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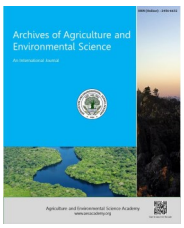

REVIEW ARTICLE

A review of ecological agricultural practices as an important component of climate resilient management

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ABSTRACT

The pressing need to systematically redirect agricultural practices, towards sustainable, biodiversity based eco-agriculture and the basic agro-ecological principles cannot be overemphasized, especially in this era of threat to food and livelihood security caused by climate change in several developing countries of the world is evident. This is on account that the ecological aspect of agricultural production, which is resilient to climate and productive is based on principles that create biological diversity and build healthy soils, which also prioritizes indigenous and farmers' knowledge. Ecological agricultural techniques are the foundations for the adaptation strategies needed urgently by the farmers in various developing countries, who will suffer greater from the climate change effects. Many answers lie in farmers' farms and knowledge. Thus, this review is focused on how to improve the biodiversity of the agricultural system, build better healthy soils that will be drought tolerant and also to add social resilience required to face the increased uncertainty in weather patterns.

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INTRODUCTION

The threat imposed by changing climate globally has caused serious concern as crop growth and yield could be affected badly by alterations in major climatic variables such as temperature, droughts and rainfall. Also agricultural production and security of food and livelihood could be influenced locally and globally (Cline, 2007; Asima *et al.,* 2017; Tariyal, 2017). Although the climate change influence on the yield of crops are most likely to differ greatly from one zone to another, the expected changes are anticipated to have great and far-reaching impacts mostly in tropical agricultural regions of the rural developing countries were precipitation patterns ranges from humid to semiarid (Cline, 2007).

The climate change is having effect on the agriculture directly or indirectly, globally and is a significant challenge that affects the long-term growth and yields of cereals (Kumar and Chopra, 2009; Kumar, 2015). Fluctuation in temperature, concentrations of green-house gases, rainfall pattern, and high humidity directly affect the agricultural crops, pathogens, insects, and weeds diversity and population. Many types of new diseases, weeds, and insect pests have started appearing with the changing climate (Asima *et al.,* 2017). According to the 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2009), they warns that warming by 2100 will be worse than previously anticipated, with a probable temperature rise of 1.8 ^{o}C to 4 ^{o}C and a possible increase of up to 6.4 ^{o}C. Doering (2002) reported that as temperature increase continue, the agricultural effects will be remarkable. Moreover, climatic fluctuations have been reported in the Uttarakhand Himalayan region by Tariyal (2017). These effects are also being experienced already by several village communities in Africa and Southern hemisphere. Altieri and Koohafkan (2008) observed that heavy precipitation and a rise in droughts will also be witnessed, and these will further damage crops via crop failure, flooding, wind and soil erosion.

However, in continuous adaptation with weather extreme that has the possibility to bring solutions to several uncertainties that face humanity in this climate change era, Denevan (1995) observed that the agricultural systems have been handled in ingenious means, which allow small family farms to meet their livelihood in the midst of environmental change without relying much on modern agricultural techniques. Although many of the ingenious systems according to Wilken (1987) have crumbled or vanished in many parts of the globe, the persistence of millions of hectares of cultivable land under indigenous farming is a living evidence of an effective traditional agricultural technique, which is a testament to the "creativity" of smallholders' farmers across the developing countries. Until today and well into the 21st century, there are

in the world, millions of smallholders, family farmers and indigenous people practicing ecological agriculture which is a tribute to the outstanding resiliency of agro-ecosystems in the era of uninterrupted environmental and economic change, while helping substantially to food security locally, regionally and worldwide (Netting, 1993). This write-up is therefore aimed to review ecological agricultural practices as an integral component of climate resilient management.

What is ecological agriculture: The term "ecological agriculture" (eco-agriculture) was defined as a small-scale agricultural system that display environmental, ethical, and aesthetic aspects (Wang *et al.,* 2007). It has the fundamental aim of trying to practice agriculture on the fundamental principles of ecology, rather than chemistry. "Ecological" according to Lockeretz (1988) refers to the principles and processes that govern the natural environment. Ecological agriculture has been well-established against agricultural over-production and serious pollution to the environment; some of its supporters believe that human health and survival, in fact can be threaten by water and soil pollution. Ecological agriculture thus, is founded on the fact that the source of pollutants in food chain is avoided, thereby preventing soil and water pollution (Kumar *et al.,* 2017).

The system of production is relatively easy, usually based on growing crops only or occasionally a system of crops and animals. It selectively utilizes chemical fertilizers, but stringently rejects herbicides, hormones, pesticides, and the like (Lockeretz, 1988). The ecological agriculture practice involves integrating the strengths of natural eco-systems into agro-ecosystems, purposely disturbed for the production of food and fiber (Magdoff, 2007). According to Shen *et al*. (1993), they observed that since ecological agriculture stresses the environmental benefits to the detriment of reduced output and profits, the value of the resulting ecological products is much superior to that of conventional agricultural products. The overall principles at the farm level that guide a farmer who make ecologically decisions, also supply the village family farms with their desired life quality, which include adequate income, while being socially sound (Magdoff, 2007). These principles are achieved by improved above and below-ground soil habitat management. Ecological agriculture involves all techniques that restore ecosystem services, which includes water infiltration and its retention, increased biodiversity, carbon storage and soil erosion prevention (Wachira, 2016). Many methods are used that include strip intercropping, no till, terrace cultivation, multispecies cover cropping, shelter belts and pasture cropping etc.

Essentiality of ecological agriculture: The sociological and ecological issues of modern conventional agriculture are almost in the news daily (Magdoff, 2007). For instance, water pollution from nitrogenous and phosphorus compounds leads to algal blooms while pathogens results in health hazards. Many of these impacts are felt local, others are such as pollution of Chesapeake Bay or the Lake Champlain is regional, and some (nitrates entering the Mexico Gulf) are really continent-wide in scope (Magdoff, 2007). Additionally, in the Third World countries, an over- dependence on monocultures of grain crop and loss of crop biodiversity caused by 'green revolution' has led to loss of balanced diets (Magdoff, 2007). Also, aforestation for intensive commercial agricultural production has continuously caused a rapid oxidation (decomposition) of soil organic matter (SOM), leading to substantial carbon dioxide (CO_2) releases into the atmosphere. Houghton and Hackler (2006) observed that the carbon stored in soils is more than thrice that present in the atmosphere as CO_2. Thus, the CO_2 release from soils through oxidation of SOM is of fairly large magnitude, while simultaneously the soils turns out to be less healthy due to loss of SOM. Other problems of conventional agriculture linked with environment consist of improved soil erosion created by water and/or wind, pesticides on food and in groundwater, pesticide contaminating farm workers, the pesticide 'treadmill' due to pesticides resistance by pest, disease microorganisms contamination of meat and its produce, and regular usage of antibiotics for animals, resulting to antibiotic-resistant strains of organisms (Magdoff, 2007).

Based on the forgoing, the eco-agriculture is essential because it assured the sustainably of grown crop which integrates indigenous farming knowledge, modern technology and innovation with regards for biodiversity and nature (Okore, 2017). It is established on the assumption, that the cultivated crops take benefit of natural resources to improve soil fertility, fight diseases and pests, without making use of any microorganisms that have been genetically engineered and avoiding the artificial use of chemicals such as antibiotics, fertilizers, and pesticides (Oana, 2017). In this way, it ensures that healthy, nutritious and natural foods are acquired. Furthermore, ecological agriculture helps to achieve greater sustainability of the environment through the protection of soil, water and the climate, thus causing least environmental impact (Oana, 2017).

Strategies to enhance the ecological resilience of agricultural systems: Climate change will require a range of adaptation measures across many aspects of agricultural systems, from little changes in the varieties of crop grown to decisions to jettison cropping completely in accordance to Jones and Thornton (2008). For instance, in some rainfed zones in developing countries, water to continuously produce crops will not be sufficient; in these regions, agriculturalists may modify their means of living based entirely on pastoralism, or they may move to other cities or regions. In other zones integrated farming system may be adopted (Jones and Thornton, 2008). In all areas, peasant farmers working towards adaption to climate change will need to acquire practices which will help them to improve the resilience of their farming systems via building healthier soils, integrating more rainwater harvesting and management techniques, improving the biodiversity of the system, particularly in rainfed regions, where greater number of the rural poor farmers farm are located and adding social resilience with emphasis on women which constitute the world's most smallest producers. Jones and Thornton (2008) suggested that these practices must be prioritize by every governments and other funding agencies as they promote transitions to climate resilient management methods in agro-ecological.

Building resilience through biodiversity: The resilience of agricultural system can be achieved by enhancing biological diversity according to Altieri and Koohafkan (2008). Practices that improve biodiversity enable farms to imitate ecological processes naturally, and allow them to respond better to change and also reduce risk. Altieri and Koohafkan (2008) and Ensor (2009) observed that peasant farmers who enhance biological diversity suffer least damage during unfavourable weather events, relative to farmers who practice conventional monocultures. Similarly, Ching and Stabinsky (2011) stated that diversity of farming systems can be improved via increasing the variety of crops planted at once on the parcel of land, and by incorporating trees and animals into the farming sys-

tem. Also, farmers can enhance the diversity of their farming system by increasing the biodiversity of crop via cultivating the same crop with different varieties which have different attributes, for example, early maturing varieties, which may be advantageous if there is inadequate rainfall, or crop varieties with more nutritious forage for the feeding of farm animals (Ching and Stabinsky, 2011). Nicholls and Altieri (2012) observed that the more diverse the plant communities means more resilient to environmental disturbances caused by extreme weather events. Undoubtedly, diversification of crop constitutes a viable long-term strategy for peasant farmers facing erratic weather, which can considerably decrease their vulnerability and safeguard their livelihoods. Farmers that use crop diversity as a management strategy normally add high quantity of organic matter into the soils, furthermore enhancing the capacity of the soil to retention water (Nicholls and Altieri, 2012). Moreover, Sheikh *et al.* (2017) also observed that the litter component in the temperate coniferous forests of Kashmir Himalayas, India have the potential of carbon sequestration and therefore, the forests plays a very crucial role to regulate the climate.

Building better soil health: Farmers can enhance productivity by building healthy soils. Ching and Stabinsky (2011) argued that since climatic changes will most likely significantly decrease yields over time, any improvement in productivity via healthier soil and fertility will serve to moderate the expected productivity reduction. Furthermore, by improving the soil health, farmers can enhance the soil water-holding capacity and the infiltration capacity, thereby augmenting the speed at which water can percolate into soils and thus the ability to take more advantage of heavier rains that are expected under climate change (Tirado and Cotter, 2010). Supporting soil health equally increases the biodiversity of beneficial rhizosphere organisms in the soils, which are responsible for decrease in overall pathogen burden and enhance nutrients access (Ching and Stabinsky, 2011). Many well-established agro-ecological practices increase the health and fertility of soil, and with these, productivity is enhanced. Ching and Stabinsky (2011) observed that organic manure or compost addition is prominent among these practices which bring necessary nutrients into the soil. They also improve the soil structure, making it better to retain more nutrients and water together.

By the improvement in soil structure, water infiltration is better, thus more water is captured during periods of heavy rainfall (Edwards *et al.,* 2009). Other eco-agricultural practices that can enhance the soil structure and increase fertility include growing green manures like sesbania, crop rotation, cover cropping, and mulching (Magdoff, 1998). These practices according to Nicholls and Altieri (2012) are all standard in agro-ecological systems, which work to increase fertility naturally, protect the soil from erosion, but also add biomass that in turn helps to increase the SOM levels. They equally use the system diversity to control pests and diseases, while increasing habitats for pollinator insects and other useful organisms.

Emphasis on management of rainwater and harvesting techniques: Climate change adaptation will need more emphasis than is presently given to increasing rainwater harvesting and management in rainfed zones of many developing countries. Many traditional methods in use already to improve rainwater utilization efficiency can be exchanged by the use of 'farmer-to-farmer' techniques according to Altieri and Koohafkan (2008). For example, the zaï methods of the Sahel zone have received much attention. This is because in the past decades, water pits are used by Mali and Burkina-Faso farmers to recover thousands of degraded hectares of lands (Altieri and Koohafkan, 2008). Farmers have increasingly become interested in the zaï as they observe that the pits efficiently collect and concentrate runoff water and function with little amounts of organic compost and manure. The practice also allows peasant farmers to raise their resource and household security. In addition, Altieri and Koohafkan (2008) observed that the yields obtained on fields managed with zaï are consistently higher than those obtained on fields without the zaï technique. There are many other effective traditional rainwater-harvesting techniques actively in use globally by farmers in rainfed regions, some of the techniques have been fully explained by Altieri and Koohafkan (2008).

Building social resilience: Social resilience is stated as the capacity of communities or groups to adjust to external political, social, or environmental stresses that must work hand-in-hand with ecological resilience. For rural societies to be resilient, Tompkins and Adger (2004) stated that they must have the ability to buffer disturbance with agro-ecological techniques adopted and spread via self-organization and group action. Also, the resilience of agro-ecosystems to change in climate can further be enhanced through reducing the social vulnerability by social networks extension and consolidation, both at the community and regional levels (Tompkins and Adger, 2004). The rural farming communities' vulnerability relies upon the establishment of the social and natural capital, which gives peasant farmers and their systems resilience against climate and other shocks. This adaptive ability resides in a set of sociological and agro-ecological conditions that influence the capacity of individuals or groups, and their farms, to respond to climate change in a resilient manner. Nicholls and Altieri (2012) stated that the ability of the farming communities to react to environmental changes occurs at various degrees, but the reactions are always not sustained. The fundamental challenge is to identify the responses, which can be sustained and thus upscale such responses.

This can be obtained through enhancement of the reactive ability of the farming communities to utilize agro-ecological techniques that enable them to withstand and regain from climatic events and thus minimizing their vulnerability. Social organization strategies such as food exchange, solidarity networks, etc. utilized by rural farmers to adapt with the difficult situations imposed by such extreme events, are thus a fundamental component of resilience (Nicholls and Altieri, 2012). Women, in particular, who constitute the majority of the world's smallest producers, must play an essential role on the road to social climate-resilient in agricultural systems. To do so, Ching and Stabinsky (2011) argued that women must be incorporated into the rural research and establishment and given the necessary tools to carry out their own research on-farm, with the ability to share their gained knowledge with other farming groups in farmer-to-farmer networks. This is because the challenges facing agriculture in this era of changing climate are too enormous to ignore the important role of women farmers, their innovation skills and knowledge toward contribution in the establishment of climate-resilient agricultures.

Conclusions

The world generally requires climate-resilient agriculture and ecological agriculture which is a significant component of it should be pivotal to agricultural adaptation, as the benefits to farmers mostly in rural developing countries in particular would be manifold. The practices of eco-agriculture will

contribute greatly to climate resilience and improve adaptive capacity as explained above. Concerted effort is thus required to assist the change from conventional to ecological agriculture. Anything less would put the livelihoods and food security of millions, mostly rural poor at risk.

REFERENCES

Altieri, M.A., Koohafkan, P. (2008). Enduring farms: Climate change, smallholders and traditional farming communities. TWN Environment and Development Series 6. Third World Network, Penang.

Asima, G., Dar, Z.A., Lone, A.A. Yasin, A., Ali, Y. and Habib, M. (2017). Breeding climate change resilient maize and wheat for food security. *Archives of Agriculture and Environmental Science,* 2(2): 129-133.

Ching, L.L. and Stabinsky, D. (2011). Ecological agriculture is climate resilient. Retrieved from www.twnside.org.sg/title2/susagri/2011/susagri189.htm

Cline, W.R. (2007). Global Warming and Agriculture: Impact Estimates by Country. Centre for Global Development, Washington, DC.

Denevan, W.M. (1995). Pre-historic agricultural methods as models for sustainability. *Advance Plant Pathology,* 11: 21-43.

Doering, O.C. (2002). *Effects of Climate Change and Variability on Agricultural Production Systems*. Kluwer Academic Publishers, Dordrecht, Netherlands.

Edwards, S., Asmelash, A., Araya, H. and Egziabher, T.B.G. (2009). The impact of compost use on crop yields in Tigray, Ethiopia, 2000-2006 inclusive. TWN Environment & Development Series 10. Third World Network, Penang.

Ensor, J. (2009). Biodiverse agriculture for a changing climate. Practical Action, UK.

Houghton, R.A. and Hackler, J.L. (2006). Carbon flux to the atmosphere from land-use changes. Retrieved from http://cdiac.ornl.gov/trends/landuse/houghton/houghton.html**.**

IPCC. (2007). Climate Change 2007. Impacts, Adaptation and Vulnerability. The Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Cambridge University Press, Cambridge.

Jones, P.G. and Thornton, P.K. (2008). Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change. *Environmental Science & Policy,* doi:10.1016/j.envsci.2008.08.006.

Kumar, V. (2015). Carbon sequestration through reforestation: An effective measure to mitigate the climate change. *Journal of Environment and Health Sciences,* 1(3): 1-2. DOI 10.15436/2378-6841.15.e003

Kumar, V., Shaktibala and Khan S. (2017). Importance of weather prediction for sustainable agriculture in Bihar, India. *Archives of Agriculture and Environmental Science,* 2(2): 105-108.

Kumar, V. and Chopra, A.K. (2009). Impact of climate change on biodiversity of India with special reference to Himalayan region -An overview. *Journal of Applied and Natural Science,* 1(1): 117-122.

Lockeretz, W. (1988). Open questions in sustainable agriculture. *American Journal of Alternative Agriculture,* 3(4): 174–181, https://doi.org/10.1017/S0889189300002460

Magdoff, F. (1998). Building soils for better crops. University of Nebraska Press, Lincoln.

Magdoff, F. (2007). Ecological agriculture: Principles, practices, and constraints. Renewable *Agriculture and Food Systems,* 22(2): 109-117.

Sheikh, Muzamil Ahmad, Tiwari, A. and Sharma, S. (2017). Carbon sequestration potential of various litter components in temperate coniferous forests of Kashmir Himalayas, India. *Archives of Agriculture and Environmental Science,* 2(3): 162-166.

Netting, R. McC. (1993). *Smallholders, Householders*. Stanford University Press, Stanford.

Nicholls, C.I. and Altieri, M.A. (2012). Agro-ecological approaches to enhance resilience. *Farming Matters*, 14-17.

Oana (2017). The importance of ecological farming. Digital Magazine for Farmers and Agricultors. Retrieved from http://agronomag.com/importance-ecological-farming/

Okore, G. (2017). Kenyan Youths vouch for Ecological Farming. African Science News. Retrieved from http://africasciencenews.org/kenyan-youths-vouch-for-ecological-farming.

Shen, H., Kang, X. and Zhang, W. (1993). Chinese agricultural modernization and the analysis of the eco-economy at its different developing stage. *Eco-Agriculture Research,* 1(2): 15-26.

Tariyal, K. (2017). Climatic fluctuations in Uttarakhand Himalayan region and resulting impacts: A review. *Archives of Agriculture and Environmental Science,* 2(2): 124-128.

Tirado, R. and Cotter, J. (2010). Ecological farming: drought-resistant agriculture. Exeter, UK: Greenpeace Research Laboratories.

Tompkins, E.L. and Adger, W.N. (2004). Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society,* 9 (2): 10.

Wang, H., Qin, L., Huang, L. and L. Zhang (2007). Ecological agriculture in china: Principles and applications. *Advances in Agronomy*, 94:181-208.

Wachira, A. (2016). Farmers demand investment in ecological farming. Retrieved from http://biasharaleo.co.ke index. php/2016/11/14/farmers-demand-investment-in-cological-farming.

Wilken, G.C. (1987). Good Farmers: Traditional Agricultural Resource Management in Mexico and Guatemala. University of California Press, Berkeley.