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CLIMATE CHANGE AND VARIABILITY IN RIVER FLOW PATTERN IN THE SEMI ARID ENVIRONMENT (A CASE OF RIVER RIMA, SOKOTO)

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ABSTRACT:

This study looked at the parameters influencing the flow rate of River Rima. It involves a field survey through measurement of depth, width and the discharge of the river. The secondary data included the discharge of the River from 1962-1971 at Wammako gauging station obtained from Sokoto Rima River Basin Development Authority and the rainfall data collected from Sultan Abubakar International Airport. Data collected from both authorities were correlated using Pearson Correlation Coefficient. These data were also correlated with the stage (discharge) and rainfall data of 2008, using Spearman's rank correlation. The study revealed that there is very little relationship between rainfall and the discharge velocity of the three points. It also revealed that there is a very strong relationship between the hydro geometric factors (depth and width) and the discharge. As such the study recommends that the periodicity nature of the River Rima should be monitored with care by the authorities concerned, it also recommended that for future study on variable flow rate there will be need for use of modern technology such as remote sensing and Geographical information system (G.I.S) for such study.

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Introduction

Since the beginning of time, rivers have been important to man who provides him with water to drink and for other domestic uses. Rivers, lakes, streams and other fresh water sources on the earth consists of only 0.32% of the global water in the world (Waugh, 1990). Due to the importance of rivers many scientists tends to study its features such as its origin, depth, channel, slope drainage, and flow rate among others.

Rivers are complex systems influenced by a number of variables like in any natural system. Change in one variable influences the other. According to Hamblin, 1995, important variables in the study of river include discharge, velocity, gradient, and sediment load with discharge being the most important.

Chorley, (1969) and Ayoade, (1988) stated that water in the rivers came from various sources such as channels precipitation (rainfall), overland flow, base flow and ground water seepage or effluence. However, the prevalent sources depend mainly on environmental conditions (soil, vegetation and climatic conditions) in the basin. These variables contribute to the morphology of any river and in turn affect availability of water in the basin.

Robert (1969), Ward (1975) points that the aim of studying any river is to understand its features, and to control its wild nature among others. All the features of a river determine the type of activities that takes place at or near the river, such as fishing, irrigation, Hydro Electric Power (H.E.P) generation, navigation and supply of pipe water for domestic usage. Thus, effective management of the highly variable water resources of any river requires an understanding of its flow features such that suitable quality water can be provided under various conditions within institutional constraints (Folorunsho, 2000). The major ways of developing any river system for water utilization therefore is to have an understanding of the river features, devise ways of harnessing its potentials for use and controlling the supply of water from a river through building of dams and large reservoirs to sustain a reliable water supply in such environment. Also, it is to activate the potential of the river basin so as to control downstream flooding, generate hydroelectric power, irrigation and other uses.

Statement of the Problem

Rivers has been studied from various points of view. For example, it has been studied from perspective of understanding channel network, sediments deposits and water conservation, and in the present time, the drainage basin as a geomorphic unit landscape drained by a river and its tributaries (Chorley, 1969). The drainage basin refers to the entire area supplying runoff and sustaining part or all of the river flow to the main river and its tributaries (Gregory and Walling 1973).

Water shortage in many urban centers of Nigeria is becoming a serious problem due to increase in population, lack of proper maintenance of water supply infrastructure and dwindling finance of Water Corporation. Usually a moderate increase in demand for water is met by a city, provided there is still equilibrium between the numbers of people, the availability of energy and the size of the water distribution system, unfortunately this equilibrium have now been upset in some third world cities, such as, the Sokoto metropolis. In such metropolitan area, authorities are not able to keep up with the water demand because of rapid increase in the population due to many factors among which is rural-urban migration and above all the effect of climate change.

Recently, urban residents in Nigeria patronize several sources of water in order to meet their water requirements (Ayoade, 1997). Such major sources include stream flow and groundwater which are heavily dependent on rainfall received in the area. It is believed that climatic changes on a global scale tend to produce a drastic reduction in the rainfall amount every year in Nigeria (Adeduwon et al, 1990). Presently in Nigeria there is a debilitating effect of the climatic change on the water resources development and management and that the surface temperature at many locations are increasing especially in the northern part of the country (Oyebande, 1995).

This paper focuses on the hydro-geometric features of selected points of River Rima and their relationship with rainfall variability in the area. The research among other things will looked at the depth, width and discharge of the river over the years.

Hypothesis

HO There is no significant relationship between the hydrogeometric parameters and the flow rate of River Rima.

METHODOLOGY

Both primary and secondary sources of data were used in the research. The primary data was obtained from the field through a survey carried out in the river where measurements of the depth, width and river discharge were taken for the three points. While secondary data was obtained from the Sokoto Rima River Basin Development Authority and Sokoto Airport where river discharge data and rainfall data for Sokoto area was collected.

Experimental layout

Data Collection: The survey method was used for this study. Thereby being geared mainly towards the determination of status of the phenomenon under study rather than towards the isolation of causative factors. The velocity area method was used in collecting water flow in unit of length per second and multiplied by the cross-sectional area of the water body unit in cubic meters per second (Chorley, 1969). Thus the formula given below:

$A = d\, \varepsilon\, h/n$ but $\hbar = \varepsilon\, h/n$

$v = s/t$

Where A is the area of the points taken, d is the width, h is the depth, v is the flow rate, s is the distance covered and t is the time.

Discharge velocity = V/A

Three points were chosen at systematically after dividing the river into four parts from the source giving rise to three study points, the first point falling along Ginga village, the second and third points being at regular interval of 5km.

INSTRUMENTS USED: The following instruments were used for data collection at the field.

1. Float- used to measure the flow velocity of the selected points
2. Tape line- Used to measure width of the selected points
3. Pole- used to measure the depth of the river.
4. Stop watch- used to time the flow rate**.**

Secondary source: The discharge data (monthly) of River Rima was collected from the Rima Basin and Rural development at Wammakko gauging station Sokoto and it covered the period of 1962-1971. The mean monthly rainfall data was obtained from Sultan Abubakar International Airport Meteorological Station Sokoto which also covered the period of 1962-1971. Rainfall data of 2008 was also collected.

DATA ANALYSIS

This paper succeeded in examining the discharge and rainfall records of 1962-1971. The data was correlated using the Pearson's Correlation. The discharge velocity of the three points A, B and C, were also correlated with the year 2008 rainfall data using Spearman's Correlation. The hydro-geometrical factors (depth and width) was also related with discharge velocity of the three points (A, B and C).

To find the relationship between rainfall and discharge of River Rima, the Pearson's Coefficient of Correlation was used. The formular:

$$R = \frac{n(\varepsilon xy) - (\varepsilon x)(\varepsilon y)}{\sqrt{N(\varepsilon x^2) - (\varepsilon x)^2 (n(\varepsilon y^2) - (\varepsilon y)^2}}$$

Where 'n' is the number of data pairs, 'x' is the rainfall and 'y' is the discharge. Each variable covered a period of 10 years between 1962-1971.

Relationship between rainfall and discharge velocity of the three separate points for the year 2008 was by using Spearman's Correlation. The formula:

$$Rs = 1 - \frac{6\varepsilon d2}{n(n2-1)}$$

Where 'd' is the difference in rank and 'n' is the number of pairs.

A line graph was used to provide a clear understanding of the discharge and rainfall data.

Discharge Record of River Rima at Wamakko Guaging Station

The monthly discharge record of River, Rima at Wamakko gauging station is presented in table 4.1. It shows that the highest monthly discharge occurs in the month of September, 1971 with a discharge value of 916.68m^3/mth and the lowest occurring in the month of April, 1970 with a discharge value of 0.18m^3/mth. The annual discharge of 1962 – 1971 had been recorded where 'the highest discharge was recorded on the year 1971 with a value of 2096.57m^3. Also the lowest annual discharge was recorded on the year 1968 with a value of 950.52m^3.

Table 1

Discharge Record of River Rima at Wamakko Gauging Station

Month	Year									
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
January	-	4.54	4.3	4.65	6.99	3.4	3.44	1.47	0.83	1.93
February	-	2.16	-	2.99	3.92	2.44	2.56	1	0.5	1.43
March	-	1.28	1.37	1.73	2.96	2.12	1.68	0.85	0.28	1.17
April	-	0.76	1.12	1.68	2.36	1.78	3.07	0.91	0.18	0.87
May	-	0.73	4.48	1.32	20.78	6.96	13.34	9.48	1.14	0.98
June	49.55	85.14	5.87	164.96	89.52	49.84	57.12	47.59	9.65	17.5
July	166.19	149.27	167.25	218.74	146.71	201.45	251.99	191.1	127.94	239.55
August	525.82	288.19	369.39	628.03	308.33	590.55	337.55	615.31	793.95	810.93
September	873.94	351.54	667.59	731.52	591.45	717.12	268.99	632.91	820.98	916.68
October	377.63	250.61	249.36	134.78	295.87	201.93	13.45	134.76	274.78	102.5
November	21.87	38.52	16.53	18.07	14.87	10.42	3.12	14.11	8.7	5.68
December	8.84	6.89	7.36	10.59	4.89	4.96	1.89	3.18	3.33	2.75
Total	**2023.84**	**1179.63**	**1494.62**	**1919.06**	**1488.65**	**1783.23**	**950.52**	**1648.44**	**2040.47**	**2096.57**

Source: SRRBDA, 2008

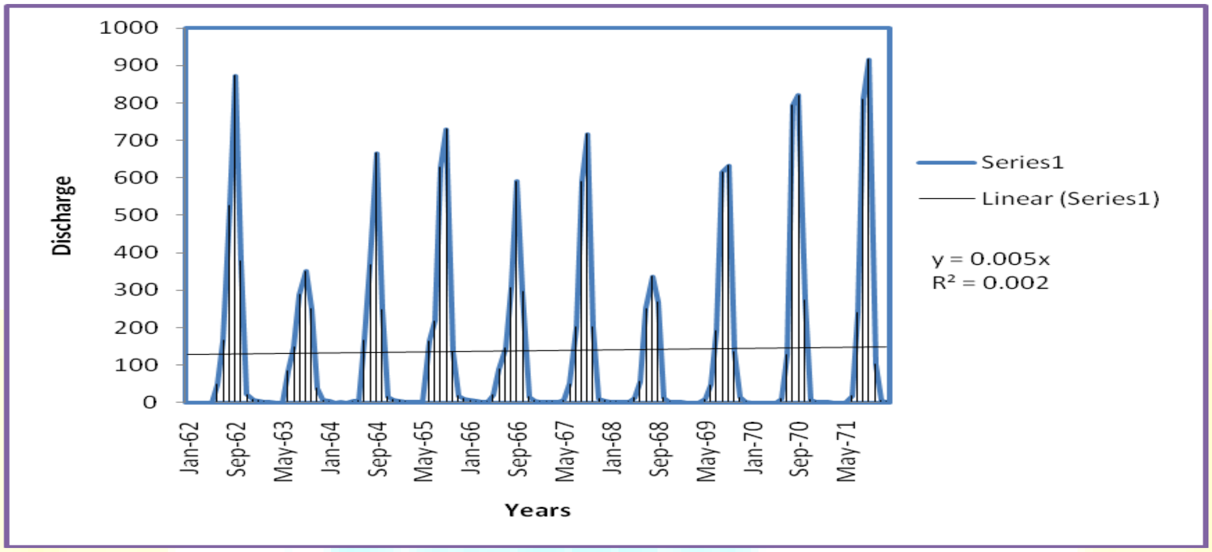


Fig. 1 Discharge Record of River Rima at Wamakko Gauging Station (B site)

Rainfall Data of Sokoto State Metrological Agency. (1962 – 1971).

The monthly rainfall record collected from metrological agency presented in table 4.2 shows that the highest monthly rainfall in September, 1971 with a value of 716.68 inches (23283.672mm and the lowest in May 1963 with 0.73 inches (18. 542mm).

The annual rainfall of 1962 – 1971 have been recorded where the highest rainfall was recorded on 1971 with a value of 2696.57inches (53252.878mm) and the lowest in the year 1963 with a value of 31.2inches (792.48mm).

Table2. Rainfall Data for Sokoto from 1962-1971

Month	Year									
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
January	0	0	0	0	0	0	0	0	0	0
February	0	0	0	-	0	0	0	0	0	0
March	0	-	0.15	0	0	0.36	0	0	0	0
April	0.29	0.16	0	-	0.49	0.13	1	0.79	0	0
May	1.27	1.67	1.86	1.77	1.04	0.44	1.4	1.58	0.46	1.4
June	6.38	4.04	6.61	11.17	2.87	3.43	3.34	4.1	1.33	0.67
July	7.28	7.45	8.89	4.99	5.52	4.89	4.62	9.44	12.0 1	5.24
August	7.42	9.75	5.83	12.6	6.87	9.97	5.44	7.91	6.84	9.17

September	4.47	4.64	5.37	7.81	6.07	5.11	0.8	3.95	3.93	2.58
October	0.33	3.49	0	0.19	0	0.13	2.02	0.54	0.14	0
November	0.02	0	0	0	0	0	0	0	0	0
December	0	0	-	0	0	0	0	0	0	0
Total	**27.46**	**31.2**	**28.71**	**38.53**	**22.86**	**24.46**	**18.62**	**28.31**	**24.71**	**19.06**

Source: Sultan Abubakar International Airport, Sokoto, 2008

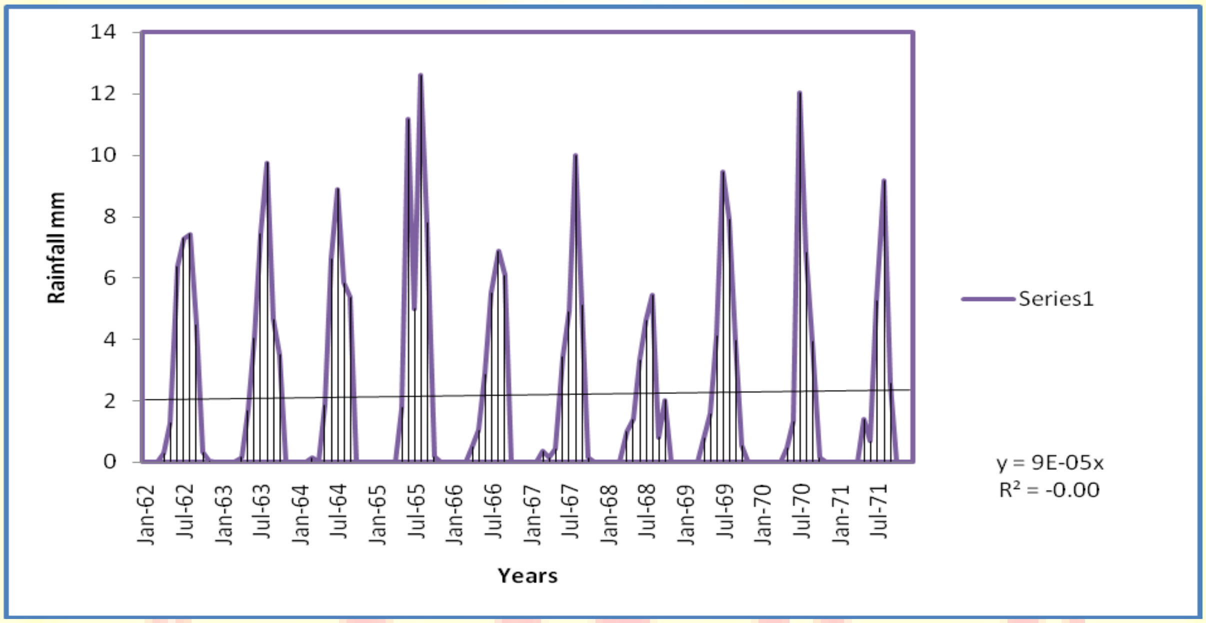


Fig. 2 Rainfall Data for Sokoto from 1962-1971

Rainfall Data of 2008 Collected from Metrological Agency.

The rainfall data recorded in 2008 presented the highest rainfall at August with a value of 130.2mm and the lowest in April 0.7mm.

Table 3 Rainfall Data 2008

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	0.0	0.0	0.0	0.7	41.3	94.7	52.2	130.2	93.9	1.61	0.0	0.0

Source: Meteorological Station

Survey Discharge Data of the Three Points

The discharge velocity data of the three points (A, B and C) where collected primarily through field survey. It involves measurement of the depth, width and flow rate. The discharge data of the points where collected from April to September, the first point (point A) recording 21.23m/mth and the lowest recorded in April from point C recording 4.5mm/mth. The highest mean depth was recorded in September at point B which recorded 3.94m/mth and the lowest depth recorded is in April at point C.

The highest discharge velocity of the three points (A, B and C) was recorded in September at point A with a discharge record of 13.312m^3/s, and the lowest was recorded in April at point C with a discharge of 1.563m^3/s.

Results

The study examined parameters influencing variable flow rate across selected points of River Rima. This study was carried out basically for the sole purpose of obtaining vital information on parameters influencing flow rate for water resource management and utilization in the Sokoto state metropolis. The data used were obtained from the Rima basin rural and development agency, Sultan Abubakar International Airport Meteorological Agency, Sokoto and field survey of discharge velocity of three points of the river.

Table: Data for the Surveyed Points

Month	Points	Widths (m)	Mean Depth (m)	Flow Rate (m/s)	Discharge (m3/s)
April	A	8.00	1.77	0.157	2.124
	B	4.53	1.96	0.176	1.563
	C	7.33	1.70	0.163	2.031
May	A	9.41	1.80	0.165	2.795
	B	4.82	2.13	0.183	1.878
	C	7.57	2.18	0.177	2.921
June	A	12.12	1.89	0.192	4.434
	B	6.25	2.50	0.216	3.375

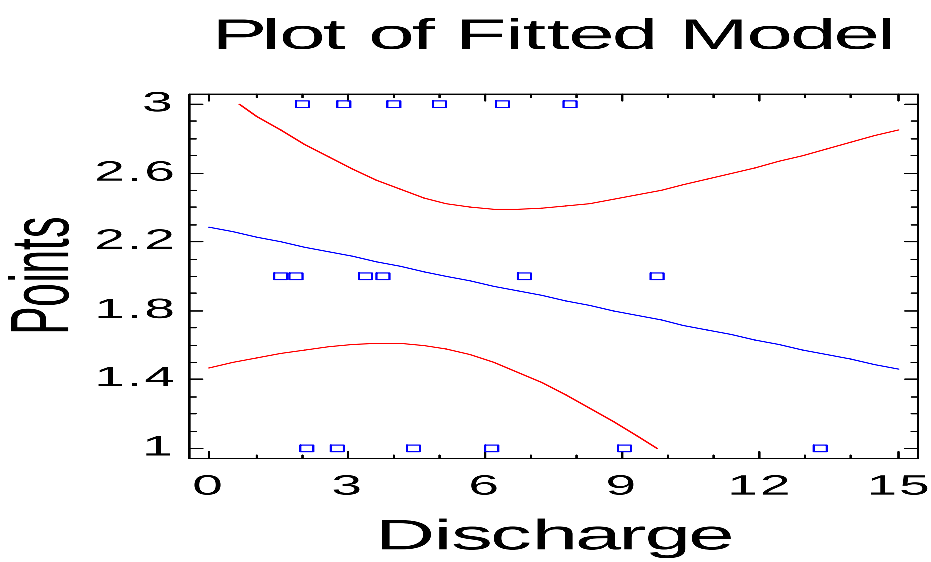
	C	8.13	2.52	0.196	4.016
July	A	12.56	2.49	0.197	6.161
	B	6.48	2.62	0.222	3.769
	C	8.91	2.66	0.212	5.025
August	A	15.40	2.83	0.208	9.065
	B	8.23	3.47	0.240	6.854
	C	9.20	2.97	0.233	6.366
September	A	21.23	2.93	0.214	13.312
	B	9.41	3.94	0.263	9.751
	C	10.11	3.38	0.230	7.860

Source: Field Work, 2008

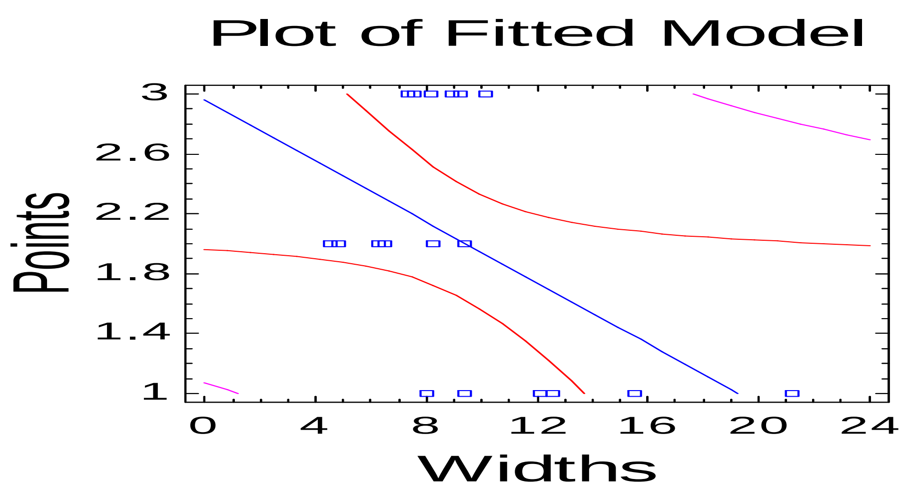
Parameters examined include the discharge velocity of the river at Wamakko gauging station (1962 –71), rainfall data of the study area (1962 – 71 and 2008), measurement of discharge velocity of three points. Also considered were relationship existing between the annual discharge and annual rainfall, monthly discharge of three points and monthly rainfall of 2008 and the relationship between the hydro geometric features (depth and width) and the discharge velocity of the three points.

The rainfall – discharge relationship for the river was analyzed using the period 1962 – 1971. The Pearson's Correlation Coefficient values of 0.632 were obtained and were found to be significant at 0.05 level of significant.

The rainfall and discharge records of the three points for the months of April – September, 2008 was analyzed using the Spearman's Correlation and values of 0.7 was obtained with a degree of freedom of 4 at 0.05 significant level. Finally, the hydrogeometric factors (depth and width) of the three points and discharge velocity of the three points were analyzed using Pearson's Correlation Coefficient. The results obtained shows that there is very high relationship between the hydrogeometric factors and the discharge of the river.

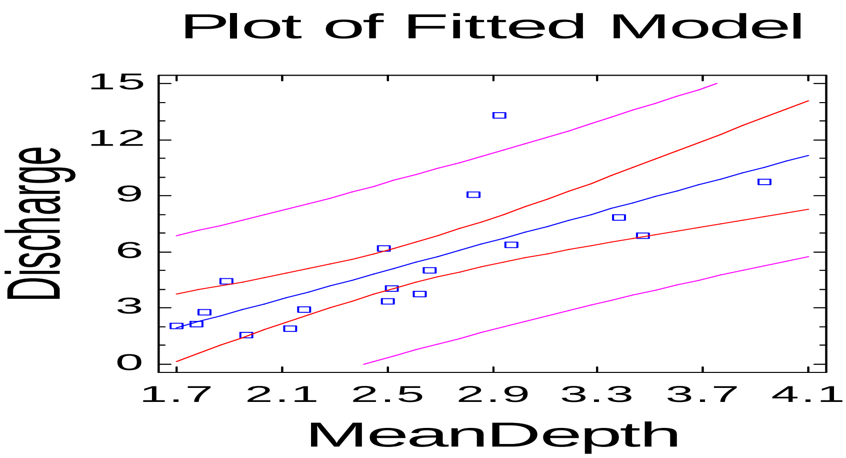


From the results obtained, it was observed that the discharge of River Rima exhibit a strong seasonality



and

It was also discovered that the rainfall in the study area has little or no effect on the discharge of the river, but the hydrogeometric factors (depth and width) affects to a large extent the discharge of the river Rima.



Suggestions

Based on the observations and findings of this paper it is being suggested here that:

(i) There should be constant and continuous data recording and monitoring of the river.

(ii) There is a need to establish a data bank river discharge of river Rima for future studies.

(iii) For future study on parameters affecting variability in river flow, there will be need for the use of modern geotechnical equipments and software systems such as G.I.S and Remote Sensing.

(iv) The periodic nature of the river should be monitored with care by the Sokoto Rima River Basin Development Authority for planning purposes especially in the event of water shortage periods.

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