**Strategies For Soil Health Restoration To Reduce Risks Of Soil Degradation For Crop Productivity. A Review**

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**ABSTRACT**

 The demand for food, coupled with the increased world population which is projected to reach 9.5 billion by 2050, compels an increase in agricultural productivity by 70%. To sustain and achieve the desired increase in agricultural production, soil degradation needs to be curtailed. soil degradation has led to reduced soil health, lower crop productivity and farm profitability. Among the key soil degradation processes are accelerated erosion, decline in soil organic carbon, lower abundance, activity, and diversity of beneficial organisms, loss of soil fertility and nutrient imbalance as well as acidification and salinization. The issue of degradation in the soil can be ameliorated via a restorative land use and adoption of soil health recommended management practices. The strategies for soil health restoration to reduce risks of soil degradation are to reduce soil erosion, improve soil organic carbon and nitrogen budgets, increase the activity and species diversity of soil biota and improve structural stability and pore geometry. Improving soil health such as increasing soil organic carbon pool, improving soil structure and soil fertility can reduce risks of any forms of soil degradation while improving the environment. Enhancing the soil organic carbon to above the critical level of 10 to 15 g/kg is significantly essential to commence the restorative trends. There are some site-specific techniques adopted to restore soil quality which include conservation agriculture, integrated nutrient management, continuous vegetative cover such as residue mulch and cover cropping, and controlled grazing. Therefore, the paper seeks to reduce the impact of soil degradation for sustainable agricultural productivity by reducing losses and increasing soil, water, and nutrient use efficiency.

**Keywords:** soil quality; soil degradation; soil functions; desertification; soil carbon sequestration

**I. INTRODUCTION**

 Over the years the population of developing countries has tremendously increased, leading to a large proportion of them depend on agriculture for their livelihood(Van *et.al*, 2014). In fact, more than a billion categories of these people who are small-scale farmers cultivate less than 2 hectare of agricultural farm land (IFAD 2010). With respect to dearth of resources and inability to access agricultural inputs, there is need to manage and sustain soil quality for improved ecosystem services. Soil degradation has remain a big threat to the world especially tropical and subtropical region with its attendant consequences to lower productivity, and it is understood as a change in the soil health status resulting in a diminished capacity of the soil ecosystem to provide goods and services for its beneficiaries(Leon *et.al*, 2014). Accelerated soil degradation has reportedly affected so many agricultural farm lands by negatively impacting on crop production, dampening economic growth and development (Bini,2009). Above all, there are also health risks associated with soil erosion and other degradation processes. According to Lai, 2009,soil degradation is the loss of soil's production capacity in terms of loss of soil fertility, soil biodiversity, and degradation with an attendant reduction in ecosystem functions and services. Most soil degradation can occur anthropogenic ally by land misuse and soil mismanagement, and naturally due to climate change and related factors. Hence, there are four types of soil degradation which include physical degradation, chemical degradation, biological degradation as well as ecological degradation.

 Soil physical degradation involves the destruction of soil structure, dispersion of soil particles, crusting, sealing, compaction, low water infiltration, reduced root penetration, water logging and increased surface runoff, accelerated erosion(wind and water), endangered or extinct soil, un-optimal soil temperature which fluctuates, and inhibited aeration. These processes increase propensity for desertification. Soil chemical degradation is characterized by loss of nutrients or organic matter, acidification, salinization, low cation exchange capacity, soil pollution as a result of high Aluminium or Manganese toxicities, Calcium or Magnesium deficiencies, elemental imbalance, leaching of NO3-N or other essential plant nutrients, or contamination by industrial wastes or by-products, and fertility decline. The removal of nutrients reduces the capacity of soils to support crop growth and production which cause acidification. Soil biological degradation reflects decline in soil organic matter/ soil organic carbon, loss in soil biodiversity and soil borne pathogen, loss of soil C sink capacity, and high emissions of greenhouse gases from soil into the atmosphere. The significant threat pose by soil biological degradation is that soil becomes a net source of greenhouse gas emissions such as carbon dioxide(CO2) and methane(CH4) rather than a sink. Soil ecological degradation involves a combination of other three soil deterioration, which leads to disruption in ecosystem functions and services such as disruption in nutrient cycling, loss of nutrients and carbon, decline in use efficiency of inputs, water infiltration and purification, perturbations of the hydrological cycle, and a decline in net biome productivity and inhibited denaturing of pollutants. The generalised decline in soil quality has strong positive feedbacks leading to a decline in ecosystem services and reduction in nature conservancy. Therefore, the paper seek to review the role of soil resources in provisioning essential ecosystem services as well as outlining the impacts of soil deterioration on decline in ecosystem services, and identify strategies for restoring soil health to mitigate risks of soil degradation for sustainable crop production.

**A. Soil and Ecosystem Services**

 Soil is a non-renewable resources**,** and is the essence of all terrestrial life and a cultural heritage(Bini et.al,2015). The Soil is threatened by degradation via natural and anthropogenic factors. Soils have a large function in the health of ecosystem functions in the world. It is the link between the air, water, rock, and organisms, and is responsible for many different functions in the natural world called ecosystem services. These soil functions include air quality and composition, temperature regulation, carbon and nutrient cycling, water cycling and quality, natural waste( decomposition) treatment and recycling, and habitat for most living things and their food. Human beings and other living things could not function and survive without these soil functions. In order words, soil quality /health need to be restored to increase these services (Robinson *et. al*,2012). Soils are the environment in which seeds germinate. They provide heat, nutrients, and water that are made available for use to nurture plants and crops. These plants in association with other living things and microbial organisms create a niche for ecosystems. Ecosystems solely depend on the soil, and soils can assist to determine the location of ecosystem. Thereby, these plants provide essential and valuable habitat and food sources for the growth of animals, microorganisms etc. A well protected soil curtails erosion. A wind blow across the surface of the soils create wind erosion and as such suspended the soil particles or debris in the air. These are easily inhaled, consequently causing major respiratory challenges. These soil particles may have fungi and bacteria, causing infection and diseases. Soils play a role in temperature regulation which is important in many processes such as chemical reactions and biological interactions. These include processes like seed germination, bugs and microbial agents living in the environment, and how quickly plant and animals break down. With soils that are colder, there is less biological and chemical reactions than warmer soils, hence more carbon can be stored in the soils. Soils is also the storehouse of carbon and play a key role in nutrient cycling. Soil contains great quantity of stored carbon, and the natural processes are all cyclical. Carbon cycles involves carbon storage in fossil fuels, soils, oceans and rocks. Processes in the soil affect the balance of organic carbon, and when released to the air formed carbon dioxide. These processes also happen with nitrogen, phosphorus and other chemical materials. Soil acts as sponge, soaking water into the soil in order to filter it. As the water filtered into the soils, plants, microbes and other living things utilize them. The water moves underground as aquifers and rivers. When soils are not protected, soils and nutrients pollute the water, washing away into streams and oceans. In addition, application of excess nitrogen and phosphorous fertilizers can sieve through and result in runoff to rivers and thereby contaminate groundwater bodies. With this, most freshwater systems having contaminated with either phosphorous or nitrogen can breed the growth of photosynthetic organisms. Soils have the ability to convert waste products to a better reusable materials. Humans and other living organisms use soils to decompos waste materials to a new one. Once organisms die, it falls to the soil which lead the biological and chemical processes to convert these dead materials as food for living organisms (Robinson *et. al*,2012)..

**B. Soil Organic Carbon and Its Impact on Soil health.**

The Soil organic carbon is one of the defining constituent of soil (Krupenikor *et.al*, 2011). Soil organic carbon remains the reliable indicator of checkmating accelerated erosion(Rayan *et.al*, 2010). Erosion decimates the soil organic Carbon, together with other nutrients such as nitrogen, phosphorous and sulphur. In addition, loss of soil organic carbon serve as a principal cause of soil degradation. Some methods are developed to main soil organic carbon above the threshold or critical level of 10 to 15 g/kg (1.0%–1.5%), which is essential for reducing soil degradation risks and reversing degradation trends. Such methods include the following: Integrated nutrient management is one method that embodies sustainable management of soil organic carbon and its related attributes (Vanlauwe *et.al*,2012). Adoption of integrated nutrient management practices can result to a positive soil carbon budget which can not only increase crop productivity but also sequester more carbon dioxide( CO2) into the soil organic carbon pool. Enhancing the soil organic carbon pool is important to sustain and maintain soil fertility and crop productivity. The organic carbon of agricultural soils is severely diminished by over-exploitation of natural resources(Lar,2004). The soil can be managed to increase soil carbon and vegetation to mitigate the degraded agro-ecosystem services. In addition to soil organic carbon, soil moisture content is another major indicator of climate change(Eaton *et.al*, 2012). In addition to variations in soil moisture content, expected global warming may also affect the rate of decomposition of soil organic carbon ,including that of fine woody debris. Together with the sever effects of soil erosion and other soil deterioration processes, the soil organic carbon is also threat to unfavourable climate change and associated changes in temperature and moisture contents. The imposed soil deterioration process is severely increased by the interaction between processes, factors and causes of soil degradation. Processes include the types of soil degradation. Factors which consist of agents of degradation may relate to natural or anthropogenic factors such as climate, physiographic, socio-economic or ethnic/cultural parameters. There are few causes of soil degradation such as deforestation, land use conversion, extractive farming practices or over-exploitation, excessive grazing, excessive plowing, and these specific activities aggravate the adverse effects of processes and factors. So, these processes and factors are critical to restoring soil health and mitigating degradation (Melillo *et.al,* 2010).

**C. Soil Health Index**

 The soil organic carbon remains a key indicator of soil health, and an important factor of agricultural sustainability. Furthermore, there are other parameters of soil organic carbon are its depth distribution, attributes (which may be physical, chemical and biological), and the turnover rate of soil organic carbon. Also, indicators of soil physical quality which include soil aggregates; seal crusting and compaction; porosity; infiltration rate and amount of water transmission and retention as plant-available water capacity; aeration and gaseous exchange; rooting depth; heat capacity and temperature content of the soil. In the same vein, soil chemical indicators are soil pH, cation exchange capacity, availability of nutrient; and favourable elemental balance and dearth of any toxicity or deficiency( Gugino,2009). Soil biological indicators which are relevant are microbial biomass carbon, biodiversity of soil fauna and flora, lack of pathogens and pests as indicated by a soil’s disease-suppressive attributes. These properties such as physical, chemical and biological status of the soil affect crop productivity, water use efficiency, nutrients and other inputs availability, and can sustain other management systems. Soil health indicators simply vary within soil types, climates and land uses. A technique called reflectance spectroscopy has been developed and proposed to assess soil health (Paz-kagan *et.al*, 2014). This technique combined the characterization of physical, chemical and biological attributes to assess and show the status of a soil and how well the soil functions for a particular purpose.

**D. Conservation Agriculture and Soil Health**

 According to Lar, 2015, there are four basic principles that associate with conservation agriculture. They include retention of crop residue mulch, integration of a cover crop in the rotation cycle, use of integrated nutrient management that have combination of inorganic(synthetic) and bio fertilizers(organic fertilizers),and eradication of soil mechanical disturbances. Conversation agriculture has many benefits such as decrease in consumption of fuel and high soil carbon sequestration which can be properly implemented on suitable suitable soil types. Use of tractors to till the soil, if the usage is reduced can properly eliminate the consumption of fossil fuels. Further, a high soil organic carbon occur in soils which are not prone to accelerated erosion, and with those which have improved management strategies. There is need to incorporate the acceptable tillage systems which can restore soil health, reduce soil erosions , increase water use efficiency and fertilizers; reduce soil organic carbon and deplete nutrient availability.

 The following factors can degrade soil health, deplete soil organic carbon as well as increase the risks of soil erosion: indiscriminate use of tillage practices such as plowing, together with excessive removal of plant residues and inappropriate application of synthetic fertilizers (So,2001). However, there is need to convert plow tillage practice to conservation agriculture, especially on vulnerable sloping soils to water and wind erosion under conventional practice, could be conservation-effective, overturn degradation trends, and hence, increase soil health restoration processes. Incorporation of crop residue mulch as well as addition of a cover crop in the crop rotation systems while reducing fallows could conserve soil and water, and improve Soil organic carbon in the soil surface layer. According to Pittelkow *et.al*,2015, soil aggregates can be improved, and soil carbon encapsulated with micro aggregates by improving soil biodiversity, increasing the activity of earthworms and termites. Enhancing the elemental cycling, and increasing the cycling of carbon and water, could imprpove soil carbon sink capacity and soil profile depth via established bioturbation by earthworms, and application of some deep-root plants. With adequate improvement of soil health , there will be improved total biome productivity, increase in water and nutrient use efficiencies, and enhance biomass carbon in the ecosystem. Other factors which could restore soil health and reduce degradation may be an improvements in rhizospheric processes facilitated by biotic mechanisms. Furthermore, to enhance soil quality, it requires more than the input of new varieties of crops and synthetic fertilizers.

**E. Soil Fertility Management to Restore Soil Health**

 The ability to sustain and improve crop productivity via reducing losses and enhancing the water and nutrient use efficiency, is only achievable by improvement of soil quality as well as soil chemical quality or soil fertility. Although not the only way to increase soil fertility, The adoption and application of integrated nutrient management to increase soil fertility, serves as an effective method for achieving sustainable crop production. Low crop productivity occurs as a result of reduction in nutrient availability and loss of soil fertility. Abiven *et.al*,2008 reported that one of the major strategy to increase soil fertility as well as improving the soil physical attributes i.e structural stability or aggregates is the application of soil organic amendments, in conjunction with recycling urban wastes. Though, application of nitrogen fertilizer is vital to improving soil fertility and crop production. Its overuse can results to soil and water pollution.

**F. Soil Health and Water Resources**

 A healthy soil is the bedrock for sound and sustainable economy, environment, and terrestrial biosphere. There is a correlation existing between health of a soil and water resources, perhaps the health of coastal ecosystems. Tsatsaros *et.al*,2013 reported that land use transformation have an effect on the quality of water and pollutant. Chemical waste materials of agricultural origin, when released to the environment find its way to the water bodies leading to contamination, water pollution and eutrophication problems. According to Atapattus *et.al*, 2009, the adverse impact of agricultural chemicals on the surface of the soil which may have leached to the water bodies are river desiccation, ground water decrease, surface and ground water pollution, accelerated erosion, sedimentation, salinization, and nutrient reduction. Agronomic practices such as irrigation remains one of the vital management strategy for improved crop productivity. Improper use of irrigation waters has heightened the challenges with saline-sodic soils which affect the irrigated lands. In addition, some soils are threatened by wastes contaminants via sub-surface agriculture irrigation and drainage. These soils are affected by chemical toxicity problems in aquatic life and other animals due to water contaminants which drained through the soil sub-surface to the water bodies. Dakoure *et.al*, 2013 pointed out that saline challenges are complicated by the reapplication of untreated waste gray water) in agriculture, where water shortages are marginally of low quality. So, the ability to restore the quality of soil within ecosystems remain critical in improving and sustaining water quality. In order to achieve that it is important to fine tune ways for improved integrated management of soil and water resources because of the soil-water-waste interconnectivity. In as much as integrated water management practices remain useful, the soil-water interconnectivity cannot be overlooked. Apitz *et.al*,2002 showed that there is a need to manage contaminated sediments which is one of the crucial component of the soil-water interconnectivity.

**G. Strategies for restoring soil health**

 Soil health restoration is a crucial process for reducing the risks of soil degradation and ensuring sustainable crop productivity. Lar, 2015 reported that there is need to decarbonise the decrease soil organic carbon pool, which is essential to numerous soil functions. This requires continuous application of biomass carbon and essential mineral elements such as nitrogen, phosphorous and sulphur. Here, are some basic strategies to promote and restore soil health and eliminate soil degradation; minimizing losses from soil solum ; creating a positive soil carbon budget, while enhancing biodiversity; and strengthening water and elemental cycling. Others include cover cropping, No-Till or reduced tillage, organic matter management, Mulching, Reduction of over application of chemical fertilizers and pesticides, Conservation tillage, Terracing and contour farming , companion planting, Soil testing and balanced fertilization, water management, Agro forestry and windbreaks, and Bio-char application.

**1. Management of Soil erosion**

 Soil erosion should be prevented to the tolerable limits of presumed value of 12.5 Mg/ha per year. Accelerated erosion also diminishes the soil organic carbon and nutrient contents. The enrichment ratio of soil organic carbon, clay and other essential plant nutrients such as nitrogen, phosphorus and sulphur are far more greater one ,and most cases more than five because of the removal of these mineral constituents. Helman *et.al*, 2014 revealed that converting plow tillage to conservation agriculture decrease the threat associated with soil erosion and nutrient los with its other benefits. The two major cause of accelerated soil erosion remains land misuse and soil mismanagement. Over-grazing and the trampling effect of animals can degrade soil structure, decrease water infiltration, increase runoff, and hence exacerbate soil erosion, which can cause adverse loss to economic development.

**2. Enhancing Soil diversity**

 Microorganisms in the soil are very crucial to the improvement of soil health. Their activity decrease the risks of degradation and desertification. Soil biota such as bacteria, fungi, nematodes, earthworms, insects especially termites are major component of soil biodiversity. They are critical for the following ecosystem services such as decomposition of biomass, cycling of nutrients and carbon dioxide moderation in the air. They can assist the soil to suppress diseases. To restore and promote soil health status, reducing the threat associated with soil degradation, soil microbial agents such as soil fauna and flora needs to be improved by practicing a good agricultural management activity (Bastida *et.al*,2006). Parameters such as microbial biomass carbon, soil respiration, water soluble carbohydrates, enzymatic activities, dehydrogenase activity and activities of urease, protease, phosphatas and β-glucosidase can be improved. Biotic and a biotic factors have an effect on the soil biological resources. Some seasonal changes as well as moisture content of the soil influence soil microbiological processes like microbial biomass content and activity. Earthworm and termites activities play significant role to the soil by ensuring the improvement of soil fertility. Agricultural activities such as converting plow tillage practices to conservation agriculture, coupled with residue mulch and cover cropping influenced the activity of earthworm, and also improve physical structural properties. The conversion of plow tillage practises to conservation have its own implications with respect to transportation of pollutants into the drainage water. To mitigate the threat associated with the degradation of the soil health, there is need to adopt land use and management system that can enhance soil biological processes, thereby, introduce beneficial microbial agents through inoculation. Ayuke *et.al*, 2012 reported that the presence of nematodes, insects such as termites and other soil microorganisms are significant indicators of soil quality.

**3. Practice of soil restorative farming(Cropping Systems)**

 Crop rotations, soil fertility and soil erosion management , control of grazing rate, and water management have significant effect on the severity challenges of soil degradation which can alter soil organic carbon, soil aggregates, compaction and other soil properties. Efficiently managed irrigation practices prevent soil erosion and nutrient leaching. There is need to adopt water-saving technologies like drip irrigation or rainwater harvesting. Planting a diverse range of crops in rotation can break pest and disease cycles, improve nutrient cycling and enhance soil structure. Different crops have varying root structures and nutrient requirements, which can help maintain soil and reduce soil degradation. Ryan *et.al*,2008 reported that crop rotations and grazing, particularly have great impact to the soil organic carbon pool as well as its attendant soil properties. Increase in compaction and reduction of soil organic carbon are challenges that need to be resolved . To reduce the threat of degraded soils, there is need to efficiently manage and conserve the soil-water vi an improved knowledge of the hydrological attributes.

**4. Cover Cropping**

 Planting of cover crops during fallow periods or between cash crops help to protect the soil from erosion, suppress weeds, and enhance organic matter content when incorporated into the soil. They can fix nitrogen as well as improve water retention capacity of the soil. Cover crops also improve the soil structure, increase nutrient availability for subsequent crops (Helma et al 2014)..

**5. Organic Matter Management**

 Incorporation of organic matter through the addition of compost, manure, or other organic materials enhances soil structure, nutrient availability together with water holding capacity. Practices such as incorporating crop residues, cover cropping, and introduction of compost or manure can contribute to higher organic carbon levels(Berazzneva et al, 2014).

**6. Mulching**

 Application of organic mulches e.g straw, wood chips can protect the soil from accelerated erosion, temperature fluctuations, and weed growth. Mulching also introduces organic matter to the soil as they decompose(Govaerts et al, 2006).

**7. Nutrient management or overuse of chemical/synthetic fertilizers and pesticides**

 Excessive use of inorganic fertilizers and pesticides can have adverse effect on the beneficial soil organisms and disrupt the soil ecosystem services. Applying fertilizers judiciously/ based on soil nutrient analysis and crop requirements prevents over application, which can contribute to nutrient runoff and soil degradation. Balanced nutrient management promotes optimal plant growth and minimizes the risk of nutrient imbalances in the soil(Diacono et al, 2010)

**8. Integrated Pest Management(IPM).**

 Implementation of Integration Pest Management practices helps to reduce the reliance on synthetic pesticides, which can negatively impact on soil health. IPM combines various strategies such as biological control, crop rotation, and habitat manipulation to manage pests effectively while minimizing environmental harm. Hence, incorporation of integrated pest management practices reduce the rate of chemical inputs in the soils(Leon et al, 2014).

**9. Conservation Tillage**

 Reducing or eliminating tillage helps to minimize soil erosion and compaction, as well as preserve soil structure and organic matter. Conservation tillage such as No-till or reduced tillage can be employed to retain crop residues on the soil surface, improve water infiltration, and enhance soil microbial activity. Therefore, implementation of conservation tillage practices that disturb the soil minimally, maintain soil structure, improve water infiltration, and reduce erosion(Diacono et al, 2010).

**10. Windbreaks, terracing and contour farming**

 Integration of trees and shrubs into agricultural landscapes, along field edges helps to provide windbreaks, curtail soil and wind erosion, and thereby reducing nutrient loss and enhance soil fertility. Contour farming where crops are planted along the contour lines of the land, helps slow down water runoff, preventing soil erosion and retaining moisture on the soil(Bastida *et.al*,2006).

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**11. Companion planting**

 Compatible plant species are grown together to reduce and eliminate pests, improve nutrient uptake, and support a diverse soil micro biome(Diacono et al, 2010).

**12. Soil Testing and Monitoring.**

 Regular soil testing allows farmers to assess or determine the soil health parameters such as nutrient levels, pH of the soils and organic matter content. Unbalanced nutrients attract application of fertilizers in a balance manner to meet the crop requirements without over application. Monitoring soil health over time helps to identify degradation risks, make informed management decisions, and track the effectiveness of restoration efforts(Bastida *et.al*,2006).

**13. Bio-char Application**

 A stable forms of charcoal called bio-char can be added to the soil to improve the nutrient retention and enhance soil structure (Greenland *et.al*,1994)

**H. Soil Resilience**

 Soil resilience is the capability of the soil to recover its functional and structural quality after any natural or anthropogenic disturbances. Greenland *et.al*,1994 defined soil resilience as an elastic attributes of the soil which enables any soil to regain its functional and structural quality with regards to alleviating destabilizing influence. Improved rhizospheric processes are important for soil resilience against any forms of disturbances. The root section of crops are a dominant zone of microbial metabolism, and so identifying systems that provoke soil microbiotic activity and related microbial processes are vital. Lynch 2002 indicated that quality of soil organic carbon is important in identifying appropriate management practices which can strengthen soil resilience and thereby decrease the threat of soil degradation . There is a relation between soil organic carbon and the quantity of microbial biomass content inputs. The continual input of the biomass content regulate moderates microbial biomass content, and provides plant nutrients such as nitrogen, phosphorous and sulphur , affects cycling of nutrient, and stabilizes soil aggregates, compaction etc and pore sizes. There are also some organic management options such as bio-char , a carbon enrichment soil amendment that can reduce the risks of soil degradation as well as promote soil resilience, and at the same time reduce climate change(Brevlman *et.al*,2015).

**II. CONCLUSIONS**

 Soil resources are significantly important to all terrestrial life. It threatened by soil degradation due to land misuse and mismanagement. Soil degradation can occur as a result of decrease in soil structure, crusting, compaction, erosion, anaerobiosis, water imbalance which are physical attributes while acidification, salinization, elemental imbalance, nutrient deficiency remain the chemical attributes of soil degradation. The third aspect is soil biological degradation which are reduction of soil organic carbon, decrease in soil biodiversity and microbial biomass carbon While distortion in elemental cycling, decreased in carbon sink capacity remain the ecological aspect of soil degradation. Soil degradation results to decrease in ecosystem functions and services with respect to human interest, and conservation of nature. The soil organic carbon is an important component of soil health and ecosystem services. Soil degradation reduces the soil organic carbon content, and to restore and enhance soil quality, it has to reach at least 11 to 15 g kg−1. There are important ways or strategies to enhance soil health and reduce soil degradation risks which include controlling soil erosion, maintaining and creating sound ecosystem carbon budget, improving nutrient availability, be it macronutrients such as nitrogen, phosphorous, sulphur and micro-nutrients such as zinc, iron, copper etc, enhancing soil biodiversity especially the microbial process and increasing rhizospheric processes. Hence, there is need to adopt an integrated soil resource management approach for the improvement and restoration of soil health.

**REFERENCE**

Van Pham, L and C. Smith, C. Drivers of agricultural sustainability in developing countries: A review. *Environmental System Decision, vol. 34*, 2014,pp. 326–341.

 IFAD. International Fund for Agricultural Development*. The Rural Poverty Report 2011*: Rome, Italy.2010

Leon, J and Osorio, N. Role of Litter Turnover in Soil Quality in Tropical Degraded Lands of Colombia. *Science World Journal.* 2014, *13*, doi:10.1155/2014/693981.

Berazneva, J., Conrad, D., Guerena, Lehmann. Agricultural productivity and soil carbon dynamics: A bio-economic model. In Proceedings of the Agricultural and Applied Economics Association 2014 Annual Meeting, Minneapolis, MN, USA, 27–29 July 2014.

Bini, C. Soil: A precious natural resource. In *Conservation of Natural Resources*; Kudrow, N.J.,Ed.; Nova Science Publishers: Hauppauge, NY, USA;2009 pp. 1–48.

Diacono, M. and Montemurro, F. Long-term effects of organic amendments on soil fertility: A review. *Agronomy Sustainable Development.* 2010, *30*, 401–422.

 Lal, R. Soil degradation as a reason for inadequate human nutrition. *Food Sec*.; vol. *1*, 2009, 45–57.

 Robinson, D., Emmett, B., Reynolds, B., Rowe, E., Spurgeon, D., Keith, A., Lebron, I., Hockley, N., Hester, R. and Harrison, R.. Soil Natural Capital and Ecosystem Service Delivery in a World of Global Soil Change. *Soils Food Security .;vol.* *35*,2012, 41–68.

Manlay, R.; Feller, C.; Swift, M. Historical evolution of soil organic matter concepts and their relationships with the fertility and sustainability of cropping systems. *Agricultural Ecosystem Environment.* 2007, *119*, 217–233.

Govaerts, B.; Sayre, K.; Deckers, J. A minimum data set for soil quality assessment of wheat and maize cropping in the highlands of Mexico. *Soil Tillage Reources.* 2006, *87*, 163–174

Vanlauwe, B., Hester, R. and Harrison, R. Organic Matter Availability and Management in the Context of Integrated Soil Fertility Management in sub-Saharan Africa. *Soils Food Security; vol.35*, 2012, 135–157.

Eaton, W., Roed, M, Chassot, O. and Barry, D. Differences in soil moisture, nutrients and the microbial community between forests on the upper Pacific and Caribbean slopes at Monteverde, Cordillera de Tilaran: Implications for responses to climate change. *Tropical Ecology; vol. 53*,2012, 235–240.

Melillo, J.M., Steudler, P.A., Tian, H. and Butler, S. Fertilizing change: Carbon-nitrogen interactions and carbon storage in land ecosystems. In *Handbook of Climate Change and Agroecosystems:* *Impact, Adaptation and Mitigation*; Hillel, D., Rosenzweig, C., Eds.; Imperial College Press: London, UK; 2010, pp. 21–36.

Paz-Kagan, T., Shachak, M., Zaady, E. and Karnieli, A. A spectral soil quality index (SSQI) for characterizing soil function in areas of changed land use. *Geoderma*, vol. *230*, 2014,171–184.

 Gugino, B.K. *Cornell Soil Health Assessment Training Manual*; New York State Agricultural Experiment Station Cornell University: New York, NY, USA.2009

 Lal, R. On Sequestering Carbon and Increasing Productivity by Conservation Agriculture. *Journal of Soil Water Conservation.* in press.2015

 So, H., Kirchhof, G., Bakker, R. and Smith, G(2001). Low input tillage/cropping systems for limited resource areas. *Soil Tillage Resources;* vol. *61*,2001, 109–123.

 Pittelkow, C., Liang, X., Linquist, B.,van Groenigen, K., Lee, J., Lundy, M., van Gestel, N., Six, J., Venterea, R. and van Kessel, C. Productivity limits and potentials of the principles of conservation agriculture. *Nature;* vol.*517*, 2015, pp.365–482

Abiven, S., Menasseri, S. and Chenu, C. The effects of organic inputs over time on soil aggregate stability. *Soil Biological Biochemistry .;vol.* *41*,2008,pp. 1–12.

Tsatsaros, J., Brodie, J., Bohnet, I. and Valentine, P. Water Quality Degradation of Coastal Waterways in the Wet Tropics, Australia. *Water Air Soil Pollution; vol.* *224*,2013 doi:10.1007/s11270-013-1443-2.

 Schaffner, M., Bader, H. and Scheidegger, R. Modeling the contribution of point sources and non-point sources to Thachin River water pollution. *Science of Total Environmen; vol.* *407*,2009,pp. 4902–4915.

Atapattu, S. and Kodituwakku, D. Agriculture in South Asia and its implications on downstream health and sustainability: A review. *Agricultural Water Management; vol.* *96*, 2009,pp.361–373.

 Dakoure, M., Mermoud, A., Yacouba, H. and Boivin, P. Impacts of irrigation with industrial treated wastewater on soil properties. *Geoderma;* *200*,2013, pp. 31–39.

Apitz, S.E., Brils, J., Marcomini, A., Critto, A., Agostini, P., Micheletti, C., Pippa, R., Scanferla, P., Zuin, S. and Lanczos, T. Approaches and frameworks for managing contaminated sediments—A European perspective. In *Assessment and Remediation of Contaminated* *Sediments*; Springer: Berlin/Heidelberg, Germany. 2006

Kohli, R.V., Singh, H.P., Batish, D.R. and Jose, S. Ecological interactions in agroforestry: An overview. In *Ecological Basis of Agro forestry*; Kohli, R.V.S., Batish, D.R., Jose, S., Eds.; CRC Press: Boca Raton, FL, USA;2008, pp. 3–14.

 Helman, D., Lensky, I, Mussery, A. and Leu, S. Rehabilitating degraded dry lands by creating woodland islets: Assessing long-term effects on aboveground productivity and soil fertility. *Agricultural For. Meteorological.;* *195*, 2014, pp.52–60.

Bastida, F., Moreno, J., Hernandez, T. and Garcia, C. Microbiological degradation index of soils in a semiarid climate. *Soil Biological. Biochemistry;* *38*, 2006, pp.3463–3473

Ayuke, F., Karanja, N., Okello, J, Wachira, P., Mutua, G., Lelei, D., Gachene, C., Hester, R. and Harrison, R. Agro-biodiversity and Potential Use for Enhancing Soil Health in Tropical Soils of Africa. *Soils Food Security*; vol. *35*,2012, pp. 94–134.

Greenland, D.J. and Szabolcs, I.(!994) Eds. *Soil Resilience and Sustainable Land Use*; CAB International: Wallingford, UK.

Breulmann, M. and van Afferden, M.and Fühner, C. Biochar: Bring on the sewage. *Nature* ; vol. *518*, 2015, pp. 483.

 Sortino, O.; Montoneri, E.; Patane, C.; Rosato, R.; Tabasso, S.; Ginepro, M. Benefits for agriculture and the environment from urban waste. *Science Total Environment.* 2014, *487*, 443–451