BEST: International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS)
ISSN 2348-0521
Vol. 2, Issue 7, Jul 2014, 27-32

AN ASSESSMENT OF SPATIAL COVERAGE OF RAINFALL DATA IN KATSINA STATE

SU USMAN, AI ABDULHAMID, BA SAWA, YUSUF Y. O & A. K. USMAN

Department of Geography, Ahmadu Bello University, Zaria, Kaduna, Nigeria

ABSTRACT

Rain gauge density differs from one region or country to another due to physical, economic or political factors. Right rain gauge density is an the important prerequisite for obtaining rainfall data that give a true picture of rainfall condition in an area, which is indispensable in agricultural planning and water resource management. This study investigates spatial coverage of rainfall data in Katsina state by determining the optimum number of rain gauge stations needed for the state. The study involves rainfall data from five selected stations across the state. Choice of the stations is based on their spatial distribution and availability of continuous data for at least the last thirty years. Optimum number of stations required for the state was determined based on the coefficient of rainfall variability of the state. Results reveal that 21 stations as evenly distributed as possible are required for proper spatial rainfall pattern of the state to be obtained. Knowledge of the right rain gauge density for states holds a lesson for agricultural planning and development and water resource management.

KEYWORDS: Coefficient of Variability, Rain Gauge Density, Rainfall Pattern, Synoptic Station

INTRODUCTION

Due to differences in topography, rainfall producing systems, political will, economic considerations, accessibility of areas and environmental prudence, rain gauge density varies from one region or country to another. For instance, in the USA it is one rain gauge per 576 km^2, in Australia it is one per 256 km^2, in England and Wales it is one per 34 km^2, in Israel it is one per 25 km^2 (Linacre, 1992) and in India it is one per 500 km^2 (Arora, 2007). Rain gauge density refers to the area covered by a rain gauge. And right rain gauge density in a given area provides adequate data from which local rainfall pattern of the area can be obtained which is necessary for effective agricultural planning and water resource management.

In Nigeria, the Nigerian Department of Meteorological Services (NDMS) uses 50 synoptic stations, 500 rainfall and agrometeorological stations, 20 automated weather stations, 3 weather surveillance radars, 1 total ozone station, 1 Global Atmospheric Watch (GAW) station and 10 global surface climate stations in observing meteorological parameters and providing weather related services for the country (Akeh *et al*., 2000). However, since in Nigeria, domestic water supply and agricultural planning and development are to the largest extent the responsibilities of states government, there is the need for detailed monitoring of rainfall characteristics at states level. And this can only be achieved when there is high-quality rainfall data obtained from the right density of functional rain gauge networks.

For Katsina state and indeed other states located within the Sudano-sahelian region which is a marginal agricultural area in Nigerian context, the need for generating local spatial rainfall pattern can never be overemphasized. This is because in this area, the success or failure of agricultural production is to the largest extent directly tied to rainfall stability or instability. And agriculture is the key element important to the region’s economic vitality and social stability. For Nigeria as a whole, agricultural sector employs over 70% of the labour force (FRN, 2003), while in the Sudano-sahelian region the proportion is much higher. This region is also the one with the most variable rainfall in the country (Kandji *et al*., 2006; Ibrahim *et al*., 2011) and with drought as an inherent characteristic (Oladipo, 1993a) whose frequency of occurrence ranges from seven to ten years on average (Abaje, 2010). In addition, inadequate climate data has been identified as one of the major factors that contributed to poor detection and mitigation of the drought events that bedeviled the region in the 1970s (Apeldoorn, 1981).

Research has established the importance of determining the right rain gauge density for water resource management (for example Awadallah, 2012) and for both agriculture and water resource management (Rossel, 2001). In Katsina state, rainfall data from a dozen rain gauge stations spread across the state are being used in agricultural planning by the state's ministry of agriculture and the Katsina State Agricultural and Rural Development Authority (KTARDA). This study intended to determine the spatial coverage of rainfall data in Katsina state by determining the coefficient of rainfall variability and from it, the right rain gauge density for the state.

STUDY AREA

Katsina state is located between latitudes 11^o06^IN and 13^o21^IN and longitudes 6^o50^IE and 9^o00^IE. The state forms part of the extensive undulating plains known as the High Plains of Hausaland. The plains generally rise gently from 360m in the north-east, to 600 m in the south-west of the state. Almost all the major rivers in the state have been dammed mainly for irrigation and urban water supply purposes. The dams include; Jibia, Zobe, Daberam, Sabke, Ajiwa and Mairuwa. Climate of the area is tropical continental which can be sub-divided into tropical wet and dry and semi-arid. The southern part of the state, with Northern Guinea savanna type of vegetation belongs to the former, with average annual rainfall of about 1000 mm. the central part, with Sudan savanna type of vegetation, has average annual rainfall of about 800 mm. The extreme northern part, with Sahel savanna type of vegetation belongs to the latter and has average annual rainfall of less than 600 mm. The state has a population of about 6 million people (www.population.gov.ng/index.php/katsina-state) and the major occupation of the populace is cultivation of cereal crops (through both rain fed and irrigation agriculture) and rearing of animals such as cattle, sheep and goats.

MATERIALS AND METHODS

Monthly rainfall data used in this study are obtained from five selected stations across the state. The criteria for selecting each station are based on the ability of the station to satisfy the following conditions:

- Rainfall data available at the station could be either daily or monthly.
- There should be continuous rainfall data for at least the last 35 years.
- The stations should be as evenly distributed as possible across the state.

The selected stations are; Katsina synoptic station (13^o0'8"N, 7^o39'34"E), Tambu (12^o58'54"N, 8^o14'57"E), Kafin-soli (12^o30'3"N, 7^o44'24"E), Malumfashi (11^o46'24"N, 7^o36'57"E) and Funtua (11^o30'31"N, 7^o19'18"E) agrometeorological stations. Rainfall data for Katsina synoptic station were collected from the Nigerian Department of Meteorological Services, Oshodi, Lagos. And data from the other four stations were collected from the KTARDA headquarters, Katsina. The data were used to determine the optimum number of rain gauge stations required for the state.

The optimum number of rain gauge stations depends upon the coefficient of variation (cv) of the mean rainfall values at the selected stations at a given allowable degree of error (e). It is determined as:

$$m = [\frac{cv}{e}]^2 \qquad (1)$$

Where *cv* and *e* are expressed as percentages.

The coefficient of variation is determined as:

$$cv = [\sigma/\overline{p}] \times 100 \quad (2)$$

Where σ is the standard deviation and $\overline{p}$ is the average annual rainfall over the state (here average annual rainfall of the selected stations), determined as:

$$\overline{p} = \frac{\Sigma p}{n} \quad (3)$$

Where *n* is the number of stations and Σp is the sum of the mean annual rainfall of all the stations.

The standard deviation is determined as:

$$\sigma = \sqrt{\frac{\Sigma(p-\overline{p})}{n-1}} \quad (4)$$

The number of additional rain gauge stations required is determined as:

$$m - n \quad (5)$$

And the stations should be as evenly distributed as possible across the state.

RESULTS AND DISCUSSIONS

Results of data analyses are presented in Table 1. From this table, the state has average annual rainfall of 782.6 mm, standard deviation of 108.3 and *cv* of 23.04%. Coefficient of variability is a measure or is an indicator of rainfall certainty or uncertainty; the higher the *cv* the more uncertain the rainfall and vice versa. It increases with aridity, thus, northward in Nigeria.

Table 1: Results of Data Analyses

$\overline{P}$	**782.6 Mm**
σ	108.3
cv	108.3
e	5%
m	21.23
n	5
$m - n$	16

Table 1 also shows that 21 rain gauge stations are required in order to effectively characterize the weather of the state. This means that high quality rainfall data from 21 stations evenly distributed across the state are needed for a clear picture of spatial rainfall pattern of the state to be obtained.

High coefficient of rainfall variability coupled with complex climatic and environmental phenomena characteristic of the state and indeed the whole region – such as frequent droughts and dry spells and desert encroachment call for adequate monitoring of rainfall characteristics in the state. This is because droughts and dry spells are highly variable in space and time (Oladipo, 1993b; Sawa and Adebayo, 2011). And they have serious implications on water supply and agriculture which is the mainstay of people's economy and perhaps, social stability in the state.

Many of stations in the study area are characterized by missing data, in most cases from the late 1990s. Therefore, even if the optimum number of rain gauge stations is to be provided, there is the need for all the stations to be fully functional at all times. Indeed, with 21 fully functional rain gauge stations evenly spread across the state, water resource management and agricultural planning and development will be greatly enhanced. This is because each station will characterize the rainfall pattern of about 1,152 km^2 out of the state's total land area of 24,192 km^2. Although this will be short of the ideal situation recommended by the World Meteorological Organization (WMO) for areas like Katsina state (flat tropical regions) – one station for 600 – 900 km2, but will be well within the acceptable range recommended – one station for 900-3,000 km^2 (www.theconstructor.org).

Sudano-sahelian region of Nigeria is the cereal basket of the nation. And cereal crops constitute the major staple food for the people in the region and beyond. The region also houses more than 80% of the livestock (especially cattle, sheep and goats) in the country. Frequent drought events and rapid population and urban growths led to the construction of dams across the major rivers in the state. These dams are being used for urban water supply, irrigation of crops and supplying drinking water to the teaming population of livestock found in the state and those that come during the dry season from neighbouring countries. Thus any effort of achieving food security, water resource sustainability and even social stability that will neglect the issue of adequate monitoring of rainfall characteristics in Katsina state will be nothing but a feeble and ineffectual one.

Furthermore, in West Africa, a 131mm of rainfall decrease per latitude northward has been established (Kowal and Kassam, 1978), and Katsina state spans about 1^o30^I latitude. Thus, it is evident that annual rainfall amount varies from north to south in the state. For this reason, the need for monitoring a true picture of this variation can never be overemphasized.

CONCLUSIONS AND RECOMMENDATIONS

Going by the results of this study, the WMO recommendations and environmental realities in Katsina state, more functional rain gauges are required for the state. And it is recommended that provision of the right number of stations sited at the right locations should be accompanied with recruitment of well-trained and dedicated weather observers to man the stations. In addition, to ensure accuracy and quality of data, the stations should be inspected by experts at recommended intervals.

REFERENCES

1. Abaje, I.B. (2010) Occurrence of Droughts in the Sudano-sahelian zone of Nigeria (1949-2008). Unpublished M.Sc. Thesis, Department of Geography, A. B. U. Zaria
2. Akeh, L.E., Nnoli, N., Gbuyiro, S., Ikehua, F. and Ogunbo, S. (2000) Meteorological early warning system (EWS) for drought preparedness and drought management in Nigeria. In: *Early Warning Systems for Drought Preparedness and Drought Management*, World Meteorological Organization, Lisboa, 154-168
3. Apeldoorn, G. Jan van (1981) *Perspectives on Drought and Famine in Nigeria*. George Allen and Unwin. London
4. Arora, K.R. (2007) *Irrigation, Water Power and Water Resource Engineering*, Standard Publishers Distributors. Delhi p27
5. Awadallah, A.G. (2012) selecting optimum locations of rainfall stations using Kringing and Entropy. *International journal of Civil and Environmental Engineering* 12(01): 36-41
6. FRN (Federal Republic of Nigeria) (2003) *Nigeria's First National Communication Under the UN Framework Convention on Climate Change*, Federal Ministry of Environment. Abuja p64

7. Ibrahim, A.A., Hassan, Y.G., Iguisi, E. and Ati, F. (2011) An assessment of monthly rainfall profile for Kano, Nigeria. *Brazilian Geographical Journal* 2 (2): 354-368

8. Kandji, S.T., Verchot, L. and Mackensen, J. (2006) Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural sector. World Agroforestry Centre (ICRAF)/United Nations Environment Program (UNEP)

9. http://www.unep.org/Themes/Freshwater/Documents/pdf/climatechangesahelcombine.pdf [Accessed 23 July 2013]

10. Kowal, J.M. and Kassam, A. (1978) *Agricultural Ecology of the Savanna: A Study of West Africa*. Clarendon Press. Oxford

11. Linacre, E. (1992) *Climate Data and Resources*, Routledge. London p273

12. Oladipo, E.O. (1993a) A comprehensive approach to drought and desertification in Northern Nigeria. *Natural Hazards* 98): 235-261

13. Oladipo, E.O. (1993b) Some aspects of spatial characteristics of drought in Northern Nigeria. *Natural Hazards* (8): 171-188

14. Rossel, F. (2001) Reassessment of the Island's [Cyprus] water Resources and Demand. Ministry of Agriculture, natural Resources and Environment of the Republic of Cyprus Water Development Department and Food and Agricultural Organisation of the United nations Land and Water Division. TCP/CYP/8921

15. Sawa, B.A. and Adebayo, A.A. (2011) Relationship between dry spells and crop yield in drought areas of northern Nigeria. *Proceedings of the International Conference of the Nigerian Meteorological Society*.Department of geography, Ahmadu Bello University, Zaria. 13-17 November, 2011

16. http://www.theconstructor.org/water-resources/design-of-raingauge-networks/4477/ [Accessed 23 July 2013]