

Climate change and African drylands

Frank Berninger¹ and Eshetu Yirdaw²

(1) Department of Forest Ecology

P.O.BOX 27

Fin 00014 University of Helsinki

(2) Viikki Tropical Resources Institute (VITRI)

P.O.BOX 28

Fin 00014 University of Helsinki

Background

Drylands are in many respects a difficult research topic for climate change: While, on the one hand, these ecosystems are fragile and are increasingly degraded, they are, on the other hand, very resilient towards disturbances (Janzen 1988). Especially fire seems to be an element that causes regular disturbances in all Savannah ecosystems. Human action as fire management for pastures, hunting and shifting cultivation have been an integral elements in most drylands for several millennia and drylands would probably look different without human management.

Although drylands provide the livelihood for a large proportion of the worlds population they are particularly problematic in relation to climate change research. One reason is, certainly, insufficient support for research, but also the frequency of disturbances, the huge climatic variation drylands are exposed to and the interactions between grasses, animals and trees make it difficult to understand dryland.

In this paper we try to describe the current state of climate change predictions for dryland Africa and to discuss the possible responses of drylands to climate change as well as possible opportunities to manage drylands for carbon sequestration.

Climatic trends and their implications

From the 1960s onwards droughts in Sub-Saharan Africa have been severe and increasing in their frequency. Rainfall has been lower than in the earlier climatic records. Climatologically, the drought has been connected to the El-Niño-Southern Oscillation (ENSO) index, an indicator of circulation patterns in the Southern hemisphere.

However, it is not clear to what extent the current drought in the Sahelian zone is part of the natural variation of climate and to what extent it is a consequence of global warming. Reconstructions of the ENSO indicate a large degree of variation over the past few 100 years, but during recent years

the amplitude and variation of the index have increased (Stahle et al. 1998). Figure 1 displays the rainfall for Bamako, Mali from 1919 to 1995 as an illustration.

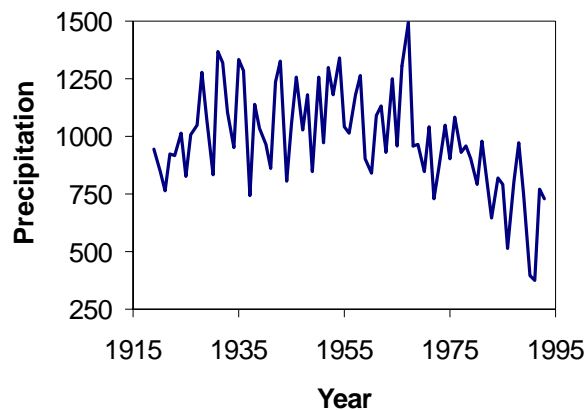


Figure 1. Rainfall for Bamako (Mali) from 1919 to 1995.

Another explanation for the increasing drought in Sub-Saharan Africa has been increasing deforestation: Deforestation decreases surface roughness and atmospheric mixing, as well as possibly the emission of aerosols by vegetation. Modelling studies have shown that all these factors may lead to decreases in precipitation on a local or regional scale.

However, water balance has two elements: input (or precipitation) and output (i.e. evaporation or runoff). Climate warming should in principle increase evaporation from vegetation, i.e. aggravate the effects of possible reductions of precipitation. However, recent studies have shown that this has not happened (Roderick and Farquhar 2002) but pan evaporation from most stations has been reduced. The reasons are probably that relative humidity has increased and the diurnal temperature range decreased (the so called night-time warming).

Predictions of climate change models for rainfall in Sub-Saharan Africa are poorly defined. Current predictions indicate that rainfall in Southern Africa and some of the Mahgreb might decrease, rainfall in eastern Africa would increase and models do not agree on possible rainfall changes in the Sahel. Changes in evaporation are somehow large, but agreement between different climate models is not very good (IPCC 2001).

Climate change impacts on African drylands

Climate change will affect growth of forests in the African drylands in two different ways:

- Decreasing precipitation and increasing temperature could decrease production of forests. However, it is not clear to what extent rainfall will

decrease and if increased temperatures are really associated in increases in evaporative demand (Roderick and Farquhar 2002).

- Increases in CO₂ may increase forest production, especially under moderate drought.

These changes would bring about changes in vegetation productivity and vegetation structure, like shifts in species composition. An interesting point is that African savannah ecosystems are usually composed of two main components: C4 grass species and trees (that have a C3 type of photosynthesis). Now, C4 species do not increase production as a result of increased CO₂ concentrations while C3 species do. Therefore, increasing CO₂ concentrations without climate change would increase the production of the tree component, but not the grass component of savannah. This means also that increased CO₂ per se will not increase fuel production in grassland dominated savannah ecosystems.

While rainfall predictions for much of Africa are not clear it is arguable what will be the responses of the vegetation in total and we would suggest that the discussion should focus on management issues to mitigate effects of climate change locally. An obvious danger (even under an increased rainfall scenario) is an increase in desertification due to poor resource management or over-exploitation of the resources.

For example Gonzalez et al. (2001) used repeated aerial photograph analysis and found that savannah vegetation in Senegal was getting more and more xeromorphic and that tree densities have decreased. They attributed this shift to climate change, but it is not clear to what extent increasing population pressure can be responsible for the changes.

Altogether, current climate predictions are not clear for most of the Sahel. In eastern Africa rainfall and ecosystem resilience might increase, while it would decrease for southernmost Africa.

Altogether this shows that there is no clear picture on the effects of climate change on African dryland ecosystem. These ecosystems are, however, very vulnerable and future management will largely determine the fate of these ecosystems. Climate, on the other hand, has a large role to define how much “human induced stress” the ecosystem can cope with.

Carbon sequestration

Vegetation in dryland Africa is the result of a long term coexistence between human populations and nature. Savannah ecosystems, in particular Guinea and Sudan savannahs, are so called “fire climax” ecosystems, where the existence and extent of woody tree cover is regulated by the frequency and severity of fires in the area. Many, especially more humid, savannah ecosystems will close up and become semi-closed (or even closed) forest if fire is excluded. Current land use trends, however, seem to rather increase the degradation of these ecosystems into treeless grasslands.

Research from a Savannah in America (San Jose et al. 1998) shows that carbon sequestration in such an ecosystem will increase, once fire is excluded (with carbon sequestration being around $1.4 \text{ T C ha}^{-1} \text{ yr}^{-1}$). Our own sparse observations from some plots in Africa point into the same direction.

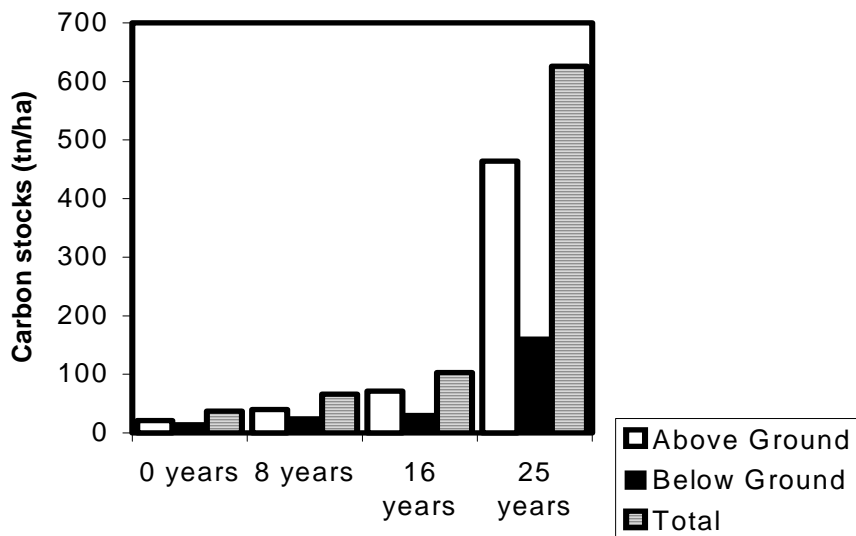


Figure 2. Carbon stocks of a subhumid savannah in Venezuela after fire exclusion.

There are, however, other ways to increase carbon storage in dryland ecosystems. These are changes on agricultural technologies (i.e. no tilling agriculture), use of more productive agricultural technologies (i.e. improved pastures, rotational grazing) and agroforestry systems.

In the Clean Development Mechanism (CDM) there was originally the option to make carbon sequestration from these activities a tradeable environmental service. It was defined in the Kyoto Protocol as a tool to allow for sustainable development and to help industrialised countries to reach their obligations of the Kyoto protocol. However, the Marrakech conference of parties reached relatively restrictive criteria for the Kyoto protocol, i.e. only afforestation (and possibly agroforestry) are accountable

Current prospects for afforestation carbon sequestration projects are somehow dim, while the market price for CDM derived carbon is somehow low (<10 US \$ per ton of carbon) the transaction costs for CDM forestry projects seem to be high. A recent survey in Central America mentions that about US \$70,000 is required for project certification and registration. This would make successful projects very large and might be difficult considering the complex land ownership issues in Africa. Also, it is not clear how questions of permanence of carbon sequestration will be solved for afforestation projects (i.e. the questions how to avoid accounting for possible deforestation of previously afforested areas after the end of the project). Also, large scale afforestation projects (particularly projects based on exotics) have drawn criticism from environmental NGOs.

Another option would be afforestation-based energy projects. These small projects could be more easily accepted under the CDM and for small projects simplified acceptance procedures are possible.

Conclusions

While the impacts of climate change on African drylands are pretty uncertain degradation of the drylands due to human influences is going on. Actions which make these ecosystems more resilient will also help to mitigate the effects of climate change.

Financing of these issues through the Clean Development Mechanism is, however, difficult (or impossible) because accountable activities are restricted to planting of forests and the modalities for project acceptance are heavy.

References

Gonzalez P 2001 Desertification and a shift of forest species in the West African Sahel *Climate Res* 17: 217-228

IPCC 2001 Climate change
<http://www.grida.no./climate/ipcc.tar/wg2/index.htm>

Janzen DH 1988. Tropical dry forests: The most endangered major tropical ecosystem. In: Wilson, E.O. (Ed.). *Biodiversity*. National Academic Press, Washington. pp. 130-137.

Roderick ML, Farquhar GD 2002 The cause of decreased pan evaporation over the past 50 years *Science* 298: 1410-1411.

San Jose JJ, Montes RA, Farinas MR 1998 Carbon stocks and fluxes in a temporal scaling from a savanna to a semi-deciduous forest *Forest Ecol Manag* 105: 251-262.

Stahle DW, D'Arrigo RD, Krusic PJ, et al. 1998 Experimental dendroclimatic reconstruction of the Southern Oscillation. *B Am Meteorol Soc* 79: 2137-2152.