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Road Map for Rehabilitation of 26 Mha Degraded Lands in India

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
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Preface

Land degradation is a major threat to sustainable development of agriculture and food security. Sustainable Development Goal, SDG 15, focuses on restoration of 350 million hectares of degraded lands by 2030 at the global level. At COP 14, Prime Minister Narendra Modi announced that 'India would raise its ambition of the total area that would be restored from its land degradation status, from 21 million hectares to 26 million hectares between now and 2030'. It means restoring the lost land productivity and ecosystem services of 26 million ha of degraded lands, including vulnerable lands, by adopting a 'landscape restoration approach'. It is a holistic approach requiring multi-ministerial interventions to achieve this target. The ministries related to agriculture, rural development and environment & forest are key stakeholders in achieving land degradation neutrality.

To develop an action plan to rehabilitate 26 million ha of degraded lands by 2030, the National Academy of Agricultural Sciences (NAAS) organized a brainstorming session on December 9, 2021 under the convenership of Dr Ch. Srinivasa Rao, Dr J.C. Katyal and Dr Anil K. Singh. This document is an outcome of the deliberations and discussions in this brainstorming session. I am thankful to the conveners and the editors Dr Partap S. Birthal and Dr Malavika Dadlani for bringing this document in the present shape. I hope recommendations contained in it will be useful to policymakers and all other stakeholders including scientific community and corporate sector in taking appropriate decisions on land management, especially regarding maintenance of soil health.

December, 2022
New Delhi

(Trilochan Mohapatra)
President, NAAS

Road Map for Rehabilitation of 26 Mha Degraded Lands in India

1. INTRODUCTION

The International Union for the Conservation of Nature (IUCN) and the Government of Germany launched the Bonn Challenge in 2011 targeting restoration of 150 Mha of deforested and degraded land by 2020 and 350 Mha by 2030. India was the first Asian country to join this Challenge, and pledged restoring 26 Mha of degraded land by 2030.

Degraded land is the land that has lost at least 10% of its natural productivity due to human-caused management processes – land use shifts, deforestation, transgressing carrying capacity, exclusive focus on man-made inputs ignoring the use of organic manures and microbial potential, excessive tillage, etc. From the point of developing policies to reduce emissions from deforestation and forest degradation (REDD+), degraded lands refer to areas with low carbon stocks (<35t/ha). Among the 17 UN SDGs targeted to be achieved by 2030, the SDG 15.3 has a primary focus on achieving a Land Degradation Neutral (LDN) World. The LDN is defined as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services, and to enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems" (UNCCD). It impacts several other 'SDGs' also (Figure 1).

Of the 196 countries, which participated in the 14th Conference of Parties (COP 14) of the United Nations Convention to Combat Desertification (UNCCD) in 2019, 123 countries, including India, had already committed targets on LDN. At COP14, Prime Minister Narendra Modi announced, "*India would raise its ambition of the total area that would be restored from its land degradation status, from 21 million hectares to 26 million hectares between now and 2030*". India, therefore, has the commitment to restore 26 Mha of degraded lands and fulfilling the requirements of LDN by 2030. It means restoring lost land productivity and ecosystem services of 26 Mha of degraded lands including vulnerable lands by adopting a 'landscape restoration approach'.

To develop an action plan responding to the call of the Prime Minister, the National Academy of Agricultural Sciences (NAAS) organized a brainstorming session on December 9, 2021. It was attended by 60 participants, representing researchers

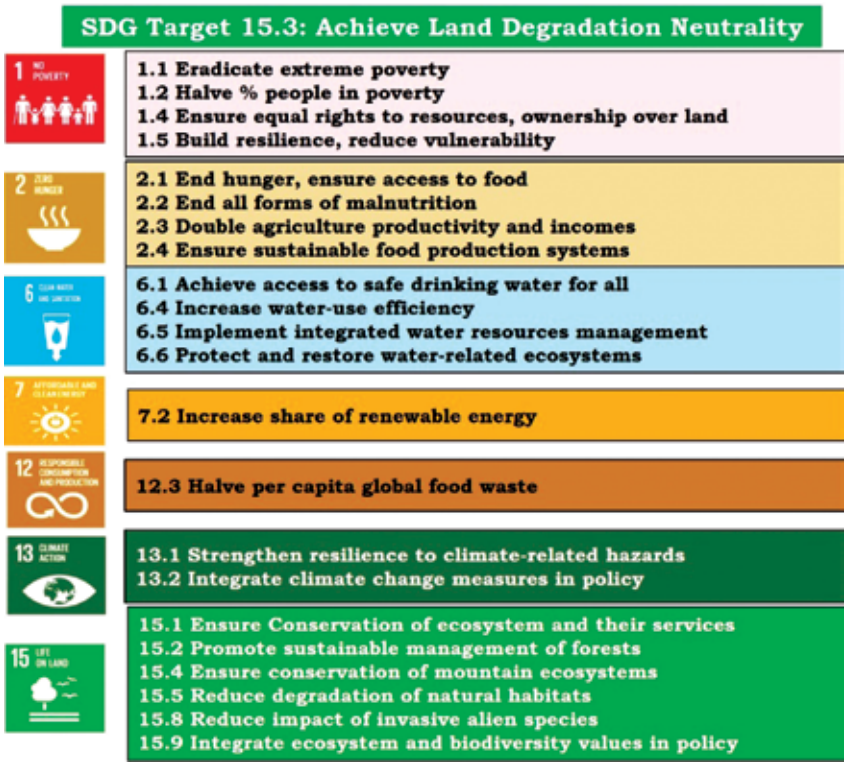

Figure 1: Impact of SDG 15.3 on other SDGs

from the ICAR and State Agricultural Universities, policymakers, and non-government organizations.

1.1 Status of Land Degradation in India

The estimates of land degradation vary from 100 to 300 Mha, depending on the methodology and criteria employed. ICAR - National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) estimated 147 Mha of land area as degraded (NBSS&LUP, 2004). Of this, 83 Mha was due to water erosion, 25 Mha due to chemical degradation, 12 Mha due to wind erosion, 1.1 Mha due to physical degradation, and 7 Mha due to salinity/alkalinity. In 2008, National Rainfed Area Authority (NRAA), Indian Council of Agricultural Research (ICAR), National Remote Sensing Agency (NRSA) and NAAS brought out harmony in various estimates of degraded land, and arrived at a figure of 121 Mha, comprising 105 Mha arable land and 16 Mha open forest area. In a recent report, Space Application Centre-ISRO (2016) has estimated 96 Mha area of land affected by degradation.

1.2 Economic and Environmental Costs of Land Degradation

Globally, land degradation is affecting the well-being of at least 3.2 billion people, costing >10% of the annual global gross product. On an average, the benefits of land restoration are 10 times higher than the costs, estimated across nine different biomes (IPBES, 2018). It is predicted that by 2050, land degradation and climate change will reduce crop yields by 10%, which may go up to 50% in some regions. Additionally, land degradation will force several million people to migrate to safer havens by 2050. Annual economic loss due to land degradation and changes in land use has been estimated at Rs 3.17 lakh crore (US $46.90 billion) in 2014-15, equivalent to 2.5% of the gross domestic product (GDP) as per Business Standard Report (2018).

1.3 Where and How Land Degradation is Happening in India?

Land degradation in arid, semi-arid and dry sub-humid regions is termed as desertification. In this paper, land degradation and desertification are used interchangeably. In a 2011-13 estimate on desertification, Rajasthan, Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh, and Telangana states contributed up to ~24% of the Total Geographical Area (TGA). Remaining states contributed <1% individually.

The most significant process of land degradation in 2011-13 was water erosion (10.98%), followed by vegetation degradation (8.91%), and wind erosion (5.55%). It was further estimated that arid, semi-arid, and dry sub-humid regions together have 82.64 Mha of desert area. Wind erosion is a dominant cause in the arid region, while vegetation degradation and water erosion are predominant in semi-arid and dry sub-humid regions (Srinivasarao et al., 2015; Ramesh et al., 2019). Besides water and wind erosion, thinning of vegetation, water logging, salinity/alkalinity, acidity, pollution with heavy metals are other important causes of land degradation. Man-made degradation due to over-use of agro-chemicals, disuse of organic manures, excessive tillage, mono-cropping, intensive farming without restorative inputs, irrigation without drainage cause land degradation that manifests in the form of deterioration of soil health and productivity loss.

1.4 Rehabilitation of Degraded Lands for Food Security and Nutrition

By 2050, India's population is projected to cross 1.65 billion. This necessitated that the carrying capacity of the land resources be improved with restoration and technology innovations. Apart from moderating population rise, a key imperative for India is to increase productivity sustainably by infusion of holistic land management

practices. The goal should be to: (i) conserve the health and quality of existing land, (ii) ameliorate the lands lost to degradation, and (iii) sustain the quality of lands thus recovered. To accomplish these, the scientific interventions must be farmer-centric and focus on improving the bio-physical resources of a production system. Additionally, holistic land management that harmonizes efficient use of man-made inputs and native resources has to mainstream the role of livestock and biologically enhanced soil technology. An overarching policy, supporting R&D in a bigger way, will be necessary to fulfill the commitment for neutralizing land degradation in 26 Mha.

2. INDICATORS TO MONITOR PROGRESS OF LDN PROJECTS

The United Nations Convention to Combat Desertification COP 11 (Convention of Parties) (UNCCD, 2013) (https://www.unccd.int/sites/default/files/sessions/documents/ICCD_COP12_4/4eng.pdf) suggested following three indicators for reviewing LDN projects:

(i) Trends in land cover (or land cover changes),

(ii) Trends in land productivity (or net primary productivity), and

(iii) Trends in carbon stocks or soil organic carbon (SOC) measured at a depth of 30 cm.

A positive outcome of all the three indicators is must to certify that the goal of an LDN project has been achieved; with one-out-all-out principle.

A critical review of these monitoring indicators reveals their adequacy in answering the question, “whether the goal set for achieving LDN is being reached or not”. It is said that their positive impact serves the cause of sustaining economic productivity and provisioning environmental services – the two drivers describing sustenance of soil health and land quality. Of the three criteria, yield shifts are fast in response to regenerative treatment or bad management. Comparatively, SOC changes are sluggish. To overcome this, it is suggested to measure its labile pools (e.g., soil respiration, microbial biomass and N) as proxies. Though under natural conditions, the land cover changes are slow, sudden land use changes like diversion of green covers for infrastructure can have an immediate impact. Logging is another example of damage to vegetative shield that protects land from degradation.

In addition to the UNCCD proposed three indicators, Cowie et al. (2018) recommended a scientific approach to public policy, describing government’s willingness to implement and enforce a mechanism for LDN progress monitoring. They also

suggested a set of socio-economic outcome indicators (right on land, tenancy laws, and payment for environmental services) to assess medium and long-term impact of LDN projects.

3. LAND DEGRADATION MANAGEMENT INITIATIVES

Government of India had been taking several initiatives from time to time to deal with land degradation by restoring the natural resources. The Drought Prone Areas Program (DPAP) was launched in 1973-74 in 972 blocks of 195 districts in 16 states to deal with the problems faced due to recurrent drought conditions. In 1977-78, the Desert Development Program (DDP) was launched in 235 blocks of 40 districts in 7 states to mitigate the adverse impacts of desertification. In 1985, the Government set up the National Wastelands Development Board (NWDB) for arresting and reversing land degradation. The Integrated Wastelands Development Program (IWDP) was launched in 1989-90 along with the "shifting agriculture" scheme for the northeastern region. A scheme of soil conservation was initiated in Third Five Year Plan (1961-62) for the Catchments of River Valley Project and Flood Prone Rivers. It was subsumed in the Rastriya Krishi Vikas Yojana (RKVY) in 2014. The National Forest Policy (NFP) 1988 aimed at substantially increasing tree cover through afforestation and social forestry programs, especially on denuded, degraded and unproductive land. The Reclamation and Development of Alkali and Acid Soils (RADAS) program launched in the Seventh Five Year Plan (1985-86) was also subsumed in RKVY. The National Watershed Development Program in Rainfed Areas (NWDPRA) was launched in 1990-91 in 99 rainfed districts in 25 states. The Integrated Watershed Development Program (IWDP) launched in 2008-09 to restore the ecological balance was subsumed in NWDPRA.

The National Mission for Sustainable Agriculture (NMSA) was launched in 2010 under the National Action Plan on Climate Change (NAPCC) to address issues regarding 'Sustainable Agriculture' in the context of risks associated with climate change by implementing appropriate adaptation and mitigation strategies. The National Agroforestry Policy (NAP), launched in 2014 is directed at promoting sustainable and resilient agricultural practices. Green India Mission (GIM) launched in 2015 under the National Action Plan on Climate Change (NAPCC) aimed at protecting, restoring and enhancing India's diminishing forest cover and responding to climate change. Under GIM, which is still in its nascent stage, 32,066 hectares of degraded land was afforested and restored. The National Bamboo Mission approved by the Cabinet Committee on Economic Affairs (CCEA) in 2018 aims to promote holistic growth of bamboo sector and to increase the area under bamboo

cultivation and marketing. The National Afforestation and Eco-Development Board (NAEB), of the MoEF & CC, through its flagship scheme "National Afforestation Program" (NAP), plans rehabilitation of degraded forests and afforestation around forests. Implemented by the State governments to promote participatory and sustainable management of degraded forest areas between 2012-13 to 2016-17, a total of 282,389 hectares of degraded land was restored and afforested under NAP across the country. The National Rural Employment Programme/Rural Landless Employment Guarantee program (NREP/RLEGP) (1976), Jawahar Rozgar Yojana (JRY) (1989), Sampoorna Grameen Rozgar Yojana (SGRY) (2001), and the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (2005) aimed to generate rural employment by creating and maintaining community assets and improving natural resources. These national initiatives also contributed to global efforts on rehabilitation of degraded lands through the UN Conventions on Biological Diversity (CBD), Climate Change (UNFCCC), and Combating Desertification (UNCCD).

State governments are also implementing various programs of rehabilitation of degraded lands. Programs like *Haritha Haram* in Telangana; *Chettu Meeru* in Andhra Pradesh; watershed management and farm ponds in Rajasthan, AP, Karnataka, Maharashtra; crop residue management in Punjab and Haryana, Conservation Agriculture (CA) in many states, *jhum* land rehabilitation in northeastern hill states, are few examples in this direction. Rajasthan has been implementing large-scale plantation program towards rehabilitation of degraded lands. NABARD is supporting various programs for systematic promotion of watershed projects in several states where land degradation management strategies are at central stage.

4. EXISTING STRATEGIES FOR REHABILITATION OF DEGRADED LAND

An objective analysis of the existing strategic action plans, covering various aspects and issues of LDN, was carried out by Katyal (2020). Application of holistic management of an agroecosystem needs focus while prescribing activities and practices to rejuvenate lands suffering from degradation. Accordingly, several innovative methods have been recommended to fulfill the commitment of rehabilitating degraded lands.

Rehabilitation options vary across ecosystems such as arid, semi-arid, dry sub-humid, hilly and coastal. Many ecosystems need several technologies for rehabilitation of degraded land; however, the priority of implementation depends on the nature of technology and its cost. Soil erosion reduction with long period of soil covers was

central point for overall degradation mitigation of lands (Lal, 1990; Srinivasarao et al., 2013). Ecosystem wise land degradation reduction technologies are summed up in Table 1.

Table 1. Degradation-wise technologies

Sl. No.	Degradation type	Technology	States
1	Water Erosion	Contour farming; contour bunding; bench terracing, contour trenches, half-moon terracing, strip cropping, mulching, conservation agriculture, agroforestry, mulch cum manuring, aerial grassing, cover crops, bund stabilization, rainwater conservation, and farm ponds, watershed management, silt traps in farm ponds, relay cropping, tank silt recycling, intercrops etc.	Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Tripura, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, Uttarakhand, Bihar, Jharkhand, West Bengal, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu.
2	Wind Erosion	Planting of trees in borders of agricultural lands to act as shelterbelts; mulching, strip cropping, high density planting, agroforestry, sand dune stabilization, grassing, etc.	Rajasthan and adjoining areas.
3	Salinity/ Alkalinity /Sodicity	Tolerant tree species cultivation (Planting of *Salvadoraoleoides*, *T. troupii*, *etc.*) to reduce the EC levels; Gypsum application for high alkali soils; leaching process for reducing salinity; green manuring; growing tolerant crop species, on farm generation of organic matter and recycling.	Haryana, Punjab, Uttar Pradesh, Bihar, Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu.
4	Soil Acidity	Lime application, growing acid tolerant varieties, plantation cropping, fruit cropping, agroforestry, organic matter addition, cultivation of legumes	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Haryana, Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Bihar, Jharkhand, West Bengal, Chhattisgarh, Maharashtra, Kerala, Tamil Nadu.

Sl. No.	Degradation type	Technology	States
5	Soil Fertility Depletion	Judicious use of chemical fertilizers; Combined application of fertilizers with organic amendments-INM; animal manures; SSNM, Introduction of legumes in mono-cropping, mulching, green manuring, conservation agriculture, crop residue recycling, biochar and biofertilizers and legume cover crops, location specific Indigenous technical knowledge practices like sheep penning etc.	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Rajasthan, Gujarat and others.
6	Soil Compaction	Subsoiling and organics	Vertisols of Maharashtra, North Karnataka, Madhya Pradesh.
7	Water Logging	Combined application of fertilizers with organic amendments; animal manures; Adoption of integrated nutrient management, intercultural operations. Adoption of water use efficient technologies, provision of drainage	Heavy rainfall and High clay soils; Maharashtra, Karnataka, AP, MP, Chhattisgarh, etc. Canal irrigated areas
8	Barren/ Rocky Lands	Biofuel plantations; medicinal and aromatic plantation; agroforestry, afforestation. tank silt addition.	Arid areas of India; Rajasthan and other regions.

The technologies shown in Table 1 are meant to ameliorate degraded lands. Results on their application lack long-term perspective on monitoring progress of reaching the goal of LDN. Participants of the brainstorming session discussed in detail the future research, development, and policy needs for accomplishing the vision of LDN with reference to India. Based on these deliberations, various suggestions were made for rehabilitating 26 Mha of degraded lands vis-à-vis review of progress conforming to the three UNCCD prescribed monitoring indicators.

Driven by the UNCCD framework, participants agreed on evolving research, development, and policy interventions, and constituting LDN strategic action plan, on three elements: (i) protecting land from degradation, (ii) reversing existing land degradation, and (iii) safeguarding by regenerative activities. Instead of individual fields,

the action plan would focus on farmers and farming practices that are community-based for wide area infusion of holistic land management methods. Sustainable growth in productivity, significant buildup of SOC and improvement in living land cover will remain monitorable indicators of the progress on LDN.

5. ROAD MAP FOR REHABILITATION OF DEGRADED LANDS

India has several sectoral policies in place; however, land degradation is a national issue affecting all ecosystems and land uses. Therefore, we urgently require a land use policy that integrates various sectors, ministries, departments, and ecosystems (including forests, wetlands, croplands, and grasslands) and to have a common vision for restoring land.

The latest estimate of 96.4 Mha of degraded lands equals 29.32% of the total geographical area (TGA) slightly more than 94.53 Mha in 2003-05. A land degradation atlas was released on the occasion of the *"World Day to Combat Desertification",* on June 17, 2016, jointly organized by MoEF&CC, and Arid Zone Forest Research Institute (AFRI) at Jodhpur, Rajasthan.

Rajasthan contributed 23.95% to the land degradation/desertification in 2011-13 and 23.64% in 2003-05, followed by Maharashtra, Gujarat, Jammu & Kashmir, Karnataka, Jharkhand, Odisha, Madhya Pradesh and Telangana. In Jharkhand, Rajasthan, Delhi, Gujarat and Goa, more than 50% of the land is degraded, while it is less than 10% in Kerala, Assam, Mizoram, Haryana, Bihar, Uttar Pradesh, Punjab and Arunachal Pradesh. Between 2003-05 and 2011-13, the degraded land increased by 1.87 Mha. During the same period, 1.95 Mha was reclaimed and 0.44 Mha was converted from high severity to low severity degradation class. On the other hand, 3.63 Mha of productive land was degraded, and 0.74 Mha was converted from low severity to high severity degradation class. During this period, high desertification/land degradation increased by 4.34 to 11.03% in Delhi, Tripura, Nagaland, Himachal Pradesh, and Mizoram, whereas there was a decline in degraded land (-0.11 to – 1.27%) in Odisha, Rajasthan, Telangana and Uttar Pradesh.

The geospatial database together with corresponding satellite data can be used for regional planning to feed into the ongoing National Action Plans (NAP) and Sustainable Land and Ecosystem Management (SLEM) program for combating desertification/land degradation.

For restoring 26 Mha of degraded lands by 2030, the following aspects are critical: (i) annual target, (ii) state wise targets, (iii) already rehabilitated land, and (iv)

land degraded simultaneously in other regions. Ecosystem or state wise targeted degraded area for rehabilitation may be considered on the basis of (i) ease of restoration, (ii) high vulnerability of regions, (iii) more benefits to communities, (iv) cost of rehabilitation, and (v) environmental services due to rehabilitation.

Based on these factors, 10 Mha water eroded lands from northeastern region and high density populated states like UP, Bihar, West Bengal, Odisha, Karnataka, AP and Maharashtra; 3 Mha wind eroded lands in Rajasthan and AP; 2 Mha of acidic soils; 2 Mha of saline soils; 2 Mha with improved vegetation cover in hills ecosystems; 2 Mha under agro forestry; 2-3 Mha waste lands; and 2-3 Mha by restoring soil fertility and organic matter through resource conservation technologies can be rehabilitated to meet the total target of 26 Mha by 2030.

6. RECOMMENDATIONS

6.1 Research and Development (R&D)

Farming community must be a part of the mechanism for defining the R&D agenda. In pursuance of that:

A structured questionnaire may be developed to gather feedback on constraints, needs and aspirations of the community owning land in an ecosystem, a watershed, or landscape forming a production system. Synthesis of this information should be utilized for drawing the action plan. To achieve the above, 'Farmer Field School (s) on Land Management' (FFSLM) may be created for sustainable land management interventions by appropriate extension agencies for appropriate regenerative practices. An over-arching policy instrument on assuring administrative and financial support would be required along with necessary HRD.

6.2. National Land Use Policy (NLUP)

Land use planning is a state subject; hence development of a NLUP necessitates adopting a process similar to that used for developing Goods and Services Tax (GST) regulations. Introduction of NLUP is necessary to arrest ongoing land degradation happening due to diversion of good lands for other uses (infrastructure development), and to meet the goal of recovering and regenerating land, already lost to degradation. It may be noted that as per an IUCN assessment in 2018, India had restored around 9.8 Mha between 2011 and 2018. This implies that almost 1.4 Mha area was restored annually. If this rate is sustained from 2019 onwards, 26 Mha would be restored by 2030.

6.3 Regenerative Practices

6.3.1. Productivity growth

- Sustainable targeted productivity growth, besides application of precision agronomic practices, is possible by regular adoption of holistic/sustainable management (HLM/ SLM) practices viz. conservation agriculture (CA), *Bhartiya Prakritik Krishi Padhati* (BPKP) or regenerative agriculture (RA).
- Despite being known to produce economic (savings in input cost at no penalty to yield) and environmental benefits, adoption of these technologies are low. There is a need to eliminate farmers' impassivity, which may be due to lack of means and confidence necessary for adoption, and lack of awareness about the advantages of these alternative farming methods. In pursuance of spreading application and adoption, following actions are recommended:
- Strengthen extension apparatus to include advisories on CA/RA/BPKP.
- Popularize new regenerative technologies by 'adaptive trials' in participatory mode on a large scale like the Experiments on Cultivators' Fields (ECF) on fertilizers.

6.3.2. Building a lasting soil cover

- It is important to bring public institutions, civil society organizations (NGOs), and forest-dependent communities (FDCs) on a common platform for restoring lost soil cover (reforestation), and afforesting denuded and barren land. In this arrangement, public institutions should provide technology, quality planting material, and logistic support. FDCs should share labor for developing planting sites, ensuring after care, and have specific rights to utilize products generated from developed forest. The NGOs are to act as social stimulants facilitating collaborative activities.
- Save ecologically productive lands from diversion to other uses by enacting an effective legal instrument on minimizing encroachment of public and common (common property resources) lands and recovery of what has already been encroached upon.
- Introduce site-suitable (representing an agroecology) agroforestry systems (like ber/khejri intercropped with pearl millet in rainfed ecologies) for Lands Capability Classification (LCC) as LCC IV Agro-pastoral/silvi-pastoral systems may be introduced for lands belonging to LCC V or worse.

6.3.3. Building SOC

Indian climatic conditions and agronomic practices are in general aggravate SOC breakdown, a major source of land degradation. While infusion of HLM is imperative to stem the SOC slide, role of organics needs a greater focus. The following suggestions are made for a sustained use of organic sources:

- ✦ Extend public support for professional methods of composting e.g. one compost pit/land holder.
- ✦ Cultivating a legume intercrop between two cereal crops; Encouraging mixed cropping/agroforestry systems for typically rainfed ecologies
- ✦ Integrate crop and livestock farming by providing inputs and technologies that strengthen farmers' led systems.
- ✦ Educate farmers on the benefits of retaining maximum proportion of crop residue after harvest.
- ✦ Introduce a policy on incentivizing and rewarding farmers who successfully build SOC by linking periodic data (minimum rotation period 3 years) recorded in their soil health cards.

REFERENCES

Cowie, A.L., Orr, B.J., Castillo Sanchez, V.M., Chasek, P., Crossman, N.D., Erlewein, A., Louwagie, G., Maron, M., Metternicht, G.I., Minelli, S., Tengberg, A.E., Water, S., and Welton, S. (2018). Land balance: The scientific conceptual framework for land degradation neutrality. Environmental Science & Policy. 79: 25-35.

IPBES (2018): The IPBES assessment report on land degradation and restoration. Montanarella, L., Scholes, R., and Brainich, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 744 pages.

Katyal, J.C. (2020). Achieving land degradation neutrality: Strategy and action plan. Indian Journal of Fertilizers. 16(8).

Lal, R. (1990). Soil erosion and land degradation: The global risks. Advances in Soil Science, Springer, New York

National Bureau of Soil Survey & Land Use Planning (NBSS&LUP). (2004). Soil Map (1:1 million Scale); NBSS&LUP: Nagpur, India.

Ramesh, T., Bolan, NS., Kirkham, M.B., Wijesekara, H., Manjaiah, K.M., Srinivasarao, Ch., Sandeep, S., Rinklebe, J., Ok, YS., Choudhury, B.U., Want, H., Tang, C., Song, Z., and Freeman II, O.W. (2019). Soil organic carbon dynamics: Impact of land use changes and management practices: A review. Advances in Agronomy, 156; 1-125.

Srinivasarao, Ch., Lal, R. Prasad, J.V.N.S., Gopinath, K.A., Singh, R., Jakkula, V.S., Sahrawat, K.L., Venkateswarlu, B., Sikka, A.K., and Virmani, S. M.. (2015) Potential and Challenges of Rainfed Farming in India. Advances in Agronomy. 133. 113-181.

Srinivasarao, Ch., Venkateswarlu, B., Lal, R., Singh, A.K. and Kundu, S. 2013. Sustainable management of soils of dryland ecosystems of India for enhancing agronomic productivity and sequestering carbon. Advances in Agronomy **121**, 253-329.

UNCCD, 2013) (https://www.unccd.int/sites/default/files/sessions/documents /ICCD_ COP12_4/ 4eng.pdf)

UNCCD (2017). Global Land Outlook. First Edition. Bonn, Germany. www.unccd.int

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Note: The designations and affiliations of the participants are as on the date of BSS.

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