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Management of Drought and Desertification for Sustainable Agricultural Development in Nigeria

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Abstract**—** *It is no gain saying today that uncontrolled and uncoordinated roles of man are responsible for geo-environmental degradation in Nigeria, be it intentional or inadvertent. Take for instance, Nigeria which will be the focus of this paper has some conservation legislations currently in force and yet the state has not and may never recover from devastating drought years. Many failed measures have been advanced as efforts to improving the productivity of the needed potential of large expanse of land put under cultivation proved unsuccessful. That is, all the measures ever launched to improve agricultural output are not yielding much needed positive results. This is partly due to poor management during persistent drought spells. However, this paper sets to unravel the drought management skills that could be employed to actualise agricultural sustainability. Basically, literature search of information from articles from Google scholar, libraries, etc. as well as personal survey to federal and state ministry of agriculture were exploited. It may be safe to state, therefore, that designing strategies to control or curb drought should take advantage of archived data for present and future research studies that may help arrest the seemingly physical march of the Sahara Desert into West Africa.*

Keywords**— *Agriculture, Desertification, Drought, Management, Nigeria, Sustainable.***

I. INTRODUCTION

Rural population through Africa are the de facto managers of renewable natural resources, and that, if existing system of resource management are to be improved and sustainability ultimately achieved, then the active participation and support of local communities are essential (Bourn et. al., 1991). The problem of Africa today is not caused by climate change but uncontrolled and uncoordinated roles of man as the major factor of geo-environmental degradation, be it intentional or inadvertent. The country has Laws and Acts covering all facets of conservation as contained in Table 1. Added to these are the establishments by decrees and Acts set up to enhance agricultural output such as the ADP, DFFRI, FACU, NALDA, FDALR, etc., all being subsidiaries of the Federal Ministry of Agriculture and Natural Resources while the RBDA, FEPA, NARESOON and others are watchdogs for Environmental protection and conservation.

Table 1: Conservation Legislations Currently in Force in Nigeria

S/N	Conservation Legislations	Establishment Year
1	Exclusive Economic Zone Cap 116 LFN	1990
2	River Basin Development Authority Act Cap 390 LFN	1990
3	Sea Fishermen Act Cap 404 LFN	1990
4	Territorial Water Cap 404 LFN	1990
5	Land Use Act Cap 202 LFN	1990
6	Natural Resources Conservation Council Act Cap 286 LFN	1990

7	Agricultural (Control of Importation) Act Cap 12 LF	1990
8	Pest Control of Produce Act Cap 349 LFN	1990
9	Guarantee Act Cap 384 LFN	1990
10	Bee (Import Control and Management) Act Cap 33 LFN	1990
11	Endangered Species Act Cap 108 LFN	1990
12	Life Fish (Control of Importation) Act Cap 209 LFN	1990
13	National Crop Varieties and Livestock Breed Cap 249 LFN	1990
14	The Forest Ordinance (chapter 75)	1937
15	The Eastern Forest Law	1955
16	The forestry Ordinance with Amendments, Northern Region	1960
17	The Forestry (amendment) Edict; Western State	1969
18	The Forestry (amendment) Edict; Western State	1973
19	The Wild Animals Preservation Law (Western Nigeria)	1959
20	The Wild Animals Law (Northern Nigeria)	1963
21	The Wild Animals Preservation Law (Lagos State)	1972
22	The Wild Animals Law (Eastern Nigeria)	1965
23	The Wild Animals Preservation Edict (NE States)	1972
24	The Wild Animals Preservation Edict (Kano State)	1972
25	The National Parks Governing Board Decree No. 36	1991

Source: National Conservation Centre, 1993

Nigeria went broke trying to import everything from seedlings to fertilizers without re-course to fundamentals of sustainable development rather than conducting research into drought effects and reverse the obnoxious legislations which discouraged the productive grassroots sector of the agricultural economy. It was as if money can buy back the lost glory in the agricultural sector without much thought given to the plight of peasant/rural farmers who constitute over 90% of the work force in agriculture.

It was still that same 'wild-goose' chase that led to the establishment of National Agricultural Land Development Authority (NALDA) as it pilot farms covering less than 3% of the total landmass of Nigeria (over 920,000km square) will do the 'miracle' without actually involving the grass-root farmer on non-pilot project basis of which extension service based on scientific and technological breakthrough is essential.

Institutionalisation of agriculture and centralisation of legislations at the Federal level began to take its toll following that 1969 – 73 drought as Nigeria export trade on the major cash crops – Cocoa, Palm produce, Groundnuts, etc., dropped to abysmally low-levels as shown in Table 2.

Table 2: Agricultural Exports of Nigeria (A Comparative Analysis)

Commodity	1960/66				1987/1991				Remarks
	A	B	C	D	A	B	C	D	
Cocoa	2nd	180	35	30%	16th	100	15	2%	E
Palm Produce	1st	617	38	35%	12th	22	0	0	F
Groundnut	1st	619	22	20%	8th	540	0	0	G
Rubber	1st	58	14	10%	5th	99	N/A	-	H
Cotton	N/A	151	5	6%	-	-	-	-	Not among first 18 Countries

Sources: FAO, 1991

Note:

A = position in the World.

B = Tonnage (x 10^3)

C = Earned Revenue ₦ (x 10^6)

D = Percentage (%) λ GPN

E = Leader are Cote D'Ivoire, Brazil, Ghana, Malaysia, Cameroon.

F = Leader in Malaysia (5 Million metric tonnes) which came to buy seedlings from Nigeria in Sixties.

G = Leading producers are India, China, USA, Senegal, World leaders are Chine, USSR, USA, Brazil.

II. NATIONAL RE-ORIENTATION ON THE ENVIRONMENT

UNCED – 92, (Agenda 21), with its emphasis on the environment; poverty alleviation and economic development, opened the way to a more purposeful future in countries like Nigeria already side-lined by agriculture epileptic policies which hinge purely on economic rather than sustainable development – theories and techniques. The first and major attributes of the Rio Summit at the local level – as far as conservation is concerned – is the foundation of which was laid in 1993. Effectively, through the centre and in accordance with World Conservation Strategy, provisions are to be made for:

i. Respect and care for ecosystem
ii. Improvement in the quality of life
iii. Conservation of life support system and bio-diversity
iv. Reduction in depletion of non-renewable resources
v. Focus on sustainable agriculture for economic renewal poverty alleviation and conservation.

However, there are pre-requisites for the achievement of the above goods in view of repetitive drought, threats of desertification and failing surface and underground fresh water resources. The journey is far, for Nigeria has actually not started. An 'eye-opener' to the unpreparedness can be summed up in the report below which not only makes a mockery of the country's anxiety to join others in the quest for GIS data-base for sustainable development but also portrays her as a nation without vision in the area of science and technology.

Rainfalls and Enhanced Productivity

Drought has three components – Meteorological, Agricultural and Hydrological. Meteorological drought is the only aspect to which most establishment in Nigeria pay major attention. It is the simplest but most inconsequential in relation to plant life as it is a mere diminution in total annual rainfall amount normally received over a specific period. Soil moisture inadequacy or water below soil surface for nutrient intake by plants is not just a function of rainfall, but its spatial and temporal spread, distribution, and reliability (seasonality). Hence, the form and type of data presented is very important in drought research.

The problem of communication gap underscores the need to have relevant resource data that could be directly applicable to planning. That research results are not being effectively utilized in national development efforts stems also from the format of most of the research Reports and Results on very important topical issues. Many of them are 'shrouded' in technical languages that are difficult to translate for application. Others which are to be synthesis of large numbers of data like rainfall, may not be produced at a 'scale' commensurable with the problem at hand. Thus, although the data is available, it has not been transformed into a resource package that can be directly applied in planning and development.

To highlight the importance of resource data in sustainable development, an example that readily comes to mind, and which is relevant to the discussion here, is rainfall as a natural resource in Nigeria. Always taken for granted, over 1,000 rainfall stations for varying number of years are available. It will be cumbersome to use all these data for planning in their raw form. Appropriate statistical tools are, therefore, required to estimate the most important direct and derived parameters and present them in the best format either pictorial or digital (tabular) form. Where these are done, the utility value of such fundamental parameters of precipitation effectiveness will only be enhanced if and only if presentation of results: meets with requirements of the user; and is done with appropriate and convenient FORMAT for easy understanding and application.

Statement of the Problem

On observed and derived parameters of precipitation effectiveness that could enhance development, especially in the agricultural and water resources sectors. (in Nigeria) and guarantee a balanced ecosystem, the problem may not be lack of data but its adaptation from the raw to refined state suitable for particular 'goals'. Nigeria within the past two decades, starting with the global drought of 1969 – 1973, has experienced great difficulties in food production and a myriad of solutions have been advanced. It started with the importation of selected grains and meat in the mid-seventies to UN backed agrarian adventures through such agencies as World Bank, FAO, ADB, etc. Since the early 80's, emphasis has been shifted to dam construction for water conservation and mechanisation of agriculture as a way of bridging the gap between low rainfall expectations and sustained food production. Both decades (70s and 80s) saw the importation of fertilizer as a necessary corollary to any

efforts at improving the production potential of the large expanses of land put under cultivation. Despite those huge investments, the problem has persisted, partly due to poor management during persistent drought spells especially in the latter decade.

However, the most painful aspect of all the laudable programmes by Government was the resort to absolute rainfall amounts and total neglect of precipitation – which is known and recognised, a prior, as the 'pillar' of any agrarian venture for its character, type and spatial/temporal features. Even after 20years of programmes on drought mitigation (1969 – 1973), very little grass root information is available (Bourn, et. al., 1991). There is, however, hope in the well-informed HYDRONIGER programme which focuses attention on rivers Niger and Benue to carry out (among others) the following: Data Bank for Hydrological Information System (HIS); Early Warning System on drought; and Defining and delineating water-sheds.

There remain, however, a wide gap between the relevance of applied research in assessing the gravity of the problems and the indication of drought and desertification (Adefolalu,1991). It is certain that 'designing' strategies to control or curb drought should take advantage of archived data for present and future research studies that may help 'arrest' the seemingly physical march of the Sahara Desert into West Africa.

Aspects of Precipitation Effectiveness

Indicators of drought which have hitherto not been applied in control measures against desertification let alone their application for Early Warning System in crop production planning and water and geo-environmental conservation and preservation include the following: Onset, Cessation, and Length of Raining Season (LRS); Breaks in the course of a normal raining season; Seasonality Index of rainfall; Degree of wetness or dryness (Hydrological Ratio, λ) and Water equivalent to avert drought.

To the extent that precipitation ineffectiveness is a measure of drought, the parameters above will make for a better understanding and solution of those components of drought (Meteorological, Agricultural and Hydrological) which, 'couple' with human pressure, tend to aggravate the desertification of the semi-arid zones of West Africa.

Previous Classification Attempts

Classification of the drought-prone Sahelian belt of West Africa by adopting some critical rainfall limits (maximum and minimum) are varied. While Davy, et. al. (1976) suggest that 300mm to 650mm range describes the Sahel in general terms. However, Nimet (2009) has modified it to lie within the 400mm to 750mm isohyet.

These precipitation limits are based on the fact that 'drought-escape' perennial grasses in this belt, which are seasonal in nature, are capable of maintaining their luxuriant growth. However, 'drought-resistant' tree-plants such as Baobao, thorny and non-thorny shrubs can survive stresses due to soil moisture deficiency for considerable period during the October to April dry season when water demands are very high. It has been noted that potential evaporation of this belt, in Nigeria for example, ranges between 3.000mm and 4,500mm (Adefolalu, 1988).

The importance of the variable nature of the seasonal low precipitation has suggested as a contributory factor to the delicate ecosystem of the Sahelian belt. This is because of the variability of rainfall and time trends are important to plant development. Horowitz (1972) re-affirmed the importance of rainfall regime when he stated that rainfall may be evenly distributed throughout the four months of the rainy season in Sahel (June to September) or it may be concentrated in a few intense periods. For example, in 1968 – 1969, annual rainfall in Niamey (in the 'heart' of the Sahel) was 550mm – 600mm. but due to earlier than normal rains which terminated prematurely, plant wilted and were subsequently scorched by the sun later. The point has also been stressed by Adefolalu (1986b) to effect that while mean annual rainfall provides a useful guide on the boundaries of a stable ecosystem, the pattern and trends, both in space and time, affect the type of soil and consequently the vegetation in any region. Super-imposed on this is, of course, the constraints posed by increasing population pressure.

III. THE NIGERIA SITUATION

The problem of desertification in Nigeria is no more an illusion. Adefolalu (1986,1990) confirmed that while Sahel-type vegetation (shrub/dry grassland) was almost non-existent up to about 1950, it has now spread southward to latitude 10°N in West Africa. With trends in desertification suggesting an increase in areas to be covered by 'treeless' desert conditions in the Sahel, it is only a question of time for such conditions to spread into the Sudan-Savanah belt further south.

The Sudano – Sahelian regions of Nigeria are the most vulnerable areas to drought and desertification processes. These regions already have low of biological productivity, organic matter and aggregate stability. Their vegetation and plant covers are relatively sparse, and soils are relatively more susceptible to accelerated erosion by water and wind. People at risk and at loss in the Sudano – Sahelian regions are more than 19million and 17milliom respectively. In Yobe State alone, the drought that occurred resulted in the

loss of about 3,142 metric tons of expected harvest (Abubakar and Yamuda, 2003).

It is perhaps the neglect of the land of result-oriented research on precipitation effectiveness that has been responsible for contradictory advice by eminent scholars in such areas as agro-ecological zoning and water resource development for control measures against rapid desert encroachment. This has resulted in a myriad of approaches including (and sadly) proliferation of research-oriented Federal Establishments all competing for the same and dwindling oil revenue with other organs of Government.

Apart from turning Federal Ministry of Agriculture into a 'parasite' – which for most times act as conduct pipes for funds to those Agencies, the only time one sees some bubble of life in that Ministry nowadays is during the Fertilizer 'season'. In addition to the pursuit of research problems in an orderly manner – as a follow-up to similar projects in the past (e.g. Obas, and Ebohon, 1996, Kowal, et. al., 2016), co-ordination of agro-related establishments will not only guarantee the collection of most up-to-date information necessary for a standard data-bank for solving geo-environmental problems, but will also conserve funds through avoidance of duplication of efforts and overlapping.

The severity of the incursion of desert conditions has reached such alarming proportions in relation to rural energy needs that palliative in terms of relief aids will not suffice. Globally, it has been stated that '350Billion Dollars' worth of agricultural products would be lost if current rate of desert encroachment is not stopped. In Nigeria, the World Bank (1991) estimated that 100Billion Naira or 40% of its GDP will be required to maintain the present levels of development not to talk of cost of sustaining it. These reasons, therefore, call for the advocating of multi-disciplinary approach to research as the only viable solution.

Environmental Hydrology

The major vulnerable sector to drought in Nigeria is the water resources. Water resources represent a major prerequisite and driver of socio-economic development and cater for other economic sectors such as domestic, agriculture and fisheries, industry, bio-diversity, power and energy generation (NiMet, 2014).

Precipitation is the most important element of climate in relation to water resources development in Nigeria and the key to understanding the precipitation regime is hydrologic cycle. While most of the southern parts of Nigeria have surplus surface flow, the drought-prone northern states suffered so much from drought in the seventies, that dam construction was adopted as 'the solution' with the major rivers as basis. However, the performance of the most open dams and reservoirs for water storage facilities have been so unsatisfactory to the extent that Government had to institutionalise Directorate of Food Road and Rural Infrastructure (DFRRI) in 1986 to correct (among others tasks) the imbalance in water needs of rural dwellers by bore-hole drilling, well-digging etc. This approach has only temporary advantages as Sircoulon (1990) observed that daw-down of Lake Chad is not unconnected with large scale rapping of underground water coupled with poor rainfall replenishing in the area.

During drought spells experienced in Nigeria between 1969 and 1984, distance of perennial rivers like Niger and Benue (and their tributaries) has been minimal (Sircoulon, 1990). The dilemma for the country now relates to the prospects of sustaining developmental efforts in the water sector if decreased rainfall in drought-prone areas, as a result of climate change persists. For instance, it is not until recently that Government realised the advantages of inter-basin water transfer and has now committed substantial amount for applied research on the very important aspect of sustainable development in the water sector (Adeyemi and Akanbi,1991).

Although, the turn-round in relation to Government interest in research is laudable, there is no doubt that a comprehensive study involving the root causes of scarcity of water derivable from precipitation (among others) will, in long run, prove more beneficial to Nigeria. Because, while a single project on inter-basin transfer may serve the purpose of relieving pressure in a particular catchment basin, sustainable development as a function of long term planning should consider such components of the hydrologic cycle as surface flow, through-flow and evapotranspiration. Impact of global warming in relation to river regime in Nigeria should receive serious attention henceforth.

Bio-Diversity

A critical aspect of Bio-diversity relates to INPUTS (chemical additives) that are used in maximizing agricultural outputs which include fertilizer, pesticide, fungicide and herbicide. The level of bio-degradation of those inputs vary. Some of these inputs degrade easily while others are more persistent. Some others degrade to toxic substance which will pollute surface and sub-surface fresh water. Studies that have carried out on the persistence of these chemical in soils and plants and the attendant side-effects on the environment are mostly limited to pilot schemes with little or nothing at all from large river catchment basins or farmers' fields. There is, therefore, a need to generate substantial data on bio-chemical aspects of improved farming practices within the most arable but degradation-prone low-lying basins that have become the 'show-piece' of fresh water-related agricultural ventures.

At present, most streams and rivers face decline arising from the construction of dams, dredging and modification of natural channels. The lentic eco-systems on the other hand are ephemeral features of the landscape which fill-in, become smaller and finally are replaced by a terrestrial community. The degree to which these processes occur is to a large extent dependent on how adequate the water-shed is protected. For example, siltation is one of the most individual forms of river pollution. The silt, when toxic chemicals are present, destroys steam habitats and kills aquatic organisms while suspended clay particles prevent light penetration and growth of aquatic plants.

The net effect of these processes is a decrease in the diversity of ecosystem which results in a more unstable system. In such a situation, aquatic communities are usually subject to wide fluctuations in population of organisms and are easily influenced by the vagaries of weather and climate Aside from sea fishing which is dependent on plankton regeneration, fresh-water fish development which accounts for 30% of animal protein consumption in Nigeria is a 'climate-conscious' enterprise (Sikoki and Chinodah, 2004). It is recognized that the survival of any species in a seasonally unstable environment is only possible to a certain point. Beyond some critical climate condition, adjustments are impossible as reproduction may deterred. In Nigeria, local current production of about 0.5million tons falls short of the demand of 2.5millions tons. To meet such high demand, fish farming must be developed nationally to take advantage of the changing climates. Meanwhile, to-date, there no useful environmental data on the role of climate on local fish farming innovations. For instance, low-level fresh water which could lead to destruction of fish habitats, breeding grounds and the general well-being of and other aquatic animals has not been properly documented in Nigeria. The thrust of future projects in this respect should focus attention on base-line data on fresh water statistics.

With respect to animal production, environmental factors do also influence production capabilities. The degree of influence, observed in the overall productivity performance over a given period of time, is a function of fresh water availability and the production of fodder for both in-door experiments and pastoralism. It is regrettable to note that know that while 'cold' countries produce at enhanced levels despite limitations imposed by climate in available water-sheds, tropical countries like Nigeria depend on solely on pre-medieval pastoralism practiced by illiterate (although highly knowledgeable) herdsmen who themselves are few and have become endangered species. Production indices that are mostly affected include reproduction, milk-yield, weight gain and survival of young ones. Fresh water intake directly or from herbaceous plant is critical. Thus, data inventory on the most climatically-viable river catchment basins in the highly productive belts of Nigeria (free of pest diseases) is expedient if rangeland management is ever to be given the over-due attention. Nigeria will be well advised to 'borrow' a leaf from New-Zealand which has well over 21million cows and 60million wool-producing sheep but do not suffer from over-grazing. She adopts 'Hi-Tech' which improves the carrying capacity of the land three-fold through 'lavish' use of breeding stock and gives emphasis to pasture management on intensive rotational (not wild and uncontrolled rangeland) grazing practices; careful conservation of herbage by mechanised hay-making and silage etc.

In agriculture which has been the major base of most 'south' countries (i.e. third world poorly industrialised countries), massive 'importation of technology (farming tractors, harvesters, etc.), and fertilizers was thought was thought to be the 'bridge' between lower crop yields and population demands. Nevertheless, the picture today is different. Having gone into huge debts, which can hardly be serviced, and faced with acute and perennial food shortages, south countries have had to rely on importation of food grains, thereby, compounding their economic woes, increasing poverty and neglect of the degraded environment. The problem of environmental degradation, relating to desertification, which is usually attributable to climate-induced drought is more man-made than natural, at least in the agrarian land-use sector. It is, therefore, expedient that management of drought and desertification has to do with effective utilization of resources without compromising future needs.

For any meaningful programme of economic development for poverty alleviation by enhancing food production, there is only one way to go – micro-scale surveys including carrying capacity of soils and fertility evaluation for planning.

IV. AGRICULTURE ACTIVITIES AND MANAGEMENT

Agriculture remains the pivot of the common man in Nigeria whose livelihood depends on farming activities. Eighty percent of Nigeria's 85million odd people still live in rural areas toiling daily to produce raw food materials and engage in plantation agriculture to improve their economic base through production of cash (export oriented) commodities like cocoa, palm produce, groundnuts, soybeans, etc. However, as projections for a rise in staple food production are made, so also has demand (due to uncontrolled population growth) continue to outstrip production to the extent that a deficit of 35million tons is forecast for the year 2015. More serious, in the short-term is the shortfall of 11million tons forecast for the year 2000

– about eleven years from now (Federal Ministry of Environment, 2004).

Agriculture is one of the main economic activities in Nigeria that accounts for about 40% of the country's GDP and which employs about 60% of the active labour force, hence, drought would lead to catastrophe with unprecedented repercussions. During each period of drought, agricultural production is reduced. Majority of the people in the drought prone areas are peasant farmers, living on marginal lands in rural areas and practicing rain fed agriculture. Drought threatens agricultural production on these marginal lands, exacerbating poverty and starvation as agriculture is the mainstream of Nigeria's rural economy (Federal Ministry of Environment, 2012).

Without any expansionist tendencies, therefore, Nigeria has no alternative than to adopt 'high-tech' for staple food production (some have prescribed reduced population growth rates which may be more difficult to achieve). The most logical approach is to ensure high crop yield through scientific methods. High crop yields cannot be assured without a carefully planned improvement of impoverished soils – especially in erosion-prone and semi-arid environments. Firstly, the carrying capacity the land must be determined. To do otherwise and engage in arbitrary application of chemical activities will only worsen the degradation of top soils thus making it impossible to ensure sustainable development.

The 'high-tech' approach to animal husbandry by countries like New-Zealand is the only way out. Deliberate efforts must be made to (among others): breeding new and improved grasses for fodder; adopt alternative feed stuffs rather than allow nomads to continue roaming rangelands – setting fire to old grass-stocks to accelerate off-shoot growth; emphasise pasture management on intensive national growth; and careful conserve herbage by mechanised techniques.

Drought Management

While the first three sets of parameters above depict drought occurrence or non-occurrence, management is possible through Degree of Wetness or Dryness (λ) and water equivalent to avert drought. For optimum results, computations are best at micro-scale (sub-synoptic scale) grass root levels. In the examples for Ekiti State of Nigeria using 16stations, it is observed that the state can no longer depend on rain fed agriculture too much due to current trends of drought, although it is a remote possibility for desertification to affect the State at the level now currently being observed in the northern parts of the country. For amelioration, dams for irrigation agriculture must be introduced with precision in order to enhance the capability of State as an agricultural area. Similar recommendation was made in the case of Niger State by Adefolalu (1990).

V. SUGGESTION FOR FUTURE CLASSIFICATION

Apart from mean rainfall amounts and variability, thereof, the measure of precipitation effectiveness are onset and cessation dates and length of the Hydrologic Growing Season (HGS) (Adefolalu, 1986a). On the nature of the Sahelian drought which contributes to the desertification process in West Africa, Adefolalu (1986b) has shown that consequences of precipitation deficiency with respect to these three parameters may over-weigh the damage done by actual deficient in rainfall amounts. Unfortunately, most studies in the SSR countries have paid little or no attention to them despite the overwhelming evidence confirming their relative merits in the tropics in general. It is, therefore, pertinent that future studies on management of desertification trends in the SSR and GSB countries, must concentrate on this badly neglected parameters of drought indicators in the tropics.

Furthermore, recent studies suggest that in order to cover more areas, satellite data can be used to derive precipitation rates from clouds quantitatively. This approach is highly recommended in the sub-region of West Africa where surface conventional stations are few especially in the Sahel and Sahel-Sahara belts.

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