Original Research Paper

Volume - 13 | Issue - 05 | May - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Science

IMPACT OF CLIMATE CHANGE ON SOIL HEALTH: EMERGING ISSUES

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ABSTRACT Climate change is the single biggest threat facing humanity. Soil health is impacted by climate change. Climate change effects soil formation, soil structure and soil health which are complex processes affecting each other. Impact assessment of climate change on agriculture, horticulture and forests did not consider for a long time the soil quality issues. In this review, impacts of climate change on soil texture, soil structure, porosity, soil physico- chemical-biological components are reviewed. Role of soil microbes, soil carbon and crop diversification on soil health are also discussed.

KEYWORDS : Climate change, soil health, soil components, crop diversification, soil health impact, mitigations

INTRODUCTION

Soil health is the key intermediating factor in the assessment of climate change on agriculture. Documentation and information on impact of climate change on soil health is scarce. Presence of soil constituents indicate that the soil health reflects also soil carbon content. Soil health is also interconnected directly or indirectly to human health. Soil health refers to the capacity of soil to perform agronomic and environmental functions, capacity to sustain and support growth of crops and animals (Rattan Lal, 2011). Soil health is a term used to describe the soil quality (Sassenrath, 2018). A healthy soil is always the foundation of the food production system. Soils help to produce healthy crops. Plants derive their nutrients demand from two natural sources of soil viz., organic matter and the minerals (Balasubramanian, 2017). Soil health is the capacity of soil to function as a vital living system within land use boundaries, which sustains biological productivity and also maintains the quality of surrounding environment and human health. The quality and health of soil determines agricultural sustainability and environmental quality, which jointly determine plant, animal and human health (Laishram et al., 2012). Researchers in the past (Hiremath and Shiyany, 2013) didn't consider soil and soil components for calculating the Agriculture Vulnerability Index (AVI). Parameters such as productivity of major crops, cropping intensity, area under cultivation, irrigation intensity and livestock population were considered. Similarly Shivakumara and Shrikantha Murthy (2019) also didn't consider soil and soil health as a factor affecting Climate Change Vulnerability Index (CCVI) and AVI. Shahane and Shivay (2021) traced the historical development of the concept of soil health from 1910 – 2017. They pointed that the concern of the soil quality is not limited to agricultural science, natural resource management and policy issues but also to the farming community. There is a strong need for the development of methods to access and monitor soil quality by integration of multiple soil parameters. Major emphasis should be laid on ecological approaches for soil health with major soil biological characteristics. Several attempts were made to develop soil quality indices based on a set of soil attributes. In developing Soil Quality Index (SQI) the role of soil biological indicators is meagre. The soil organic carbon, microbial biomass carbon, labile carbon, protein index, dehydrogenase activity and substrate induced respiration were used to estimate the SBQI. The quadrant-plot based methods were developed to estimate the biological quality as a unit- less scale. According to W Tumwesigye et al. (2021), soil health components affect climate and climate affects soil health and human wellbeing. Soil health and climate change are complex and intertwined and multi-disciplinary processes that require multi- disciplinary approaches for better understanding and improvement of crop production. Bastida et al. (2008) reviewed SQI as well as the parameters that make them-up. The most straight forward index used is the metabolic quotient respiration to microbial biomass ratio widely used to evaluate ecosystem development, disturbance or system maturity. Molecular indicators have not yet been used for soil quality indices. The lack of applicability of soil quality indices resides on poor standardization of methodologies, spatial scale issues, poor definition of soil natural conditions and functions. Climate change effects on soil formation, soil structure and soil health are intertwined complex processes that affect each other (Wycliffe Tumwesigye et al., 2021). Agriculture is a contributor because it emits significant amounts of greenhouse gases, and vulnerable because climate change have considerable impacts on agricultural production. The effects of climate change on soils are expected mainly through alteration in soil moisture conditions and increase in soil temperature and CO2 levels (Navneet Pareek, 2017). Soil organic matter (SOM) is the key indicator of the soil health; it contains both living and non-living components. Living components include soil microbial biomass and living roots, non-living SOM is a heterogeneous organic matter (Ram et.al 2011). In order to determine the impact of climate change on crop productivity and reveal significance of soil health, this review on the published information was undertaken.

Methodology

The literature documented on the role of soil in determining crop productivity was retrieved from different sources, embracing primary and secondary data sets. The primary data sources included information generated after interacting with farmers, technocrats, policy makers, agrometerologists and had interactions with officials of departments of agriculture, horticulture, silviculture, social forestryetc. The secondary data sources included published scientific articles and journals, reports of the relevant departments of agriculture and horticulture. The information retrieved was validated and cross-checked.

Soil health

A healthy soil is always the foundation of the food production system. Soil helps to produce healthy crop by providing nutrients and habitat to organisms that are living in the soil. The soil organic matter also binds the soil particles to form soil aggregates and improve the water holding capacity of soil (Balasubramanian, 2017). Soil health is closely associated with sustainable agriculture, because soil microorganism diversity and activity are the main components of soil health, it has always been important to humans and their health, providing a resource that can be used for shelter and food production (Abrahams, 2001). Measures of soil capacity to fulfil environmental and economic functions is pH, temperature and rainfall changes caused by variable and changing climate on soil pH and some related properties . Soil health broadly, comprises all soil properties and influence soil productivity, soil capacity to carry pathogens and cause plant diseases is strongly influenced by pH (Z. Rengel, 2011). Quality food production includes the production of sufficient amount of adequate nutrient content in the food products excluding potentially toxic compounds. Soil health is an integrative property that reflects the capacity of soil to respond agricultural interventions and soil which acts as dynamic living system that delivers multiple ecosystem services such as sustain water quality and plant productivity, controlling of soil nutrient, recycling, decomposition process and removing greenhouse gases from the atmosphere is also considered as healthy soil (Shahane A A & Shivay Y S,2021). Soil health is the continued capacity of a soil to function as a vital system, within ecosystem and land use boundaries, to sustain biological productivity, maintain the quality of air, water, environment, plant, animal and human health (Patil, 2018). Soils are also a major source of nutrients, and they act as natural filters to remove contaminants from water. However, soils may contain heavy metals, chemicals, or pathogens that have the potential to negatively impact human health; exposure to heavy metals through soil contact is a major human health concern. Heavy metals may enter soil naturally through weathering of rocks to a limited extent, but they have also been introduced into soils by human activity to a greater extent. Adverse effects on soil health and soil quality arise from nutrient imbalance in soil, excessive fertilization and soil pollution (Joylata Laishram et al., 2012). Patil and Lamnganbhi (2018) reviewed the impact of climate change on soil health. Adverse effects on soil health and soil quality raised from nutrient imbalance in soil, excessive fertilization, soil pollution and soil-loss processes. Johannes Lehmann et al. (2020) focused on soil health, crop production and human health. Ecosystem services provided by soils, the indicators used to measure soil functionality and their integration into soil health indices is crucially important to understand role of soil health in crop production.

Soil texture

Soil texture is the relative proportion of sand, silt and clay in a soil. The organization and arrangements of primary and secondary particles in a soil control the amount of water and air present in the soil. Health of the soil includes organic carbon, infiltration capacity, movement and storage of water, root and microbial activity. The nature and quality of the structure is strongly influenced by the amount and quality of the organic matter, inorganic constituents and cultivation methods. Soil structure indirectly influences emission of GHGs such as nitrous oxide (N2O) and methane (CH4) via its ability to determine soil physical properties such as soil moisture characteristics, aeration and gaseous movement (Chan, 2011). Soil texture refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil. Soil texture is important because it influences the amount of water, the soil can hold the rate of water movement through the soil. The size ranges for the soil separates and the relative size of the particles (Fig.1). Texture often changes with depth so roots have to cope with different conditions as they penetrate the soil. Texture of soil also varies in its type such as sandy, sandy loam, loam, silty loam, clay loam etc. (https://www.qld.gov.au›land›soil›soil-properties).

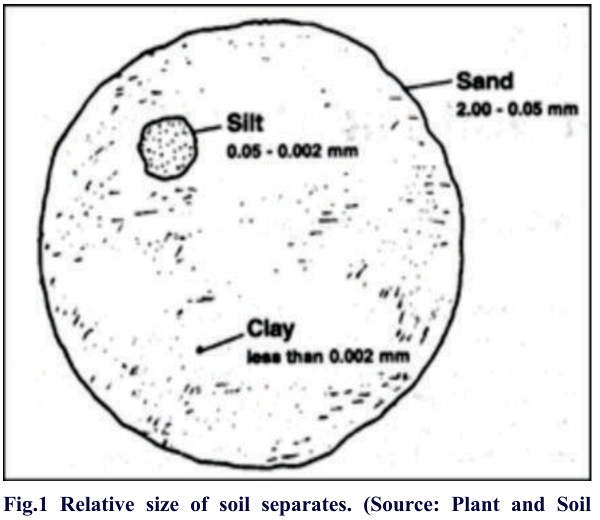

Fig.1 Relative size of soil separates. (Source: Plant and Soil Sciences eLibrary 2022).

Soil structure

Soil structure refers to the arrangement of soil separates into units called soil aggregates. An aggregate possess solids and pore space. Silt and fine sand particles may also be part of an aggregate. Soil structure includes various types such as granular- round surfaces, crumb-rounded surfaces but larger than granular, sub angular blocky-cube-like with flattened surfaces and rounded corners. Structure is one of the defining characteristics of a soil horizon. A soil exhibits only one structure per soil horizon, but different horizons within a soil may exhibit different structures. All of the soil-forming factors, especially climate, influence the type of structure that develops at each depth (https://passel2.unl.edu).

Porosity

Porosity is a measure of the void spaces in a material as volume and pore size distribution provide the ability of soil to store roots, water and air necessary for plant growth. It also regulates water retention and transmission, aeration and thermal regime (W D Reynolds et al., 2002). Soil porosity is the ratio of nonsolid volume to the total volume of soil. In crop production, soil porosity is important to conduct water, air, and nutrients into the soil (Indoria et al., 2017). Porosity varies depending on particle size and aggregation. It is greater in organic soils than in sandy soils. A large number of small particles in a volume of soil produce a large number of soil pores. Fewer large particles can occupy the same volume of soil. So there are fewer pores and less porosity. Pores of all sizes and shapes combine to make up the total porosity of a soil (https://passel2.unl.edu).

Components of soil health

The major soil components affecting soil health can be broadly classified as physical, chemical and biological. SOM is essential in maintaining physical, chemical and biological functions in soil. Hence, SOM matter is the key indicator of soil health. Non- living SOM is a heterogeneous organic matter (Ram, 2011).

Soil Physical-bio components

Biophysical components act as bio filter for solids, liquids, and gases. Biophysical components of soil are related to physical and biological components. It is important from the environmental point of view, absorption and emission of oxygen, carbon dioxide, methane, nitrous oxide in the soil (Witold Stepniewski, Rainer Horn 2002). In India, about 90 million hectare area is experiencing soil physical degradation. Soil physical constance is the key factor severely limiting crop productivity. Sub-surface soil hard pan and compactness, encrusting and harding, slow and high permeability, non-optimal porosity, and poor soil structure, poor water receptivity, retention and transmission, etc. are important properties of soil influencing water infiltration. It has been understood and established that for better crop production and genetic yield potential of a crop is irrigated and rainfed conditions, optimum soil physical environment is required. Analysis of soil organic content that influences the physical and biological quality of soil, soil testing helps to estimate the level of nutrients present in the soil that are available to plants (Ashish Chauhan and Bharti Mittu, 2015).

Soil chemical components

The chemical components of soil include the pH, nutrients–such as nitrogen (N), phosphorus (P), potassium (K). Soil chemical components directly or indirectly benefit and cause harmful effect to human health. The chemical components of soil depends to a large part on the soil physical component. The important aspects are linking soil health with human health through quality of the food and their micronutrients, protein, and essential amino acids concentration [I, Fe, Se, CO, Cr, Cu, F, Mn, Mo, Zn, Ni, Si, V] (Lal, 2011). The chemistry of soil plays the primary role in all concepts of soil ecology, chemical properties of soil includes organic and inorganic matter of soil, colloidal properties of soil particles, soil reaction-buffering action basics, acids and pH of soil. The electrochemical properties of soil are important for the understanding of the physico- chemical phenomena which affect soil fertility and the availability of nutrients for plants, many chemical properties of soils center round the soil reactions. As per the reaction and their nature, some soils are neutral, acidic and basic (Balasubramanian, 2017).

Other soil health components

Sufficient supply of nutrients, good soil tilt, sufficient depth, good internal drainage, low populations of parasites, high populations of plant-health promoting organisms, low weed pressure, no toxic chemicals, resistance to being degraded and resilience are the characteristics soil health components confer. Soil health also depends on soil's physical condition - degree of compaction, amount of water storage and drainage. The levels of available nutrients, the pH, the salt content, etc. are important determinants of soil health. Plant growth can be adversely affected by either low nutrient levels, high levels of a toxic element or high salt concentrations (Fred Magdoff, 2001)

Soil health indicators

Soil health improves the productive capacity of the soil, producing more crops and of higher quality (Sassenrath, 2018). Soil health indicators are a composite set of measurable physical, chemical and biological attributes (D E Allen et al, 2011). The chemical, physical and biological indicators of soil health are indicated in Table 1. Soil health also indicates that it has good tilt; it has sufficient depth through which roots can grow to find water and available nutrients. Soil should be free from harmful chemicals and toxins (Anjani Kumar, 2018).

Table 1 Chemical, Physical and Biological indicators of soil health

Chemical Indicators	Physical Indicators	Biological Indicators
Soil pH	Soil texture	Microbial biomass
Soil electrical conductivity	Soil particle and bulk density	Population of soil micro and macro organisms.
Organic matter content	Penetration resistance of soil	Soil enzyme activities
Total carbon and nitrogen	Aggregate stability	Pollutant detoxification
Cation exchange capacity	Soil water holding capacity	Soil respiration
Soil essential nutrient	Soil aeration and porosity	Soil pathogens
Heavy and toxic metals	Soil infiltration rate	-

Source: Anjani Kumar and Mohanta, 2018).

Fig.2: Global map of soil quality indices(F Bastida et al., 2008)

Soil quality and soil quality index

Soil quality is the capacity of soil to function within natural or managed ecosystem boundaries and to sustain plant productivity while reducing soil degradation (Atanu Mukherjee and Rattan Lal, 2014). SQI uses several physical, chemical, and biological attributes either individually or in combinations to determine whether the soil functions is improving, stable, or degrading. Soil quality indicators are defined as selected soil attributes used to assess the soil quality (S Andrews et al., 2002). SQI is the minimum set of parameters that, when interrelated, provides numerical data on the capacity of soil to carry out one or more functions (Selvaraj et al., 2020). Soil quality indicators are scored between 0 and 1 or 0 and 10 (Tunsisa T et al., 2018). Assessment of management-induced changes in soil quality is important to sustain higher crop yield. It is a complex functional concept and it cannot be measured directly in the field or laboratory (R LalAtanu Mukherjee, 2014). Rathan Lal (2014) compared three methods for estimating SQI. The methods were i) simple additive SQI (SQI-1), ii) Weighted additive SQI (SQI-2), iii) statistically models SQI (SQI-3) based on principal component analysis (PCA). The SQI values varied between 0-0.9 (1 being the maximum SQI). SQI-3 values were significantly correlated with crop yield, the correlation coefficient range between 0.74-0.78. The SQI was not affected by soil depth but more by management and soil type. All the three methods of estimating SQI were relatively easy, user friendly and significantly correlated with crop yield. SQI-3 was regarded as the best and easiest model to predict crop yield and objectively approach with lower number of indicator selection which should be regarded as less expensive procedure over SQI-1 and SQI-2. Researchers have reviewed soil quality and soil health. Laishram et al.(2012) and Gayan et al.(2020) made an assessment of soil quality indicators for rice ecosystem in Assam, India. SQI were developed using statistical tools like principal component analysis (PCA) techniques and expert opinion (EO). Relative soil quality index (RSIQ) was also developed for grouping the soils into categories. In calculation of PCA-SQI, soil enzymes played a major role towards maximum values of SQI for the soils, establishing the importance of biological properties of sensitive indicators with physicochemical properties being important. The PCA-SQI with the EO-SQI and RSQI adequately provide information required for selection of soil management practices. Monitoring soil quality and its periodic assessment is necessary for sustenance of agricultural productivity and maintain environmental parameters. Soil quality can be assessed using a combination of physical, chemical and biological properties (Anjuma et al., 2020).

According to Rattan Lal (2016) Soil Organic Carbon (SOC) strongly impacts soil quality, functionality and health. Through supply of macro- and micronutrients, soil health is mediated by SOC dynamics which is a strong determinant of global food and nutritional security. Soil carbon pool consists of two but distinct components, SOC and SICS (soil inorganic carbon). The SIC pool comprises of primary and secondary carbonates, improvements in soil health, along with increasing availability of water and nutrients increases soils resilience against extreme climate events and imparts busy suppressive attributes. Regression analysis revealed that, temperature had significant influence on the variations of SOC stock under all land use types, under dry deciduous forest and plantation there was no significant influence of rainfall. However, under tropical thorn forest, scrub land, crop land and fallow land, there was significant influence of rainfall on SOC stock. Future climate change will have an adverse impact on a SOC stock in 0-30 cm soil depth. A flowchart showing impact of climate change on SOC loss is given in Fig.3. Soil organic carbon is important for soil health. SOC serves as a source and store house of plant nutrients and has positive role in crop production improvement and in soil health. The functions soil organic carbon in soil health is given in Table 2. The presence of organic carbon in soil is a key factor for soil quality and productivity. Soil being the largest carbon sinks also control global warming. Carbon sequestration in soil depends on soil carbon saturation deficiency, protected recalcitrant carbon fractions, aggregation and aggregate associated physically shielded carbon. Labile organic carbon is the soil nutrient receiver and is closely related with diversified soil biology (Shovik et al.2015).

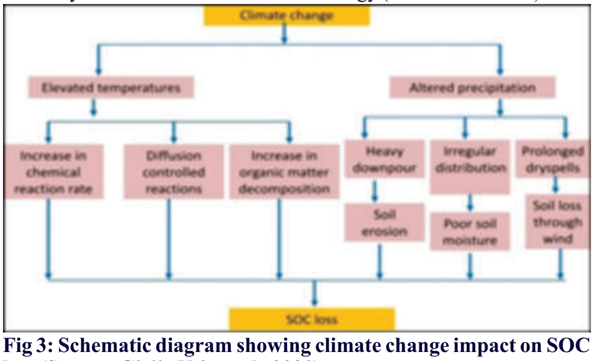

Fig 3: Schematic diagram showing climate change impact on SOC loss (Source: Girija Vein et al., 2020)

Table 2: Functions of soil organic carbon

Plant	Soil		
	Improvement	Maintenance	Reduce
Crop yield Improvement	Aggregate stability	Temperature	Bulk density
Quality improvement	Porosity	Soil consistence	Erodibility and erosion
Profitability enhancement	Chelation of micronutrients	Optimu m soil moisture	Accu mulati on of toxic materi al
Sustainability in production system	Cation exchange capacity and base saturation	pH	Soil crusting and compaction
Reduce biomolecule of soil pollutants in the plant products	Water and nutrient retention capacity	Desirabl e soil structure	-

Source: Shahane and Shivay, 2021)

Role of Soil Microbes

Soil provides base for agricultural crop production. Microbial activity is important to improve soil health for healthy crop growth because microorganisms play an important role in building a complex link between plants and soil. Microbes help in different biological

Volume - 13 | Issue - 05 | May - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

transformations such as organic matter conversion and biological nitrogen fixation. The soil is the major source of plant nutrients, but soil quality is necessary for agricultural production and quality is improved by soil bacteria, fungi and protista (Muller et al., 2016). Soil microorganisms like bacteria, algae fungi, actinomycetes, protozoa and the infective agents such as viruses are the bodies within the massive resources of activities of microscopic diversity (Andreote et al, 2014). The status of nutrients is determined by the quality and identification of microbes in soil (Lombard et al., 2011). Soil microbes create a link between soil and roots, nutrients recycling, organic matter decomposition and react rapidly to any variations that occur in the ecology of soil by performing as perfect indicators for definite functions in the surroundings of soils (Jacoby et al, 2017).

Soil health and Agronomic Practices

Shahane and Shivay (2021) concluded from a review on soil health and its management that diversification of nutrient sources with emphasis on use of organic manures and other alternatives to compliment and supplement the chemical fertilizers has potential to significantly contribute to the improvement of soil health. Diversification of production system through conservation agriculture and organic farming is important for soil health improvement. Improvement in resource-use efficiency and an integrated farming system will sustain soil health. There is a need to take care of soil biological health with enhanced soil microbial diversity and curtailment of soil pollution will go a long way in improving soil health. Soil related constraints agronomic productivity of crop is indicated in Fig. 2. Key indicators of soil health are soil texture, tilth, color, biodiversity, water intake rate, doughtiness, internal drainage, and resilience against perturbation. The projected climate change may adversely impact soil health by reducing soil organic matter content, decreasing soil structure, and increasing vulnerability to erosion and other degradation processes (Rattan.Lal, 2016).

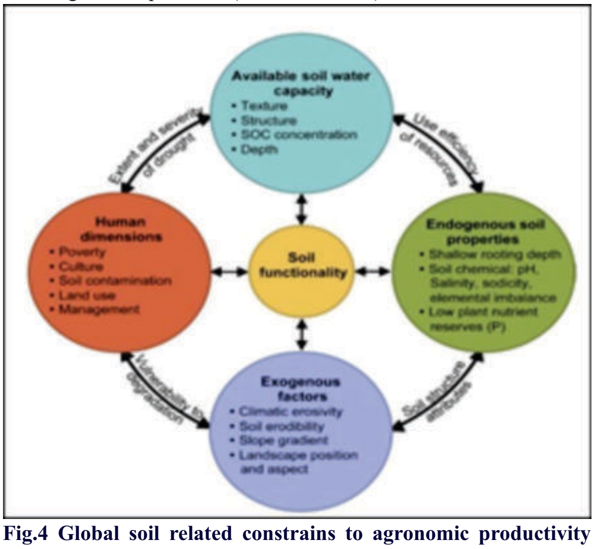

Fig.4 Global soil related constrains to agronomic productivity (Rattan Lal, 2016)

Crop diversification

Crop diversification is a shift from low profitable cropping system to high profitable cropping system. It is one of the most important factors to increase the quality and quantity of crop production and economy in agriculture. It offers scopes for employment at the time of performing the value addition process of the farmer products. Crop diversification influences the economic condition and it is beneficial for the farmers. Rainfall, temperature, irrigation and soil fertility are the factors affecting on the crop diversification (Subhrajyoti Dalal and Tanmoy Shankar 2022). Crop diversification and its characteristic features have several advantages which also includes agroforestry and mixed farming (Lin 2011) (Table-3).

Table-3 Diversification of agricultural systems

Diversification types	Description of diversification	Main characteristics
Genetic diversity in monoculture	Growing mixed varieties of a species in a monoculture	Farm level; same land unit
High-value crops	A shift from less profitable and sustainable crop or cropping system to more profitable and sustainable crop or cropping system.	Farm level; same land unit
Crop rotations	Temporal diversity through crop rotation	Farm level; different spaces; different times
Agroforestry	Growing crops and trees together	Farm level; different spaces; different times
Mixed landscape	Development of larger scale diversified landscapes with multiple ecosystem	Larger scale; spatial temporal

Table 4 represents benefits from crop diversification with respect to sustainable development goals (Diana Feliciano, 2018). Crop diversification is one the important practice to minimize losses due to climate change in Agriculture. Pardeep Singh et al.,(2022) calculated crop diversification index by including all food and cash crops taking their area under cultivation. The diversification index was categorized into four classes; low diversified, moderately diversified, medium diversified, and highly diversified. The coefficients of population density, percentage of marginal and small farmers, cropping intensity, cultivator's marginal workers and main workers were found to be significant with the crop diversification, implying that these factors enhance the crop diversifications. The weather variables reduce the crop diversification and irrigation intensity has a negative impact on crop diversification due to poor canal management and lack of perennial rivers, crop diversification is positively correlated with cropping intensity and negatively correlated with irrigation intensity.

Table 4: Benefits of crop diversification

Aspects	Type of benefit	Specific benefits of crop diversification
Life on land	Environmen tal protection	Avoids soil exploitation, reduces soil erosion
Climate action	Climate change mitigation	Reduces need for consequently less greenhouse gas emission
	Climate change adaptation	Improves tolerance to drought and water- logging, increase yield stability, serve as insurance against rainfall variability as different crops are affected differently by climate change
Sustainable production	Crop productivity	Increase soil fertility; improve productivity of the crop and also yields

(Source: Diana Feliciano, 2018)

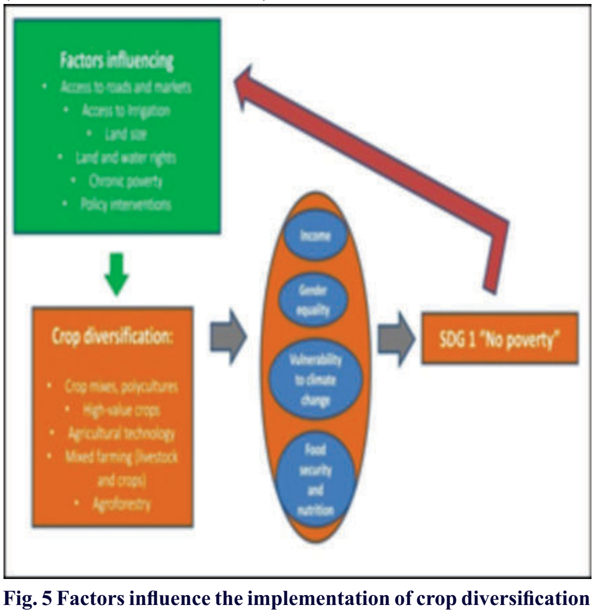

Fig. 5 Factors influence the implementation of crop diversification (Diana Feliciano, 2018)

Crop diversification was found to be higher in districts with lower irrigation intensity, this indicates that higher cropping intensity is restricted to mono- cropping where irrigation intensity is relatively higher, where as it is associated with multicropping in the rainfed. Crop diversification is heavily influence by rural population density. The rainfall coefficient is negative with regard to the impact of rainfall and minimum temperature on crop diversification. The maximum temperature is positively related to and increase the likelihood of droughts, floods and irregular rainfall. Crop diversification index is positively related to cultivators and other primary workers. It also implies that cultivators and other primary workers helps to increase crop diversification. In Fig.5, the graphical representation shows the factors influence the implementation of crop diversification.

Methods to improve soil health

Strengthening of the nutrient cycle, conservation of soil and water, better ways to water harvesting, recycling and irrigation, use of lime in high rainfall areas, use of water soluble fertilizers, promote bio-fertilizers, ensure sufficient carbon content in soil, avoid compaction, use manure and fortified compost (Chauhan and Mittu, 2015) are the practices that contribute in improving soil health. In farmlands and rangelands reduces soil disturbance. Crop rotation practices in farmlands, promote plant diversity and living roots. Production systems in farmlands and in rangelands, can be diversified by adding soil organic amendments Livestock into cropping systems in farmlands can be integrated, promoting diverse plant species with different rooting depths. Sustainable animal grazing practice in rangelands (John Idowu 2019) can be encouraged.

Strategies/Mitigation practices for soil health management

Improper land use, crop cultivation, animal grazing and fertilization lead to soil health degradation and functional losses. Effective soil management practices are necessary to maintain and enhance the soil health of agricultural land. Climate change and agriculture are interrelated and climate change will have significant impacts on agriculture, soils, livestock and economy of farmers. Apart from declining food production, nutrition quality will also be reduced. So efforts are being made to mitigate negative impacts of climate change on agriculture and human health. Zero tillage, retaining crop residues, extending fallows, increasing the production diversity, altering amounts and timing of external inputs as well as agronomic management practices or strategies are important in this context. Emission of carbon dioxide can be reducing through reduced biomass burning and more efficient energy use. Nitrous oxide emissions can be reduced through improved management of N fertilizers including rate and method of application and soil management (Naveen Pareek, 2017).Climate change may increase the potential for soil erosion, reduce soil quality, lower agricultural productivity and negatively impact food security and global sustainability. Management for climate change through mitigation and adaptation is key for environmental conservation, sustainability, soil and water quality and food security (Rathan Lal et al., 2011). Use of different crops in crop rotations, particularly cereal-pulses system increases soil organic matter and nutrients and biodiversity in the soil. It also improves nutrient use efficiency, improves water quality and conserves soil water.

CONCLUSIONS

This review summarizes published information on impact of climate change on different physical, chemical and biological properties of soil, as soil plays a crucial role in crop productivity.

A healthy soil is always the foundation of the food production system and the role of different components of soil health like bio-chemical components, physical properties of soil and soil organic matter (SOM) have been dealt with. Recently, the role of crop diversification has received crucial attention in sustaining soil health. Crop diversification is a shift from low profitable to high profitable cropping system, which not only help in increasing farmer's income, but also in increasing soil fertility and in maintaining soil health. The concept of soil health evolved from the soil quality. Soil quality is the capacity of soil to function within natural or managed ecosystem, soil quality (SQ) assessment is related to agricultural sustainability. Effective soil management practices are necessary to maintain and enhance soil health, as soil is vital for surrounding environment and human health.

Acknowledgement

Authors are grateful to The Director General, Director of Research and Officer In- charge EMPRI and staff, Malleshwaram office for facilities and encouragement. Authors are also thankful to the comments received from Dr Thimmegowda, Head, AICRP, GKVK, UAS Bangalore on the earlier drafts of the manuscript.

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