Research Application Summary

Assessment of climate change impact on sorghum productivity in Sudan

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Abstract

Water rather than land is the limiting factor for crop production in Sudan. More than 80 percent of sorghum, which is the major stable food crop in the country, is grown in the rainfed subsector. This paper reports on a study of the impact of climate change on the sorghum production and sorghum productivity in Gedaref region in east Sudan. The climate change analysis included calculation of the Standard Precipitation Index (SPI), rainy days and rainfall amount and distribution. For the crop analysis, area cultivated, area harvested and the grain yield for the period 1971-2008 were used. The drought index showed that there was moderate to extreme drought events during the period 1983-2008. There was also evidence that the length of the growing season also became short (less than two months). While there was drastic change in both rainfall amount and distribution, rainfall occurred mostly during end of July and August. Crop data analysis indicated that the sorghum productivity (kg/ha) significantly declined (6%- 52%) from 1981 to 2008 and also showed that 20% reduction in annual rainfall reduced the sorghum production by up to 25%. The relation between the drought index and the crop parameters indicated that there was strong correlation with crop productivity. The above result indicates that Gedaref region had witnessed a significant decline in crop productivity due to decline in rainfall and persistent drought.

Key words: Drought, rainfed agriculture, SPI, Sudan

Résumé

L'eau plutôt que la terre est le facteur limitant de la production agricole au Soudan. Plus de 80 pour cent de sorgho récolté, qui est la principale culture vivrière stable dans le pays, proviennent du sous-secteur pluvial. Cet article vise à étudier l'impact du changement climatique sur la production du sorgho et la productivité du sorgho dans la région de Gedaref à l'Est du Soudan. L'analyse du changement climatique comprenait le calcul de l'Indice Standard de Précipitation (SPI), les jours de pluie ainsi que la quantité et la distribution des précipitations. Pour l'analyse des cultures, la superficie cultivée, la superficie récoltée et le rendement en grain pour la période 1971-2008 ont été utilisés. L'indice de sécheresse a montré qu'il y avait les occurrences de sécheresse qui allaient des modérées aux extrêmes durant la période 1983-20008. Il a été prouvé aussi que la longueur de la saison de croissance de cultures est également devenue de courte durée (moins de deux mois). Bien qu'il y ait un changement radical à la fois dans la quantité et la distribution des pluies, les précipitations se sont produites beaucoup plus à la fin des mois de Juillet et Août. L'analyse des données culturales a indiqué que la productivité du sorgho (en kg / ha) a significativement diminué (6% - 52%) de 1981 à 2008. Cette analyse a également montré que la réduction de 20% des précipitations annuelles a réduit la production du sorgho jusqu'à 25%. La relation entre l'indice de sécheresse et les paramètres des cultures a indiqué qu'il y avait une forte corrélation avec la productivité des cultures. Le résultat ci-dessus indique que la région de Gedaref a connu une baisse significative de la productivité des cultures due à la baisse des précipitations et à la sécheresse qui persiste.

Mots-clés: Sécheresse, agriculture pluviale, SPI, Soudan

Background

Food security in Sudan depends on three cereal crops, namely sorghum, wheat and millet, however, sorghum ((*Sorghum bicolor* L) is the most important, with more than 80% of the crop grown in the rainfed subsector (Faki *et al.*, 1995). Sorghum is considered as staple food, most important calorie source in Sudanese diet and provide about 60% of total quantity of cereal consumed (Abdelrahman, 1990). From late 1960's the country was stricken by a severe drought and famine. Indeed the climate of Sudan has been changing in many aspects, including reduction of rainfall (Elagib and Elhag 2011; Hulme, 2001), and a significant association between the trend of warmth and dryness was recorded (Elagib, 2010). It is thus important to monitor the impact of climate change and variability on sorghum, since the livelihood of the majority of Sudan population depends on it.

Literature Summary

In the Sudan, drought events have become more recurrent in recent decades during early to mid-1970s, mid-1980s, early 1990s and 2000s (Elhag, 2009). Due to the dependence on water resources and soil moisture reserves during various stages of crop growth, agriculture and natural vegetation cover is often the first sector to be affected by the onset of drought (Narasimhan and Srinivasan, 2005). During the 1980s, poor rainfall contributed to low and variable growth in food production. For example, a 10 percent decline in average rainfall levels induced a 5 percent drop in the national cereal production (Teklu *et al*., 1991).

Various techniques are available for monitoring drought events. In particular, the Standardised Precipitation Index (SPI) has been found to be more appropriate for monitoring droughts because it is more easily adapted to the local climate, has modest data requirements, is easy to interpret and can be computed at almost any time scale (McKee *et al*., 1993 and Agnew, 2000). This paper analyses the impact of climate change on the sorghum production and sorghum productivity in Gedaref region in east Sudan, and has adopted SPI for drought analysis..

Study Description

The study area is located in eastern Sudan. This area was selected as result of it being one of the most important agricultural productive area (under rainfed sorghum and sesame) in Sudan (Sulieman and Buchroithner, 2009).The distribution of vegetation in the region depends largely on two factors, namely, rainfall and soil. Agriculture is the main economic activity, followed by livestock farming in the traditional seasonal transhumant pattern. Nearly one third of sorghum, the primary stable crop, and Sesame (*Sasemum indicum*) produced in Sudan is cultivated in Gedaref area (Fig. 1).

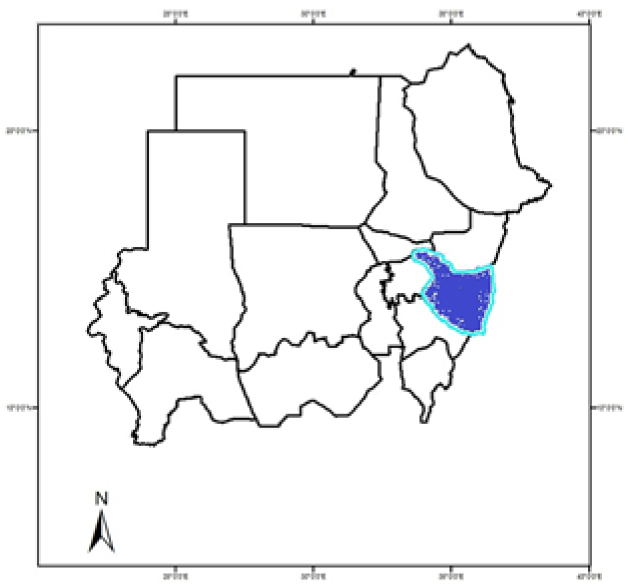

Figure 1. Map of Sudan showing Gedaref region.

Data and Data analysis. Rainfall data was obtained from Sudan Meteorological Authority (*SMA*), for the period 1971-2008 for Gedaref station. The crop data used for analysis included area cultivated, area harvested, crop production and crop productivity (Kg/ha).As stated earlier, drought occurrence was monitored using the Standardised Precipitation Index (SPI), which is the difference between the precipitation data and the mean for that particular time scale, and dividing by the standard deviation. Positive SPI values indicate greater than median precipitation (wet condition), while negative values indicate less than median precipitation (i.e. drought) (Hayes, 2001). Hayes *et al.* (1999) suggested the SPI classification scale given in Table 1.

The method suggested by Elagib (2010) to set the rainfall classes was adopted in this study. These rainfall classes have the ranges greater than 0.0 mm and less than 0.05 (trace), 0.1-1.0 weak, 1.1-10.0 moderate, 10.1-20.0 moderately strong, 20.1-30.0 strong mm and greater than 30.0 mm very strong rainfalls, respectively.

Table 1. Classification scale for SPI values (Hayes *et al*., 1999).

SPI	Category
2.00 and above	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to –1.49	Moderately dry
-1.50 to –1.99	Severely dry
-2.00 and less	Extremely dry

Results and Discussion

The occurrence of drought is illustrated using 12-month time scale SPI (Fig. 2). Data from Gedaref station showed that there were two extremely dry years namely 1984 and 1990 and two severe dry years 1991 and 2006, while 1983, 1987, 1988 and 2001 were moderately dry. From 1980 there was 18 year below long term average rainfall. Figure 3 shows the number of rain days for the effective rainfall (10 mm, 20 and 30) which represent moderate, strong and very strong rainfall. Elagib (2010) found the annual rainfall depend mainly on strong and very strong events. Tthis would mean that heavy rainfalls are more likely to diminish in drought years and increase in wet years. The result showed that the coefficient of variation (CV) for different rainfall classes increased significantly during 1971-2008 (Fig. 3). The analysis showed that there were no significant

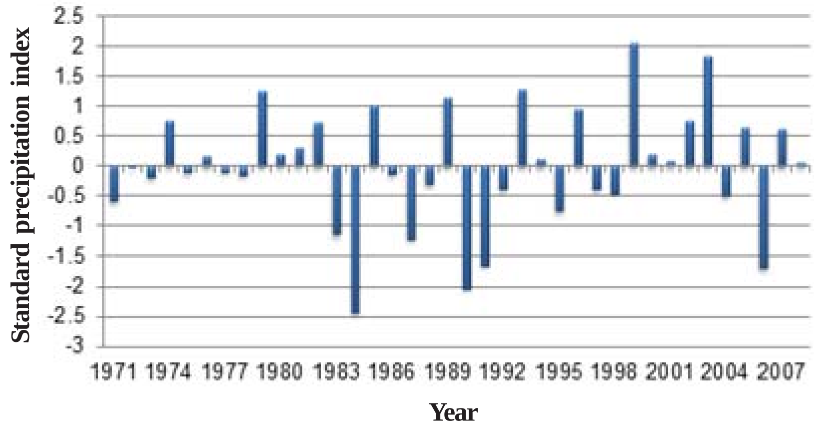

Figure 2. Standard Precipitation index for the period 1971 - 2008.

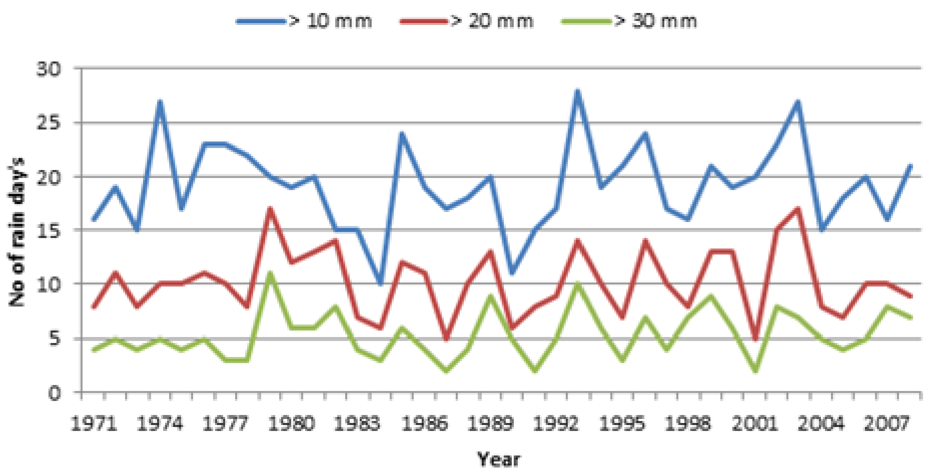

Figure 3. Number of rainfall day's classes.

correlation between the number of rain days with 10 and 20 mm and the productivity in years with normal and the moderate wet, while number of days with 30 mm had strong correlation (0.69). The situation was different in drought years where there were strong correlation between number of days with 10 and 20 mm and productivity (0.9 and 0.7, respectively), while there was no correlation with > 30 mm. These observations may be attributed to the fact that soils in Gedaref regions are heavy clay with high water holding capacity.

The analysis further showed that the length of the growing season became short (less than two months). While there was drastic change in rainfall amount and distribution, the rainfall occurred only during end of July and August.

Figure 4 showed that the correlation was not significant between the reduction of the rainfall amount and the productivity. The highest correlation was found between the productivity reduction (%) and the annual rainfall (0.6). While there were many years with high rainfall after 1996, productivity decline, probably due to the soil deterioration.

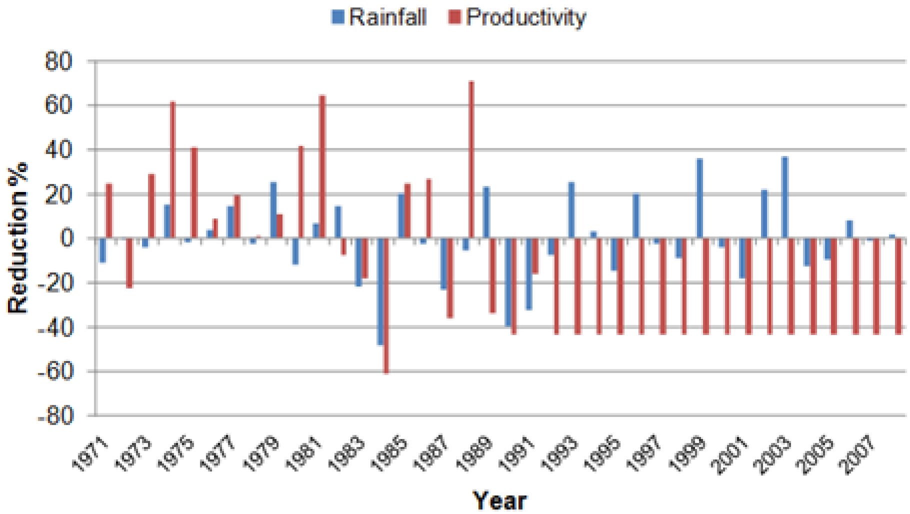

Figure 4. Correlation between reduction in rainfall and productivity.

Research Application

Climate change and variability directly affects agricultural production, as agriculture is inherently sensitive to climate conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change. This is evident for the Gedaref region, where climate change and variability has grossly affected sorghum production, yet the region is breadbasket for Sudan. The climate data for the region showed that there was moderate to extreme drought events during the period 1983-2008. While there was drastic change in rainfall amount and distribution, the rainfall during the period occurred only during end of July and August. Crop data analysis indicated that the sorghum productivity (kg/ha) significantly declined (6%- 52%) from 1981 to 2008 and also showed that 20% reduction in annual rainfall reduce the sorghum production by up to 25%. As a result, Gedaref region recorded a significant decline in crop productivity due to decline of rainfall, persistent droughts and soil deterioration.

The result of this study has been presented to policy makers and a Climate change response strategy is being developed. In addition, to help the country be able to monitor and predict droughts and associated climate change effects, the University of Gezira with support of the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM, www.ruforum.org) is launching an MSc Programme in Agro-meteorology and Natural Risk Management, to help the country develop the required human capital to deal with climate change and variability

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