Grasslands classification in Yobe state Nigeria using Integrated Orderly Classification System of Grassland (IOCSG)

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Abstract
Integrated Orderly Classification System of Grassland (IOCSG) was initiated by Professor Ji-Zhou Ren in the 1960s and it has satisfactorily served to direct theory and practice of grassland classification for the last several decades in China. In this study IOCSG is adopted to classify the grasslands in Yobe state Nigeria, using 30 years (1984-2013) data on precipitation and temperature from 12 satellite stations across the state. Humidity (moisture index) was estimated as the ratio of precipitation per annum to annual temperature. The results revealed a trend of decline in precipitation and moisture index with latitude; from 772.63 mm and 0.72 in the south (110 08' N) to 303.81 mm and 0.32 in the northern part of the state (130 27' N), respectively. The average cumulative annual precipitation and moisture index in ten (10) of the stations ranges from 772.63 mm and 0.72 to 436.50 mm and 0.41 respectively. While the remaining two (2) stations recorded 407.77 and 303.81 mm as cumulative average precipitation as well as 0.38 and 0.28 as cumulative average annual moisture index. The Average cumulative annual temperature in the state was >100000C across the stations. Two grassland class; Tropical arid and Tropical extra-arid grasslands were identified in the state at the first level of IOCSG. Therefore, tropical arid grassland management techniques should be fully employed for efficient utilization of grassland resources in the study area and further classification of the grasslands into subclasses using edaphic conditions, according to the IOCSG should be carried out.

Introduction
Grassland classification is the theoretical foundation of grassland science, which provides the necessary basis for the evaluation of the grassland role in the society and its overall regional production (Ren et al., 2008). African continent contains significant percentage of terrestrial area in the world. Grassland classification particularly in Nigeria has been vegetation-based classification, where Nigerian vegetation is classified into coastal (mangrove, fresh water swamp), rain belt (rainforest), Guinea savanna (woodland and tall grass savanna, Montane), Sudan savanna (short grass savanna) and Sahel savanna (Marginal savanna) (Shiawoya and Tsado, 2011). However, this classification is too broad and vegetation specific, it does not accommodate other climatic and edaphic factor, as well as changes in species type that will provide basis for estimation of grassland productivity.

Being a dynamic system of grassland classification, the IOCSG adopted in this study, is amenable to global application, and is also an open system that can accommodate any new grassland type (Ren et al., 2008). It involves three classification levels: class, subclass, and type. Therefore, this study seeks to determine the grassland class in Yobe state Nigeria using the IOCSG.

Methods and Study Site
Yobe State is one of the 36 states of Nigeria situated at a Latitude 10.578-13.377^0 N and Longitude 9.654-12.689^0 covering 47,153 km^2 (Fig. 1b). Thirty (30) years (1984-2013) data on rainfall and temperature from 12 satellite stations (S1-12) across the state were obtained from https://globalweather.tamu.edu (Fig. 1c).

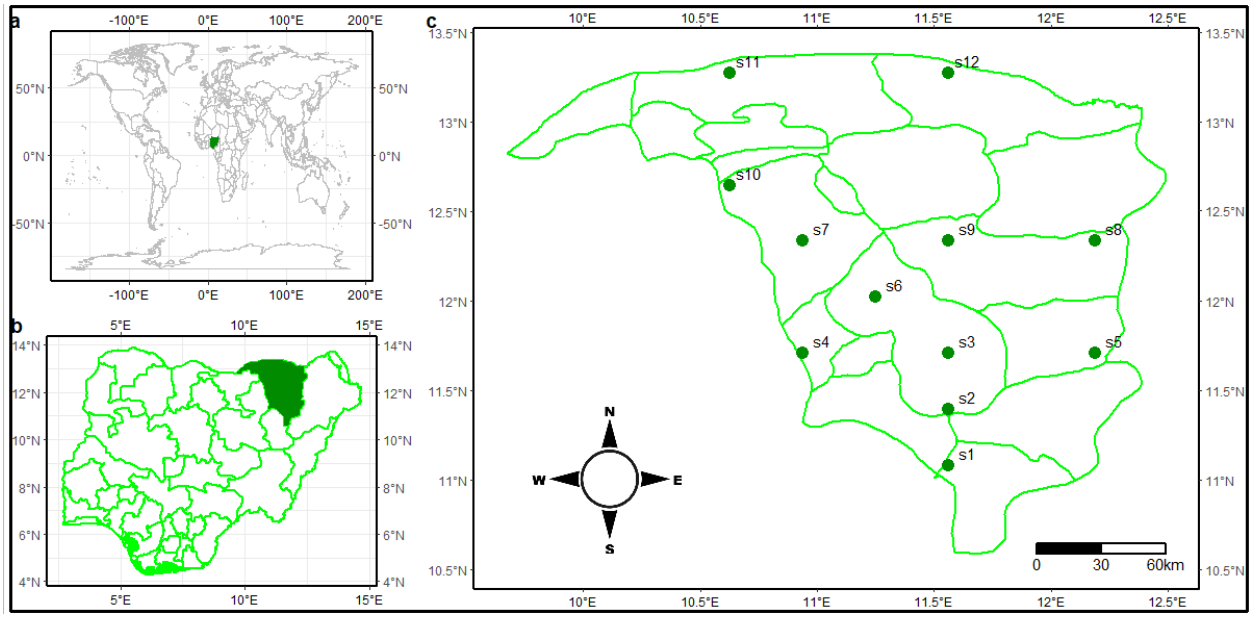

Figure 1(abc): World map showing Nigeria, Nigerian map showing Yobe state and Yobe state map showing the location of the satellite stations (S1-S12)

The mean annual cumulative rainfall, temperature, and humidity were used to classify the grasslands according to the index chart for determining grassland class in the IOCSG (Fig. 2) (Ren et al., 2008). Humidity (moisture index) was calculated from the rainfall and temperature data according Ren et al. (2008) as follows:

$$Moisture\ index = \frac{r}{0.1\sum\theta}.$$

Where: r is annual precipitation and $\sum\theta$ is annual cumulative temperature.

Maps were generated using ggplot2 package (Wickham, 2016) and other supporting packages in R statistical software (R Core Team, 2020).

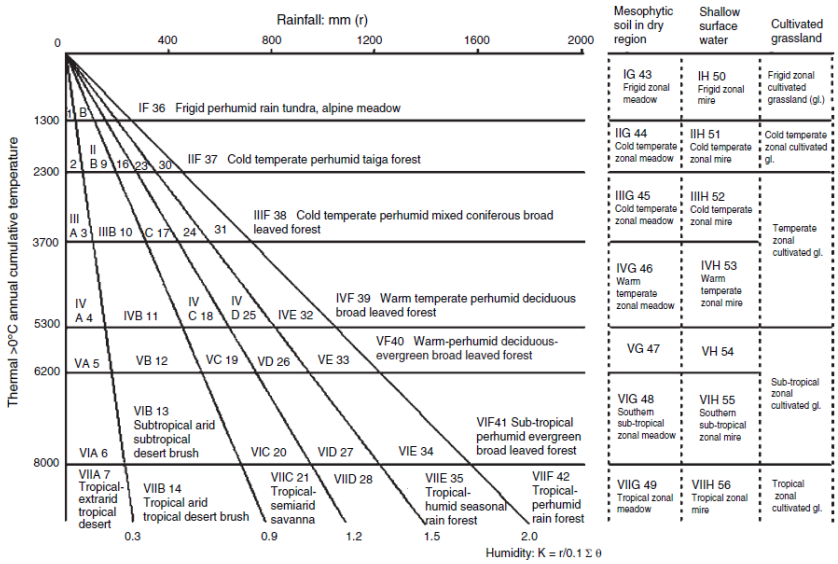

Figure 2: IOCSG index chart for classification of grasslands (Ren et al., 2008)

Results

The results revealed that average cumulative annual rainfall decline from 772.63 mm in the southern part of the state (S12; 110 08' N) to 303.81 mm in the northern part of the state (S1; 130 27' N), respectively. However, the average cumulative annual temperature in the state was generally >10000^{0}C across all the stations (Fig. 3). Similarly, the humidity also shows the same trend as rainfall. The values for the humidity declined from 0.72 in S1 to 0.28 in S12 (Fig. 4). The average cumulative annual precipitation and moisture index in ten (10) of the stations ranges from 772.63 mm and 0.72 to 436.50 mm and 0.41 respectively. While the remaining two

(2) stations recorded 407.77 and 303.81 mm as cumulative average precipitation as well as 0.38 and 0.28 as cumulative average annual moisture index. Generally, two classes of grasslands were identified using the IOCSG index chat. These grasslands are tropical grassland in the northern part of the state and extra-arid grassland in the northern part of the state (Fig. 5).

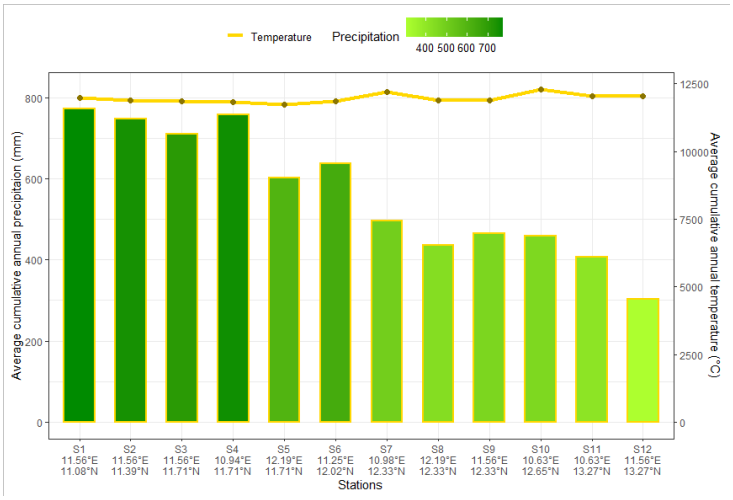

Fig. 3: Rainfall and Temperature recorded from 12 satellite stations in Yobe state

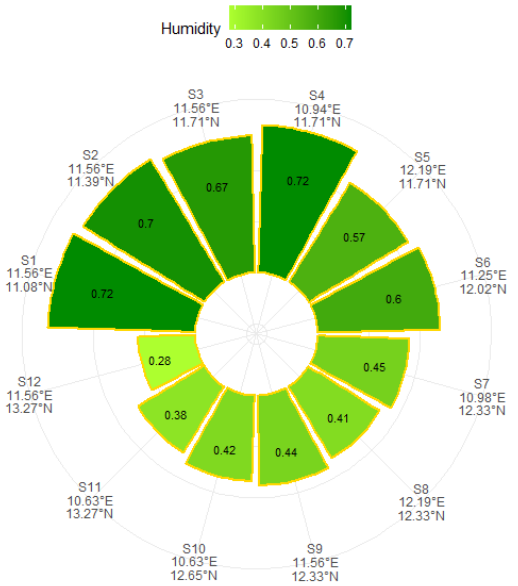

Fig. 4: Humidity (Moisture index) of the 12 satellite stations in Yobe state

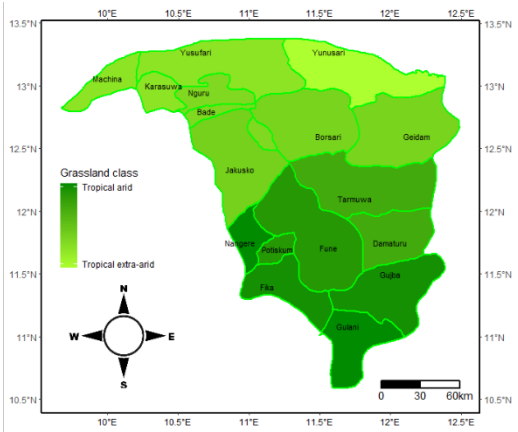

Fig. 5: Map of Yobe state showing the different grassland class using IOCSG

Discussion

This study uses the first level of IOCSG, which requires only rainfall, temperature and computed moisture index to classify grassland. The results obtained for rainfall were in agreement with the rainfall situation reported by Hassan et al. (2019). They acknowledge variation in total annual rainfall and its distribution across the state and attributed the condition to the severe drought experienced in some parts of the state. On grassland classification, grassland of an area with a cumulative annual temperature above 8000^0C is considered tropical grassland (Ren et al., 2008). Hence, the cumulative annual temperature across the state, as obtained from the satellite stations, strongly indicated that the area's grassland is tropical grassland. Using the computed humidity and the IOCSG index chart, two grasslands classes (Tropical arid and Tropical extra-arid grasslands) were identified in Yobe state Nigeria. Yobe state is categorised as one of the states with a severe desertification rate (Olagunju, 2015), which is typical of an arid area. Therefore, tropical arid grassland management techniques should be fully employed for efficient utilization of grassland resources in the state, and further classification of the grasslands into subclasses using edaphic conditions, according to the IOCSG should be carried out.

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