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Variability of Precipitation and Flow Over Three Niger River Sub-Basins, Guinea

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Abstract: It is in order to understand the variability of climatic and hydrological factors and their impacts on the agro-pastoral activities of the populations living along the Upper Niger basin that we have written this article. The research focused on three sub-basins and the data obtained through services were collected and analyzed. At the end of the work, the study revealed that there are variations that impact flow rates, rainfall levels and yields, allowing an agricultural calendar to be established. The main results obtained during this research are as follows: The month of September is the month of heavy rains with the total rainfall amounts varying from 5090mm between (1922-1931) to 7547mm between (1962-1971) and the month June is the least rainy month when the rainfall totals range from 2476mm to 37,033mm. The year 1974 was the driest with rainfall amounts of 29.6mm in May. For the 1955-1984 observation series, the mean flow is 187.38 m^3/s for the Milo River and 242.72 m^3/s for the Niandan River. The statistical calculation gives an average of 235.67 m^3/s for the first decade and 199.25 m^3/s for the sixth decade.
Keywords: Variability, flow, flow, precipitation, Basin, Niger

1. Introduction

Understanding the factors involved in the variation in rainfall and river flows, as well as studying their spatial and temporal variations, requires the availability of data. These are essential and constitute a prerequisite for any hydrological analysis; whether for the purpose of carrying out a study of the water cycle, environmental impacts or for the sizing of hydraulic structures.

The surface water resources of the large hydrographic basins of West Africa exhibit very marked inter-annual fluctuations, which clearly reflect the climatic variations experienced by this vast region. Over the past twenty years, the downward trend that seems to be exhibiting tropical watercourses since the end of the last century has worsened [1-5].

Knowing the regime of watercourses allows us to prevent flooding in cultivated areas and to choose cultivation techniques as well as appropriate seed varieties, to calculate the water requirements of the crops and finally to plan an agricultural calendar that takes into account local realities. To achieve this end, a significant amount of hydro-rainfall data has been collected; these data are sometimes insufficient or erroneous. It then becomes interesting to complete the studies already carried out which were limited to the 1960s. At the station scale, the spatial dispersion of rainfall is often strong and variable from one year to another; hence our option to analyze the spatial averages over three sub-watersheds, which blur the spatial disparities. We will focus on monthly and seasonal rainfall and discharge totals and their temporal and spatial variations. We will compare the evolution of the totals [6-10].

This is faced with the importance of hydrology, agriculture, environment, fish farming etc ... and, after initiating the students to research, linking theory to practice; we thought of publishing the results of this research on the theme "variability of precipitation and runoff over three sub-basins of Upper Niger, Guinea".

2. Materials and Method

2.1. Materials

During this research, we used hydrological and meteorological data collected from the National Directorate of Hydrology (DNH) and the Regional Directorate of Hydrology of Kankan (DRH) for the development of this article.

2.1.1. Study data

A- Collection and inventory

Hydrological observations on the rivers and rivers of Upper Guinea have been carried out by several organizations. The availability and quality of the data depend on the monitoring of the measurement network, its maintenance and the willingness of each organization to transmit the observations made.

The Regional Direction of Hydrology (DRH) manages a hydrometric database, generally at daily time step, which contains almost all the measurements carried out on the Upper Niger Basin since the beginning of the 1950s, for the most part. stations. These measurements were carried out first by researchers from ORSTOM (currently IRD) and then, since 1980, by the HRD, a department of the National Directorate of Hydraulics (DNH). These measures have been reactivated with international or bilateral programs (GIRENS), (IRD) and finally (GIRE).

The first hydrometric stations were installed following economic concerns. This is how the first scales were installed (for hydroelectric purposes) from 1938 on the Milo, in 1940 on the Niandan at Baro, in 1954 on the Tinkisso at Ouaran, Observations were carried out continuously until in 1987. Part of these data (up to 1983 and 1993 for certain stations) was criticized and published in hydrological directories and monographs. The rest (1984 to 1987) is stored in raw form on reading cards. After 1987, due to the change of regime and budgetary constraints, the hydrological service no longer guaranteed the continuity of observations on 12 stations. We immediately note a very significant deterioration in the number of stations observed, ie six stations in the three sub-basins under study.

B- Rainfall data

Some rainfall data used for this study were taken from the collection of daily, monthly and annual rainfall published by the DNM (National Direction of Meteorology) and the DRMHG (Regional Direction of Upper Guinea Meteorology) of Kankan. The data at certain stations were supplemented until 2001 by other information collected directly from the managers of the rainfall stations during field trips. They were used in the calculations of useful rainfall for determining the useful soil reserve and the easily usable reserve.

For each of the study watersheds, we have chosen a rainfall station: the Milo watershed (1943-2010), the Tinkisso watershed (1922-1980), and the Niandan watershed (1922-1974).

Table 1: Average rainfall at the selected stations

PREFECTURES	Medium (mm)
Kankan (1943 2010)	**1538**
Kouroussa 1922-1974)	**1529**
Dabola (1922-1980)	**1333,7**

Source: Prefectural Directorate of Meteorology 2014

2.2. Method

Several methods - statistical analyzes, graphic representations, variation indices and comparisons of the water balance terms - are used to highlight different aspects of the variability of precipitation and runoff on the 3 selected representative watersheds, at different scales. time (monthly, seasonal, annual and ten-year).

To carry out this research, we have set ourselves a main objective and specific objectives which are among others:

2.2.1. Primary objective

Study the variability of rainfall and runoff in three sub-basins of the Upper Niger Superior.

2.2.2. Specific objectives

- Detect the impacts of climate change in these sub-basins through rains and flows on agro-pastoral activities.
- Detect the irregularity of the rainfall and flow patterns.
- Build up a body of knowledge that can be shaped and used by other researchers in the future.

3. Results and Discussion

After the inventory of available data and the reconstruction of certain missing values, any fluctuations were characterized within the time series of rainfall and hydrological variables, in the three selected watersheds. The analyzes mainly focused on:
- the annual rainfall totals,
- seasonal and monthly rainfall totals,
- the annual average total flows,
- the average seasonal and monthly total flows,
- the characteristic low and high water flow rates (DCE and DCC),

3.1. Rain variability

3.1.1. The rainy season

To appreciate the variability of the rains of the rainy season, we considered the classification of the seasons made by hydrology in part and that of agronomists which takes into account the humidity present in the soil; moisture useful for crops. Climatic contrasts are also noticeable in the seasonal distribution of precipitation.

3.1.2. The dry season

This analysis does not cover all decades. The dry season is long in the upper Niger basin, six months (October to April), except that it lasts two to one month (February to April) in part of the Milo Basin (southern part). During this period, this basin is entirely covered, especially in the southern part, with mist coming from the south-eastern trade winds of the Simandou mountains of Beyla and those of Banankoro.

The analysis and interpretation of Figure 1 shows that in Kouroussa, September is the month of heavy rains; total September rainfall heights ranged from 5090mm (1922-1931) to 75147mm (1962-1971); June is the least rainy month where the total values vary from 2476mm to 37033mm.

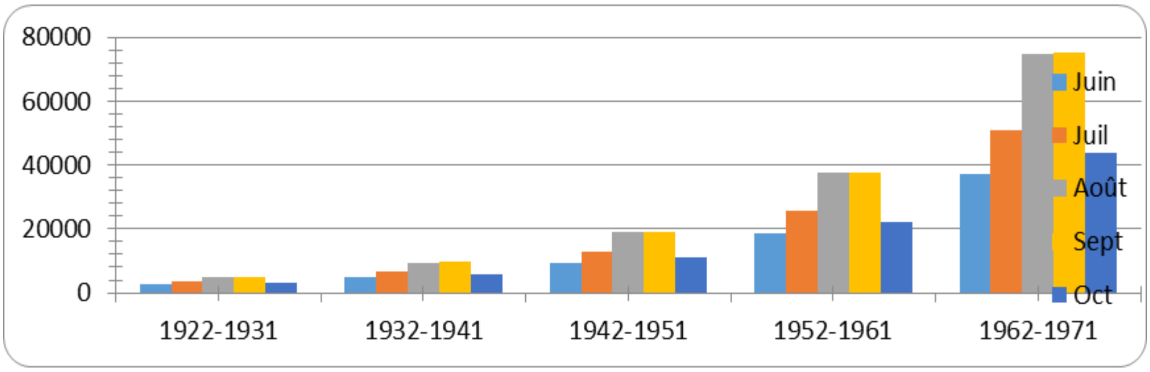

Figure 1: Ten-year rainfall amounts in rainy months (example) Kouroussa

One of the advantages of knowing the rainfall heights during the dry season lies in the possibility of predicting the humidity in the soil for vegetable crops. The driest months are November, December, January, February and March. In April the humidities start to increase and in May become high. The year 1974 was the driest with rainfall amounts of 29.6mm in May.

On each watershed, the spatialized average of the rainfall is calculated at monthly time steps. For the same period, Kankan presented the greatest amount of rain, then Kouroussa and finally Dabola. This leads us to determine the correlation between the various hydrological parameters retained in the three sub-basins.

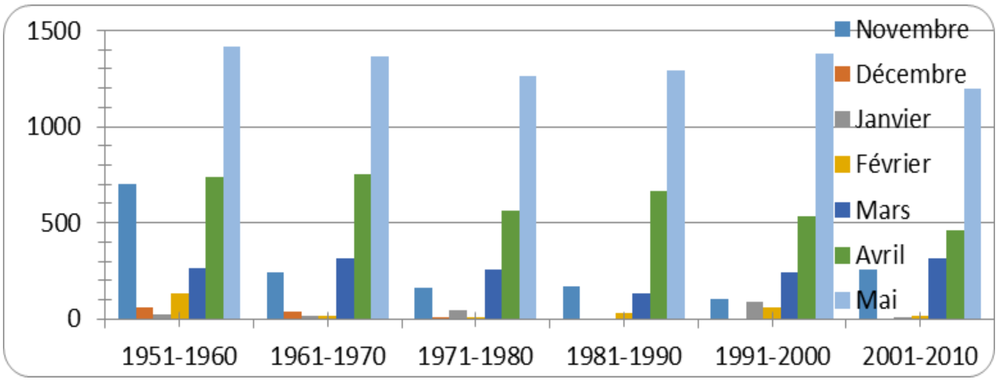

Figure 2: Temporal variability of monthly rainfall averages for the dry season months (example) Kankan

3.2. Hydrometric data

As for the flow data used for this study, they too were taken from the collection of Daily, monthly and annual flows published by the DNH and the DRH of Kankan; in some stations, they were supplemented until 2001 by other information collected directly from the managers of hydrometric stations during field trips. Since the main crop is rice in Upper Guinea and this is done along the rivers; flood forecasting requires knowledge of the flow rates of rivers through their fluctuations.

Using the annual and ten-year averages (rainfall-discharge), we were able to calculate the correlation between the three basins.

3.2.1. Study of the correlation of average flow-flow of the three rivers and average rainfall-flow rates for the 1955-1984 observation series (30 years) (example Milo-Niandan)

Table 2: Milo-Niandan flow correlation parameters

Average flow (m^3/s) Milo	*parameters*	*Average flow (m^3/s) NIANDAN*	*parameters*
Average	187,3806667	Average	242,7266667
Standard error	7,512824666	Standard error	12,57189525
Median	190,695	Median	247,65
Standard deviation	41,1494354	Standard deviation	68,85910619
Number of samples	30	Number of samples	30
Trust level (95,0%)	15,36545147	Trust level (95,0%)	25,71241243

Following the analysis of the results of the correlation of rainfall and flow, we found a good linear correlation.

Table 3: Summary of statistical calculation: mean flow rates, Cv and standard deviation per decade, for example of the Milo river

Decade	Average	Standard deviation	Cv	Decade	Average	Standard deviation	Cv
1st Decade	235,67	38,36	0,16	2nd Decade	199,54	**41,64**	**0,20**
3rd Decade	178,4	**37,95**	0,21	4th Decade	140,24	**26,50**	**0,188**
5th Decade	157,35	53,59	0,34	6th Decade	199,25	**58,13**	**0,29**

The same calculations carried out on the other two sub-basins have informed us of the regression of the average flow rate or a tendency for recovery.

3.3. The variability of flows

The variability of the flows is studied using data collected from various banks, criticized, and whose ten-year values are shown in Table 4.

Table 4: Results of calculation of flow variability

Decades	Tinkisso	Niandan	Milo
1954-1963	2802,2	2880,6	235,67
1964-1973	1476,5		
1961-1970		1983,6	199,54
1971-1980		2297,63	178,4
1974-1983	1392,72		
1981-1990		663,879	140,24
1984-1993	579,82		
1991-2000		1369,6	157,35
2003-2011			199,25

From the analysis of this table, it emerges that the flows of the three courses of these three sub-basins do not vary in proportion to the area of their basins, but to the amount of precipitation. However, the surfaces of their basins with all their characteristics should play their buffer role. The decrease in these flows indicates future humidity gains in areas of cultivation, water supply and hydroelectric structures. Relevantly all these watercourses have experienced unobserved decades: The Niandan and the Milo have in common the unobserved decades (1964-1973, 1974- 1983, 1984-1993), years recognized as years of drought, according to [11]. The Tinkisso on which a hydroelectric dam and flow regulator is built, there is an absence of observations of 2 decades out of 6, which denotes a lack of follow-up in the hydrometric data collection.

After determining the months of drought, the water requirements of the plants and the possible flooding periods, we developed an agricultural calendar, as a strategy to aid the promotion and agricultural management for the peasants.

Table 5: Agricultural calendar of the research area

Periods	Janu	Feb	Mar	April	Mai	Jun	Jully	Augu	Septemb	Octob	Novemb	Decemb
Cultures												
Plain rice	Conditioning				Plowing / Sowing						Harvest	
Plain rice	Harvest / packaging						Smashing Sowing or transplanting			Weed control		Harvest
Upland rice						Plowing / Sowing	Weed control				Harvest / packaging	
Corn				Plowing / Sowing / Weeding					Harvest			
Market gardening	Harvest										Plowing Sowing or Planting	Watering
Sorghum / Millet				Plowing / Sowing / Weeding						Harvest		
Corn in trays				Plowing / Sowing / Weeding				Harvest				
Peanut				Plowing / Sowing / Weeding					Harvest			

Fonio				Plowing / Sowing / Weeding				Harvests				
Cassava, potato, yam	Harvest / packaging			Hilling / Planting				Weeding	Hilling / Planting			Harvest
Mango trees			Harvests				Planting					
Cashew trees	Harvests						Planting					

Conclusion

At the end of this study, our main objective, to study the variability of rains and flows in three sub-basins of the Upper Niger was achieved.

The specific objectives also, which consisted of: Detecting the impacts of climate change through rains and flows on agro-pastoral activities; Detect the irregularity of the rain patterns; To compensate for the disappearance of fertile land and, as a corollary, the drop in agricultural production, equip the peasants with an agricultural calendar established on a scientific basis, predict the times of recession and flood, finally, constitute a sum of knowledge put fit and usable by other researchers in the future.

After processing the data, analyzing and interpreting the results, the trend curves made it possible to see in which direction the rains and flows are changing. This information of great environmental and agronomic interest needed to be confirmed by analyzes. The trends observed in most of these analyzes show changes for several years in the frequency of events; but also in the duration of the dry sequences during the monsoon season from April to October.

However, different time and space scales correspond to different climatic phenomena. What favored by place and by time :

- Reduction in cereal yields of up to 50% in a dry year and 10% in a normal year.
- The increased water needs of irrigated crops.
- The reduction in the length of the vegetative cycles of crops.
- Stronger erosion leading to more soil degradation.
- The emigration of populations to new lands or the adoption of water management techniques, the adaptation of crop species to climatic conditions and the characteristics of the land.
- As the variability of rainfall becomes important, the more livestock and cereal production occupy an important place.

Although these sub-basins undergo several types of evolution: plantations of fruit trees, area reserved for breeding with an abandonment of cultivation, fixation of agriculture with the use of fertilizers, herbicides and manure. This research gives an opportunity to the populations for the programming of agricultural, breeding and fishing activities.

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