MEASURE, MONITOR, MANAGE – THREE M'S FOR SUSTAINABILITY IN CROP PRODUCTION SYSTEMS

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Themes identified

- Soils - foundation for family farming. 2014
- Healthy Soils for a Healthy Life. 2015
- Soils and pulses - Symbiosis for life 2016
- Caring for the planet starts from the ground. 2017
- Keep soil alive - Protect Soil Biodiversity 2020
- Halt soil Salanization, boost soil productivity. 2021
- Soils - Where food begins 2022
- Soil and water – Source of Life 2023

World Soil Day - 2024

Theme – Caring for Soils: Measure, Monitor, Manage

- Underscores the importance of accurate soil data and information on soil health parameters
- Periodical monitoring of soil health to assess extent of deterioation
- Soil management strategies for sustainable production, environment protection and food security.

Pressures on Food production Systems

- Global population pressure
- Present seven million to rise by nine million by 2050
- Current production has to be doubled
- Competition for land, water and energy will intensify,
- Effects of climate change will intensify
- Enormous demands for food, water, nutrients, energy and biodiversity loss
- Meeting growing demand for food has to take care of biodiversity loss and maintain ecosystem services (Glenn *et al*,2008)

Green Revolution and After

- Introduction of high yielding varieties of crops especially wheat and rice substantial increase in production
- Intensified farming and high use of fertilizers and pesticides
- The increased yields soon saw a yield decline in the mid nineties, mostly in annual crops on which the small farmers livelihood solely depended
- Decline in soil fertility with development of multi nutrient deficiencies
- Soil degradation in various forms, pollution from fertilizers and pesticides of surface and ground water
- Increased emission of green house gases.
- Deforestation, consequent, soil erosion rendered many areas unfit for cultivation.
- Loss of biodiversity and indigenous crops (Daisy and Giridhra, 2021)

Soil Health

- Healthy soils have optimal biological, chemical, and physical conditions enabling high yields of crops.
- Roots are able to proliferate easily, plentiful water enters and is stored in the soil,
- Sufficient nutrient supply, there are no harmful chemicals
- Beneficial organisms are very active and able to keep check on potentially harmful ones . (Richard MacEwan, and Sonja Tymms,2010)

Sustainability in food production systems

- Sustainability is now widely used in development circles.
- Group on International Agricultural Research (1988) states sustainable agriculture as the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources

Measurement of Soil Health/Quality

- Soil health/quality is the foundation of sustainable crop production
- Continued maintenance requires measurement and monitor of real-time information on parameters essential for sustainable agricultural management. (Sishodia *et al*. 2020).
- Conventional methods of laboratory analyses are costly, labour intensive and time-consuming.
- Ground-based, and hand-held sensors can rapidly collect high-resolution data and, even allow real-time analysis and processing by taking measurements as frequently as once per second
- Sensor-based soil analysis, potentially provides several advantages and enable collection of large data sets while traversing a field.
- Procurement of quality data on various soil health parameters is possible in a short time enabling planning of appropriate soil health management strategies (Chaudhari et al 2021)

Soil Spectroscopy

- A promising technology for soil analysis for health assessment parameters
- Compared to traditional wet chemistry. the new technique of soil spectroscopy is fast, cost-effective, environment friendly, and repeatable

Sensors for Automated Measurements

- Infrared electromagnetic radiation at specific wavelengths, provide a spectral signature on the mineral and organic composition of the soil
- Innovative Solutions for Decision Agriculture (iSDA) under International Centre for Research in Agro Forestry (ICRAF) has set up an initiative to establish a new global soil spectral library and estimation service.
- Actual soil samples or online light reflectance scans send to the centralized server will be ,provided estimates of a range of soil properties.
- Global Soil Net Work(GLOSOLAN) of the Food and Agriculture Organization's (FAO)

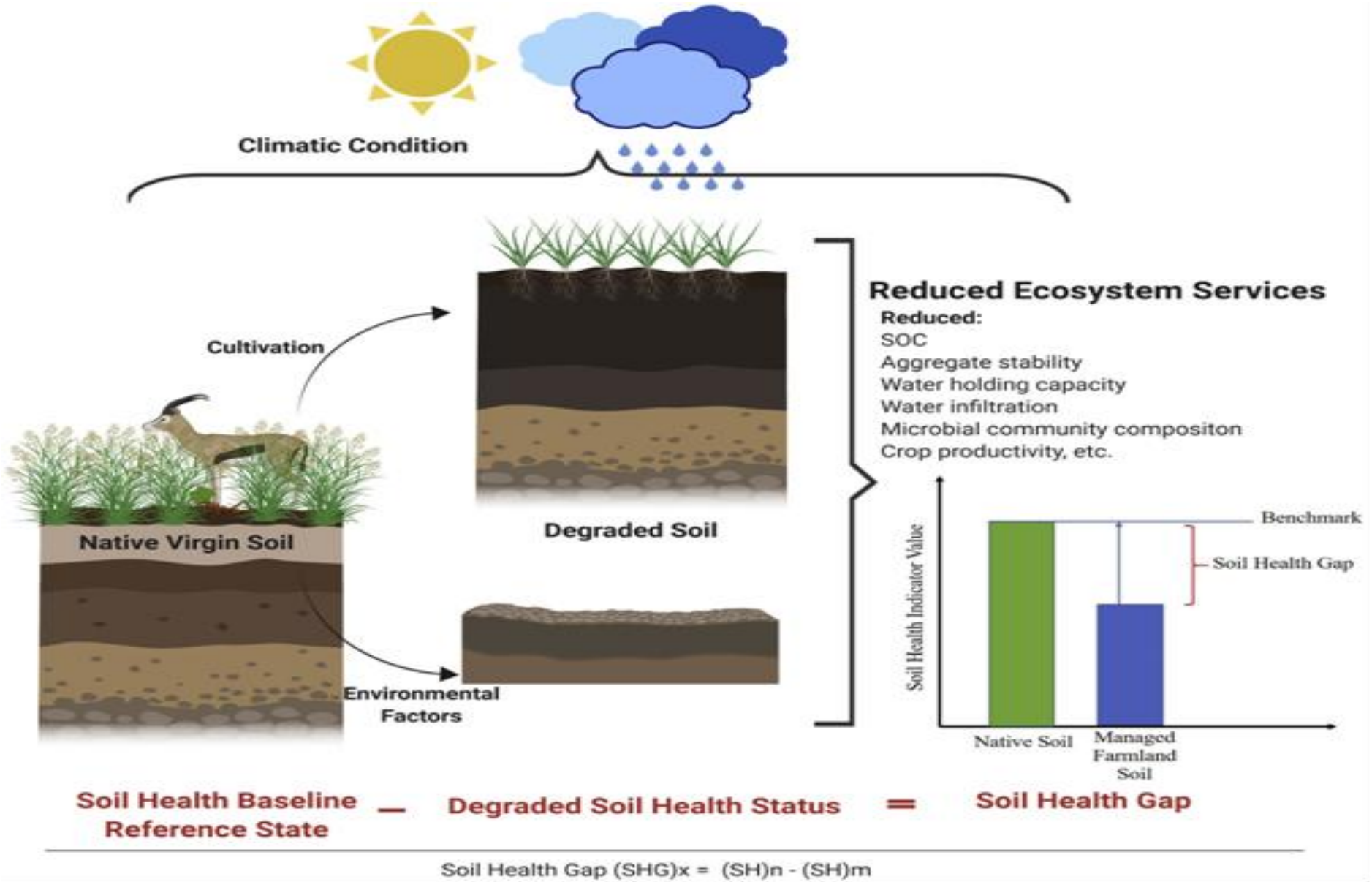
- Precision agriculture utilizes geospatial technologies like GPS, GIS remote sensing and variable rate fertilizer application for site specific nutrient management
- Various types of sensors like electrical, electro magnetic. optical, radiometric, electrochemical and mechanical sensors are being used for study of large scale spatial and temporal variability in soil properties.
- Soil texture, moisture, cation exchange capacity, pH and other soil parameters can be measured using appropriate data analysis techniques.

Need for Benchmarking Soils for Health Monitoring

- Climate change and population expansion add to the global urgency to optimize use of soil resource
- Management and restoration of degraded lands to enhance and maintain soil health and ecosystem services, is the need of the hour to ensure food and livelihood security for a growing population

Soil Health Gap - Definition

- Soil Health Gap is defined as the “difference between soil health in an undisturbed native virgin soil and current soil health of a cropland in a given agro ecosystem”(Bijesh *et al* (2020)
- $SHG_x = SH_n - SH_m$
- SHG_x Soil health Gap (SH)n and (SH)m refer to soil health in n; native soil and m; managed cropland soil.


Climatic Condition
Cultivation
Native Virgin Soil
Degraded Soil
Environmental Factors
Reduced Ecosystem Services
Reduced:
SOC
Aggregate stability
Water holding capacity
Water infiltration
Microbial community compositon
Crop productivity, etc.
Soil Health Indicator Value
Benchmark
Soil Health Gap
Native Soil
Managed Farmland Soil
Soil Health Baseline Reference State
Degraded Soil Health Status
Soil Health Gap
Soil Health Gap (SHG)x = (SH)n - (SH)m

Soil Health Critical Values

- Soil health critical values will determine the limit at which soil health will deteriorate if soil health management practices are not introduced.
- These limits are dynamic and change with climate and soil properties (Arshad and Martin, 2002).
- The SHG would be based on the difference in soil health benchmark property from the native undisturbed soil and the cropped land to represent the extent of soil degradation

Soil Quality Assessment and Monitoring

- Cannot be measured directly because it is an integration of several properties
- These measurements are called soil quality indicators (Gugino, *et.al*, 2009).
- Soil health assessment has to be approached at four levels.
- General field observation
- Field assessment using qualitative indicators
- Comprehensive soil health test
- Other targeted soil analysis for specific problem (Fred Magdoff and Harold Van, (2009).

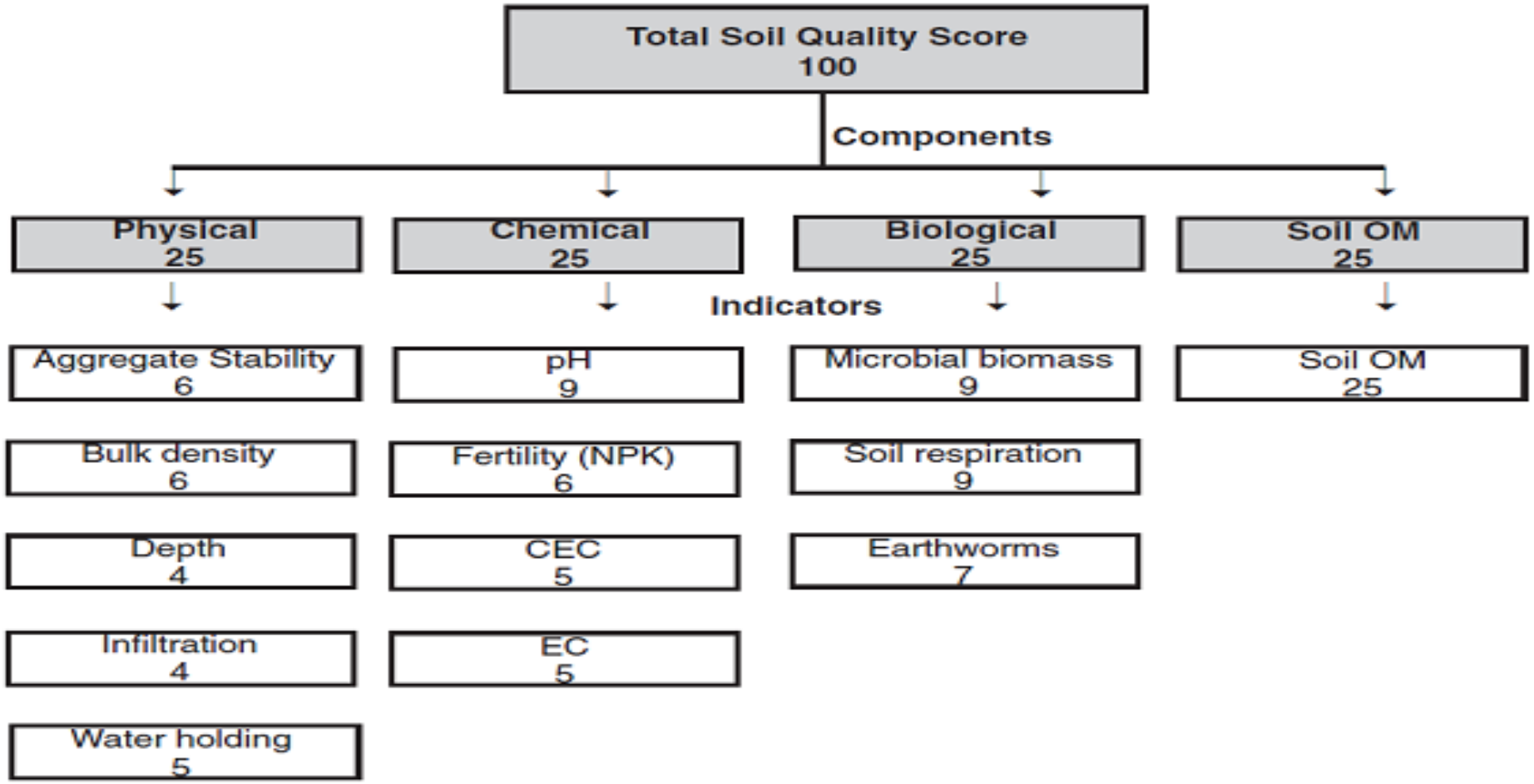
Soil Health Assessment indicators

- Soil health assessment has to start with field observations which are usually reflected in the crop growth and performance
- Physical properties (soil depth, texture, bulk density, structure, aggregate stability, gravelliness, available water capacity)
- Chemical properties (pH, EC, OC, P, K, Ca, Mg, S, Cu, Zn and B)
- Biological properties (soil organic matter, active carbon, potentially mineralizable N, root health, earthworms and soil respiration rate) .
- Critical Values of indicators for optimal soil quality are needed based on available data.
- These standard values and ratings for soils for different regions are available in literature

Applying Scoring System to Assess Soil Quality level

- Based on the available standard values and the current available data soil quality index has to be worked out
- Comparison of the present values and standard values scores have to be worked out
- The total of the scores within components physical, chemical, biological has to be calculated
- Total of the scores for various components will form the soil quality index

Maximum score for different soil components and soil quality indicators



Interventions

- Once the soil quality status is determined, the next step is to devise an intervention plan. Intervention varies with the soil type, crop and management history, and resources needed.
- If total score is >90 only minor intervention is needed
- Score between 80-90 needs moderate intervention based on indicators with low score.
- A score less than 80 involves major interventions, starting from the indicator with the lowest score within a component
- A master property such as OM or pH has to be given thrust.
- Intervention needs to be comprehensive and simultaneous within a given time frame
- Can involve interventions of several soil amendment practices at the same time
- However, addition of OM is the single most important practice that is effective to bring to optimum level many soil parameters simultaneously. (PSS 2262)
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Summing up

Agro ecological approaches that foster synergies between agriculture and biodiversity have to be scaled up and mainstreamed in all relevant policies, instruments and institutions.

The specific value of Soil Science research using modern soils information have to be demonstrated through inter- and transdisciplinary studies on SDGs in areas related to food security, water scarcity, climate change, biodiversity loss and health threats. It is only through intensive and genuine collaboration with stake holders the goals envisaged for sustainable development can be realized.

Community based production of biological inputs by self help groups/farmers organizations helps to achieve the twin benefits of livelihood support and reduction in input cost.

Farming systems approach, with appropriate blend of crop-livestock integration has to be adopted to offset total income loss since many in any enterprises are involved.

Post Harvest Technology and Value addition of crop, livestock products, remunerative marketing strategies can ensure livelihood security for millions of small farmers.

Kerala Scenario – Action Plan

- Inventory of the resources of the Panchayat using Remote sensing and GIS techniques and identification of crop clusters
- Integrated farming system approach with appropriate combinations of crop, livestock, fisheries suited to the agro ecological unit in the Panchayat
- Good Agricultural Practices covering soil health, agronomic management, pest and disease surveillance and protection

Contd...

- Value addition, post harvesting processing, market intervention for sale of farm produce without intermediaries .
- All farming activities to be initiated by farmer clusters through self help groups covering various components of the system.
- Management stratagies proposed is to achieve the maximum productivity of the components of the system, livelihood security for the community, sustainability and environment quality

Reference

Brijesh Maharjan, Saurav Das, Bharat Sharma Acharya, 2020, Soil Gap: A concept to establish a benchmark for soil health management, Global Ecology and Conservation, Vol 22, e01116

Way Forward

A successful transition to sustainable, productive and resilient agriculture is one of the major challenges of our time. The concept of Nature-based Solutions (NBS) opens the door to a new approach to balancing environmental and agricultural development goals. By harnessing NBS it can help us reach multiple global goals, including those related to food security, climate change and biodiversity, and deserves to be considered as one of the top political priorities on the international agenda. (Larbodiere et al,2020)


Thank You