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Improving sustainable food and nutrition systems with agro-biodiversity in recent paradigm of conservation agriculture: A review

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Abstract
Agricultural biodiversity is critical for food security throughout the world. At the genetic, species, and farming systems levels, biodiversity provides valuable ecosystems services and functions for agricultural production. How can the erosion of agro-biodiversity be halted? How can it effectively be conserved and enhanced? This review article highlights key practices for the sustainable use, conservation and enhancement of agro-biodiversity for sustaining food security. There is an urgent need to adopt an agro-ecosystems approach, beyond a focus on genetic resource conservation alone, to implement other biodiversity-enhancing methods in farms, such as integrated ecological pest and soil management. However, agricultural biodiversity is an essential component in the sustainable delivery of a more secure food supply. Diversity of kingdoms, species and gene pools can increase the productivity of farming systems in a range of growing conditions, and more diverse farming systems are also generally more resilient in the face of perturbations, thus enhancing food security. Diversity can maintain and increase soil fertility and mitigate the impact of pests and diseases. Agricultural biodiversity will also be absolutely essential to cope with the predicted impacts of climate change, not simply as a source of traits but as the underpinnings of more resilient farm ecosystems. Many of the benefits of agricultural biodiversity are manifested at different ecological and human scales, and cut across political divisions, requiring a cross-sectoral approach to reassess the role of agricultural biodiversity in sustainable and secure food production.

Below-ground biodiversity constitutes and maintains the soil that is required to grow crops, while plant resources comprise the fodder and pasture that sustains livestock herds. A broad range of other ecosystem services also enable, maintain and protect agricultural productivity and output, such as land erosion control, soil fertility, water quality and supply, climate change adaptive capacity, natural pest control, pollination and seed dispersal by wild birds, mammals and insects. These services are fundamental if global food production is to meet the world's growing need for food. Agro-biodiversity entails the variety and variability of animals, plants, fungi and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem. This diversity of animals, plants and fungi is an essential source of food for rural poor who rely on these agro-ecosystems for their livelihoods and consumption. However, unsustainable agricultural practices such as extensive use of pesticides and mono-cropping are threatening agro-biodiversity and the sustainability of their subsequent agro-ecosystem services. Maintaining agro-biodiversity by cultivating a wide variety of crops and livestock and taking into account ecosystem functions reduces the need for external farm inputs, increases availability of animal and plant nutrients, and reduces pests through natural means. A rich biodiversity contributes significantly to the nutrient recycling processes that support and enable crop production. Additionally, essential plant and crop pollination is provided by many insect, bird and bat species. Globally, rich agricultural biodiversity is highly valued and contributes significantly to household income and national food security.

Keywords: Biodiversity conservation, food security, agro-ecosystem, sustainability, nutrition

Introduction
The agricultural practices of different farming systems, including their productivity and production, agro-biodiversity, environment, and related ecosystem services' issues towards the progress in human wellbeing and needs, and sustainable development, are challenging in biosphere reserves. Food systems are at the centre of global environmental, social, and economic challenges such as resource scarcity, ecosystem degradation, and climate change (Gladek *et al.*, 2016; IPES- Food, 2015) [15, 21]. Poverty, hunger and malnutrition, land degradation, water scarcity, biodiversity loss, and climate change are inherently rooted in the way we produce, distribute, and consume food (FAO, 2015) [11]. Current food systems are generating negative outcomes such as land, water, and ecosystem degradation; biodiversity loss; excessive greenhouse gas emissions; persistent malnutrition and hunger, and fail to

eradicate poverty particularly of rural populations (Godfray *et al*., 2010) [17]. Currently, more than enough food is produced to feed the global population but the food insecurity problem persists—characterized by large differences between countries, even within the same country and even the same household (IFAD, & WFP, 2015). Future food systems will have to provide food and nutrition security while facing unprecedented sustainability challenges—this underlines the need for a transition to more sustainable food systems (World Bank, 2015) [35].

Modern, intensive agriculture reduces agricultural biodiversity. In fact, it is predicated on such a reduction. Farms specialize in livestock or crops, reducing the number of species; fields are enlarged, reducing the extent of field margins and hedgerows; soil amendments enhance the uniformity of soils; and monocultures of genetically uniform individuals tend to dominate. Within this framework, agricultural biodiversity is often seen simply as something to conserve as a source of traits that can be used to improve breeds and varieties for this approach in several different realms (Conner and Mercer, 2007; Huang *et al*., 2002; Welch and Graham, 2004) [3, 19, 34] [Fig.1]. While this is certainly true, we argue that agricultural biodiversity as such is an important asset that delivers substantial benefits in many different realms and that there is increasing evidence that diversity per se needs to be a central element of sustainable agricultural development.

Fig 1: A paradigm shift from industrial agriculture to diversified agroecological systems

Fig 2: Agricultural biodiversity nourishes people and sustains the planet

Agro-biodiversity for Sustainable Food and Nutrition Systems

The global population will grow from 7.4 billion now to about 9.3 billion people by 2050 (Forum for the Future, 2014) [12]. The global middle class is expected to more than double in size to almost 5 billion by 2030, and two out of three people will live in a city Forum for the Future, 2014) [12]. The world population is getting older; by 2100 young children will be 6% and older people 23% of the population (FAO, 2017). Higher incomes, urbanization, a growing population and changing dietary patterns are driving intensified demand for increased production of food (FAO, 2017). This puts pressure on natural resources, and leads to high and volatile prices for commodities exacerbated by growing demand for more homogenous Western diets and for processed convenience foods Forum for the Future, 2014) [12]. Both diets and agricultural systems have been greatly simplified over the past century. Within each individual country there has never been so much choice. However, diets from one country to another are becoming more similar to each other, converging towards a Westernized diet based on major cereal crops, such as rice, wheat and maize, as well as sugar and oil (Khoury *et al*., 2014) [22]. These crops increasingly dominate our agricultural production and therefore global food supplies (Khoury *et al*., 2014) [22]. Sustained investment in producing more high-yielding starchy staples has led to a situation where of the 5,000–70,000 plant species documented as human food only three – rice, wheat and maize – provide half the world's plant-derived calories (FAO, 2015) [11]. In much of the world, farmers are not benefiting from the growing demand for food. Within the agricultural sector, 800 million people live below the global poverty line (World Economic Forum, 2017) [36]

In the other ways the natural resources include land, soil, water and biodiversity. Agriculture covers up to 38% of the Earth's surface Forum for the Future, 2014) [12], but 33% of the world's farmland is degraded (FAO, 2017). Agriculture accounts for 70% of all freshwater withdrawn (Forum for the Future, 2014; FAO, 2017) [12, 36], and drives 80% of deforestation worldwide (FAO, 2017). The loss of forest and other wild biodiversity can lead to erosion of genetic diversity, which reduces options for breeding new plant varieties better adapted to climate change (FAO, 2017). The global food production system contributes around 24% of global greenhouse gas emissions (IPCC, 2010; Vermeulen *et al*., 2012) [33] and is the single largest user of fresh water on the planet (Rockström *et al*., 2017) [27]. In addition, 62% of globally threatened species are negatively affected by agriculture (Maxwell *et al*., 2016) [23]. About 40% of the world's rural population lives in areas that are water scarce (FAO, 2017); yet demand for water are expected to rise by a further 40% by 2030. The effects of agriculture on natural resources are further exacerbated by climate change, changing diets, population growth and urbanization. Meat-rich diets drive depletion of natural resources through forest clearing for pastures and increasing methane emissions (FAO, 2017; Tilman and Clark, 2014) [30].

Westernized diets put more pressure on natural resources; e.g. the production of 1kg of beef uses 12 times as much water as 1kg of wheat, and five times as much land (Forum for the Future, 2014; Hallström *et al*., 2015; Stoll-Kleemann and Riordan, 2015) [12, 18, 29]. Modern diets are also linked to the triple burden of under-nutrition, malnutrition and obesity (FAO, 2017). More than 2 billion people lack vital micronutrients (e.g. vitamins and minerals), and 2 billion are overweight or obese Forum for the Future, 2014) [12]. Poor nutrition can lead to non-communicable diseases such as heart disease and type 2 diabetes, which are now the leading cause of death in all regions (World Economic Forum, 2017) [36]. In fact, 6 of the top 11 risk factors driving the global burden of disease are related to diet (Global Panel on Agriculture and Food Systems for Nutrition. 2016) [16]. This has real economic consequences that the estimated impact of under-nutrition on GDP is 11% a year (Global Panel on Agriculture and Food Systems for Nutrition, 2016) [16]. Intakes of pulses, fruits and vegetables are declining around the globe alongside a rising predominance of starches, meat and dairy (Khoury *et al*., 2014) [22] [Fig.2]. The supply of fruit and vegetables, nuts and seeds falls about 22% short of population requirements according to nutritional recommendations (Siegel *et al*., 2014) [28] with direct consequences for health.

Efforts to develop and implement new food and agricultural policies that systematically address challenges are likely constrained by existing metrics of agricultural productivity, which have failed to capture critical environmental and societal impacts and often lead to an incomplete understanding of production costs and related tradeoffs (Davis *et al*., 2012) [5]. Specifically, analyses that more comprehensively evaluate the impacts of agricultural production on energy, water, land, health, or other resources are generally lacking, but those that do exist reveal the importance of such research. In general, biologically diversified farms managed using insights from agro-ecology can remain productive and resilient while also conserving water and energy resources, and enhancing other ecosystem services.

Using agricultural biodiversity can take many forms. It can mean identifying which plant species or varieties contain important traits, such as salinity resistance or nutrient density, and using them to breed new varieties. At the farm level, it can refer to farming practices in which genetically distinct varieties of the same species are planted together as a mixture to increase resistance to diseases, or planting different varieties in different areas of the same farm to respond to different microenvironments. It can mean planting certain varieties of a crop because they have particular nutritional or cooking qualities. Using agricultural biodiversity might entail integrated farming systems where animals, crops and trees interact, with benefits of increased yields, lower fertilizer requirements and more food groups available for healthy diets. It can also involve adopting certain farming practices such as intercropping or crop rotations, which promote beneficial interactions among species. At a landscape level, using agricultural biodiversity refers to creating a mosaic of different land uses –managed forest, cultivated fields, waterways, hedges and copses – to create beneficial synergies, such as water capture, pest control or pollinator habitat. It often involves matching land use to land form and soil type in order to tailor production to land capability, and in so doing reduce land degradation such as soil erosion. At the same time, diversity in the landscape can ensure that different food groups are produced all year round. Using agricultural biodiversity draws on the local agro-ecological knowledge and embodied in the development and use of certain varieties, species and landscape patterns, together with the scientific knowledge and among others, to create innovation. Using agricultural biodiversity often means a focus on locally specific species, breeds and varieties, which are not well known on a global scale and are under-represented in formal research because of the variety and variability that they represent in a system and their suitability to local environmental conditions and cultural requirements.

Fig 3: Sustainable development for food systems and sustainable development goal

Agricultural biodiversity's role in the agro-ecosystem

Decomposition and nutrient cycling: Decomposer communities are highly diverse and are central to nutrient cycling, organic matter dynamics and other ecosystem functions, although detailed knowledge of the extent and functions of this diversity is limited, especially in aquatic environments.

Biomass production and yield efficiency: Diverse agro-ecosystems (fish poly-cultures, mixed herds, intercrops, and integrated agro-sylvo-pastoral) are generally highly productive in terms of their use of energy and unit land area. This efficiency is largely a product of the systems' biological and structural complexity, increasing the variety of functional linkages and synergies between different components.

Soil and water conservation: Soil, water and nutrient conservation have been improved with the use of windbreaks, contour farming with appropriate border crops and cover crops in a wide range of agro-ecosystems.

Pest control: Predators, parasitic wasps and micro-organisms play a key role in controlling agricultural pests and diseases. For example, more than 90% of potential crop insect pests are controlled by natural enemies living in natural and semi-natural areas adjacent to farmlands. Many methods of pest control, both traditional and modern, rely on biodiversity.

Pollination and dispersal: There are more than 100,000 known pollinators (bees, butterflies, beetles, birds, flies, and bats). Pollination mediated by components of agricultural biodiversity is an important function in a variety of terrestrial agro-ecosystems. About half of all plant species, including food-producing crop species, are pollinated by animals.

Biodiversity conservation: There is no strict divide between 'wild' and 'domesticated' species important for food and livelihoods. Whilst not necessarily the subject of conscious management by herders or farmers, many wild plant and animal species thrive in, or are dependent on, agro-ecosystems, especially structurally and biologically complex agro-ecosystems.

Climate: As a source of atmospheric constituents agricultural biodiversity contributes significantly to the chemical composition and properties of the atmosphere and thus has a marked influence on climate. In turn changes in climate have a strong feedback on agricultural biodiversity and its multiple functions, and thereby influence gaseous emissions by biological organisms.

Functions in the water cycle: Agricultural biodiversity plays a crucial role in cycling water from the soil to the atmosphere and back. It also has measurable impacts on water quality.

Farming systems according to the role of ecosystem services and external inputs

Farming systems of industrial agriculture are based on strongly simplified crop sequences, standardised crop management and systematic use of chemical inputs. One challenge is to accurately assess the levels of input ecosystem services in time and space to optimise the amounts of additional external inputs required to reach desired production levels. Precision-agriculture technologies based on sensors in the soil or on the crop, machinery, drones, planes and satellites allow monitoring of the dynamics of multiple variables and optimisation of required inputs. They are well developed to deal with nutrient cycling and weeds. In addition, farmers use cultivars and animal breeds which are less sensitive to limiting or reducing factors while exhibiting yields which are as high or higher. These technologies may allow farming systems to increase input-use efficiency, reduce environmental impacts and, depending on the technology costs, economic performance.

One challenge is to develop and manage planned biodiversity from fields to field borders up to the farmland area to increase ecosystem services. Regarding biological regulations, two main complementary strategies can be distinguished: (i) developing direct effects of plant biodiversity on pathogens, animal pests and weeds and (ii) developing effects of planned biodiversity and non-crop habitats on naturally occurring associated biodiversity, which provides biological control of weeds and animal pests ("top-down" effects of natural enemies) (Ratnadass *et al*., 2012; Tscharntke *et al*., 2012) [26, 31]. When biodiversity-based farming systems use chemical or biological inputs to increase production beyond the level allowed by input ecosystem services alone, they must use them sparingly to avoid reducing expected short- and long-term benefits of the input ecosystem services (Pisante *et al*., 2015) [25]. In biodiversity-based farming systems, agricultural practices (including species and cultivar choices) to provide high levels of input ecosystem services are site-dependent (Giller *et al*., 2015) [14]. Thus, agricultural practices are considered as "situated action" (Crane *et al*., 2011) [4]. Managing uncertainties in effects of agricultural practices on ecological processes and, in turn, on ecosystem services, requires implementing an adaptive management strategy [Fig.3]. This corresponds to experiential learning about system functioning based on iterative cycles to design and implement actions and to monitor and assess their effects (Duru *et al*., 2015a) [8].

Towards Sustainable Food Systems: New Approaches and Paradigms Needed

Creating the enabling conditions for the shift to more sustainable food systems will require systems based approaches that can consider the range and complexity of interactions prevalent in the production, distribution and consumption of food. These links between food production, distribution, consumption, and nutritional health and the underlying social-economic, cultural and institutional elements, ultimately affect the quantity, quality and affordability of food, as well as health and wellbeing. Fostering transition towards SFS implies also gaining a better understanding about multifaceted and complex relations between food systems, diets, and food and nutrition security (Capone *et al*., 2016) [2]. Sustainable food systems embrace the interconnectedness of all the food -related activities and the environment within which these activities occur (production, distribution and consumption of food) operating at local, regional, national, and global levels. There is no one model of a sustainable food system, but a set of principles that constitute sustainability. Therefore, approaches to allowing this shift should evolve from the particular contextual conditions of the food system under consideration (UN, 2016). However, there has been a tendency among scientists and policymakers to address the problems related to food systems as individual pieces of the puzzle, and to over look their interrelations. To address food and nutrition challenges, food systems have to be considered in their entirety, acknowledging the interdependency of consumption and production (IPES-Food, 2015) [21] [Fig.4].

Meeting the challenges facing the agricultural and food and non-food systems means dealing with complexity and working in an integrated manner (EC, 2016). The system - based and holistic approach implies to go beyond the research undertaken at the level of the components of the system to better understand the interactions between those components. Therefore it is necessary to take due account of the different disciplines and science (IPES-Food, 2015) [21]. This implies also the development of knowledge and methods enabling integrated assessments of system performance across, space, time and the full range of dimensions (economic, environmental, social and cultural).

Sustainable Food and Nutrition Systems in recent paradigm of Conservation Agriculture

Farming and food industry is on an unsustainable course in economic terms. We believe it is also unsustainable environmentally — without substantial change… in the last 50 years…Soil organic content has declined and phosphorus levels in top soils have increased. Agriculture is now the number one polluter of water in the country. Land use changes have contributed to increased danger of extreme flood events, affecting thousands of homes. Beyond any doubt the main cause of this decay has been the rise of modern, often more intensive, farming techniques. … Things are still getting worse…in soil compaction and erosion, in the loss of certain species. A lot of the environmental damage in the countryside over the last 50 years has to be laid at the door of modern farming techniques. …. Much damage by farmers is not wilful but arises out of ignorance. We believe a major advice effort will be needed… to help farming meet its new challenges. It will be very important that advice should also cover environmental issues.

This, so called 'modern' agriculture paradigm based on genetics, agro-chemicals and intensive tillage, is beginning to run out of steam and being increasingly challenged and replaced by a different paradigm as represented by the practice of good quality. Conservation Agriculture which offers optimal resource use with high productivity and enhanced ecosystem services. This alternative paradigm has been shown to work in many parts of the world, and is biologically and ecologically as well as economically more efficient in producing the required outputs of goods such as edible and non-edible biological products and of water while at the same time taking care of other essential ecosystem services that regulate soil, crop and ecosystem health, protect habitats and biodiversity, drive carbon, nutrient and hydrological cycles as well as conserve stocks of carbon, nutrients and water, and protect soils and landscapes from erosion and other forms of degradation.

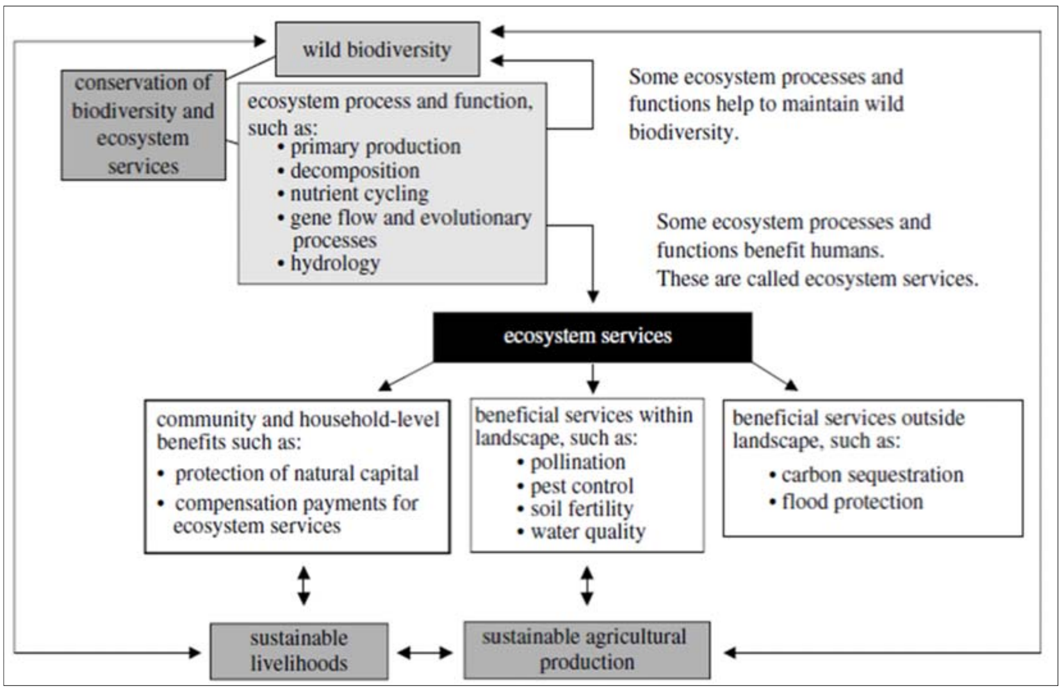

Fig 4: Ecosystem services are a key to the synergies between conservation, sustainable agricultural production and sustainable livelihoods (Buck *et al*., 2004).

Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture. It includes plants' genetic resources: crops, wild plants harvested and managed for food, trees on farms, pastures and rangeland species, medicinal plants and ornamental plants of aesthetic value. Animal genetic resources include domesticated animals, wild animals hunted for food, wild and farmed fish and other aquatic organisms, insect pollinators and microbial and fungal genetic resources. Agricultural biodiversity provides humans with food, raw materials for goods such as: cotton and wool for clothing; wood for shelter and fuel; plants and roots for medicines; and materials for bio-fuels. Agricultural biodiversity also performs ecosystem services such as soil and water conservation, maintenance of soil fertility, conservation of biota and pollination of plants, all of which are essential for food production and for human survival. In addition, genetic diversity of agricultural biodiversity provides species with the ability to adapt to changing environments and to evolve by increasing their adaptation to frost, high temperature, drought and water logging as well as their resistances to diseases, insects and parasites.

The importance of agricultural biodiversity encompasses socio-cultural, economic and environmental elements. All domesticated crops and animals result from management of biodiversity, which is constantly responding to new challenges to maintain and increase productivity under constantly varying conditions and population pressures. Agricultural biodiversity is essential to satisfy basic human needs for food and livelihood security. Biodiversity, food and nutrition interact on a number of key issues. It contributes directly to food security, nutrition and well-being by providing a variety of plant and animals from domesticated and wild sources. Biodiversity can also serve as a safety-net to vulnerable households during times of crisis, provide income opportunity to the rural poor and sustain productive agricultural ecosystems. Coping mechanisms based on indigenous plants are particularly important for the most vulnerable people who have little access to formal employment, land or market opportunities. Wild indigenous plants provide alternate sources of food when harvests fail.

Agricultural biodiversity as a potential tool for improving nutrition security

Frison *et al*. (2011) [13] reported that the sustainability of the global ecosystem in general and of the agriculture in particular, is dependent on the conservation, enhancement and utilization of biological diversity, or biodiversity. Biodiversity includes the variety of plants, terrestrial animals and marine and other aquatic resources along with the variety of genes contained in all individual organisms and the variety of habitats and biological communities. Biodiversity is essential for humanity, providing food, fibre, fodder, fuel, and medicine in addition to other ecosystem services. Agricultural biodiversity (agro-biodiversity), that sub-component of biodiversity important for food and agriculture, plays an important role in productivity and the livelihoods of all farmers, regardless of resource endowment or geographical location. Agricultural biodiversity refers to the biological variety exhibited among crops, animals and other organisms used for food and agriculture, as well as the web of relationships that bind these forms of life at ecosystem, species, and genetic levels. It includes not only crops and livestock directly relevant to agriculture, but also many other organisms that have indirect effects on agriculture, such as soil fauna, weeds, pollinators, pests and predators. Agricultural biodiversity provides the basic resources farmers need to adapt to variable conditions in marginal environments and the resources required to increase productivity in more favourable settings.

FAO (2010) [10] estimates that of a total of 300,000 plant species, 10,000 have been used for human food since the origin of agriculture. Out of these, only 150–200 species have been commercially cultivated of which only four – rice, wheat, maize and potatoes – supply 50 per cent of the world's energy needs, while 30 crops provide 90 per cent of the world's caloric intake. Intensification of agricultural systems has led to a substantial reduction in the genetic diversity of domesticated plants and animals. Some on-farm losses of genetic diversity have been partially offset by conservation in gene banks (Millennium Ecosystem Assessment, 2008) [24]. Even so, the implications of this loss of agricultural biodiversity (as well as loss of associated ecological knowledge) for the biodiversity and quality of the global food supply are scarcely understood, especially from the perspective of nutrition. Agricultural biodiversity furthermore includes species with under-exploited potential for contributing to food security, health, income generation, and ecosystem services. Terms such as underutilized, neglected, orphan, minor, promising, niche, local and traditional are frequently used interchangeably to describe these potentially useful plant and animal species, which are not mainstream, but which have a significant local importance as well as a considerable global potential for improving food and nutrition security.

Deckelbaum *et al*. (2006) [6] observed that the interrelationships among nutrition and human health, agriculture and food production, environmental health, and economic development. It argued that individuals and families caught up in the poverty trap find themselves in a negative feedback loop, unable to practise productive agriculture because of lack of access to resources leading to environmental degradation through unsustainable agricultural practices; that environmental degradation leads to low yields which further provokes problems of malnutrition which leads to increased incidence of disease, or simply insufficient caloric intake to provide the human energy needed for labour-intensive sustainable field management. The important contribution of eco-nutrition to human nutrition is in defining the relationship between crop diversity, nutritional diversity and human health. DeClerck *et al*. (2011b) [7] working with subsistence farmers and found that farmers who had greater in-field crop nutritional diversity, where the unit of measure was not species diversity but the nutritional diversity of the crops, were less likely to suffer anaemia than farmers with lower field-based nutritional diversity.

Eco-nutrition as an interdisciplinary field of study considers human nutrition to be a function of multiple ecosystem services. Considering the definition of ecosystem services, the benefits that humans receive from ecosystems, and the MEA (2005) distinction of four categories of services, multiple nutrition entry points become evident.

- The production of foods in agro-ecologically intensified systems is a primary provisioning service.
- Maintaining soil fertility or the inter-annual productivity of cropping systems are defined as regulating services.
- Soil micro-flora and fauna that convert soil organic matter into nutrients available to plants play important support services.
- Cultural services are central to nutrition – how you eat may be as important as what you eat as diets are the product of an evolutionary interaction between groups of people and the edible species found in our environments.

Inherent in the notion of eco-agriculture is the recognition that productive agriculture is dependent on biodiversity through the provision of ecosystem services such as pollination, pest control services and healthy soils that human livelihoods are dependent on agricultural land uses, not only for the production of healthy foods, but also for the production of clean water and other ecosystem services; and that both the conservation and production goals of eco-agricultural landscapes are dependent on human communities. Eco-agriculture takes us away from the paradigm that conservation should only occur in natural reserves and protected areas, with agriculture parsed to designated production areas. Rather, eco-agriculture suggests that landscapes should provide both production and conservation functions, and that the additive value of this integration is greater than their segregation. Eco-agriculture values the contribution that agricultural landscapes can make to conservation and recognizes the contribution of conservation to agricultural production and sustainability.

Conclusion

A paradigm shift is needed in agriculture to stop the large-scale loss of biodiversity in the agricultural landscape and soil, but even more than that to rethink the use of the role of soil life, landscape elements and biodiversity in sustainable agriculture. The agricultural intensification which focuses on increasing productivity per hectare or per unit input (such as feed) is the main cause of the decline. Apparently we reached a tipping point where rethinking our agricultural practices is needed in the face of sustainability and production of food. There are different successful initiatives, but a large scale change is not observed. The framework focuses on the use and management of biodiversity to improve productivity in agricultural system along with sustainability and therewith on lowering the long term risk of production loss.

The transformation of agricultural production from one of the greatest threats to global biodiversity and ecosystem services to a major contributor to ecosystem integrity is unquestionably a key challenge of the twenty-first century.

Many elements of eco-agriculture landscapes could also help to achieve the critical goals of agricultural sustainability, resilience of food systems and adaptation to climate change. To realize these potentials, the agricultural and conservation research and policy communities will need to re-evaluate and coordinate their priorities and strategies.

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