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Relevant Issues for Sustainable Agriculture in Sub-Saharan Africa

Ademola A. Adenle[1] and Julius I. Agboola[2]
[1]*United Nations University-Institute of Advanced Studies, Yokohama, 6F International Organizations Center, Pacifico-Yokohama*
[2]*United Nations University, Institute of Advanced Studies, Operating Unit in Ishikawa/Kanazawa, Kanazawa, Ishikawa, Japan*

1. Introduction

Given the food security problems, rising population and unsustainable agriculture practice through conventional approach, the role of agricultural sustainability can not be overemphasised. But not many countries in Africa especially Sub-Saharan African (SSA) are practising sustainable agriculture, even if there are, they are very few and uncoordinated. Agricultural sustainability has a key role to play towards agricultural development in SSA, particularly improving agricultural productivity and food security, conserving biodiversity and creating friendly environment.

This chapter focuses on relevant issues including constraints that affect sustainable agricultural development in SSA. In section two, we review relevant issues for sustainable agricultural development such as land use system, government institutions and infrastructure and agricultural technology, demonstrating current literature examples in our arguments. Third section focuses on effect of climate change on agricultural production, also exploring the link between climate change and agriculture biodiversity as well as climate regimes in SSA. Fourth section examines conservation of biodiversity which is also relevant to sustainable agricultural development, particularly when considering the roles of ecosystem and ecological species in the environments. The chapter concludes by summarising the policy implication that requires the attention of national governments and relevant organisations towards successful adoption of sustainable agriculture practice in SSA.

2. Relevant issues for sustainable agricultural development

2.1 Land use system

Land use in Africa has undergone evolutionary transformation from the simple hunting to more complex sedentary, shifting or commercial cultivation system. Rural land use has evolved from bush hunting in tropical Africa like Kalahari Desert and nomads practice like Pygmies in the Zaire/Congo Basins going through shifting cultivation that is widely practiced in the Miombo woodlands of SSA where the soil and vegetation are allowed to fallow before further cultivation (Pritchard, 1979). The sedentary or permanent agriculture is known to be practiced among Souafa population in the Sahara where vegetation, fruit, palm tree, eucalyptus trees and rice are planted, and animals such as goats, camels and sheep are reared. In East Africa (Uganda) the root and tubers, cereals and legumes also form agronomic practices of sedentary agriculture. The population engaged in this kind of farming practices are known to settle in the villages in many parts of Africa but Rwandans farmers settled across tops of the hills with fertile soils where bananas are planted around the houses, and coffee grown a bit farther down the hill (Clay and Lewis, 1990). This gradually evolves to shifting cultivation where farmers can move from one land to another without the right to possession of land after vacation, and the use of axe and hoe are prevalent for cultivating land particularly in high rainfall regions. Under this indigenous agronomic system and application of low level of agricultural technology, the land is put into use to ensure food security and sustainable agricultural practices in the communities. Following this agronomic system, particularly during the colonial era in some of the African countries like Zambia, Kenya, Zimbabwe and Malawi, a semi-permanent, ox and tractor-plough cultivation emerge where arable land can be put into use for as long as 10 years before the land is allowed to fallow for a limited period of time coupled with the use of cattle manure for maintenance of soil fertility (Trapnell and Clothier, 1996). During this period, cash crops such as tea, maize, tobacco, cotton and others were largely cultivated for commercial purposes which resulted to a combination of sedentary, modern and commercial cultivation as introduced from colonial masters to African farmers.

Agricultural practice then was well coordinated and more sustainable compared to African present situation. The traditional system of using slopes, for examples, wood lots, fallow and pasture (Clay and Lewis, 1990), and plant cover such as mulches and crops offered effective protection against erosion (Wischmeier and Smith, 1978). The traditional land use system was not under increasing pressure and competition. For example, in Zambia and Ethiopia, the process of acquiring land for farming purposes was duly followed as stipulated in the law (Gilks, 1975; White, 1959). After several African countries gained political independence and as the population increased, modern agricultural techniques were diffused leading to the birth of an indigenous group of commercial farmers (Baylies, 1979) and more individual traditional agricultural practice emerged, and as a result the land tenure law system expressed in English law was transformed and revised in response to social, cultural, political and economic changes in these countries (Mvunga, 1980). But traditional agricultural practice in Africa that involves true shifting cultivation is now rare, pressure of increasing population due to reduction of the fallow has led to massive deterioration in food production, and current land tenure system constrains sustainable agricultural practices. In majority of African countries, national policies on land and economic development are not aligned with agricultural practices, particularly among the rural poor.

The era of land degradation and insecure land tenure system; lack of formal documentation as to who has the right to the land remains an obstacle to improve agricultural productivity and food security, to promote investment and encourage better natural-resource management, thus contributing to increasing level of poverty in Africa. Land degradation has become one of major problems with nearly 2 billion hectares of land affected in Africa, and 300 million hectares out of this accounts for considerable loss of nutrients, desertification and soil erosion (Nkonya et al., 2008; Pintstrup-Anderson and Pandya-lorch, 1995). Loss of nutrients and soil erosion are basic indicators of land degradation. For example, in Uganda, it was reported that six major agro-ecological and farming zones were affected due to soil depletion with an average of 179 kg/ha of N, P, and K per year equivalent to about 1.2 percent of the nutrient stock stored in the topsoil (0–20 cm depth). Nkonya et al (2008) argue further that the replacement of depleted nutrients is equivalent to one-fifth of the household income obtainable from agricultural production based on minimum price of inorganic fertilizers. Much of highlands of eastern and central Africa are affected, particularly the densely populated areas and step mountain slopes with volcanic fertile soils (Henao and Baanante, 2006; Smaling et al., 1997; Voortman et al., 2000). For example, in Ethiopia, around 30% of agriculture was degraded in 1990 due to soil erosion that occurred in 1970s which was equivalent to10 billion metric tons per year of soil (Hutchinson et al., 1996; Myers, 1986). A more recent report has shown that annual agriculture gross domestic product (GDP) of Africa can be reduced by 3% due to land degradation (Jansky and Chandran, 2004).

Africa exploding population leading to more people in urban area than rural, and more occupation of land in urban areas without proper legal structure for land ownership has become a big threat to economy, innovation and job opportunity in the city. Africa rural population has increased by 265% and urban population with nine fold increase between 1950 and 2000 (UN, 2004). And large dependence of rural population on subsistence agriculture for their livelihoods due to population pressure invariably result to expansion of agricultural lands (Wood et al., 2000). Given the current land tenure system, improving agricultural productivity and food security that will contribute to economy growth and sustainable development still remain a big challenge in Africa. But the question is how to create enabling environment to safeguard the livelihood of small-scale farmers that account for over 80% of agricultural production in rural Africa to have equal right or access to land, particularly enacting law to support land titling and registration that can benefit poorer society. Also, in urban areas, how can hundreds of millions of people who live in crudely built shacks have equal right to land? As over 72% of Africa urban population live in the slum areas (UN-HABITAT, 2003). It has been reported that farmers near urban areas can be easily displaced due to rising land values and their agricultural land being converted to building for public works or commercial purposes either legally or illegally in Africa (Benjaminsen and Sjaastad, 2002).

While in many countries, land or private assets acquired by governments must be expropriated as stipulated under country constitution, for example, the United States (US) constitution requires compensation for all takings of private property, and the Philippine and Brazil constitution similarly requires that payment through compensation, and Cambodia constitution mandates that the states make fair and just compensation for taking possession of land from any person (ECV, 2011). Loss of land or private assets acquired is often not compensated in Africa, although payment of improvement alone can be enforced in many countries but often inadequate and late (Benjaminsen and Sjaastad, 2008; Cotula, 2008; Kasanga and Kotey, 2001). Kasanga and Kotey (2001) demonstrate that Ghanaian governments have not yet paid compensation for land taken which was estimated to be billions of Ghanaian Cedis. Acquiring property and land by the governments without compensation can be more devastating in other African countries, particularly among the poorer and less politically power groups. For example, in Zimbabwe, almost a quarter of a million people who had an illegal markets and business activities near capital Harare and other urban centres in 2005 lost their properties, lands and homes as mass eviction was carried out by the government without compensation, and this left majority of these people in a permanent difficult situation for the rest of their lives (de Plessis, 2005).

2.2 Government institutions and infrastructures

The role of government institutions is fundamental to sustainable agricultural development in Africa. In modernised society, government institution plays a critical role in information-dissemination, interaction, knowledge-sharing, awareness-creation and public education, particularly in relation to development and implementation of agricultural policies towards sustainable agriculture. Switzerland is a good example, recent interviews with key stakeholders demonstrates that agriculture practice is quite sustainable and government institution has been very effective, although adaptive approach for sustainable agricultural practices dated back to 19th century in the country has changed after World Wars in Europe (Aerni, 2009). A broad-based perspective on sustainable agriculture also emphasizes on components such as the roles of diverse actors, linkages, innovations, development strategies, partnerships and networks across other institutions to ensure better delivery packages. All these components are integrated together to allow present needs to be met without compromising future needs which is one of the hallmarks of a sustainable agricultural system.

Large majority of African populations engaged in agricultural practices is mainly found in rural areas but often not involved in active participation of debates or issues relating to agricultural development in the rural communities. Common understanding on introduction of new technology or any concept for agricultural development, and clarity on the roles of different stakeholders including farmer groups is very vital. While the responsibility of government institutions, particularly the Ministry of Agriculture and other relevant agencies at national level is to carry along and work in partnerships with local governments that deal directly with local communities, it is the government that makes the decisions, for example, the kind of new technology that suit the farmers and their environments without prior consultations. A report by (Uphoff, 1986) describes that local governments are important for mobilising resources and regulating their use with location specific knowledge so as to produce a locally interpreted and oriented results that can suit local people and their environments with a view to facilitating sustainable agriculture and rural development. He describes further that using participatory approach such as ''bottom up'' that begins with self-help efforts and later engages higher-level resources with limited efforts or commitments is inefficient but proposes a frame work of local institutions based on demand-driven strategy and result-oriented. A framework based on demand-driven is common to majority of agricultural practices in African countries, but however African governments often fail to fulfil their tasks and responsibility in this regard. For example, in Kenya, current agricultural extension services are demand-driven and require adequate capital to cover transport and other costs but extension officers have little or nothing to render their services (KSP, 2005; KSRA, 2004).

Without doubt, efficient and effective agricultural extension is one of the keys to increasing agricultural production but unfortunately agricultural extension services in majority of African countries have been alarmingly poor. For example, the most five important difficulties as stated by Nigerian extension officers in five states in order of magnitude are given as follows; insufficient transport facilities, low prices and lack of proper markets, lack of cooperation from other agencies in program implementation, lack of staff motivation and inadequate technical training in agriculture (Nigel, 1989). In addition, Tanzanian extension officers also stated and rated the following factors for their inability to deliver adequate and necessary training to the farmers; lack of transportation (50%) unavailability of inputs and training facilities (49%), lack of research input and technical support (43%), lack of incentives and administrative support (31%). These factors remain a huge problem to render adequate extension services to the poor farmers, particularly in the rural areas and can not be remedied by extension officer's individual effort which indicates failure in government institutions. However, non-governmental organisations (NGOs) have been playing an increasingly important role (e.g. research and extension services) in working with African local communities, particularly where huge holes have been created by country governments with a view to closing the gaps and contribute to sustainable agricultural developments in Africa (Levine, 2002; Rukuni et al., 1998). For examples, in Southern Africa and Eastern Africa, farmers are being assisted by forming a strong local group to shift from conventional to sustainable agriculture, integrating people into decision-making process, revitalising farmers' organisations as well as improving markets links through holistic approach. It was estimated by World Bank that over $7.6 billion of aid have been distributed through international NGOs to developing countries including Africa continent in 1992 alone (WB, 2002), one can imagine what could have been spent between that period of time and now.

Lack of well-developed and maintained infrastructures has been an obstacle to agricultural growth and rural development in Africa continent for many decades. The poor state of communication, transportation, irrigation and storage facilities across different African countries does not encourage sustainable agricultural development. Poor infrastructure affects the quality and frequency of services, for example, it prevents access to important services such as extension, market information, credits, health and education in Africa. Access to information and knowledge are important factors to speed up agricultural development, particularly in adoption of improved agricultural practices, marketing system and effective post-harvest management (Bertolini, 2004; Poole and Kenny, 2003). But majority of African farmers lack access to the right information and knowledge on good agricultural practices due to inability of the governments to respond to changing needs of farming communities. Most roads in rural areas are not motorable, and where rural roads exist, they are often poorly maintained and later abandoned. According to (Riverson et al., 1991), the maintenance standards of the rural roads in SSA have fallen significantly during the 1980s, for example, 42% of unpaved roads were reported to be in poor conditions in 1988 compared to 28% in 1984. Due to unreliable rainfall in many African countries, farming practices can be extremely difficult and irrigation can be expensive for the small-scale farmers, and there is lack of well-developed and locally appropriate means of small-scale irrigation that can benefit the farmers. Also, lack of access to credit facilities means farmers can not afford to buy agricultural inputs such as fertilizers and seeds, and micro-credit schemes that could support rural finance are rare and not widely promoted. Even when they are available, they are inefficient, inconsistent and unreliable. Moreover, African agricultural products lack competiveness and access to global trade and international markets that determine economic growth and development prospect of any particular country. African farmers often find it difficult to meet quality standard required to export their agricultural products due to lack of skills to invest in marketing, capital and processing facilities that can increase and add values to their final market output. As a result of bad policy, market failure and very limited mechanized farming system coupled with poor infrastructure and dispersed settlements, most private sectors as demonstrated in Tanzania are unwilling to invest (Ponte, 2001) and leaving them in an unfavourable and largely uninfluential position in the world trading system (Allen and Thompson, 1997; Stiglitz, 2003). Taken together, agricultural production system in Africa is characterised by weak linkages (supply chains, firm structure, organisational support, extension services and poor infrastructure) and poor systemic coordination.

2.3 Agricultural technology

A wide variety of technology is always associated with sustainable agricultural development, particularly with focus on the kind of technology that will be of a greater advantage to developing countries including African continent where agriculture is the main escape route from the poverty. The introduction of new agricultural technologies into African farming system is important for the region development. Given high level of poverty, food insecurity, rising population, pattern of global climate and low yields, adoption of improved technology is fundamental to solving some of these agricultural problems. A recent port on agricultural technology use in Mozambique shows that agricultural productivity is generally low, for example, maize yields are estimated at 1.4 tons/ha which is far below the potential yields of 5 – 6.5 tons/ha (Zavale et al., 2006). However, a good number of literatures have shown that adoption of improved agricultural technologies can lead to higher crop yields, lower food prices, higher real wages for unskilled workers, improved food security and reduced poverty (Cunguara and Darnhofer, 2011; Karanja et al., 2003; Kassie et al., 2011; Kijima et al., 2008; Minten and Barret, 2008). Kassie *et al* (2011) reports that adoption of improved groundnut varieties in Uganda, has a great potential to increase house income in the range of US$130-US$254 leading to reduced level of poverty incidence. According to Minten and Barret (2008), they conclude that improved agricultural technology diffusion appears to be the most effective means of improving agricultural productivity, lowering poverty rates and food security problems in Madagascar. They conclude further that, other than these means, there are no magic bullets to food production and for better agricultural performance in Africa. Despite the fact that, new agricultural technologies can bring a lot of advantages to the farmers, and as observed by (Zavale et al., 2006); the use of improved agricultural technologies is very limited and unequal, and most of agricultural production is rainfed which enhances the effectiveness of improved agricultural technologies. The observation by Zavale and his colleagues is consistent with (Cunguara and Darnhofer, 2011) that describe that an adequate rainfall is required for most improved technologies to be productive and effective. In view of the fact that productivity enhanced technology is required for sustainable agriculture around world (especially developing countries) and the need to increase agricultural production is important, there is no major consensus yet as to technological innovation that can deliver the result while considering factors such as erratic weather, inconsistent policy regime and poor infrastructures in developing countries (DFID, 2008). However, there is overwhelming response and support for research on increasing agricultural productivity in developing countries. For example, greater emphasis is laid on research based on the use of simple and low-cost technology including applying indigenous knowledge for agricultural practices and agricultural biotechnology (e.g. traditional plant breeding and genetic modification) (DFID, 2008; UNCTAD-UNEP, 2008).

3. Climate change in the Sub-Saharan Africa

According to the Intergovernmental Panel on Climate Change (IPCC) report, Africa is the most vulnerable continent to climate change even though its contribution to the increasing concentrations of greenhouse gases has been minimal. Sub-Saharan African countries are particularly vulnerable to climate change because of their dependence on rainfed agriculture, high levels of poverty, low levels of human and physical capital, and poor infrastructure (Nelson et al., 2009). Also, due to its high exposure to climate change impact and as widespread poverty severely limits its capabilities to adapt; it is one of the most adversely affected regions in the world. Thus, there is a wide consensus that climate change will worsen food security in Africa through continuous climatic shifts, as well as an increase in extreme events.

With 40 percent of its population living on arid, semi-arid, or dry sub-humid areas (UNDP 1997), Africa is one of the areas of the world most exposed to global warming. It has experienced a warming of approximately 0.7°C during the past century, and the temperature is expected to increase by between 0.2°C and 0.5°C each decade. Moreover, the decline in rainfall observed in the Sahel in the last 25 years was the most substantial and sustained recorded anywhere in the world since instrumental measurement began (Hulme and Kelly, 1993). In these contexts, climate change means that future farming and food systems will face substantially modified environments as they struggle to meet the demands of a changing global population. Efforts to cope with the stresses caused by growth in demand for food and water will be confounded by a range of stresses, for example, higher temperatures, changing rainfall patterns and rising sea levels.

Climate change increases the risk of reductions in crop and livestock yields. Within a given region, different crops and livestock are subject to different degrees of impacts from current and projected climate change (Lobel et al., 2008). The negative effects of climate change on crop production are especially pronounced in SSA, as the agriculture sector accounts for a large share of GDP, export earnings, and employment in most African countries (Nelson et al., 2009), and the vast majority of the poor reside in rural areas and depend on agriculture for their livelihoods. The numbers of hydro-meteorological disaster including extreme temperature, from a large scale to a small scale country level, continue to provide indicators of a changing climate as shown in Table 1 (Guha-Sapir et al., 2011), regional analysis on natural disaster occurrence and impacts revealed that in 2010, Africa experienced slightly more disasters (69) compared to the annual average disaster occurrence during the last decade (64). This was mostly due to an increase in the number of hydrological disasters (events caused by deviations in the normal water cycle and/or overflow of bodies of water caused by wind set-up). On average, other disasters occurred less frequently than observed over the last decade. Consequently, hydrological disasters took an 82.6% share in 2010, while from 2000 to 2009 they represented 66.5% of all disasters in Africa.

Number of Natural Disaster	**Africa**	**Global**	**Africa's Global percentage**
Climatological 2010	6	50	12
Avg. 2000-9	9	54	16
Geophysical 2010	1	31	3.2
Avg. 2000-9	3	31	9.7
Hydrological 2010	57	216	26
Avg. 2000-9	43	192	22
Meteorological 2010	5	88	5.7
Avg. 2000-9	9	105	8.6
Total 2010	69	385	18
Avg. 2000-9	64	387	16.5

Table 1. Regional analysis on natural disaster occurrence and impacts (Adapted from Guha-Sapir et al 2010).

3.1 Linking climate change and agricultural biodiversity

The issues of climate change and biodiversity are interconnected, not only through climate change effects on biodiversity, but also through changes in biodiversity that affect climate change (CBD, 2009). The work of IPCC has made us all aware that Climate Change is likely to be the main driver of biodiversity loss in the future, suggesting a strong nexus between climate change and agricultural biodiversity. Biodiversity has already been affected by recent climate change and projected climate change for the 21st century is expected to affect all aspects of biodiversity (IPCC, 2002). Also, in like manner, Isbell (2010) hypothesized that Global ecosystem changes are currently destabilizing species interactions (Figure 1) and that this will lead to future declines in biodiversity, ecosystem functioning, and ecosystem stability. This means we must start radically reducing emissions now and stay on a low emissions pathway to avoid increasing the amount of CO_2 in the atmosphere.

However, in response to these challenges, the Consultative Group on International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security (CCAFS) research initiative launched by the CGIAR and the Earth System Science Partnership (ESSP) has recognized the need to overcome the threats to agriculture and food security in a changing climate, exploring new ways of helping vulnerable rural communities adjust to global changes in climate. One major way suggested was to address the increasing challenge of global warming and declining food security on agricultural practices, policies and measures through a strategic collaboration.

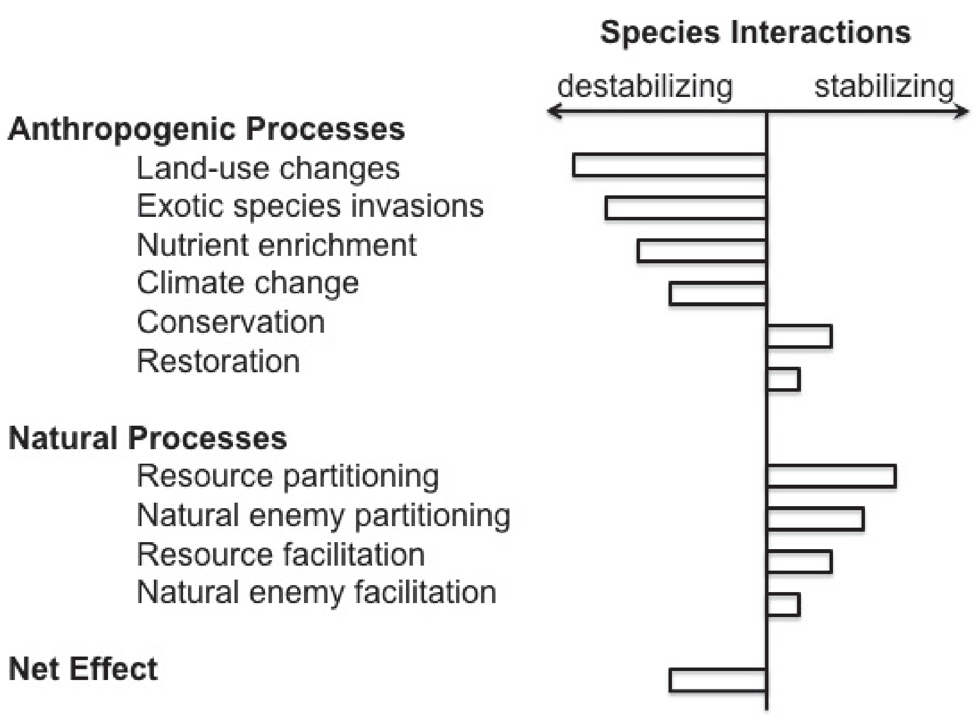

Fig. 1. Hypothesized effects of anthropogenic and natural processes on stabilizing species interactions. Source: (Isbell, 2010)

Here, we opine that the relationship between climate Change and agricultural biodiversity should be viewed in a synergistic approach that assumes that sustainable environmental management and sustainable agriculture can be achieved globally and especially in the SSA. The links between biodiversity and climate change flow both ways (CBD, 2009).

Agricultural Biodiversity, and associated ecosystem services are the cornerstone of sustainable development including food security. Biodiversity also has a very important role to play in climate change mitigation and adaptation. Whatever agricultural revolution Africa wants to undertake, it needs to take into account the carrying capacity of the natural resources and adapt to it.

3.2 Climate regimes and zones

SSA has a wide variety of climate regimes and zones (Fig. 2). The most common regimes are the tropical wet and dry, tropical wet, and tropical dry. In the tropical wet-and-dry climate, there is a distinct dry season during the winter months characterized with droughts and less rainfall. Rainfall occurs during the remainder of the year and can be highly irregular, varying tremendously from one year to the next. In this climate regime, destructive floods can be followed by severe drought. Vegetation in the tropical wet-and-dry regions of SSA is mainly tall savanna grass and low, drought resistant deciduous trees. In this climate regime, sustainable agricultural activities is seasonal and widely considered to be the zone at greatest risk of declining agricultural production at present, and parts of it have been severely affected by drought and food shortages in recent years. At the same time, the parts of the savanna that receive adequate rain have an enormous potential for the expansion of rainfed agricultural production (Higgins et al. 1982).

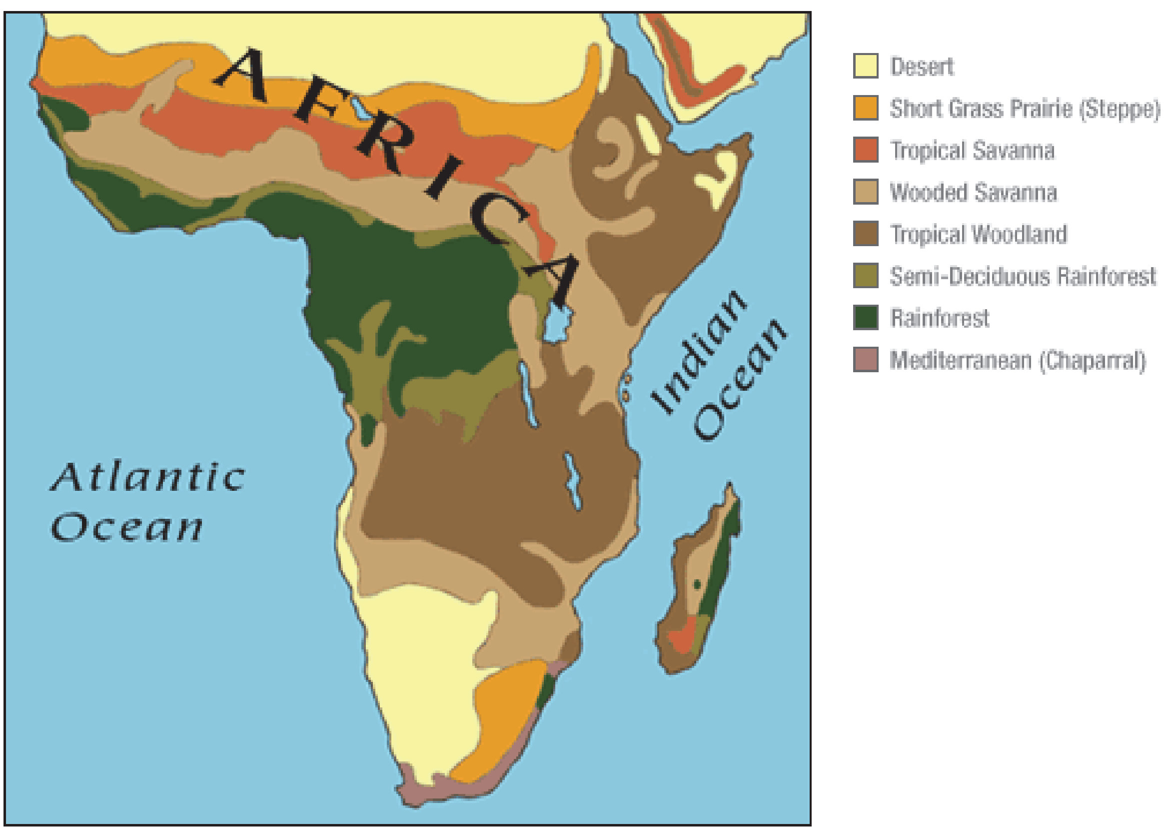

Fig. 2. Climatic zones or biomes in SSA. Source: NASA Earth Observatory.

The tropical wet climate regime affects much of western central Africa. In this region, trade winds from the northern and southern hemisphere meet. As the winds meet, air is forced upward. As the air rises, moisture condenses and towering rain-producing clouds, also called cumulonimbus clouds, form. These cumulonimbus clouds produce heavy rainfall. The heavy rainfall and warm temperatures provide the conditions necessary for the growth of tropical rain forest. Rain forests have higher plant diversity than any other habitat on earth. In terms of the amount of biomass, the natural vegetation is very luxuriant in tropical rainforests, but the natural conditions for developing farming in tropical rainforests are not so favourable. A vivid example is the intensive subsistence cultivation and small holdings which is practised in Nigeria or Ghana in West Africa (i.e. wet rice cultivation). Agricultural use of some rainforest land proves to be a failure because of the nutrient-deficient, acidic soils of these forests. Nevertheless, many commercial agricultural projects are still carried out on rainforest lands, although many of these revert to cattle pasture after soils are depleted.

Tropical dry climates are characterized by very little rainfall and high temperatures. Even when rain does fall, the region remains dry because the high temperatures cause high rates of evaporation. The tropical dry climate can be divided into the semi-arid and arid climates. The semi-arid regions receive more rainfall than the arid regions. Vegetation in the semi-arid region is mostly short grass prairie. Arid environments receive very little rainfall and are characterized as deserts. Land use in semiarid agriculture is characterized by subsistence agriculture and nomadic pastoralism. Because livestock is considered an important component in the livelihoods of semiarid communities, degradation has always been attributed to this sub sector (Sidahmed and Yazman, 1994). According to the World Resources Institute (WRI, 1992), over grazing is the pervasive cause of soil degradation. It has been estimated that overgrazing causes land degradation of 49 % in semiarid regions of Africa.

4. Conserving agricultural biodiversity

Biodiversity is the diversity of life on Earth and includes the richness (number), evenness (equity of relative abundance), and composition (types) of species, alleles, functional groups, or ecosystems. Agricultural biodiversity, sometimes called Agrobiodiversity, "encompasses the variety and variability of animals, plants and micro-organisms which are necessary to sustain key functions of the agroecosystem, its structure and processes for, and in support of, food production and food security"(FAO, 1998). It further "comprises genetic, population, species, community, ecosystem, and landscape components and human interactions with all these''(Jackson et al., 2005). However, MA (2005) suggests that biodiversity declines may diminish human wellbeing by decreasing the services that ecosystems can provide for people (Figure 3). A group of scientists further postulated that biodiversity is rapidly declining worldwide, and there is considerable evidence that ecosystem functioning (e.g., productivity, nutrient cycling) and ecosystem stability (i.e., temporal invariability of productivity) depend on biodiversity (Naeem et al., 2009). Thus, there is the need to formulate and implement biodiversity conservation strategies if sustainable agriculture in SSA is to become a development paradigm.

In terrestrial habitats, tropical regions like the SSA are typically rich in biodiversity. In SSA, agriculture represents 20% to 30% of GDP and 50% of exports. In some cases, 60% to 90% of the labour forces are employed in agriculture (Peter, 2011). Most agricultural activity is subsistence farming. This has made agricultural activity vulnerable to climate change and global warming. Biotechnology has been advocated to create high yield, pest and environmentally resistant crops in the hands of small farmers. As a result, maintaining agrobiodiversity may be critical in developing climate-change-resistant crop and livestock varieties and genotypes, such as those resistant to drought, heat stress, disease, and saline conditions (Fowler, 2008; Kotschi, 2007), and to ensure the continued survival of crop wild relatives (Jarvis et al., 2008). Also, given the above-mentioned impacts of climate change on agricultural systems, practices that enhance soil conservation and sustainable use and maintain favorable microclimates are important for adaptation in agriculture.

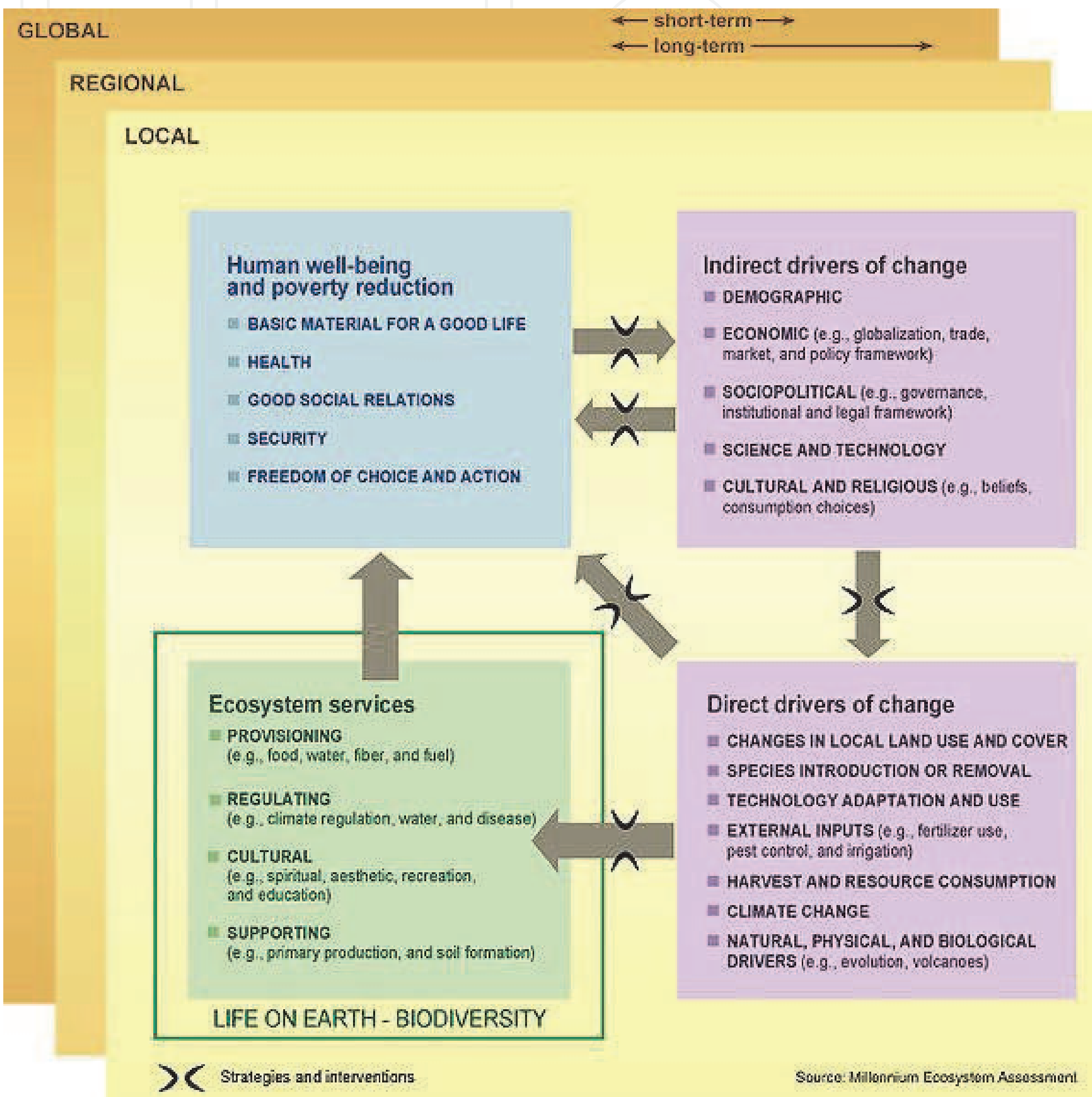

Fig. 3. A schematic image illustrating the relationship between biodiversity, ecosystem services, human well-being, and poverty (MA, 2005). The illustration shows where conservation action, strategies and plans can influence the drivers of the current biodiversity crisis at local, regional, to global scales.

Conserving crop and livestock diversity in many cases helps maintain local knowledge concerning management and use. Developing new varieties may, in addition to meeting adaptation needs, generate co-benefits in the context of health and biodiversity conservation and sustainable use. For example, varieties resistant to crop diseases may contribute to the

reduction of pesticide use, also, the use of currently under-utilized crops and livestock can help to maintain diverse and more stable agroecosystems (Bowe, 2007). Also, cultivated and traditional crop varieties represent high levels of genetic diversity and are therefore the focus of most crop genetic resources conservation efforts. Agricultural biodiversity is the basis of our agricultural food chain, developed and safeguarded by farmers, livestock breeders, forest workers, fishermen and indigenous peoples throughout the world. The conservation ethic advocates management of natural resources for the purpose of sustaining biodiversity in species, ecosystems, the evolutionary process, and human culture and society (Dyke, 2008; Wake and Vredenburg, 2008). Thus, the use of agricultural biodiversity (as opposed to non diverse production methods) can contribute to food security and livelihood security. In conserving agricultural biodiversity, ecosystem-based adaptation, which integrates the use of biodiversity and ecosystem services into an overall adaptation strategy, can be cost-effective and generate social, economic and cultural co-benefits and contribute to the conservation of biodiversity (CBD, 2009).
Establishment of diverse agricultural systems, where using indigenous knowledge of specific crop and livestock varieties, maintaining genetic diversity of crops and livestock, and conserving diverse agricultural landscapes secures food provision in changing local climatic conditions; and establishing and effectively managing protected-area systems to ensure the continued delivery of ecosystem services that increase resilience to climate change.

4.1 Examples of conservation approaches

4.1.1 Resource allocation

This requires focusing on limited areas of higher potential biodiversity promises greater immediate return on investment than spreading resources evenly or focusing on areas of little diversity but greater interest in biodiversity. A second strategy focuses on areas that retain most of their original diversity, which typically require little or no restoration. These are typically non-urbanized, non-agricultural areas. Tropical areas often fit both criteria, given their natively high diversity and relative lack of development (Jones-Walters and Mulder, 2009).

4.1.2 Biodiversity banking

Also known as biodiversity trading, biodiversity offsets or conservation banking is a process by which biodiversity loss can be reduced by creating a framework which allows biodiversity to be reliably measured, and market based solutions applied to improving biodiversity. Biodiversity banking provides a means to place a monetary value on ecosystem services. One example is the Australian Native Vegetation Management Framework.

4.1.3 Gene banks

Genes are responsible for the traits exhibited by organisms and, as populations of species decrease in size or go extinct, unique genetic variants are lost. Thus, a gene bank helps preserve genetic material, be it plant or animal. In plants, this could be by freezing cuts from the plant, or stocking the seeds. In animals, this is the freezing of sperm and eggs in zoological freezers until further need. In plants, it is possible to unfreeze the material and propagate it, however, in animals; a living female is required for artificial insemination. While it is often difficult to utilize frozen animal sperm and eggs, there are many examples of it being done successfully. In an effort to conserve agricultural biodiversity, gene banks are used to store and conserve the plant genetic resources of major crop plants and their crop wild relatives. There are many gene banks all over the world, with the Svalbard Global Seed Vault being probably the most famous one.

Another approach that may be considered is: reducing and better targeting of pesticides allows more species to survive in agricultural and urbanized areas.

Lastly, today's loss of biodiversity has been primarily adduced to habitat alteration caused by human activities, thus, halting or reducing the current spate in human adverse activities amongst others will be attempt to conservation of agricultural biodiversity.

5. Conclusion

This chapter has examined issues that are relevant and at the same time important for sustainable agricultural development in SSA. The issues examined reflect many constraints that are still facing sustainable agriculture practice in SSA, thus demanding serious attention from different actors, particularly the governments, private sector and international organisations. For example, land management, infrastructures, access to appropriate technology and vulnerability to climate change still remain a big challenge for sustainable agricultural development in majority of African countries. Given the challenges and constraints facing the agriculture in this region, proactive steps and concerted efforts as well as creating enabling policy environment must be put in place by the country government towards solving these problems. Individual country government, particularly the Ministry of Agriculture should introduce and integrate policy based on sustainable agricultural options into national targets, the extension programme and agricultural curriculum. Government policies should promote sustainable and conservation agriculture practices with less reliance on conventional farming.

Low cost-agriculture technology based on traditional knowledge should form part of the government policies so as to facilitate and encourage sustainable agriculture among small-scale farmers. Government policies should embrace new technological innovation like genetic modification technology that has great potentials to produce disease resistant crops, drought tolerant crops, high-yielding varieties crops as well as improving quality of life for sustainable development. Investing in agricultural research and development and training of extension workers will facilitate sustainable agriculture. Active participation and engagement of farmers that meet the public interest particularly in the development of new technology should be clearly spelt out in government policy. Improved access to higher-value markets, agricultural inputs and good infrastructures such as roads, transport, storage facilities and effective communication system would motivate many more farmers to engage in sustainable agriculture practices. Land reform policy and measures should be provided to aid and strengthen management of agricultural resources and protect the ecological environment. In order to tackle climate change problems, government policy should focus on best practices identified for enhanced agricultural productivity, increased resilience and low carbon agriculture, and environmental sustainability. Hardly any African country has integrated sustainable agriculture practise into its agricultural policies, and adopting sustainable agriculture and integrating into national policies will go a long way towards solving food security problems, combating global warming and improving agricultural productivity in general.

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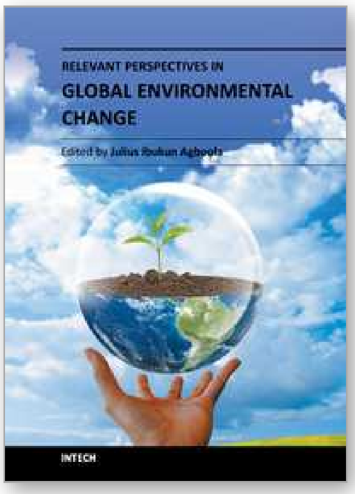

Relevant Perspectives in Global Environmental Change

Edited by Dr. Julius Agboola

ISBN 978-953-307-709-3
Hard cover, 154 pages
Publisher InTech
Published online 22, December, 2011
Published in print edition December, 2011

Over the years, environmental change has sharpened significant dynamic evolution and knowledge in organizational structures of organisms, from cellular/molecular to macro-organism level including our society. Changes in social and ecological systems due to environmental change will hopefully result in a shift towards sustainability, with legislative and government entities responding to diverse policy and management issues concerning the building, management and restoration of social-ecological systems on a regional and global scale. Solutions are particularly needed at the regional level, where physical features of the landscape, biological systems and human institutions interact. The purpose of this book is to disseminate both theoretical and applied studies on interactions between human and natural systems from multidisciplinary research perspectives on global environmental change. It combines interdisciplinary approaches, long-term research and a practical solution to the increasing intensity of problems related to environmental change, and is intended for a broad target audience ranging from students to specialists.