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RESEARCH ARTICLE

Sustainable Livelihoods in ASALs through Agro-biodiversity: Lessons from Baringo, Kenya

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Abstract

It is becoming increasingly difficult for people, especially with arid and semi-arid areas, to meet their socio-economic needs without causing damage to the environment. This is mainly due to increases in population and levels of affluence. This paper discusses how food and other needs in the Baringo area in Kenya can be met on sustainable basis through cultivation and exploitation of biological resources by promoting agrobiodiversity. Cultivation of non-traditional crops such as Aloe vera, Artemisia spp., Azadirachta indica and increased production of honey are examples of such activities. Exploitation of these resources can enhance food security in the area, reduce household poverty, increase access to health and education, thus contributing positively towards achieving the millennium development goals (MDGs). The paper concludes that for this to succeed, there is need for changes in both government policy and socio-cultural values.

Key Words: ASALs, Sustainable Development, Food Security, Conservation, Alternative Farming, Conflict Resolution, Agro-Biodiversity

Introduction

One of the fundamental problems facing mankind today is how to meet the needs of all people on earth without destroying the environment, i.e. “the stock of physical and social resources available at a given time for the satisfaction of human needs”, from which ultimately these needs have to be met (Tolba, 1982). There seems to be conflicts between the methods man is using to meet his needs and the continued operation of the environment. Conversion of forests to agricultural land interferes with plant and animal species, destroys water catchments, lowers CO_2 sequestration, which when combined with exhausts from industries and cars, is causing changes in global weather patterns. Industrialization is also increasing air and water pollution and the rapid depletion of non-renewable energy resources. Efficient transportation systems (jets) and accumulation of chlorofluorocarbons (CFCs) are interfering with ozone layer, which protects us from dangerous radiations. These are examples of environmental signals to man that all is not well. Significant decline in biodiversity has been associated with use of agro-chemicals in Ethiopian highlands (Hadgu *et al.,* 2009).

The question everybody is asking is whether development, defined as "the processes pursued by societies with the aim of increasing human well being” (Tolba, 1982), can be attained without degrading the environment. Development is inevitable; man has to look for methods of attaining sustainable development, i.e. development that will be able to meet present needs without compromising the ability of the future to meet its own needs (WCED, 1987). Sustainable development can be achieved by a) identifying and eliminating the source of conflict between development and environmental conservation and, b) enhancing the beneficial interactions between production and consumption systems. Despite the emphasis of "human beings" in the definitions of environment and development, there seems to be an agreement between their objectives, i.e. to improve the quality of life. How then does conflict between these apparently compatible objectives arise?

It is not easy to answer this question, but the problem can be associated with man's disregard of the symbiotic relationship between him and the environment. By assuming a superior place in the environment, man seeks to control and exploit, rather than use the stock of available resources. Using technology, which he wrongly mistakes for "ability to be independent of nature", for a long time man has sought economically cheap alternatives, totally disregarding their long-term effects on the environment. As populations grow and demands increase, more technological solutions are developed. The cumulative effect of their environmental damage has started becoming obvious. We have reached a stage where this trend has to be stopped or possibly reversed.

This paper focuses on how this paradox could be addressed in the developing world in general and specifically in arid and semi-arid areas (ASALs). In Kenya, ASALs which are characterized by low and erratic rainfall, high temperatures and shallow soils, comprise 80% land surface, host 50% of the livestock and provide the sole means of livelihood for the pastoralists who make 25% of the Kenyan population. Can development in such areas be achieved through the promotion of agro-biodiversity? The paper argues that the national policy of increasing food security, reducing poverty, increasing access to health and education, can be achieved through sustainable exploitation of naturally occurring biological resources, which will contribute towards achieving the millennium development goals (MDGs). Further, the national goal of "industrialisation" can also be attained by developing agro-based industries for extracting and processing biodiversity resources in line with the national vision for ASALs in Kenya (Kenya, 2005).

Study Area

The study area is located in the greater Baringo District (presently Baringo and Koibatek districts) in the Rift Valley Province of Kenya. It is bounded by latitudes 0° 10' South and 1° 40' North and longitudes 35°30' and 36° 30' East, covering an area of approximately 10,949 km^2 of which about 165 km^2 is water, Lakes Baringo and Bogoria (Figure 1). The area is quite heterogeneous in terms of topography, soils, vegetation and climatic conditions, creating a highly diverse landscape with varying potentials.

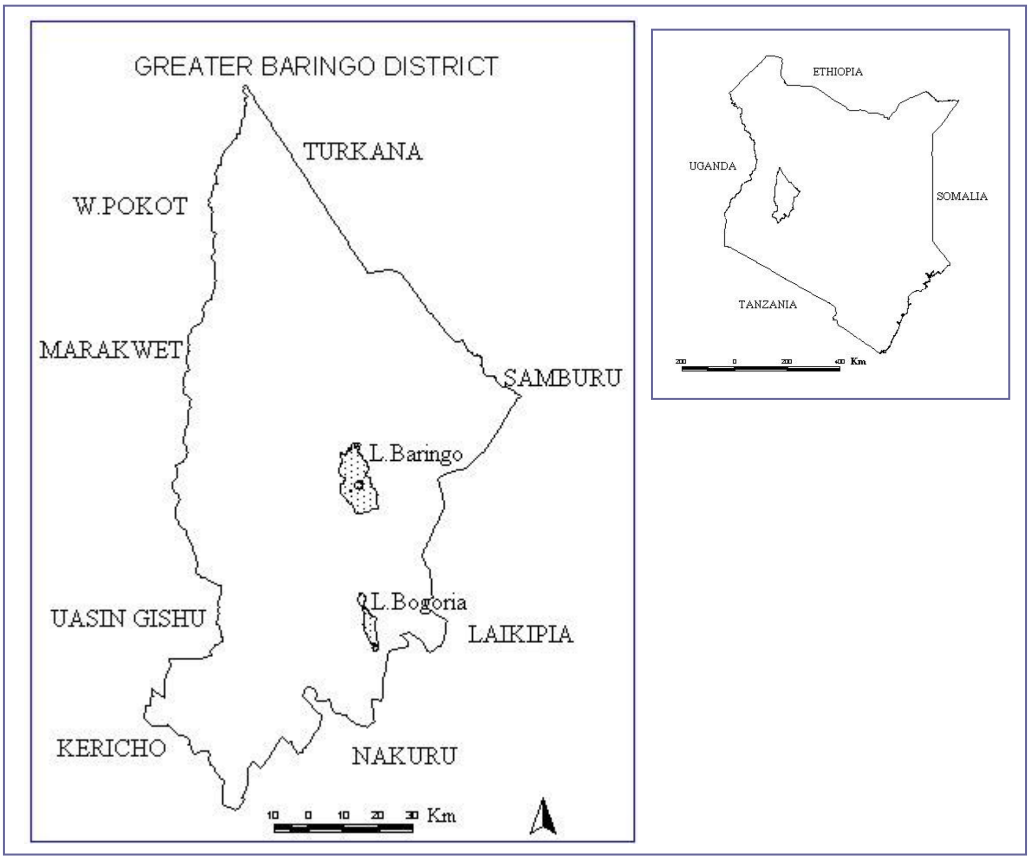

Figure 1. Location of the Study Area

A large part of Baringo lies in the floor of the Rift Valley. Apart from the Laikipia Escarpment and the Tugen Hills, which extend to 2860 m above sea level, most of the area lies below 1800 m. This change in elevation occurs over a distance of less than 4 km resulting into steep slopes. The soils along the slopes are generally shallow and stony, as a consequence of erosion. The vegetation is predominantly woody, ranging from *Acacia* dominated deciduous shrubland on the valley floor to evergreen forests on the highlands. A wide diversity of both annual and perennial shrubs, forbs and grasses undergrow the woody vegetation. Rainfall in the lowlands is low and unreliable while the highlands enjoy good rainfall patterns.

The area has been predominantly occupied by pastoralists, however sedentarization and crop farming is rapidly spreading. In 1969, the population of the district was 161,741 persons, which increased to 203,792 by 1979. By 1989 the population had increased to 289,686, indicating an increase in annual growth rate from 2.3 to 3.5 between the two census periods.

According to the latest census report (1999) there are 403,141 persons in the area, implying a current growth rate of 3.3 people per annum, a value higher than the current national average of 2.5. This means there is a rapidly increasing demand for food and other resources in the area, leading to resource over-exploitation and hence environmental degradation. More degradation will eventually lead to higher levels of poverty. It is thus necessary to develop and promote more sustainable resource exploitation strategies for prosperity. The area has undergone significant changes, most of which have lowered the quality of the environment and are human-driven (Mwasi, 2004).

Materials and Methods

The information used was gathered from field observations, discussions and literature. Changes in life-styles, production systems and natural environmental conditions in the area are readily observable. Discussions with local communities confirmed these observations and provide insight into the dynamics of some of these changes. Literature also shows significant changes, mainly degradation, changes in vegetation characteristics in general and declining biodiversity in particular. No formal data was collected specifically for this research. Consequently, the analysis will also be in the form of descriptive situation analysis.

Theoretical Framework

The aim of this paper is to provide a scientific framework for supporting policy makers in promoting agro-biodiversity by demonstrating its ability to improve a) food security situation; b) rural incomes and; c) environmental conservation by applying a strategy referred to as 'planning with nature'. This is a development strategy which seeks harmony with nature. Consequently, the production system is designed to fit into the nature of the environment, making use of the existing comparative advantages, rather than struggling to transform the environment to suit the production of a preferred commodity.

Food production has been increased over time through agricultural development, which has evolved through several stages including: i) non-managed systems - hunting and gathering, ii) settlement of mankind, iii) domestication of plants and animals iv) technological innovation - mechanization, agrochemicals (green revolution), v) breeding - selective breeding of favoured genotypes and, vi) biotechnological (genetically modified organisms (GMOs) development). Besides being expensive, these methods have proved to have some adverse effects due to their extensive interference with the natural ecosystem. For this reason, methods which incorporate the structure and functioning of a natural ecosystem are preferred. Implementations of such methods require an understanding of the ecological functioning of the ecosystem being exploited.

An ecosystem can be defined as a collection of interacting organisms and their physical environment together with the flow of energy and nutrients within the system. The efficiency with which any ecosystem functions is determined by the energy flows and losses within and without it, which depends on its biological composition as well as the state of physical environment (solar radiation, temperature, water availability, and the availability of essential nutrients). Two types of ecosystems can be identified, natural ecosystems and agroecosystems (agricultural ecosystem). A natural ecosystem is one which exits and functions without the influence of man. In a simplified form it consists of the sun (source of energy), the plants or autotrophs (the primary producers which convert solar energy, carbon dioxide and water into chemical energy through photosynthesis), herbivores and carnivores, also known as the heterotrophs (which are the primary consumers) and finally the scavengers and decomposers, which break down remains of plants and animals into organic matter as shown in Figure 2a. All these components, except the sun, use the earth's physical environment - soil and the atmosphere as a platform to function and interact, and as a source of oxygen, water and nutrients. These components function in a manner forming an almost closed cycle known as the food chain.

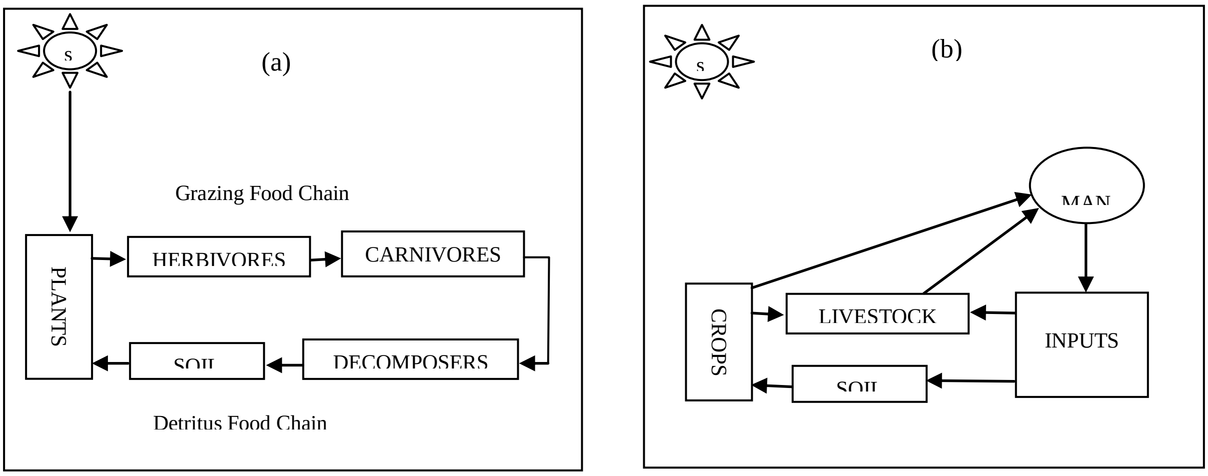

Figure 2. Simplified Food Chain (a) Natural Ecosystem (b) Agro-ecosystem

An agro-ecosystem on the other hand, is an assemblage of plants and animals created by man with the aim of maximizing the harvest simplified in Figure 2b. Unlike natural ecosystem which evolve to sustain and perpetuate itself, agro-ecosystems are developed to maximize production of specific commodities needed by an external user - man. Agriculture has evolved from subsistence form which emphasized self-sufficiency in food production, to a highly complex intensive agriculture whose goals are to maximize profits through food production, by using "high inputs of energy and resources" (Lambert, 1986).

Although different natural ecosystems have unique structures, characterized by their species combinations and the physical environment, they all exhibit five characteristics, which are the basis of their smooth functioning. These are; a) *adaptability* - species exist where they do because the conditions (physical and biological) are favourable; b) *continuity* - boundaries between species are marked by changing conditions, species give way smoothly to others through zones of transitions; c) *diversity* - natural ecosystems are characterized by a high biological diversity which seems to blend with highly diverse physical environment; d) *system control* - through the process of succession, natural ecosystems regulate and perpetuate themselves and; e) *system functioning* - natural ecosystems operate as closed systems.

In contrast, agro-ecosystems are characterized by low species diversity, inability to control and perpetuate themselves and a high demand for external inputs of energy and resources. These characteristics arise from the modification of the structure and dynamics of the systems as they are converted from natural to agro-ecosystems. Transfer of harvest from the point of production to that of consumption tilts this balance further. These modifications interfere with three basic ecological functions with regard to soil-producer-consumer relationships. First, it reduces the proportion of energy that flows through the detritus food chain. When a forest is converted into a wheat farm, man harvests the grain for his use and the straw for his animals, only the roots enter the detritus food chain. Secondly, agriculture increases the importance of nutrient and energy export from the system, in large scale farming, neither the grain nor the straw are consumed where they are produced. This energy and nutrient leakage from an agro-ecosystem has to be balanced using external inputs of fertilizers. Finally, physical disturbance of soil during cultivation lowers its quality through direct exposure to rain, sun, compaction, etc. It is therefore obvious that demands for increased food production cannot be met sustainably using the traditional methods of agricultural developments such as expansion of area under cultivation, irrigation, mechanization, use of agro-chemicals, breeding and biotechnology, the strengths and weaknesses of which are well documented. This paper focuses on increasing ecosystem productivity by exploiting and enhancing existing biological diversity by promoting agro-biodiversity.

Agricultural biodiversity or agro-biodiversity refers to the variety and variability of animals, plants, and micro-organisms on earth that are important to food and agriculture which result from the interaction between the environment, genetic resources and the management systems and practices used by people (FAO, 1998). It is argued that enhanced agro-biodiversity will lead to increased food, improved household income and enhanced environmental conservation. This concept is simplified in Figure 3 below.

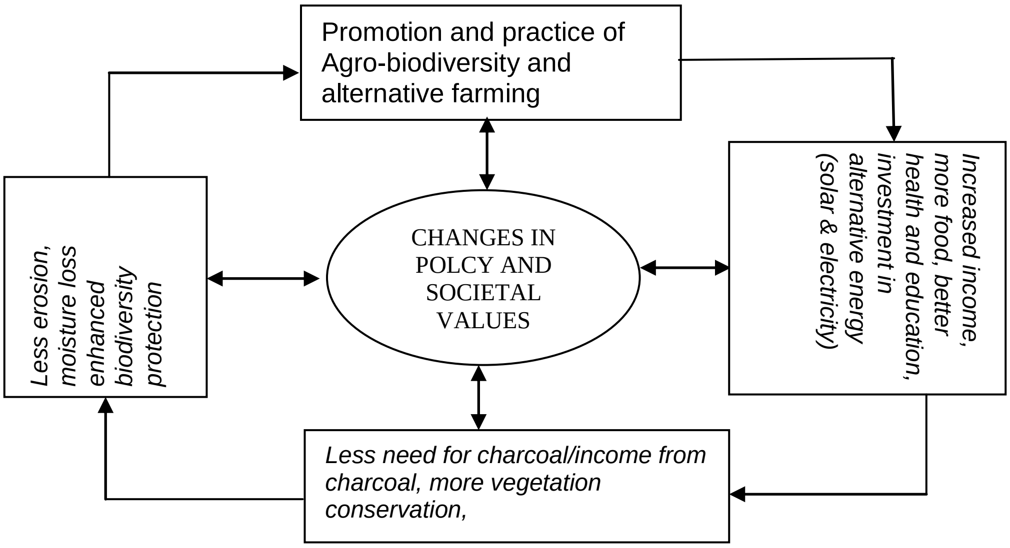

Figure 3. Conceptual Framework

At the global level, there exists a large amount of *inter-species* diversity. Out of the 250,000 or so plant species that have been identified, some 30,000 are edible and about 7,000 have been cultivated or collected for food and the provision of other goods and services at one time or another. Similarly, several hundred animal species including mammals, fish, reptiles, molluscs and arthropods also contribute to food and livelihood security. However, today the diet of most Kenyans, and indeed most human beings, revolve around less than 20 plant species and an even smaller number of animal species. By broadening our food-base, we can have more food without any further modifications of the environment.

Secondly, agro-biodiversity can lead to increased incomes for the rural population through both tangible and non-tangible goods and services. This is because most of the plants in the wilderness have multiple uses, for example Grace *et al.* (2009) identifies 11 use categories of *Aloe spp.* There is a great potential of increasing rural incomes through the exploration, extraction and exploitation of biological diversity for commercially valuable genetic and biochemical resources, i.e. bio-prospecting. Most natural landscapes, particularly those within the tropics, harbour many species capable of producing valuable chemicals for industrial, medicinal and domestic products. However, evidence from existing research indicate that local communities, and in some cases governments, receive only a minuscule proportion of the profits generated from sales of products that embody their knowledge and resources. For example, one study has estimated that less than 0.001 per cent of the market value of plant based medicines has been returned to local and indigenous peoples from whom much of the original knowledge came (Posey & Dutfield, 1996). If this situation was rectified, by making all international codes of conduct developed to guide sharing of benefits between bio-prospecting companies and local communities (Cunningham, 1993; FAO, 1993; Shelton, 1995; UNESCO, 1996) legally binding, many rural economies would develop appreciably. Further, conserved biodiversity can lead to increased honey production and enhanced eco-tourism, both of which can bring additional income. However, proper policies are required to ensure that income from tourism and eco-tourism does not bypasses local communities as has been in many instances. Increased incomes, will improve access to food, education and health services, thus alleviating overall poverty.

Finally, agro-biodiversity can improve environmental conservation in many ways. First, each species in an agro-ecosystem is part of a web of ecological relationships connected by flows of energy and materials. While each species occupies a specific ecological niche as a primary producer, consumer, decomposer, it is involved in sustaining many different ecosystem functions and environmental processes directly or indirectly. In this sense the different components of agricultural biodiversity are inherently multifunctional and contribute to the resilience of production systems by providing environmental services at the larger landscape level. Secondly, by increasing available income, agro-biodiversity can make communities less dependent on charcoal, invest into other energy alternatives (solar and electricity), leading to more conservation of vegetation. Third, a well-designed agro-biodiversity system needs to emphasise products that require less or zero-tillage farming. This will conserve soil and moisture, and considerably reduce soil erosion particularly in steep slopes, with shallow soils and un-reliable rainfall conditions.

Analysis of Agro-biodiversity Potential

The high vegetation diversity in the study area has, to a large extent, been exploited traditionally (Reckers, 1994). Wild plants have been used as food, human and veterinary medicine, livestock forage, firewood and as a source of construction and furniture material (Table 1). Similarly, wild animals have been used as sources of food. A recent study in semi-arid Brazil identified at least 166 useful plants for food, medicinal and veterinary purposes which need to be conserved and used sustainably (Albuquerque *et al.,* 2009).

The honey bee (*Apis melifera*) for example, is one of the most economically beneficial wild animals in the area. Many families have between 10 and 20 traditional beehives with an average production of 4 kg of pure honey per harvest. Honey production has been declining in the area because of two reasons. First, there some economic disincentives, no proper markets and/or processing facilities exist. Second, the rampant vegetation destruction, mostly for charcoal burning, has affected honey production potential. With more trees conserved, and improved beehives production of honey per hive could rise, and at the current price of over Kenya shillings 300 per kg, this could bring substantial income.

Table 1. Commonly used Biodiversity Resources

	Species Name	
Usage	Plants	Animals
Human Food	*Balanites aegyptica, Berchmia discolor, Boscia coriaca, Cordia sinensis, Grewia spp., Maerua subcordata, Meyna tetraphylla, Rhus natalis Salvadore persica, Slcerocarya birrea*	*Apis melifera* (Honey bees) Several herbivores and rodents
Human Medicine	*Acaclypha fruiticosa, Albizia anthelmintica, Aloe secundiflora, Aloe vera, Carissa edulis, Cassia italica, Gardenia volkensi Maerua crassiflora, Salvadora persica* Azadirachta indica,	*Snakes*
Veterinary Medicine	*Aloe secundiflora, Capparis cartilaginea, Ximemia Americana, Zanthoxylum chalybeum*	
Fodder	*Acacia tortilis, Balanites aegyptica,Boscia augustifolia, Ficus sycomorus, Terminalia brownii*	
Fuel	*Acacia tortilis, Acacia mellifera, Balanites aegyptica, Cordia sinensis*	
Timber and construction materials	Woody Plants	
Furniture and artefacts	Woody plants, particularly hard woods	Skins of many animals
Others		
- Water Purifying	Maerua subcordata	
- Mosquito repellent	Artemisia annua	
- Textiles		Silk worms

Source: Herlocker *et al.* (1994

However, there has been a considerable reduction in usage of most of wild plants and animals as food. This has been caused by decline in species populations, changes in societal/cultural practices and government regulations. For example, consumption of game meat is prohibited in Kenya. Similarly, the trade of Aloe, several species of which grow locally in the study area was banned in Kenya to reinforce an international convention meant to protect the plant. Aloe species have been used for a long time in the management of disease as well as cosmetics, all over the world. The ban of Aloe in Kenya has led to illegal exploitation, almost leading to its extinction, with minimal benefits to the residents of Baringo. However, there are some indications of policy changes, and soon farmers will start trading the commodity legally, paving way to a more sustainable utilization through propagation and protection. In deed, plans are underway to construct an aloe extracting and processing plant in the area. The anticipated incomes are high and some farmers have already started bulking the plant. Commercial production of *Aloe vera*, interspersed with different acacia species, using the zero tillage system will form an efficient agro-ecosystem, which could improve the economy of the area through sale of Aloe and honey, provide a good micro climate for other annuals, including the propagation of wild vegetable species, conserve soil and moisture, etc. Other potential money-makers, which grow wildly in the area include the *Artemisia annua* and *Azadirachta indica* (Neem tree). Attempts of producing these tree species on commercial basis are already underway. *Artemisia annua* produces the chemical artemisinin, an effective anti-malarial drug. *Artemisia annua* is an annual shrub which takes about seven months to mature. There is already an international market for this product. Organisations such as ICIPE, and home-based industries, are already producing soaps and other medico-beauty products from *Azadirachta indica.*

The potential for broadening the food-base in terms of crops cultivated remains largely unexploited. At the moment most farmers seem to prefer cultivation of cereals (maize, sorghum and millet) combined with some leguminous crops such as beans, pigeon and cow peas. It would make ecological sense to cultivate drought resistant tubers (cassava, sweet potatoes, etc), which require minimal tillage. Production of groundnuts, castor and cotton could also flourish if access to markets, through construction of extraction/processing plants or development of transportation infrastructure. These are relatively high-income earners, with great potential for value adding. Besides increasing income, adding value through processing, creates employment opportunities and enhances infrastructural development (roads and electric power). Other possible unexploited potentials include fish growing, silkworms cultivation and gum/resin harvesting.

Conclusion

The potential for improving food security, increasing rural incomes and improving health from agro-biodiversity in the study area through agro-biodiversity has been demonstrated. This development approach promotes rural development, thereby enabling the country move a large proportion of its population towards poverty alleviation. Further, the paper has shown that these increased benefits can be obtained with an added premium of enhanced environmental conservation and improved ecosystem efficiency. It has been proved elsewhere that diverse ecosystems, including agro-ecosystems, are highly productive in terms of their use of energy and output per unit land area or water volume (Vandermeer, 1988).

However, there is evidence that there need to be policy frameworks to enhance exploitation of biodiversity and to ensure that benefits accruing from this are equitably shared between the bio-prospectors and the community. Cases of bio-piracy need to be investigated to conclusion and all loopholes closed to protect the countries biological resources (Juma, 1989).

Secondly, societal values need to change also towards conservation and utilization of biodiversity resources. We need to broaden our food base. This can be facilitated by more research on nutritional and medicinal aspects of both traditional foods (cassava, arrowroots, yams, etc) and wild foods (wild vegetables, fruits, etc), followed by their processing/preserving to elongate their shelf-lives and aggressive advertising. Finally, there is need for seed companies to collect and bulk for sale seeds for wild foods and indigenous plants for easy of propagation.

Finally, a detailed study need to be carried out to, among other things, a) establish the potential, current and extent of loss of biodiversity in the area; b) determine the economic returns that could be generated by cultivating non-traditional crops and; c) determine the optimum combinations of plants and animals for creating agro-biodiversity production for different spatial and temporal circumstances.

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