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Impact and control of desertification in the drylands: A review article

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Abstract

The inherent variation in the impacts of desertification and the criteria and methods used for its control significantly influence the success of its combat. This paper provides a critical review of the empirical studies that have been carried out and of the assessment approaches that have been developed in the drylands. A number of local but differentiated case studies were reviewed. The current knowledge is established, and areas of possible future research work are identified. To combat desertification in a sustainable manner local case studies should be promoted for the reason that diverse areas demand different assessment and prescriptions. The community involvement and the assimilation of socioeconomic measures in the packages of control is the panacea to desertification conundrum.

Keywords: Desertification, Impact, Control, Sustainable Land Management

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1. Introduction

An intense debate over the phenomenon of desertification has been raging for well over two decades since the Sahelian drought of the 1970s. The debate has generated some new knowledge, interests and realities but also some myth, to the extent that some have questioned the existence of such phenomenon (Smith and Koala, 1999). Earlier, Lamprey (1975) attempted to quantify the state of the Sahara by comparing the location of the Southern margin at two different times, 1958 and 1975. During this period, he observed a 90-100km displacement thus concluding that desert edges were encroaching at a 5.5km per year (Veron et al., 2006). Another manifestation was one based on observation by European foresters working in West Africa during the early years of the 20th century (e.g. Stebbing, 1935; Aubreville, 1949) who suggested that real deserts were being born in the regions where annual rainfall is from 700-1500mm. However, Hellden (1991) and Tucker et al. (1991) did show Lamprey's approximation as mistaken as it ignored the fundamental role of climate variability. Through a combination of field work and satellite remote sensing they showed the desert boundaries were very dynamic, their positions tightly linked to annual rainfall (ibid). These and other findings (Hellden, 1988 and Olsson, 1985) challenged the tenets of desertification and led to the abandonment of the initial simplistic paradigm (Thomas, 1997). Recent findings based on analyses of satellite images report an increase in greenness over vast areas of the Sahel since the mid-1980s, which has been interpreted as a recovery of the vegetation from the great Sahelian droughts (e.g. Tucker and Nicholson, 1999; Eklundh and Olsson, 2003). This recently observed greening trend as observed by Veron et al. (2006), has challenged notions of irreversible damage inflicted on the Sahelian ecosystem and renewed the debate about the concept of desertification (Herrmann and Hutchinson, 2005). Two completely opposed positions emerged and are represented by those who see human mismanagement as the cause of irreversible desertification (Le Houerou, 2002) and those who refute the concept of desertification altogether and stress the importance of natural fluctuations in rainfall and consequently vegetation response (Tucker and Nicholson, 1999; Eklundh and Olsson, 2003). A similar study carried out in Sudan in 2001 through the use of a combination of satellite images proved there was neither a systematic advancement of the desert or other vegetation zones nor reduction or disappearance of vegetation cover. However, a replacement of forage with woody species was observed, thus indicating declining soil quality (Macaulay, 2014). The study further revealed that the changes in vegetation were a result of drought and noted that there was a full recovery of the land as soon as the drought ended. This observation is in line with the findings by Tucker and Nicholson (1999).

Whereas the areas of disagreements have been mainly predicated on reversibility, location, rate of progression, causes, and cure, the confusion stems from the multiplicity of words, the evolution of the concept in time and the background of the authors (Verstraete, 1986).

The first decade of this century witnessed severe drought in the Sahelian region in the 1970s, catastrophic events like the Dust Bowl in the United States in the early thirties and perceived expansion of the Sahara Desert impacted on western scientific thinking profoundly (Thomas and Middleton, 1994; Smith and Koala, 1999; Hellden, 2003). The contextual preview started in 1949 when Aubreville introduced the concept 'desertification'. As forest expert, he was observing the progressive replacement of tropical and sub-tropical forests in Africa by savannahs, a process he termed "savannization". He identified local population's action of

fire and deforestation as the disturbing mechanisms that allow more arid conditions to set in and used the term 'desertification' to designate extreme case of "savannization", characterized by soil erosion, change in the physical and chemical properties of the soils and invasion of more xeric species (Verstraete, 1986).

According to Dregne (1986), the United Nations Educational Scientific and Cultural Organization (UNESCO) launched its major project in scientific research in Arid Lands in 1951. The project led to the publication of a newsletter, the provision of funds for establishing and strengthening arid land research institutes, Organization of conferences and symposium and publication of series of research reviews and special reports on a broad range of topics. The impetus generated by the UNESCO project led to expanded interest in and support of arid lands studies throughout the world (Dregne, 1986; Verstraete, 1986).

During the 1960s, the rainfall intensity, onset and cessation in the Sahel region started to shift and resulted in severe drought conditions that became clearly identifiable in 1968. The drought became the focus of attention for some years in the early and mid-1970s, and it became clear that drought was not the only or even the main culprit in the extensive disaster that followed.

Simultaneously, the developed world started showing interest in environmental conservation and quality of life that saw the holding of the Stockholm Conference on Environment in 1972 and the creation of the United Nations Environmental Programme (UNEP). The same year, unusual climatic events occurred in many regions of the earth such as El-Niño, drought and floods. The United Nations General Assembly in 1974 ordered the creation of UNSO, now the United Nations Sudano-Sahelian Office and requested UNEP to organize the International Conference on Desertification (UNCOD) all in response to the magnitude of the problems encountered in the Sahel. The Conference took place in Nairobi, in 1977. In preparation for this Conference, many studies and documents provided the first attempt to synthesize the understanding of the problem of desertification (Rechkemmer, 2005).

The word 'desertification' is not the only word in literature to describe environmental degradation in the arid regions. Verstraete (1986) in his work on the definition of desertification reported that 'desiccation' was used by Hubert (1917), Schwartz (1919) and Chudeau (1921) to refer to what they perceived as a progressive drying of the climate particularly in the margins of the Sahara. In 1947, Aubreville introduced 'bovalization' followed in 1949 by 'savannization' and 'desertification.'

Some ten years later, it was further reported by Verstraete (1986) that Le Houerou (1959) recognizing that the word desertification was being used to describe ecological degradation in any environment including tropical forests, invented the word 'desertization' to refer specifically to semi-desertic areas bordering actual deserts. In a bid to provide solution to the definition difficulty by the participants to a seminar series entitled 'Desertification: Process, Problem and Perspectives' held under the auspices of Arid and Semi-Arid Natural Resources Program of the University of Arizona in Tucson in 1975, proposed the use of the word 'aridization' (ibid).

Disagreements continued in defining desertification as different meanings are attached to the same word. Gurdano (1977) was reported by Verstraete (1986) to explain desertification as the impoverishment of arid, semi-arid and sub-humid ecosystem by the impact of man's activities. This definition clearly emphasizes on human land use. Le Houerou (1975) defined desertification as degradation of various types and forms of

vegetation including sub-humid and humid forest areas, which have nothing to do with deserts, either physically or biologically. The pivot of this definition is on landforms and vegetation.

UNEP (1977) defined desertification as the diminution or destruction of the biological potential of land, which can lead to desert-like conditions and emphasized that it was an aspect of the widespread deterioration of the ecosystems which had diminished or destroyed the biological potential of the land, i.e. plant and animal production, for multiple purposes at a time when increased productivity was needed to support growing populations in quest of development. Thus, the definition revolved around economic impacts. This latter definition is the one given in the United Nations Plan of Action to Combat Desertification, which emerged from the UNCOD in 1977.

A group of scientists seriously challenged UNEP's concept of desertification during the 1980s and at the beginning of 1990 on the nomenclature (Mainguet 1991; Hellden, 1984). This challenge caused a modification of the definition, introducing a caveat that desertification does not have to lead to the development of desert or desert-like conditions. Desertification simply became land degradation in the drylands of the world and adverse human impact on the environment became its only causal factor (UNEP, 1990, Odingo 1990, Hellden 2003), even though some researchers such as Darkoh (1982: 320), had pointed out earlier that desertification could be "caused by natural factors such as climate or could be man-induced" and further that more often it was the outcome of "the concomitant action or interaction of man and nature". Despite this, the prevailing notion of "adverse human impact" remained the accepted paradigm. This adverse human impact paradigm as the *primum mobile* of desertification was so strongly supported by UNEP that in mid-1991, the latter gave its fiat by defining desertification explicitly as "land degradation in arid, semi-arid, dry sub-humid areas resulting from adverse human impact". However, the paradigm was short-lived as it was overtaken by the Rio or Earth Summit in 1992 that recognized that not only human impact but also various factors, including climatic variations are important causes of land degradation in the drylands. The Earth Summit 1992 reached a negotiated agreement as "land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities" (UNCED, 1992).

Irrespective of these conceptual problems, the international community, has long recognized desertification as a major economic, social and environmental problem of concern to many countries in the regions of the world (UNCCD, 2002). Desertification occurs in arid, semi-arid and dry sub-humid regions of the world characterized by:

- 1- Low, infrequent, irregular and unpredictable precipitation.
- 2- Significant variations between day and night-time temperatures.
- 3- Soil containing little organic matter and a lack of water.
- 4- Plants and animals adapted to climatic variables (drought resistant, salt tolerant, heat-resistant and able to cope with a lack of water) (UNCCD, 2011).

1.1. Extricating desertification from drought, dessication, climate variability and climate change

Thus, it is important to distinguish the phenomenon of desertification from drought, desiccation, climate variability and climate change and to point briefly out their interlinkages. Drought is the naturally occurring

short-term phenomenon when precipitation is significantly below normal recorded levels (UNCCD, 1994 and Darkoh, 1996). Usually, such temporary deficits in rainfall can be contained by existing ecological and social strategies (Darkoh, 1996). Wilhite and Glantz (1985) identify and discuss the different types of drought which include meteorological, agricultural and hydrological as well as socioeconomic drought. Desiccation refers to longer term (decadal order) deficits in rainfall which seriously disrupt ecological and social patterns and require national and global responses (ibid). Drought or desiccation per se does not necessarily cause desertification, but if their effects are reinforced by the effects of human land mismanagement, they often give rise to desertification in the Drylands (Hulme and Kelly 1993, Darkoh 1996). Climate variability and climate change refer to short-term climate variations and longer term climatic trends or shifts caused by natural mechanisms or by human activity (Kelly and Hulme 1993, Darkoh 1996). According to Glantz and Orlovsky (1983), fluctuations may occur in any or all of the atmospheric variables (such as precipitation, temperature, wind speed and direction, evaporation, etc.). A result of such fluctuations, ecosystems could be altered, and this could eventually affect societal activities that are associated with the exploitation of those ecosystems. In contrast, climate change refers to the view that the statistics that represent the average state of the weather for a relatively longer period are changing, and that desertification is primarily a result of such natural shifts in climate regimes (IPCC, 2007). The linkages and feedback loops between desertification and climate change are complex. However, IPCC (2007) and MA (2005) reported that desertification affects global climate change through soil and vegetation losses. The studies observed that unimpeded desertification may release a major fraction of the greenhouse gas primarily CO₂ to the global atmosphere, with significant feedback consequences to the world climate system. On the other hand, the effect of global climate change on desertification is seen to exacerbate desertification due to increase in evapotranspiration and a likely decrease in rainfall in drylands. Nicholson (1978), Glantz and Orlovsky (1983) and Kelly and Hulme (1993) have observed that there has been a trend towards a net shift to hyperaridity in the West African Sahel, a natural desiccation of the region that man can do nothing to stop. Also, some studies including Darkoh (1996), Brauch (2003) and Reed and Stringer (2015) have pointed to the fact that climate change clearly is occurring and contributing to desertification and land degradation in Africa. However, little is known about how climate change and desertification processes are interacting in different socio-ecological zones and how they might interact under different scenarios. What is not in doubt, however, is that they are concomitantly interacting to produce adverse effects on the existing ecosystems.

1.2. Global status

Global assessments of desertification indicate that the percentage of total land area that has been degraded or being degraded increased from 15% in 1991 to 24% in 2008 with more than 20% of all cultivated areas, 30% of natural forests and 25% of grasslands undergoing some form of degradation (Bai et al., 2008). It has been estimated that 24 billion tons of fertile soils disappear annually affecting one-quarter of landscapes of the globe (UNCCD, 2011). Land covering 12 million hectares, equivalent to Bulgaria or Benin is lost every year (ibid).

The total population of the world's dry land population, excluding the hyper-arid areas is 2000 million and a home to one in three people in the world today (MA, 2005). Drylands support 50% of the world's livestock.

The majority of the world's dry land population is in developing countries (UNEP, 1994; UNCCD, 2011; Reynolds and Smith, 2001).

The extent of desertification in China is approximately 2.6 million km², about 28% of the country based on monitoring results by the end of 1999 (FAO, 2005). In Latin America and the Caribbean, land degradation affects 16% of the land area (Kafalanga, 2008). The African Sahel has been the region most affected by drought and desertification during the recent decade (Reynolds and Stanford-Smith, 2001). Three major areas are susceptible to desertification in Africa. These areas are the Mediterranean region of northern Africa, the Sudano-Sahel region, including parts of East Africa and the Horn of Africa and Africa South of the Sudano-Sahel where the main areas are the Kalahari-Namib region of Southern Africa and South-Western Madagascar (Darkoh, 2003).

2. Impact of desertification

Desertification is a very complex phenomenon comprising of multiple interactions between human and environmental systems. The initial limitation of its analysis to biophysical environmental disciplines is a failure to appreciate the complexity of desertification. Impacts refer to measurable changes in key features associated with the problem (Grainger, 2009).

It is clear that when thresholds are crossed, the human environment system will move into a new state (Grainger, 2009). The effect of any form of destabilization of the environment has always been intolerable and vicious. Thus, the generic impacts can be understood within the limits of causation of phenomenon, but the diagnosis can be better appreciated and applied based on the specific site or location. The Millennium Ecosystem Assessment (2005) emphasized that the magnitude and impact of desertification vary widely from place to place and change over time. The variability is driven by the degree of aridity combined with the pressure people put on the ecosystems. There is, however, a wide gap in our understanding and observation of desertification and its underlying factors (MA, 2005). Thus, FAO (1993) views the consequences of desertification as dependent on four factors that vary by region, country and year:

- The seriousness and extent of land degradation;
- The severity of climatic conditions;
- The number and diversity of affected population; and
- The level of development of the country involved.

Thus, the poorer the people and the less developed the countries, the more profound will be the future effects of desertification and the greater the potential for tragedy when natural conditions mainly climatic become difficult.

Worldwide, desertification reduces the productivity of land and deprives people of biological resources that are essential for human sustenance (Darkoh, 1996, 1998). It, therefore, has secondary social impacts in the form of malnutrition and diseases that arise through poor farm yields, poverty and constraints on water quality and availability (UNCCD, 2013). Desertification also reduces vegetative productivity, leading to declining in

livestock yields, plant standing biomass and plant diversity (Mortimore, 1989; El-Kanrouri, 1986; Nneji, 2013; Stephen, 2014 and Olagunjo, 2015). Desertification is also accompanied by the loss of biodiversity and the measure of variability of living organisms at any spacio-temporal point (Senanayake, 2012). Grazing lands and pasture provisioning are also severely affected by desertification (Okello, 2014 and Ijah, 2014). The list of socio-economic consequences is large and includes loss of social capital, an increase in household debt and loss of local customs and traditional environmental knowledge (Zaman, 1997; Fredrickson et al., 1988). Desertification has an impact on the increase in migration (Olagunjo, 2015; Abdi et al., 2013 and Ababa, 2007). It has been widely reported to have a significant impact on the use of natural resources resulting in a conflict between different user groups (Oladipo, 2015; Ijah, 2014 and Abbas, 2014). Pastoralism a significant undertaking in the drylands is also affected by desertification (Mortimore, 1989; Stilles, 1993 and Tully and Shapiro, 2014). Breaking the strong connection of people to the land produces profound changes in social structure, cultural identity and political stability (FAO, 2001). The exposure of more and more people to water scarcity and hunger opens the door to the failure of fragile states and regional conflicts (UNCCD, 2014).

In China, the consequences of desertification include a rapid decline in productive arable land and reduction of the ecosystem services provided by vegetation; constraints on the quality of life in urban industrial growth zones and higher costs of maintaining physical infrastructure and, above all, an increase in rural poverty and environmentally-induced migration. The damage has taken on international proportions. Fine sediments from dust and sandstorms are already reaching the American west coast. These sandstorms are having a health impact in the eastern and southern part of China as well as Japan and Korea. Desertification threatens the livelihoods of millions and racks up annual economic losses of reduced productivity. Farmers were forced to relocate; as a result, the demographic distribution in China's east and the west are becoming more and more uneven. Social stability has been threatened due to the rising unemployment rate and crimes and conflicts between urban and rural dwellers are intensified (Zeng, 2005).

In Mexico, Schwartz and Notini (1994) posit that the impact of desertification has become widespread as people abandon the degraded land and move onto marginal lands that are less suitable for agriculture. The study falls short of taking into consideration the poverty level of Mexico, as 2/3 of its population are mostly poor. The study failed to address desertification impact indicators, the change in crop yields and types of crops cultivated.

The consequences of desertification in Burkina Faso, according to a study by the UN are reduction/loss of soil fertility, regression or disappearance of vegetation cover and fragile ecosystems; loss of biodiversity; the aggravation of the climatic changes; reduction of the incomes and increased poverty; conflicts between farmers and herders and movements of people and livestock (migration, transhumance, nomadism) (www.org/esa/sustdev). Kambou (2002) identified important desertification impact indicators to include an increase in poverty in rural communities and migration patterns. The change in livestock size and types in a country with pastoralists and pronounced poverty, vegetation, and forage cover decline should have been viewed as important impact indicators by the UN for a more systematic understanding of the impact of desertification on pastoralism. Additionally, state indicators were lumped together with impact indicators making the distinction fuzzy. Kambou (2002) could not provide a clearer indication of migration patterns.

In a study commissioned by FAO, Gomes (2006) identified local conflicts between Somali clans and lineages over control of new boreholes and the surrounding pastures as the major impact of desertification in Somali. The study has left a gap in knowledge of possible changes in livestock type and size over time. In Ghana, Environmental Protection Agency (2002) cited the impact of desertification to include reduced soil productivity and crop yield, prevalence of barren land and reduced quality and quantity of vegetation cover, and reduction of the land's resilience to natural climatic variability. The socio-economic impact includes increased scarcity of forest products, famine, increased migration, low incomes, and an increase in poverty. As a national report it is presumed that it would be holistic in improving our understanding of the phenomenon, but with over 1.25 million cattle, 2.4 million sheep and 2.5 million goats in the savannah of Ghana, it will have been more encompassing to highlight the impact on livestock in the assessment. Additionally, the vegetation cover reduction as an important state indicator of desertification was vaguely defined with no temporal inclination. Further, an important livelihood variable and impact indicator, crop yield variation over time, was inconspicuous in the study.

Abdi et al. (2013) in a study of desertification in Sudan report that desertification is the primary factor that causes the migration of rural population to urban centers. Political and social instability has a strong bearing on land degradation, citing civil strife in Southern Sudan that has led to the displacement of a vast number of people to Kenya. The study further revealed the loss of vegetation and disappearance of useful species. The decline in rainfall results in the familiar pattern of vegetation degradation, soil erosion and decreased crop yields and livestock productivity coupled with increased migration. There is an information gap in migration indices and crop yield decline which are significant impact indicators. Further the study could have incorporated the survey methodology to tap in more details from the inhabitants of the area.

In Ethiopian Highlands, 14 million hectares are badly eroded, and if this trend of soil degradation stays, per capita income in the highlands will fall by 30% in 20 years' time (Tamir, 2000). The study concluded that the land is no longer able to support vegetation with attendant loss of organic matter. Due to degradation, increasing the number of Ethiopians has become vulnerable to drought. The study could not, however, integrate its contextual review and field observation with a questionnaire and interview to elicit more valid information particularly on crop yield and extent of migration.

Jones (2006) in a case study on initiatives and their impact on poverty and governance in Namibia cited that the main consequence desertification has is a considerable effect on the economy. Similarly, Seely and Klintonberg (2011) in a study on desertification in Central Namibia identified the impact of desertification based primarily on deforestation and woodland degradation, rangeland degradation, degradation of arable land and soil erosion. The annual economic loss in central Namibia was estimated at a minimum of US\$10million per year. The decreased availability of construction materials and fuelwood exacerbated by the time required for their collection or the substitute cost of commercially purchased materials were identified as major costs. Both Jones (2006) and Seely and Klintonberg (2011) studies were biased towards the economics of desertification relegating elicitation of information from those who bear its brunt for a more holistic view of the phenomenon. Additionally, Klintonberg and Seely (2004) reported that 70% of the population in Namibia are dependent on subsistence farming. The study, however, failed to provide data on the impact of desertification on crop production. A similar desertification impact study in Namibia by Quan

et.al (1994) assessed the economic impact of desertification in Namibia. The study found that in the communal areas where the majority of Namibians depend on the land, the impact of desertification are complex affecting the subsistence and cash income they get from livestock, the time, and effort needed for fuelwood and fencing and family food security. In commercial areas, the nature and impact of desertification were shown to be very different, with bush encroachment affecting grazing areas and hence stock numbers off-stake and sales. Though the study provided an economic assessment of the effects of desertification on livelihoods in Namibia, it overlooked the occurrence of migration and immigration which could influence home remittances and subsequently the economy.

In Nigeria, Emeka (2013) stated that the socio-economic impact on the over one million inhabitants of the periphery of the floodplain and who depend on the wetland for their livelihood as fishermen, farmers and cattle rearers has been severe. Another indicator of the adverse impact of drought and desertification in the Sudan and Sahel zones is in the area of fish production from Nigeria's rivers, lakes, swamp and flood plains (Nwafor, 1982). It has been estimated that the combined production from all fresh water sources showed a decline of 54% in annual yield between 1980 and 1985 (Ajayi, 1996). Emeka (2013) and Nwafor (1982) studies left a gap in knowledge on analysis of important impact indicators, (conflict between farmers and cattle owners) which is so prevalent in the Northern Nigeria where the Frontline states are situated. There is an information gap in the study of Ajayi (1996) on whether the resulting yield decline was a result of the type of crops grown. Thelma (2015) in a study on desertification in Northern Nigeria reported that desertification is a serious threat to the economy, and food security and employment are the major impacts of desertification in the region. The study further found that most conflicts in the region are environmentally based. The conflicts are mainly between farmers and cattle herdsman. The study, however, left a gap in knowledge on the impact of crop cultivation on desertification.

According to the Government of Nigeria, desertification has aggravated the food situation in the area, resulting in low food security index. Drought causes much economic disruption. For example, drought was held responsible for the drastic fall in the GDP of 18.4 percent in 1971-72 and of 7.3 percent in 1972-73. It was also seen as causing the rapid rise in the price index for foodstuff and the relative decline in non-oil exports. A major consequence of desertification/drought-induced migration is separation from families as men usually abandon the women and children to seek employment in the urban centers (FMEnv, 2001). There is a gap in knowledge of the consequences of desertification on pastoralism, an important livelihood variable, and impact indicator. A very disturbing trend from these countries emerged from the nature of the impacts which shows that the third World Countries is at the brink of precipice. The consequences of desertification in Ghana, Nigeria, and Burkina Faso, as well as Sudan, indicated a hot spot of social tension and uncertainties. The countries have revealed under the regime of poverty, conflict over the use of natural resources as well as migration to cities consequent of desertification. The severity of desertification in China could be a result of the number and diversity of its population.

3. Desertification control measures

It has been established beyond any doubt that combating desertification and land degradation is important if not a vital part of sustainable development strategies in countries affected by the scourge (UNCCD, 2006). Because of international concern about the growing scale and effects of desertification, the United Nations Convention to Combat Desertification was adopted in Paris in 1994 and by the year 2000 over 172 countries were signatories (UNCCD, 2006). The Southern Sudan on the 19th May 2014 became the 195 Party to the Convention, which focused action on Africa and was concerned with combating desertification and mitigating the effect of drought. It advocated measures of control to be tailored to each country's specific condition (UNCCD, 2006). Further to this, the UNCCD advocated measures such as:

- Anticipating and or limiting land degradation
- Repairing degraded land
- Raising awareness and informing those who are affected by land degradation
- Improving the social context by eliminating poverty, improving health and educational conditions, developing and spreading knowledge on sustainability and the importance of natural resources.
- Reintroducing indigenous knowledge.

In Benin, a participative process allowed for the creation of community conservation areas to preserve the biological diversity of coastal wetlands (www.worldbank.org). Deeply involved in the process, about 150 communities now enjoy the sustainable use of the biological diversity of marine resources and benefit from environmentally friendly business activities. The project has helped bring the riparian populations out of poverty which had forced them to destroy the natural resources. Now they know that protecting mangroves, coastal zones and forests is essential for the survival of future generations. Similar World Bank-funded projects focusing on lowland areas in selected sub-watersheds in Burkina Faso have demonstrated how communities can improve the productive capacity of rural resources. Through sustainable conservation of biological and agricultural diversity and rehabilitation of soil and water resources, the Burkinabe were able to generate income and environmental benefits simultaneously. The Sahel Integrated Lowland Ecosystem Management (SILEM) Project pioneered the concept of biodiversity in a production landscape. It created and catalysed community dynamics for the sustainable management of natural resources at the micro-watershed level by implementing incentives, creating an investment framework consistent with the country's priorities, and by rewarding while continuing to strengthen individual and collective know-how. Around 160 villages benefited from investment funds to support various natural resource management activities that included soil and agriculture techniques, water conservation technologies, livestock and fishery management, reforestation and forest management techniques and natural resource protection (UNCCD, 2013). Both studies of the World Bank failed to highlight a major state indicator, desertification enlightenment campaign.

In Kenya the work of the Rehabilitation of Arid Environments (RAE), a charitable trust involved in rural development in Kenya is well known. RAE is based in the Baringo County in the arid and semi-arid lowlands of Kenya's Rift Valley, where it has operated for over 30 years. When RAE began operations, about 70 percent of Baringo County's land was unproductive owing to increasing soil erosion and vegetation and biodiversity losses. The land was severely degraded, and insecurity and ethnic conflicts were rife due to resource scarcity.

Poverty was high, up to 90 percent in some areas and food insecurity was common. Lake Baringo, the largest source of fresh water in the area, had become silted. Taking a participatory approach and building on traditional knowledge, RAE introduced a multi-faceted strategy to rehabilitate the degraded areas. Specifically, RAE began to restore the natural savannah grass ecology by seeding the land with indigenous grass species that had disappeared due to overgrazing. RAE agreed on a method to manage the reseeded areas. Fencing was used by the sedentary groups and community-based grazing by the pastoralists. These approaches are complemented by income-generating activities such as baling hay, harvesting and selling the grass seed, bee keeping, leasing fields, selling milk, thatching grass and collecting fuel wood. The UNDP (2013) in its study of emerging lessons of empowering local communities undertook livelihood improvement and, drought mitigation projects and the use of indigenous knowledge. Today, over 20,000 people benefit directly from the project, with 380,000 of the county's population of 550,000 benefitting indirectly (UNCCD, 2013). While some project management issues have still to be resolved, native grass and tree species that had disappeared from the area are currently flourishing. The soil's physical qualities—nutrition and infiltration rates—have improved. Poverty levels have fallen, and food security has improved for community groups. Men and women are profiting from the utilization and sustainable management of their improved natural resources and diverse income generating activities (www.reatrst.org). The study, however, did not take into cognizance the fact that endemic poverty, ethnic conflict, and food insecurity are precursors to migration. It is clear that there is no clear monitoring mechanism of desertification at the local level, an institutional weakness not highlighted.

Similarly, in a study of desertification control in Ethiopia and Kenya, UNEP (2002) and Hellden (2003) pointed out that the recommended biophysical cure in most control plans includes terracing efforts, besides general efforts to reclaim vegetation, wood and fuelwood resources through Agroforestry and Afforestation programs. Huge international aid funded (e.g. Work for Food) terracing and agroforestry programs have been implemented in Ethiopia over the years. They seem to have been successful in checking water erosion. When combined with land rehabilitation measures of socio-economic character they have sometimes been successful in increasing the well-being and the standard of living of the people. A good example is Machakos in Kenya. On the other hand, there are examples of huge terracing programs with a questionable environmental and economic effect. This is true in the driest parts of Ethiopia suffering from prolonged severe drought periods or desiccation trends. The terracing programs carried out in these areas are probably a waste of efforts based on the misleading assumption that what is good policy and works well in one part of the country (or the continent) should work as well in any other part overlooking differences in climate, ecology, economy, culture and human activities. A similar study conducted by Tamir (2000) in the highlands of Ethiopia outlined the control measures of desertification in the area to include physical and biological conservation measures, disaster prevention and preparedness Programme and the establishment of environmental protection agency. The study, which aimed to highlight desertification in the Ethiopian highlands, left a gap in knowledge on the effectiveness of these responses which are primarily institutional arrangements in response to desertification. Also, the study was silent on socio-economic strategies applied in the highlands.

According to Arntzen et.al.(1994), Chanda (1996) and Darkoh (2000), in order to survive in the harsh environment with recurrent droughts, the local people in Mid-Boteti have traditionally developed several adaptations such as the practice of flood recession cultivation which makes seasonal river flow in an otherwise

semi-arid environment; practice of mixed cropping techniques; mobile livestock strategies largely determined by available water resources; replacement of cattle by goats during drought; engagement in a combination of agricultural and non-agricultural activities to reduce vulnerability.

A study by Klintonberg and Seely (2004) on land degradation monitoring in Namibia listed measures of combatting desertification to include raising awareness about the causes and effects of land degradation, the establishment of the National Monitoring System in close cooperation with both local communities and scientists. A case study by Jones (2006) revealed the institutional arrangement to include the establishment of Namibia's Programme to Combat Desertification (NAPCOD). NAPCOD worked with rural resources users to investigate land uses, agricultural practices, and alternative livelihoods through pilot activities in some communities. The intervention of the LIFE project, funded by USAID, Namibia's Ministry of Environment and Tourism and World Wildlife Fund (WWF) is aimed to support the national community-based resource management in Namibia. The project has three focal areas: improving the natural resource base, establishing local institutions and developing natural resource based enterprises. It, therefore, integrates biodiversity conservation, democracy, governance and enterprise development in one project. The study, though holistic in the institutional response left a failed to address the mechanism of monitoring the effectiveness of control measures. This is in addition to an information gap of how the local population fits into the framework, particularly in biophysical control measures. There appeared to be no indication of a survey detailing the local population's responses to desertification in the study.

In Tanzania, control measures included government establishment of tree seedlings nurseries in many parts of the country and the distribution of hundreds of various species for planting to the villages (Darkoh 1982, 1987a). There had been a mounted campaign in regions to educate people of the dangers of desertification and the importance of afforestation. The government further formulated a national human settlement and land policy, including the preparation of regional and physical land use plans, reduction of fuelwood consumption by using alternative sources of energy especially coal, natural gas, solar and wind power. Additionally, control of soil erosion and overgrazing, promotion of popular participation, training of environmental officers and encouragement of research were prioritized. The outlined control measures integrated the bio-physical and socio-economic strategies to combat desertification. The study opened several windows for further research on desertification in Tanzania. A study by Muyungi (2007) indicated a serious involvement of the government of Tanzania in environmental issues and sustainable management after the Rio Conference in 1997. Major milestone achieved included the National Environmental Action Plan prepared to carry out a national analysis and provide a framework to incorporate environmental consideration into government decision-making process; the National Action Programme to Combat Desertification developed in 1999 and the institutional framework for Environmental Management in Tanzania. The study was inherently deficient in outlining a framework for monitoring the effectiveness of intervention measures. As a case study with emphasis on mitigating land degradation, it could have been more encompassing in integrating people's adaptive responses and be specific on biophysical strategies.

3.1. Sustainable land management

Current global developments call for more sustainable management of our land. Vast areas of land have been affected by land degradation partly resulting from the unsustainable land use (Darkoh, 1998). Consequently, the International Policy and Scientific Fora acknowledged that sustainable land management (SLM) might be the way to address land degradation. SLM can be defined as the use of land resources--including soils, water, animals, and plants--to produce goods that meet changing human needs while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental factors (Schwilch, 2002). It would also contribute to increased food production, mitigating climate change, and preserving our natural resource base (ibid). SLM strategies and intervention are particularly relevant to dry land region at the local and regional scales that aim to increase productivity, improve people's livelihoods and preserve ecosystems (Schwilch et al., 2012). SLM strategies and practices can enable farmers and communities to become more resilient to climate change by increasing food production, conserving soil and water, enhancing food security and restoring productive natural resources (TerrAfrica Partnership, 2009). According to Schwilch et.al.(2002) the SLM technologies positively affected biophysical processes relevant for agricultural production and positively affected the ecological services of the land. Water harvesting technologies and more efficient use of irrigated water showed the greatest potential and benefits. Most of the applied techniques appear resilient to expect climatic variations and half of them provide off-site benefits such as reduced damage to neighbouring fields, public or private infrastructure, and reduced downstream flooding. This opens up the possibility of promoting SLM technologies to protect goods and services by using reward schemes aimed at farming communities. It also highlights the capacity of SLM technologies to support disaster risk reduction(ibid).

There were 38 case studies investigated in the DESIRE project; 30 for SLM technologies and eight for SLM approaches. The physical practices used in the field to control land degradation and enhance productivity – the SLM technologies, in other words – could be divided into five groups: cropping management, water management, cross-slope barriers, grazing land management and forest management. They addressed all the main types of land degradation. Most of them were applied to cropland, although the grazing land is equally important – perhaps even more important in spatial terms – in drylands. Depending on the kind of degradation addressed, agronomic, vegetative, and structural or management measures were used, or some combination of these (Schwilch et al., 2012).

The DESIRE project has had its principal strides in biophysical practices in the combat of desertification but has left a vacuum in our understanding of the complex relationship between these practices and the combative socio-economic measures. An additional gap has to do with the selection of the study sites for the project, which, despite the continental importance and the Sahelian expanse in Africa, only Morocco, Tunisia and Botswana have been investigated. The management practices, application, and possibilities of up-scaling sustainable land management measures in West Africa, the most populous region in the continent, is at best unidentified and unreported.

3.2. Regional intervention to control desertification

When it was realized that the efforts made in the implementation of the UNCCD Program and other similar programs proved well below the objectives sought both concerning natural resources conservation and poverty alleviation, the need for a more pragmatic approach became necessary (OSS, 2008). The African Heads of State and Government endorsed the Great Green Wall in 2007 and since then, it continued to evolve to a development-programming tool. The Great Green Wall was originally conceived as a thematic project focusing on the creation of the wall of trees of some 15 km wide and 7775 km long from Dakar in the west to Djibouti in the Horn of Africa in the east through 11 countries (Burkina Faso, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Chad). These 11 African countries created the Pan- African Agency of the Great Green Wall (PAGGW).

Since then, it has gradually shifted to a holistic, multi-sectoral and integrated vision of sustainable land management and poverty eradication. For each participating country, a requirement is the development of an action plan that will detail how the country intends to tackle the problem of desertification in its affected areas. The African Ministerial Conference on Environment adopted a harmonized strategy for the Green Wall in September 2012 (Goffner, 2013). The initiative aims to support the efforts of local communities in the sustainable management and use of forests, rangelands and other natural resources in drylands (ibid). The initiative seeks to contribute to climate change mitigation and adaptation as well as improve the food security and livelihoods of the people in the Sahel and Sahara.



Figure 1. The GGWSS (Source FGN, 2012)

The Great Green Wall is still at an embryo stage focusing only on a wall of trees. It is a replication of the Great Green Wall of China, where the country's economic growth is incomparable to any in the African continent. Many scholars have challenged the limitation of the meaning of desertification to the advancement of the desert southwards. The countries in the path of the Great Green Wall have national domestic issues competing for attention, thus having a severe deficit in political will to execute the project. The GGWSSI is at conception, lacking in addressing socio-economic components of desertification without which, the poor people of the region will continue with unsustainable attitudes of land management. Besides, the project is lacking in knowledge on any concrete framework of monitoring and assessment of the 7775 km of the trees over time.

The Kalahari-Namib Project is another project that has focused on land degradation. It is facilitated by the Global Environmental Facility (GEF) strategically with a mandate to enhancing decision making through interactive Environmental Learning and Action in Molopo-Nossob River Basin in Botswana, Namibia, and South Africa. (IUCN, 2013). The Molopo-Nossob River Basin is an ecologically fragile marginal dryland which continues to experience land degradation, loss of biodiversity and primary productivity. According to IUCN (2013), the overall goal of the project is to support communities, community-based organizations, non-governmental organizations (NGOs), local and national governments, including local and regional policy makers in Botswana, Namibia, and South Africa to effectively implement and scale up long-term SLM in the MOLOPO-Nossob basin area. The project will address the numerous barriers and constraints that affect the implementation of SLM practices both locally and internationally. These include limited access to appropriate information and technology, weaknesses in institutional infrastructure and participation, unsustainable land use practices, the conflict between land use goals and weak tenure and resource governance arrangements (IUCN, 2013). Support from the GEF will assist to elevate local site-specific efforts and strategies to a planned and coordinated longer term regional approach with greater sharing of information within and across borders.

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4. Conclusion

It is clear from preceding studies that desertification is posing a threat not only to the physical environment but also the livelihoods of the people that bear its brunt. The identified impacts and measures of control represented some site-specific cases. Despite the outlined huge interventions, the failure to achieve success in combating desertification could be due to the non-inclusion and participation of the communities involved, and the serious attachment accorded preferentially to bio-physical conservation measures. In Africa, for instance, where the majority of the countries are riveted with economic difficulties and a multitude of domestic challenges the conservation measures could not be attached any concern by local communities. Thus, whatever the appeal of the physical control of desertification, the locals will have done better by appealing to their participation and addressing some of their socio-economic trepidations. Secondly, Nations and States must develop a monitoring mechanism on all social and physical indicators to address the effectiveness of the components of the desertification combat routinely. For the study of desertification to have meaning to the policy makers, a local case study integrating a tripartite combination of remote sensing, questionnaire/interview and field observation will place the findings more perceivable and easily deciphered.

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