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Rainfall variability and desertification

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Abstract Due to the high interannual rainfall variability droughts recur at irregular intervals in the Sahel. Mobile and flexible animal husbandry systems can react quickly to the interannual fluctuations in the water resources and biomass. Until recently, extensive migration patterns, and common property rights inhibited an over-exploitation of the Sahelian pastures. The abolition of exclusive land use rights in the eastern Sahel in 1971, and the unilateral promotion of land cultivation has triggered off resources mismanagement in the core areas of agro-pastoral activities. In the Butana region (northeast Sudan), site degradation and desertification have already induced a decline in the quality and the quantity of the pastures. The present land tenure situation in the eastern Sahel requires the re-introduction of instruments for regulating and ensuring a sustained utilization of the natural resources, especially in years with below-average rainfall.

INTRODUCTION

Recent changes to the land tenure systems in the Republic of the Sudan have led to a free and uncontrolled accessibility to the biomass of the Sahelian zone. Field investigations in the Butana region (Fig. 1), in the northeast of the Republic of the Sudan, were carried out in order to determine the long-term ecological and also socio-economic effects of the "open access regime" in a region with an interannual rainfall variability of up to 60%.

METHOD

Vegetation mapping in the Butana region over several successive years enabled the differentiation between human induced changes to the herbaceous layer, and the short-term floristic fluctuations in the Sahelian pastures, which are induced by the annually alternating rainfall amounts. The identification of "increasers" and "decreasers" (i.e. species which are spreading and species that are becoming rare) in the herbaceous layer, and their specific characteristics (e.g. palatability, nutrients, biomass production) were indispensable for the assessment of the vegetal condition, i.e. the degree of plant cover degradation caused by the regular exploitation of the biomass.

Soil samples were derived from various Sahelian relief units, and analysed according to their nutrient budget, and granulometric composition (erosion potential).

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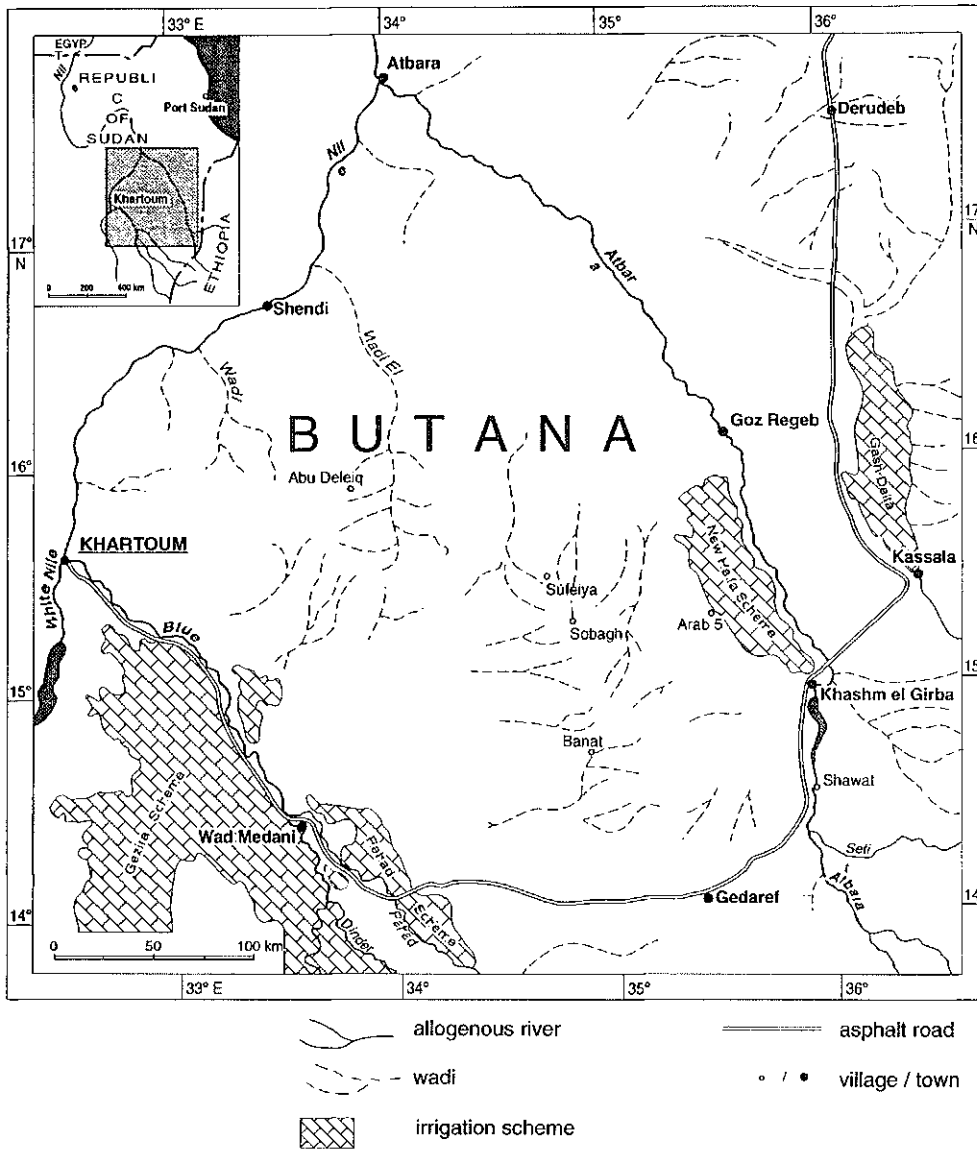


Fig. 1 Location of the study area (Butana region).

The amount and the distribution of the soil seed reserves enabled a precise interpretation of the natural vegetation regeneration capacity of regularly utilized grazing lands.

The analyses of multi-temporal satellite data (MSS, TM, NOAA) and aerial photographs supplemented the regular field surveys. Combined with rainfall data sets, which were analysed on a daily basis, remote sensing data permitted the estimation of the annual biomass production, as well as the identification of core areas of agro-pastoral activities in the eastern Sahel.

Ecological datasets were interfaced with the information gained on socio-economics, anthropology and animal production. Field studies were mainly carried out among the Rashaida and Shukriya tribes, and in the New Halfa irrigation scheme.

RAINFALL CHARACTERISTICS AND LAND USE SYSTEMS IN THE BUTANA

The Butana region has a north–south extension of approximately 400 km. Interannual rainfall variability of over 60% in the north, and less than 20% (% deviation from the mean) in the Sudano-Sahelian south characterize this region, which since time immemorial was well known for its high quality pastures (DHV Consultants, 1989). In wet years extensive pastures with a coverage of >65% emerge even on the friable sandy soils of the Saharo-Sahelian Butana. In lean years relevant biomass production for the animal husbandry is restricted to the southern Butana. Field surveys in two successive vegetation periods (in 1991 rainfall amounted to 30% of the long-term mean (1899–1992 period); 1992 received average rainfall), disclosed a rainfall induced expansion of densely grown grasslands (>65% coverage) by more than 5-fold in just two years (Akhtar, 1995). In the vegetation period of 1992/1993 the entire eastern Sahel was transformed into an extensive grazing land. Simultaneously, the average rainfall event increased the biodiversity of the herbaceous cover, naturally enhancing the grazing quality of the pastures.

Mobile nomadic animal husbandry systems react quickly to the interannual fluctuations in the available biomass. With the onset of the summer rains and the emergence of a new herbaceous layer, nomadic herds (mainly camels) are driven towards the north. Camels can march more than 50 km per day and require water in intervals of 5–9 days (Schutzbar, 1994). Thus, the limited water sources of the northern Sahel do not curb a dispersed grazing. In wet years, Saharo-Sahelian pastures are extensively utilized even during the first half of the dry season (from October/November to January/February).

In very wet years, the southward migration of the nomadic herds commences at the latest in the beginning of the second half of the dry season. However, in dry years meagre or no biomass production in the central and northern Sahel restricts the migration radius of the animal herds to the Sudano-Sahelian subzone (400–600 mm annual rainfall). (For definition of the Sahelian subdivisions see Le Houérou, 1989.)

ECOLOGICAL EFFECTS OF CHANGES IN THE LAND TENURE OF THE EASTERN SAHEL

Traditional land use rights guaranteed exclusive common property rights over water, vegetal resources, soils, and cultivable lands in the wadis. Based on strict resources regulation and monitoring mechanisms, local tribal authorities prevented uncontrolled accessibility to the natural resources of their tribal lands (dars). For instance, water scarcity in tribal areas triggered off a resource regulation mechanism in order to keep outsiders from entering the dars. Especially in years with below-

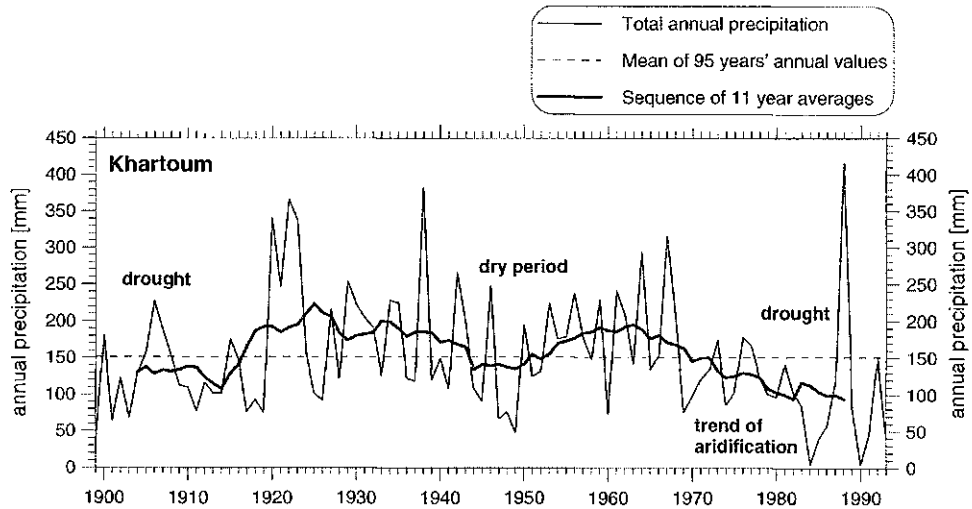
average rainfall, this measure checked the overstocking of the sparse pasture resources in the tribal lands. Extensive damage to the regeneration potential of the plant cover could be reduced.

Amendments to the land laws in the years of 1969–1971 culminated in 1971 in the abolition of these traditional land use rights and resources regulation mechanisms in the Butana (Kirk, 1994). The state declared the Butana region an open access system. This enabled outsiders to enter the former tribal areas, and use the resources without any seasonal or other restrictions. As the state failed to enact new resource control rules, the exploitation of the natural pastures drifted into the unrestrained and individual maximization of utility.

Although the drying trend in the eastern Sahel of Sudan commenced in the 1960s, the average or above-average rainfall events of the 1970s still secured the regular emergence of extensive pastures in the northern Sahel. This enabled a dispersed utilization of the pastures, and retarded the ecological effects of the uncontrolled exploitation of the plant cover. However, since the early 1980s extreme negative deviations from the long-term mean resulted in the two severe droughts of 1984/1985 and 1990/1991 (Fig. 2). The data of the Khartoum meteorological station, which borders the west of the investigated Butana region, were considered, as this data set matched accurately with the statements of the land users (farmers and nomads) with regard to the environmental conditions in the 1980s and 1991/1992.

Prior to the drought of 1984/1985, years with higher rates in biomass production and carrying capacity of the natural pastures enlarged the animal herds. This led to a number of 182 000 TLU (Tropical Livestock Units) in the eastern Central Butana, which exceeded the calculated carrying capacity (110 000–140 000 TLU) of the area (Pflaumbaum, 1994).

Annual rainfall characteristics in the Butana in the years from 1978 to 1993, and the mapping of the distribution pattern of the pastures in different years, indicate that in at least 8 years the bulk of the biomass production was totally confined to the



(Sources: World Weather Records (1899-1949), Sudan Meteorological Dept. Khartoum (1950-1993))

Fig. 2 The long-term rainfall structure in the eastern Sahel.

south of 15° latitude. In these dry years, the extensive migration patterns with large animal herds gave way to an increasingly convergent exploitation of the south Sahelian vegetation. This region was identified as the core area of agro-pastoral activities during dry periods (Fig. 3).

However, the unilateral promotion and mechanization of land cultivation (rainfed and irrigated cultivation) in the Sudano-Sahelian subzone has reduced the available dry season or dry year grazing lands. In the dry year of 1991, in the Butana region, only a strip of natural grazing lands, at maximum 70 km wide, was left directly north of the rainfed cultivated lands. The grazing pressure on this remnant of the former dry season or dry year pastures has been further aggravated since 1984, when farmers started charging for the crop residues on their fields (Rahmann, 1994). As this feed resource is no longer freely available to the mobile livestock owners, nomads defer the purchase of crop residues as far as possible into the dry season. The pressure on the dry season rangelands is further intensified as the few migration corridors, leading through the rainfed agricultural zone to the remaining grazing lands in the south, are only opened after harvesting has finished, i.e. usually in the middle of March.

In the average rainfall year of 1992, grasslands emerged to the north of the 15° line of latitude (Fig. 3). In this year, investigations into the herbaceous layer revealed an increase in the diversity within the floristic composition, as well as a rise in high quality grasses when moving away from the core area of agro-pastoral activities, towards the northern Sahel. Hence, it could be concluded that the decline in the biodiversity in the southern Sahel is the result of the land use practises. North of 16° latitude, the plant cover was ultimately restricted to topographically favourable sites (depressions, wadis), and the floristic diversity declined due to the increase in the aridity.

INDICATORS OF SITE DEGRADATION OR DESERTIFICATION

The extreme rainfall variability and water scarcity still restrict the seasonal length and regularity of the utilization of the herbaceous layer in the central and northern

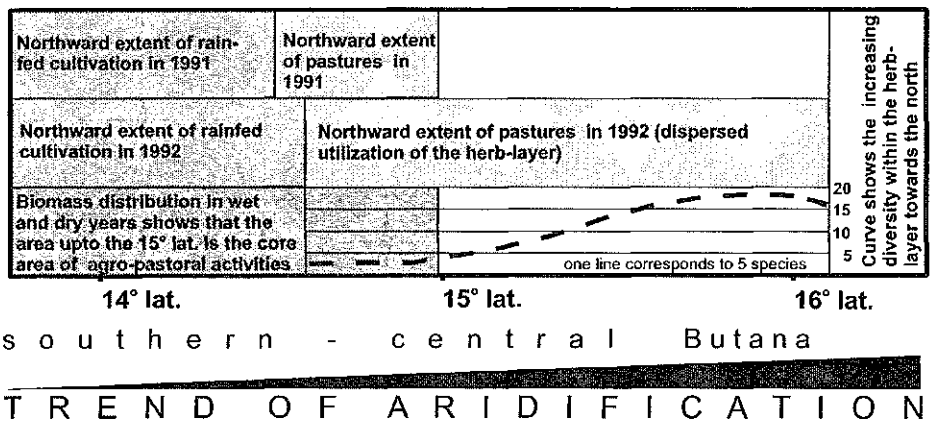


Fig. 3 Identification of the core area of land use activities in the eastern Sahel.

Sahel. Investigations into the floristic composition of these pastures, and the analyses of the seed reserves of the soils indicate an intact pasture and regeneration potential, even almost three decades after the introduction of the open access regime to the region. High quality grasslands, comprising *i.a. Schoenefeldia gracilis*, *Eragrostis diplachnoides*, *Sehima ischaemoides*, *Sporobolus humifusus*, emerge in the northern Sahel (Akhtar, 1995).

Due to the uncontrolled and regular access to the Butana pastures of the southern Sahel, these are exposed to severe stocking pressure, especially during the prevailing dry period, when the northern Sahel has limited or no grassland (Fig. 3). A rapid decrease in the biodiversity of the herbaceous layer, and a decline in perennial dry season grazing plants (e.g. *Blepharis edulis*) have reduced the grazing quality of these southerly pastures. The perennial *Blepharis* was formerly defined as the backbone of the Butana pastures (Harrison, 1955). However, during vegetation mapping in 1991–1993, this species could only be recorded in pinpoint locations. Simultaneously, due to the regressive features in the population of perennial species, the fluctuations in the seasonal availability of biomass in the southern Sahel have increased. Annual, and often inferior grazing grasses (*Aristida spp.*, *Urochloa trichopus*) or even noxious plants (*Ocimum basilicum*, *Tribulus terrestris*) prevail in the rangelands of the southern Sahel. These ephemerals do not provide any stability to the pastures (cf. also Harrington *et al.*, 1984).

CONCLUSIONS

Field investigations showed that dry periods are not the initiators of desertification. Rather, the elimination of common property rights is the key factor for the rapid degradation of the pastures in the eastern Sahel. Especially in dry years, the deregulating interventions of the open access system have had a severe impact on the Sahelian plant cover, triggering desertification. In order to guarantee a sustained utilization of the pastures, it should be considered, whether, during years with sub-optimal rainfall, exclusive common rights over the water and plant resources can be reintroduced.

This could imply that in dry years, groups which are alien to lands lying in the core area of agro-pastoral activities, would no longer be guaranteed free access to the natural resources. In wet years, due to the dispersed utilization of the extensive pastures, exclusive rights over the resources would only be required during the second half of the dry season and up to the onset of the next rainy season. Hence, the annual rainfall event would determine the seasonal length of the exclusive land use rights.

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