**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 number of people in the world which is targeted to be 9.5 billion by 2050, compels a rise to agricultural productivity by 70%. To sustain and achieve the desired improvement in agricultural productivity, degradation of the soil needs to be curtailed. Soil degradation has led to decrease in soil health, reduced productivity of crops and farm profitability. The major degradation processes include accelerated erosion, decline in soil organic carbon, reduced biodiversity, soil fertility loss and nutrient unavailability as well as acidification and salinization. The issue of soil degradation can be ameliorated through a restorative land use and adoption of soil health recommended management practices. Strategies for restoration of soil quality to reduce risks of soil degradation are to curtail soil erosion, improve organic carbon of the soil, nitrogen budgets, enhance the activity and biodiversity of soil biota and increase structural stability and pore geometry. Factors enhancing the health of the soil include improved soil organic carbon, soil structure and soil fertility which could reduce the risks of any forms of degradation thereby improving the environment. Enhancing soil organic carbon to the critical level ranging from 10 to 15 g/kg is significantly important to begin the restorative trends. There are some techniques accepted to restore the quality of soil such as conservation agriculture, integrated nutrient management, residue mulch and cover cropping, and controlled grazing. Therefore, the paper seeks to address the impact of soil degradation, by reducing losses and improving the soil, water, and nutrient use efficiency for sustainable agricultural productivity.

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

**I. INTRODUCTION**

 Over the years developing countries has experienced a tremendous increase in population which led to a greater percentage of them depend on agriculture for their livelihood(Van *et.al*, 2014). More than a billion people who are farmers utilize less than two hectares 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. A change in soil quality affects the soil ecosystems to provide its goods and services (Leon *et.al*, 2014). Soil deteriorations have affected many agricultural lands which impacts negatively on crop productivity, reducing economic growth and development (Bini,2009). In addition, soil degradation is simply defined as the loss of soil's capacity with respect to loss of soil fertility, soil microbiota, and deteriorations with their attendant decrease in ecosystem functions and services(Lai, 2009). Most soil degradations occur due to land and soil mismanagement, climate change and its related factors. Hence, soil degradations are grouped into the following degradations; physical, chemical, biological and ecological degradations.

 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 water/wind erosions, endangered soil, un-optimal soil temperature which fluctuates, and inhibited aeration. These degradation processes increase desertification. Chemical degradation of the soil simply leads to the loss of nutrients or organic matter, acidification, salinization, reduction in cation exchange capacity, increased Aluminium or Manganese toxicities, Calcium or Magnesium deficiencies, elemental imbalance, leaching of nitrates, essential nutrients or contaminated industrial wastes and decline in soil fertility. Leaching of nutrients affect negatively the soil capacity to enhance crop growth and production which may cause acidification. Biological degradation of the soils lead to lower soil organic matter, reduction in soil microbial, decrease in soil carbon storage capacity, as well as high greenhouse gas emissions from the soil to the atmosphere. The major threat occasioned by biological degradation of the soil is the carbon dioxide and methane gas emissions from the soil instead of the carbon sink. Ecological degradation of the soil lead to the combine effects of soil physical, chemical and biological deterioration, which affect disruption in nutrient cycling, nutrient and carbon losses, decrease in use efficiency of inputs, infiltration and purification of water , perturbations of the hydrological cycle, and reductions in net biome productivity and inhibited denaturing of pollutants. The overall low soil quality has strong positive feedbacks which cause a decline in ecosystem functioning, services and decline in nature conservancy. Therefore, the review seeks to highlight the impacts of soil resources in provisioning ecosystem functions and services together with soil deterioration impacts on decline in ecosystem services, and identify strategies for soil health restoration to reduce the risks of soil degradation for crop productivity.

**A. Soil and its Ecosystem Services.**

 Soil is a non-renewable resourceswhich harbour all the terrestrial life and cultural heritage(Bini et.al,2015). The Soil is threatened by degradation via natural and anthropogenic factors. Soils perform a large function in the ecosystem which linked between the air, water, rock, and organisms. The soils are responsible for many different functions in the natural world which includes the quality and composition of air, temperature control, Cycling of carbon and nutrient, water quality and cycling, natural waste decomposition management 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 support seeds germination, and made available the provision of heat, nutrients, and water to nurture plants and crops. These plants form association with other living things and microbial organisms to create an ecological niche. 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 resulting to major respiratory challenges. Soil particles may have contain some minute microorganisms which cause infections and diseases. Soils play a role in temperature control which is important in many chemical and biological processes. Soils is also a storehouse of carbon and nutrient cycling. Soil contains great quantity of stored carbon as carbon is stored in fossil fuels, soils, oceans and rocks. Soil processes affect the balance of organic carbon which results to carbon dioxide release in the atmosphere. These processes also happen with nitrogen, phosphorus and other chemical materials. Soil serves as filtration medium which allows water to filter through the soil for plants, microbes and other living things use. In addition, excessive nitrogen and phosphorous fertilizer applications can sieve through the soils to contaminate ground water 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 decompose waste materials to a new products (Robinson *et. al*,2012).

**B. Impacts of soil organic carbon on Soil health.**

Soils consist organic carbon which remains an indicator for checkmating erosion (Krupenikor *et.al*, 2011; Rayan *et.al*, 2010). Erosion decimates the soil organic Carbon, together with other nutrients such as nitrogen, phosphorous and sulphur. In addition, loss in organic carbon of the soil results to soil degradation. To reduce the risks of soil degradation, soil organic carbon should be above the critical level which range from 10 to 15 g/kg( i.e.1.0% to 1.5%) and by so doing, degradation trends could be reversed. Soil organic carbon levels could be maintained through the adoption of integrated nutrient management which sequester more carbon dioxide into the organic carbon of the soil for better soil fertility and crop productivity(Vanlauwe *et.al*,2012). The agricultural soil organic carbon could be affected by over-exploitation in natural resources(Lar,2004). In addition, soil moisture content remains another indicator to climate change which could affect the rate of decomposition of soil organic carbon (Eaton *et.al*, 2012). The combination of soil erosion with loss in soil organic carbon pose a big threat to climate change and its associated changes in temperature and moisture contents (Melillo *et.al,* 2010).

**C. Soil Health Index**

 The organic carbon of the soil remains an important factor of soil health and agricultural sustainability. Other parameters of soil health indicators are soil organic carbon depth, distribution, attributes and the turnover rate of soil organic carbon. Soil health indicators may be either physical, chemical or biological. Soil physical qualities are aggregates, seal crusting and compaction, porosity, water infiltration rate, water transmission and retention, soil aeration, depth of root, soil heat capacity and temperature content while that of chemical indicators are pH of the soil, cation exchange capacity, nutrient availability, and elemental balance and reduction in any deficiency( Gugino,2009). Further, soil biological indicators are microbial biomass carbon, soil biodiversity, lack of harmful pathogens and pests. The whole soil health indicators may affect crop productivity, water use efficiency, nutrient availability. These indicators may vary among soil types, climates and land uses. To assess the soil health status, reflectance spectroscopy may combine the soil physical, chemical and biological attributes as well as using the state of soil functions for a particular purpose(Paz-kagan *et.al*, 2014).

**D. Conservation Agriculture and Soil Health**

 Lar (2015) stated that there are four basic principles that associate with conservation agriculture which are crop residue mulch retention, integration of crop rotation and integrated nutrient management practices with combination of inorganic and bio fertilizers, and reduction 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. 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, low organic carbon which increases soil erosion, indiscriminate use of tillage practices such as plowing, plant residues removal, and inappropriate synthetic fertilizer applications (So,2001). However, conversion of plow tillage practice to conservation agriculture could increase soil health restoration. Incorporation of crop residue mulch, cover crops and reduction of fallows could preserve the soil as well as improving soil organic carbon. 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 improve soil carbon levels and depth of soil profile via established use of some rooted plants. With adequate improvement of soil health , there will be improved total biome productivity, increased water and nutrient use efficiencies, and enhanced biomass carbon.

**E. Soil Fertility Management.**

 The ability to sustain and improve crop productivity is only achievable by improvement of soil quality. The adoption and application of integrated nutrient management increases soil fertility and 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**

 Healthy soil is the bedrock for sound and sustainable economy. There is correlation existing among 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. Atapattus *et.al*,( 2009) stated that there is adverse effect of chemical inputs on the soil. These chemical inputs may leach to the water bodies to cause river desiccation, 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 which affect the irrigated lands. In addition, some soils are threatened by wastes contaminants. 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 water quality. To achieve that, there is need to improve 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 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 very important process in reducing the risks associated with soil degradation and ensuring sustainable crop productivity. Lar, 2015 reported that there is need to decarbonise soil organic carbon levels. This needs the continuous application of carbon and essential mineral elements. Some basic strategies to restore soil health and eliminate soil degradation are minimizing losses from soil, creating adequate soil carbon contents, and at same time, enhances biodiversity, and strengthening 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. Soil erosion Management.**

 Soil erosion causes soil degradation and as such should be handled. Erosion reduces organic carbon and nutrient availability. The ratio of soil organic carbon, clay and other essential plant nutrients 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 conversion of plow tillage to conservation agriculture reduces the threat posed by soil erosion and nutrient loss. The two key effects of soil erosion are land and soil mismanagement. Other effects could be over-grazing of animals which can degrade soil structure, reduce water infiltration and also increase runoff. Soil erosion 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). 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 are conversion of plow tillage practices to conservation agriculture, residue mulch and cover cropping. These influence earthworm activities, 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. The presence of nematodes, insects such as termites and other soil microorganisms are significant indicators of soil quality (Ayuke *et.al*, 2012).

**3. Soil restorative farming Practice**

 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 organic carbon levels of the soil and 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 efficiency.

**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**

 Application of inorganic inputs 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 crop growth. It minimizes the risk of nutrient imbalances (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. Integrated pest management combines biological control, rotation of crops, and habitat manipulation to manage pests efficientlys 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**

 Eliminating tillage helps to minimize erosion in the soil and compaction, preserve structure of the soil and organic matter. Conservation tillage practice can be employed to retain crop residues on the surface of the soil, improve water infiltration, and enhance microbial activity. Therefore, conservation tillage practices 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. During contour farming, crops are planted on 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 are added to the soil to improve the nutrient retention and enhance soil structure (Greenland *et.al*,1994)

**H. Soil Resilience**

 Soil resilience refers to the ability of the soil to withstand and recover from various disturbances or stresses, while maintaining its essential functions and productivity. 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. It involves the soil's capacity to handle changes in environmental conditions, such as drought, flooding, pollution, or land management practices, without undergoing substantial degradation or loss of functions. Soil resilience is vital for sustainable agriculture, ecosystem health, and mitigating the impacts of climate change. It is influenced by factors like soil organic matter, nutrient content, microbial, and soil structure. Implementing sustainable soil management practices, such as crop rotation, cover cropping, reduced tillage, and adequate nutrient management, can enhance soil resilience and promote long-time soil health. Lynch (2002) indicated that quality of soil organic carbon is important in identifying soil management practices which can improve soil resilience and thereby decrease the threat of soil degradation . There is a relationship existing 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 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 biological degradation of the soil which include reduction in soil organic carbon, decrease of soil biodiversity and microbial biomass carbon While distortion in elemental cycling, decreased carbon levels remain the ecological aspect of soil degradation. Degradation of soil results with decrease of ecosystem services. The organic carbon of the soil is an important component of soil health and ecosystem services. Soil degradation reduces the soil organic carbon content, and restore 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 the microbial processs. Hence, there is need to adopt an integrated soil resource management approach for the improvement and restoration of soil health.

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