1458	146	219	300	408	268
5	Kamarbund	1678	168	252	377	449	311
6	Honowal	1964	196	295	477	497	366
7	Titabor	1799	180	270	420	470	335
8	Borhalla	1697	170	255	384	453	315
9	Negheriting	3168	317	475	899	662	588
10	Sycota	1322	132	198	253	381	241
11	Khumtai	1835	184	275	432	476	342

Source: Compiled by the Author

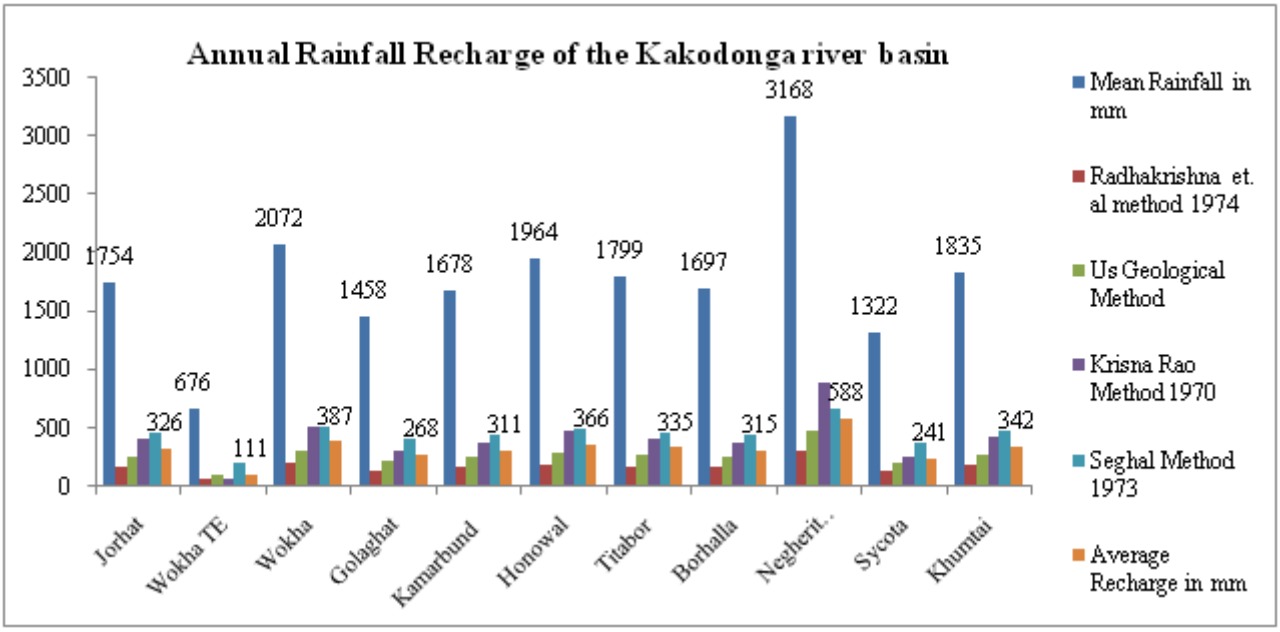

Figure 10: Annual Rainfall Recharge