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Mini Review

Permaculture: A Key Driver for Sustainable Agriculture in Nepal

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Abstract

Our study primarily focused on permaculture for sustained agriculture. Permaculture can be a best alternative for modern industrial and commercial based agriculture which has given a good yield at present but, it is deteriorating soil quality and other environmental aspects. More ever it can lead to a global threat in the future due to overuse and somewhere due to unutilized resources which may give rise to the food and economic insecurity. By compiling the different literatures, we reviewed that permaculture enriches soil quality by increasing organic matter in soil thus increasing water retention capacity, infiltration, nutrient availability, microbial activities and decreasing the erosion. Thus, it increases physical, chemical and biological properties of soil. It provides food and economic safety by providing diverse crops, increasing yield and income of farm and providing least cost inputs with increasing output. It is an efficient in terms of resource use as it utilizes renewable resources and makes connections like a web among resources. This review can be useful information for students, research topic for permaculturists for making it smoother and other environmental enthusiast.

Keywords: Permaculture; Sustained agriculture; Soil organic matter; diverse crop; Web among resources

Introduction

Permaculture was developed in the early 1970 by two Aussies ecologists Bill Mollison and David Holmgren. It is used alternatively with agroforestry but we are not familiar more with term permaculture although it is practiced from long ago (Tomczak, 2007). The term permaculture has itself 3 words permanent, agriculture and culture (Tomczak, 2007). It is bounded with the principle that a stable, sustainable culture is possible only if we integrate it with a system of sustainable agriculture (Holmgren, 2002; Whitefield, 2004). It is principally focused on developing the strong relation between community and agriculture with secured status of food and economy for long term agriculture. Permaculture system seeks for ameliorating the danger and destructiveness resulted by modern agro industrial products such as fertilizer, pesticide, herbicide, insecticide (Gever *et al*., 1991; Holmgren, 2002). The four assumptions on which permaculture is based are (1) The environmental crisis is real and if its magnitude increases it will threaten the existence of a society (2) Humans are subjected to some natural laws that teach them to govern the universe (3) The industrial era and population explosion can be attributed to exploitation of cheap abundant fossil fuels (4) The energy resources are scarce but human has unlimited desires so resources will be depleted and human society will return to preindustrial era (Holmgren, 2002). In permaculture humans and nature cannot be isolated from each other as they are closely linked therefore caring the earth means fulfilling the objectives of people (Holmgren, 2002; Mollison *et al*., 1991). Permaculture is a philosophy,

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a sustainable practice and an act based on ethics of 1. care for earth 2. care for people 3. setting limits to consumption (Tomczak, 2007). Principles on which permaculture is based as described by Holmgren (2002) are listed below:

1. Observing and interacting: Beauty is in the eye of beholder.
2. Catching and storing energy: Make hay while the sun shines
3. Obtaining a yield: you can't work on empty stomach.
4. Applying self-regulation and accepting feedback: Sins of feathers are visited on the children onto 7th generation
5. Using and valuing renewable energy sources: Let nature takes it course
6. Producing no waste: Waste not, want not.
7. Designing from patterns to details: Can't see the wood for the trees
8. Integrating rather than segregating: Many hands make light work
9. Using small and slow solutions: Slow and steady wins the race
10. Using and valuing diversity: Don't put all your eggs in one basket
11. Using edges and valuing the marginal: Don't think you are on right path just because it is easily travelled
12. Creativeness for using and responding to change: Vision is not seeing things as they are but as they will be.

"Permaculture is the conscious design and maintenance of agriculturally productive ecosystem that is characterized by sustainable, diversified, stable and resiliency with integration of all components of ecosystem so that various objectives of a community are fulfilled in a sustainable way" (Mollison *et al*., 1991). The primarily understood and applied designed tools in permaculture are zone and sector analysis (Hemenway, 2000; Holmgren, 2002; Mollison *et al*., 1991; Whitefield, 2004). There are 6 zones in permaculture and the components of each is applied at different scales, both physically and conceptually. For example on a household scale, zone 0 would be at inside home, zone 1 intensively managed gardens and landscape just outside the home, zone 2 less intensively managed orchards, zone 3 field crops, zone 4very low management grazing and zone 5 the wilderness (Whitefield, 2004).

Rationale of Study

After the Green Revolution period, with increased crop yield due to high use of modern agro inputs, the Asian agriculture has also suffered from many problems like sustainability, stagnant yield, water logging, soil erosion, fluctuation in prices and severe natural calamities (MahendraDev, 2012). In Nepal about 65.6% people are engaged in agriculture and agriculture constitutes about 33 % of GDP (MoAD, 2017).It is reported that Soil organic carbon has been depleted due to long term nutrient exhaustive farming system and transformation of existing natural ecosystem to cropping and grazing lands (MahendraDev, 2012) .It is revealed that most agricultural soils have lost 30 to 40 MT of carbon per hectare and their current reserves of soil organic carbon are much lower than their potential capacity (Lal, 2009). Most of the researchers believed that urea based fertilizer leads to more nitrous oxide gas emissions than ammonium or nitrate fertilizers. But from the recent research it is reported that both environmental factors such as soil conditions and climate and management factors such as tillage operations and cropping culture play a key role in nitrogen loss from field as nitrous oxide (Flynn, 2009). It is reported that land degradation and soil erosion in South Asia are mainly due to unscientific land use practices, rapid rate of deforestation, poor irrigation and drainage, inadequate soil conservation, steep slopes and overgrazing (Vasudeva, 2002). Shifting cultivation for farming has also resulted in impacts on environment. It is shown that recent trend for keeping fallow for short period has also resulted in declined soil fertility, decreased crop yield and threatened food security (Grogan,2012). It is reported that high land fragmentation and accelerated rate of conversion of agricultural land as a result of urbanization are two main threats for food security in Nepal (Paudel, 2014). Agricultural technologies also attribute for environmental degradation.

Soil nutrient loss has become a serious issue in Nepalese agriculture. Pesticide related health problems are common in developing countries reaching to extremity and it is affected by various factors like poverty, illiteracy, lack of health facilities or ignorance (Devi, 2009). Many problems such as food insecurity, poverty and demographic dynamics are caused by environmental degradation due to lowered agricultural productivity (Acharya and Kafle, 2009). Pesticides residues are also causing environmental degradation. The impact of pesticides on agricultural goods vary according to the type of pesticides used but, it was revealed that all pesticide residue caused nutrient imbalance and decreased quality of agricultural produce (Prescott, 2002). Unsafe pesticide application has caused harm to the health of applicator along with the health of other farm residents (Nicole, 2003).It is reported that long-term exposure to pesticides causes asthma (Hoppin *et al*., 2002) ,sterility (Tuc *et al*., 2007). Scholars believed that pesticide catalysed the development of cancer and pesticide poisoning was more significant in developing countries as compared to developed countries (Hou, 2010). All these problems are encountered mostly as well in Nepalese agriculture due to our unscientific farming practices but, we have ample resources which can build a good permaculture design and rectify these problems of Nepalese agriculture. This review article is written from review of different

literatures so that it can be a useful information for students, a good research topic for permaculture specialists and other environmental enthusiasts who are trying to do research in environmental sectors integrating agriculture.

Permaculture for Sustained Agriculture

Amelioration of Soil Quality

Permaculture is a good approach for ameliorating soil quality. Permaculture is a new opportunity for soil protection and its nourishment as well as it is an alternative way to save natural resources thus, ensuring greater self-sufficiency (Korze, 2018). Soil is a medium for all plant growth and life in the earth is healthy only if the soil is maintained healthy. Permaculture varies from other soil management practices which links resources found in our communities and ecosystems and requires less inputs (Korze, 2018). Beneficial effects of permaculture with soil quality can be proved through increased organic matter of soil, improved soil structure, root penetration, increased moisture content, increased rate of infiltration and decreased soil susceptibility to compaction, erosion and landslides which can conserve soil and its nutrient reserve (Korze, 2018). Mulching in the soil has kept humidity in the upper horizon of soil and it has significant effect in soil moisture retention in extreme climatic conditions so that crop cannot face moisture stress (Korze, 2018).The darker color in upper horizon of soil after two years of permaculture research was due to weathered organic matter which was in the soil (Korze,2018).He too found decreased skeleton in soil, lumpy soil structure and loamy textured soil with less clay in two years of permaculture research. Utilization of compost manure, vermicompost, green manure and slurry have an attribute for increasing soil fertility. They also enhanced microbial activities in soil. Soil management through organic farming techniques play key role in increasing soil resistance against wind and water erosion and other damage which may result from climatic stress (Bird and Drizo, 2009). Soil fertility enhancing and quality promoting practices such as crop rotations, intercropping, symbiotic associations, cover crops, organic fertilizers, minimum tillage are main elements of organic practices (Banjara, 2016). Agroforestry is linked with many practices such as farming with trees on contours in slopy sides, intercropping, multiple cropping, bush and tree plantation, keeping fallows, establishing shelter belts and windbreak and buffer strips which can improve land productivity by securing a favourable microclimate, providing permanent cover, improved soil structure and increased organic carbon content and infiltration of soil thus, reducing erosion (WOCAT 2011). According to (Ramesh *et al*., 2010) there is lower soil bulk density, slightly increased soil pH and electrical conductivity, increased organic carbon content and increased availability of both macro (N, P, K) and micro nutrient (Zn, Cu, Fe, Mn) in organic farms as compared with conventional farms. When compared with conventional farms, farms which were organically managed had higher levels of dehydrogenase (By 52.35 %), alkaline phosphatase (28.4%) and microbial biomass carbon (33.4%). This indicates high microbial activities in organically managed soils than in conventional farms which is vital and utmost important for nutrient transformations and thus increasing nutrient availability for plants. It is reported from long term field experiments in West African agro ecosystems that use of mineral fertilizers without recycling of organic materials resulted in high yields but, there was severe loss of soil organic matter by 5 % and 2% per annum on sandy soils and more textured soils respectively (Bationo *et al*., 2012). It was found that the plantation of stem cuttings and flooding resulted in greater biological nitrogen fixation, 307 & 209 kg nitrogen per hectare by *Sesbania rostrata* and *Sesbania cannabina* respectively for restoring fertility of soil (Pandey, 2007). Leaf litter promotes the soil fertility by adding organic matter, tree leaf controls the speed of rain drops and allow them to go to the land surface slowly and thus decrease soil loss, increases infiltration, high potential of source of water reservoir in future due to accumulation of excess leached water and such conditions are very suitable for growth of microorganisms and plants in the soil (Pandey, 2007). In organic fertilizing study, the interaction of Compo Guano and lime together was not clear but, in long term it could be declared as a best solution because it had positive consequences on both soil pH and available nitrogen and also preserving microbial biomass level with labile organic matter in soil (Mursec, 2012). Tree root hold soil within the rhizosphere region, loosen compact soil and improve porosity of soil through root decaying (Sanchez, 1997). Diversified and healthy soil flora and fauna created stable soil (Sanchez, 1997). Fungal colonization in soil is due to trees with their symbiotic relation with fungi known as mycorhiza. Mycorhiza enhances nutrient uptake from different region of soil and reduces the negative impacts resulted by many soil pathogens (Borowicz 2001; Newton and Pigott 1991). Extensive network of fungal hyphae in soil helps to allow forested systems to maintain their integration during any external disturbances (Perry et al., 1990). Nutrients which are mined at depth in the soil that couldn't be uptake by small plants are taken up easily by trees and they deposit on the soil surface in the form of leaf litter where then it is readily available to shallow rooted species (Sanchez, 1997). Sheet mulching which corresponds to the leaf cover found in forest floors serves as nutrient banks and thus slowly make the nutrients available to the plants for longer time. They also attract the earthworms which result in best fertilizer known as vermicomposting. It is reported that when Arbuscular Mycorrhizal Fungi (AMF) strains and permaculture soil were used as an inoculant resulted in increased nutrient uptake efficiency of naranjilla plant and also reduced the application of mineral fertilizers during cultivation process

(Symanczik, 2017). The Increased phosphorus uptake with permaculture soil as an inoculant was attributed to abundancy of AMF strains in permacultured soil (Symanczik, 2017). Long term studies depict that legumes and manure based fertilized system takes comparatively more time to reach in a state of its full potential when compared within organic fertilized system but in long term legume and manure based fertilized system is more productive and has ability to cope with adverse climatic condition such as drought (Krebs and Bach, 2018).

Food Security and Economic Security

Permaculture is a key driver of food and economic security. Permaculture is an old practice and new emerging issue for sustainability in agriculture and one of its creator defines it as a "consciously designed landscapes which mimics the pattern and relation found in the nature by yielding an abundance of food, fibre and energy for provision of local needs and other services " (Lovell, 2014). The most distinct concept in permaculture is that multiple level of crops are typically grown in the same area thus creating more biodiversity (Thomas, 2017). It is reported that utilization of diverse group of crops may require an additional manual labour during harvests but, this is a beneficial approach because there is a mutually benefitted relationships between a diverse group of crops as disease resistance, companion plants having different nutritional requirements and acting as repellent or showing antibiosis (Thomas, 2017). The preference for perennial food crops which may yield less edible mass per season but it is beneficial as it benefits farm by reducing the cost of annual planting labour and soil tillage operations (Kelsey, 2014; Toensmeier, 2007). It is revealed that along with increasing farmer's potential economic output, Maltese trees will provide wider habitat, different microclimates and also help to control disease and pest(Vella,2010). It was reported from a research that maize supported few number of Striga weed which is a root parasite when it was grown in permaculture system than sole grown maize and yield was also significantly higher in maize grown in permaculture rather than sole grown maize (Tera, 2013). In permaculture, "food forest" or edible forest garden is defined for perennial food production system that integrates tree crops which needs little human management practices and providing harvest from various crop species year round (Van Bemmel, 2017). Wild asparagus (*Asparagus acutifolius*) holds high potential as a new crop when grown in combination with olive tree rather than cultivation of olive only (Mantovani and Rosati, 2014). Evidence from ecological farming initiatives across the world shows that ecological farming when sufficiently supported by policy instruments can be a successful tool in providing stable financial benefits to small holder farmers in turn benefitting rural communities and advancing their rights to a rewarding and securing livelihood. Increasing yields of crops blindly at any price anywhere in the world is not a solution of problem existing in other areas because increasing yields of maize in U. S. doesn't help for Asian people. So it should be time and location specific (Reyes, 2015). Permaculture has the potential to maximize the work that nature does and also reduces the need of human labour, extra materials and other resources which are positively associated with economy of farms. Various aspects of permaculture lend themselves if they are integrated properly thus making more economic farm (Barrette, 2011). It was reported by researchers that full organic farmers in the Philippines grow on average 50% more crops as compared to conventional farmers and also have net incomes higher by 1.5 times than those of conventional farmers (Altieri *et al*., 2012).

Table 1: Agricultural technologies and their impact on the environment

Agricultural technologies	Impact on environment
Mono-cropping	Decrease in number of insects so increased use of pesticides
Continuous cropping	Soil fertility declines due to nutrient exhaustion
Conventional tillage	Reduces soil organic matter and leads to increased soil erosion
Intensive hillside cultivation	Increases soil erosion and soil degradation
Inorganic fertilizers	Increased acidification and lower ph.
Irrigation system	Inadequate drainage and over irrigation causes water logging and salinization in field
New seed varieties	Increased need for inputs due to high input requirement which reduces soil fertility.
Intensive rice cultivation	Methane production Salinization and water logging Nutrient problem
Intensive livestock farming	Increases soil compaction and erosion caused by hoof action and overgrazing respectively

Source: Killebrew, (2010).

Richardt (1995) reports that permaculture is economical in medium to long term but it may not be economical in case of short run because of high cost of establishing a productive practice initially along with other resources. It was reported from FAO (2014) that in most countries small and medium size farms tends to have high agricultural yield per hectare when compared to large scale farms but, they have drawback that labour productivity of farm is low. Gliessman (1998) states that integrated farming systems where small farmers simultaneously diverse group of crops such as grains, fruit, vegetables, fodder, animal products, there the yield advantages can range from 20% to 60 % because polycultures have the compensation benefit which is associated with less loss due to weed, pest and pathogens. It was reported that training in permaculture in the communities contributed significantly for poverty alleviation and ensuring food security in South African communities (Arko-Achemfuor, 2014).Permaculture is unlocked with a potential to produce diverse group of crops including about600 indigenous edible plants (Thornton, 2008) which obviously broaden an individual's diet, providing required nutrients and physiological fuel which are needed for healthy diets and performing daily activities thereby protecting malnutrition and stunting (Conrad, 2010). It is revealed that permaculture can purposefully utilize all 12 months of the year and thus reducing food deficit situation (Conrad, 2010). It was reported that after the first few years of permaculture which required significant physical labour and cost to rejuvenate the land , cost would be minimized because of self-regulated system which enhanced food production (Nordin, 2008). Permaculture becomes more economic as it reduces the cost for seeds, fertilizers and other resources which would be self-produced after a period of time (Conrad, 2010).

Utilization of Local Resources and Knowledge

We have abundant resources in Nepal for a permaculture. Many resources around us just go unseen or unutilized due to our orientation towards commercial based agriculture or due to our transition from subsistence to modern industrial agriculture. Permaculture not only uses the natural resources around us but also create a link among resources that is single resource used for many purpose but in a sustainable way. Permaculture is always inspired from naturally occurring ecosystems existing in the local area and permaculture specialist aim to design permaculture so that crops are planted making base on those ecosystem (Thomas, 2017). It was reported that permaculture was beneficial for local environment which mimics with natural ecosystems in a place, it required adequate resources such as soil and other environmental resources (Thomas, 2017). Permaculture provides a holistic approach on how farmers should understand their surrounding environment ,use available resources and work in harmony to produce diverse organic produce, increase energy output ,reduce waste , protect their existing ecosystem which all are associated positively with resource use efficiency (Jacke, 2005).The crucial role of Permaculture is that it reduces the sink and cost of inputs in agriculture by reducing energy inputs and recycling of resources existing within the system and has motto to increase biodiversity (Madeley, 2002). Permaculture finds and exploits indigenous foods which are given less importance in society or neglected long years ago (Thornton, 2008). Permaculture is implemented through the concept of zone and guilds where Zone refers to spatial function of land and space that is similar with particular agricultural activities in order to optimize energy and resource usage (Nordin 2005). Guilds are means of organizing crops within each zone and ideally each guild will have crops that perform 7 functions to maximize use of resources (Nordin, 2007). For example, a variety of tree can perform 6 functions at once by providing edible fruits, fixing nitrogen in soil, being a climber, being a supporter of climber, being a biological plough and acting as a protective bar or fence or windbreak (Conrad, 2010). A paradigm shift is required for today's problem of energy crisis, decreased efficacy of available resources and this shifting is possible if permaculture is taken as an alternative of agriculture through well maintained policies (Kazakova-mateva, 2015). It is revealed that renewable energy uses on the rise and it can be a best key for fostering sustainability (US Energy Information Administration, 2017). It is very important for attesting local knowledge as a useful element while designing a permaculture system as it is a design with nature rather than design against nature to go in a sustainable way (Salleh, 2018). Permaculture specialist always aim to work with nature rather than against the nature and without altering the ecosystems such as biocides and conservation tillage, thus using resources in a judgeful way (Miller, 2014). It is reported that ecosystems always cope with limiting inputs by providing a path that produces renewable resources, provide provision and acts as regulatory system. Therefore, the effort concentrated to use and value renewable resources is a core principle of permaculture (Holmgren, 2011). Permaculture is not only about the natural resources but, also mutual connections among the resources with the environment to work as multidirectional functional system (Meech, 2016). It is revealed that for changing modern agriculture to permaculture in a practical way is possible through the conservation of indigenous vegetation, resources, rearing of free range of local farm animals, installing solar and wind energy devices, solar water heater, greenhouses, vermicomposting, water catchment system and grey water purification systems as suggested by MOAM in Malta (Vella, 2010).

Conclusion

Our review was focused on the sustained agriculture through permaculture based on soil nourishment, food and economic security and efficient utilization of local resources. There was limitation in research and literatures regarding permaculture but compiling different literatures

we came to conclude that permaculture enriches soil quality by increasing organic matter of soil thus increasing water retention capacity, infiltration, nutrient availability, microbial activities and decreasing the soil and nutrient erosion. Thus, it increases physical, chemical and biological properties of soil. It provides food and economic safety by providing diverse group of crops, increasing yields and income of farm and providing least cost inputs with increasing output. It has high resource use efficiency as it utilizes local renewable resources and makes connections like a web among the resources.

References

Acharya AK & Kafle N (2009) Land degradation issues in Nepal and its management through agroforestry. *J Agri Environ* **10**: 133-143. DOI: 10.3126/aej.v10i0.2138

Altieri MA, Funes-Monzote FR & Petersen P (2012) Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agr for Sust Dev* ***32*****:** 1-13. DOI: 10.1007/s13593-011-0065-6

Arko-Achemfuor A (2014) Teaching Permaculture to Ensure Food Security in Rural South Africa: The Case Study of Tiger Kloof. *J of Hum. Eco* 47**:** 251-255. DOI: 10.1080/09709274.2014.11906759.

Banjara RK (2016) Opportunity of organic farming to improve socio-economic life of Nepalese farmers. *European J of Agri and Fo Res* **4:** 22-31.

Barrette E (2011) Permaculture on Low to No Budget. *Commu.* **153**: 33.

Bationo A, Waswa B, Abdou A, Bado BV, Bonzi M. Iwuafor E & Mugwe J (2012) Overview of long term experiments in Africa. In *Lessons learned from long-term soil fertility management experiments in Africa*: 1-26. Springer, Dordrecht. DOI: 10.1007/978-94-007-2938-4_1

Bird SC & Drizo A (2009) Investigation on phosphorus recovery and reuse as soil amendment from electric arc furnace slag filters. *J of Env Sci and Hea, Part A* **44:** 1476-1483. DOI: 10.1080/10934520903217922

Borowicz VA (2001) Do arbuscular mycorrhizal fungi alter plant–pathogen relations? *Eco*. ***82***:3057-3068. DOI: 10.1890/0012-9658(2001)082[3057:DAMFAP]2.0.CO;2.

Conrad A (2010) The Potential of Permaculture: Addressing Subsistence Farming and Food Security in Malawi. Working Paper. *Applied Anthropology*.

Devi P I (2009) Health Risk Perceptions, Awareness and Handling Behaviour of Pesticides by Farm Workers. *Agri Econo Res Rev* ***22***.

Flynn HC & Smith P (2010) Greenhouse gas budgets of crop production: current and likely future trends.

Grogan P, Lalnunmawia F & Tripathi SK (2012) Shifting cultivation in steeply sloped regions: a review of management options and research priorities for Mizoram state, Northeast India. *Agrofo Sys* ***84***: 163-177. DOI: 10.1007/s10457-011-9469-1

Holmgren D (2002) Permaculture: principles & pathways beyond sustainability.

Hoppin JA, Umbach DM, London SJ, Alavanja MC, & Sandler DP (2002) Chemical predictors of wheeze among farmer pesticide applicators in the Agricultural Health Study. *Amer J of Resp and Critl care medi****165***: 683-689. DOI: 10.1164/ajrccm.165.5.2106074

Hou, B & Wu, L (2010) Safety impact and farmer awareness of pesticide residues. *Food and agri. Immunol.****21***:191-200. DOI: 10.1080/09540105.2010.484858.

Jacke D & Toensmeier E (2005) *Edible forest gardens, Volume II: Ecological design and practice for temperate-climate permaculture* (Vol. 2). Chelsea Green Publishing.

Kazakova-Mateva Y & Radeva-Decheva D (2015, October) The role of agroecosystems diversity towards sustainability of agricultural systems. In *147th EAAE Seminar CAP Impact on Economic Growth and Sustainability of Agriculture and Rural Areas*.

Kelsey A (2014) Edible *Perennial Gardening: Growing Successful Polycultures in Small Spaces*. Permanent Publications.

Killebrew K & Wolff H (2010) *Envir. impacts of agricul. Techno.* (No. UWEC-2011-01).

Kim KH, Kabir E & Jahan SA (2017) Exposure to pesticides and the associated human health effects. *Sci. of the Total Envt.****575*****:** 525-535. DOI:10.1016/j.scitotenv.2016.09.009.

King CA (2008) Community resilience and contemporary agri-ecological systems: reconnecting people and food, and people with people. *Systems Research and Behavioral Science: The Offi. J of the Intl. Federation for Sys. Res.****25*****:** 111-124. DOI: 10.1002/sres.854.

Korže AV (2018) Permaculture for Sustainable Life Style ***2***: 34–39. DOI: 10.5923/j.ijire.20180202.02.

Korže AV & Korže D (2018) Agroecology for Our Future. *Intl. J of Inspir. & Resil. Econ.****2*****:** 1-10. DOI: 10.18576/ijye/020104

Krebs J & Bach S (2018) Permaculture—Scientific Evidence of Principles for the Agroecological Design of Farming Systems. *Sust.****10***: 3218. DOI: 10.3390/su10093218.

Lal R (2009) Soils and food sufficiency: A review. In *Sustainable agriculture* (pp. 25-49). Springer, Dordrecht. DOI: 10.1007/978-90-481-2666-8_4

Madeley J (2002) Food for all. *Appr. Tech.* ***29***: 32. DOI: 10.1002/he.65

Mahendra Dev S (2012) Climate change, rural livelihoods and agriculture (focus on food security) in Asia-Pacific region.

Mantovani D & Rosati A (2014) Does the wild asparagus like olive trees. *Spatial and temporal distribution of light in olive orchards and wild asparagus.*

Meech HD (2016) Natural *Resources, Permaculture, and the Permaculturist.*

Miller O (2014) Evaluation *of the Permaculture Movement and its Limitations for Transition to a Sustainable Culture*

(Doctoral dissertation, The Ohio State University). DOI: http://hdl.handle.net/1811/63143.

MOAD (2017) Statistical Information On Nepalese Agriculture 2072/73 (2015/16), *73*.

Mollison B, Slay RM, Girard JL & Girard JL (1991) *Introduction to permaculture*. Tyalgum, Australia: Tagari Publications.

Mursec M (2011) *Agricultural practices impact on soil quality and health: case study of slovenian irrigated or organic orchards* (Doctoral dissertation, Université de Bourgogne).

Naresh RK, Gupta RK, Rathore RS, Dwivedil A, Singh HL, Kumar V, Shukla AK, Singh V, Singh SP, Tyagil S. (2017) Crop residue management and soil health with changing climate in smallholders farming: a subtropical Indian perspective. *Int J Curr Microbiol App Sci* **6(**2): 1591-1609. DOI: 10.20546/ijcmas.2017.602.178.

Nordin S (2005) Low input food and nutrition security: growing and eating more for less. http://www.eldis.org.

Pandey DN (2007) Multifunctional agroforestry systems in India. *Current sci.* 455-463.

Perry DA, Borchers JG, Borchers SL & Amaranthus MP (1990) Species migrations and ecosystem stability during climate change: the belowground connection. *Cons. Biol.* ***4*****:** 266-274. DOI: 10.1111/j.1523-1739.1990.tb00288.x

Prescott CE (2002) The influence of the forest canopy on nutrient cycling. *Tree physol.* ***22***: 1193-1200. DOI: 10.1093/treephys/22.15-16.1193.

Ramesh P, Panwar NR, Singh AB, Ramana S, Yadav SK, Shrivastava R, & Rao AS (2010) Status of organic farming in India. *Current Science*: 1190-1194.

Reyes T (2015) Ecological Farming - The seven principles of a food system that has people at its heart, (May), 68. DOI: 10.1002/14651858.CD004963.pub3.

Richardt AL (1995) The Economics of permaculture.

Salleh AM, Rosli FM, Esa N & Ibrahim MH (2018) Permaculture Design: Linking Local Knowledge in Land Use Planning for House Compound. In *SHS Web of Conferences* (Vol. 45, p. 03003). EDP Sciences. DOI: 10.1051/shsconf/20184503003.

Sanchez PA, Shepherd KD, Soule MJ, Place FM, Buresh RJ, Izac AMN & Woomer PL (1997) Soil fertility replenishment in Africa: an investment in natural resource capital. *Rep. soil fertile. in Africa* 1-46.

Symanczik S, Gisler M, Thonar C, Schlaeppi K, Van der Heijden M, Kahmen A & Mäder P (2017) Application of Mycorrhiza and Soil from a Permaculture System Improved Phosphorus Acquisition in Naranjilla. *Front. in plant sci.****8***: 1263. DOI: 10.3389/fpls.2017.01263.

Tera EAA, Ondo FK & Toh KI (2013) 1989 - Petersen-Homan - Isentropic Now casting Model.pdf: 114–119.

Thomas C (2017) Pursuing Sustainable Agriculture in the Bahamas. *i-ACES* 3: 46-52.

Thornton H (2008) Permaculture adoption among Malawian farmers: a positive deviance inquiry.

Tomczak JM (2007) Spectral and optical properties of correlated materials (Doctoral dissertation, PhD thesis, Ecole Polytechnique).

Tuc VP, Wangsuphachart V, Tasanapradit P, Fungladda W, Van Trong P & Nhung NT (2007) Impacts of pesticide use on semen characteristics among rice farmers in Kienxuong District, Thaibinh Province, Vietnam. *Southeast Asian j of trop. Medi. and pub. health* **38:** 569.

Van Bemmel K (2017) The potential of permaculture principles in the agrifood transition. HAS Research Group: New Business Models for Agrifood Transition, Den Bosch, the Netherlands

Vasudeva G (2002) Environmental security: A South Asian perspective. *Tata Energy and Res Inst Arlington.*

Vella SS (2010) Sustainable Agricultural Management and Landscaping through Agroforestry and Permaculture Case Study: Northern Malta. https://commons.lib.jmu.edu/master201019/433

Whitefield P (2004) Earth *care manual: A permaculture handbook for Britain & other temperate climates*. Permanent publications.