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The role of biodiversity in food security

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Abstract

Currently, the world population is increasing at an alarming rate and production of food should be increased. Biological Diversity or biodiversity component particularly agro-biodiversity such as crop and horticultural biodiversity, animal biodiversity, Forest biodiversity, and microbial biodiversity are essential to world food security.

Crop and horticultural biodiversity are important to food security because they are a source of food, fodder for livestocks, carry gene for desirable traits or characteristics, and also are a foundation for crop improvements. In addition, terresterial and aquatic animal biodiversity play an important role in increasing food security including as source of food, alternative source of food, and breed improvement and source of gene for desired trait. Furthermore, animal biodiversity plays indirect role in food security as the skins are sold to purchase food in return, and also as a there dung are used to increase soil fertility there by increasing crop production.

Forest genetic resource are also vital for food production and security in many ways. Maintaining soil fertility, income generation and employment, as a source of food and increasing food production, source of fodder and soil erosion control are the main ways by which forest biodiversity contribute to food security. The other component of biodiversity which is microbial biodiversity contribute to food security through increasing plant growth, increasing soil fertility and nutrient cycling. Generally, collection, conservation and sustainable use of biological diversity without compromising future will be necessary and and is vital to food security now and even more so in the future.

Keywords: Food security; Food production; Biodiversity; Conservation; Hunger

1. Introduction

Currently, the world population is increasing at an alarming rate. According to 2017 UN World Population Prospects, the world's current population of nearly 7.4 billion will continue growing, reaching 8.5 billion in year 2030, 9.7 billion in year 2050, and exceeding 11 billion by 2100 [1]. By 2030, the world population expected to reach 8.3 billion and the Earth will have to feed an extra 2 billion people, of whom 90% will live in developing countries and that there is a need for 70–100% more food [2]. It is therefore crucial to ensure not only that enough food can be produced reliably to feed this expanding population, but also that it is accessible to all.

Food is important to survival, growth and reproduction of living organisms. It refers to any substances or materials that than can be used as sources of nourishment, such as carbohydrates, proteins, fats, vitamins and minerals [3]. Cited in [4], food security is defined as a 'situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'.

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Biodiversity is the diversity of life. The Convention on Biological Diversity defines biological diversity as "variability among living organisms". It includes the diversity of ecosystems, the range of species, and genetic diversity within species. The so-called functional diversity adds a fourth level, which considers the interactions within and between the other three levels. Agricultural diversity, or agrobiodiversity, is part of biodiversity. It includes the ecosystems and species (including their wild forms) that are used for agriculture. In contrast to natural diversity, it was created by humans.

Food production and security depend on the wise use and conservation of biodiversity in general and agro-biodiversity in particular. Crops and their wild relatives provides the raw material for breeding new crop varieties, through classical breeding and biotechnological techniques, in response to environmental and demographic changes. Animal diversity is important for improvement, meat and as a pollination agent. Further more forest plays an important role in food security by securing the ecosystem through which food is produced. Microbial diversity is also necessary in food security by increasing soil fertility and protecting its structure. However, many of these genetic resources are currently under-used or at risk. Hence, the purpose of these paper was to review the role of biodiversity components particularly agro-biodiversity such as animal biodiversity, crop an horticulture biodiversity, Forest and biodiversity, microbial biodiversity in food security.

1.1 Biodiversity and its conservation

Biodiversity is the diversity of life. The Convention on Biological Diversity defines biological diversity as "variability among living organisms". It includes the diversity of ecosystems, the range of species, and genetic diversity within species. The so-called functional diversity adds a fourth level, which considers the interactions within and between the other three levels. Agricultural diversity, or agrobiodiversity, is part of biodiversity. It includes the ecosystems and species (including their wild forms) that are used for agriculture. In contrast to natural diversity, it was created by humans.

Across scales from genes to species, landscapes, and biomes, biodiversity is an important resource for humanity. It is the key for a broad range of services provided by ecosystems. Biodiversity helps regulate the nutrient cycle and water (e.g.,floods) and mitigates impacts of climate change. Biodiversity is also of direct importance for human well-being and for cultural and other values including recreation. The provisioning of clean water and diverse food supply makes it vital for all people.

Despite this importance, biodiversity at all levels, including the diversity of genes, species, and ecosystems, is lost at alarming rates. The loss of biodiversity is accelerating around the world and ecosystem services are deteriorating. Critical factors for these trends are habitat destruction, global warming, and the uncontrolled spread of alien species. Pollution, nitrogen deposition, and shifts in precipitation further affect biodiversity. It is estimated that due to human-induced environmental changes and based on current trends, one million animal and plant species are threatened with extinction [5]. This poses a serious risk to global food security and makes agriculture less resilient to climate change, pests and diseases.

The conservation and sustainable use of biodiversity for food and agriculture play a critical role in the fight against hunger, by ensuring environmental sustainability while increasing food and agriculture production. It is imperative to do so in a sustainable way: harvesting resources without compromising the natural capital, including biodiversity and ecosystem services, and capitalizing on biological processes. We need more sustainable food production systems to better conserve and sustainably use biodiversity. New challenges like the digitalisation of genetic information must be addressed. Therefore, there is crucial need for conservation of biological diversity at all level.

1.2 Food, food security and food production

Food is important to survival, growth and reproduction of living organisms. It refers to any substances or materials that than can be used as sources of nourishment, such as carbohydrates, proteins, fats, vitamins and minerals [3].

Cited in [4], food security is defined as a 'situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. According to [4], food security is influenced by: 1) the availability of sufficient quantities of food of appropriate quality; 2) access to adequate resources for acquiring appropriate foods for a nutritious diet; 3) utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being; and 4) access to food at all times, not to be impeded by sudden shocks such as economic or climatic crisis or cyclical events due to seasonal food insecurity.

Food security faces significant challenges due to population growth, poverty, globalization, climate change, and other factors. Supplying healthy food to all citizens is crucial for global development—to reach it, not only food production but also equitable access to food for all people must be improved substantially. Biodiversity loss and global food security are hence two major challenges of our time. Linking these two areas from a research perspective and seeking synergies between them are likely to generate multiple benefits for social, ecological, and economic development.

Food production and security will be a major issue for supplying an increasing world population. The problem will almost certainly be exacerbated by climate change. There is a projected need to double food production by 2050. In recent times, the trend has been for incremental modest yield increases for most crops. There is an urgent need to develop integrated and sustainable approaches that will significantly increase both production per unit land area and the resource use efficiency of crops.

The concern for global food security results primarily from an imbalance between the supply and demand of the major food crops (wheat, rice and maize). Increasing production on a sustained basis is an essential component of ensuring food security; however, the wider issues of distribution and economics are also major challenges for the whole of society. Currently, at least 1 billion people are chronically malnourished and the situation is deteriorating; more people are hungrier now than at the start of the millennium. The United Nations Millennium Development Goal of substantially reducing the world's hungry by 2015 will not be met. Reliable food production and distribution determine the availability of food, and both are key factors in achieving food security.

1.3 Relationship between food security and biodiversity

Biodiversity and food security are connected in many ways. Across scales from genes to species, landscapes, and biomes, biodiversity is an important resource for humanity. It is the key for a broad range of services provided by ecosystems. Biodiversity helps regulate the nutrient cycle and water (e.g.,floods) and mitigates impacts of climate change. Biodiversity is also of direct importance for human well-being and for cultural and other values including recreation. The provisioning of clean water and diverse food supply makes it vital for all people. Biodiversity at all levels, including the diversity of genes, species, and ecosystems, is lost at alarming rates. Critical factors for these trends are habitat destruction, global warming, and the uncontrolled spread of alien species. Pollution, nitrogen deposition, and shifts in precipitation further affect biodiversity.

Food security faces significant challenges due to population growth, poverty, globalization, climate change, and other factors. Supplying healthy food to all citizens is crucial for global development—to reach it, not only food production but also equitable access to food for all people must be improved substantially. Biodiversity loss and global food security are hence two major challenges of our time. Linking these two areas from a research perspective and seeking synergies between them are likely to generate multiple benefits for social, ecological, and economic development.

2. The role of biological diversity in food security

Whether they are used in traditional farming systems, conventional breeding, or new biotechnologies, plant and animal genetic resources are the foundation for sustainable agriculture and global food security now and in the future. Genetic diversity in agriculture enables plants and animals to adapt to new pests and diseases, changing environments and climates. The ability of a certain variety to withstand drought, grow in poor soil, resist an insect or disease, give higher protein yields, or produce a better-tasting food are traits passed on naturally by the variety's genes. This genetic material constitutes the raw material that plant breeders use to breed new crop varieties. Without genetic diversity, options for long-term sustainability and agricultural self-reliance are lost.

Farmers especially in developing countries are responsible for managing agricultural biodiversity in agricultural ecosystems as a critical resource for providing them with food security, nutrition and sustenance of their livelihoods.

Agro-biodiversity for food and agriculture is constituted by various biological diversity components that include crops, fish, livestock, pests, inter-acting species of pollinators, predators and competitors among others. Cultivated agro-biodiversity together with wild relatives provides humanity with genetic resources for food and agriculture. Infact, the global food supply rests essentially on the biological diversity developed and natured by indigenous communities, local farmers and farming communities residing in genetic resources centers of origin and diversity.

2.1 The role of crop and horticultural biodiversity in food security

7,000 species of plants are consumed by humang beings and out of this only I50 species are commercially important, and about I03 species account for 90 per cent of the world's food crops. Just three crops-rice, wheat, and maize- account

for about 60 per cent of the calories and 56 per cent of the protein people derive from plants. Reduction in diversity often increases vulnerability to climatic and other stresses, raises risks for individual farmers, and can undermine the stability of agriculture. The following are some of the role of crop biological diversity in food security:

Crop improvement: Success in any breeding programme depends largely on the extent of genetic variability present at different levels. Diversity in plant genetic resources (PGR) provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics, which include both farmer-preferred traits (yield potential and large seed, etc.) and breeders preferred traits (pest and disease resistance and photosensitivity, etc.). From the very beginning of agriculture, natural genetic variability has been exploited within crop species to meet subsistence food requirement, and now it is being focused to surplus food for growing populations.

Source of genes for desirable traits: Genes for desirable traits are embedded in biodiversity and as such crop genetic diversity has a critical role to play in increasing and sustaining production levels and nutritional diversity throughout the full range of different agro ecological conditions. Wild relatives of current crop plants, although agronomically undesirable, might also have acquired many desirable characteristics as a result of their long exposure to natural selection, and can therefore make very useful contributions to crop. wild species of crop plants and their relatives are the source of many genes imparting resistance against many disease pests and abiotic stresses. They are also source of genes that determine quality and other attributes.

Enables adaptation to environmental stress: crop genetic diversity in agriculture enables plants and animals to adapt to new pests and diseases, changing environments and climates. The ability of a certain variety to withstand drought, grow in poor soil, resist an insect or disease, give higher protein yields, or produce a better-tasting food are traits passed on naturally by the variety's genes. This genetic material constitutes the raw material that plant breeders use to breed new crop varieties. Without genetic diversity, options for long-term sustainability and agricultural self-reliance are lost.

Source of medicine: Plants are also a source of medicine. The pharmaceutical industry is based on these biological resources and related local knowledge.

Generally, the shrinking food basket and the extinction of crops and landraces have a direct impact on the food and nutrition security of the economically-vulnerable sections of the community. Therefore it's necessary to conserve and use wisely crop and horticultural diversity.

2.2 The role of aquatic and terrestrial animal biodiversity in food security

Animal biodiversity is a vital source of food security and nutritional quality. Livestock is an important component of food security in most developing countries, accounting for more than 40 percent of overall agricultural output. Livestock make a substantial contribution to achieving food and nutrition security due to various factors including the high nutritional quality of animal-source foods. Animal genetic diversity including both domestic and wild have proven role in food security as a source of food, breeding of better performing strain, and also indirectly contribute to food security.

Source of food: Meat products are important contributors of nutrition to human diets, as they provide essential protein, amino acids, minerals, and vitamins [6; 7]. Locally produced foods in highly biodiverse areas are known to be important sources of nutrients, particularly micronutrients [8]. FAO has estimated that demand for meat will double by 2030 (2000 basis) and demand for milk will more than double in this 30-year period.

In addition to domestic animal, wild animal are also contributing to food security. Bushmeat, is a significant source of animal protein in Central African countries, and a crucial component of food security and livelihoods in rural areas. Estimates of bushmeat consumption across the Congo Basin range between 1 million tonnes [9] and 5 million tonnes [10] and harvest rates are estimated to range from 23 to 897 kg/km2/year [11].

Furthermore, world's oceans are also seen as major food reserves on the planet. According to estimates of the Food and Agriculture Organization (FAO), globally some 200 million people depend on fishing and aquaculture. In a number of developing countries consumption of fish provides close to or more than 50 percent of total animal proteins. Especially the extreme poor lack livelihood alternatives to fishing and are extremely vulnerable to environmental changes. Marine fishery depends even more on biodiversity than terrestrial agriculture as it harvests the produce of wild marine ecosystems and rests upon natural infrastructure. Fish stocks in many places are exposed to over-exploitation and depletion by fishery.

Generally, meat, milk, eggs, and other animal products, including fish and other seafoods, as well as insects will play an important role in achieving food security for several reasons.

Alternative source of food: With a growing world population and increasingly demanding consumers, the production of sufficient protein from livestock, poultry, and fish represents a serious challenge for the future. According to [12], approximately 1,900 insect species are eaten worldwide, mainly in developing countries. They constitute quality food and feed, have high feed conversion ratios, and emit low levels of greenhouse gases. Some insect species can be grown on organic side streams, reducing environmental contamination and transforming waste into high-protein feed that can replace increasingly more expensive compound feed ingredients, such as fish meal.

Breed improvement for required trait and Source of genes for desirable trait:

Livestock genetic diversity allows farmers to develop new breeds in response to changing and very unpredictable conditions [13; 14], including climate, diseases, knowledge of human nutritional requirements, and changing market conditions or societal needs.

Animals diversity may carry genes and gene complexes that may be used in future breeding program. genetic diversity is necessary for genetic change within a biological population for the sustainability of a breed to respond to selection to increase productivity and for adaptation to changing environmental conditions that are associated with climate, changes in markets, management and husbandry practices, and disease challenges. According to [15], livestock genetic diversity allows the existence of livestock in very marginal environments sustainably that are unsuitable for cultivation which account for two-thirds of the world's land surface. For example, cattle breeds that are resistant to trypanosomosis are one of the few ways to produce meat and milk in large swathes of the tropics. N'dama cattle breeds of West and Central Africa and Sheko cattle breed of Southern Ethiopia can be a good example for adapting to tsetse infested marginal environments of Africa.

Indirect role in food security: Animals such as insect pests, predators, parasites, snakes, birds, butter flies, many pollinators and other animals in aquatic ecosystem increase food security indirectly by the way of pollination and increasing soil fertility. Some of these species play an important role in agricultural production by associating them with pollination, improving soil condition, fixing atmospheric nitrogen, improving soil physical properties and decomposition of organic matter etc. Furthermore, animal dungs are used for increasing the soil fertility and thereby increasing crop production.

Pollinators are also required for reproduction of almost 90% of angiosperms and consequently are a limiting factor of most plant communities and vegetation types. Further, as cited in [16; 17], pollinators improve production of 70% of the globally most important crop species (124 crop species, based on data from 200 countries) and influence 35% of global human food supply (although staple crops such as cereals, corn and rice are predominantly self-pollinating).

2.3 The role of forest biodiversity in food security

Source of food: According to [18], world forests directly or indirectly supply the food to an estimated 200-300 million people annually. Foods gathered and hunted from forests provide humans with calories, animal and plant protein, minerals (e.g., iron and iodine), and vitamins A, C, Bs, D, and E [18]. Furthermore, Bush meat, including mammals, birds, fish, snails, and insects, from forests provides a stable food sources.

Increasing food production: According to [19], farmers integrate various types of trees into crop production systems to increase food production in several ways. Most families in developing countries grow fruit trees, such as coconut and banana, which directly contribute to their food supply. For example, in southern Rwanda 86% of the small land owners have fruit trees on their holdings [20]. The use of trees in crop production is a great asset in helping to control erosion and reducing water runoff. Moreover, when leguminous trees are planted, essential nitrogen is added to the soil [21]. Such tree plantings may occupy from 10% to 50% of cropland with- out diminishing crop yields. Despite the fact that one-half of the agricul-tural land is covered by the trees, total food corp production may be double that when the crop is cultivated without trees [21].

Source of fodder: Tree and shrub vegetation serves as nutritionally valuable fodder for livestock. Fodder trees contribute in several ways to the overall food security of households. They make a significant contribution to domestic livestock production which in turn influence milk and meat supply. In addition, fodder trees contribute to maintaining drought animals and producing manure for organic fertilizer thereby supporting agricultural production [18].

Income generation and employment: In addition to food from forests, many non-timber products are sold by rural people to enhance their income and their ability to purchase food [22]. Forest products such as fuel wood, dyes, rattan, fibres, fruits, nuts, leaves, mushrooms, bamboo, medicines, gums, and forest game generate income which in turn used to by food [23].

Maintaining soil fertility and soil nutrients: Basically, adequate supplies of fertile soil, water, and diverse biological species provide the foundation for a productive and ultimately secure food system. Trees and shrubs help preserve all these resources whether used as shelterbelts or integrated into the crop system. Trees hold fertile soil in the fields against wind and rainfall and prevent rapid water runoff, thus preventing the loss of valuable soil and water resources. Further, leguminous trees add nitrogen to soils, while the roots of other trees bring a variety of nutrients up to the soil surface. When integrated into the crop system, trees not only protect the environment but also make it more productive. The process through which trees improve soil fertility includes organic matter maintenance, nitrogen fixation, nutrient recycling and augmentation of nutrient uptake.

Erosion control: Soil erosion is a serious threat to continued agricultural productivity. Erosion whether by wind or water leads to the loss of top soil where soil nutrients are concentrated thus leading to the disruption of agricultural production and degradation of the soil. In addition to adding nutrients, the presence of trees prevents soil erosion and minimizes the loss of soil nutrients [24]. A fertile topsoil typically contains 1-6 kg of nitrogen per ton, whereas an eroded soil may have nitrogen levels of only 0.1-0.5 kg per ton [25]. Lost nutrients, unless replaced by fertilizers, result in declining crop.

2.4 The role of Microbial diversity in food security

According to [26], soil microorganisms contribute to the sustainability of agroecosystems, especially plant growth-promoting microorganisms (PGPM), since they increase crop growth and health, by improving the acquisition of nutrients by plants, mitigating biotic and abiotic stress, and protecting against pests and diseases by various mechanisms. In addition to promoting plant growth, microbial communities play an important role in improving soil fertility, where microbial genera such as Azotobacter, Azospirillum, Heliobacterium, Bradyrhizobium, Bacillus, Gluconacetobacter, Methylobacterium, Nitrosomonas, Nitrobacter, Klebsiella, and Pseudomonas are involved, for example, in the N cycle including N2 fixation, nitrification, denitrification, and ammonification [27].

Furthermore, microbial communities are responsible for carrying out between 80 and 90% of its biological processes, including biogeochemical cycles (indispensable for maintaining the equilibrium of agro-ecosystems), organic matter decomposition, soil formation, primary production, climate regulation, and disease control, among others [28; 29].

According to a review by [30], microbial biodiversity are important in improving global food security via: (i) reduction of food spoilage/wastage (as in food preservation); (ii) microbial protein production for addressing malnutrition; (iii) generation of alternative source of energy (as in the case of bio-fuel production); (iv) enhancement of food production (as in, the exploitation of microbes as bio-control agents, bio-fertilizer and bio-pesticides).

3. Conclusion

Currently, the world population is increasing at an alarming rate and production of food should be increased. Biological Diversity or biodiversity component particularly agro-biodiversity such as crop and horticultural biodiversity, animal biodiversity, Forest biodiversity, and microbial biodiversity are essential to world food security. Crop and horticultural biodiversity are important to food security because they are a source of food, fodder for livestocks, carry gene for desirable traits or characteristics, and also are a foundation for crop improvements. In addition, terresterial and aquatic animal biodiversity play an important role in increasing food security including as source of food, alternative source of food, and breed improvement and source of gene for desired trait. Furthermore, animal biodiversity plays indirect role in food security as the skins are sold to purchase food in return, and also as a there dung are used to increase soil fertility there by increasing crop production.

Forest genetic resource are also vital for food production and security in many ways. Maintaining soil fertility, income generation and employment, as a source of food and increasing food production, source of fodder and soil erosion control are the main ways by which forest biodiversity contribute to food security. The other component of biodiversity which is microbial biodiversity contribute to food security through increasing plant growth, increasing soil fertility and nutrient cycling.

Generally, collection, conservation and sustainable use of biological diversity without compromising future will be necessary and and is vital to food security now and even more so in the future.

Based on the review, the following should be considered as recommendation:

- Improving the adaptation of crops to climate change; especially, to extreme weather conditions will be necessary for food security
- Greater diversity in cropping systems to enhance ecological processes that contribute to short term yield stability and long term productivity and sustainability. Furthermore, a more dedicated plant–soil–crop management for optimizing crop performance under contrasting conditions in land use (rainfed, irrigated) and climatic conditions.
- Integrating biophysical and socio-economic research on productivity and sustainability of cropping systems, taking into account land use and global change.
- Effort should be made to protect the indigenous variety of food crops.
- Introduction of genetically modified crops could be prevented as they destroy the traditional crop diversity.
- Gene bank for all wild crop varieties could be created to conserve their species.
- The government should discourage the mono crop cultivation practices as they destroy crop diversity.
- Conservation of as many animal, plant, and microbial genetic resource for future purpose
- The People should be educated about the importance of biodiversity towards food security.
- Low input sustainable agricultural practices should be encouraged with a view to protect the soil biodiversity.

Compliance with ethical standards

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