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Horticultural Agroforestry Systems Recommended for Climate Change Adaptation: A Review

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ABSTRACT

High input costs, environmental degradation and climate change have generated new challenges in the agriculture, horticulture and forestry sector. The objective of this paper is to identify the main horticultural agroforestry systems useful for climate change adaptation and mitigation. *Agri-horticulture, Horti-olericulture, Silvi-olericulture, Horti-pasture, Horti/Silvo-medicinal, Horti/Silvo-ornamental, Horti-silviculture, Horti-entomoforestry* and *Horti-Pisciculture* are horticultural agroforestry systems recommended. Agroforestry systems in comparison with monoculture systems, have better use of water, soil and light, can help reduce the application of herbicides, fungicides, pesticides, fertilizers, increasing food security, biodiversity protection and climatic change adaptation. We recommended national politics, subsidies, technical support and credits for global farmers.

Key words: Annual vegetable, Fruit tree, Medicinal crop, Ornamental crop.

Growing consensus in the scientific community indicates from climate change resulting that higher temperature and changing precipitation levels (such as erratic rainfall, floods and droughts), consequently, changes in water availability and land cover, altered nitrogen availability and nutrient cycling Alemu *et al.* (2019), moreover, the intensification of agriculture has contributed to an increase in the negative effects of climate change Mauricio *et al*. (2019), affecting agricultural production, where its impacts on economic growth, in general, are still issues in debate Kimaro *et al*. (2019). Mono cropping systems offer low-cost food for consumers with significant negative environmental costs or externalities (water pollution, soil degradation and greenhouse gas), generally externalities not considered in market value Jalón *et al.* (2018), so that, need to reduce agricultural inputs without significant productivity loss may require a fundamental re-design of cropping systems Jamar *et al.* (2016).

The dramatic increases in crop productivity in modern agriculture have been accompanied in many instances by environmental degradation and social problems Altieri *et al.* (2018), agroforestry systems can contribute to feeding a growing population in a sustainable way Groeneweg *et al.* (2018), world population will reach 9.7 billion by 2050 (United Nations 2015), sufficient food production for an increasing global population while conserving natural capital is a major challenge to humanity Barrios *et al.* (2017). In response, Agroforestry interventions were successful in combatting food insecurity, by responding to challenges and opportunities related to climate change Tsuji *et al.* (2019), moreover, has attracted considerable attention in recent years because of its potential to reduce poverty, reduce land degradation and mitigate climate change Buyinza *et al.* (2019).

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The multilayered structures of agroforestry can maintain the stability of internal microclimates which are strong assets for extreme weather adaptions Wu *et al*. (2016), trees cause important changes in microclimate (immediately under and adjacent to trees), mesoclimate (tens to hundreds of square meters away from the trees) and macroclimate (at a landscape scale of tens to hundreds of square meters), moreover, trees at wide spacing also helps them to develop more stable root systems to resist damage from storms and regular pruning of lower branches helps to avoid wind throw Santos *et al*. (2019). Trees play a significant role in reducing the amount of rainfall reaching the soil due to canopy interception and in moisture conservation, having the potential to increase infiltration rate of rainwater and check the runoff Chaturvedi *et al.* (2018), additionally, agroforestry systems increase water quality Pande *et al.* (2018), better water use dynamics Paut *et al.* (2018) and better water use efficiency Abul-Soud *et al.* (2014).

Horticulture based agroforestry has played a multifarious role in agricultural production and protection of the environment through carbon sequestration to mitigate on going climate change problem for better well-being of mankind. The recommendation is to use well-adapted tree-crop combinations, thereby limiting competition for resources and maximizing synergies Pardon *et al*. (2018), to optimize plant density, the seeding rate of each crop on the mixture is adjusted below the full rate to reduce competition from overcrowding Ouma *et al.* (2010). All the different components of agroforestry systems are continuously interacting. Their interactions are determined by the management of the system, including the selection of species and their functional characteristics, planting density, stratification and fertilization regime Niether *et al.* (2019).

At the present day, the climate change mitigation and food security are two of the main challenges of human society Feliciano *et al*. (2018), the promotion of agroforestry as a mitigation practice requires an understanding of the economic benefits and its acceptability to farmers De Giusti *et al.* (2019), so it is recommended that farmers can recognize the agroforestry effect combining ecological services and diversified production, it is more stable and resilient over time than monocultures with respect to climate change and price volatility of agricultural products Vaast *et al.* (2016).

Finally, the climate change is affecting all economic sectors and ecosystems (Raj, 2017), Agroforestry land use has the real potential to contribute to food security, climate change mitigation and adaptation while preserving and strengthening the environmental resource base of rural landscapes Mbow *et al.* (2014), Agroforestry should be a major climate-smart agriculture option as it combines sustainable production with adaptation and mitigation of climate change Vaast *et al.* (2016), so that, the main objective of this paper was to identify the main horticultural agroforestry systems useful for climate change mitigation and adaptation.

The search for scientific papers was performed between January and September 2019, at Universidad Autónoma Chapingo Mexico, considering publications on agroforestry systems with a horticultural component, using SCOPUS, Web of Science and SciELO databases.

HORTICULTURE BASED AGROFORESTRY SYSTEMS

Agri-horticulture

Agroforestry system where fruit trees and annual crops are intercropped Bhardwaj *et al.* (2017), fruit trees and field crops can be grown together in many variations Lallianthanga *et al.* (2014). *Mangifera indica* Das *et al.* (2017)*, Psidium guajava* (Swain, 2016)*, Citrus spp.* Dubey *et al.* (2016)*, Prunus spp.* Bellow *et al.* (2008)*, Malus spp.* Hong *et al.* (2017)*, Annona squamosa* Raj *et al.* (2019)*, Pyrus sp.* Song *et al*. (2010) *and Cocos nucifera* Maheswarappa *et al.* (2010) are mainly intercropped with *Zea mays, Triticum spp*., *Sesamum indicum and Sorghum spp.*

Horti-olericulture

Agroforestry system where fruit trees and annual vegetables are intercropped (Singh and Dwivedi, 2018), *Citrus spp.* Blair *et al.* (2016), *Prunus spp.* Bhutia *et al. (*2015), *Psidium guajava* (Krishnan, 2016), *Artocarpus heterophyllus* (Gogoi, 2015), *Musa spp.* Nedunchezhiyan *et al.* (2012), *Mangifera indica* Mirjha *et al.* (2016), *Pyrus spp.* Nerlich *et al.* (2013) *Morus alba* Asati *et al.* (2007) *Zizyphus mauritiana* Sereke *et al.* (2014), *Coffea arabica* Iijima *et al.* (2003) and *Carica papaya* Aiyelaagbe *et al.* (1992) are mainly intercropped with *Fabaceae, Solanaceae, Brassicaceae and Euphorbiaceae* crops.

Horti-pastures

Agroforestry system where fruit trees and forage crops are intercropped, this system is ideal for the population living in rainy areas Kumar *et al.* (2016). *Psidium guajava* Korwar *et al.* (2005)*, Annona spp.* (Rakhi, 2015)*, Prunus spp.* Nerlich *et al.* (2013)*, Zizyphus spp.* Toppo *et al.* (2018) *and Punica granatum* Pareek *et al.* (2008) are compatible fruit trees, *Stylosanthus hamata, Cenchrus ciliaris*, *Panicum máximum*, *Dicanthium annulatum and* natural grasses are compatible forage crops. Other horti-pasture systems are Silvo-oleri-pasture (timber trees + annual vegetables + pastures) Saha *et al.* (2012), Agri-Horti-Silvi-pasture (timber trees + fruit trees + annual crops, + forage crops (Gogoi, 2015), Agri-hortipasture (fruit trees + fodder crop + annual crop) Pareek *et al.* (2008).

Silvi-olericulture

Agroforestry system where mainly legume, timber, oleaginous tree and trees annual vegetables are intercropped (Handa and Dhyani, 2015), *Cajanus cajan* Salami *et al.* (2005), *Gliricidia sepium* (Acquaah 2009), *Calliandra callothyrsus* Nolte *et al*. (2005), *Tectona grandis* (Handa and Newaj, 2017), *Eucalyptus spp.* Dhyani *et al.* (2013), *Poplar spp.* Dhillon *et al.* (2012), *Hevea brasiliensis* He *et al.* (2012), *Grewia optiva* Verma *et al.* (2010) and *Bambusa spp.* Behera *et al.* (2016). Some oleaginous trees examples are *Arecha catechu* + *Ananas comosus* Bhatt *et al*. (2006), *Moringa sp.* + *Solanum lycopersicum* Asati *et al.* (2007), *Juglans regia* + *Lactuca sativa* Wang *et al.* (2014), *Elaeis guineensis* + *Ananas comosus* Ashraf *et al.* (2018) and *Ricinus communis* + *Vigna spp.* y *Capsicum spp.* Singh *et al.* (2014).

Horti/Silvo-medicinal

Agroforestry system where fruit, wood, legume, oleaginous tree and medicinal crops are intercropped Suvera *et al.* (2015). *Eucalyptus spp., Hevea brasiliensis, Pinus spp., Paulownia tomentosa, Bambusa spp., Cunninghamia lanceolata, Cedrus deodara, Abies spp., Acacia auriculiformis, Populus spp., Albizia lebbeck, Eucalyptus tereticornis, Gmelina arborea, Leucaena leucocephala* and *Areca catechu* are compatible Rao *et al.* (2004). *Coffea spp.,* *Cocos nucifera, Musa spp., Malus spp., Mangifera indica* and *Theobroma spp.* are compatible fruit trees Thakur *et al.* (2005).

Horti/Silvo-ornamental

Agroforestry system where fruit, wood, legume, oleaginous tree and ornamental crops are intercropped. Fruit tree agroforestry orchards include *Psidium guajava* + *Hellianthus annuus* Bhoyar *et al.* (2016), *Prunus domestica* + *Hellianthus annuus* Nerlich *et al*. (2013), *Prunus domestica* + *Gladiolus sp*. Juárez *et al*. (2014), *Malus sylvestris* + flowers Sereke *et al*. (2014), *Vaccinium corymbosum* + ornamentals Workman *et al.* (2003) and *Diospyros virginiana* + cut flowers Workman *et al*. (2003).

Horti-silviculture

Agroforestry system where leguminous, timber and oleaginous trees are fruit trees, are intercropped. *Leucaena leucocephala, Cajanus cajan, Gliricidia sepium, Acacia spp.*, *Tectona grandis, Eucalyptus spp., Populus spp., Hevea brasiliensis*, *Mangifera indica, Theobroma cacao, Musa spp., Psidium guajava and Citrus spp.,* are recommended. Another example is oleaginous tree species, such as *Elaeis guineensis* + *Theobroma cacao* Ashraf *et al.* (2018).

Silvi-Horti-Agri/olericulture

Agroforestry system where leguminous, timber and oleaginous trees are fruit trees, vegetables or annual crops are intercropped Rani *et al.* (2016), the timber tree is established in the high stratum, the fruit tree in the medium stratum and the vegetable or the annual crop in the low stratum. Some examples of this system are: *T. grandis* + *M. indica* + *S. melongena* o *Abelmoschus esculentus* (Gunaga, 2017), *C. serrata* + *M. indica* + *Grewia sp*. + *Triticum aestivum* (Rajput, 2016) and *Trema orientalis* + *Musa spp*. + *Zea mays* or *Phaseolus spp*. or root crops Dagar *et al*. (2016).

Horti-pisciculture

Agroforestry system where leguminous, timber and oleaginous trees are fruit trees, vegetables, annual crops herbs are management synergistically along ponds in which fish is cultivated Bhardwaj *et al.* (2017), Handa and Dhyani (2015) report culture of *Azolla spp*., *Oryza sativa,* annual vegetables, fruit trees, *Paulownia spp*., *Salix spp*., *Populus spp*., *Tectona grandis* will can be included, data indicate that using water from fish cultures on vegetables, rice and mulberry may eliminate the need for commercial fertilizers Chang *et al*. (1997).

Horti-entomoforestry

Horti-apiculture is an agroforestry system where fruit trees and the production of honey (Singh and Dwivedi, 2018), *Pyrus pashia* Asati *et al*. (2007), *Litchi chinensis* Upadhyay *et al.* (2009), *Syzygum cumini* Karshie *et al.* (2017), *Coffea spp.* Boreux *et al.* (2013), *Ribes spp*. Sereke *et al.* (2014) y *Citrus spp.* Grajales *et al.* (2013), *Zea mays*, *Sesamun indicum*, *Helianthus annuus*, *Medicago sativa*, *Coriandrum sativum, Foeniculum vulgare and* the family *Brassicaceae* are compatible Shanker *et al.* (2000). Horti-sericulture is an agroforestry system where *Morus spp.* y *Bombyx mori* were cultivated integrally (Singh and Dwivedi, 2018)**,** *Antheraea myllitte*, *Phelosamia ricini and Antheraea assamensis* are other options to integrate into this system Handa *et al.* (2016).

Horticultural Agroforestry Systems for Climate Change

Agroforestry can be a multifunctional tool for high food production, poverty population reduction, input reduction, water conservation, improved soil quality, biodiversity conservation, climate change mitigation and climate change adaptation Toppo *et al.* (2018). Four major ecosystem services and environmental benefits: (1) carbon sequestration, (2) biodiversity conservation, (3) soil enrichment and (4) air and water quality for not only the landowners or farmers, but for society at large (Jose 2009). Moreover, agroforestry systems so as to make them better able to handle ever-changing climate conditions and to preserve habitats and ecosystems services Castro *et al.* (2019).

The increased pollution of ground and surface water have provided an additional impetus for the development and adoption of agroforestry around the world Kumar *et al*. (2012), from the early twentieth century, with the rise of both the global population and society's consumerism, agriculture was intensified, having a direct impact the degradation of soils, water, air, natural landscapes and biodiversity Pavlidis *et al.* (2018). Land intensification and degradation, energy use and inputs, complex environmental management, social issues facing farming communities and climate change are just some of the headline sustainability concerns threatening the viability of farming Fleming *et al.* (2019), currently the challenge is intensification methods that have not succeeded in providing sufficient food for the world population in a sustainable way and has contributed to an increase in the negative effects of climate change Mauricio *et al.* (2019).

The modification in microclimate potential for positive interspecific interaction exists Kumar *et al.* (2018), microclimate variations play a major impact on crop environment Singh *et al.* (2016), the presence of trees modify site microclimate in terms of temperature, water vapor content, wind speed, temperature reductions and can help reduce heat stress of crops Jose *et al.* (2004), wood plants also modify the microclimate by reducing evapotranspiration and moderating extremes in soil temperatures and daily photosynthetically active radiation Re *et al*. (2019), Shade trees modify the interception of radiant energy by the foliage of crops Monteith *et al*. (1991), that affect the physiology of the undergrown crop Charbonnier *et al.* (2017), photosynthetically active radiation and temperature are reduced, while the humidity is increased Sangwan *et al*.

(2017), water use efficiency and carboxylation efficiency is better Sangwan *et al.* (2015), reducing vulnerability, increasing resilience of farming systems against climate-related risks (NRCAR 2013; Sureshbhai *et al*. 2017).

The microclimate changes will impact biological processes on insect pests of crops (directly proportional to the temperature of the crops) and the increase of air humidity, can promote the development of foliar diseases like mildews and rusts. Farmers know that these diseases are more frequent near the dense hedgerows Lawson *et al.* (2018), more efficient management practices and new/innovative agroforestry solutions are required and must incorporate the regional and local abiotic factors of climate, soil, water and nutrient balances as well as the biotic conditions (pests, diseases and dispersal agents) Castro *et al.* (2019).

Climate change is the most important global environmental challenge which is facing by all living organism including humans and disturb natural ecosystems, agriculture and health. In this situation agroforestry emerge as a robust farming practice addressing food security problem by making feeds to people, mitigate adverse effects of climate change by enhancing environmental quality, sustain economic viability and enhance quality of life (Toppo and Raj 2018). Global climate change threatens the sustainability of agriculture and agroforestry worldwide through increased heat, drought, surface evaporation and associated soil drying (Borland *et al*. 2015).

Climate change and its variability are posing the major challenges influencing the performance of agriculture including annual and perennial horticulture crop, the extreme weather events of hot and cold wave conditions have been reported to cause considerable damage to many fruit crops. The various impacts need to be addressed in a concerted and systematic manner in order to prepare the horticulture sector to face the imminent challenges (Malhotra 2017). Exposure of crops and forests to warmer and drier environments will increase leaf: air water vapor–pressure deficits (VPD) and will result in increased drought susceptibility and reduced productivity, not only in arid regions but also in tropical regions with seasonal dry periods Borland *et al.* (2015).

Several evaluations have documented that agroforestry systems seem to be a viable and economically viable solution for the farmer to meet the challenges of food, nutrition, energy, employment and environmental security Verma *et al.* (2017), especially in developing countries Pande *et al.* (2018). The adoption of agroforestry technologies depends on the edaphic-climatic, socio-economic status and needs of farmers Gunaga *et al.* (2007), normally, management is influenced by physical, demographic and, institutional factors Bayard *et al.* (2007).

One of the main motivations for farmers to grow simultaneously a variety of vegetables and fruits is to reduce the overall risk on production through a diversification effect Paut *et al.* (2018). Farmers are interested in growing annual plants among young timber trees to receive the benefits of annual fertilization and weed management. however, to obtain optimal benefits, farmers must make important initial decisions about tree species, plant density and a good understanding of their advantages and disadvantages Nissen *et al.* (2002). While fruit trees have a long gestation period (4-5 years) to provide income; the interspaces can be used for the cultivation of agricultural crops profitably until they develop canopy (Gunaga 2017).

However, several characteristics of the trees like slow growth, long term effects, on their surroundings, long life, area over which the influence of trees extends, etc., complicating the issue of assessment and adoption Hymavathi *et al.* (2010). This paper can be used in the design of policies, credits, subsidies and technical support that can help increase global adoption of horticultural agroforestry systems in farmer, urban and peri-urban zones, for increasing global food production, conserve the environment, water resources protection Pavlidis *et al*. (2018).

Agroforestry systems are a possible solution to restore some of the damages from farming to improve the ecosystem services associated with soil and water Udawatta *et al.* (2017), the primary agroforestry objective of soil conservation is to improve or maintain soil fertility aboveground and soil C stocks to mitigate climate changes Tiwari *et al.* (2017). The increase the number of trees planted in agricultural systems, or agroforestry can improve the productivity and sustainability of future rural agricultural landscapes Fleming *et al.* (2019), tree presence increase C sequestration per unit of land due to the C sequestered by the tree itself Sureshbhai *et al.* (2017), the potential of C sequestration is dependent on the tree component Nair *et al.* (2009).

According to Kyoto protocol, agroforestry is recognized as an afforestation activity that, in addition to sequestering carbon dioxide (CO_2) to soil, conserves biodiversity, protects cropland, works as a windbreak and provides food and feed to human and livestock, pollen for honey bees, wood for fuel and timber for shelters construction, so that, Agroforestry is more attractive as a land use practice for the farming community worldwide instead of cropland and forestland management systems (Abbas *et al*. 2017). Agroforestry also has implications for emissions of other greenhouse gases, like nitrous oxide and methane and provides opportunities for the adaptation of crop production to climate change, maintain agricultural production and enhance carbon sequestration Lawson *et al.* (2018).

Finally, climate change poses a great threat to agriculture and food security (Lasco *et al*. 2016), the increasing land-use conflicts call for the development of land-use systems that reconcile agricultural production with the provisioning of multiple ecosystem services, including climate change mitigation. Agroforestry has been suggested as a global solution to increase land-use efficiency while reducing environmental impacts and economic risks for farmers (Paul *et al*. 2017). This article offers a great diversity of horticultural agroforestry systems that can be adopted by farmers in different countries around the world, these systems must be adapted according to the internal requirements of each country and synergistically promote mitigation and adaptation to global climate change.

CONCLUSION

Agri-horticulture, Horti-olericulture, Silvi-olericulture, Horti-pasture, Horti/Silvi-medicinal, Horti/Silvi-ornamental, Horti-silviculture, Horti-entomoforestry and Horti-Pisciculture are agroforestry systems recommended for climatic change mitigation and adaptation. Horticulture based agroforestry systems area possible multifunctional solution for global food security, environmental protection and mitigate and climatic change adaptation. In comparison with monoculture systems, they have better use of water, soil and light and can help reduce the application of herbicides, pesticides and fertilizers. *Leucaena leucocephala, Cajanus cajan, Gliricidia sepium, Tectona grandis, Poplar spp., Hevea brasiliensis, Mangifera indica, Psidium guajava, Prunus persica, Citrus* spp. and *Annona squamosa* are compatible tree. *Fabaceae, Solanaceae, Euphorbiaceae* and *Brassicaceae* are compatible annual vegetable. *Zea mays, Triticum spp. and*, *Sesamum indicum* are compatible annual crops and *Cenchrus ciliaris, Cynodon dactylon* and *Dicanthium annulatum* are compatible grasses. We recommended national politics, subsidies, technical support and credits for global farmers.

REFERENCES

Abbas, F., Hammad, H., Fahad, S., Cerdà, A., Rizwan, M., Farhad, W., Ehsan, S. Bakhat, H. (2017). Agroforestry: a sustainable environmental practice for carbon sequestration under the climate change scenarios-a Review. Environmental Science and Pollution Research. 24: 11177–11191. DOI: 10.1007/s11356-017-8687-0.

Abul-Soud, M., Emam, M., Abdrabbo, M. (2014). Intercropping of some brassica crops with mango trees under different net house color. Research Journal of Agriculture and Biological Sciences. 10: 70–79.

Acquaah, M. (2009). Effect of *Gliricidia sepium* and *Senna siamea* prunings on the growth and root yield of cassava. Kwamw Nkrumah University of Science and Technology, Kumasi.

Aiyelaagbe, I. and Jolaoso, M. (1992). Growth and yield response of papaya to intercropping with vegetable crops in southwestern Nigeria. Agroforestry Systems. 19: 1-14. DOI:https://doi.org/10.1007/BF00130090.

Akondé, T., Steinmüller, N., Leihner, D. (1997). Alley cropping on an Ultisol in subhumid Benin Part 3: nutrient budget of maize, cassava and trees. Agroforestry Systems. 37: 213-226. DOI: https://doi.org/10.1023/A:1005863818511.

Alemu, T. and Mengistu, A. (2019). Impacts of climate change on food security in Ethiopia: adaptation and mitigation options: A Review. In: Sustainability of Agricultural Environment in Egypt. 397–412. DOI: 10.1007/978-3-319-75004-0_23.

Altieri, M., Farrell, J., Hecht, S. (2018). Toward sustainable agriculture. In: Agroecology. The Science of Sustainable Agriculture, p.13.

Amara, D., Sanginga, N., Danso, S., Suale, D. (1996). Nitrogen contribution by multipurpose trees to rice and cowpea in an alley cropping system in Sierra Leone. Agroforestry Systems. 34: 119–128. DOI: https://doi.org/10.1007/BF 00148156.

Asati, B., Tomar, J., Asati P (2007). Agrihorticulture develoment in north eastern region. Himalayan Ecology. 15: 22-30.

Ashraf, M., Zulkifli, R., Sanusi, R., Tohiran, K., Terhem, R., Moslim, R., Norhisham, A., Ashton, A., Azhar, B. (2018). Alley-cropping system can boost arthropod biodiversity and ecosystem functions in oil palm plantations. Agriculture, Ecosystems and Environment. 260: 19–26. DOI: https:// doi.org/10.1016/j.agee.2018.03.017.

Atayese, M., Awotoye, O., Osonubi, O., Mulongoy, K. (1993). Com- -parisons of the influence of vesicular-arbuscular mycorrhiza on the productivity of hedgerow woody legumes and cassava at the top and the base of a hillslope in alley cropping systems. Biology and Fertility of Soils. 16: 198–204. DOI: https://doi.org/10.1007/BF00361408.

Balasubramanian, V. and Egli, A. (1986). The role of agroforestry in the farming systems in Rwanda with special reference to the Bugesera-Gisaka-Migongo region. Agrofororestry. Systems. 4: 271–289. DOI: https://doi.org/10.1007/BF00 048104.

Barreto, A. and Fernandes, M. (2001). Cultivo de *Gliricidia sepium* e *Leucaena leucocephala* em alamedas visando a melhoria dos solos dos tabuleiros costeiros. Pesquisa Agropecuária Brasileira. 36: 1287-1293. DOI: https:// doi.org/10.1590/ S0100-204X2001001000011.

Barrios, E., Valencia, V., Jonsson, M., Brauman, A., Hairiah, K., Mortimer, P., Okubo, S. (2017). Contribution of trees to the conservation of biodiversity and ecosystem services in agricultural landscapes. International Journal of Biodiversity Science, Ecosystem Services and Management. 14: 1-16. DOI: https://doi.org/10.1080/21513732.2017.1399167

Bayard, B., Jolly, C., Shannon, D. (2007). The economics of adoption and management of alley cropping in Haiti. Journal of Environmental Management. 84: 62-70. DOI: 10.1016/j.jenvman.2006.05.001.

Behera, S., Mahapatra, A., Mishra, P., Pattanayak, S. Panda, D. (2016). Performance of bamboo based agri-silvicultural systems in North Odisha, India. International Journal of Bio-Resource and Stress Management. 7: 218-221. DOI: 10.23910/IJBSM/2016.7.2.1542.

Bellow, J., Nair, P., Martin, T. (2008). Tree–Crop Interactions in fruit tree-based agroforestry systems in the western highlands of Guatemala: Component Yields and System Performance. In: Toward Agroforestry Design. Advances in Agroforestry, vol 4. [Jose S., Gordon A. (eds)] Springer, 111–131. DOI:

https://doi.org/10.1007/978-1-4020-6572-9_8.

Bhardwaj, D., Navale, M. Sharma, S. (2017). Agroforestry practices in temperate regions of the world. Agroforestry, Springer Singapore, pp.163–187. DOI: https://doi.org/10.1007/978-981-10-7650-3_6.

Bhatt, B., Sachan, M., Singh, K. (2006). Production potential of traditional agroforestry systems of Meghalaya: a case study. In Agroforestry in North East India: Oportunities and Challengues. Eds. B. Bahatt and K. Bujarbaruah. 337-349.

Bheemaiahi, G. and Subrahmanyam, V. (2004). Effect of green-leaf manuring on productivity of sunflower (*Helianthus annuus*) under guava (*Psidium guajava*)-based agri-horticultural system. Indian Journal of Agricultural Science. 74(10): 515-520.

Bhoyar, S., Deshmukh, H., Mahajan, R., Sharma, N. (2016). Traditional agroforestry systems practiced in lower hills of Melghat region, Chikhaldara tehsil, Maharashtra, India. Bioved. 27: 131–140.

Bhutia, P., Thakur, C., Sarvade, S., Bhardwaj, D., Kaushal, R., Bhutia, K. (2015). Varietal performance of pea (*Pisum sativum* L.) under peach based agroforestry system in mid hill conditions of Himachal Pradesh. Indian Journal of Agrofororestry. 17: 14–17.

Blair, W., Wu, X., Bhandari, D., Zhang, X., Hao, J., Devendra, B., Zhang, X., Junjie, H. (2016). Role of legumes for and as horticultural crops in sustainable agriculture. Organic Farming for Sustainable Agriculture. 185–211. DOI: https://doi.org/10.1007/978-3-319-26803-3_9.

Böhringer, A. and Leihner, D. (1996). A comparison of alley cropping and block planting systems in sub-humid Bénin. Agroforestry Systems. 35: 117–130. DOI: https://doi.org/10.1007/BF00122773.

Boreux, V., Kushalappa, C., Vaast, P. (2013). Interactive effects among ecosystem services and management practices on crop production: pollination in coffee agroforestry systems. Proceedings of the National Academy of Sciences of the United States of America. 110: 8387–8392. DOI: https://doi.org/10.1073/pnas.1210590110.

Borland, A., Wullschleger, S., Weston, D., Hartwell, J., Tuskan, G., Yang, X. Cushman, J. (2015). Climate-resilient agro--forestry: Physiological responses to climate change and engineering of crassulacean acid metabolism (CAM) as a mitigation strategy. Plant, Cell andamp; Environment. 38: 1833–1849. DOI: https://doi.org/10.1111/pce.12479.

Buyinza, J., Muthuri, C., Downey, A., Njoroge, J., Denton, M., Nuberg, I. (2019). Contrasting water use patterns of two important agroforestry tree species in the Mt Elgon region of Uganda. Australian Forestry. 1–9. DOI: https://doi.org/10.1080/00049158.2018.1547944.

Castro, P., Azul, A., Filho, W., Azeiteiro, U. (2019). Climate Change-Resilient Agriculture and Agroforestry.

Chang, S., Wang W., Zhu, Z. (1997). Temperate agroforestry in China. Temperate Agroforestry Systems. CAB International, pp.149–179.

Charbonnier, F., Roupsard, O., le Maire, G., Guillemot, J. (2017). Increased light-use efficiency sustains net primary productivity of shaded coffee plants in agroforestry system. Plant, Cell andamp; Environment. 40: 1592–1608. DOI: https://doi.org/10.1111/pce.12964.

Chaturvedi, O., Dagar, J., Handa, A., Kaushal, R., Pandey, V. (2018). Agroforestry Potential for Higher Productivity from Degraded Ravine Watersheds. Ravine Lands: Greening for Live--lihood and Environmental Security, Springer, Singapore, 335–360. DOI: https://doi.org/10.1007/978-981-10-8043-2_14.

Chauhan, K. (2016). Effect of tree leaf mulch on pearl millet (*Pennisetum glaucum*) in guava (*Psidium guajava*) based agri-horti system in Vindhyan. Thesis. Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

Chouchane, H., Krol, M., Hoekstra, A. (2018). Expected increase in staple crop imports in water-scarce countries in 2050. *Water Research X,* 1-100001. DOI: https://doi.org/10.1016/j.wroa.2018.09.001.

Dagar, J. and Tewari, J. (2016). Agroforestry research developments: anecdotal to modern science. In: Agroforestry Research Developments, NOVA, 1–45.

Das, B., Dhakar, M., Sarkar, P., Kumar, S. (2017). Performance of mango (*Mangifera indica*) based agri-horticultural systems under rainfed plateau conditions of eastern India. Indian Journal of Agricultural Sciences. 87: 521-527.

Das, S.K., Sharma, S., Sharma, K., Saharan, N., Nimbole, N., Reddy, Y. (1993). Land use options on a semi-arid Alfisol. American Journal of Alternative Agriculture. 8: 34-39. DOI: https://doi.org/10.1017/S0889189300004902.

De Giusti, G., Kristjanson, P., Rufino, M. (2019). Agroforestry as a climate change mitigation practice in smallholder farming: evidence from Kenya. Climatic Change. 153: 379-394. DOI: https://doi.org/10.1007/s10584-019-02390-0.

Dhakar, M., Sharma, B., Prajapat, K. (2013). Fruit crop-based cropping system: a key for sustainable production. Popular Kheti. 1: 39-45.

Dhara, P., Panda, S., Sarkar, S., Sarkar, S., Das, N. (2017). Agroforestry Systems Practised in New Alluvial Zone of West Bengal. International Conference on Agriculture, Food Science, Natural Resource Management and Eviromental Dynamics: Thetechnology, the People and Suistainable Development, New Delhi. 162-164.

Dhillon, W., Chauhan, S., Jabeen, N., Singh, C., Singh, N. (2012). Growth performance of intercropping system components and nutrient status of soil under horti-silvicultural system. International Journal of Environment and Resource. 1: 31–38.

Dhillon, W., Chohan, S., Singh, N., Rattan, C., Singh, D. (2010). Pre-bearing behaviour of some fruit crops under horti-silviculture system. Indian Journal of Horticulture. 67: 311-314.

Dhyani, S., Handa, A., Handa, A. (2013). Agroforestry in India and its potential for ecosystem services. Agroforestry Systems in India: Livelihood Security and Ecosystem, 345-365. DOI: https://doi.org/10.1007/978-81-322-1662-9_11.

Dubey, S., Sharma, N., Sharma, J., Sharma, A., Kishore, N. (2016).

Assessing citrus based intercropping in the irrigated areas of northern plains of Haryana. Indian Journal of Horticulture. 73: 441–444. DOI: 10.5958/0974-0112.2016.00094.3.

Ernst, S. (1994). Potential of alley cropping maize and cassava in south Benin, West Africa: evaluation of the establishing-phase. In: Potential of Alley Cropping Maize and Cassava in South Benin, West Africa: Evaluation of the Establishing -phase.160.

Evensen, C., Dierolf, T., Yost, R. (1995). Decreasing rice and cowpea yields in alley cropping on a highly weathered Oxisol in West Sumatra, Indonesia. Agroforestry Systems. 31: 1–19. DOI: https://doi.org/10.1007/BF00712052.

Fanish, S. and Priya, S. (2013). Review on benefits of agro forestry system. International Journal of Education and Research. 1: 1-12.

Feliciano, D., Ledo, A., Hillier, J., Nayak, D. (2018). Which agro--forestry options give the greatest soil and above ground carbon benefits in different world regions? Agriculture, Ecosystems and Environment. 254: 117–129. DOI: https://doi.org/10.1016/j.agee.2017.11.032.

Fleming, A., O'Grady, A., Mendham, D., England, J., Mitchell, P., Moroni, M., Lyons, A. (2019). Understanding the values behind farmer perceptions of trees on farms to increase adoption of agroforestry in Australia. Agronomy for Sustainable Development. 39:(1): pp. 9. DOI: https://doi.org/10.1007/s13593-019-0555-5.

Ghuman, B., Lal, R., Shearer, W. (1991). Land clearing and use in the humid Nigerian tropics: i. soil physical properties. Soil Science Society of America Journal. 55: 178-183. DOI: doi:10.2136/sssaj1991.03615995005500010031x.

Gogoi, B. (2015). Soil productivity management and socio-economic developmen through agroforestry in north-east India. Asian Journal of Science and Technology. 6: 2048–2053.

Grajales, J., Meléndez, V., Leopoldo, C., Sánchez, D. (2013). Native bees in blooming orange and lemon orchards in Yucatán, Mexico. Acta Zoológica Mexicana. 29: 437-440.

Groeneweg, D., Vischedijk, F., Appelman, J., Buiten, G. van, San Giorgi, X., Hautier, Y. (2018). Polycultures in agroforestry. 4th European Agroforestry Conference Agroforestry as Sustainable Land Use, Nijmegen, Netherlands 452-456.

Gunaga, R. (2017). Crop biomass and yield patterns of dominant agroforestry systems of Navsari district, Gujarat, India. Indian Journal of Agroforestry. 19: 72-78.

Handa, A. and Dhyani, S. (2015). Three decades of agroforestry research in India: Retrospection for way forward. Agricultural Research Journal. 52: 1–10. DOI: 10.5958/2395-146X.2015.00028.9.

Handa, A. and Newaj, R. (2017). Agroforestry systems and technologies for diferent agro-climatic regions of India. In: Forestry Technologies: A Complete Value Chain Approach. [T. Parthiban (ed.)], 177–193.

Handa, A., Toky, O., Dhyani, S., Chavan, S., Toky, O. (2016). Innovative agroforestry for livelihood security in India. World Agriculture. 7: 7–16.

Harrison, S. and Harrison, R. (2016). Financial modelling of mixed-species agroforestry systems in Fiji and Vanuatu, based on traditional tree species. In: Smallscale and Community Forestry and the Changing Nature of Forest Landscapes, Australia.

Hasan, M., Ahmed, M., Miah, M. (2008). Agro-economic performance of jackfruit-pineapple agroforestry system in madhupur tract. Journal of Agriculture and Rural Development. 6: 147–156. DOI: https://doi.org/10.3329/jard.v6i1.1672.

He, S., Luo, Z., Hua, M., Wang, X., Li, X., He, F., Fan, H. (2012). Study on young rubber/Tainong NO. 16 pineapple intercropping pattern. Guangdong Agricultural Sciences. 13: 16.

Hong, Y., Heerink, N., Jin, S., Berentsen, P., Zhang, L., van der Werf, W. (2017). Intercropping and agroforestry in China–Current state and trends. Agriculture, Ecosystems and Environment. 244: 52–61. DOI: https://doi.org/10.1016/j.agee.2017.04.019.

Hymavathi, H., Kandya, A., Patel, L. (2010). Beneficial effects of multiple plantation patterns in agroforestry systems. Indian Forester. 136: 465-475.

Iijima, M., Izumi, Y., Yuliadi, E., Sunyoto, Afandi, Utomo, M. (2003). Erosion control on a steep sloped coffee field in indonesia with alley cropping, intercropped vegetables and no-tillage. Plant Production Science. 6: 224-229. DOI: https://doi.org/10.1626/pps.6.224.

Jalón, S. de, Graves, A., Palma, J., Upson, M., Williams, A., Burgess, P. (2018). Modelling and valuing the environmental impacts of arable, forestry and agroforestry systems: a case study. Agroforestry Systems. 92: 1059-1073. DOI: https://doi.org/10.1007/s10457-017-0128-z

Jamar, L., Rondia, A., Lateur, M., Minet, L., Froncoux, A., Stilmant, D. (2016). Co-design and establishment of innovative fruit-based agroforestry cropping systems in Belgium. Acta Horticulturae. 1137: 347-350. DOI: 10.17660/Acta Hortic.2016.1137.48.

Jha, S. and Vandermeer, J. (2010). Impacts of coffee agroforestry management on tropical bee communities. Biological Conservation. 143: 1423–1431. DOI: https://doi.org/10.1016/j.biocon.2010.03.017.

Jose, S. (2009). Agroforestry for ecosystem services and environ--mental benefits: an overview. Agroforestry Systems. 76: 1–10. DOI: https://doi.org/10.1007/s10457-009-9229-7.

Jose, S., Allen, S., Nair, P. (2008). Tree-crop interactions: lessons from temperate alley-cropping systems. In: D. Rani R. Kumar S. Jose, H. Singh (eds.), Ecological Basis of Agroforestry. Taylor and Francis Group, U.S.A., 15–36.

Jose, S., Gillespie, A., Pallardy, S. (2004). Interspecific interactions in temperate agroforestry. Agroforestry Systems. 61: 237–255. DOI: https://doi.org/10.1023/B:AGFO.0000029002.85273.9b.

Juárez, D. and Fragoso, C. (2014). Comunidades de lombrices de tierra en sistemas agroforestales intercalados, en dos regiones del centro de México. Acta zoológica Mexicana. 30: 637–654.

Kanmegne, J. and Degrande, A. (2002). From alley cropping to rotational fallow: Farmers' involvement in the development of fallow management techniques in the humid forest zone of Cameroon. Agroforestry Systems. 54: 115-120. DOI: https://doi.org/10.1023/A:1015095320293.

Karshie, E., Ajayi, O., Gideon, P., Bulus, J. and Mtomga, N. (2017). Farmers' Participation in Agroforestry Practices in Taraba State, Nigeria: An Analysis of Benefits. Greener Journal of Agricultural Science. 7: 182–188.

Kass, D., Araya, J., Perreira, P., Sanchez, J. (1995). Ten years experience with alley farming in Central America. International Alley Farming Conference, Ibadan, Nigeria.

Khaki, B., Wani, A., Bhardwaj, D. (2016). Soil Carbon Sequestration under Different Agroforestry Land Use Systems. Indian Forester. 142: 734-738.

Kimaro, A., Sererya, O., Matata, P., Uckert, G., Hafner, J., Graef, F., Sieber, S., Rosenstock, T. (2019). Understanding the Multidimensionality of Climate-Smartness: Examples from Agroforestry in Tanzania. In: The Climate-Smart Agriculture Papers, Springer . 53–162. DOI: https://doi.org/10.1007/978-3-319-92798-5_13.

Klein, A., Steffan-Dewenter, I., Buchori, D., Tscharntke, T. (2002). Effects of land-use intensity in tropical agroforestry systems on coffee flower-visiting and trap-nesting bees and wasps. Conservation Biology. 16: 1003–1014. DOI: https://doi.org/10.1046/j.1523-1739.2002.00499.x.

Korwar, G. and Pratibha, G. (2005). Existing and improved agroforestry systems in low rainfall areas of India. Sustainable Agriculture Systems for the Drylands. 3: 11-23.

Krishnan, T. (2016). Effect of inorganic and organic fertilizer on growth and yeild of green gram (*Vigna radiata*) under guava (*Psidium guajava*) based agri-horti system, Thesis. Banaras Hindu University, Varanasi.

Kumar, B., Kumar, A., Dhyani, S. (2012). South Asian Agroforestry: Traditions, Transformations and Prospects. In: [Nair P., Garrity D. (eds)] Agroforestry - The Future of Global Land Use. Advances in Agroforestry, Springer, Dordrecht. 359–389. DOI: https://doi.org/10.1007/978-94-007-4676-3_19.

Kumar, M., Kumar, S., Uthappa, A., Kalappurakkal, S. (2018). Influence of *Prosopis cineraria* L. on microclimate conditions under agroforestry system in arid region of India. Indian Journal of Agroforestry. 20: 35-39.

Kumar, S., Shukla, A., Singh, H., Ahmed, A., Rai, A. (2016). Sustainable production of guava based hortipasture system with different in situ soil and moisture conservation in semi-arid region of India In: International. International Grassland Congress, New Delhi.

Lallianthanga, R., Colney, L., Sailo, R. (2014). A Remote Sensing and GIS approach for Land use Planning in Lunglei District, Mizoram, India. International Journal of Engineering Sciences and Research Technology. 2: 29–34.

Lasco, R., Espaldon, M., Habito, C. (2016). Smallholder farmers' perceptions of climate change and the roles of trees and agroforestry in climate risk adaptation: evidence from Bohol, Philippines. Agroforestry Systems. 90: 521–540. DOI: https://doi.org/10.1007/s10457-015-9874-y.

Lawson, G., Dupraz, C., Watté, J. (2018). Can silvoarable systems maintain yield, resilience and diversity in the face of changing environments? Agroecosystem Diversity. 145–168. DOI: https://doi.org/10.1016/B978-0-12-811050-8.00009-1.

Leihner, D., Ernst, R., Akondé, T., Steinmuller, N., Steinmüller, N. (1996). Alley cropping on an Ultisol in subhumid Benin. Part 2: Changes in crop physiology and tree crop competition. Agroforestry Systems. 34: 13–25. DOI: https://doi.org/10.1007/BF00129629.

Lose, S., Hilger, T., Leihner, D., Kroschel, J. (2003). Cassava, maize and tree root development as affected by various agro--forestry and cropping systems in Benin, West Africa. Agriculture, Ecosystems and Environment. 100: 137–151. DOI: https://doi.org/10.1016/S0167-8809(03)00182-8.

Maheswarappa, H., Palaniswami, C., Dhanapal, R., Subramanian, P. (2010). Coconut based intercropping and mixed cropping systems. Coconut Based Cropping/Farming Systems, 9-31.

Malézieux, E., Crozat, Y., Dupraz, C., Laurans, M., MakowskI, D., Ozier, H., Rapidel, B., de Tourdonnet, S. (2009). Mixing plant species in cropping systems: concepts, tools and models: a review. In: [Lichtfouse E., Navarrete M., Debaeke P., Véronique S., Alberola C. (eds)] Sustainable Agriculture. Springer. 329–353. DOI: https://doi.org/10.1007/978-90-481-2666-8_22 .

Malhotra, S. (2017). Horticultural Crops and Climate Change-A Review. Indian Journal of Agricultural Sciences. 87: 12-22.

Mauricio, R., Ribeiro, R., Paciullo, D., Cangussú, M., Murgueitio, E., Chará, J., Estrada, M. (2019). Silvopastoral systems in latin america for biodiversity, environmental and socio--economic improvements. Agroecosystem Diversity. 287–297. DOI: https://doi.org/10.1016/B978-0-12-811050-8.00018-2.

Mbow, C., Van Noordwijk, M., Luedeling, E., Neufeldt, H., Minang, P., Kowero, G. (2014). Agroforestry solutions to address food security and climate change challenges in Africa. Current Opinion in Environmental Sustainability. 6: 61–67. DOI: https://doi.org/10.1016/j.cosust.2013.10.014.

Mirjha, P. and Rana, D.(2016). Yield and yield attributes, system productivity and economics of mango (*Mangifera indica*)-based intercropping systems as influenced by mango cultivars and nutrient levels. Indian Journal of Agronomy. 61: 307–314.

Monteith, J. Ong, C., Corlett, J.(1991). Microclimatic interactions in agroforestry systems. Forest Ecology and Management. 45: 31–44. DOI: https://doi.org/10.1016/0378-1127(91)90204-9.

Moura, A., Aguiar, A., Agostini, T., Moura, E. (2017). Food quantity and quality of cassava affected by leguminous residues and inorganic nitrogen application in a soil of low natural fertility of the humid tropics. Bragantia, 76: 406–415. DOI: https://doi.org/10.1590/1678-4499.007.

Murray, G. and Bannister, M. 2004). Peasants, agroforesters and anthropologists: A 20-year venture in income-generating trees and hedgerows in Haiti. Agroforestry Systems. 61-62: 383–397. DOI: https://doi.org/10.1023/B:AGFO.0000029012.28818.0c.

Nair, P., Kumar, B., Nair, V. (2009). Agroforestry as a strategy for carbon sequestration. Journal of Plant Nutrition and Soil

Science. 172: 10–23. DOI: https://doi.org/10.1002/jpln.200800030.

Nedunchezhiyan, M., Jata S., Gangadharan B. (2012). Sweet potato-based cropping systems. Fruit, Vegetable and Cereal Science and Biotechnology. 6: 11–16.

Nerlich, K., Graeff-Hönninger, S. and Claupein, W. (2013). Agroforestry in Europe: a review of the disappearance of traditional systems and development of modern agroforestry practices, with emphasis on experiences in Germany. Agroforestry Systems. 87: 475–492. DOI: https://doi.org/10.1007/s10457-012-9560-2.

Niether, W., Schneidewind, U., Fuchs, M., Schneider, M., Armengot, L. (2019). Below- and aboveground production in cocoa monocultures and agroforestry systems. Science of The Total Environment. 657: 558–567. DOI: https://doi.org/10.1016/j.scitotenv.2018.12.050.

Nissen, T. and Midmore, D. (2002). Stand basal area as an index of tree competitiveness in timber intercropping. Agroforestry Systems. 54: 51–60. DOI: https://doi.org/10.1023/A:1014273304438.

Nolte, C., Tiki, T., Badjel, S., Gockowski, J. (2005). Groundnut, maize and cassava yields in mixed-food crop fields after calliandra tree fallow in southern Cameroon. Experimental Agriculture. 41: 21–37. DOI: https://doi.org/10.1017/S0014479704002145.

Oelbermann, M., Voroney, P., Kass, D., Voroney, R., Kass, D. Voroney, P., Kass, D. (2004). *Gliricidia sepium* Carbon Inputs and Soil Carbon Pools in a Costa Rican Alley Cropping System. International Journal of Agricultural Sustainability. 2: 33–42. DOI: https://doi.org/10.1080/14735903.2004.9684565.

Okon, I. (2011). Tree pruning regimes on three cassava genotypes. Insight Botany. 1: 39–44. DOI: 10.5567/BOTANY-IK.2011.39.44.

Osonubi, O., Atayese, M., Mulongoy, K. (1995). The effect of vesicular-arbuscular mycorrhizal inoculation on nutrient uptake and yield of alley-cropped cassava in a degraded Alfisol of southwestern Nigeria. Biology and Fertility of Soils. 20: 70–76. DOI: https://doi.org/10.1007/BF00307844.

Ouma, G. and Jeruto, P. (2010). Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops: A review. Agriculture and Biology Journal of North America. 1: 1098–1105. DOI: 10.5251/abjna.2010.1.5.1098.1105.

Pande, V., Kurothe, R., Kumar, G., Singh, H., Tiwari, S. (2018). Economic assessment of agri-horticulture production systems on reclaimed ravine lands in Western India. Agroforestry Systems. 92: 195-211. DOI: https://doi.org/10.1007/s10457-016-0025-x.

Pardon, P., Reubens, B., Mertens, J, Verheyen, K., De Frenne, P., De Smet, G. (2018). Effects of temperate agroforestry on yield and quality of different arable intercrops. Agricultural Systems. 166: 135–151. DOI: https://doi.org/10.1016/j.agsy.2018.08.008.

Pareek, O. and Awasthi, O. (2008). Horticulture-based farming systems for arid region. Diversification of Arid Farming System. 12–22.

Paul, C., Weber, M., Knoke, T. (2017). Agroforestry versus farm mosaic systems – Comparing land-use efficiency, eco--nomic returns and risks under climate change effects. Science of The Total Environment. 587–588: 22–35. DOI: https://doi.org/10.1016/j.scitotenv.2017.02.037.

Paut, R., Sabatier, R., Tchamitchian, M. (2018). Benefits of diversified horticultural systems: assessment with the modern portfolio theory. International Farming Systems Association (IFSA) Symposium, Farming Systems: Facing Uncertainties and Enhancing Opportunities, 1-5 July 2018, Chania, Crete, Greece (Pp. 1-9). International Farming Systems Association (IFSA) Europe.

Pavlidis, G. and Tsihrintzis, V.(2018). Environmental benefits and control of pollution to surface water and groundwater by agroforestry systems: a Review. Water Resources Management. 32: 1-29. DOI: https://doi.org/10.1007/s11269-017-1805-4.

Raj, A, (2017). Sustainable agriculture with agroforestry: adoption to climate change. New India Publ. Agency (NIPA), New Delhi 287–293.

Raj, A., Jhariya, M., Yadav, D., Banerjee, A. (2019). Agroforestry with Horticulture: A New Strategy Toward a Climate-Resilient Forestry Approach. Agroforestry and Climate Change. 67–96.

Rajasekharan, P. and Veeraputhran, S. (2002). Adoption of intercropping in rubber smallholdings in Kerala, India: a tobit analysis. Agroforestry Systems. 56: 1–11. DOI: https://doi.org/10.1023/A:1021199928069.

Rajput, P. (2016). Carbon storage, soil enrichment potential and bio-economic appraisal of different land use systems in mid hill and sub-humid zone-II of Himachal Pradesh.

Rakhi, K. (2015). Comparative performance of different crops in open field and custard apple (*Annona squamosa*) based agri-horticultural system, Banaras Hindu University Varanasi-India.

Rani, S., Benbi, D., Rajasekaran, A., Chauhan, S. (2016). Litterfall, decomposition and nutrient release patterns of different tree species in Taran Taran district of Punjab, India. J. Applied and Natural Science Foundation. 8: 1260-1266. DOI: https://doi.org/10.31018/jans.v8i3.951.

Rao, M., Palada, M., Becker, B., Becker, B. (2004). Medicinal and aromatic plants in agroforestry systems. New Vistas in Agroforestry. 107–122. DOI: https://doi.org/10.1007/978-94-017-2424-1_8.

Re, G., Piluzza, G., Sanna, F., Molinu, M., Sulas, L. (2019). Polyphenolic composition and antioxidant capacity of legume-based swards are affected by light intensity in a Mediterranean agroforestry system. Journal of the Science of Food and Agriculture. 99: 191–198. DOI: https://doi.org/10.1002/jsfa.9160.

Saha, R., Chaudhary, R., Somasundaram, J. (2012). Soil health management under hill agroecosystem of North East India. Soil Management for Sustainable Agriculture. 9. DOI: https://doi.org/10.1155/2012/696174.

Salami, A. and Osonubi, O. (2003). Influence of mycorrhizal inoculation and different pruning regimes on fresh root yield of alley and sole cropped cassava (*Manihot esculenta*) in Nigeria. Archives of Agronomy and Soil Science. 49: 317–323. DOI: https://doi.org/10.1080/036503403100 0148390.

Salami, A., Odebode, A., Osonubi, O. (2005). The use of Arbuscular Mycorrhiza (AM) as a source of yield increase in sustainable alley cropping system. Archives of Agronomy and Soil Science. 51: 385–390. DOI: https://doi.org/10.1080/03650340500 133175.

Sangwan, A., Dhillon, W., Chauhan, S., Singh, N., Bath, M. (2017). Performance of Garlic under Agri-Horti-Silvicultural System in Relation to Physiological Behaviour and Yield. Indian Journal of Ecology. 43: 724–729.

Sangwan, A., Dhillon, W., Singh, H., Chohan, S., Gill, P. (2015). Influence of horti-silviculture combinations on pre-bearing growth and physiological parameters of pear. Indian Journal of Horticulture. 72: 21-27. DOI: 10.5958/0974-0112.2015.00004.3.

Santos, P., Crouzeilles, R., Sansevero, J. (2019). Can agroforestry systems enhance biodiversity and ecosystem service provision in agricultural landscapes? A meta-analysis for the Brazilian Atlantic Forests. Forest Ecology and Manage--ment. 433: 140–145. DOI: https://doi.org/10.1016/j.foreco. 2018.10.064.

Sereke, F., Graves, A., Dux, D., Palma, J., Herzog, F. (2014). Innovative agroecosystem goods and services: key profitability drivers in Swiss agroforestry. Agronomy for Sustainable Development. 35: 759–770. DOI: https://doi.org/10.1007/s13593-014-0261-2.

Shanker, C. and Solanki, K. (2000). Agroforestry: An ecofriendly land-use system for insect management. Outlook on Agriculture. 29: 91-96. DOI: https://doi.org/10.5367/000 000000101293095.

Sharma, I., Singh, R., Tiwari, P., Sharma, P. (2017). Effect of different spacing and phosphorus levels on growth and yield parameters of mungbean under guava based Agri-horti System. Journal of Pharmacognosy and Phyto--chemistry. 993-996.

Singh, A., Sharma, R., Chauhan, S., Arora, D. (2016). Microclimate and turmeric yield under different tree species. Journal of Agrometeorology. 18: 320–323.

Singh, B. and Bhardwaj, D. (2014). Economic analysis of different land use systems in temperate North-Western Himalayas. Agri Bio Research Publishers. 19: 152–156.

Singh, B. and Dwivedi, S. (2018). Horticulture-based Agroforestry Systems for Improved Environmental Quality and Nutritional Security in Indian Temperate Region. In: Agroforestry, Springer, Singapore, [T. V. Dagar J. (ed.)], 245–261. DOI: https://doi.org/10.1007/978-981-10-7650-3_9.

Singh, G. (1987). Alley farming in the semi-arid regions of India. Agroforestry a Decade of Development. pp.117–138.

Smith, B.D., Pearce, B., Wolfe M. (2013). Reconciling productivity with protection of the environment: Is temperate agro--forestry the answer? Renewable Agriculture and Food Systems. 28: 80–92. DOI: https://doi.org/10.1017/S17 42170511000585.

Song, B., Wu, H., Kong, Y., Zhang, J., Du, Y., Hu, J., Yao, Y. (2010). Effects of intercropping with aromatic plants on the diversity and structure of an arthropod community in a pear orchard. BioControl. 55: 741–751. DOI: https://doi. org/10.1007/s10526-010-9301-2.

Sureshbhai, P., Thakur, N., Jha, S., Kumar, V. (2017). Productivity and carbon sequestration under prevalent agroforestry systems in Navsari District, Gujarat, India. International Journal of Current Microbiology and Applied Sciences. 6: 3405–3422. DOI: https://doi.org/10.20546/ijcmas.2017. 609.419.

Suvera, A., Thakur, N., Bioscan, S., Jha, K. (2015). Herbage and essential oil yield of *Ocimum spp.* Intercropped under *Pongamia pinnata* based silvi-medicinal systems in Gujarat, India. The Bioscan. 10: 81–85.

Swain, S. (2016). Influence of intercropping systems on soil health, productivity and quality of guava (*Psidium guajava*) in Eastern India. Journal of Plant Nutrition. 39: 2037–2046. DOI: https://doi.org/10.1080/01904167.2016.1187751.

Thakur, P., Dutt, V., Sehgal, S., Kumar, R. (2005). Diversification and improving productivity of mountain farming systems through agroforestry practice in Northwestern India. AFTA 2005 Conference Proceedings.

Tiwari, P., Kumar, R., Thakur, L., Salve Scholar, A., Parmar, Y. (2017). Agroforestry for Sustainable Rural Livelihood/ : A Review. International Journal of Pure and Applied Bioscience. 5: 299–309. DOI: http://dx.doi.org/10.18782/2320-7051. 2439.

Tonye, J., Duguma, B., Tiki, T. (1994). Stepwise approach to alley cropping technology development and transfer in the forest zone of Cameroon. Agroforestry Systems. 28: 269–278. DOI: https://doi.org/10.1007/BF00704760

Toppo, P. and Raj, A. (2018). Role of Agroforestry Systems in Climate Change Mitigation. Journal of Pharmacognosy and Phyto--chemistry. 7: 241-243.

Tsuji, L., Wilton, M., Spiegelaar, N., Oelbermann, M., Barbeau, C., Solomon, A., Tsuji, C., Liberda, E., Meldrum, R., Karagatzides, J. (2019). Enhancing food security in subarctic canada in the context of climate change: The harmonization of indigenous harvesting pursuits and agroforestry activities to form a sustainable import-substitution strategy. Sustainable Solutions for Food Security, Springer. 409–435. DOI: https://doi.org/10.1007/978-3-319-77878-5_20.

Udawatta, R., Gantzer, C. Jose, S. (2017). Agroforestry Practices and Soil Ecosystem Services. Soil Health and Intensification of Agroecosytems. 305-333. DOI: https://doi.org/10.10 16/B978-0-12-805317-1.00014-2.

United Nations (2015). World Population Prospects: The Revision. Working Paper No. ESA/P/WP.241., New York.

Upadhyay, M. and Yadava, M. (2009). Agroforestry System Practiced in Nepal. Tribhuvan University Institute of Forestry Office of the Dean Pokhara.

Vaast, P., Harmand, J., Rapidel, B., Jagoret, P., Deheuvels, O. (2016). Coffee and cocoa production in agroforestry-A climate-smart agriculture model. Climate Change and Agriculture Worldwide, Springer Netherlands, 209–224. DOI: https://doi.org/10.1007/978-94-017-7462-8_16.

Verma, K. and Thakur, N.(2010). Economic analysis of Ashwagandha (*Withania somnifera*) based agroforestry land use system in mid hill Western Himalayas. Indian Journal of Agroforestry, 12: 62-70.

Verma, P., Bijalwan, A., Dobriyal, M., Swamy, S., Thakur, T., Swamy, S. (2017). A paradigm shift in agroforestry practices in Uttar Pradesh. Current Science. 112: 509-516.

Wang, Q., Xu, Z., Hu, T., Rehman, H., Chen, H., Li, Z., Ding, B., Hu, H. (2014). Allelopathic activity and chemical constituents of walnut (*Juglans regia*) leaf litter in walnut–winter vegetable agroforestry system. Natural Product Research, 28: 2017-2020. DOI: https://doi.org/10.1080/14786419.2014.913245.

Weersum, K. (1982). Tree gardening and taungya on Java: examples of agroforestry techniques in the humid tropics. Agroforestry Systems. 1: 53–70. DOI: https://doi.org/10.1007/BF00044329.

Williams, P. and Gordon, A. (1992). The potential of intercropping as an alternative land use system in temperate North America. Agroforestry Systems. 19: 253–263. DOI: https://doi.org/10.1007/BF00118783.

Wilson, G., Kang, B., Mulongoy, K. (1986). Alley cropping: trees as sources of green-manure and mulch in the tropics. Biological Agriculture and Horticulture. 3: 251–267. DOI: https://doi.org/10.1080/01448765.1986.9754474.

Workman, S., Allen, S., Jose, S. (2003). Agroforestry potential in the southeastern United States: perceptions of landowners and extension professionals. Agroforestry Systems. 59: 73–83. DOI: https://doi.org/10.1023/A:1026193204801.

Wu, J., Liu, W., Chen, C. (2016). Can intercropping with the world's three major beverage plants help improve the water use of rubber trees? Journal of Applied Ecology. 53: 1787–1799. DOI: https://doi.org/10.1111/1365-2664.12730.

Yadav, A. (2017). Effect of inorganic and organic fertilizer on growth and yield of black gram (*Vigna mungo*) under guava (*Psidium guajava*) based agri-horti system, Thesis. Institute of Agricultural Sciences, BHU. Varanasi.