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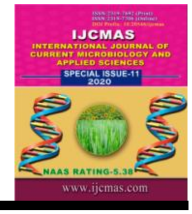

Review Article

Soil Health: A Better Sustainable option for Nation's Food Security

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A B S T R A C T

Keywords

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Soil health, soil quality, and soil security, all the three mainly focused on the status of the soil fertility that is essential for all living things in the terrestrial environment. Soil health can define as the capacity of soil to function as a vital living system within land use boundaries. This function which sustains biological productivity of soil also maintains the quality of surrounding environment and human health. Thus, the term is used to distinguish that, soil health presents the soil as a finite non-renewable and dynamic living resource. Due to several anthropogenic and natural sources, soil degradation is one of the major constraints for agricultural productivity. Around 40% of the arable land is already degraded for various factors including urbanization and soil sealing, soil acidification, salinization, soil erosion, soil contamination, etc. The theme for World Environment Day 2012 encompasses various aspects of human living, ranging from transport to energy to food to sustainable livelihood. Green technology, an eco-friendly clean technology, contributes to sustainable development to conserve the natural resources and environment which will meet the demands of the present and future generations. Despite there is a link between soil quality and food productivity, the status of global food production has been updated regularly rather than the status of world soil resources. Both the UN Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) emphasized to ensure the food security globally as we need to serve more than 9 billion people by 2050. Further, the soil acts as a carbon sink efficiently rather than aquatic ecosystems in many parts of the world, which will help to mitigate the climate change. Hence, the soil protection is of the utmost importance for all the securities especially water, food, and energy. Sustainable soil management and agricultural practices such as efficient water utilization, climate-smart agriculture, Aero Farms, and organic farming are the key aspects to ensure the food security globally.

Introduction

The theme for World Environment Day 2012 encompasses various aspects of human living, ranging from transport to energy to food to sustainable livelihood. Green technology, an eco-friendly clean technology, contributes to sustainable development to conserve the natural resources and environment which will meet the demands of the present and future generations. The implementation of the principles of sustainability is a world's challenge in managing a life-sustaining and environmentally sound global ecosystem.

We are currently facing a lot of global environmental issues during the twenty-first century such as:

population of >7.0 billion with an increase at the rate of 1.14% year^{-1},

per capita arable land area of 0.22 ha and decreasing to< 0.07 ha for 30 countries by 2025.

Soil degradation of 2 billion ha (Bha) and increasing at the rate of 5-10 million hectares (Mha) year $^{-1}$,

Renewable fresh water supply of < 1000 m3 for 30 countries and increasing to 58 countries by 2050,

Atmospheric C02 Concentration of 378 ppm and increasing at o.46% year^{-1},

Energy use of 435 quards (1015 BTU) year-1 and increasing at the rate od 2.2% year^{-1} and

Decrease in per capita grain consumption of 300 Kg year $^{-1}$.

Most of these issues are mainly due to anthropogenic activities under Anthropocene era.

Soil security, an overarching concept of soil motivated by sustainable development, is concerned with the maintenance and improvement of the global soil resource to produce food, fiber, and freshwater, to contribute to energy and climate sustainability, and to maintain the biodiversity and the overall protection of the ecosystem (McBratney *et al.,* 2014). In this review, soil security has been discussed toward sustainable food production integrated with soil health, hindering of soil fertility, and strategies of improving soil nutrients.

The world population has doubled at least ten times during the last 10,000 years, and it will project 11 billion people by 2100. Further, the future increase in population (expected to a combined population of 9 billion by 2150) will mostly occur in developing counties of Asia and Africa, and those regions are more prone to soil and water stresses. In addition, increasing standards of living and change in food habits of people from emerging economies especially China and India will remain a major challenge until 2050 and perhaps beyond. Agricultural land is occupying 40% of the land surface (Tilman *et al.,* 2002) and 70% of all the water withdrawn from aquifers, streams, and lakes only for the purpose of agriculture (FAO 2011).

Demand of Food Productions in Country

India remains the second largest producer of rice and wheat among the cereals and the top producer of pulses globally. The rice production is estimated to be 106.54 Mt, a new record and higher by 1.30 Mt than the production of rice during 2012–2013. Similarly, the wheat production is estimated to be 95.91 Mt which is a record and higher than the production of 93.51Mt during 2012–2013. There will be an increase in the food consumption levels in India from the current level of 2400 kcal/capita per day to about 3000 kcal/capita per day in 2050. Also, there will be a demand for cereals to 243 Mt in 2050 (Singh 2009). Similarly, there will be an increase in the rainfed crops to 1.8 t/ha in 2030 and 2.0 t/ha in 2050. During the above period, the irrigated crops are expected to increase from 3.5 to 4.6 t/ha. In India, the projected increase in the cereal production was 0.9% per year from 1999 to 2001 and is expected to exceed the demand by 2050.

Present Status of Agriculture in India(As on March 2020)

India ranks second highest worldwide in farm output. India is the second highest producer of wheat, rice, sugar, vegetables, fruits and groundnut and cotton. The average annual growth rate in real terms in agriculture as well as its allied sectors has remained static in the last six years, in turn impacting farmers' income, the Economic Survey 2019-20, released on January 31, 2020 estimated by the Ministry of Agriculture. The annual growth rate in real terms in agriculture and its allied sectors was 2.88 per cent from 2014-15 to 2018-19, according to the Survey. The estimated growth rate in 2019-20 is 2.9 per cent. It sought a combination of resource efficient methods including dynamic cropping patterns, judicious use of chemical fertilisers and efficient irrigation systems. Agricultural productivity was impacted by inefficient irrigation systems and degradation of soils due to improper use of chemical fertilisers. Farmers should be incentivised to adopt water-efficient practices in order to avert a looming water crisis, the Survey said. It called for shifting the focus in agriculture to 'irrigation water productivity' from 'land productivity'.

India is the largest producer of tea, mangoes, sugarcane, banana, turmeric, milk, coconut, pulses, ginger, cashew nuts, & black pepper and also accounts for 10 percent of the world's fruit production

Food scarcity on globe

Nearly 1.4 million children are at "imminent risk" of death in famines in Nigeria, Somalia, South Sudan, and Yemen according to recent report in UNICEF. Globally some 795 million people are chronically undernourished; 125 million under 5-year-olds (one out of four) are estimated to be stunted in spite of considerable progress. Also, 2.1 billion adults are overweight and obese, and many are deficient in key micronutrients, particularly iron, zinc, and vitamin A (Global Nutrition Report 2016).

Challenges for Food Production and Productivity

As expected from the population explosion and changing in the food consumption pattern globally, we need to increase the agricultural areas as well as yield potential of staple food crops to meet the future projected demand of food that is challenging nowadays. The "Status of the World's Soil Resources" report is released by the UN's Food and Agriculture Organization (FAO 2015).

Scarcity of Water and their Resources

About 40% of the world's food depends on irrigation, which draws largely from stores of underground water, called aquifers, which make up 30% of the world's freshwater. The impact of agriculture expansion into marginal areas will also be felt through increased competition for irrigation water (Matuschke 2009).

Land Crisis

Among the 13.2 billion ha of global land mass, 12% (1.6 billion ha) is currently in used for the cultivation of agricultural crops, 35% (4.6 billion ha) includes grasslands and woodland ecosystems, and 28% (3.7 billion ha) are covered with forests(FAO 2011).

The demand for new agricultural land (due to population pressure, diet change, and demand for biofuels) is expected to increase by about 50% by 2050. Utilization of tropical forests for agricultural purposes will lead to an increase in the extent of soil degradation. According to FAO (2015), the arable area in developing countries will have to increase by almost 13%, or 120 million ha, over the years from 1997–1999 to 2030 to meet the food demand.

Urbanization as in the Name of Globalization and Soil Sealing

The imminent population increase will be accompanied by rapid expansion of cities (urbanization). In the past 200 years, the proportion of the world's population living in cities has grown from about 5% to more than 50%. The urbanization process affecting soils was coined as "land take" and "soil sealing". Increases in soil productivity will not compensate reductions in the extent of agricultural areas and thus will not be sufficient to buffer overall losses in crop yields (Gardi *et al.*, 2015).

Change in Climatic Conditions

Although several reasons have mentioned for the soil degradation, global climate change issues are the major threat to the agricultural system. Due to deforestation, transportation sectors, and industrialization especially emission from thermal power stations are the major sources of greenhouse gases released to the atmosphere. According to US National Oceanic and Atmospheric Administration (NOAA), the CO_2 concentration is 410.28 ppm as on April 25, 2017.

Loss of Food Stability

Increased climate variability will decrease food stability especially in semiarid and subhumid areas such as sub-Saharan Africa, Southeast Asia, and parts of the Americas (Brown and Funk 2008).

Climate change will increase the occurrence of water- and food-borne diseases and especially increase the frequency of food and reef-fish poisoning (ciguatera and salmonellosis) in temperate and tropical regions, respectively.

Irregular Rainfall Pattern and Behaviour

According to India Meteorological Department (IMD) data, India received normal rainfall as 2% less than the 100-year average by the end of August 2016 after two consecutive droughts; however, more than one third (221 out of 610 districts) of India suffered deficit rainfall pattern.

Also, the IMD data revealed that as much as 16% of the country's area is now rain deficient. The monsoon deficit was greater (between 30 and 40%) in northeast India which was repeating the situation in 2013.

Relation between El Nino and Drought in India

The El Nino – characterized by surface waters of the equatorial Pacific warming up more than half a degree – is known to dry up monsoon rains every 6 out of 10 years.

The most prominent droughts in India, eight of them, since 1871 have been El Ninotriggered droughts, including the recent ones that occurred in 2002, 2009, 2014, and 2015. Nevertheless, it is important to note that all El Nino years do not lead to drought in India.

Drastic Decrease in Agricultural Productivity

The warming trend in India over the past 100 years has indicated an increase of 0.6 °C, which is likely to impact many crops, negatively impacting food and livelihood security of millions of farmers.

Climate change could result in global crop yield losses as large as 5% in 2030 and 30% in 2080 (Hunger Report 2017). In 2015, 42.2 million Americans were food insecure, including 29.1 million adults and 13.1 million children (Hunger Report 2017).

Nutrient Imbalances in Soil

Soil nutrient availability is the prevalent soil limitation in current cultivated land in most regions, particularly in tropical developing countries. The lower nutrient availability was evident in several countries including sub-Saharan Africa, Southern America, East Asia, Southeast Asia, and Australia and New Zealand.

The highest nutrient constraint was reported in high-income countries (76%) as compared to low-income countries (68%).

However, only 44% of cultivated soils (about 196 Mha) have no or only minor constraints in low-income countries. On the other hand, 24% of the soil (247 Mha) contains poor nutrient availability at different degrees ranged from light to severe.

In addition, the natural fertility status of some soils has deteriorated over time through "nutrient mining" (FAO 2011). The human malnutrition is related to food scarcity, and the consumption of nutrient-deficient crops especially Fe, Mg, Zn, Cu, and Mn is directly attributable to nutrient impoverished soils (St Clair and Lynch 2010).

Modern Approaches of Agronomic management Practices

Due to increase in agricultural productivity, 70% of the agricultural land followed several intensification agricultural practices such as new varieties, irrigation, and the use of inputs, and the remaining 30% is the conversion of tropical forests into agricultural land (Conway 2012). The modern agricultural practices such as continual ploughing of fields coupled with heavy input of fertilizer applications have degraded soils globally. Industrial farming contributes more greenhouse gas emissions than the transportation sector. Industrial agriculture also depends on massive phosphorus fertilizer application – another dead end on the horizon. Almost 75% of the world's reserve of phosphate rock, mined to supply industrial agriculture, is in a politically unstable area of northern Africa centered in Morocco and Western Sahara.

Soil Deterioration

Approximately 40% of soil used for agriculture around the world is either degraded or seriously degraded – meaning, among other things, that 70% of the topsoil, the layer allowing plants to grow, is gone (WEF 2012). Soil degradation mainly occurs due to several anthropogenic activities such as overgrazing of farm animals (~35%), agricultural activities (~28%), deforestation (~30%), overexploitation of land to produce fuel wood (~7%), and industrialization (~ 1).

The European Commission has also identified five threats classified as erosion, compaction, contamination, organic matter decline, salinization, landslides, and surface sealing. The mitigation of soil degradation is utmost important as the human beings are obtained more than 99.7% of food resources from land and less than 0.3% from the aquatic ecosystems. Soils are the second largest active store of carbon after the oceans; more carbon is stored in soil than in the atmosphere (760 billion tonnes) and in vegetation (560 billion tonnes) combined (Global Opportunity Report 2017).

In this view, soil degradation increases the intensity of global warming scenarios as the capability of C sequestration in soil is less.

Soil degradation such as erosion, fertility loss, salinity, acidification, soil carbon decline, and compaction have long been reported, and it directly and indirectly impacts food security through changes in soil functions. These have detrimental consequences for agricultural productivity, provision of water, increased greenhouse gases, and loss of biodiversity (Koch *et al.,* 2013).

Soil Compaction and Soil Erosion

Soil erosion is a form of land degradation leading to the removal of topsoil (typically the layer with the most effect on plant production and thus food production) by water and/or wind.

Topsoil contains organic matter, provides micro- and macronutrients to plants, and is responsible for soil structural stability – the determinant factor for the provision of water to plants (Rojas *et al.,* 2016). Thus, soil erosion affects soil health by reducing the thickness of the topsoil, altering soil properties, and depleting SOM and nutrients. Blanco and Lal (2010) identified Asia, Sahel, Central America, and Africa as the regions predominately affected by soil erosion.

The authors also reported that 60% of the rural population in the African tropics and subtropics affected food insecurity due to 40% of soil erosion. Effective land management practices with sustainable utilization of soil resources are the only option to achieve the food security in these affected regions. The African losses cropland of about 100,000 km^2 (approximately the size of Iceland) due to soil erosion, which is the type of soil degradation that refers to ultimate soil losses in terms of topsoil and nutrients.

If the scenario will persist in the same trajectory, the agricultural productivity will be lesser (about 30%) over the next 20–50 years. In addition to soil erosion, inappropriate land management may cause surface crusting and soil compaction, which hampers seed germination.

Saline Soils

Soil salinity is a severe abiotic stress caused primarily by an abundance of sodium chloride (NaCl), from both natural accumulations and from irrigation and crop evapotranspiration (Flowers and Flowers 2005). Saline soils are characterized by having an electrical conductivity higher than 4 ds m^{-1} (where 4 ds m^{-1} ~ 40 mMNaCl), which many crops are unable to tolerate. Poor-quality irrigation water, overuse of fertilizers, and seawater intrusion onto land also contribute to salt accumulation in soil. More than 75 countries around the world are struggling with salinity problems (Alaghmand *et al.,* 2016).

Saline soils are distinguished by the large content of soluble salts, sodic soils with higher levels of sodium ions, and saline-sodic soils with an excess of salts and exchangeable sodium (Sastre-Conde *et al.,* 2015).

It is estimated that at least 20% of the irrigated lands in the world are affected by varying levels of salt. Almost 40% of salt-affected soils in the world are saline and 60% are sodic.

Acidic soils

Soil acidification (pH <5.5) is one of the major constraints for the agricultural productivity and nearly 50% of the arable land affected globally. The problem of soil acidification has been intensified in many agricultural systems (Goulding 2016). Soil acidification can lead to increased toxicities of aluminium and manganese to crops and cause deficiency of phosphorus, base cations (Calcium, potassium and magnesium).

Contaminated Soils with Heavy Metals

Heavy metals are ubiquitous environmental pollutant throughout the world. Atmospheric deposition (mainly from mining, smelting, and fly ash) and livestock manures are the main sources of trace elements contaminating arable soil.

By obstructing the breakdown of soil organic matter and altering nutrient cycling, soil contamination is considered responsible for decreasing soil biodiversity and fertility and decreasing soil health. According to the data provided by the European Environmental Agency (EEA 2014), total potentially contaminated sites in Europe are estimated to be more than 2.5 million, of which 340,000 are thought to be actually contaminated. Approximately one third of the high-risk sites have been positively identified as contaminated, and of these only 15% have so far been successfully remediated (EEA 2014).

Asian countries experience considerable contamination of agricultural soil and crops by trace elements, and this contamination is becoming a threat to human health and the long-term sustainability of food production in the contaminated areas. In China, approximately one fifth of China's total farmland (nearly 20 million ha) is contaminated by heavy metals which may result in a reduction of more than 10 million tonnes of food supplies each year (Wei and Chen 2001).

Among the different trace elements contaminating Chinese agricultural soils, Cd is the biggest concern. Due to its high mobility in the soil (except in poorly drained soil where sulphides are present), it can be easily transferred to the food chain and so poses risks to human health. Arsenic is also naturally present in groundwater in many regions of Southeast Asia especially in Bangladesh and West Bengal in India. This represents a threat to agriculture, particularly in rice paddy fields where anaerobic conditions prevail (Hugh and Ravenscroft 2009).

Asia is also the largest contributor to the atmosphere of anthropogenic Hg, which originates from the chemical industry, from Hg mining and from gold mining. All across Asia, areas under rapid economic development are experiencing moderate to severe contamination by heavy metals (Ng 2010).

Soil Health: A Prerequisite for Sustainable Food Security

Soil is one of the fundamental production factors determining food production stability, food nutrient quality, and yield quantity (FAO 2008). The decrease in soil quality at a pace of up to 100 times greater than the rate of soil formation. It takes around 500 years for just 2.5 cm of topsoil to be created amid unimpeded ecological changes. The measured average soil production rates are ca. 0.036 ± 0.04 mm year^{-1} and are even lower on most agricultural soils because agricultural soils have a certain thickness and soil production rates decrease with increasing soil dept. Like atmosphere and oceans, soils of both the agricultural and non-agricultural lands are vital for humanity life support system. Hence, we need to ensure the soil quality is fundamental to fulfill other global essential needs including water and food. Soil security is a new, wide-ranging, multidimensional, multidisciplinary concept that has antecedence in notions such as soil conservation, care, quality, health, and protection. Soil security as in McBratney *et al.,* (2014) as being concerned with the maintenance and improvement of the world's soil resource to produce food, fiber, and freshwater contributes to energy and climate sustainability and maintains the biodiversity and the overall protection of the ecosystem.

Based on the concept of soil security, the seven functions of the soil to (1) produce food and other biomass would be related to soil capability and soil condition, while soil capital would relate to (2) storing, filtering, and transformation and (3) the provision for a habitat and gene pool. The cultural environment for mankind (4) is related to soil connectivity and valued through the soil capital, where (6) acting as a carbon pool is related to soil condition and capital, and being an archive for archaeological heritage (7) is covered by soil condition and its connectivity. Although described as a function, we would consider (5) source for raw materials, as a threat (McBratney *et al.,* 2014).

In 2012, the Food and Agriculture Organization (FAO) of the United Nations established the "Global Soil Partnership" to highlight effective and concerted actions against soil degradation and to advocate healthy soils for ensuring food security globally. Food security has four dimensions: (1) food production and availability through agronomic management of soil resources, (2) stability of food production and availability at all times, (3) food access through economic and physical capacity of households or communities, and (4) food safety and utilization through nutritious and biological quality (FAO 2011).

The success of food security concept is entirely dependent on availability, access, and utilization; these are the three pillars of food security. Essentially, food availability is referring to having sufficient quantity and a reliable source of food supply, and access focuses on having the resources to obtain high-quality and nutritious food (Godfray *et al.,* 2010).

Food use describes having the knowledge of basic nutrition, as well as access to non-food inputs of adequate water and sanitation or lack of contamination (World Health Organization 2012). Based on these three concerns, stimulated efforts have been taken to ensure food security by improving yield and quality, minimizing loss of productivity by land degradation, pollution, and urbanization, as well as the need for water supply and storage (Godfray *et al.,* 2010).

Sustainable Soil Management: A Healthy Way towards Global Food Security

A Way toward Global Food Security The world could produce up to 58% more food for restoring and protecting living soils through sustainable soil management. The soil is the habitat for the largest gene pool and diversity of species, and these organisms participate actively in soil processes that affect its formation and function. This gene pool will also contribute to the future development of products that sustain human health (Brevik and Burgess 2013).

Soil microorganisms mainly contributed to the maintenance of the organic matter and energy transfer in terrestrial environment especially for contribution to nutrient and water efficiencies, improve soil structure, and protect against soilborne diseases (Brussaard *et al.*, 2007). The promotion of sustainable soil management should aim to: (a) manage soil erosion through soil conservation and soil rehabilitation/restoration, (b) increase or maintain soil organic matter content which constitutes the key factor in effective soil management and resilience, (c) limit soil sealing (land take) especially on the most suitable and productive agricultural soils, (d) enhance soil water storage through improved soil structure (i.e., increase soil organic matter content), (e) boost long-term soil fertility through integrated management approaches, (f) maintain and enhance soil biodiversity as a foundation for soil health, and (g) increase soil carbon sequestration.

Ultimately, sustainable soil management is an important precondition to address the increasing pressures on soils posed by rapid global population growth. The Global Soil Partnership (GSP), established by members of the FAO in 2012, aims to enhance synergies and to promote coordination and partnerships through numerous initiatives, actions, and actors worldwide aimed at promoting sustainable soil management.

To achieve sustainable soil management and ensure food security, the established GSP identified five pillars of action: (1) adoption of soil protection and conservation strategies for sustainable food production; (2) encouragement of investment, technical cooperation, policy, education awareness, and extension in soil; (3) promotion of soil research and development on identified gaps and priorities (4) enhancement of the quantity and quality of soil data and information; and (5) harmonization of methods, measurements, and indicators for sustainable soil management (Montanelli and Vargas 2012). The Government of India established All India Soil Survey Organization in 1956 with headquarters at the Indian Agricultural Research Institute with five Regional Soil Correlation Centres at Bangalore, Delhi, Kolkata, Jorhat, and Udaipur. Later in 1958, this scheme was integrated with the Land Use Planning Scheme of the Central Soil Conservation Board primarily to carry out detailed soil surveys in the catchment areas of major River Valley projects, with setting up the organization, "All India Soil and Land Use Survey." Recently, the Government of India launched the Soil Health Card Scheme in February 2015 to assess the soil quality parameters periodically. The objective of this scheme is to issue the soil cards to about 14 crore farmers spread all over India by 2017.

The process of this scheme as the various soil testing laboratories in the country will carry out the testing of the soil samples, the results of which will be analyzed by the experts. The results are related to the strength and weaknesses of the soil. The experts also suggest methods to improve the soil quality. These results and suggestions are displayed in the soil health cards.

Sustainable Food Productivity

Sustainable agricultural practices include many farming practices that can both maintain crop production and improve soil quality, such as uses of organic fertilizers, no-till or minimum tillage, polyculture, and biological pest management. These approaches aimed at enhancing farming systems resilience and spreading the risks to agricultural practices through high levels of adaptation and mitigation approaches to climate change. These practices should increase soil health by improving soil water storage capacity and soil structure with organic matter, controlling soil erosion, managing soil organic matter (SOM) for soil carbon sequestration, and boosting nutrient management (FAO 2013).

Organic Agriculture

Organic agriculture, commonly understood as farming with no synthetic pesticides and fertilizers, is a key dimension of agroecology. Among the 1.24 million tonnes of organic production in the country, around 80,000 million is supplied from Sikkim. In India, the other leading states for organic farming practices are Kerala, Mizoram, and Arunachal Pradesh. Sustainable farming goes a step ahead as it provides environmental protection, biodiversity conservation, and better agricultural production with enhanced soil quality by crop rotation, intercropping, polyculture, covering crops, and mulching.

India continues to be the country with the highest number of producers (585’200), followed by Ethiopia (203’602) and Mexico (200’039) (The World of Organic Agriculture 2017). Further, the report also highlighted that the countries with the largest share of organic agricultural land of their total farmland are Liechtenstein (30.2%), Austria (21.3%), and Sweden (16.9%). In eleven countries, 10% or more of all agricultural land is organic. Several authors (Niggli *et al.,* 2008) argued that organic agriculture could benefit developing countries because organic practices contribute considerably to increasing soil stability and resilience, an important factor in food supply stability, and also save water, another critical resource in many areas.

According to the recent report on global data for organic farming worldwide by the Research Institute of Organic Agriculture (FiBL) and IFOAM – Organics International, a total of 50.9 million hectares were organically managed at the end of 2015, representing a growth of 6.5 million hectares over 2014, the largest growth ever recorded. Australia is the country with the largest organic agricultural area (22.7 million hectares), followed by Argentina (3.1 million hectares), and the USA (2 million hectares). Further, 2.4 million organic producers were reported in 2015.

Climate Resilient Agriculture (CRA).

According to the Food and Agriculture Organization (FAO), climate-smart agriculture (CSA) is an integrated approach that addresses the interlinked challenges of climate change and food security with the objectives of (1) sustainably increasing productivity to support equitable increases in farm incomes; (2) adapting and building resilience of food production systems to climate change at multiple levels such as drought, flood, heat/cold wave, erratic rainfall pattern, pest outbreaks, and other threats caused by changing climate; and (3) reducing GHG emission from agriculture (including crops, livestock, and fisheries). In India, the estimated countrywide agricultural loss in 2030 is expected to be over $7 billion that will severely affect the income of at least 10% of the population. However, this could be reduced by 80%, if cost-effective climate resilient measures are implemented.

Ensuring Global Food Security : Role of MDGS and SDGS

Role of MDGs and SDGs Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (World Food Program 2009).

The above definition focuses on four dimensions of food security such as (1) availability of food, (2) accessibility (economically and physically), (3) utilization (the way it is used and assimilated by the human body), and (4) stability of these three dimensions. The countries China, Indonesia, India, Bangladesh, and East and West Africa (particularly Nigeria) have been identified and forecasted as food security hotspots in both 2005 and 2050 (Matuschke 2009).

According to Global Hunger Index 2016 released by the International Food Policy Research Institute (IFPRI), India ranked 97 among 118 countries; 15% of Indian population is under nourished – lacking in adequate food intake, both in quantity and quality. The GHI is calculated by taking into account four key parameters: shares of undernourished population, wasted and stunted children aged under 5, and infant mortality rate of the same age group. The Millennium Development Goals (MDGs) provided a framework to mobilize global action against hunger and poverty and other development objectives.

The Asia-Pacific region has achieved the Millennium Development Goals' hunger target (MDG-1c) of halving the proportion (236 million) of undernourished people in 2015. However, this was not sufficient to meet the target set by the World Food Summit of halving the number of undernourished people by 2015 (FAO 2015).

Future Outlook

Innovative strategies are needed to strengthen and to attain the sustainable soil management, which plays a crucial role in food security. These are:

A multidisciplinary approach and/or experts with extensive knowledge from geology, geography, environmental science, and agricultural science are involved to solve the various issues on soil and food security. Initiative and reports to be updated regularly including the areas of various categories of soil degradation especially contaminated sites, and these information's will be helpful for remediation and rehabilitation of such contaminated sites.

Similar to Global Strategy for Plant Conservation, identification of different sustainable soil management and agricultural productivity strategies depending upon the site/land condition and other influential parameters for increased food productivity (e.g., a diversified production system, with soil conservation practices, incorporation of trees, and reduced energy use, provides both adaptation and mitigation benefits for more adaptation; monocrop with reduced tillage and reduced use of agrochemicals reduced GHG emissions for more mitigation).

Extensive utilization of multigene approach for various staple food crops rather than rice and wheat.

To find the possibility for many plants through Aero Farms as the productivity increased 75 times per square feet than the commercial farm. Identification for alternative source of phosphatic fertilizers – possibility for exploration of mechanisms in several thousand species of AM fungi use to extract phosphorus from the environment or how these processes work in degraded soils and in various crop types.

To ensure proper price for farmers products without any intermediates especially for smallholder farms, which use less than 2 ha of land; 83% of such farms are existed in Asia and sub-Saharan Africa.

References

Alaghmand S, Beecham S, Woods J A *et al.*, (2016) Quantifying the impacts of artificial flooding as a salt interception measure on a river-floodplain interaction in a semi-arid saline floodplain. *Environment Model Software*(79) pp167–183.

Blanco H, Lal R (2010) Soil erosion and food security. Principles of soil conservation and management. Springer, Dordrecht, pp 493–512.

Brevik E C, Burgess L C (2013) Soils and human health. CRC Press, Boca Raton.

Brown M E, Funk C C (2008) Food security under climate change. *Science* (319) pp580–581.

Brussaard L, de Ruiter P C, Brown G G (2007) Soil biodiversity for agricultural sustainability. Agric *Ecosystem Environ*ment (121) pp233–244.

Conway G (2012) One billion hungry: can we feed the world. Cornell University Press, Ithaca.

European Environment Agency (EEA) (2014) Progress in Management of Contaminated Sites, European Environment Agency.

FAO (2008) The state of food insecurity in the developing world. FAO, Rome. http://www.fao.org/ docrep/012/i0876e/i0876e00.HTM. Accessed 20 Jan 2010.

FAO (2011) The state of the World's land and water resources for food and agriculture (SOLAW) – managing systems at risk; Food and Agriculture Organization of the United Nations: Rome, Italy; Earthscan: London, UK, 2011. Available online: http://www.fao.org/docrep/017/i1688 e/ i1688e.pdf. Accessed 15 Sept 2015

FAO (2013) State of Food and Agriculture (SOFA) 2013 – food systems for better nutrition. FAO, Rome FAO (2015) The State of Food Insecurity in the World 2015: meeting the 2015 international hunger targets: taking stock of uneven progress. FAO, Rome, 8, 44. http://www.fao.org/3/a-i4646e.pdf

Gardi C, Panagos P, VanLiedekerke M *et al.*, (2015) Land take and food security: assessment of land take on the agricultural production in Europe. *Journal of Environment Plan Manage* 58(5)pp898–912.

Global Nutrition Report (2016) IFPRI, Washington, DC: International Food Policy Research Institute, 2016.

Global Opportunity Report (2017) First edition, DNV GL AS, Hovik, Oslo.

Godfray C, Beddington J, Crute I *et al.*, (2010) Food security: the challenge of feeding nine billion people. *Science* (27) pp812–818.

Hugh B, Ravenscroft P (2009) Arsenic in groundwater: a threat to sustainable agriculture in South and South-east Asia. *Environ Int* 35(3)pp647–654.

Hunger Report (2017) Fragile Environments, Resilent Communities. Bread for the World Institute, Washington, DC

Koch A, McBratney A B, Adams M *et al.*, (2013) Soil security: solving the global soil crisis. *Glob Policy Journal* (4) pp434–441

Matuschke I (2009) Rapid urbanization and food security: using food density maps to identify future food security hotspots

McBratney A, Field D J, Koch A (2014). The dimensions of soil security. *Geoderma*(213) pp203–213.

Montanelli L, Vargas R (2012) Global governance of soil resources as a necessary condition for sustainable development. *Environment Sustainability*(4) pp559–564.

Ng H (2010) Regional assessment: soil contamination policy and practice in Asia. Asian Environmental Compliance and Enforcement Network (AECEN).

Niggli U, Slabe A, Schmid O *et al.*, (2013) Vision for an organic food and farming research agenda to 2025 organic knowledge for the future. IFOAM

Rojas R V, Achouri M, Maroulis J *et al.*, (2016) Healthy soils: a prerequisite for sustainable food security. *Environment Earth Science*(75)180.

Sastre-Conde I, Carmen Lobo M, IcelaBeltrán-Hernández R *et al.*, (2015) Remediation of saline soils by a two-step process: washing and amendment with sludge. *Geoderma*(247–248) pp140–150

Second Advance Estimates of Production of Food Grains for 2016–17, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, February 15, 2017. http://eands. dacnet.nic.in/Advance Estimate/2nd_Advance_Estimate_ENG.pdf

Singh R B (2009) towards a food secure India and South Asia. Making hunger a history. http:// www.apaari.org/wp-content/uploads/2009/08/towards-a-food-secure-india makinghungerhistory.pdf

St Clair S B, Lynch J P (2010). The opening of pandora's box: climate change impacts on soil fertility and crop nutrition in developing countries. *Plant Soil*(335) pp101–115.

The World of Organic Agriculture (2017) Research Institute of Organic Agriculture (FiBL).

Tilman D, Cassman K G, Matson P A *et al.*, (2012) Agricultural sustainability and intensive production practices. *Nature*(418) pp671–677.

World Economic Forum (2012) What if the world's soil runs out? WEF in collaboration with TIME talked to University of Sydney Professor John Crawford on December 14, 2012.

Wei C Y, Chen T B (2001) Hyperaccumulators and phytoremediation of heavy metal contaminated soil: a review of studies in China and abroad. *ActaEcolSinica*(21) pp1196–1203.

World Health Organization (2012) Trade, foreign policy, diplomacy and health: food security. (http://www.who.int/trade/glossary/story028/en/.Accessed 25 Oct 2012.