Triggers and Processes Of Desertification In The Dry Lands Of North Cameroon

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***Abstract*-Desertification is officially defined as: "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities (Seely, 2002). The definition clearly supports the basis for a vigorous research programme to combat desertification which now affects many developing countries. This paper seeks to enhance an understanding of the triggers and processes of desertification as a link between research on the one hand and implementation of programmes to combat desertification on the other hand. It uses a combination of primary and secondary data to distinguish between the impacts of rainfall variability and desertification on reduced biomass productivity. The study posits that anthropic factors have had an overwhelming role to play in the desertification of the region even though the climatic factor remains the important trigger. Finally, it concludes that in combating desertification, the interplay of the various environmental aspects must be considered side-by-side: that is, the effects of climate change, the destruction of biodiversity and the mounting scarcity of water resources. Synergies need to be developed to produce more integrated and holistic approaches which will lend the measures being implemented additional success and breadth of effect.**

Keywords-Desertification, trigger factors, dry lands, sustainable development, appropriate measures.

I. INTRODUCTION

Desertification – meaning land degradation and resource destruction is a worldwide problem. Arid regions constitute 40 percent of the Earth's land surface. Currently, an area three times the size of Europe is affected (Ingrid-Gabriela, 2002). Many developing countries are suffering from advancing desertification, in particular the least developed countries. According to Ingrid-Gabriela (2002) the survival of around one billion people is at substantial risk from processes of soil erosion. The economic losses in the form of forfeited incomes in the affected areas are extremely high. For example, in Cameroon the droughts of 1972, 1984, and 2005 in North Cameroon caused livestock to die and grain crop failure. On a global scale annual losses resulting from desertification are put at some USD 42 billion. It is the poorest and most vulnerable members of the society who bear the costs: poverty, poor health, malnutritional status and lack of secure food supplies. These initiate migration flows of the population, and environmental refugees. The central role of research should revolve around enhanced understanding of the processes of desertification and its reversal. The paper therefore seeks to

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And desertification on reduced productivity. enhance an understanding of these processes by distinguishing betweenthe impacts of rainfall variability and desertification on reduced productivity.

II. THE STUDY AREA

From a broad perspective, the areas which can be considered as Cameroon's arid lands in transition are situated between latitudes 10o and 11o30'N and longitudes 13o45' and 15o5E in the savannah-steppe or sudano-sahelian climate. It lies to the south of the Sahel zones which is the southern ecological zone bordering the Sahara Desert. The region has three broad morphological units, namely, the Alluvial Flood Plains (Years), the Diamare Plain and Mandara Highlands. The vegetation is dry savannah type.

The climate of Cameroon like that of Africa is affected by two air masses emanating from anticyclones situated on both sides of the equator. These winds are generally easterly: northeast and southeast trade winds due to the earth's rotation. The variations in African climate result from the north-south shift of these zones as the earth revolves around the sun. During the northern winter, when the zones shift south, all of Cameroon and Africa north of the equator is under the influence of the northeast trade winds. Cameroon and most of West Africa is subjected during this period to the harmattan, a dry wind coming from the Sahara Desert. The dry harmattan invades and the dry season is experienced. The zones shift north in northern summer, since the convergence zone lies generally north of the equator the system moves northwards causing an inflow of moist air over the whole country and this is the wet season. The amount and duration of rainfall decreases northwards.

Most of the areas rainfall comes from monsoons with line squalls occurring mainly at the beginning and end of the wet season. By analysing daily rainfall amounts for areas exceeding 200 mm of rain in the Sudano-Sahelian zone, Ledger (1964) has found that the increase in rainfall southwards from the Lake Chad shores to the Diamare Plain is due to an increase in the number rather than the size of storms. Extreme variability of annual rainfall amounts is also typical. Dresch (1973) reports that the "Shorter the rainy season, the more irregular the rainfall is in space, in time over the year and from one year to another. The rains may start earlier or later, and may last longer or a shorter time.

The population density on the average is about 56 inhabitants/km2 with an annual population growth rate of

3.6%. Considering the low returns per hectare of cultivated sorghum in order to increase harvests, there is certainly population pressure on land, water and biological resources. Graigner (1986) estimates that every additional person in dry lands requires one more hectare of land to supply him or her with 250kg of grain per year needed for basic subsistence. Subsistence farming involves rain-fed cultivation of sorghum and millet and nomadic and semi-nomadic raising of cows, goats, and sheep. With low biomass productivity a cattle stock rate of 2 heads/hectare exceeds the carrying capacity of natural rangelands in the Diamare Plain. Growing human and animal populations continue to cause biological stresses on the environment and greater poverty, resulting in ever increasing degradation of soil, water and biological resources of the region.

III. Materials and Methods

The study was carried out in the Diamare and Chad Plains. Rainfall data for some meteorological stations was collected for the period 1934 to 1984. For each station the years with the highest and lowest rainfall amounts were noted and the percentage changes calculated as indicators of variability for the period in time and in space. The average annual distribution of rainfall for selected meteorological stations was obtained from the Regional Meteorological Service in Maroua. In order to obtain an indicator of the interaction of climatic effects on vegetation, the potential evapo-transpiration for Maroua station was obtained using the Piché Evaporimeter. Together with rainfall data and an assumed soil moisture reserve of 300mm within the root zone, the climatic and soil moisture balance was estimated and their effects on vegetation productivity established. Different natural plant community sites in the area were identified and the percentage concentration of rainfall per month per site calculated as an indicator of the vegetation period or the period of biological activity. Based on the work of Fulton et al. (1974) and 1987 aerial photographs produced by National Geographic Institute (IGN) for the area, the degree of vegetation degradation per plant community site was established. Fulton et al. (1974) established the potential biomass productivity of each range site. The planimetric analysis of actual land uses and vegetation maps of the area assisted in the establishment of degree of vegetation degradation and the actual vegetation productivity per morphologic unit. The estimated land necessitating extensive cultivation of millet and vegetation yields per site were obtained from previous studies in the area. The interpretation of the data so obtained was assisted by field observations and relevant documented data.

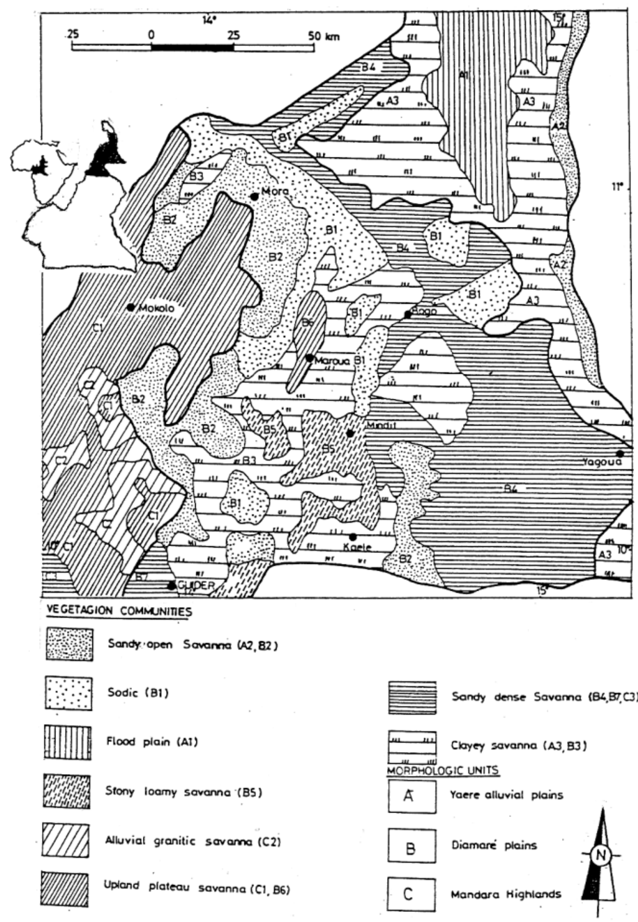

Figure 1: Location of Study Area and Floristic Communities (See table 3 and 4) (after Fulton *et al*., 1974)

IV. Results

Table 1: Frequency of Variability of Annual Rainfall (1970 – 1988) and mean annual total number of rainy days (1940 – 2060)

Probability of rainfall greater than the threshold indicated	Threshold rainfall (mm)			
	Kaele	Maroua	Garoua	Toubouro
0.8	622	631	820	987
0.5	655	675	883	1054
0.2	781	780	1014	1247
Average for the period	666	752	951	1180

Mean total number of rainy days computed from trend lines						
Stations	1940	1960	1980	1995	2030	2060
Maroua	72.8	71.8	70.8	70.1	68.4	66.9
Garoua	82.1	79.7	77.2	75.4	71.1	67.4

Table 1 presents the frequency of rainfall variability for the period 1970 to 1988 and the mean number of rainy days computed from trend lines (Ayonghe, 2001) for the period 1940 to 2060. According to Ayonghe (2001) high rainfall was evident from 1951 to 1967, 1977 to 1980, and 1989 to 1995, while low rainfall was observed from 1930 to 1950, 1968 to 1976 and 1981 to 1988. In general the mean total number of rainy days for the period 1940 to 2060 is on the decline. The rainy season lasts three to six months depending on the location and it is characterized by inter-annual variability of rainfall. Figure 3 presents the frequency of the total annual rainfall with a probability of 8 out of 10 years for the period 1952 to 1969 and 1970 to 1989. It again depicts inter-annual variability.

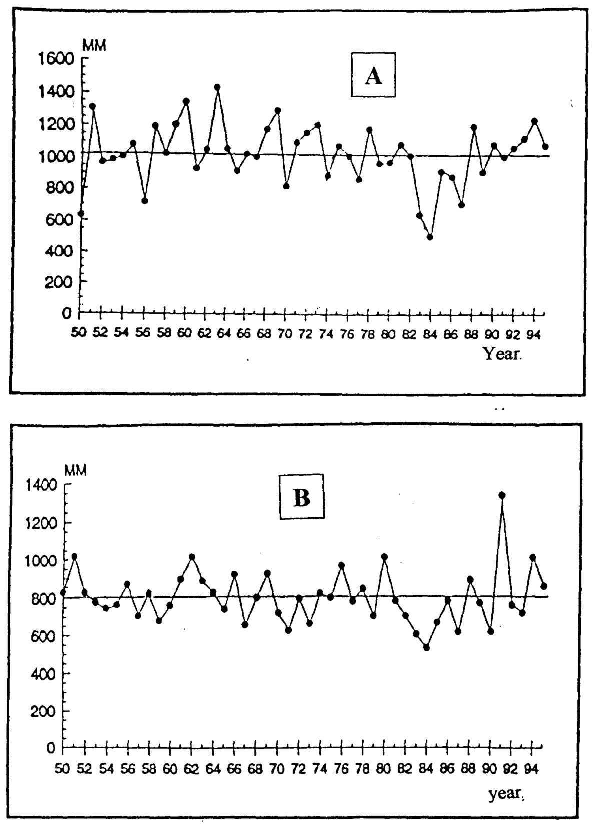

Figure 2: Evolution of annual rainfall in some stations: A = Garoua from 1950 to 1995 and B = Maroua from 1950 to 1995 (after Donfack, Boukar and M'Biandoun, 1996)

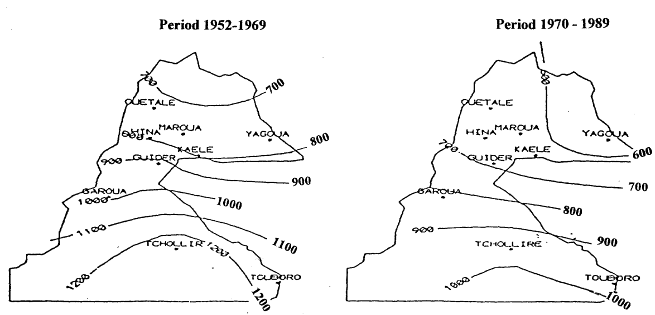

Figure 3: Frequency of total annual rainfall (mm): 8/10 (after Donfack, Boukar and M'Biandoun, 1996)

Station	Evaporation (mm/month)												
	J	F	M	A	M	J	J	A	S	O	N	D	**Total**
Poli	236	279	323	225	127	66	55	56	51	81	149	202	**1850**
Maroua	228	296	365	304	203	199	81	60	83	143	229	213	**2396**
Kousseri	345	389	506	451	362	265	149	74	96	206	353	341	**3519**

Source: Maroua: Provincial Meteorological Station

Figure 2 presents the inter-annual variability of rainfall in Maroua and Garoua. Table 2 presents the evaporation rates for some stations in the area. Evaporation rates are high and large water deficits occur (Figure 4). The moisture available to plants is related to the capacity of the soil to absorb and retain water. Data from the Maroua weather station was used to estimate the moisture balance in well drained upland soils (Figure 4). In figure 4 the average monthly rainfall (R), potential evapotranspiration (PE) and actual evapotranspiration (AE) were estimated using the Piche Evaporimeter. The annual values of PE, AE and rainfall are 1744mm, 969mm and 968mm respectively.
zThe moisture in the soil at the end of each month was calculated by adding the amount of available moisture at the end of the previous month. For example, at the end of June about 25mm of moisture available to plants was stored in the soil. During July rainfall was about 250mm and plants utilized about 140mm of moisture. At the end of July approximately 135mm of moisture were stored in the soil [(25mm + 250) – 140mm]. This then was the amount of available moisture for use by plants in August. The shaded part shows the amount of moisture in the soil that is available in plants. For about 110days from July through October, the available moisture in the soil exceeds PE, and plant growth is rapid. The unshaded part below the PE graph shows that growth is restricted by lack of moisture until the next period of high rainfall. For soils that retain less than the maximum available moisture for plants (about 260mm at Maroua) this period is shorter because excess water moves through the soil to replenish the ground water. The rainfall is concentrated in a very short time of the year. Evaporation rates are equally very high: Maroua has 2396 mm/year while its rainfall is only 804mm. within this climatic context the possibilities of reconstituting ground water reserves and the availability of water to plants are very limited. The area experiences deficits between evapotranspiration and rainfall, which is practically concentrated in 3 to 4 months of the year.

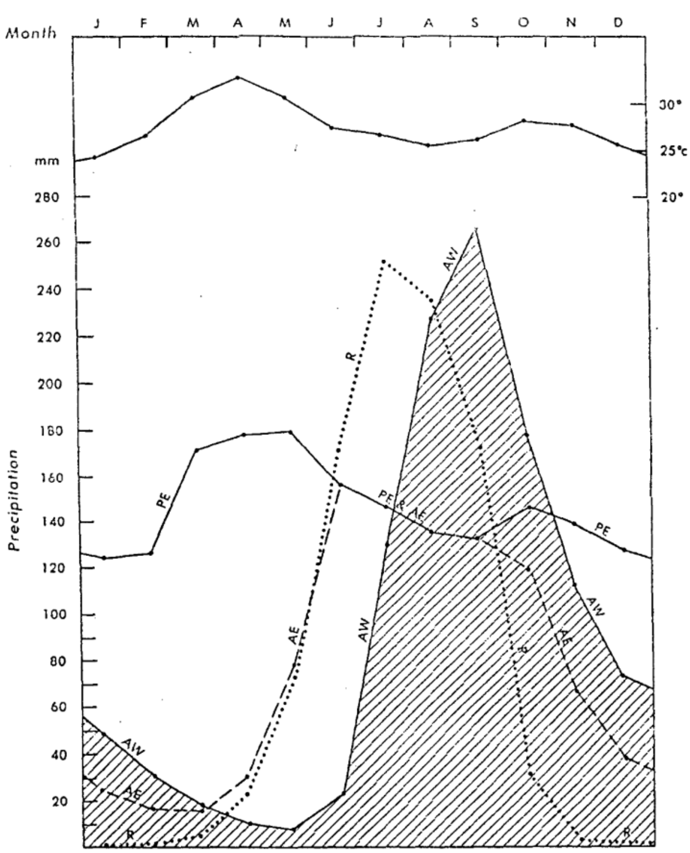

Figure 4: Climatic balance and soil moisture balance in Maroua for the dry lands of Cameroon. (Elevation: 421m)

The consequences of this climatic situation are a biological rhythm with two phases:

- An active vegetative phase of very intense growth of about 5 months. The reconstitution of ground water reserves is essentially achieved from July to August when rainfall exceeds evapotranspiration. This reserve is rapidly depleted as soon as the dry season sets in (November to May)
- The wet season is followed by a dry and hot season during which ground water reserves are exhausted by high rates of evaporation. The physiological activities of plants are very restricted and much of the vegetation dries out.

Streams and rivers are characterized by irregular flow rates. The plains consists of numerous small elongated, sub-water sheds that are parallel to the broad alluvial plain of the Logone River. These discharge runoff water and deposit sediments in a network of outwash splays. flood plain pastures during the dry season degrades the two-transhumance sites. Livestock raisers tend to follow rainfall events in space as a result of spatial variations of rainfall. They practice opportunistic grazing – following rainfall and floods events in space and time. Surface streams dry up during the dry season. The growing season

The limited growing seasons imposes extensive agricultural land use systems which degrade the vegetation. Land clearance for agriculture interrupts this fragile ecology. Overgrazing of upland pastures during the wet season and is limited and the risk of famine high, especially when a drought offsets the fragile balance (Beauvilain, 1981). Sustaining man, plants and animals becomes difficult. Under these circumstances low vegetation productivity is typical.

Natural plant communities in the area were studied with respect to the rainfall distribution in time, soil characteristics, the vegetation period and anthropogenic impacts. These natural plant communities are presented in Figure 1. For each plant community the rainfall concentration during the wet season is as follows:

Sandy open savannah: 85% of total rainfall occurs in July and August.

- *Sodic zones:* 75% of rainfall occurs in July, August and September.
- *Flood plain:* 90% of rainfall occurs in the period from June to September.
- *Stony loamy savannah:* 85% of the rainfall occurs in June to September.
- *Alluvial granitic savannah:* 85% of annual rainfall occurs in July to September.
- *Upland plateau:* 85% rain occurs in June to September.
- *Sandy dense savannah:* 80% of rain occurs in June to September.
- *Clayey savannah:* 80% of rain occurs in July and August.
- The vegetative period is therefore very restricted. Consequently, the vegetation is restricted to ephemerals. These are herbs, forbs and grasses. Perennial trees must be drought resistant. These are fragile environments that degrade rapidly once the natural ecological balance has been disturbed by farming, grazing and deforestation

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Table 3: Degree of Vegetation Degradation (See Figure 1

Community site	Map code	Degree of Degradation of the Potential Vegetation
Sodic	B1	75 to 100 percent of the potential plant community has been degraded and replaced by annuals.
Sandy open savannah	A2, B2	50 to 75 percent of the potential plant community has been degraded and replaced by annuals or other species
Alluvial/granitic savannah	C2	
Clayey savannah	A3, B3	25 to 50 percent of the potential plant community has been degraded and replaced by annuals and other species
Stony loamy savannah	A5	
Sandy dense savannah	B4, B7, C3	
Flood plain	A1	The present plant community is almost the same as the potential plant community. Degradation has been minimal. This because of remoteness from man.
Upland plateau	C1, C6	

Source: Established after potential plant communities and vegetation productivity by Fulton et al. (1974).

Table 3 presents the degree of vegetation degradation for each of the plant community sites. The anthropogenic impacts on the plant communities were assessed. The results are (Table 4):

Table 4: Vegetation Productivity on Plant Community Sites (See Figure 1)

Site	Vegetation composition	Estimated yield (kg/ha)
Sodic. (Strongly alkaline, eroded clay) (B1)	*Acacia species* *Hyperrhenia rufa* *Artistida species* *Annual grasses*	100 – 500 (0.1 – 0.5t/ha)
Sandy open savannah (A2, B2)	*Hyperrhenia rufa* *Pennisetum species* *Ctenium species* *Aristida species* *Eragrostic tremula* *Combretum glutinasa* *Annual grasses*	500 – 1000 (0.5 – 1.0t/ha)
Alluvial/granitic savannah (colluvial foot slopes and outwash plains) (C2)	*Hyperrhenia rufa* *Pennisetum species* *Eragrotis robusta* *Annual grasses* *Ficus species* *Balanites acgyptica* *Ctenium canesiens* *Acacia albida* *Acacia seyal* *Acacia Senegal* *Acacia tortilis* *Combretum glutinosum* *Commiphora africana* *Seleracarva bierre*	600 – 1200 (0.6 – 1.2t/ha)
Stony, loamy savannah (A5)	*Hyperrhenia rufa* *Pennisetum species* *Acacia species* *Aristida species* *Eragrostis species* *Balanites acgytica* *Andropogon gayanus*	2000 – 3000 (2 – 3t/ha)
Flood plain (nearly level, clay soils) flooded 4 – 5 months yearly (A1)	*Hyperrhenia rufa* *Sporobolus pyramidalis* *Seteria palidifusa* *Rottobellia exaltata* *Annual sorghums* *Oryza barthii*	6000 – 8000 (6 – 8t/ha)
Upland plateau (shallow gravely – loamy soils) (C1, C6)	*Hyperrhenia rufa* *Seteria palidifusca* *Pennisetum species* *Aristida species* *Andropogon gayanus*	1500 – 2500 (1.5 – 2.5t/ha)
Clayey savannah (clayey soils on alluvial flood plain) (A3, B3)	*Aristida species* *Hyperrhenia rufa* *Annual seterias* *Acacia species* *Combretum glutinosa* *Andropogon gayanus* *Other annual grasses*	800 – 1500 0.8 – 1.5t/ha)

Source: *Calculated after established potential vegetation productivity by Fulton et al, (1974).*

- **Sodic Zone (B1):** It has a low tree population and thus has a low potential as a source of fuelwood and poles for building. Overgrazing by domestic livestock has altered the plant community. Herds from the neighbouring countries also use this area while in transit. Much of the area requires reseeding. See Tables 3 and 4.
- **Sandy Open Savannah (A2, B2):** Because the soils are droughty, excessive grazing alters the plant community. Annual grasses replace the perennial species, shortening the period during which green grass grows thus reducing vegetation production on the site. The site has a low potential as a source of fuelwood and poles for small dwellings. Trees are intensely degraded.
- **Alluvial Granitic Savannah (C2):** The site has a moderate potential as a source of firewood and poles for small dwellings. Excessive grazing by domestic livestock is common on these alluvial granitic savannas. Droughty soils and a high population density prevent rapid vegetation productivity and recovery.
- **Clayey Savannah (A3, B3):** These are seasonally grazed by cattle. It is predominantly grazed by sheep and goats for most of the year. Trees are degraded for fuelwood and building. This Sahel zone has few trees thus presenting a park savannah landscape.
- **Stony Loamy Savannah (A5):** The site has a moderate potential as a source of fuelwood and poles for small buildings. It has not been seriously degraded.
- **Flood Plain Zone (A1):** Flooding and repeated burning by hunters and herders have prevented woody vegetation from growing on the site (dry season grazing lands). Isolated patches of trees and shrubs grow on humps or raised hillocks on the plain.
- **Upland Plateau (C1, C6):** The upland plateau site remains in grassland. Most trees are in clusters and near streams where the soils are deeper. The potential of the site as a source of firewood and poles for small dwellings is high. Due to the low availability of water for livestock, this site has not been seriously grazed and degraded. Most of the settled zone is a domesticated landscape, due to a high human population density (Park Savannah landscape).

The consequences of the climatic and anthropic factors on the quantity and quality of the environment include:

- A decline in annual production of pasture vegetation;
- A decline in the palatable grass species, particularly perennials which are also good at holding the soil together (soil aggregation);
- An increase in ephemeral plants, which spring up with the onset of the rains rather than having a permanent presence, thus decreasing the durability of pastures;
- Soil compaction as a result of sealing and trampling by stock near water holes and overgrazing of wet-season pastures;
- Damage to vegetation on crests and stable sand dunes resulting in erosion. These provoke a desertification process; and

These processes result in high soil erosion rates (Figure 3). Drought triggers a crisis, but does not cause it. One effect of extremely variable climate is that during wet periods marginal areas are cultivated and herds expand. Then, when a major drought occurs, these marginal areas are unfit for cultivation, and over-expanded herds are critically affected. As there is no vegetation to hold the soil, non-marginal cultivated areas also deteriorate, and erosion occurs. Another climatic problem is that the sudden line squalls occurring north of 11° north cause a great deal of soil erosion. While the adjacent land is depleted, organic and mineral nutrients are deposited in depressions, where they become so excessive that they are inimical to flora growth. Cultivation leads to environmental problems which include:

- Declining soil fertility and falling crop yields;
- Crusting of exposed topsoil by rain and sun. Rainfall intensities in Maroua are averaged at 81mm/hr and the hours of sunshine are long throughout the year;
- Increased surface runoff, sheet erosion and gullying; and
- General desertification of the land.

V. Discussions

A combination of climatic and anthropic factors cause desertification. Desertification is a man-induced process. Climate variability is simply the trigger factor. In these dry lands precipitation is low and losses via evapotranspiration are high, to the point that soil moisture limits production. Current land use is involved in the transformation of rangelands to croplands and investments in water resources for the development of irrigation infrastructure. This presents the risk of soil and ground water salanization. The degradation of vegetal resources has reached a crisis situation. In combating desertification the interplay of various environmental aspects must be considered side-by-side, that is, the effects of climate change, the destruction of biodiversity and the mounting scarcity of water resources. Synergies must be developed to produce more integrated and holistic approaches which lend the measures taken additional successes and breadth of effect. Sustainable development of dry lands implies a development that has no associated desertification risk. This requires the following strategic recommendations (Safriel, 2002):

- Identify those dry land attributes that can be harnessed to provide local people with an economic competitive advantage, compared to inhabitants in non-dry land regions. For example, the curses of intense solar radiation and high temperatures, low quality water and the desolation and wilderness can be converted into the blessings of solar energy production, precious aquaculture and tourism industry assets.
- Match specific aspects of development with dry land attributes and assess the feasibility of their sustainability.
- Maintain the natural integrity of dry lands. Do not convert drylands in order to make them function as non-drylands. The risk here is that this strategy will diversify the dry land ecosystems and perpetuate the poverty of dryland inhabitants and collapse of fragile ecological niches.
- Research should seek to enhance an understanding of the processes of desertification and mitigation measures. Indigenous knowledge and local practices should be researched and further elaborated and developed, such that they can be improved and exchanged between regions.

Exploit the global concern of the detrimental effects of global climate change and biodiversity degradation by implementing and demonstrating appropriate technologies for combating desertification and the sustainable development of agro-pastoral enterprises in a holistic manner, that is, technologies that also mitigate climate change, and conserve biodiversity, and hence benefit local populations as well as regional and global interests

VI. Conclusions

Some decades ago, some scholars took the 1968 – 1972 drought in the Sahel as an indication of a long-term trend towards greater aridity in the arid and semi-arid zones of West Africa. The Sahara, it was said, was spreading southwards because the various rainfall belts were moving south. The drought problem did not come to the forefront because it did not produce the same human suffering as in 1972 – 1973 and 1982 – 1984 period. Drought triggers a crisis, but does not cause it. Over-cultivation and overgrazing weaken the land, allowing no margin when drought arrives. When rainfall returns to more “normal” levels as it did in 1974 and in 1986, there is a natural tendency to intensify farming again. Afforestation, agro-silvopastoral programmes, agroforestry and water harvesting technologies are urgently required to combat the desertification process and to sustain rural livelihoods in the region. In 1977 United Nation’s Conference on Desertification (UNCOD) adopted a detailed plan for national, regional and international action. Transnational projects were to revolutionalise stock rearing in the Sahel, establish green belts north and south of the Sahara and manage regional aquifers. Little of that plan called for has yet been accomplished. There are few visible signs of progress against desertification. The fourth session of the conference of the parties to the United Nations Convention to combat desertification (UNCCD), held in Bonn, Germany in 2000. Despite the known conflicts of interest between industrialized and developing countries was able to give new impetus to the necessary intensification of cooperation between the countries of the North and South. Financing issues have been a difficult compromise between North and South. The implementation of the convention must be more strongly dovetailed with other areas of national policy such as the issues of poverty reduction and climate change.

VII. References

1. Ayonghe, S. (2001) A quantitative evaluation of global warning and precipitation in Cameroon from 1930 to 1995 and projections to 2060: Effects on environment and water resources. In: C.M. Lambi and E.B. Eze (eds.) *Readings in Geography*. Unique Printers, Bamenda p. 142-155.
2. Beauvilain, A. (1985) Remarques Sur la situation pluviométrique actuelle au Nord Cameroun. In ; *Cameroon Geographical Review*, Vol. 5, No. 1 Yaounde University. p. 47 – 62.
3. Beauvilain, (1981) Elevage et eleveurs dans le Grand Yaeré – Nord Cameroun. In : *Cameroon Geographical Review Vol. 2, No.2*, p. 163 - 176
4. Donfack, P; Boukar, S. and M’Biandoun, M (1996) Les grandes caractéristiques du milieu physique In: Agricultures des savannes du Nord Cameroun. Boukar et al (eds), *Actes de l’atelier d’échange*. CIRAD/CA p. 29 – 40
5. Dresch, J. (1973) : Drought Over Africa. The United Nations Economic, Social and Cultural Courier, U.N. New York.
6. Fulton, D ; Brower, j ; Boulet, J. *et al* (1974) Resources inventory of North Cameroon – Africa. USAIS-FAC (France) p. 64 -67
7. Grainger, A. (1986) Desertification. Earthscan Publication, International Institute for Environment and Development, Washington D. C. p. 25 26.
8. Ingrid – Gabriela, H. (2002) The convention to combat desertification – aims and implementation. *Agriculture and Development Vol. 9, No. 1*, GTZ, DSE, CTA, DLG, p. 49 – 53
9. Ledger, M. (1964) Some hydrological characteristics of West African rivers. *Transactions of the Institute of British Geographers*.
10. Mahamat, S. (1983) : L’Exploitation des resources végétales dans le logone-Chari. In : Cameroun, Geographical Review Vol. 4, No. 2, p. 16-24
11. Mahe, G. and Olivry, J. (1991) Changements climatiques et variations des écoulements en Afrique Occidentale et Central, du mensuel a l’international. In: *Proceedings of Vienna Symposium*. IASH No. 201.

12. Molinier, M; Sighomnou, D. and Sigha, K. (2000) Pertubation du milieu naturel du Yaere dan le Nord Cameroun: changement climatiques ou action anthropiques? In: F. Kengne and G. Courade (eds) *Societés et environnement au Cameroun*. NGCC, The University of Yaounde I. p 155 -170.
13. Naah, E. (1990) Hydrologie du grand Yaere du Nord Cameroun. Unpublished Doctorate Thesis. Faculty of Science, University of Yaounde.
14. Olivry, J.C. (1978) Supended solid transport load in Cameroon. In: *ONAREST scientific papers*, vol. No. 1. Yaounde. p. 47 -60.
15. Olivry, J.C. (1986) Fleuves et rivières du Cameroun MESRES – Yaounde / ORSTOM. *Coll. Monographies hydrologiques*, No. 9. 733p.
16. Olivry, J.C. (1993) Vers un appauvrissement durable des resource actuelle sur l'écoulement du fleuve sénégal et l'hypersalinité de la Basse-Casamance. In: *Proceedings of the Vancouver Symposium*, August 1987, IAHS, publication No. 168.
17. Olivry J.C.; Briquet, J. and Mahe, G. (1994) De l'evolution de la puissance des
18. crues des grands cours d'eau intertropicaux d'Afrique depuis
19. Safriel, U. N. (2002) Options for sustainable development of dry lands.
20. *Agriculture and Development Vol. 9, No. 1*, GTZ, DSE, CTA, DLG, p. 54 – 56
21. Seely, M. (2002) Research Competence in combating desertification.
22. *Agriculture and Development, Vol. 9, No. 1*, GTZ, DSE, CTA, DLG, p. 57 – 61 décennies. *Dossier de la Revue Geographie Alpine*, No. 12.
23. Sighomnou, D. (1996) Restauration hydrotechnique de plaine de Logone dans Extreme-Nord du Cameroun. *Prévision des Inondation*, Yaounde.
24. Roupsard, M. (1985) la riziculture irrigué dans les plaines de l'Extreme-Nord du Cameroun: La SEMRY. *Cameroon Geographical Review*. University of Yaounde I.