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Integrated Soil and Water Resource Management for Livelihood and Environmental Security

D. J. Rajkhowa, Anup Das, S. V. Ngachan, A. K. Sikka and M. Lyngdoh

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Front cover photo: An watershed based farming system unit, Tynnai-Photjaud village, South west Khasi Hills, Meghalaya
Back cover photo: Pond based farming system in Ladsyat village, Ribhoi, Meghalaya

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FOREWORD

Agriculture plays a vital role in Indian economy with about 52% of the population dependent on agriculture for livelihood. India presently supports 18% of the world's human and 15% livestock population with only 2.4% of the land mass and 4.2% fresh water. It is estimated that by 2050, about 22% of the total geographical area and 17% of the population will face water scarcity. Per capita water availability, which was about 1704 m^3 in 2010, is projected to be 1235 m^3 in 2050. Consequently, the share of agriculture sector in total water use is expected to reduce warranting improved management of this vital resource for sustaining agricultural production in the country.

About 121 million ha land in India is prone to various kinds of degradation. Among the negative impacts of soil erosion by water and wind, the loss in crop productivity, disruption of nutrient cycle, alternation in water and energy balances, reduction of reservoir capacity, loss of biodiversity and natural disasters like floods and droughts have a strong bearing on national food and environmental security.

It is estimated that by 2050, the country's food grain requirement will be 377 million tonnes for feeding the 1.6 billion strong population. Sustainable and increased productivity depends solely on judicious use and management of natural resources to meet the growing food requirements and for maintaining environmental security. Shrinking and degrading natural resources, coupled with climate variability and climate change are posing serious limitations.

Managing soil and water resources to meet the growing human and animal needs in terms of food, fibre, fodder, timber and fuel, is therefore of paramount importance. Rainfed areas, which constitute about 58% of the net cultivated area, contribute only 42% to the total food production. The challenge before the Indian agriculture, therefore, is to transform rainfed farming into more sustainable and productive systems through efficient use of natural resources. Harnessing the potential of integrated farming systems, integrated nutrient management and integrated water management through location specific technologies holds the key.

Watershed approach has been the single most important landmark in the direction of bringing visible benefits in rural areas and attracting people's participation in rainfed agriculture. Identification of location-specific stress tolerant varieties and breeds are desirable to minimize the risks of farmers. Crop diversification, contengency planning, private-public partnership and bringing convergence among various development agencies and research institutes may bring desirable changes to the livelihood of farmers. Conservation agriculture, agroforestry, fodder and forage based land use models are envisaged for soil and water conservation and for mitigating climate change. Community water resource management, replacing high water requiring crops with water efficient crops, promotion of micro-irrigation etc. are envisaged in irrigated areas for food and environmental security.

I am happy to learn that a team of ICAR scientists has edited a book on "Integrated Soil and Water Resource Management for Livelihood and Environmental Security" that would be useful in providing guidance and direction to the researchers and planners including extension personnel on efficient management of natural resources for food and environmental security. I compliment the authors for their effort in bringing out the book.

Dated the 20th April, 2015 **(S Ayyappan)**
New Delhi

Preface

"Soil is soul and water is life" is the central theme of sustainable soil and water management practices. Soil degradation has become a serious problem in both rainfed and irrigated areas of India. In India, 147 million hectare (Mha) of land suffers from various kind of degradation such as 94Mha from water erosion, 16 Mha from acidification, 14 Mha from floods, 9 Mha from wind erosion, 6 Mha from salinity and 7 Mha from a combination of factors. India supports 18 % of the world's human population and 15% of livestock population but has only 2.4 % of world's land area. Agriculture, forestry and fisheries account for 17% of gross domestic product and employs about 50% of the total work force of the country. The green revolution brought about a technological breakthrough, leading to the use of short duration high yielding varieties that helped intensify land use within a year by increasing the area under irrigation and greatly increasing the use of chemicals such as fertilizers and pesticides.

Agriculture is one of the principal sources of greenhouse gas (GHG) emission globally. However, the opportunity is that, agriculture can be also an important solution to mitigate climate change by reducing net GHG emission from the manufacture and use of agricultural inputs and employ efficient technologies to use scarce natural resources to attain food security and mitigate impact of climate change.

Accelerated soil erosion due to anthropogenic activities and conventional tillage has numerous adverse impacts on ecosystem services. It is predicted that if current trends of greater agricultural intensification an land clearing were to continue,~1 billion ha of land would be cleared globally by 2050, with CO_2-C equivalent GHG emission reaching ~3 Gt y^{-1} and N use ~250 Mt y^{-1} by then. However, if 2050 crop demand was made by moderate intensification focused on existing croplands, adaptation and transfer of high yielding conservation effective technologies to these croplands and global technologies improvements, analysis forecast land clearing of only ~ 0.2 billion hectare, GHG emission ~1 Gt y^{-1} and global N use of ~225 Mt y^{-1}.

Foodgrain production of India has increased from 50 Mt to over 260 Mt, over the last five decades. This however, had further consequences, including loss of plant biodiversity and environmental pollution. Widespread land degradation caused by inappropriate agricultural practices has a direct and adverse impact on the environment, food and livelihood security of farmers. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and imbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticides overuse, inadequate crop residue and/or organic carbon inputs and poor crop planning. Agricultural activities and practices can cause land degradation in a number of ways depending on land use, crops grown and management practices adopted. Some of the common causes of land degradation by agriculture include cultivation in fragile deserts and marginal sloping lands without any conservation measures, land clearing and deforestation, depletion of soil nutrients due to poor farming practices, overgrazing, excessive irrigation, over drafting (the process of extracting groundwater beyond the safe yield of the aquifer), commercial development and land pollution through industrial waste disposal to arable lands.

The already imbalanced consumption ratio of 6.2:4:1 (N:P:K) in 1990-1991 has widened to 7.2:7:1 in 2000-2001 compared to a target ratio of 4:2:1. As food grain production increase with time, the number of elements deficient in Indian soils increased form one (N) in 1950 to nine (N, P,K,S,B,Cu,Fe,Mn and Zn) in 2005-2006. Although the use of fertilizer has increased several folds, the overall consumption continues to be low in most parts of the country. Widespread Zn deficiency, followed by S, Fe, Cu, Mn and B are common throughout the country. Every year, ~20 Mt of the three major nutrients are removed by growing crops, but the corresponding addition through inorganic fertilizers and organic manure falls short of this harvest.

Intensive agriculture has also led to doubling of irrigated crop land over the past four decades, from 19 to 38%. Most of this water has been extracted from limited ground water resources. Excess nitrate has leached into ground water due to heavy N fertilizer use. Excessive tillage for land preparation and planting, indiscriminate irrigation and excessive fertilizer applications are the main source of GHG emission from agricultural systems. Burning of crop residues for cooking, heating or simply disposal is a pervasive problem in India and contribute to soil organic matter (SOM) loss. About ~500 Mt of crop residues are generated every year and ~125 Mt are burnt in the country. Improper crop rotation couple with lack of proper soil and water conservation measures is important reasons contributing to soil erosion in lands under cultivation. In addition, cultivation of marginal lands on steep slopes, in shallow or sandy soils, with laterite crusts and in arid or semi-arid regions bordering deserts resulted in land degradation.

Mechanical soil and water conservation measures are required for controlling soil erosion, retaining maximum rainfall within the slope and safe disposal of excess run off from the top to the foot hills of India. Agronomical practices like use of cover crops, mixed/ inter/strip cropping, crop rotation, green manuring and mulch farming are vital practices associated with integrated nutrient management. Growing soybean (*Glycine max*)/ groundnut (*Arachis hypogoea*)/ cowpea (*Vigna radiata*) with maize (*Zea mays*)/ jowar (*Sorghum bicolor*)/ bajara (*Pennistum glaucum*) is a common example for intercropping in the dry lands.

Development and management of watershed resources to achieve optimum production without causing deterioration to the resources base is the focus of integrated watershed management. The objectives are to increase percolation of water, decrease run off and improve water availability. Integrated nutrient management increase crop productivity, improves SOC content and decreases soil loss. Liming is the most desirable practice for amelioration of acid soil for increasing the availability of plant nutrient and reduces toxicity of Fe and Al.

Salt affected soils are reclaimed by leaching followed by application of green manure. Gypsum is the major chemical use for reclamation of alkali soils.

Adoption of conservation principles in crop production and integrated farming systems for efficient recycling of on- and off-farm biomass are the two simple and environmentally sustainable technologies for achieving twin objectives in food and environmental security. Agro-forestry has significant role in reversing trend of land degradation and improve livelihood, ecosystems services in terms of C-sequestration and soil water conservation. Thus, for ensuring food and nutritional security in one hand and conserving natural resources and ensuring environmental security in other hand, there is urgent need to employ and adopt conservation effective best practices in various aspects of agriculture and allied sectors. National Initiative on Climate Resilient Agriculture (NICRA) is being implemented by ICAR to address the impact of climate variability and climate change in agriculture and to develop appropriate technologies for bringing resilience to the agricultural production systems. During last four years a good number of locations specific technologies including resource management modules, low carbon technologies, crop varieties, livestock breeds have been identified and demonstrated under technology demonstration component in farmers field for a climate smart farming.

The present book is an attempt to bring together the potential technologies on integrated soil and water management practices and best agricultural technologies for food and environmental security in one compilation for the end users. A total of 34 chapters on various aspects of soil and water management, C-sequestration, agro-forestry, GHG emission, integrated farming system, livestock production including social aspects have been covered. The chapters have been contributed by the eminent researchers engaged in the relevant field from across the country. The editors are confident that the book will be of much use for sustainable management of soil and water resources in an integrated approach involving various conservation effective technologies for promoting livelihood and environmental security.

Editors

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