Sustainable Land and Ecosystem Management in India

Sustainable Land and Ecosystem Management in India

Indian Council of Forestry Research and Education

(An Autonomous Body of Ministry of Environment, Forest and Climate Change, Government of India)

P.O. New Forest, Dehradun - 248006 (INDIA)

Published by: Biodiversity and Climate Change Division, Indian Council of Forestry Research and Education, P.O. New Forest, Dehradun – 248 006 (INDIA)

This publication has been brought out under the
World Bank funded Ecosystem Services Improvement Project

Authors:

Dr. R.S. Rawat, Scientist 'E', Biodiversity and Climate Change Division, ICFRE

Dr. Shilpa Gautam, Scientist 'E', Biodiversity and Climate Change Division, ICFRE

Dr. Deepti Verma, Consultant, ESIP, ICFRE

ISBN: 978-81-967117-2-6

Citation: Rawat R.S., Gautam S. and Verma D. (2023). Sustainable Land and Ecosystem Management in India. Indian Council of Forestry Research and Education, Dehradun (INDIA).

सत्यमेव जयते

अरूण सिंह रावत, भा.व.से.
Arun Singh Rawat, IFS

महानिदेशक
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
डाकघर न्यू फॉरेस्ट, देहरादून-248006
(आई एस ओ 9001: 2008 प्रमाणित संस्था)

Director General
Indian Council of Forestry Research and Education
P.O. New Forest, Dehra Dun - 248006
(An ISO 9001 : 2008 Certified Organization)

Foreword

Land is a vital resource for producing food and providing livelihood to a large number of local communities, especially in the rural and forest fringe areas. Large number of floral and faunal species have become extinct in the past decades due to land degradation and overexploitation of natural resources. Desertification and land degradation along with climate change and biodiversity loss have been identified as the greatest challenges to sustainable development. Sustainable land and ecosystem management can help and facilitate conservation of forest biodiversity, natural resources and restoration of degraded lands thus improving carbon sinks.

India is the seventh largest country in the world which occupies only 2.4% of the world's geographical area and supports about 18% of the world's human population. Dry land areas that comprise of arid lands, semi-arid land and dry sub-humid areas are 69.6% of the total geographical area in India. The land degradation covers 29.77% of the geographical area of the country. An ever-increasing human and cattle population have enormous pressure on land which has led to drastic changes in the proportion of land utilized for agricultural activities, urbanization and industrial development. Issues such as human and animal pressure on land, over-exploitation of soil and water resources, unscientific land use, climate change resulting in natural calamities like drought and floods are major factors responsible for land degradation in India.

ICFRE implemented the World Bank funded Ecosystem Services Improvement Project in the states of Madhya Pradesh and Chhattisgarh and scaled up sustainable land and ecosystem management (SLEM) best practices over 25000 ha areas and ICFRE has also developed roadmap for institutional and policy mainstreaming of SLEM, SLEM knowledge sharing portal and knowledge products on SLEM. This publication on 'Sustainable Land and Ecosystem Management in India' has been brought out under the Ecosystem Services Improvement Project for sharing the knowledge on SLEM and will be useful for all the stakeholders for addressing the issues of desertification and land degradation.

I congratulate Ecosystem Services Improvement Project team for bringing out this publication.

Dated: 28/07/2023

(Arun Singh Rawat)

Preface

Land comprises of soil, water, and associated flora and fauna and is the most important natural resource providing a variety of goods and services. Land is finite, fragile, non-renewable, and is significantly impacted by social and economic development. Land resources are under constant pressure due to growing demand of an ever-increasing population and climate change. A quarter of the world's land area is either highly degraded or undergoing high rates of degradation posing challenges for food and water security. It is estimated that one-third of the world's arable land has been lost and this loss continues at a rate of more than 10 mha per year.

India is a megadiverse country with about 7-8% of floral and faunal species, over 18% of human population and over 18% of cattle population of the world supported by a small chunk of only 2.4% of the world's land area. Due to increasing population, per capita availability of land has been reduced over the decades. In India main driver of desertification and land degradation was water erosion followed by vegetation degradation and wind erosion. Land degradation and desertification across the country have taken place due to natural and anthropogenic causes such as over exploitation of natural resources, unsustainable land use and inappropriate land management practices. About 51.1 Mha area in the country is drought prone, distributed over 13 states accounting for one-sixth area with 12% of the population of India. Majority of the drought prone area is distributed in arid, semi-arid, and dry sub-humid regions of Maharashtra, Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Odisha.

Desertification, land degradation and drought, whether driven by human actions or biophysical factors or a combination of both, result in the loss or damage to natural capital. It reduces land productivity and hampers the ability of the land to provide sustainable flow of ecosystem services and ultimately leads to ecological and socio-economic consequences. Desertification, land degradation and drought are collectively impacting the prime sectors and resources like agriculture, water, forest, biodiversity etc. Poor communities are the most affected by desertification, land degradation and drought as they do not have the available means to compensate the loss of land productivity. The issue of desertification and land degradation if not addressed timely will force millions of people to migrate thus leading to huge loss to economy.

In order to address the problems caused by land degradation and desertification the nations of the world realised the need to come together to commit themselves to undertake suitable activities to halt and reclaim the lost environmental entities like water bodies, land, air, biodiversity, etc. Under the aegis of cooperating bodies like the United Nations, some important commitments have been made and agreed to by the countries. Following the principles of traditionally ingrained ecological sustainability in the working ethos of Indian culture, India too has made several commitments to achieve the common goals of environmental protection, land reclamation, reduction of greenhouse gas emission, and combating desertification and land degradation.

There is a need for a monitoring framework to assess the progress made in addressing issues related to desertification, land degradation and drought at national, regional and international level. United Nations Statistical Commission in 2016 approved a draft of 'Global Indicator Framework'

to monitor the progress made to reverse land degradation. UNCCD, CBD, UNFCCC and FAO observed that adequate national capacities for using appropriate data and methods to assess and monitor land degradation could be achieved relatively in a short span of time. Most of the countries need to follow suitable method, acquire correct data and develop expertise in monitoring and evaluation of the progress made to combat land degradation. UNCCD pointed out the necessity of elaborating indicators to make the complex process quantifiable and communicate the information obtained.

India has launched various schemes and programmes at national level such as Desert Development Programme, Integrated Watershed Management Programme, National Afforestation Programme, National Mission for a Green India, Mahatma Gandhi National Rural Employment Guarantee Scheme, Soil Conservation Programme for Enhancing the Productivity of Degraded Land, Fodder and Feed Development Scheme for Grassland Development, etc. for addressing the issue of desertification, land degradation and drought.

Sustainable land and ecosystem management (SLEM) is one of the best options for addressing desertification, land degradation and drought. SLEM comprises of practices aimed at the protection, conservation and sustainable use of natural resources and restoration of degraded ecosystems. SLEM practices prevent and mitigate land degradation and desertification, conserve soil, water, forest and biodiversity and enhance ecosystem services. Many SLEM practices are being implemented throughout the world for combating desertification and land degradation. SLEM practices which are tested, proven, cost-effective and can be replicated in other similar ecological conditions are known as best practices. Documentation of SLEM best practices is the formative step in knowledge sharing, capacity building and scaling up, thereby contributing in combating desertification, land degradation and drought and achieving land degradation neutrality.

Databases of SLEM practices are being developed by various organisations for sharing of knowledge and their implementation for addressing desertification, land degradation and drought. A roadmap for institutional and policy mainstreaming of SLEM in India developed by Indian Council of Forestry Research and Education under the World Bank funded Ecosystem services Improvement Project (ESIP) provides specific guidelines and action plan to different Ministries, Departments, Research Organizations and Civil Society Originations involved in restoration of degraded lands and combating land degradation and desertification for achieving Land Degradation Neutrality, Sustainable Development Goals and Nationally Determined Contribution targets of India.

Desertification, land degradation and climate change are closely related phenomena, one of the main solutions to combat desertification and land degradation may be the implementation of effective policies and scaling up of SLEM practices. Scaling up of SLEM practices, innovative ways to produce more food, focus on cultivation of improved and resilient crop varieties, sustainable water harvesting methods, soil conservation approaches and focus on reducing greenhouse gas emission could be the ways to mitigate and combat desertification, land degradation and drought.

This publication on Sustainable Land and Ecosystem Management in India is an effort to share the knowledge on the practices and means that are in place at national and international levels to combat desertification, land degradation and drought. It also puts together the information on various best practices and success stories related to SLEM that can be scaled up for addressing desertification, land degradation and drought. The publication covers status of desertification,

land degradation and drought in India and their impacts on Key Sectors, India's international commitments related to SLEM, desertification, land degradation and drought monitoring framework, Government initiatives to combat desertification, land degradation and drought, SLEM best practices and success stories and road map for institutional and policy mainstreaming of SLEM.

To bring out this publication, whole-hearted support and encouragement from various quarters are highly appreciated. We are grateful to the Ministry of Environment, Forest and Climate Change, Government of India and the World Bank for providing necessary guidance and support. We would like to express our deep gratitude to Sh. Arun Singh Rawat, Director General, ICFRE and Ms. Kanchan Devi, Director (International Cooperation), ICFRE for direction and support. Constant guidance, support and encouragement provided by Dr. Anupam Joshi, Senior Environmental Specialist & Team Task Leader, ESIP, the World Bank is gratefully acknowledged. We thankfully acknowledge Dr. Rajesh Sharma, Assistant Director General (Biodiversity and Climate Change), ICFRE for review, comments and valuable suggestions during preparation of this publication.

We are also thankful to the officers and staff of ESIP Project Management Unit at MoEFCC and Project Implementing Units at ICFRE, Madhya Pradesh Forest Department and Chhattisgarh Forest Department.

Dated: 28/07/2023

Authors

Contents

Abbreviations

AAI	Aridity Anomaly Index
AISLUS	All India Soil and Land Use Survey
AISMR	All India Summer Monsoon Rainfall
CADP	Command Area Development Programme
CADWMP	Command Area Development and Water Management
CBD	Convention on Biological Diversity
cm	Centimeter
CO_2eq	Carbon dioxide equivalent
CoE	Centre of Excellence
COP	Conference of the Parties
CPR	Common Property Resources
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSSRI	Central Soil Salinity Research Institute
DAFW	Department of Agriculture and Farmers Welfare
DANIDA	Danish International Development Agency
DDP	Desert Development Project
DIP	District Irrigation Plan
DLDD	Desertification, Land Degradation and Drought
DMP	Drought Management Plan
DoLR	Department of Land Resources
DPAP	Drought Prone Area Programme
DPR	Detailed Project Report
DPSheIR	Driving force, Pressure, State, human and environment Impact Response
DPSIR	Driving force, Pressure, State, Impact and Response
ELD	Economics of Land Degradation
EMP	Environment Management Plan
ESIP	Ecosystem Services Improvement Project
ESSO-IMD	Earth System Science Organization- India Meteorological Department
FAO	Food and Agricultural Organization
FRA	Forest Rights Act 2006
FSI	Forest Survey of India

ft	Feet
GBF	Global Biodiversity Framework
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIM	Green India Mission
GIS	Geographic Information System
GLA	Global Land Area
gm	Gram
GoI	Government of India
$GtCO_2eqyr^{-1}$	Gigatonnes of Carbon Dioxide Equivalent per Year
ha	Hectare
HDPE	High Density Polyethylene
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forestry Research and Education
ICS	Improved Cook Stove
IGNP	Indira Gandhi Nahar Pariyojana
IGWDP	Indo German Watershed Development Programme
IMD	Indian Metrological Department
INCCA	Indian Network on Climate Change Assessment
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRS AWIFS	Indian Remote Sensing Advanced Wide Field Sensor
IUCN	International Union for Conservation of Nature
IWDP	Integrated Watershed Development Programme
IWMP	Integrated Watershed Management Programme
JFMC	Joint Forest Management Committee
Kg	Kilogram
KML	Keyhole Markup Language
LDN	Land Degradation Neutrality
LiFE	Lifestyle for Environment
LISS	Linear Imaging and Self Scanning Sensor
m	Metre

MEA	Millennium Ecosystem Assessment
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
Mha	Million Hectares
mm	Millimeter
MMA	Macro Management of Agriculture
MoA	Ministry of Agriculture
MoAFW	Ministry of Agriculture and Farmers' Welfare
MoDW&S	Ministry of Drinking Water and Sanitation
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment, Forest and Climate Change
MoJS	Ministry of Jal Shakti
MoRD	Ministry of Rural Development
MT	Metric Tonne
NABARD	National Bank for Agriculture and Rural Development
NAP	National Afforestation Programme
NAP	National Action Plan
NCR	National Capital Region
NDC	Nationally Determined Contribution
NDVI	Normalized Difference Vegetation Index
NFC	National Forest Commission
NGO	Non-Governmental Organization
NIDM	National Institute of Disaster Management
NITI	National Institution for Transforming India
NRAA	National Rainfed Area Authority
NRSA	National Remote Sensing Agency
NRSC	National Remote Sensing Centre
NTFP	Non-Timber Forest Produce
NWDB	National Wasteland Development Board
NWDPRA	National Watershed Development Project in Rainfed Areas
OECD	Organization for Economic Co-operation and Development
PESA	Panchayats Extension to the Scheduled Areas
PIA	Project Implementing Agency
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana

PRAIS	Performance Review and Implementation System
PRIs	Panchayati Raj Institutions
R&D	Research and Development
RET	Rare, Endangered and Threatened
RS	Remote Sensing
Rs.	Rupees
SAC	Space Applications Center
SBB	State Biodiversity Board
SDG	Sustainable Development Goal
SEEA	System of Environmental Economic Accounting
SERI	Sustainable Europe Research Institute
SHG	Self Help Group
SLEM	Sustainable Land and Ecosystems Management
SLEM-CPP	Sustainable Land and Ecosystems Management-Country Partnership Programme
SLM	Sustainable Land Management
SLUSI	Soil and Land Use Survey of India
SO	Strategic Objective
SPI	Standardized Precipitation Index
sq km	Square kilometre
SRI	System of Rice Intensification
STARMAP	Spatial Technology Approach for Restoration. Mapping and Planning
TERI	The Energy and Resources Institute
TFO	Technical Facilitation Organisation
TGA	Total Geographical Area
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
USD	United States Dollar
UT	Union Territory
WHO	World Health Organization
WOCAT	World Overview of Conservation Approaches and Technologies
WSP	Water and Sanitation Programme

Introduction

Land comprises of soil, water, and associated flora and fauna and is the most important natural resource on which all the activities of human beings are based. Land is finite, fragile, non-renewable, and is significantly impacted by social and economic development. As per the Land Use Statistics of FAO (2021), out of total global land area (GLA) of 13 billion ha (excluding Antarctica), in 2019 agricultural land area was about 4.8 billion ha (37% of the GLA), forest land area was 4.1 billion ha (31% of the GLA) and other land area was 4.2 billion ha (32% of the GLA). Land resources are under constant pressure due to growing demand of an ever-increasing population and climate change. About 60% of all the ecosystem services have degraded (MEA, 2005) and about 75% of the genetic diversity of agricultural crops has been lost (FAO, 2004). A quarter of the world's land area is either highly degraded or undergoing high rates of degradation which may reduce global food production. It is estimated that one-third of the world's arable land has been lost and this loss continues at a rate of more than 10 mha per year (FAO, 2011). Globally, 0.36 hectare of arable land was available to feed one person in 1961 which decreased to 0.18 ha in 2021. Arable land per person in India has also decreased from 0.34 ha in 1961 to 0.11 ha in 2021[1].

India with only 2.3% of the world's land and less than 4% of the global fresh water is fulfilling the food and water requirement of about 18% of global population. Out of 0.31 billion ha of total geographical area (TGA) of India, agricultural land area was 0.18 billion ha (59% of TGA), forest area was 0.07 billion ha (24% of TGA), pasture area was 0.01 billion ha (3% of TGA) and other land area was 0.04 billion ha (14% of TGA) in 2017-18 (MoAFW, 2021).

In 1994, the United Nations Convention to Combat Desertification (UNCCD) has adopted the definition of land degradation given by the Earth Summit as "*reduction or loss in biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities of habitation patterns*".

The term land degradation and desertification are highly interconnected, but various definitions have come up to define land degradation and desertification. UNCCD has defined desertification as '*when the land of dry land areas specifically the arid, semi- arid and dry sub-humid areas degrade due to any reason*'. Desertification is viewed as an advanced stage of land degradation. The United Nations has defined desertification as a "*diminution or destruction of the biological potential of the land which can lead ultimately to desert-like conditions*".

Land degradation is reduction in the capacity of the land to provide ecosystem goods and services and assure its functions over a period of time. Land degradation results in soil erosion, reduced agricultural productivity, loss of biodiversity, decline in water table/ ground water and lesser availability of water in the degraded areas. Globally, more than 6.1 billion ha (about 40% of GLA)

[1] *https://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC?end=2021&start=1961&view=chart*

is dryland and is home to over 35.5% of global population. Global assessments of land degradation showed that land degradation ranges between 20-40% of GLA (UNCCD, 2022) however, 29.77% (97.85 mha) of total geographical area of India is undergoing land degradation during 2018-19 (SAC, 2021).

Numbers to Ponder

- *The earth surface consists of 70.9% water and 29.1% land*
- *Earth's fresh water resources are 3% of which 70% is used for agriculture*
- *Large-scale extraction of groundwater for irrigation leads to a sea level rise of 0.8 mm per year*
- *About 2.8 billion global population (40%) is living in water–scarce regions*
- *About 0.9 billion global population lacks access to safe water*
- *About 60% of the ecosystem services are degraded*
- *About 75% of the genetic diversity of agricultural crops are lost*
- *25% of the world's land area is highly degraded*
- *Land use change and degradation are responsible for about 20% of carbon emissions globally*

Source: UNCCD, 2014

Land has cultural as well as productive value and its resilience to natural calamities and other environmental disturbances helps in stabilizing the climatic conditions, minimizing the ill impacts of disturbances caused by natural and anthropogenic factors and rejuvenates as well as maintains the ecosystem balance. With the increasing population, demand for food, water and other land resources have increased enormously. Over exploitation of natural resources, unsustainable land use practices have made the life less resilient and more vulnerable to the climate change thus leading towards land degradation and desertification. Over exploitation has not only depleted the natural resources but also affected the livelihood and food security of the rural communities. Topographical features, change in land use and land cover for agriculture-based activities, climatic conditions, soil erosion, pests and diseases, unsustainable land use practices, and developmental activities are categorized as proximate drivers of land degradation. High population density, insecure land tenures and poverty are few of the underlying drivers of land degradation. Proximate and underlying drivers have been identified as root cause of land degradation (Mirzabaev *et al.,* 2015). Among all the drivers, human activities such as expansion and intensive use of agricultural lands, poor irrigation practices, deforestation, and overgrazing are some of the major anthropogenic activities responsible for desertification and land degradation. Ultimately, overexploited drylands suffer from erosion, soil salinization, loss of productivity, and decreased resilience to climate change. Unsustainable agricultural practices are the foremost human induced drivers which have adversely affected the productivity of land thereby leading to soil erosion.

IPCC Special Report on 'Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems' stated that "*agriculture, forestry and other land use activities accounted for around 13% of carbon dioxide, 44% of methane, and 82% of nitrous oxide emissions from human activities globally during 2007-2016,*

representing 23% (120 ± 3.0 Gt CO_2 eq yr^{-1}) of total net anthropogenic emissions of greenhouse gases" (IPCC, 2019).

Land Degradation and Climate Change

- *Land degradation affects people and ecosystems throughout the planet and is both affected by climate change as well as contributes to it.*
- *Climate change exacerbates the rate and magnitude of several ongoing land degradation processes and introduces new degradation patterns.*
- *Land degradation is a driver of climate change through emission of greenhouse gases and reduced rates of carbon uptake.*
- *Reducing unsustainable use of traditional biomass reduces land degradation and emissions of CO_2 while providing social and economic co-benefits.*
- *Lack of action to address land degradation will increase emissions and reduce carbon sinks and is inconsistent with the emissions reductions required to limit global warming to 1.5°C or 2°C.*
- *Land degradation can be avoided, reduced or reversed by implementing sustainable land management, restoration and rehabilitation practices that simultaneously provide many co-benefits, including adaptation to and mitigation of climate change.*

Source: IPCC, 2019

Desertification and land degradation at local level is a result of unsustainable soil and land management practices, thus, conservation of soil is equally important for addressing the land degradation issue. Desertification, land degradation and climate change are closely related phenomena, one of the main solutions to combat desertification and land degradation may be the implementation of effective policies and scaling up of sustainable land and ecosystem management practices.

Scaling up of sustainable land and ecosystem management practices, innovative ways to produce more food, focus on cultivation of improved and resilient crop varieties, sustainable water harvesting methods, soil conservation approaches and focus on reducing greenhouse gas emission could be the ways to mitigate and combat desertification, land degradation and drought.

02
Chapter

Status of Desertification, Land Degradation and Drought in India

Land resources include soil, water, flora and fauna as the components of ecosystem, and provides multiple ecosystem goods and services that support life. The most noticeable services that land provides include food, water and plant materials. The World Atlas of Desertification (2018) reveals that over 75% of the land on earth is already degraded and over 90% could become degraded by 2050. Atlas also highlights that about 418 mha of land degrades annually at global level. Desertification has mostly affected the developing countries of the world, of which African and Asian countries are most affected. Exponentially growing population in developing countries has exerted tremendous pressure on land thereby severally affecting land productivity and pushed the limits of production into increasingly marginal lands. Marginal lands are considered more susceptible to soil erosion and salinization, and high pressure on land productivity has accelerated the rate of soil degradation. The alternative livelihood options such as intensification of agriculture in fertile areas, off-farm employment generation etc. are considered as factors, which may help to minimize the high pressure on land for over production.

2.1. Land Resources in India - An Overview

India is a megadiverse country with only 2.4% of the world's land area, accounts for 7-8% of all recorded species, including over 45,000 species of plants and 91,000 species of animals. It supports over 18% of human population and 18% of cattle population of the world. Being one of the 17 identified megadiverse countries, India has 10 biogeographic zones and is home to 8.58% of the mammalian species documented so far, with the corresponding figures for avian species being 13.66%, for reptiles 7.91%, for amphibians 4.66%, for fishes 11.72% and for plants 11.80%. Four of the 34 globally identified biodiversity hotspots, namely the Himalaya, Indo-Burma, the Western Ghats-Sri Lanka and Sundaland, are represented in India. India is an acknowledged centre of crop diversity and harbours hundreds of varieties of crop plants such as rice, maize, millets etc. The diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, grasslands, wetlands, desert, coastal and marine ecosystems which harbour and sustain high biodiversity and contribute to human well-being (MoEF, 2014 a).

As per the Agricultural Statistics at a Glance 2022, land use in India for the year 2019-20 comprised of about 42% of land under net area sown, 21.83% of area under forest land, 7.77% area under permanent pastures, grazing land and miscellaneous trees and 7.61% area under fallow land (Table 2.1). About 13% land was not available for cultivation (MoAFW, 2022).

As per the India State of Forest Report 2021 (FSI, 2021), the total forest and tree cover of the country was 80.95 Mha which comprises of 71.38 Mha of forest cover and 9.57 Mha of tree cover. Total forest and tree cover constituted 24.62% of the total geographical area of the country (Table 2.2). The total growing stock of forest and trees outside forests is estimated to be 5768 million cum.

Table-2.1:

Details of the land use in India

S.No.	Land Classification	Area (Mha)	% of TGA
1.	Total Geographical Area (TGA)	328.75	-
2.	Reporting Area for Land Utilisation Statistics	307.09	-
3.	Forest Lands	71.75	21.83
4.	Area not available for cultivation (area under non-agricultural uses, barren and unculturable land)	44.32	13.48
5.	Other uncultivated lands (permanent pastures and other grazing land, and land under miscellaneous trees)	25.56	7.77
6.	Fallow Lands	25.01	7.61
7.	Net Area Sown	139.9	42.56

Source: MoAFW, 2022

Table-2.2:

Forest and tree cover of India in 2021

Class	Area (sq km)	Percent of Geographical Area
Forest Cover		
Very Dense Forest	99779	3.04
Moderate Dense Forest	306890	9.33
Open Forest	307120	9.34
Total Forest Cover	**713789**	**21.71**
Tree Cover	95748	2.91
Total Forest and Tree Cover	**809537**	**24.62**
Scrub	46539	1.42

Source: FSI, 2021

Due to increasing population per capita availability of land has been reduced over the decades. The per capita availability of land in India has declined from 0.89 hectares in 1951 to 0.27 hectare in 2011, while the per capita availability of agricultural land has also reduced from 0.48 hectare to 0.15 hectare during this period[2].

About 29.77% (97.85 mha) of the total geographical area of India is undergoing land degradation

2.2. Land Degradation and Desertification in India

Land degradation is reduction in the productive capacity of land due to soil degradation, forest degradation, deforestation, climatic extreme events including drought, floods etc. The factors

[2] *https://agriwelfare.gov.in/en/NaturalResource#:~:text=The%20per%20capita%20availability%20of,0.15%20hectare%20during%20this%20period.*

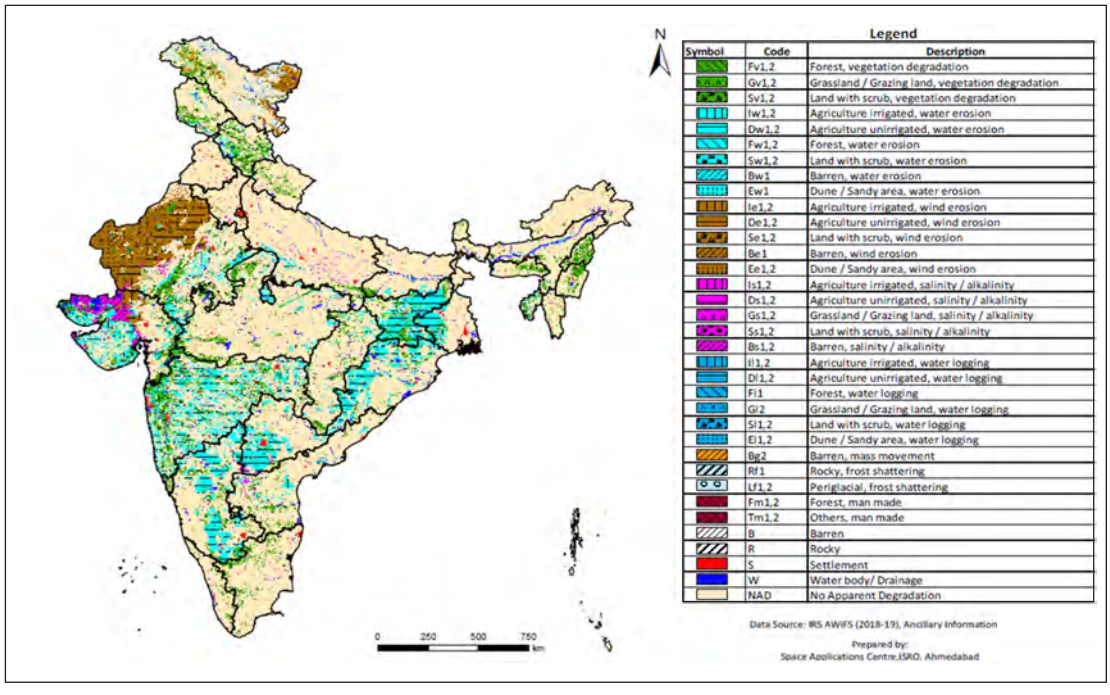


Figure 2.1: Desertification and Land Degradation Status Maps of India- 2018-19 *Source: SAC, 2021*

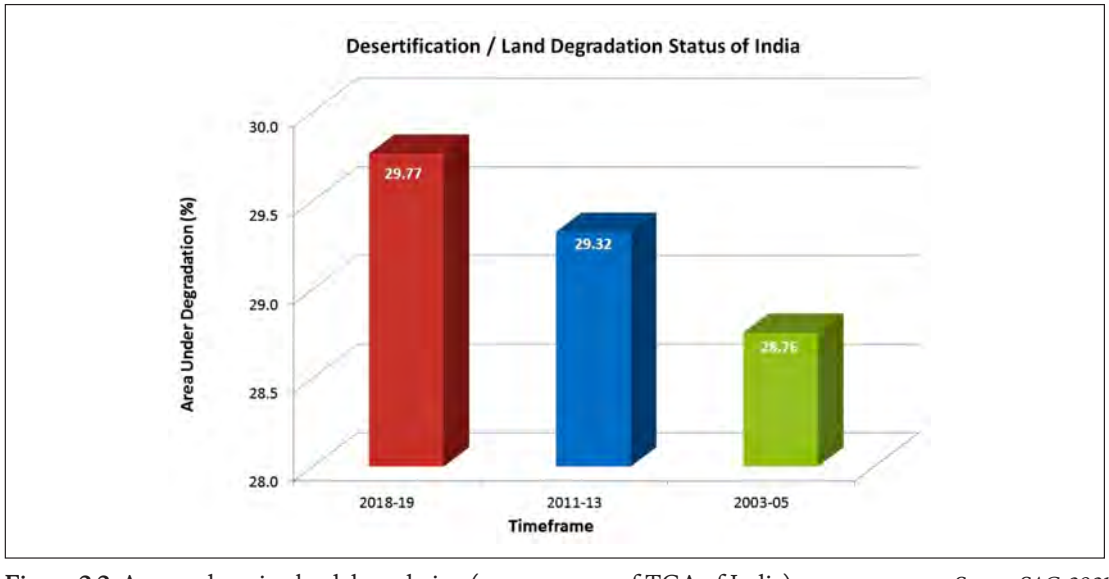


Figure 2.2: Area undergoing land degradation (as percentage of TGA of India) *Source: SAC, 2021*

affecting degradation are rainfall, wind, type of soil, length and degree of slope, conservation measures and vegetation cover. Dry land areas in India are about 228.3 Mha which is 69.6% of TGA. As per to various estimates, about 29 to 35% of the TGA of India is subjected to land

degradation. According to Space Application Centre, 97.85 Mha area (29.77%) of TGA of India is under desertification and land degradation during 2018-19 (SAC, 2021). Whereas, 96.40 Mha area (29.32%) of the TGA of the country was under land degradation during 2011-13 and 94.53 Mha area (29.32% of TGA) was under land degradation which was 28.76% of the TGA of the country during 2003-05 (SAC, 2021).

State-wise data of desertification and land degradation shows that states like Jharkhand, Rajasthan, Delhi, Gujarat and Goa have more the 50% area under desertification and land degradation while Kerala, Assam, Mizoram, Haryana, Bihar, Uttar Pradesh, Punjab and Arunachal Pradesh show the ray of hope with less than 15% area under desertification and land degradation (SAC, 2021). State-wise status of land degradation and desertification is given in Table 2.3.

Table-2.3:

State-wise status of desertification and land degradation

S.No.	State/ Union Territories	Total area (in Mha) under desertification and land degradation		
		2018-19	2011-13	2003-05
1	Rajasthan	21.24 (62.06%)	21.53 (62.90%)	21.63 (63.19%)
2	Maharashtra	14.31 (46.49%)	13.83 (44.93%)	13.35 (43.38%)
3	Gujarat	10.25 (52.22%)	10.26 (52.29%)	10.08 (51.35%)
4	Ladakh	7.11 (43.31%)	6.91 (41.12%)	6.58 (39.14%)
5	Karnataka	6.96 (36.29%)	6.95 (36.24%)	6.94 (36.19%)
6	Jharkhand	5.48 (68.77%)	5.50 (68.98%)	5.42 (67.97%)
7	Odisha	5.36 (34.42%)	5.30 (34.06%)	5.32 (34.18%)
8	Madhya Pradesh	3.86 (12.52%)	3.80 (12.34%)	3.77 (12.24%)
9	Telangana	3.64 (31.68%)	3.60 (31.34%)	3.66 (31.86%)
10	Himachal Pradesh	2.40 (43.11%)	2.39 (43.01%)	2.14 (38.46%)
11	Andhra Pradesh	2.38 (14.84%)	2.30 (14.35%)	2.27 (14.16%)
12	Chhattisgarh	2.31 (17.06%)	2.21 (16.36%)	2.18 (16.10%)
13	West Bengal	1.78 (20.10%)	1.73 (19.54%)	1.68 (18.95%)
14	Tamil Nadu	1.60 (12.30%)	1.54 (11.87%)	1.52 (11.66%)
15	Uttar Pradesh	1.55 (6.43%)	1.53 (6.35%)	1.84 (7.62%)
16	Jammu and Kashmir	1.13 (20.86%)	1.06 (19.67 %)	0.97 (17.86%)
17	Nagaland	0.83 (50%)	0.79 (47.45%)	0.64 (38.74%)
18	Assam	0.83 (10.64%)	0.72 (9.14%)	0.57 (7.30%)
19	Bihar	0.75 (7.93%)	0.70 (7.38%)	0.66 (7.00%)
20	Uttarakhand	0.67 (12.60%)	0.65 (12.12%)	0.58 (10.87%)
21	Manipur	0.61 (27.44%)	0.60 (26.96%)	0.59 (26.56%)

S.No.	State/ Union Territories	Total area (in Mha) under desertification and land degradation		
		2018-19	2011-13	2003-05
22	Meghalaya	0.56 (24.86%)	0.49 (22.06%)	0.48 (21.35%)
23	Tripura	0.45 (42.66%)	0.44 (41.69%)	0.33 (31.21%)
24	Kerala	0.42 (10.87%)	0.38 (9.77%)	0.37 (9.54%)
25	Haryana	0.36 (8.24%)	0.34 (7.67%)	0.31 (7.12%)
26	Goa	0.195 (52.64%)	0.193 (52.13%)	0.86 (50.37%)
27	Mizoram	0.27 (13.08%)	0.19 (8.89%)	0.10 (4.55%)
28	Arunachal Pradesh	0.20 (2.40%)	0.15 (1.84%)	0.14 (1.63%)
29	Punjab	0.17 (3.34%)	0.15 (2.87%)	0.09 (1.85%)
30	Delhi	0.091 (61.73%)	0.090 (60.60%)	0.07 (49.57%)
31	Sikkim	0.085 (11.92%)	0.079 (11.10%)	0.078 (11.06%)
	Total	**97.85 (29.77%)**	**96.40 (29.32%)**	**94.53 (28.76%)**

Value in the parenthesis is % of the total geographical area

So far as the drivers of desertification and land degradation are concerned, water erosion (11.01% in 2018-19, 10.98% in 2011-13 and 10.83% in 2003-05) was the main driver of desertification and land degradation in India followed by vegetation degradation (9.15% in 2018-19, 8.91% in 2011-13 and 8.60% in 2003-05) and wind erosion (5.46% in 2018-19, 5.55 % in 2011-13 and 5.58 % in 2003-05) (SAC, 2021). Figure 2.3 depicts the process wise status of desertification and land degradation in the country.

Seventy-six districts from all over the country and 2 sub-basins of the Leh District (Ladakh UT) were identified as drought prone areas which need special focus to combat desertification, land degradation and drought (SAC, 2018). List of drought prone areas is given Table 2.4.

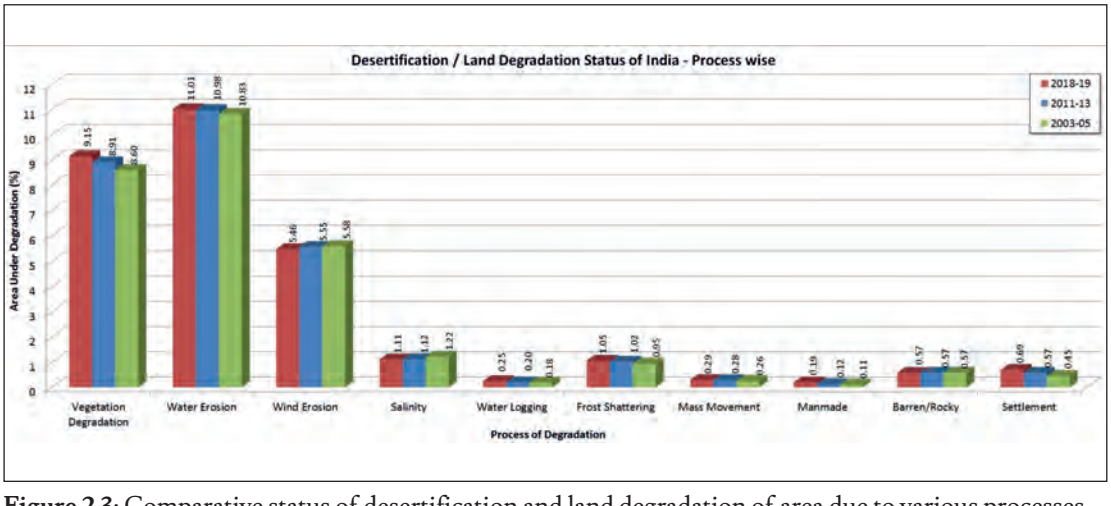


Figure 2.3: Comparative status of desertification and land degradation of area due to various processes

Source: SAC, 2021

Table-2.4:

Drought prone areas in the country

S.No.	Districts/ Sub-basin	Total area (Mha)	Area (Mha) 2011-13	Area (Mha) 2003-05	Degraded Area increased / decreased (%)
1	Anantpur (Andhra Pradesh)	1.91	1.2321	1.2314	0.04
2	Tawang (Arunachal Pradesh)	0.22	0.099	0.098	0.35
3	Tirap (Arunachal Pradesh)	0.12	0.017	0.015	2.05
4	Golaghat (Assam)	0.35	0.055	0.056	-0.10
5	Hailkandi (Assam)	0.13	0.024	0.021	2.13
6	Kokrajhar (Assam)	0.33	0.035	0.026	2.70
7	Bhabua (Bihar)	0.33	0.106	0.103	0.65
8	Samastipur (Bihar)	0.29	0.009	0.012	-0.81
9	Sitamarhi (Bihar)	0.22	0.004	0.007	-1.24
10	Durg (Chhattisgarh)	0..85	0.068	0.066	0.25
11	Raipur (Chhattisgarh)	1.24	0.207	0.202	0.38
12	Rajnandgaon (Chhattisgarh)	0.81	0.087	0.090	-0.48
13	North Goa (Goa)	0.17	0.087	0.086	0.46
14	Bhavnagar (Gujarat)	0.83	0.297	0.323	-3.07
15	Panch Mahals (Gujarat)	0.52	0.272	0.274	-0.22
16	Sabar Kantha (Gujarat)	0.74	0.234	0.224	1.28
17	Surendranagar (Gujarat)	1.04	0.537	0.535	0.19
18	Bhiwani (Haryana)	0.48	0.076	0.062	2.94
19	Sirsa (Haryana)	0.43	0.044	0.053	-1.97
20	Kangra (Himachal Pradesh)	0.57	0.113	0.112	0.12
21	Kinnaur (Himachal Pradesh)	0.64	0.463	0.463	0.02
22	Lahul & Spiti (Himachal Pradesh)	1.38	1.115	1.115	-0.03
23	Badgam (Jammu & Kashmir)	0.14	0.051	0.055	-3.28
24	Kargil (Jammu & Kashmir)	1.40	1.098	1.098	0.01
25	Kathua (Jammu & Kashmir)	0.25	0.122	0.113	3.46
26	Bokaro (Jhakhand)	0.29	0.194	0.194	0.06
27	Giridih (Jhakhand)	0.49	0.358	0.358	-0.02
28	Pashchimi Singhbhum (Jharkhand)	0.96	0.449	0.448	0.05
29	Bellary (Karnataka)	0.85	0.354	0.354	0.06
30	Chamarajanagar (Karnataka)	0.56	0.266	0.268	-0.40
31	Kasaragod (Kerala)	0.20	0.023	0.022	0.47
32	Palakkad (Kerala)	0.45	0.034	0.032	0.27
33	Dhar (Madhya Pradesh)	0.82	0.208	0.207	0.14

S.No.	Districts/ Sub-basin	Total area (Mha)	Area (Mha) 2011-13	Area (Mha) 2003-05	Degraded Area increased / decreased (%)
34	Morena (Madhya Pradesh)	0.50	0.178	0.177	0.17
35	Neemuch (Madhya Pradesh)	0.43	0.147	0.147	0.02
36	Ratlam (Madhya Pradesh)	0.49	0.103	0.102	0.17
37	Ahmadnagar (Maharashtra)	1.70	0.963	1.007	-2.57
38	Dhule (Maharashtra)	0.72	0.462	0.457	0.72
39	Sangli (Maharashtra)	0.86	0.393	0.395	-0.32
40	Chandel (Manipur)	0.33	0.113	0.117	-1.26
41	Churachandpur (Manipur)	0.46	0.224	0.220	0.88
42	Jaintia Hills (Meghalaya)	0.38	0.088	0.087	0.32
43	West Khasi Hills (Meghalaya)	0.52	0.278	0.275	0.60
44	Aizawl (Mizoram)	0.36	0.189	0.172	4.81
45	Lunglei (Mizoram)	0.45	0.147	0.120	5.81
46	Kohima (Nagaland)	0.15	0.091	0.098	-4.87
47	Wokha (Nagaland)	0.16	0.060	0.065	-3.09
48	Bargarh (Odisha)	0.58	0.358	0.365	-1.24
49	Kendujhar (Odisha)	0.83	0.440	0.437	0.31
50	Koraput (Odisha)	0.88	0.488	0.487	0.07
51	Mayurbhanj (Odisha)	1.04	0.450	0.450	0.00
52	Hoshiarpur (Punjab)	0.34	0.011	0.009	0.71
53	Pathankot (Punjab)	0.09	0.010	0.009	0.87
54	Ajmer (Rajasthan)	0.85	0.269	0.264	0.56
55	Dausa (Rajasthan)	0.34	0.082	0.082	0.12
56	Jaisalmer (Rajasthan)	3.84	3.570	3.768	-5.18
57	Pali (Rajasthan)	1.24	0.465	0.464	0.04
58	North Sikkim (Sikkim)	0.71	0.113	0.113	0.05
59	South Sikkim (Sikkim)				
60	East Sikkim (Sikkim)				
61	West Sikkim (Sikkim)				
62	Dharmapuri (Tamil Nadu)	0.45	0.198	0.198	-0.10
63	Krishnagiri (Tamil Nadu)	0.51	0.246	0.249	-0.55
64	Theni (Tamil Nadu)	0.29	0.146	0.147	-0.08
65	Tirunelveli (Tamil Nadu)	0.67	0.122	0.122	0.08
66	Virudhunagar (Tamil Nadu)	0.42	0.043	0.042	0.05
67	Mahabubnagar (Telangana)	1.84	0.475	0.437	2.10
68	South Tripura (Tripura)	0.31	0.097	0.086	3.90

S.No.	Districts/ Sub-basin	Total area (Mha)	Area (Mha) 2011-13	Area (Mha) 2003-05	Degraded Area increased / decreased (%)
69	West Tripura (Tripura)	0.30	0.142	0.136	1.81
70	Chitrakoot (Uttar Pradesh)	0.32	0.089	0.090	-0.26
71	Etawah (Uttar Pradesh)	0.23	0.097	0.106	-3.80
72	Kanpur Dehat (Uttar Pradesh)	0.30	0.078	0.082	-1.35
73	Chamoli (Uttarakhand)	0.80	0.259	0.256	0.40
74	Pauri Garhwal (Uttarakhand)	0.53	0.027	0.026	0.22
75	Bankura (West Bengal)	0.69	0.229	0.229	0.12
76	Purulia (West Bengal)	0.63	0.357	0.354	0.59
	Sub-basin				
1.	Nubra Sub- Basin, Leh district	0.43	0.199	0.200	-0.10
2.	Shyok Sub-Basin, Leh district	2.66	1.968	1.969	-0.04
	Total	**49.66**	**22.80**	**22.94**	

Source: SAC, 2018

Land degradation and desertification across the country have taken place due to natural and human induced factors. Anthropogenic processes particularly the impacts of climatic changes, extreme weather events and geological weathering exacerbate land degradation. In addition to the aforesaid, climate change is also leading to land degradation and desertification due to droughts, floods and other extreme events including avalanches and landslides in hilly regions. Unsustainable land use and inappropriate land management practices have led to varying degrees of land degradation. Degradation is further exacerbated due to loss of vegetation i.e. deforestation, unsustainable fuel-wood and fodder collection, shifting cultivation, encroachment into forest lands, forest fires and overgrazing. Non-adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agro-chemicals (fertilizers and pesticides), improper planning and management of irrigation systems and extraction of groundwater in excess of the recharge capacity are the other major factors responsible for land degradation and desertification in dry regions. The other indirect pressures like short-term or insecure land tenancy, open access resource, and large chunk of population dependent on agriculture, have also contributed significantly to the land degradation and desertification.

2.3. Droughts in India

Generally, drought occurs when a region receives consistently below average precipitation. A drought can last for months or years, or may be declared after as few as 15 days. It can have a substantial impact on the ecosystem functions and agriculture productivity of the affected region. Droughts can persist for several years but intense drought can cause significant damage to the local ecology and economy. The vulnerability to drought is exacerbated in the event of an earlier period of drought as it gives reduced opportunity to people to recover from the preceding event. Prolonged droughts have caused mass migrations and humanitarian crises.

Drought is recognized as a major cause of desertification, also impacting water supplies for drinking, irrigation, storage and recharging ground water, which gets exhausted due to excessive extraction and small recharge during the drought periods in affected regions. Drought is a very complex phenomenon which is governed by oceanographic factors like El Nino and La Nina phenomenon of Pacific Ocean. Massive efforts are required for generating reliable database, creation of drought network and sharing oceanographic information for reliable forecasting and early warning systems for droughts. Though, huge money is spent for drought relief and drought management in the country usually after the onset of drought but there is lack of preventive mechanism to combat drought which may be due to inaccessible reliable forecasting system.

Agriculture is monsoon (June to September rainfall) dependent in India. Anomalies of summer monsoon in quantity, time of arrival, distribution, departure from normal and time of withdrawal are key factors for declaration of drought. The All-India area-weighted mean summer monsoon rainfall (based on a homogeneous rainfall data set of 306 rain gauges in India), developed by the Indian Institute of Tropical Meteorology, is widely considered as a reliable index of summer monsoon activity over the Indian region. All-India Summer Monsoon Rainfall (AISMR) anomalies reported during the period 1871-2017 are as under:

(i) There were 26 major drought years, defined as years with AISMR less than one standard deviation below the mean (i.e., anomaly below -10%): 1873, 1877, 1899, 1901, 1904, 1905, 1911, 1918, 1920, 1941, 1951, 1965, 1966, 1968, 1972, 1974, 1979, 1982, 1985, 1986, 1987, 2002, 2004, 2009, 2014 and 2015.

(ii) There were 19 major flood years, defined as years with AISMR in excess of one standard deviation above the mean (i.e., anomaly exceeding +10%): 1874, 1878, 1892, 1893, 1894, 1910, 1916, 1917, 1933, 1942, 1947, 1956, 1959, 1961, 1970, 1975, 1983, 1988 and 1994.

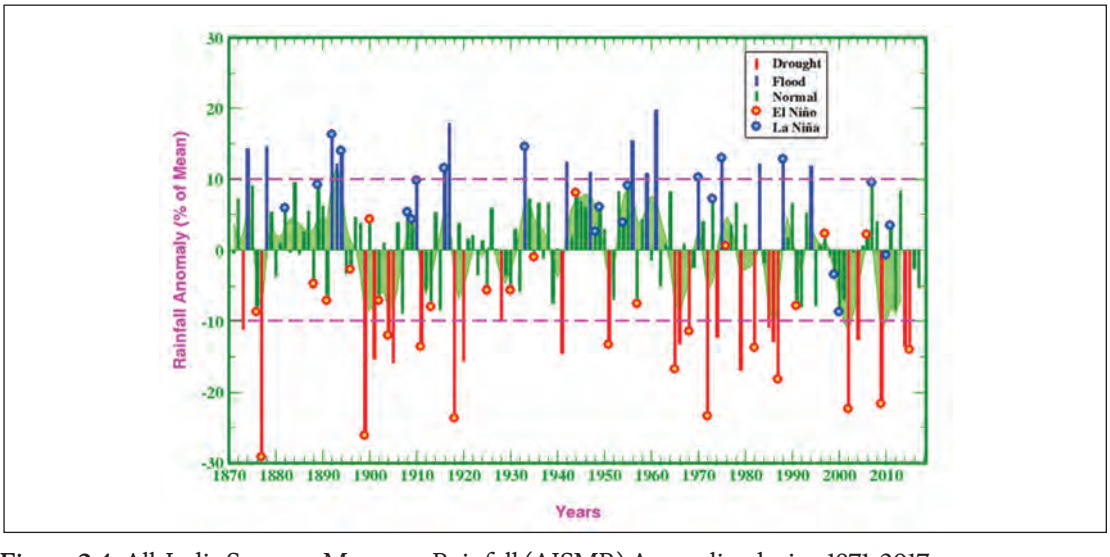


Figure 2.4: All-India Summer Monsoon Rainfall (AISMR) Anomalies during 1871-2017

Source: https://www.tropmet.res.in/~kolli/MOL/Monsoon/Historical/air.html

Drought Prone Areas of India: About 68% of the agricultural land in India is drought prone, of which about 33% is chronically drought prone, receiving rainfall of less than 750 mm per year. Majority of the drought prone area is distributed in arid, semi-arid, and dry sub-humid regions of Maharashtra, Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Odisha. About 51.1 Mha area is drought prone, distributed over 13 states accounting for one-sixth area with 12% of the population of India.

The National Commission on Agriculture (1976) identified a few more drought areas with slightly different criteria; thus, a total of 74 districts of the country were recognized as drought prone. Broadly, the drought-affected areas in India can be divided into two tracts: (i) Desert and the semi-arid regions covering an area of 60 Mha. In this region, rainfall is less than 750 mm and at some places it is even less than 400 mm; (ii) the regions east of the Western Ghats up to a distance of about 300 km from coast known as the rain shadow area of the Western Ghats; rainfall in this region is less than 750 mm and is highly erratic. This region is thickly populated and periodic droughts cause considerable suffering and distress.

Rajasthan is one of the most drought prone areas of India. Eleven districts of the state are in arid region including Jaisalmer as the driest district with extremely low rainfall of 164 mm. Nearly 57% of Rajasthan and 32% of Gujarat falls in arid zone while 61% of Maharashtra and 46% of Gujarat falls in semi-arid zone. Droughts and their spread in past century as declared by the Government are given in Table 2.5.

Table-2.5:

Drought years in the past centuries

Period	Drought years	Number of years
1801 - 1850	1801, 04, 06, 12, 19, 25, 32, 33, 37	9
1851 - 1900	1853, 60, 62, 66, 68, 73, 77, 91, 99	9
1901 - 1950	1901, 04, 05, 07, 11, 13, 15, 18, 20, 25, 39, 41	12
1951 - 2003	1951, 65*, 66, 68, 72, 74, 79, 82, 85, 87, 2002	11

Source: www.nih.ernet.in/rbis/india_information/draught.htm

The frequency and intensity of drought across the country have varied over the years. Based on long term data, Indian Meteorological Department (IMD) predicted the probability of drought across the meteorological subdivisions (Table 2.6). The probability is as high as once in 2.5 years in Western Rajasthan, Tamil Nadu, Jammu & Kashmir and Telangana and very rare once in 15 years or less in Assam. IMD has delineated sub-division wise droughts since 1875 and frequency of moderate and severe drought. Data analysis of 130 years indicates that highest frequency (i.e. 33 events) was observed in arid western region viz. Saurashtra and Kutch followed by Western Rajasthan (21 events). The probability of occurrence of drought also followed similar trends as that of frequency. In the last 5 years India witnessed 3 years of drought indicating frequent drought.

As per the World Bank (2013), out of the 10 most severe drought disasters globally in the last century six took place in India which was measured in terms of the number of people affected. Such disasters affected up to 300 million people. The droughts of 1987 and 2002-03 affected

more than 50% of the cropping areas in the country (Wassmann *et al.,* 2009). During 2002-03 the total food grain production was 38 million tonnes less than the previous year due to severe impact of drought.

Table-2.6:

Probability of occurrence of drought in different meteorological sub- divisions

Meteorological sub division	Frequency of deficient rainfall (75% of normal or less)
Assam	Very rare, once in 15 years
West Bengal, Madhya Pradesh, Konkan, Bihar and Odisha	Once in 5 years
South Interior Karnataka, Eastern Uttar Pradesh and Vidarbha	Once in 4 years
East Rajasthan, Gujarat and Western Uttar Pradesh	Once in 3 years
West Rajasthan, Tamil Nadu, Jammu & Kashmir and Telangana	Once in 2.5 years

Source: www.nih.ernet.in/rbis/india_information/draught.htm

Mishra *et al.,* 2019 stated that "*India experienced seven major drought periods (1876–1882, 1895–1900, 1908–1924, 1937–1945, 1982–1990, 1997–2004, and 2011–2015) based on severity-area-duration analysis of reconstructed soil moisture. Out of six major famines (1873–74, 1876, 1877, 1896–97, 1899, and 1943) that occurred during 1870–2016, five are linked to soil moisture drought*".

Climate change has serious implications for droughts and desertification in the arid and semi-arid regions. Increased evapo-transpiration and reduced precipitation increases frequency as well as intensity of droughts, which affects desertification and land degradation. Using Soil Moisture Deficit Index approach between the 1970s and 2030s as the drought index, it was suggested that there is an increase in droughts for those areas that have either projected decrease in precipitation or will have enhanced level of evapo-transpiration in the 2030s. Similarly, the weeks belonging to moderate soil moisture stress show an increase in severity of drought from baseline to the mid-century scenario. Moderate to extreme drought severity has been pronounced for the Himalayan region where the increase is more than 20% in many areas despite the overall increase in precipitation (INCCA, 2010).

Impacts of Desertification, Land Degradation and Drought on Key Sectors

Desertification, land degradation and drought (DLDD), whether driven by human actions or biophysical factors or a combination of the both, result in the loss or damage to natural capital. It reduces land productivity and hampers the ability of the land to provide ecosystem services and ultimately leads to poverty. DLDD is collectively impacting the prime sectors and resources like agriculture, water, forest, biodiversity etc. Poor communities are most affected by DLDD due to lack of available means to compensate the loss of land productivity. In the year 1994, land degradation was predicted to be a potentially serious threat to food production and livelihood, particularly in densely populated rural communities. The need for cultivable land can pose threat to biodiversity and water availability thereby leading to water scarcity and poor agricultural productivity. Data of the World Resource Institute also reflected that 17 countries were experiencing 'extremely high' levels of baseline water stress during 2019 (Hofste, 2019). Desertification and land degradation have adversely affected the life of millions of people.

Loss of soil productivity not only affected the lives but also led the mass migration and socio-economic conflicts. Displacement of people also emerged as one of the major consequences of DLDD. Global data has also projected that up to 700 million people will be displaced due to paucity of land resources by 2050. Southern, Eastern and Central Europe show high sensitivity to desertification where 8% of territory gets affected due to desertification and land degradation.

Estimating the cost of desertification and land degradation is an important issue. The monetary loss of ecosystem services due to desertification and land degradation is estimated between USD 6.3 to 10.6 trillion annually (ELD, 2015). If the issue of desertification and land degradation is left unaddressed, it is assumed that by the year 2050 desertification and land degradation will force 50-700 million people to migrate thus leading to huge loss to economy (IPBES, 2018). Projections also indicate that 1.2 billion people in the developing countries are already trapped in degraded agriculture land and devoid of any sustained economic development (Davies, 2019). Globally, 75 billion tonnes of fertile soil are lost every year due to land degradation and 12 mha land is lost every year due to desertification and drought. Most of the costs owing to desertification and land degradation are related to soil contamination, ecosystem services, productivity, loss of grazing cycles, decline in soil fertility, etc.

According to Young (1994), the total onsite annual economic losses due to land degradation in South East Asian countries (India, Pakistan, Bangladesh, Iran, Afghanistan, Nepal, Sri Lanka and Bhutan) was estimated to be around USD 9.8 to 11 billion per year. Land degradation in India has highly affected the agriculture sector which has highest contribution in country's gross domestic product. Findings of the study on Economics of Desertification, Land Degradation and Drought in India commissioned by Ministry of Environment, Forest and Climate Change, Government of India stated that the economic loss faced due to land degradation and change in land use pattern was 2.54% of the India's GDP, which was about Rs. 3,177.39 billion in the year 2014-15 (TERI, 2019).

3.1. Impacts on Agriculture Productivity and Food Security

Land degradation has both on-site and off-site impacts which apart from lowering the productive potential also results in deterioration of soil health, loss of water quality due to pollution of surface and ground water resources, biodiversity loss, landlessness, thus resulting in poverty, food insecurity and several types of environmental hazards. Erosion induced by water removes soil organic matter and other vital nutrients causing loss of productivity. As per Sehgal and Abrol (1994), erosion accounts for about 5 to 50% loss of productivity, and the degree of degradation depending upon type of soil, crops and the severity of erosion. However, it was estimated that nearly 5.37 to 8.4 million tonnes of plant nutrients were lost every year from the soils due to water erosion (Kumar, 2004). Moreover, water induced erosion is also responsible for sediment laden runoff where water acts as a carrier for toxic substances and organic compounds such as pesticides which cause wide range of ecological hazards downstream. The loss of vegetation due to water erosion and deforestation and forest degradation is a major cause of disasters such as landslides and floods. India is listed among the top 10 countries of the world where land resources are highly vulnerable to floods, droughts, cyclones, landslides, avalanches and forest fires[3].

Wind induced erosion results in productivity loss at both the land surface from where the soil particles are blown away and where they get deposited. Dryland ecosystems along with the human population inhabiting in such areas are considered to be the most vulnerable to extreme events such as drought and floods. Recurrent occurrence of such events also leads to human migration to other areas for sustenance. Salinization and waterlogging in agricultural lands reduces productivity thus leading to degradation of land resources.

Brandon *et al.* (1995) estimated that loss of food grain production due to waterlogging every year in India as 1.2 to 1.6 million tonnes. Reclaimed waterlogged saline soils have the potential to produce 4.0 to 9.5 MT/ha of wheat (CSSRI, 2004). Reclaimed areas were contributing nearly 6 million tonnes of paddy and wheat annually in Punjab, Haryana and Uttar Pradesh. The loss in productivity due to salinity in India was estimated to vary from 6.2 to 9.7 million tonnes (UNEP, 1993 and Bansil, 1990). It was estimated that reclamation of 8.5 Mha salt-affected soils in India with suitable ameliorative technology can produce additional 50-55 MT of food grains annually (Yadav, 2007). Depending upon level of acidity, type of soil, crop grown and climatic conditions, acid soils can reduce productivity by 10-50% (Velayutham and Bhattacharyya, 2000).

3.2. Impacts on Water Resources

Water resources are often among the first to experience the negative effects of DLDD. The limited availability of water in the face of exponentially increasing demand indicates the potential for disputes and conflict both within and among the states. Also, there is a strong link between poverty and water resources scarcity. The number of people living on less than USD 1.25 a day approximately coincides with the number of those without access to safe drinking water. Almost 80% of diseases in developing countries are associated with water, resulting in three million early deaths with 5,000 children dying every day from diarrhoea. Roughly 10% of all illnesses worldwide could be avoided by improving water supply, management and sanitation (WHO, 2008; UNCCD, 2009). The UNCCD recognized water as a valuable asset of mankind and an integral part of its

[3] *https://nidm.gov.in/easindia2014/err/pdf/country_profile/India.pdf*

collective heritage. Thus, both ground and surface water, need to be recognized as a resource whose use is common to all, subject to rights of use or limited appropriation rights that may be recognized. Water resources are impacted by major land degradation and desertification processes such as salinity, waterlogging, erosion, improper water management and industrial agriculture. The major reservoirs are facing the problem of sedimentation which is leading to loss of storage capacities hence impacting the supply of water. Coastal aquifers form a vital source of freshwater along the 7,000 km long Indian coastline (MoDW&S, 2013). These aquifers are vulnerable to intrusion of saltwater from the sea. Salt water intrusion in coastal areas is exacerbated by concentrated withdrawal of groundwater and reversal of natural hydraulic gradients. However, warming of oceans, lakes and rivers has been observed over recent decades, with implications for freshwater ecosystems, such as changes in water salinity, water nutrient content, concentration of pesticides and other pollutants, salinization of groundwater, water chemistry and pH balance (World Bank, 2013).

In India, ineffective waste disposal is a major cause of pollution which is leading to negative impacts on drinking water resources throughout the country. For example, open dumping and poorly-managed landfills pollute the water bodies and groundwater with toxic substances. In addition to this, poor sanitation facilities and insanitary conditions around drinking water sources are also polluting and contaminating water bodies in rural areas. The cumulative impacts of erosion and overutilization of pesticides and fertilizers also leads to degradation of ground and surface water resources. In rural areas, over utilization and faulty practices impact about 13% of drinking water which contains chemical contaminants including fertilizers run-off, mainly urea and its decomposed products (MoDW&S, 2013). Fertilizers and pesticides enter the water supply through run-offs and leaching into groundwater thereby pose hazards to human, animal and plant populations. Nitrate is a very common constituent in groundwater, especially in shallow aquifers. The source is mainly from anthropogenic activities and intensive agricultural practices such as fertiliser application and application of solid waste on land and run-off from the agricultural fields (Hariprasad and Dayananda, 2013).

Industrial waste water is often contaminated with highly toxic pollutants which are extremely persistent in the environment (Sangodoyin, 1991; Reza and Singh, 2010). There have been several cases in the industrial belts of the country of factory effluents being discharged into rivers or streams directly, without prior treatment, thus adversely affecting the lives and livelihoods of the people living in the vicinity. A study by the Water and Sanitation Programme estimates that inadequate sanitation causes India 'considerable economic losses' each year equivalent to 6.4% of the GDP that is USD 53.8 billion (WSP, 2010). It also revealed that children and poor households bear the brunt of poor sanitation. More than three quarters of the premature mortality-related economic losses are due to deaths and diseases in children below five years of age (MoDW&S, 2013).

3.3. Impacts on Energy and Power

India being an agrarian country overwhelmingly depends on its water resources for both irrigation and electricity production. In India many river valleys are supporting agricultural and hydro power projects which have become the backbone of the economy and agriculture. Mass movement and soil erosion in catchment regions accelerate the process of siltation in dams and reservoirs, which negatively impacts the storage capacity, water quality and reduces power and irrigation capability.

The stream sediments are mixtures of detritus derived either from exposed rocks or soils through a local drainage system. Surveys of the large and medium-sized Indian reservoirs developed for irrigation and power generation had indicated that six large reservoirs (storage > 100 million cubic metre) and three medium-sized reservoirs (storage 20-100 million cubic metre) had lost more than 25% of their capacities due to sedimentation and deposition of debris in the catchment areas which were largely erosion induced (Shangle, 1991 and Morris, 1995). Energy resources have been reported to be of strategic importance; however, use of renewable energy resources will be imperative for the long-term sustenance of hydrocarbons and reducing greenhouse gas emissions. Hydro power remains the most economic, viable and environmentally safe method of overcoming the energy crisis in a country like India.

Multipurpose reservoirs were constructed throughout the country on some of the major river systems. Due to increase in sedimentation processes these reservoirs are losing their capacity and are seriously threatened in their performance. Poor soil conservation measures and improper watershed management in upstream areas is the major cause of increased soil loss which gets settled in the downstream water reservoirs constructed for power generation. In addition, melting of glaciers and glacial lake outburst in Himalayan regions has also become a major source of silt in downstream reservoirs. It is well accepted that reservoir sedimentation poses a serious threat to available storage. The above stated factors in association with anthropogenic ones are responsible for high suspended load in rivers which ultimately impacts power generation in hydropower projects by settling in energy store reservoirs.

3.4. Impacts on Forests and Biodiversity

Vegetation degradation is an important aspect of land degradation although more attention was paid in the past to soil and water degradation. Usually, land degradation is described in terms of the loss in natural resources (soil, water, fauna and flora) or in the biophysical process by which it functions. Soil can be eroded, salinized or impoverished. Water can be lost through evapo-transpiration, evaporation, infiltration, run-off, pollution, or overuse. The forested habitats diminish due to above said factors which lead to decline in abundance, uniqueness and diversity of species. However, desertification of land resources endangers basic production systems as well as natural ecosystems. Loss of vegetation due to deforestation, over cutting beyond silviculturally permissible limits, unsustainable fuel-wood extraction, shifting cultivation, encroachment into forest land, forest fire, over-grazing, extension of cultivation onto lands of low potential or high natural hazards, non-adoption of adequate soil conservation measures and improper crop rotation were identified as some of the important factors contributing to land degradation in India (ICFRE, 2014 a).

Deforestation and forest degradation caused by demands of fuel-wood, forest land diversion for non-forest use and commercial felling which have two-fold impacts on the livelihood of the people who depend on the forests, and also the ecological impacts including soil erosion, siltation, and flooding. Indian forests are largely suffering from two major ailments – denudation and erosion, resulting in loss of the productive base. The impacts of forest degradation are catastrophic in the Himalayan landscape of the country since they possess steep terrain with fragile geology which is more vulnerable to degradation. In the Himalaya, the productive lands are getting lost due to soil erosion and the landslides which wash away the rich topsoil, hence degrading the soil resources. The loss of carbon due to forest degradation also affects the climate both at macro and micro levels.

In India more than 40% of the forests are degraded and under-stocked (Aggarwal *et al.,* 2009; Gera, 2014). The National Forest Commission report indicated that around 41% of total forest in the country was already degraded, about 70% of the forests having no natural regeneration, furthermore 55% of the forests were prone to fire (MoEF, 2006). Dependency on forests for livelihood (FSI, 2011; Davidar *et al.,* 2010), demand and supply gap of forest products resulting in exploitation beyond carrying capacity (Aggarwal *et al.* 2009), forest fires, over grazing, illegal felling and diversion of forest land for non-forest uses due to competing land use demand for developmental and other uses (Aggarwal *et al.,* 2009; MoEF, 2009; Davidar *et al.,* 2010; FSI, 2011) are some of the factors causing forest degradation in India.

3.5. Impact on Rural Livelihoods

The link between desertification and poverty is direct and intimate. It directly affects the majority since they depend on land as a basic resource, whether for crops, livestock or fuelwood. In such communities, poverty is the main reason for the steady decline in rural incomes resulting in complex demographic, economic, and social changes. The rural poor generally have access only to areas that have higher risk for health and income generation and they generally lack the resources or investment to reduce the exposure to the risk. Hence, land degradation affects the socio-economic status of the rural communities and also lowers the productivity of marginal lands. In addition to this, in such areas the most devastating risk is through drought in dryland region. The life-threatening combination of poverty and drought has serious environmental consequences that threaten future land productivity and the conservation of natural resources.

Farmers in developing countries respond to land degradation by intensifying production on smaller areas, marginal lands, change in crop types, migrating to other areas and diversifying their sources of income (Roose, 1996; Stocking and Murnaghan, 2002). The degradation of forest resources is also threatening the rural communities due to their traditional dependency on biomass for fuel wood, fodder and food. As per the Planning Commission (2000), about 270 million tonnes of fuelwood, 280 million tonnes of fodder, over 12 million cubic meters of timber and countless non-timber forest products were removed from Indian forest annually. The natural ecosystems or forest contribute about 1.0 to 2.5 % of the GDP of India with large amount of unaccounted provisional services. Increasing degradation of forests is impacting the critical livelihood-forest linkage of forest dependent communities (Davidar *et al.,* 2010; FSI, 2011) since degradation is leading to demand and supply gap for forest products which is resulting in illegal exploitation beyond the carrying capacity of forests. As per estimates, fuelwood collected from forests accounts for about 40% of the country's energy needs and is five times higher than what could be removed from the forest (MoEF, 1999). Hence rural livelihood and forest degradation mutually reinforce each other at different scales.

3.6. Cross-cutting Linkages

Land degradation possesses cross cutting linkages with other sectors in the view of climate change in addition to the impacts highlighted in the previous sections with respect to specific sectors. In the terms of land degradation and climate change, major linkages have been identified which have a direct bearing on food security and sustainable development. The impact of climate change on soils also needs to be considered in conjunction with other causes of land degradation in India such as unsustainable land management practices, erosion, salinity/ sodicity, etc. However,

it is impossible to separate the effects of such processes from climate change as they are often interactive and cumulatively impact soil and other bio-physical components of land resources. Climate change poses a real challenge by impacting agriculture, forests, water resources and health.

Over dependence of the population on natural resource base and low financial adaptive capacity cause the impact of climate change to be more profoundly. Climate change/variability is of particular concern to the 60% rainfed area of the 142 Mha net sown area of the country. Furthermore, glacial melt is expected to increase due to climate change, which would lead to increased summer flows in glacier fed river systems for a few decades followed by a reduction in flow as the glaciers start disappearing, causing subsequent structural changes in irrigated ecosystems. With the increase in annual sea water temperature by 0.8 to 2.5°C and sea level rise of 8 to 25 cm by 2050 (IPCC, 2007), coastal wetlands, especially mangroves, coral reefs, lagoons and estuaries will be destroyed. The cumulative impacts of rising temperature, uneven precipitation, occurrence of frequent droughts, and ground water depletion are negatively impacting the productivity of land in drylands. The consequent loss of productivity of agricultural land is negatively impacting the socio-economic condition of the affected populations and such lands are also getting converted into deserts.

3.7. Women and Land Degradation

Land degradation and loss of productivity in agricultural land and forests have severe impacts on women as they have a high degree of dependency on the natural resources to carry out their daily household activities. In general women are usually the ones engaged in household subsistence activities such as collection of water, fodder, fuel wood for cooking etc. from forest. Moreover, women are also involved in the management, maintenance and conservation of these resources for meeting the daily family needs and consumption hence they possess traditional knowledge of their natural resources and environment. As food producers, women have a stake in the preservation of the environment and in environmentally sustainable development.

A lack of understanding and appreciation of women's knowledge of dryland preservation techniques, as well as a disregard for their priorities as resource users, has led many development interventions to fail or to be rejected by local communities (OECD, 2008). Because of differences in women access to and use of land resources the impact of degradation of land on women also differs. In our system women often have customary access to agricultural land for food and cash crop production, and to forests for foraging and fuel collection but women rarely have legal tenure. Hence, change in land use pattern is seriously undermining the women customary and statutory rights as well as their access to land resources for household subsistence. Decline in productivity of agricultural land and degradation of forests in rural areas, force women to adopt unsustainable land practices and it also pressurize them to do more labour for meeting the basic subsistence production, fuel and water collection in degraded lands (FAO, 1993), thus negatively impacting their lives in terms of economic conditions, education and health.

04
Chapter

International Commitments Related to Sustainable Land and Ecosystem Management

The environmental issues being faced by the world are now being realized as turning into crises that can have a potential to become a grave threat to the very existence of the earth. In order to address the problems caused by continued environmental degradation due to reasons like unplanned and unsustainable developmental activities, increasing human population, demand for food and other facilities, etc. the nations of the world realised the need to come together to commit themselves to undertake activities that can help halting and reclaiming the lost environmental entities like water bodies, land, air, biodiversity, etc. Under the aegis of cooperating bodies like the United Nations, some important commitments have been made and agreed to by the countries. Following the principles of traditionally ingrained ecological sustainability in the working ethos of Indian culture, India too has made several commitments to achieve the common goals of environmental protection, land reclamation, reduction of greenhouse gas emission, combating desertification and land degradation etc. The important international commitments of India related to sustainable land and ecosystem management under different conventions, agreements etc. are outlined below:

4.1. United Nations Convention to Combat Desertification

In the 1990s, the global community for the first time expressed concern about desertification along with issues like climate change and biodiversity loss. At the UN Conference on Environment and Development at Rio de Janeiro in 1992, the global community recognized the necessity of healthy and productive ecosystems for sustainable and equitable development. This gave birth to Agenda 21 and the three Rio Conventions, namely Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD).

UNCCD is the only internationally recognized legally binding instrument that addresses the problem of land degradation in drylands. It is unique as being the only global policy body focused on combating desertification, land degradation and drought. The Convention aims at adaptation and significantly contribute to achieving the Sustainable Development Goals and poverty reduction by means of arresting and reversing land degradation. It promotes sustainable land management approach as a solution to global challenges. The approach focuses on changes in land cover and land use in order to maintain and enhance ecosystem functions and services.

The objective of the Convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification through effective action at all levels, supported by international cooperation and partnership arrangements.

"Land degradation is the result of human-induced actions which exploit land, causing its utility, biodiversity, soil fertility, and overall health to decline".

UNCCD

UNCCD places human beings at the centre of its effort to combat desertification and mitigate the effects of drought, and requires that the signatories undertake to participate in a global effort directed to combat desertification and land degradation. It does not specify the steps to be taken but asks the countries that they mobilize adequate human resources, technology, expertise, financial, legal and administrative support for combating the desertification process. Being the only international convention at the interface of environment and development, the UNCCD links the land to people, to policies and to livelihoods, highlighting novel and essentially fundamental concepts of human-environment system linkages, while also highlighting the global nature of the desertification, land degradation and drought and the challenge of associated poverty. According to Article 9 of UNCCD, "*an affected country Party is required to prepare, make public and implement national action programmes, utilizing and building, to the extent possible, on existing relevant successful plans and programmes and sub-regional and regional action programmes, as the central element of the strategy to combat desertification and mitigate the effects of drought. Such programmes shall be updated through continuing participatory process on the basis of lessons learnt from field action, as well as the result of research. The preparation of national action programmes shall be closely interlinked with other efforts to formulate national policies for sustainable development".*

National Action Programmes (NAP) is the key instruments to implement the Convention and is the guiding document for Country Parties for implementation of UNCCD. According to Articles 9 to 11 of the UNCCD, the NAP is central to the strategy to combat desertification, land degradation and drought, NAP need to be updated through a continuing participatory process while allowing for modifications to changing reality and requires regular review. NAP is developed through a participatory approach involving various stakeholders, including relevant governmental offices, scientific institutions and local communities. NAP spell out the practical steps and measures to be taken to combat desertification in specific ecosystems.

The Country Parties to UNCCD adopted the **10-year strategic plan and framework to enhance the implementation of the Convention for 2008-2018** (10-Year Strategy of the UNCCD 2008-2018) at COP8 in 2007. The Strategy specifies the need "*to forge a global partnership to reverse and prevent desertification and land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability*". This Strategy contains the "strategic objectives" to be achieved over the 10 years, and the "operational objectives" that guide the actions of short and medium-term effects. In decision 3/COP.8, affected country parties are urged "to align their action programmes and other relevant implementation activities relating to the Convention with the Strategy". Following were the objectives of the 10-Year Strategy of the UNCCD 2008-2018:

Strategic Objectives	Operational Objectives
• To improve the living conditions of affected populations • To improve the condition of affected ecosystems • To generate global benefits through effective implementation of the UNCCD • To mobilize resources to support implementation of the Convention through building effective partnerships between national and international actors	• Advocacy, awareness raising and education • Policy framework • Science, technology and knowledge • Capacity-building • Financing and technology transfer

UNCCD 2018–2030 Strategic Framework was adopted at COP 13 of UNCCD in 2017. This Strategic Framework strongly encourages country Parties to apply and, as appropriate, align their national policies, programmes, plans and processes relating to desertification, land degradation and drought, including their National Action Programmes with the UNCCD 2018–2030 Strategic Framework (Decision 7/COP.13). The strategy contributes to achieve the objectives of the Convention and 2030 Agenda for Sustainable Development particularly Sustainable Development Goal (SDG) 15 and target its 15.3 (by 2030 combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world) and other interrelated SDGs; improve the living conditions of affected populations, and enhancing ecosystems services. UNCCD 2018–2030 Strategic Framework has following objectives and expected impacts (UNCCD, 2018):

Strategic objective 1: To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality

Expected impact 1.1. Land productivity and related ecosystems services are maintained or enhanced.

Expected impact 1.2. The vulnerability of affected ecosystems is reduced and the resilience of ecosystems is increased.

Expected impact 1.3. National voluntary land degradation neutrality targets are set and adopted by countries wishing to do so, related measures are identified and implemented, and necessary monitoring systems are established.

Expected impact 1.4. Measures for sustainable land management and the combating of desertification/land degradation are shared, promoted and implemented.

Strategic objective 2: To improve the living conditions of affected populations

Expected impact 2.1. Food security and adequate access to water for people in affected areas is improved.

Expected impact 2.2. The livelihoods of people in affected areas are improved and diversified.

Expected impact 2.3. Local people, especially women and youth, are empowered and participate in decision-making processes in combating DLDD.

Expected impact 2.4. Migration forced by desertification and land degradation is substantially reduced.

Strategic objective 3: To mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems

Expected impact 3.1. Ecosystems' vulnerability to drought is reduced, including through sustainable land and water management practices.

Expected impact 3.2. Communities' resilience to drought is increased.

Strategic objective 4: To generate global environmental benefits through effective implementation of the UNCCD

Expected impact 4.1. Sustainable land management and the combating of desertification/land degradation contribute to the conservation and sustainable use of biodiversity and addressing climate change.

Expected impact 4.2. Synergies with other multilateral environmental agreements and processes are enhanced.

Strategic objective 5: To mobilize substantial and additional financial and non-financial resources to support the implementation of the Convention by building effective partnerships at global and national level

Expected impact 5.1. Adequate and timely public and private financial resources are further mobilized and made available to affected country Parties, including through domestic resource mobilization.

Expected impact 5.2. International support is provided for implementing effective and targeted capacity-building and on-the-ground interventions in affected country Parties to support the implementation of the Convention, including through North–South, South–South and triangular cooperation.

Land Degradation Neutrality: A Vehicle to Combat Desertification: The COP 12 of UNCCD endorsed concept of Land Degradation Neutrality (LDN) as a strong vehicle for driving the implementation of the Convention and invited all country Parties to formulate voluntary targets to achieve LDN and to incorporate them in their National Action Programme to Combat Desertification.

LDN aims to sustain the productivity of land, maintain the land based natural capital, support sustainable flow of ecosystem goods and services and thus meets the needs of present and future generations. LDN concept aims to achieve a balance between anticipated new land degradation and future efforts to improve degraded land through land restoration and sustainable land management.

LDN Target Setting Process aims to support countries to define national LDN targets and undertake associated measures. It is not a stand-alone process but should be embedded in national development policy processes with strong Government leadership, coordination across line ministries and active engagement of all the relevant stakeholders.

Globally, 131 countries have committed to set LDN targets out of which 109 countries have already set their targets and many have secured high level government commitment to achieve LDN

It is required to build the capacity at sub-national and national level in setting national LDN baseline on the basis of land cover (vegetative land cover), land productivity (land productivity dynamics), carbon stocks (above ground and below ground including soil organic carbon), identifying drivers of land degradation, defining national voluntary LDN targets, measures to achieve LDN, monitoring progress towards LDN targets and reporting on LDN as per operational guidelines of UNCCD.

Achieving land degradation neutrality - by preventing land degradation and rehabilitating already degraded land, scaling up sustainable land management and accelerating restoration initiatives - is a pathway to greater resilience and security for all. Restoring the soils of degraded ecosystems has the potential to store up to 3 billion tons of carbon annually.

As an integral part of its obligations, India has submitted eight national reports to UNCCD Secretariat. At the Ninth Session of the Conference of the Parties (COP 9, 2008) it was decided to use a revised reporting format from the 4th National Report onwards. The revised reporting format which supports the new result-oriented management structure of UNCCD is called "the Performance Review and Assessment of Implementation System (PRAIS). The PRAIS reporting model is indicator based and requires reporting on measuring, monitoring and assessment and evaluation. This allows the Committee for the Review of the Implementation of the Convention to effectively review the implementation of the Strategy and the Convention, based on a new methodological approach, which envisages reporting on performance and impact indicators, best practices and financial flows. The 5th and 6th National reports of the country were submitted through PRAIS portal in 2012, and 2014 to the UNCCD Secretariat through PRAIS portal as per the UNCCD 2008-2018 Strategic Plan. India submitted its 7th National Report in 2018 and 8th National Report in 2023 to the UNCCD Secretariat through PRAIS portal as per the UNCCD 2018-2030 Strategic Plan. India is committed to achieve Land Degradation Neutrality by 2030.

India hosted 14th Session of Conference of Parties to the UNCCD in 2-13 September 2019 at Greater Noida, Delhi NCR. The Conference adopted the Delhi Declaration in which parties expressed commitment for a range of issues, including gender and health, ecosystem restoration, taking action on climate change, private sector engagement etc.

4.2. United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) has the objective to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. It states that such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

The Paris Agreement is a legally binding international treaty on climate change which aims *"to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by holding the increase in the global average temperature to well below 2° C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5° C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production, and making finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development*". All Parties are to undertake and communicate ambitious efforts to achieve the goals of the Paris Agreement in the form of Nationally Determined Contributions (NDCs).

India is Non-Annex Party to UNFCCC and ratified its Kyoto Protocol and Paris Agreement. India has submitted first national communication in 2004, second national communication in

2012, third national communication in 2023, first biennial update report in 2015, second biennial update report in 2018, third biennial update report in 2021 and adaptation communication in 2023 to UNFCCC. India has submitted its NDCs to UNFCCC on 2 October 2016 towards achieving the goals of the Paris Agreement to put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation. It has aimed to adopt a climate friendly and cleaner path to achieve economic development in a sustainable way within the framework of eight qualitative and quantitative NDCs for the period 2021 to 2030. India has communicated an update to its first NDCs in August 2022 (Govt. of India, 2022) and updated NDCs are as under:

- *To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change.*
- *To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.*
- *To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level.*
- *To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology and low-cost international finance including from Green Climate Fund.*
- *To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.*
- *To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.*
- *To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.*
- *To build capacities, create domestic framework and international architecture for quick diffusion of cutting-edge climate technology in India and for joint collaborative R&D for such future technologies.*

Government of India is implementing National Action Plan on Climate Change for achieving its key goals in the context of climate change through its eight mission viz. National Mission for a Green India, National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustainable Agriculture, National Mission for Sustaining the Himalayan Ecosystem and National Mission on Strategic Knowledge for Climate Change under National Action Plan on Climate Change. India hosted 8th Session of the Conference of Parties to the UNFCCC from 23 October to 1 November 2002 at New Delhi.

4.3. Convention on Biological Diversity

Main objectives of the Convention on Biological Diversity (CBD) are conservation of biological diversity, sustainable use of the components of biological diversity and, fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

India is a Country Party to CBD and also ratified its Cartagena Protocol on Biosafety (to ensure the safe handling, transport and use of living modified organisms resulting from modern biotechnology that may have adverse effects on biological diversity) and Nagoya Protocol (on access and benefit sharing). Aichi biodiversity Targets an outcome of Nagoya Protocol included 20 targets under five goals to address the underlying causes of biodiversity loss, reduce the pressures on biodiversity, safeguard biodiversity at all levels, enhance the benefits provided by biodiversity, and provide for capacity building.

India prepared its Strategy (National Policy and Macro Level Action Strategy on Biodiversity) in 1999, and enacted Biological Diversity Act in 2002 to give effect to its commitments under the CBD. The Strategy, 1999 was revised and updated into National Biodiversity Action Plan in 2008 to bring the biodiversity agenda in alignment with the National Environment Policy, 2006. which was further updated with Addendum 2014 to National Biodiversity Action Plan in order to integrate the Strategic Plan for Biodiversity 2011- 20 of CBD. The Strategic Plan for Biodiversity 2011-20 includes 20 Aichi Biodiversity Targets covered under five strategic goals to be implemented during 2011-20. Parties to CBD were required to develop National Biodiversity Targets in line with Aichi Biodiversity Targets considering their national priorities and needs towards achieving the globally shared Biodiversity Vision 2050. Accordingly, India developed following 12 National Biodiversity Targets:

National Biodiversity Target	Related Aichi Targets
1. By 2020, a significant proportion of the country's population, especially the youth, is aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	1
2. By 2020, values of biodiversity are integrated in National and State planning processes, development programmes and poverty alleviation strategies.	2
3. Strategies for reducing rate of degradation, fragmentation and loss of all natural habitats are finalized and actions put in place by 2020 for environmental amelioration and human well-being.	5, 15
4. By 2020, invasive alien species and pathways are identified and strategies to manage them developed so that populations of prioritized invasive alien species are managed.	9
5. By 2020, measures are adopted for sustainable management of agriculture, forestry and fisheries.	6, 7, 8
6. Ecologically representative areas on land and in inland waters, as well as coastal and marine zones, especially those of particular importance for species, biodiversity and ecosystem services, are conserved effectively and equitably, on the basis of protected area designation and management and other area-based conservation measures and are integrated into the wider landscapes and seascapes, covering over 20% of the geographic area of the country, by 2020.	10, 11, 12
7. By 2020, genetic diversity of cultivated plants, farm livestock and their wild relatives, including other socioeconomically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	13

8.	By 2020, ecosystem services, especially those relating to water, human health, livelihoods and wellbeing, are enumerated and measures to safeguard them are identified, taking into account the needs of women and local communities, particularly the poor and vulnerable sections.	14
9.	By 2015, Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization as per the Nagoya Protocol are operational, consistent with national legislation.	16
10.	By 2020, an effective, participatory and updated national biodiversity action plan is made operational at different levels of governance.	3, 4, 17
11.	By 2020, national initiatives using communities' traditional knowledge relating to biodiversity are strengthened, with a view to protecting this knowledge in accordance with national legislations and international obligations.	18
12.	By 2020, opportunities to increase the availability of financial, human and technical resources to facilitate effective implementation of the Strategic Plan for Biodiversity 2011–2020 and the national targets are identified and the Strategy for Resource Mobilization is adopted.	19, 20

India submitted its First National Report (1992-1998), Second National Report (1997-2001), Third National Report (2001-2005), Fourth National Report (2005-2009), Fifth National Report (2009-2014) and Sixth National Report (2014-2018) to CBD.

Kunming-Montreal Global Biodiversity Framework (GBF) adopted by the Country Parties of CBD in its fifteenth meeting (COP 15) held at Montreal (Canada) in December 2022 as a post-2020 global biodiversity framework (GBF). GBF was built on the Strategic Plan for Biodiversity 2011–2020, its achievements, gaps, and lessons learned, and the experience and achievements of other relevant multilateral environmental agreements.

As per the decision 15/4 of CBD, "the GBF aims to catalyse, enable and galvanize urgent and transformative action by Governments, and subnational and local authorities, with the involvement of all society, to halt and reverse biodiversity loss and thereby contribute to the objectives of the CBD and its Protocols. GBF is action and results oriented and aims to guide and promote, at all levels, the revision, development, updating, and implementation of policies, goals, targets, and national biodiversity strategies and actions plans, and to facilitate the monitoring and review of progress at all levels in a more transparent and responsible manner". Vision, Mission and Goals of GBF as per the decision 15/4 of CBD are as under:

"The vision is a world of living in harmony with nature where "by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people".

"The mission for the period up to 2030 is to take urgent action to halt and reverse biodiversity loss to put nature on a path to recovery for the benefit of people and planet by conserving and sustainably using biodiversity and by ensuring the fair and equitable sharing of benefits from the use of genetic resources, while providing the necessary means of implementation".

The four long-term goals of GBF as per the decision 15/4 of CBD are as under:

1. "*The integrity, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050; Human induced extinction of known threatened species is halted, and, by 2050, the extinction rate and risk of all species are reduced tenfold and the abundance of native wild species is increased to healthy and resilient levels; The genetic diversity within populations of wild and domesticated species, is maintained, safeguarding their adaptive potential*".
2. "*Biodiversity is sustainably used and managed and nature's contributions to people, including ecosystem functions and services, are valued, maintained and enhanced, with those currently in decline being restored, supporting the achievement of sustainable development for the benefit of present and future generations by 2050*".
3. "*The monetary and non-monetary benefits from the utilization of genetic resources and digital sequence information on genetic resources, and of traditional knowledge associated with genetic resources, as applicable, are shared fairly and equitably, including, as appropriate with indigenous peoples and local communities, and substantially increased by 2050, while ensuring traditional knowledge associated with genetic resources is appropriately protected, thereby contributing to the conservation and sustainable use of biodiversity, in accordance with internationally agreed access and benefit-sharing instruments*".
4. "*Adequate means of implementation, including financial resources, capacity-building, technical and scientific cooperation, and access to and transfer of technology to fully implement the Kunming-Montreal Global Biodiversity Framework are secured and equitably accessible to all Parties, especially developing country Parties, in particular the least developed countries and small island developing States, as well as countries with economies in transition, progressively closing the biodiversity finance gap of USD 700 billion per year, and aligning financial flows with the Kunming-Montreal Global Biodiversity Framework and the 2050 Vision for biodiversity*".

India hosted 11th Session of the Conference of Parties to the CBD from 8 to 19 October 2012 at Hyderabad.

4.4. Ramsar Convention

The 'Convention on Wetlands' called the Ramsar Convention signed in Ramsar (Iran) in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are 172 Contracting Parties to the Convention, with 2439 wetland sites totalling over 254,691,993 ha. designated as Wetlands of International Importance. A key commitment under the Ramsar Convention is to identify and place suitable wetlands onto the "List of Wetlands of International Importance" also known as the Ramsar List. The Ramsar Sites, form a part of an international network of wetlands which are important for the conservation of global biological diversity and for sustaining human life through the maintenance of their ecosystem components, processes and services.

India became a party to Ramsar Convention on 01 February 1982 and 75 wetlands in India have been designated as Ramsar sites as tabulated below:

Site Designated Year	Number of Ramsar Sites	Area of Ramsar Sites (ha)
1981	2	119373
1990	4	73600
2002	13	400274
2005	6	28624
2012	1	12000
2019	11	434067.901
2020	5	13499.4
2021	14	178507.495
2022	19	66730.811
TOTAL	**75**	**1326676.607**

Source: https://www.ramsar.org/country-profile/india

National Wetland Atlas was published in March 2011 under 'National Wetland Inventory and Assessment' by Space Applications Centre (SAC) and this was the first ever scientific database of 2006- 07 on Indian wetlands using LISS-III data on board Resourcesat-1 (SAC, 2011). National Wetland Atlas: Wetlands of International Importance under Ramsar Convention was also prepared and published in 2013 (Murthy *et al*., 2013). The first wetlands inventory was updated under the 'National Wetland Inventory and Assessment-2nd cycle' by SAC using LISS-III data of 2017-18 at 1:50,000 scale and published the findings of the assessment in the form of Space based observation of Indian wetlands in 2021 (Gupta *et al.,* 2021).

4.5. United Nation Forum on Forest

Economic and Social Council of the United Nations established the United Nations Forum on Forests (UNFF) in October 2000 as a subsidiary body with the main objective to promote the management, conservation and sustainable development of all types of forests and to strengthen long-term political commitment to this end. The Forum has universal membership, and is composed of all Member States of the United Nations and specialized agencies. The United Nations Strategic Plan for Forests 2030 was adopted by the United Nations General Assembly in 2017. It provides a global framework for action at all levels to sustainably manage all types of forests and trees outside forests, and to halt deforestation and forest degradation. There are six following global forest Goals and 26 associated targets to be achieved by 2030:

1. Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change
2. Enhance forest based economic, social and environmental benefits including by improving the livelihoods of forest dependent people.
3. Increase significantly the area of protected forests worldwide and other areas of sustainably managed forests, as well as the proportion of forest products from sustainably managed forests.
4. Mobilize significantly increased, new and additional financial resources from all sources for the implementation of sustainable forest management and strengthen scientific and technical cooperation and partnerships.

5. Promote governance frameworks to implement sustainable forest management, including through the United Nations forest instrument, and enhance the contribution of forests to the 2030 Agenda for Sustainable Development
6. Enhance cooperation, coordination, coherence and synergies on forest related issues at all levels, including within the United Nations system and across member organisations of the collaborative partnerships on Forests, as well across sectors and relevant stakeholders.

The Strategic Plan invited Member States to, on a voluntary basis, determine their contributions towards achieving the Global Forest Goals and targets, taking into account their national circumstances, policies, priorities, capacities, levels of development, and forest conditions. India has announced voluntary national contributions towards achieving the Global Forest Goals and targets. India is committed to achieve Global Forest Goals which are voluntary and universal.

4.6. Sustainable Development Goals

In September 2015, the General Assembly of United Nations adopted the 2030 Agenda for Sustainable Development that includes 17 Sustainable Development Goals (SDGs) with 169 targets for achieving sustainable development for all. SDGs came into effect on 1 January 2016 and address the global challenges related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice.

Sustainable Development Goal 15 urges countries to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt & reverse land degradation and halt biodiversity loss. More specifically, target 15.3 of SDG 15 aims to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world by 2030. The COP 12 of UNCCD endorsed SDG target 15.3 in October 2015 and concept of Land Degradation Neutrality (LDN) as a strong vehicle for driving the implementation of the Convention and

invited all country Parties to formulate voluntary targets to achieve LDN and to incorporate them in their National Action Programme to Combat Desertification.

India along with other countries has signed the declaration of 2030 agenda of sustainable development goals (SDGs) and has made strong commitment for the holistic implementation of SDGs. National Development Agenda of India mirror these SDGs in its flagship programmes and priorities. India's commitment to SDGs is reflected in its convergence with National Development Agenda. National Development Goals and SDGs of India focuses on poverty elimination, promoting gender equality and climate change. Government's wide approach on sustainable development focuses on interconnected nature of SDGs across economic, social and environmental growth. At national level NITI Aayog has been entrusted with the task of coordinating with SDGs and their implementation. NITI Aayog has mapped the government schemes related to SDGs and their targets and identified the ministries for each target. State governments are also advised to go for the same mapping for the schemes running in their respective states including centrally sponsored schemes. In this regard NITI Aayog in December 2019 also developed SDG India Index 2.0 in collaboration with Ministry of Statistics and Programme Implementation (Govt. of India), United Nations in India and Global Green Growth Institute. This index tracks and encourages the accelerated progress to meet SDGs across all the states/ union territories and gives score on the basis of progress made. On the basis of this index maximum progress has been made towards Goal 6 (Clean water and sanitation), Goal 9 (industry, innovation and infrastructure) and Goal 7 (affordable and clean energy)[4]. India has identified the priority areas, best practices and existing crucial gaps for achieving SDG goals.

4.7. Bonn Challenge

The Bonn Challenge was launched by the Government of Germany and IUCN in 2011 with an aim to bring 150 Mha of degraded and deforested landscapes into restoration by 2020 and 350 Mha by 2030. It brings together countries that share borders, ecosystems and economies in regional platforms to collaborate on common goals and challenges with a goal to help catalyse political will and ambition in restoring degraded lands. India has pledged to restore 13 Mha degraded and deforested land by 2020 and 8 Mha by 2030 bringing a total of 21 Mha (7.06% of total land area of the country) of degraded and deforested land under restoration under Bonn Challenge[5]. India has increased the target to 26 Mha to be brought under restoration by 2030.

Between 2011 and 2017 India has brought 9.8 Mha of land under restoration with 95% of activities led by government agencies. These activities have increased biodiversity and forest productivity, especially in forests which are under the Joint Forest Management Committees (JFMCs). JFMCs have played a major role in protecting the forests through involvement of the society and sustainable utilization of forest resources which are essential part of livelihood of dependent, mostly socially vulnerable communities. The linking of villages to markets for sale of NTFPs, have resulted in creation of livelihood opportunities, improvement in irrigation facilities, transport and healthcare. Forest Protection has opened new dimensions by successfully involving the

[4] *https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1597981*

[5] *https://www.iucn.org/news/india/201808/india-first-all-bonn-challenge-countries-develop-progress-report accessed on 28.11.2020*

communities in sustainable harvest of NTFPs thus making forest restoration "socially inclusive". The contribution by the private sector is more of a compliance to the regulations set by the authority under the Corporate Social Responsibility and NGOs have played a small but significant role in this sector. As a part of commitment to Bonn Challenge about 91.5% of the plantations of mixed species were raised and rest were monocultured mainly mangroves in coastal regions[6].

4.8. United Nations Decade on Ecosystem Restoration (2021–2030)

The United Nations General Assembly adopted the resolution on 1st March 2019 to designate 2021–2030 as the United Nations Decade on Ecosystem Restoration, within existing structures and available resources, with the aim of supporting and scaling up efforts to prevent, halt and reverse the degradation of ecosystems worldwide and raise awareness of the importance of successful ecosystem restoration. This decade aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. It can help to end poverty, combat climate change and prevent a mass extinction. This is a global call to action to draw together political support, scientific research and finance to massively scale up restoration. It also acts as a framework for action to revitalize existing environment-related international agreements and commitments. Effective restoration simultaneously supports achievement of the biodiversity, climate and land-degradation neutrality goals of the CBD, UNCCD and UNFCCC and related global initiatives.

The United Nations Resolution (73/284)[7] encourages Member States to foster political will, the mobilization of resources, capacity-building, scientific research and cooperation and momentum for ecosystem restoration at the global, regional, national and local levels, as appropriate; to mainstream ecosystem restoration into policies and plans to address current national development priorities and challenges due to the degradation of marine and terrestrial ecosystems, biodiversity loss and climate change vulnerability, thereby creating opportunities for ecosystems to increase their adaptive capacity and opportunities to maintain and improve livelihoods for all; to develop and implement policies and plans to prevent ecosystem degradation, in line with national laws and priorities, as appropriate; to build on and reinforce existing restoration initiatives in order to scale up good practices; to facilitate synergies and a holistic view of how to achieve international commitments and national priorities through the restoration of ecosystems; and to promote the sharing of experiences and good practices in ecosystem conservation and restoration.

4.9. G20 Global Land Initiative

The G20 comprises of intergovernmental forum of the countries namely Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, United Kingdom, United State of America and the European Union. Global Land Initiative (GLI) on Reducing Land Degradation and Enhancing Conservation of Terrestrial Habitats was launched in its 15th meeting from 21 to 22 November 2020 hosted by Saudi Arabia virtually with the aim to prevent, halt and reverse land degradation and reduce degraded land by 50% by 2040. This initiative has the following three objectives:

[6] *https://sdg.iisd.org/news/india-presents-the-first-bonn-challenge-country-progress-report*

[7] *https://documents-dds-ny.un.org/doc/UNDOC/GEN/N19/060/16/PDF/N1906016.pdf?OpenElement*

- Conserving land and halting habitat loss, fragmentation and land degradation through sharing knowledge and best practices on conservation incentives and implementation of other policies and best practices to enhance land conservation and reduce land degradation.
- Promoting integrated, sustainable, and resilient land and landscape management through: nature-based solutions or ecosystem-based approaches, as well as supporting sustainable land and water management policies and sustainable agricultural practices, including traditional practices, in order to maintain and enhance ecosystem functionality.
- Restoring degraded land through sustainable and locally or regionally appropriate reforestation, afforestation, natural regeneration/ revegetation, restoration of ecosystem services, sustainable agricultural practices, and deployment of nature-based solutions or ecosystem-based approaches for biodiversity conservation, among others, in order to restore ecosystem functionality in a landscape context.

Desertification, Land Degradation and Drought: Monitoring Framework

Globally several efforts are being made to address the issues of desertification/ land degradation and drought (DLDD). Various targets and commitments have been made to halt or reverse the land degradation since 2010. Some of the global initiatives have set targets on time phases for addressing the land degradation *viz.* Aichi Biodiversity Target 15 (restore at least 15% of degraded ecosystem by 2020), Bonn Challenge (restoration of 150 mha of degraded and deforested landscapes by 2020 and 350 mha by 2030), and Sustainable Development Goal 15 (to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world by 2030) and NDC forestry target under the Paris Agreement.

'Proportion of land that is degraded over total land area as global indicator, and land cover change, land productivity, and carbon stocks as three sub-indicators of land degradation are best suited metrics for monitoring and reporting restoration, combating desertification and achieving land degradation neutrality'.

The monitoring framework is needed to assess the progress made in addressing issues of desertification, land degradation and drought at national, regional and international level. UN Statistical Commission (2016) approved a draft of 'Global Indicator Framework' to monitor the progress made to reverse the land degradation. UNCCD, CBD, UNFCCC and FAO observed that adequate national capacities for using appropriate data and methods to assess and monitor the land degradation could be achieved relatively in a short span of time. Most of the countries needs to follow the appropriate method, acquiring the correct data and to develop the expertise in monitoring and evaluating the progress made to combat desertification, land degradation and drought. UNCCD has pointed out the necessity of elaborating indicators to make the complex process quantifiable and communicate the information obtained. Though some degree of inaccuracy is associated with the indicators but identification of truly valid indicators helps in providing the maximum information out of limited available data. True indicators predict the potential risk of desertification and scope of timely action to mitigate the desertification and land degradation.

Rubio and Bochet (1998) had enlisted the criteria, procedure of selection, evaluation and application of indicators. A set of key indicators was used to describe the various factors of desertification and land degradation such as climate, soil, vegetation and management (Kosmas *et al.,* 1999). European Union had also identified more than 150 candidate indicators for assessing the progress towards combating desertification and land degradation and these were elaborated in Desertification Indicator System for Mediterranean Europe online system (Brandt and Geeson, 2005).

UNCCD follows *'one-out all out'* approach for the global indicators also suggested the use of national and sub-national indicators to fill the gaps which were not covered by the global indicators. UNCCD also defined the associated metrics of the global indicators, which quantified

for each land type. The global indicators, earlier known as impact indicators, reflect the progress made in achieving long-term benefits for people affected due to desertification, land degradation and drought for affected ecosystem and for the global environment. The global indicators along with their associated metrics are highlighted as under:

5.1. Land Cover

Land cover includes vegetation cover, water bodies and man-made structures. As an important indicator, land cover depicts the reduction or increase in fragmentation in ecosystem and potentially adverse land conversions. Land cover related information helps in interpreting the change in climatic conditions, supports the sustainable development, and assists in land use planning and natural resource management of the affected area. Land cover information depicts the change of particular land cover type to another, increase or decrease in vegetation cover and soil productivity of degraded areas. Changes in the land cover reflect the trend of land degradation, restoration and carbon stock along with other ecosystem services. Information obtained through changes in land cover are considered very useful in developing baseline for sustainable land management practices[8].

5.2. Land Productivity

Land productivity is the total above ground net productivity, which indicates the long-term changes in health and productive capacity of land. Net productivity is also a good indicator of changes that occurs in ecosystem functioning and carbon stock. Long-term earth observation data assists in calculating the land productivity thus identify the areas with declining land cover. Decrease in green cover is an early indication of land degradation over a particular area.

5.3. Carbon Stock

Carbon stock is the quantity of carbon stored in a carbon reservoir/carbon pool. Carbon pools are categorized in five different types (above ground biomass, below ground biomass, litter, deadwood/woody debris and soil). Carbon stock and land productivity are closely interconnected components. Carbon stock is considered as degraded, if an area shows decline in productivity, whereas increase in productivity depicts the improvement in carbon stock in that particular area. Carbon stock also reflects the soil health and ecosystem functioning. A systematic approach has been provided by the Intergovernmental Panel on Climate Change to estimate the changes in carbon stock from biomass and dead organic matter. Changes in plant biomass define the changes in carbon stock on seasonal and decadal time scale, whereas changes in soil organic carbon stock are considered as more relevant indicator of ecosystem functioning on longer time scale due to its adaptive capacity and resilience to natural extremities (floods and droughts)[9].

Key role of soil organic carbon in functioning, fertility and productivity of land ecosystem is well recognized. It indicates over all soil health such as soil structure, stability, soil biodiversity,

[8] *https://www.unccd.int/sites/default/files/relevant-links/2017-01/Framework%20and%20Guiding%20Principles%20for%20a%20Land%20Degradation%20Indicator.pdf*

[9] *https://www.unccd.int/sites/default/files/relevant-links/2017-01/Framework%20and%20Guiding%20 Principles%20for%20a%20Land%20Degradation%20Indicator.pdf*

vulnerability to erosion and land productivity. Changes in the land use and land management practices highly influence the soil organic carbon stock and productivity of soil[10].

5.4. Indicators to assess the status of desertification, land degradation and drought

Country Parties adopted the 10-year strategic plan and framework to enhance the implementation of the Convention in COP 8 of UNCCD in 2007 (Decision 3/COP.8) with a vision *"the aim for the future is to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability".* Six indicators were selected to assess the status of desertification, land degradation and drought in affected areas. Normalized Difference Vegetation Index (NDVI), an indicator of greenness of biomes was used for these six indicators (Table 5.1). Several studies (Prince and Goward, 1995, Field *et al.,* 1995) have highlighted the strong relationship between NDVI and Net Primary Productivity. NDVI is used as proxy to measure Net Primary Productivity and assess changes in tree cover in arid and semi-arid ecosystem. NDVI can also be used with high-resolution data to estimate trends in carbon stocks.

Table-5.1:

Use of NDVI for Indicators of UNCCD Ten-year strategic plan and framework (2008–2018)

Objective	Potential use of Normalized Difference Vegetation Index (NDVI)
Strategic objective 1: To improve the living conditions of affected populations	
SO1-1: Trends in population living below the relative poverty line and/or income inequality in affected areas	
SO1-2: Trends in access to safe drinking water in affected areas	NDVI could be combined with the Normalized Difference Water Index to monitor drought, and be linked to water use of land-use systems.
Strategic objective 2: To improve the condition of affected ecosystems	
SO2-1: Trends in land cover	NDVI is the best tested vegetation index with the longest time series for monitoring of land cover trends (33 years).
SO2-2: Trends in land productivity or functioning of the land	The relationship between NDVI and biomass productivity has been well established and NDVI can be used to estimate land productivity and monitor such productivity over a period of time.
Strategic objective 3: To generate global benefits through effective implementation of UNCCD	
SO3-1: Trends in carbon stocks above and below ground	NDVI can be used together with higher resolution data to estimate trends in carbon stocks.
SO3-2: Trends in abundance and distribution of selected species	NDVI can be used to monitor habitat fragmentation and connectivity which are crucial in affecting the abundance and distribution of species.

[10] *https://www.unccd.int/sites/default/files/relevant-links/2017-01/Framework%20and%20Guiding%20Principles%20for%20a%20Land%20Degradation%20Indicator.pdf*

Table-5.2:

Impact Indicators of UNCCD Ten-year strategic plan and framework (2008–2018)

Strategic objective	Indicators
1. To improve the living conditions of affected populations	S-1: Decrease in numbers of people negatively impacted by the process of desertification/ land degradation and drought. S-2: Increase in proportion of households living above the poverty line in affected areas. S-3: Reduction in the proportion of the population below the minimum level of dietary energy consumption in affected areas.
2. To improve the condition of affected ecosystem	S-4: Reduction in the total area affected by desertification/land degradation and drought. S-5: Increase in net primary productivity in affected areas.
3. To generate global benefits through effective implementation of the UNCCD	S-6: Increase in carbon stocks (soil and plant biomass) in affected areas. S-7: Areas of forest, agricultural and aquaculture ecosystem under sustainable management.
4. To mobilize resources to support implementation of the Convention through building effective partnerships between national and international actors	S-8: Increase in the level and diversity of available funding for combating desertification/ land degradation and mitigating the effects of drought. S-9: Development policies and measures address desertification/ land degradation and mitigation of the effects of drought

The guidance document of Commonwealth Scientific and Industrial Research Organizations 'Good Practice Guidance for the assessment and monitoring of SDG indicators 15.3.1' developed in 2017 also highlights the methodology for assessment of land degradation indicators. Principle of land degradation assessment is based on three level estimation method, which is similar to the IPCC guidelines for national greenhouse gas inventories. Following are the three approaches for assessing the land degradation in affected areas:

Tier 1: Earth observation, geospatial information and modelling

Tier 2: Statistics based on estimated data for administrative or natural boundaries

Tier 3: Surveys, assessments and ground measurements

Above guiding principles, assist countries to setup their baseline information regarding land cover, land productivity and carbon stock. Changes in each of the sub indicators such as identification of areas subject to change and their valuation or validation by participatory national inventory of land degradation is detected by countries through said guiding principles. By following these guiding principles, countries can also sum-up all the areas subject to change, whose conditions are considered negative by national authorities while using the monitoring framework to evaluate the changes within each sub-indicator and their combination. With the help of available national data (maps, database, reports, inventories on existing land management systems), these principles can also guide countries to derive the sub- indicators and other relevant information regarding socio-economic conditions and status of land resources[11].

[11] *CI_GEF_Guidance ENG_CI_R1_PRINT (1).pdf.*

A flexible framework of analytical approach developed recently by scientific research can go a long way in enabling the UNCCD country Parties to standardize a flexible use of indicator sets, adapted to specific objectives relevant for implementing the Convention. The progress made in scientific research has helped in understanding the major issues and important causes of dryland degradation. Indicator sets can be selected accordingly from a host of existing and documented indicators. Selection and combination of indicators should be done according to the transparent criteria given by existing indicator frameworks adapted to desertification conceptual frameworks such as the Dryland Development Paradigm and can act as a pragmatic entry point for selecting area and theme-specific sets of indicators from existing databases. In order to delimit and characterize the affected areas beyond national boundaries, the stratification needs to be carried out in a meaningful way by combining existing land use information with additional biophysical and socio-economic data sets. This will allow indicator-based monitoring and assessment to be amalgamated in a framework of specific dryland degradation issues and their impacts on key ecosystem services. There is a wide spectrum of criteria and indicators that can be used for the purpose of monitoring and evaluation of the progress of checking or reversing desertification and land degradation. Use of technologies *viz.* remote sensing, high end analytics, data mining and data warehousing can be used to build a strong framework for carrying out monitoring and evaluating the progress. The key to success is to develop strong references for identified key indicators.

In India, twenty agro-ecological regions of the country are facing different kinds of degradation. Considering the present scenario of land degradation in country, need was felt to consider and develop minimum set of indicators for DLDD at country level also. Thus, a report on Monitoring and Evaluation Framework on DLDD related issues was prepared to finalize the indicators for DLDD and UNCCD country reporting (ICFRE, 2014 b). Universally accepted DPSIR (Driving force, Pressure, State, Impact and Response) approach was followed for the purpose. Later DPSIR framework was modified and provisionally named as DPSheIR (Driving force, Pressure, State, human and environmental Impact Response). DPSheIR evaluates the degree of implementation of Strategic objectives and best policies to deal with DLDD and helps in improving indicators for sharing DLDD related information.

Few additional indicators along with UNCCD's progress indicators were used for the document and national monitoring and evaluation framework was developed under four themes namely, land degradation, biodiversity conservation, climate change and adaptation, and policy and institutional reforms. Theme 'land degradation' also addresses the surface and ground water level as it determines its sectoral uses, cropping pattern and land productivity. For land degradation issue, National level indicators were developed by conducting regional and national level workshops, where emphasis was given to discover as many as possible potential indicators as per the dry land situations of the states/ regions of the country.

Country Parties adopted the UNCCD 2018-2030 Strategic Framework in COP 13 of UNCCD in 2017 (Decision 7/COP 13) with a vision *'A future that avoids, minimize and reverse desertification/ land degradation and mitigates the effect of drought in affected areas at all level- to achieve a land degradation neutral world consistent with the 2030 agenda for sustainable development, within the scope of the convention'.* Following five strategic objectives were set to give direction to all the stakeholders and partners of UNCCD to achieve the mentioned vision during the period 2018-2030:

1. To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality
2. To improve the living conditions of affected populations
3. To mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems
4. To generate global environmental benefits through effective implementation of the convention
5. To mobilize substantial and additional financial and non-financial resources to support the implementation of the Convention by building effective partnerships at global and national level

Indicators used for reporting on progress towards the strategic objectives are those adopted by Parties in decision 7/COP.13, 9/COP.13 and 11/COP.14. In addition to the indicators adopted by the COP, five newly proposed indicators (i.e. SO 2-3, SO 4-3, SO 5-3, SO 5-4 and SO 5-5) are tested during the 2022 reporting process. All newly proposed indicators are considered optional in reporting until the COP takes a decision on whether to formally adopt them.

Table-5.3:

Indicators as per the UNCCD 2018-2030 strategic framework

Indicator code	Indicator name	Metrics / proxies	Adopted/ proposed	Reporting attribution for Affected country Parties
		Strategic objective (SO) 1 indicators and reporting attribution		
SO 1-1	Trends in land cover	Land cover change	Indicator adopted in decision 7/COP.13	X
SO 1-2	Trends in land productivity or functioning of the land	Land productivity dynamics	Indicator adopted in decision 7/COP.13	X
SO 1-3	Trends in carbon stocks above and below ground	Soil organic carbon stock	Indicator adopted in decision 7/COP.13	X
SO 1-4	Proportion of land that is degraded over total land area	—	Background for indicator adopted in decision 9/COP.13	X
		Strategic objective (SO) 2 indicators and reporting attributions		
SO 2-1	Trends in population living below the relative poverty line and/or income inequality in affected areas	Proportion of the population below the international poverty line or Income inequality	Indicator adopted in decision 7/COP.13	X
SO 2-2	Trends in access to safe drinking water in affected areas	Proportion of population using safely managed drinking water services	Indicator adopted in decision 7/COP.13	X

Indicator code	Indicator name	Metrics / proxies	Adopted/ proposed	Reporting attribution for Affected country Parties
SO 2-3	Trends in the proportion of the population exposed to land degradation, disaggregated by sex	Proportion of the population exposed to land degradation, disaggregated by sex	Indicator proposed in response to decision 11/COP.14, which requested the Secretariat to align reporting for SOs 1– 5 with gender-responsive indicators	Optional
		Strategic objective (SO) 3 indicators and reporting attributions		
SO 3-1	Trends in the proportion of land under drought over the total land area	Proportion of land in each drought intensity class as defined by the Standardized Precipitation Index	Indicator adopted in decision 7/COP.14	X
SO 3-2	Trends in the proportion of the total population exposed to drought	Proportion of the population exposed to drought, disaggregated by sex	Indicator adopted in decision 7/COP.14	X
SO 3-3	Trends in the degree of drought vulnerability	Drought Vulnerability Index	Indicator adopted in decision 7/COP.14	X
		Strategic objective (SO) 4 indicators and reporting attributions		
SO 4-1	Trends in carbon stocks above and below ground	Trends in carbon stocks above and below ground is a multipurpose indicator used to measure progress towards both strategic objectives 1 and 4. See progress indicator SO 1-3.		
SO 4-2	Trends in abundance and distribution of selected species	Red List Index	Indicator adopted in decision 7/COP.13	X
SO 4-3	Trends in protected area coverage of important biodiversity areas	Average proportion of Terrestrial Key Biodiversity Areas covered by protected areas	Complementary indicator and corresponding metric proposed in response to CRIC 17 recommendations and decision 7/COP.13.	Optional
		Strategic objective (SO) 5 indicators and reporting attributions		
SO 5-1	Bilateral and multilateral public resources	—	Indicator adopted in decision 7/ COP.13 as 'Trends in international bilateral and multilateral official development assistance'	—

Indicator code	Indicator name	Metrics / proxies	Adopted/ proposed	Reporting attribution for Affected country Parties
SO 5-2	Domestic public resources	—	Indicator adopted in decision 7/COP.13 as 'Trends in domestic public resources'	X
SO 5-3	International and domestic private resources	—	Indicators proposed in response to decision 11/COP.14, which requested the Global Mechanism to include additional quantitative data in the reporting template for SO 5 and provide information before the start of the next reporting process on the possible development of progress indicators on technology transfer under SO 5	Optional

Source: UNCCD, 2017[12]

Although identified true progress indicators are imperative to monitor and evaluate the progress made to address the DLDD issues at national, regional and international level, but role of data analytics and sampling strategies can also not be overlooked as they also play a major role in the monitoring process. With advanced computational facilities and availability of high-resolution remote sensing images/ data, measurements on indicators have become relatively easy and less time consuming. Backed with adequate expertise in data mining, it is possible to foresee the risks and take appropriate mitigation measures apart from judging the projects and programmes being implemented for combating desertification, land degradation and drought.

[12] *https://www.unccd.int/sites/default/files/inline-files/ICCD_COP%2813%29_L.18-1716078E_0.pdf*

06
Chapter

Government Initiatives to Combat Desertification, Land Degradation and Drought

In India, various schemes and programmes have been launched at National level for addressing the issue of desertification, land degradation and drought (DLDD). Some of the key schemes and programmes for addressing DLDD are Desert Development Programme, Integrated Watershed Management Programme, National Afforestation Programme, National Mission for a Green India, Mahatma Gandhi National Rural Employment Guarantee Scheme, Soil Conservation Programme for Enhancing the Productivity of Degraded Land, Fodder and Feed Development Scheme for Grassland Development, etc.

Some important policies and acts such as National Land Use Policy Outline 1986, National Agriculture Policy 2000, National Forest Policy 1988, National Population Policy 2000, National Environment Policy 2006, National Water Policy 2012, National Agroforestry Policy 2014, National Biofuel Policy of 2018, National Mineral Policy of 2019, Indian Forest Act of 1927, Wildlife Protection Act of 1972, Water (Prevention and Control of Pollution) Act 1974, Forest (Conservation) Act 1980, Air (Prevention and Control of Pollution) Act 1981, Environment Protection Act 1986, Biodiversity Act of 2002, and Compensatory Afforestation Fund Act of 2016 etc. were also formulated and enacted for protection and conservation of environment and sustainable management of natural resources. Natural resources such as land, water, forests, biodiversity, agriculture etc. are treated differently under the Seventh Schedule of the Constitution of India. Land, water, and agriculture are on the State list. Forest come under the Concurrent List, and Union and states having jurisdictions on the subjects.

Ministries such as Ministry of Rural Development, Ministry of Agriculture and Farmers' Welfare, and Ministry of Environment, Forest and Climate Change, and Ministry of Jal Shakti play key role in implementing the various schemes and programmes for combating DLDD. Ministry of Rural Development has formed Department of Land Resources to coordinate between different land resource development and management programmes, whereas National Wasteland Development Board of Ministry of Rural Development was formed to deal with the wasteland related issues. Ministry of Environment, Forest and Climate Change has formed National Afforestation and Eco-development Board to look at the forest land related matters.

Different approaches for sustainable land management have been adopted in India over a period of time which are highlighted as under:

1. Watershed Development Approach: Watershed development refers to the conservation, regeneration and judicious use of all natural resources (land, water, flora and fauna) within the watershed area. Watershed management includes a 'Ridge to Valley Approach' for land treatments i.e. initiating land treatments from the upper reaches having a higher slope and then treating the lower areas subsequently. The treatments reduce speed of surface runoff and soil erosion and help in augmenting ground water. Watershed approach addresses the issue of land degradation in wastelands, forests and agricultural lands. The watershed plus approach adds livelihoods, integrated agriculture, horticulture and animal husbandry in addition to soil and water conservation.

Since 1970, watershed development programmes in India are instrumental in improving the productivity of rainfed areas (which represent almost 65% of cultivable area and 55% of agricultural production) and degraded areas (that experienced severe degradation due to loss in forest cover and unsustainable agricultural and livestock practices). Over the years, the approaches in watershed development programmes have evolved from top–down, thematic and technically oriented to ecosystem based, participatory and holistic in nature.

In the 1990s and 2000s, various bilateral programmes, like the Indo German Watershed Development Programme (IGWDP), Indo Swiss Participatory Watershed Development Programme and DANIDA watershed projects involved NGOs in implementation of the programme. These programmes pilot tested many innovative concepts and methodologies in participatory watershed development. Between 2000 and 2010, financial outlays for watershed projects were enhanced. In addition to Central Government Ministries, National Bank for Agriculture and Rural Development (NABARD) also started investing in watershed development projects. Panchayati Raj Institutions were given central space in the implementation of the watershed programmes. The role of women and Self-Help Groups were emphasized in implementation of the watershed programmes. Convergence with existing Government Programmes was also emphasized to bring holistic development in the programme area. The use of remote sensing and GIS for watershed planning and monitoring was also emphasized for monitoring. The Integration of Watershed Management Programmes was initiated in 2008 by merging the Integrated Watershed Development Project (IWDP), Desert Development Project (DDP) and Drought Prone Area Programme (DPAP) programmes. Since 2015, the Integrated Watershed Management Programme has been subsumed as one of the components of Pradhan Mantri Krishi Sinchai Yojna. The institutional developments with respect to the key departments anchoring the watershed projects on a large scale have also changed over time as tabulated below:

Table-6.1:

Evolution of watershed programme in India

Year	Program/Policy/ Guideline	Major objective(s)	Relevant institution
1973–74	Drought Prone Area Programme (DPAP)	• Minimise adverse effects of drought on crop production and livestock and productivity of land, water and human resources ultimately leading to drought proofing of affected areas.	MoRD
1977–78	Desert Development Programme (DDP)	• Minimise adverse effect of drought and control desertification through rejuvenation of natural resource base of identified desert areas. • Achieve ecological balance in the long run.	MoRD
1989–90	Integrated Wasteland Development Programme (IWDP)	• Wastelands development in non-forest areas for checking land degradation. • Putting wastelands to sustainable use & increasing bio-mass availability especially that of fuelwood, fodder, fruits, fibre and small timber.	MoRD

Year	Program/Policy/ Guideline	Major objective(s)	Relevant institution
1990–91	National Watershed Development Project for Rainfed Areas (NWDPRA)	• Conservation, development and sustainable management of natural resources. • Enhancement of agricultural production and productivity in a sustainable manner. • Reduction in regional disparity between irrigated and rainfed areas. • Creation of sustained employment opportunities for the rural community including the landless.	MoA
1994	Hanumantha Rao Committee, 1994 (Guidelines for Watershed Development)	• Provide common guidelines for watershed development. • Focused on participatory approaches. • Brought DDP, DPAP and IWDP under a single umbrella. • Sought to leverage the success of NGOs.	MoRD
1999–2000	Watershed Development Fund	• Fund set up in 1999-2000 to replicate watershed activities in drought prone areas across the country. • Contribution of Rs. 1000 million each by Ministry of Agriculture, Govt. of India and NABARD. • Watershed Development projects in 100 priority districts.	MoA and NABARD
2001	Common Guidelines for Watershed Development	• 1994 guidelines were updated to adopt a more project-specific focus with greater flexibility in implementation. • Guidelines were applicable across watershed programmes-IWDP, DPAP, DDP, and other programs notified by Govt. of India. • Well-defined role for State, District and Village level Institutions • Combination of Govt. of India /NGO as Project Implementing Agency, role of women • Exit Protocol created for watershed projects • SHGs integrated with Watershed programmes • Effective use of remote sensing data furnished by NRSA	MoRD
2003	Hariyali Guidelines	• District and Gram Panchayats involved more actively in the Implementation of watershed project. • Community institutions were more meaningfully integrated in watershed projects, role for NGOs as Project Implementing Agency. • Convergence with other Government programmes for holistic development of programme areas.	MoRD
2006	Parthasarathy Committee Report (committee to evaluate DPAP, DDP and IWDP)	• Highlighted the need to improve productivity of dryland farming to contribute to food security targets. • Recommended a greater focus on watershed development programmes to increase productivity of lands in rain-fed areas to address food security.	MoRD

Year	Program/Policy/ Guideline	Major objective(s)	Relevant institution
		• Based on the report, DPAP, DDP and IWDP were integrated and consolidated into a single modified programme called Integrated Watershed Management Programme (IWMP) and launched in 2009-10.	
2006	National Rainfed Area Authority (NRAA)	• NRAA set up in 2006 with a mandate inter alia including: • Prepare perspective plan, outline National strategy and road map for holistic and sustainable development of rainfed farming areas. • Evolves common guidelines for all schemes of different Ministries including externally aided project for development of rainfed/ dry land farming systems. • Coordinate and bring convergence within and among agricultural and wasteland development programmes being implemented in rainfed areas of the country. • Evaluate the effectiveness of completed watersheds and concurrent evaluation of on-going programmes.	Planning Commission
2008	Common Guidelines for Watershed Development (revised in 2011)	• Provided a fresh framework to guide all WSD projects in all departments and ministries. • Delegating Powers to States to sanction and oversee implementation of watershed projects within their areas of jurisdiction. • Provisioned for dedicated Institutions for implementing agencies with multi-disciplinary professional teams at the National, state and District level. • Duration of the watershed programme enhanced in the range of 4 to 7 years depending upon nature of activities being undertaken. • Livelihood orientation given priority along with conservation measures. • Cluster approach of treating geo-hydrological units of average size of 1,000 to 5,000 hectares • Emphasis on scientific planning emphasized and use of technology	NRAA and Planning Commission
2009	Integrated Watershed Management Programme (IWMP)	• IWMP initiated by merging DPAP, DDP and IWDP. • These followed the Common Guidelines for Watershed Development, 2008.	MoRD
2015	Pradhan Mantri Krishi Sinchai Yojna (PMKSY)	• Scheme formulated to increase irrigation coverage and improve water use efficiency with end to end solution on source creation, distribution, management, field application and extension activities. • IWMP subsumed as one of the Components of PMKSY. • Landscape level approach through District Irrigation Plans (DIP).	DoLR

Year	Program/Policy/ Guideline	Major objective(s)	Relevant institution
2017-2022	World Bank Funded National Watershed Project	• Technical assistance project for supporting watersheds. • Use of technology. • Upscaling learnings. • Strengthening of delivery institutions.	DoLR

2. Landscape Based Approach: According to the Millennium Ecosystem Assessment 2015, landscape is "*an area of land that contains a mosaic of ecosystems, including human-dominated ecosystems*". FAO defines the landscape approach as "*dealing with large-scale processes in an integrated and multidisciplinary manner, combining natural resources management with environmental and livelihood considerations*" (MEA, 2015).

The landscape-based approach has been used in India traditionally for protected area management. However, in recent times, the approach is being used in bilateral forestry programmes. Being a recent concept, learning from landscape management projects require further experimentation to get integrated in the National policies. Landscape approach is also the cornerstone for the Green India Mission.

3. Ecosystem Based Approach: An ecosystem is defined by the Convention on Biological Diversity (CBD) as "*a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit*". Ecosystems are size and scale agnostic. The scale of analysis and action is determined by the context specific issues and challenges. The Convention on Biological Diversity (CBD) defines the ecosystem approach as "*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*".

Ecosystem approaches are highly context specific and there is no blueprint approach to implementing an ecosystem approach. However, this approach follows the following principles as defined by CBD[13]:

- *The objectives of management of land, water and living resources are a matter of societal choice.*
- *Management should be decentralized to the lowest appropriate level.*
- *Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.*
- *Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.*
- *Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.*
- *Ecosystems must be managed within the limits of their functioning.*
- *The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.*
- *Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.*

[13] *https://www.cbd.int/ecosystem/principles.shtml*

- *Management must recognize that change is inevitable.*
- *The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.*
- *The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.*
- *The ecosystem approach should involve all relevant sectors of society and scientific disciplines.*

In India, number of programmes, schemes and projects are being implemented for addressing the issue of desertification, and degradation and drought. Some of the key programmes, schemes and projects implemented for addressing desertification, land degradation and drought are highlighted below:

6.1. Soil Conservation for Enhancing the Productivity of Degraded Lands in the Catchments of River Valley Projects and Flood Prone Rivers

This centrally sponsored programme was launched in third five-year plan (1961-62) and implemented by the Ministry of Agriculture and Farmers Welfare since November 2000 of IX Five Year Plan. This programme was implemented through macro management of agriculture scheme with the aims to improve the physical conditions and productivity status of alkali soils for restoring optimum crop production. Major objectives of this programme were:

- Prevention of land degradation by adoption of a multi– disciplinary integrated approach of soil conservation and watershed management in catchment areas
- Improvement of land capability and moisture regime in the watersheds
- Promotion of land use to match land capability
- Prevention of soil loss from the catchments to reduce siltation of multipurpose reservoirs and enhance the in-situ moisture conservation and surface rainwater storages in the catchments to reduce flood peaks and volume of runoff

Under this programme 60 inter-state catchment areas were selected. All India Soil and Land Use Survey (AISLUS) had surveyed these catchments and categorized them in five categories i.e. Very high, high, medium, low, very low by using silt yield index methodology. Catchments fallen under high and very high watersheds were taken for the treatment under this programme. Various treatments (horticulture plantation, contour/ stagger trenching, bunding, afforestation, pasture development, silvi-pasture development, farm ponds, drainage line treatments etc.) were given to all type of lands either agriculture, waste land or forest land. By March 2013, about 7.9 Mha land was treated under this programme. About 80 % fund for the programme was provided by state government and rest 20% was made available through loan. The funding for this programme was discontinued w.e.f. April 2013[14].

6.2. Drought Prone Areas Programme

Drought Prone Areas Programme (DPAP) was launched in 1973-74 by Government of India for the areas facing frequent droughts. Over population of human and cattle in these areas puts

[14] *http://agricoop.nic.in/sites/default/files/BRIEF_WDP_0.pdf*

high pressure on already degraded natural resources. Thus, the affected areas face multiple environmental problems such as depletion in vegetation cover, soil erosion, water scarcity and struggle for livelihood opportunities. DPAP was thus launched with the major objective to minimize the adverse effect of drought on productivity of land, water, livestock and human resources, thereby leading to drought proofing of affected areas[15]. It was the first major programme which was focused on soil and moisture conservation in drought prone areas. As per the recommendations of Hanumantha Rao Committee (1994), comprehensive guidelines for watershed development applicable to DPAP were issued in 1994 and implemented from 1st April 1995. Participation of local communities since planning to maintenance of watershed was ensured as per the watershed development guidelines.

DPAP aimed at the overall economic development of the marginalized poor section of the target areas through equitable distribution of available resources and widening the employment opportunities for them. It followed the approach to promote developmental activities such as water resource development, afforestation, pasture development activities, in the target area so that pressure for basic need on resources can be minimized. Sixteen states such as Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal with 972 blocks of 183 districts were covered under DPAP which covers an area of 74.6 Mha. Until 1994-95, 5.71 Mha of drought areas were treated. So far, total 24363 watershed development projects covering 12.18 Mha of drought prone area were undertaken[16].

6.3. Desert Development Programme

Desert Development Programme (DDP) was launched by Government of India in 1995 to minimize the adverse effects of drought and to rejuvenate the natural resource base of the desert areas of Rajasthan, Gujarat, Haryana and cold desert areas of Jammu & Kashmir, Ladakh and Himachal Pradesh. The basic objective of the programme was to minimize the adverse effect of drought and control desertification through rejuvenation of natural resource base of the desert areas[17]. Emphasis was also given to restoration of ecological balance by conserving, developing and harnessing the available natural resources such as land, water, livestock, human resource and vegetation cover[18]. Programme has aimed to arrest the formation of deserts through shelter belt plantation[19] and to promote overall economic development and socio-economic conditions of the resource poor and disadvantaged sections residing in the deserts[20]. Initially DDP was implemented in 131 blocks of 21 districts in 5 states. Later on, 32 new blocks were added and 64 were transferred from DPAP. With reorganization of districts and blocks, DDP covers 235 blocks of 40 districts in 7 states. The total area covered under the programme was about 47 Mha. Earlier 100% funding was done by the Government of India for hot arid sandy areas and cold arid areas, whereas for hot

[15] *https://dolr.gov.in/drought-prone-areas-programme-dpap*

[16] *https://dolr.gov.in/drought-prone-areas-programme-dpap*

[17] *https://dolr.gov.in/desert-development-programme-ddp#:~:text=The%20basic%20object%20of%20the,balance%20in%20the%20long%20run*

[18] *http://iced.cag.gov.in/wp-content/uploads/2014/02/6.-PA-of-Desert-Development-Prog.-Haryana.pdf*

[19] *https://pib.gov.in/newsite/PrintRelease.aspx?relid=86789*

[20] *https://dolr.gov.in/desert-development-programme-ddp*

arid non-sandy areas 75% funding was given by Government of India. After 31st March 1999 this share was divided into 75:25 between Government of India and state government, respectively. As per the Department of Land Resources, 13476 projects were sanctioned under DDP from 1995-96 to 2005-06 to treat the 6.74 Mha arid areas. Total 3.53 Mha land was treated from 1995-96 to 2005-06[21].

6.4. Command Area Development and Water Management Programme

After independence major target of the government was to increase the agriculture production to fulfill the food requirement of its citizen. In order to achieve this target, various irrigation projects were launched in the country and it was realized that there is significant gap between the irrigation potential created and utilized. Thus, Irrigation Commission in 1972 recommended the systematic development of command areas of irrigation projects to fully utilize the irrigation potential created. In this context, Government of India has initiated Command Area Development Programme (CADP) in 1974-75 to enhance utilization of irrigation potential created and improve the agricultural productivity and production through efficient water management. Under the CADP various activities such as construction of field channels, drains, land levelling, shaping, consolidation of land holdings, realignment of field boundaries, introduction of suitable cropping patterns, farmers participation, reclamation of waterlogged area etc. were undertaken. During the review in VIII and IX Five Year Plan, few loop holes such as unreliability of water supply at the outlet, absence of links and intermediate drains to let out surplus water into main drains, non-inclusion of minor irrigation projects from non-hilly areas, lack of proper training and extension activities etc. were identified. By keeping above constraints in view and to make the programme more farmer friendly and comprehensive, CAD Programme was restructured and renamed as Command Area Development and Water Management Programme (CADWMP) in 2004 [22].

6.5. Integrated Wasteland Development Programme

Unsustainable land use practices and increasing biotic pressure have put the high pressure on productive land, especially on the farmland and converted them into wasteland. In India wastelands cover an area of 68.35 Mha, of which 50% area falls under non-forest lands. Seeing the crucial role of non-forest wasteland in ecological balance and extent of degradation of these land areas, National Wasteland Development Board (NWDB) was formed under Ministry of Environment and Forests to address the issue of land degradation, restoration of ecology and to fulfil the fuel wood and fodder requirement at national level. As NWDB had given priority to tree plantation than people's participation, thus in 1992, Board was reconstituted, and major responsibility was assigned to develop wasteland in non-forest areas by involvement of local community at every stage.

Keeping poverty, backwardness, gender equity in view, NWDB had implemented Integrated Wasteland Development Programme (IWDP) for improving the productivity of degraded wastelands. This programme was under implementation since 1989-90 and for its implementation watershed development approach was adopted like other area development programmes. Under

[21] *https://dolr.gov.in/desert-development-programme-ddp*

[22] *http://mowr.gov.in/programmes/cadwm-programme-background*

the programme entire micro watershed was taken up for the development rather than taking sporadic patches with the major objective village/micro watershed plans based integrated wasteland development. Prime importance was given to people's participation in every stage of the programme with the approach of equitable and sustainable sharing of benefits arising from the projects. People's participation at all stages during the implementation of IWDP had opened up the horizons of rural employment. Various activities were taken up during the implementation of IWDP which includes soil and moisture conservation measures, promoting agro-forestry and horticulture, developing small water harvesting structures, encouraging natural regeneration and afforestation activities in wasteland areas, pasture development, capacity building and people's participation, development and conservation of common property resources, dissemination of technology as decided by user groups living in and around the project area. During implementation of IWDP, prime focus was given to community mobilization and their active participation, which is considered as crucial to restore the ecological balance in degraded watersheds. This kind of approach not only helps in addressing the issues of land degradation but also improves the land productivity and availability of fuel wood and fodder. Besides, IWDP had also increased water table, reduced migration rate and improved the economic status of local inhabitants residing in and around the project areas.

6.6. National Watershed Development Project for Rainfed Areas

National Watershed Development Project for Rainfed Areas (NWDPRA) was launched by Ministry of Agriculture in 1990-91 for the benefit of farmers living below poverty line. NWDPRA objectives were to improve the agricultural production in rainfed areas and to restore ecological balance. It was aimed at treatment of arable lands and mainly focused on crop production components. In 1992-93, it was redesigned to focus on development of micro watersheds, promotion of *in-situ* conservation on arable lands and development of multi-tier vegetation. The scheme of NWDPRA was launched with the twin concepts of integrated watershed management and sustainable farming systems. The scheme of NWDPRA was subsumed under the Scheme for Macro Management of Agriculture from 2000-2001.

At present, this scheme is being implemented as a programme of Centrally Sponsored Scheme of Macro Management of Agriculture in 28 States and 2 Union Territories. The Scheme is presently being implemented on the basis of Common Guidelines for Watershed Development Projects issued by National Rainfed Area Authority. The main objectives of the scheme are as under:

- Conservation, development and sustainable management of natural resources
- Enhancement of agricultural production and productivity in a sustainable manner
- Restoration of ecological balance in the degraded and fragile rainfed ecosystems by greening these areas through appropriate mix of trees, shrubs and grasses
- Reduction in regional disparity between irrigated and rainfed areas
- Creation of sustained employment opportunities for the rural community including the landless.

NWDPRA was restructured on the basis of strength and success of earlier community-based projects. The selection criteria of micro-watershed under this programme were carried out in an objective manner using various scientific parameters such as extent of rainfed farming, economic status of cultivators, scope of integrated development in particular area and willingness

of villagers for improvement of degraded non-potential land, no earlier investment on selected micro-watershed and bird's eye view of the selected area. The focus was given to simple and low-cost technologies for the treatment of selected areas so that the community can understand the technique and replicate in other areas. Community participation in planning, implementation, operation and maintenance of the project was encouraged through various awareness programmes. Trainings were imparted phase-wise to promote the scientists-farmers interaction and active participation of local villagers[23].

NWDPRA follows the funding pattern of MMA (Macro Management of Agriculture) i.e. 90:10 of central and state government while for north-eastern states, it is 100%. Due to closure of MMA schemes, the funding to NWDPRA was discontinued w.e.f. April 2013. The progress made under NWDPRA since its inception to March 2013 was the development of about 11 Mha rainfed areas[24].

6.7. Watershed Development Projects for Shifting Cultivation Areas

The scheme for watershed development in shifting cultivation areas was launched during 1987-1988 covering all seven states of the north-eastern region and in the states of Andhra Pradesh and Odisha with 100% central assistance. The scheme targeted about 25,000 families practicing shifting cultivation and focused on soil conservation and watershed management in shifting cultivation areas.

6.8. Integrated Watershed Management Programme

The Integrated Watershed Management Programme (IWMP) is the one of the key programmes of Ministry of Rural Development which was implemented by Department of Land Resources in 2009-10. It was launched with the motive to bring various land restoration programme such as Integrated Wastelands Development Programme (IWDP), Desert Development Programme (DDP) and Drought Prone Areas Programme (DPAP) under one umbrella. It is the foremost initiative of Government of India to address the challenges facing rainfed areas in general and wastelands in particular. IWDP follows 'Ridge to Valley' approach for the treatment of the area[25].

Restoration of ecological balance through harnessing, conserving and developing degraded natural resources with the creation of rural employment are the main objectives of IWMP. It predicts that land restoration efforts will prevent the soil erosion, regenerate the vegetative cover, recharge the ground water table and improve the quality of life through enhanced livelihood opportunities. The programme resulted in notable and significant achievements. States of Gujarat, Madhya Pradesh and Rajasthan showed a marked improvement in resources due to this programme. Maximum reduction in soil erosion was seen in Uttar Pradesh, Tamil Nadu and Gujarat due to the measures like constructing check dams, gully plugs, contour bunds and afforestation taken for preventing soil erosion. Ground water level also increased in Gujarat, Maharashtra, Rajasthan, Tamil Nadu, Madhya Pradesh, Karnataka, Himachal Pradesh, and Nagaland. Also, increase in

[23] *http://agriculturemizoram.nic.in/nwdpra.html*

[24] *http://agricoop.nic.in/sites/default/files/BRIEF_WDP_0.pdf*

[25] *https://dolr.gov.in/sites/default/files/Changing%20Rural%20Life%20through%20Watershed%20 Development%20-%20IWMP%20-%20Compressed.pdf*

surface water level and stream flow has been seen, especially in Tamil Nadu and Rajasthan. In Tamil Nadu, 73% of the watersheds reported increase in surface water by 20-40%, while 27% reported an increase below 20%. In stream water flow, the state showed a 5-10% increase in 40% of the watersheds, while 40% reported an increase between 5-10%. In Rajasthan, 46% of the watersheds reported increase of 20-40% in water level and 49% reported an increase of 20% and 5% reported no increase. Likewise, 53% of the watersheds reported 5-10 % increase in stream water flow. In most of the project areas there was a reduction in water runoff due to contour or field bunding. Significant improvement was reported from most of the project areas in crop diversification, cropping intensity, change in land use pattern and agricultural productivity. Better crop selection backed with better quality of seeds and soil management, crop rotation and intensification helped in adding more areas for cultivation and helped in supplementing incomes for economically weaker sections of the community. The project resulted in an increase in local employment for marginalized communities which further resulted in reduced migration to other areas for employment. With higher income generated through direct and indirect involvement in the project, people were able to self-sustain themselves to a greater extent by living off the benefits accrued from higher output in agriculture, livestock and related activities.

IWMP is implemented in the state through State Level Nodal Agencies, where centre and state share of budget for the programme was 90:10. Of the total treatment requiring area i.e. 116 Mha, 85 Mha comprises rainfed portion of net cultivated area and 31 Mha. comprises cultivable wasteland. By end of the year 2014-15, 8214 projects covering an area of 39.07 Mha were sanctioned under IWMP[26]. The IWMP has now been brought under the Pradhan Mantri Krishi Sinchayi Yojana which is managed by the Ministry of Agriculture and Farmers Welfare.

6.9. National Afforestation Programme

Forests are the major target of developmental activities, which has degraded forests in an uncontrolled way. The alarming situation raised in terms of climate change, biodiversity loss, soil erosion, shifting of timber line, change in flowering pattern of few plant species etc. has made us realize the urgent need of actions to address the issue of forest degradation. In this line of thought, Ministry of Environment, Forest and Climate Change' has launched National Afforestation Programme (NAP) in 2000-02 as a centrally sponsored scheme of the Government of India. It is a flagship programme of Ministry of Environment, Forest and Climate Change, which was being implemented by the National Afforestation and Eco-Development Board for the afforestation of degraded forest lands.

NAP is basically the merger of four centrally sponsored afforestation schemes named as Integrated Afforestation and Eco-development Project Scheme, Area Oriented Fuel wood and Fodder Project Scheme, Conservation of Non-timber Forest Produce including Medicinal Plants, and Association of Schedule Tribe and Rural Poor in Regeneration of Degraded Forests[27]. Under NAP, species to be planted were selected according to the requirements of the participating communities, ecological conditions of the area to be afforested, and other local factors. The

[26] *https://dolr.gov.in/sites/default/files/Changing%20Rural%20Life%20through%20Watershed%20Development%20-%20IWMP%20-%20Compressed.pdf*

[27] *http://moef.gov.in/wp-content/uploads/2017/08/unccd-report_0.pdf*

strategies involved were afforestation through artificial and natural regeneration, protection of forests and their management. The overall objective of the National Afforestation Programme was ecological restoration of degraded forests and to develop the forest resources with people's participation, with focus on improvement in livelihoods of the forest-fringe communities, especially the poor. NAP aims to support and accelerate the on-going process of involving forest conservation, protection, management and development functions to the Joint Forest Management Committees at the village level. The major components of this programme includes afforestation under seven plantation models, maintenance of previous years' plantations and Ancillary Activities like soil and moisture conservation activities, fencing, overheads, monitoring and evaluation, micro-planning, awareness raising, entry point activities etc. Fund sharing pattern of the programme is 60:40 percent between Centre and States, whereas for north-eastern states and hilly states this share is 90: 10. NAP is implemented by three-tier institutional set up i.e. State Forest Development Agency at state level; Forest Development Agency at forest division level and Joint Forest Management Committees at village level[28].

6.10. National Mission for a Green India

The Ministry of Environment, Forest and Climate Change launched the National Mission for a Green India as one of the eight Missions under the National Action Plan on Climate Change in 2014. It aims at protecting, restoring and enhancing India's forest and tree cover and responding to climate change through a combination of adaptation and mitigation measures which would help in enhancing carbon sinks in sustainably managed forests and other ecosystems, and adaptation of vulnerable species and improvement of livelihood opportunities for forest-dependent communities. The Mission was started with the objective to increase forest/tree cover on 5 Mha of forest/non-forest lands and improved quality of forest cover on another 5 Mha land area. The mission also targeted improvement of ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 mha, enhanced annual carbon sequestration by 50 to 60 million tonnes in the year 2020, and increased forest-based livelihood income of about 3 million households (MoEFCC, 2021). The Mission's interventions were started in the year 2015-16 with the collaborative effort of Central and the State governments.

The National Mission for a Green India follows landscape specific eco-restoration interventions to deliver qualitative improvement of the degraded forest areas and to reinforce improvement of forest and tree cover on forest and non-forest areas guided by the relative vulnerabilities. Based on the Principle of Additionality, the Mission focuses its interventions to enhance reclamation and restoration process in the degraded land where the Mission interventions can generate offsets. The revised approach of Green India Mission (GIM) emphasizes on reclamation/ restoration forestry, best practices of nature based solutions, synergies with the relevant ongoing afforestation schemes, and skill enhancement of the forest dependent communities and diversification of livelihood income.

As per the Mission Document 2021 of GIM, activities of the Mission would be further implemented for the period of 10 years (2021-30) for achieving the NDC target of forest sector with the following objectives:

[28] *https://pib.gov.in/Pressreleaseshare.aspx?PRID=1596332*

- Improved quality of forest cover and increased forest and tree cover on forest/non-forest lands
- Improved ecosystem services including biodiversity, hydrological services and carbon sequestration
- Increased forest-based livelihoods and household income of forest dependent communities living in and around the forests.
- Creation of an additional carbon sink of 2.5 to 3.0 billion tonnes of CO_2 equivalent by 2030.

6.11. Mahatma Gandhi National Rural Employment Guarantee Scheme

Restoration of degraded land is not possible until enough human resource is available to implement the selective measures to arrest land degradation. To provide the enough human resource for land restoration related activities, Ministry of Rural Development (MoRD) has come forward and included these activities under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) that focuses on efficient use of resources through inter-sectoral approach for improvement of livelihoods through horticulture, sericulture, raising plantations and farm forestry etc. It operates under the Mahatma Gandhi National Rural Employment Guarantee Act 2005 and it is the world's largest social welfare programme which covers all districts of India. The scheme also partners works that are important for combating desertification and land degradation. Two-thirds of works under MGNREGS are related to agriculture, with a focus on land water and trees- MGNREGS which has strengthened the livelihood resource base of the rural poor and has also established their ownership and control over natural resources.

6.12. Fodder and Feed Development Scheme-component of Grassland Development including Grass Reserves

Besides developmental activities, over grazing has also adversely affected the forests as well as pastures. Thus, it was realized to take necessary steps to address this problem. In this regard Ministry of Fisheries, Animal Husbandry and Dairying in 1987, launched Fodder and Feed Development Scheme, which was modified twice, once in 2005 and then in 2010. With the aim to improve degraded grasslands and vegetation cover of problematic soils like saline, acidic and heavy. This scheme also assists states for development of feed and fodder. Salient features of the scheme are to:

- Promote conservation of fodder by converting crop residues into fodder blocks through use of modern technologies, bailing machines etc.
- Develop grassland including grass reserves, improvement of degraded grassland, wasteland, rehabilitation of problematic soils (saline, acidic and heavy soils), reseeding of grasslands and encourage the farmers to take up perennial fodder cultivation.
- Promote cultivation of superior variety of fodder for fodder seed (breeder, foundation and certified seed) production by creating assured market.
- Quality testing of manufactured feed and feed ingredients to promote production and supply of quality feed.
- Reduce wastage by encouraging chopping of fodder to promote better utilization.

- Establish silage-making units to preserve surplus fodder for feeding during lean periods.
- Encourage cultivation of Azolla as an alternate green for livestock feeding.
- Production of by-pass proteins for feeding high yielding dairy animals to make better use of available high-quality meals and improve feed efficiency.
- Production and promotion of area specific mineral mixture for livestock feeding to meet specific deficiency of macro and micro- minerals.
- Reduce the gap between demand and supply of feed and fodder through enhancement of production and efficient utilization of available resources.

Scheme got 100% fund from the Government of India for grassland development including grass reserves, establishment of silage making units etc.[29]

6.13. Reclamation and Development of Alkaline and Acid Soils

The Reclamation and Development of Alkaline and Acid Soil Scheme was launched during the 7th Five Year Plan and are continuing in the states of Haryana, Punjab and Uttar Pradesh. It aims to improve physical conditions and productivity status of alkaline soils in order to ensure crop production. The major components include provision of irrigation and farm development like land levelling, bunding and deep ploughing, community drainage systems, application of soil amendments and organic manure.

6.14. Projects for Addressing Desertification, Land Degradation and Drought

Besides various policies and programmes, various projects were also implemented for addressing the land degradation related issues. Some of the major projects are highlighted as under:

Indira Gandhi Nahar Pariyojna (IGNP): IGNP previously known as Rajasthan Canal Project is world's largest canal irrigation system of desert areas, which sets best example of drought proofing of dessert areas of Rajasthan where oddness of nature prevails. Aravali hills divide Rajasthan in to two parts i.e. Eastern Rajasthan and Western Rajasthan. Western Rajasthan is devoid of vegetation thus faces severe odd environmental conditions mainly drought. Being more vulnerable to drought and tough climatic conditions, maximum irrigation programmes were made for Western Rajasthan. Thus, IGNP was also launched to irrigate the desert land of Western Rajasthan with Himalaya's water and provide drinking water supply to residing population of the area. Major objective of IGNP was to utilize 9.36 billion m^3 of water annually for the irrigation of 1.87 Mha of arid land of Thar desert of India. IGNP has also aimed to provide land and livelihood opportunities to inhabitants of the area, thus 6.25 ha land was allotted to each household. It also aimed to uplift the social, economic and environmental conditions of the region[30].

Scheme for Reclamation of Alkali Soils: Some of the major attributes of alkali soil such as high pH, high exchangeable sodium, low organic carbon, abundance of carbonates and bicarbonates of sodium, calcium and magnesium makes the soil hard and this kind of soil reduces infiltration, water logging after rainfall, thus resulting reduced water availability to plants, poor seed

[29] *http://dadf.gov.in/sites/default/filess/Fodder-Feed%20Guidelines%20%20%2010_0.pdf*
[30] *http://hydrologie.org/redbooks/a268/iahs_268_0049.pdf*

emergence, poor root development, poor drainage and finally lead to soil degradation. As 6.73 Mha land in India is salt affected, of which 3.77 Mha area is having alkaline soil, which is the biggest threat to farming community. About 11 states of India are having alkaline soil and Uttar Pradesh shares largest part i.e. 35.75% of it followed by Gujarat (14.36%), Maharashtra (11.21%), Tamil Nadu (9.41%), Haryana (4.86%) and Punjab (4.02%). About 80% of total alkali land of country falls in mentioned six states[31].

If unsustainable agriculture practices continue for long, soil loses it productivity and turn barren over of time. Being an important commodity, it becomes crucial to take effective measures to regain soil health for future production. In such case reclamation of soil could address the problem of soil alkalinity. Thus, Government of India has launched a scheme of Reclamation of Alkali Soil in its 7th Five Year Plan with the aim to improve physical health and productivity of alkali soil for restoring optimum crop production. Scheme was first taken up in major agriculture producing states *viz.* Punjab, Haryana and Uttar Pradesh. In 8th Five Year Plan it was extended to states *viz.* Rajasthan, Gujarat and Madhya Pradesh and in 9th Five Year Plan it was extended to other states facing similar issue. The major component focused under this scheme were:

- To ensure the irrigation water for farm development activities
- Developing community drainage system
- Application of soil reclaiming organic manure

By the year 2005-06, 0.69 Mha alkali land out of 3.5 Mha was reclaimed and presently this scheme was subsumed within the Macro Management Scheme of Government[32].

Sustainable Land and Ecosystem Management - Country Partnership Programme: In India, an emphasis on poverty alleviation through enhanced productivity of dry as well irrigated ecosystems requires apt conservation measures for sustainable production. The genesis of SLEM was rooted in the rationale that food security through enhanced agricultural productivity cannot be achieved by further increasing the cultivated area. Sustainable and integrated management of the natural resources is vital to meet the challenges of land degradation and desertification, and to sustain the flow of ecosystem goods and services.

Keeping above approach in mind, SLEM-Country Partnership Programme (SLEM-CPP) was initiated in 2008 through the World Bank/GEF funded project on "*Policy and Institutional Reform for Mainstreaming and Up-scaling Sustainable Land and Ecosystem Management in India*", with the objective '*to enhance the institutional and policy framework for harmonization, coordination and monitoring of land based interventions and develop natural resource management strategies that promote sustainable land management and enhance agricultural productivity while minimizing environmental impacts*'. The SLEM-CPP's overall development objective was to contribute to poverty alleviation in India by promoting enhanced efficiency of natural resource use, improved land and ecosystem productivity, and reduced vulnerability to extreme weather events (droughts, floods). The SLEM-CPP supported by GEF was in itself an innovative programmatic operation specifically developed to become more inclusive in addressing the sustainable land and ecosystem management agenda by

[31] *https://krishi.icar.gov.in/jspui/bitstream/123456789/3677/1/Reclamation%20of%20Alkali% 20Soils.pdf*

[32] *https://archive.india.gov.in/sectors/agriculture/index.php?id=28*

drawing upon GEF resources from three focal areas, and setting objectives that include combating land degradation, conserving biodiversity and adaptation to climate change. In the Indian context, SLEM was innovative as it takes a multi-sectoral approach to land management relating to poverty reduction, watershed management and afforestation initiatives based on ecosystem approach that pays particular attention to safeguarding biodiversity and climate change.

One of the GEF/ World Bank funded projects titled 'Policy and Institutional Reform for Mainstreaming and Scaling-up of the Sustainable Land and Ecosystem Management' was implemented by ICFRE during 2009 to 2014 as a Technical Facilitation Organization (TFO), to coordinate among the projects implementing agencies, draw learning experiences from the projects and mainstream the same into the policy environment in the country. This project was designed to strengthen the institutional and management functions of the Indian institutions responsible for the SLEM-CPP. Under this project, ICFRE Headquarters and its regional research institutes provided the requisite technical support as and when required to SLEM projects located in different parts of the country. ICFRE has also documented SLEM Best Practices to address the issues related to increasing land productivity, sustainable utilization of biological resources, water resource management, long terms sustenance of ecological goods and services, opportunities for off-farm livelihoods and sustainable livelihood generation. It has targeted the stakeholders such as farmers groups, community-based organizations, policy makers, agriculture and natural resource institutions/departments.

Ecosystem Services Improvement Project: The GEF/ World Bank funded Ecosystem Services Improvement Project (ESIP) supported the goals of the Green India Mission by demonstrating models for adaptation-based mitigation through sustainable land and ecosystem management and livelihood benefits. The project development objective was to improve forest quality, land management and non-timber forest produce benefits for forest dependent communities in selected landscapes in Madhya Pradesh and Chhattisgarh. The project comprised of following four components:

- **Component 1:** Strengthen capacity of government institutions in forestry and land management programs in Madhya Pradesh and Chhattisgarh: Objective of this component was to enhance the capacity and skills of the State Forest Departments, the Forest Development Agencies, and local communities for improving management of forest and land resources and ensuring the delivery of sustainable benefits to local communities that depend on these resources. This component provided technical assistance for building institutional capacity and capability for planning and efficient delivery of forest ecosystem quality improvement and land management programs, and developed, tested and piloted nation-wide systems for measuring and monitoring forest carbon stocks.
- **Component 2:** Investments for improving forest quality in selected landscapes: Objective of this component was to improve the quality and productivity of the existing forests so as to ensure sustained flows of ecosystem services and carbon sequestration, and to ensure the sustainable harvesting and value addition of NTFP to provide economic benefits to forest dependent communities that promote conservation and improve ecological connectivity between critical biodiversity areas.
- **Component 3:** Scaling up sustainable land and ecosystem management in selected landscapes: Objectives of this component was to prevent land degradation and desertification and to

increase above-ground forest carbon stock through a combination of activities to implement and scaleup tried-and-tested SLEM best practices, to increase national capacity for monitoring land degradation and to track associated indicators and generate knowledge exchange on SLEM approaches.

- **Component 4:** Project Management: Objective of this component was to coordinate and monitor project implementation and progress.

ESIP was implemented in the selected landscapes in Madhya Pradesh and Chhattisgarh by ICFRE and Madhya Pradesh and Chhattisgarh State Forest Departments under the overall direction of Ministry of Environment, Forest and Climate Change, Government of India. The project recorded an increase in average carbon density from 59.88 tonnes/ha (2019) to 66.59 tonnes/ha (2023) in Madhya Pradesh and from 74.11 tonnes/ha (2019) to 79.58 tonnes/ha (2023) in Chhattisgarh. ESIP had covered a total of 25,316 ha land under SLEM, 7,387 ha of forest restored through plantations and soil conservation and 50,538 ha landscape restored through land treatment. The adopted landscape approach resulted in the restoration of up to five times the actual treated area within the selected landscapes. The improved ecosystem services resulting from the project's interventions have had widespread benefits for the larger population in the project states. More than 25,000 people, comprising of forest dwellers, small landholders, marginal farmers etc. were the direct beneficiaries of the project at the community level in the states of Madhya Pradesh and Chhattisgarh. The indirect beneficiaries of the project comprised of larger population of these states which were benefitted from the improved forest quality and ecosystems services such as improved water flows, climate amelioration, and land productivity.

6.15. Centre of Excellence on Sustainable Land Management

The Hon'ble Prime Minister of India Shri Narendra Modi while addressing the High-Level Segment of Fourteenth Conference of Parties to United Nations Convention to Combat Desertification at Greater Noida, Delhi NCR on 9 September 2019 made an announcement to set up a Centre of Excellence on SLM at Indian Council of Forestry Research and Education (ICFRE) in order to further develop scientific approach and facilitate induction of technology on land degradation issues. ICFRE prepared the Detailed Project Report (DPR) in 2021 for setting-up of Centre of Excellence on Sustainable Land Management. The Centre of Excellence on SLM was formally launched on 20 May 2023. The main role of the Centre is to share knowledge and technology amongst developing countries Parties of UNCCD to arrest further land degradation and restoration of degraded lands aiming at conservation of biodiversity, food and water security, support livelihoods along with maintaining the flow of ecosystem goods and services for posterity. It will facilitate networking of national and international institutions working on sustainable land and ecosystem management for knowledge sharing, capacity building of the stakeholders in land degradation neutrality target setting and provide technical support for land degradation mapping. The Centre envisages south-south cooperation to enable India to share its experiences on sustainable land management with other country Parties.

6.16. National Action Programme to Combat Desertification

As desertification, land degradation and drought were recognized as issues of global concern, all the developing country parties to UNCCD collectively decided to prepare the National Action

Programme to combat desertification and to mitigate the effect of drought. UNCCD has made a regional Action Programme for Asian Countries to strengthen the capacity and networking of member countries to deal with the issue of desertification. In this regard, Ministry of Environment, Forest and Climate Change, Government of India developed a National Action Programme to combat desertification in 2001 with the following objectives:

- Community based approach to development
- Activities to improve the quality of life of the local communities
- Awareness raising
- Drought management preparedness and mitigation
- R&D initiatives and interventions which are locally suited
- Strengthening self-governance leading empowerment of local communities[33]

Ministry of Environment, Forest and Climate Change, Government of India developed a National Action Plan to Combat Desertification and Land Degradation through Forestry Interventions in 2023. This revised Action Plan focuses on the landscape approach of restoration through adopting holistic ecological forestry-based interventions. The revised Action Plan highlights the need for a synergistic, efficient planning and implementation of the eco-restoration initiatives in the country. The revised Action Plan strives to realize participatory landscape designing and visioning process for a proactive and a multi-stakeholder involvement in the identification of the landscapes and the eco-restoration interventions governed by the landscape mosaic of habitat types and land uses that are best suited to prevalent environmental and socioeconomic conditions. The National Action Plan to Combat Desertification, 2023 presents the coherent and the updated version of the NAP 2001 taking due consideration with the country's commitments through forestry interventions for:

- Restoration of 26 million hectares of degraded land by 2030
- Initiative for enhanced South-South Cooperation that aims to share experiences on SLM strategies, and
- Generating an additional carbon sink of 2.5- 3 billion tonnes of CO_2 equivalent by 2030 through additional forest and tree cover

Based on the extent of degradation, existing vulnerabilities and prioritizing the potential degraded landscapes on the geographical as well as ecological conditions, fifteen states namely Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Rajasthan, Telangana, Uttar Pradesh, Uttarakhand, Tamil Nadu, Himachal Pradesh, West Bengal and Maharashtra have been identified for taking up the interventions towards achieving the land degradation neutrality by 2030 (MoEFCC, 2023).

6.17. Restoration of Degraded Land in Aravalli Region - Green Wall

Aravalli is the oldest mountain system starts from Delhi, run across Haryana and Rajasthan and reach to the plains of Gujarat near Palanpur extending for about 800 km with width varying from <10 km to over 100 km. The central part of Rajasthan is dominated by the Aravalli mountains, stretching from Rann of Kutch in Gujarat in South-West to approaching Delhi in North-East. In

[33] *http://moef.gov.in/wp-content/uploads/2019/12/Document1_0.pdf*

Delhi, it covers ridges on northern, central, south central and southern ridges. In Haryana, Aravalli are present in Mewat, Palwal, Faridabad, Gurugram, Mahendragarh and Rewari districts covering about 0.06 mha area. In Rajasthan, the Aravalli Region is spread in 12.65% area (9.28 mha) covering parts of 18 districts. Aravalli Region spans in Banaskantha, Sabarkantha and Mehsana districts of Gujarat. The Aravalli region is an important mineral resource area of the country and rich in non-ferrous minerals like zinc, gold, silver and having large reserves of ferrous minerals such as Iron-ore and manganese; non-ferrous minerals like copper ore and lead; non-metallic minerals such as dolomite, calcite, emerald, felspar, garnet, mica, rock phosphate, magnesite and building stones like marble, lime stone etc.

Aravalli helps in enhancing the precipitation and checking drought as occurrence of rainfall in north-west India depends to a large extent on the preservation of forest cover and resultant normal evapotranspiration process. It provides numerous resources to its inhabitants including fuel wood, fodder, fruits, vegetables and important commercial products like rubber, raisins and a region of economically viable products. Furthermore, this region is highly significant from both zoogeography and evolutionary point of view and because of its geographical location, this region has a mix of Saharan, Ethiopian, peninsular, oriental and even Malayan elements of flora and fauna. The vegetation being scattered over a large area and occurring on various geological and soil formation in Aravalli vary greatly in composition and quality edaphic and biotic factor chiefly determine their distribution, major area of the forest area is either occupied by bare rocks or covered sparsely with mixed deciduous and sub-tropical evergreen forests to bushes, scrub and grasses. The intensity and variety of the trees and bush growth is mainly determined with rainfall distribution.

In the Aravalli Region degradation is an alarming situation and is mainly due to increasing population of human and cattle, injudicious use of natural resources, unscientific mining, uncontrolled grazing and felling of trees. As major part of Aravalli Region falls in the states of Rajasthan and Gujarat, restoration of these regions will not only lead to curtailing the growth of the desert area but will also curb the air pollution occurring in the form of dust storms originating from the high-pressure areas of Rajasthan in the summers. Land restoration in this area can help in preserving forests and biodiversity, facilitating conservation of natural resources and thereby improving carbon sinks. This can be achieved through restoration of degraded forest and afforestation/ tree plantation of wastelands, along national and state highways and railway track, urban landscapes, promotion of agroforestry, marginal farmlands, river catchments, etc. along with various central and state government scheme under the ambit of land management.

The initiative for restoration of degraded lands of Aravalli Region aims to restore the degraded lands through creation of ecological corridor from Delhi to Gujarat. It also aims to achieve land degradation neutrality by a combination of adaptation and mitigating measures. Restoration of Degraded Land in the Aravalli Hill Region will not only improve the ecological health of the Aravalli range but it will also prevent eastward expansion of Thar Desert and will reduce land degradation by creating green barriers that will prevent soil erosion, desertification and dust storms. A Green Wall in the Aravalli region will be created which will help in mitigating climate change and achieving the NDC forest sector goal as well as land degradation neutrality by 2030. Activities such as planting native species of trees and shrubs on scrubland, wasteland and degraded forest land, along with rejuvenating and restoring surface water bodies such as ponds, lakes and

streams will be undertaken. This will also promote ecological and economic development by involving local communities in implementation of the envisaged activities.

6.18. Drought Management Plan

In India, Disaster Management Act, 2005 is the primary law at the national level that provisions for management of disasters in the country. Section 11 of the Disaster Management Act, 2005 mandates that there shall be a National Disaster Management Plan for the whole country. As per Section 37 of the Disaster Management Act, every ministry and department of the Government of India, including the hazard-specific nodal ministries, shall prepare comprehensive disaster management plans detailing how each of them will contribute to the national efforts in the domains of disaster prevention, preparedness, response, and recovery.

Government of India notified the Department of Agriculture and Farmers' Welfare (DA&FW) as the nodal agency to formulate policies, plans and institutional mechanisms related to drought management in the country. DA&FW has actively been engaged in devising guidelines and practices that should be followed by the state and district level authorities to mitigate drought conditions in their area. DA&FW has prepared the Drought Management Plan in 2017 for managing and mitigating drought.

Drought Management Plan (DMP) 2017 was designed to help reduce the time taken in mobilizing resources for an effective response and enable a harmonious relationship among stakeholders. The goal of DMP is to facilitate overall management of the drought situation in a structured and planned manner with the most efficient and optimum utilisation of time, effort and resources so that adverse impact on the community is minimised. DMP helps in delineating roles and responsibilities of different Ministries/ Departments of the Government of India involved in drought management for mitigation, preparedness and for relief measures in managing the drought. DMP ensures better preparation and timely communication among stakeholders, which is critical in managing a drought.

The revised Drought Management Manual was published by the DA&FW in December 2016, which has come into effect from Kharif season of 2017. The Manual is a guide for governments and agencies engaged in the prevention, mitigation and management of drought. It defines various set of indices and parameters appropriate for declaration of drought in a region. Based on the values of indices like Standardized Precipitation Index, Vegetation Condition Index, Percentage Available Soil Moisture, and Hydrology Indices like Reservoir Storage Index, Stream-flow Drought Index and Ground Water Drought Index, it grades the magnitude of the drought events on a scale of values as "Moderate" and "Severe".

6.19. Drought Monitoring and Early Warning Systems

A wide network of observatories routinely monitors rainfall situation over different spatial and temporal scales in the country. Since 1992, the India Meteorological Department, Earth System Science Organisation (ESSO-IMD) monitors rainfall situation throughout the year in different spatial scales. Based on this data, ESSO- IMD prepares rainfall reports for the use of different state/Government of India agencies. Until 2012, ESSO-IMD was monitoring drought using two most important drought indices viz. percent deviation of rainfall from normal and Aridity

Anomaly Index (AAI). The first one covers meteorological drought while the second one is used for agricultural drought by monitoring the incidence, spread, intensification, and recession of drought. Since 2013, ESSO-IMD started using Standardized Precipitation Index (SPI) to monitor drought in the districts of India on a monthly scale. This is in accordance with the guidelines issued by the World Meteorological Organization which recommends SPI as the most useful drought monitoring index because of its versatility in covering all three forms of drought viz. meteorological, agricultural and hydrological. Besides, the standard monthly and cumulative SPI, four weekly district SPI maps are computed and prepared every week to monitor progress, starting or ending of agricultural drought. In addition to the SPI and AAI, the Normalized Difference Vegetation Index (NDVI) is also used in drought monitoring. The Central Water Commission, National Centre for Medium Range Weather Forecasting, National Remote Sensing Centre and National Rainfed Area Authority are other key agencies that provide early warning on drought.

6.20. National Disaster Management Guidelines – Management of Drought

National Disaster Management Authority, Government of India formulated guidelines on management of drought so that the authorities involved in Drought Management at Central Government level and at State Government level will be able to manage droughts better in the future (NIDM, 2010). Forty-nine recommendations/ action points have been given in the guidelines for State Government, Government of India's Ministries and R&D organisation and NGOs for drought management in the country.

6.21. National Crisis Management Plan for Drought 2023

National Crisis Management Plan for Drought 2023 has been developed by the Ministry of Agriculture and Farmers Welfare, Government of India with the aim to help all stakeholders to be better prepared to manage drought. This will support in a timely and effective response by government agencies to reduce its impact on rural communicates and environment in the event of a drought crisis (MoAFW, 2023).

6.22. Rejuvenation of River Ganga Through Forestry Interventions

One of the major components of Ganga rejuvenation is 'forestry interventions' to enhance the productivity and diversity of the forests in head water areas and all along the river and its tributaries. Accordingly, ICFRE-Forest Research Institute, Dehradun prepared a Detailed Project Report for afforestation in an area of 134106 hectares in the Ganga river bank states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. It provides for taking up works under four major heads viz. Natural landscape, Agriculture landscape, Urban landscape and Conservation interventions. The main purpose of the forestry interventions is to contribute towards holistic conservation of river Ganga, including improving the flow in the river by adopting a multi-pronged approach throughout the pre-defined Ganga riverscape. The project of "Forestry Interventions for Ganga" is being implemented by State Forest Departments of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal as per the Detailed Project Report since year 2016-17, for which National Mission for Clean Ganga is providing financial support to the respective State Forest Departments.

6.23. Rejuvenation of Major Rivers Through Forestry Interventions

Indian Council of Forestry Research and Education prepared the Detailed Project Reports (DPRs) on Rejuvenation of thirteen Major Rivers through Forestry Interventions. Preparation of DPRs were funded by National Afforestation & Eco-development Board, Ministry of Environment, Forest and Climate Change, Government of India. The 13 rivers for which DPRs have been prepared are Jhelum, Chenab, Ravi, Beas, Sutlej, Yamuna, Brahmaputra, Luni, Narmada, Godavari, Mahanadi, Krishna, and Cauvery.

Growing water crisis on account of depleting fresh water resources especially due to shrinking and degradation of river ecosystems is a major impediment to achieving national goals pertaining to environment, conservation, climate change and sustainable development. Thirteen rivers collectively cover a total basin area of 18,90,110 sq km that represents 57.45% of the geographical area of the country. The length of 13 rivers including 202 tributaries within the delineated riverscapes is 42,830 km.

The rivers along with their tributaries are proposed for forestry interventions in the riverscape under different landscapes namely natural landscape, agricultural landscape and urban landscape. The different models of forestry plantations including timber species, medicinal plants, grasses, shrubs and fuel fodder and fruit trees are aimed to augment water, ground water recharge and contain erosion. A total of 667 treatment and plantation models are proposed in all the 13 DPRs meant for the proposed forestry interventions and supporting activities, in different landscapes. In all, 283 treatment models have been proposed for the natural landscapes, 97 treatments models in Agriculture Landscapes and 116 different treatment models in Urban Landscapes. Site specific treatments in terms of soil & moisture conservation and plantations of grasses, herbs, forestry and horticultural trees have been proposed for treatment of prioritized sites in the riverscape supported by GIS technique based on consultations with various stakeholders.

The DPRs focus on protection, afforestation, catchment treatment, ecological restoration, moisture conservation, livelihood improvement, income generation, regulated tourism by developing river fronts, eco-parks and bringing awareness amongst the masses. The proposed forestry interventions are expected to increase the cumulative forest cover of 7,417.36 km^2 across 13 riverscapes. The proposed interventions would help to sequester 50.21 million tonnes of CO_2 equivalent in 10-year-old plantations while 74.76 million tonnes of CO_2 equivalent in 20-year-old plantations.

Proposed interventions in thirteen riverscapes would help in ground water recharge to the extent of 1,889.89 million m^3 yr^{-1}, and reduction in sedimentation to the tune of 64,83,114 m^3 yr^{-1}. Timely and effective implementation of the proposed forestry interventions as envisaged in DPRs of 13 major Indian Rivers are expected to significantly contribute towards rejuvenation of the rivers in terms of ensuring *Aviral Dhara, Nirmal Dhara* besides Swachh Kinara, improved terrestrial and aquatic biota, and livelihoods. The DPRs are expected to be executed through the State Forest Departments as nodal department and with convergence of schemes of other line departments in the states towards the activities proposed in the DPRs and funding support from the Government of India.

6.24. Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management (SLEM) in India 2022

A Baseline Report on SLEM highlighted that mainstreaming and scaling up of SLEM requires a Road Map and Action Plan aimed at minimizing the policy and institutional gaps and guides the harmonization of efforts by various policies, programs and institutions at the national and sub-national level (ICFRE, 2014 a). Accordingly, a roadmap for institutional and policy mainstreaming of SLEM in India was developed and published by ICFRE under the World Bank funded Ecosystem Services Improvement Project in 2022. The roadmap provided specific guidelines and action plans to different Ministries, Departments, Research Organizations and Civil Society Originations involved in restoration of degraded lands and combating desertification and land degradation for achieving land degradation neutrality by 2030. The roadmap also provided the guidelines and action plans for achieving Sustainable Development Goals and Nationally Determined Contribution targets of India by 2030. The roadmap identifies the key nodal or initiating agencies for each of the action points, their role, agencies that they would require support from, areas of support and timeline wise breakdown of milestones (ICFRE, 2022 a and 2022 b). Key recommendations of the Roadmap are given in Chapter 8.

6.25. SLEM Knowledge Sharing and Reporting System

A portal on SLEM Knowledge Sharing and Reporting System (https://nrdp.icfre.gov.in) was developed by ICFRE under the World Bank funded Ecosystem Services Improvement Project in 2022 for sharing the knowledge, learnings, practices and success stories related to scaling up of SLEM best practices for achieving land degradation neutrality by 2030 and also help in strengthening the national capacity for reporting to UNCCD Secretariat regarding progress made in implementation of the convention. This portal was launched by the Director General, ICFRE on 28 March 2022. Key features of the portal are highlighted as under:

- Useful for number of stakeholders including various Central Ministries, departments, organizations, State Governments, NGOs and local community members.
- A repository of information on desertification, land degradation and drought as well as the best practices on sustainable land and ecosystem management.
- Help in increasing national capacity for monitoring the status of land degradation and desertification and SLEM outcomes, as well as the results of UNCCD action programs at the country level.
- Have national database on SLEM practitioners for the development of institutional and individual networks. The knowledge network also helps in developing a community of practice by connecting stakeholders with common interests in adopting and expanding SLEM approaches and knowledge dissemination.
- Provide necessary assistance for preparation of national report for submission to the UNCCD Secretariat
- Help in organizing and implementing learning events at the interface of the different stakeholders.
- Platform will have an integrated learning management system for the different courses and Trainings on SLEM for capacity building of the stakeholders.

- Help in developing network of the SLEM practitioners/ stakeholders through using integrated SLEM - Networking and Blogs.

6.26. Key Ministries, Departments and Institutions Working on SLEM

Ministries, Departments and Institutions at the Government of India level are more policy-oriented and focus on devolution of funds for major schemes, programmes and projects, whereas the state government departments and institutions are focused on implementation of the policies, schemes, programmes and projects. There are four key departments in the states and institutions under them, which are fundamentally related to SLEM, namely Forest Department, Agriculture Department, Rural Development Department and Panchayat Department. The other departments, such as the Revenue, Water Resources/ Irrigation, Soil and Conservation and Mining also contribute significantly towards sustainable land management, but their role in program implementation is limited compared to the other key departments.

Some of the key Ministries, Departments and Institutions of Government of India working on sustainable land and ecosystem management related aspects in the country are tabulated below:

Ministry of Environment, Forests and Climate Change (MoEFCC)	• Mission of the MoEFCC is "*to provide to the citizens of India a clean, green and healthy environment with peoples' participation, combat Climate change, conserve Biodiversity and support higher and inclusive economic growth through sustainable utilization of natural resources*". • MoEFCC is the nodal agency for planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes. Broad objectives of the Ministry are conservation and survey of flora, fauna, forests and wildlife; prevention and control of pollution; afforestation and regeneration of degraded areas; protection of the environment and ensuring the welfare of animals. • MoEFCC is the nodal Ministry in the Government of India for all Multilateral Environmental Agreements such as United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification, Convention on Biological Diversity, Basel Convention n Trans-boundary Movement of Hazardous Substances, Vienna Convention for the Protection of the Ozone Layer, Stockholm Convention on Persistent Organic Pollutants, Rotterdam Convention, Ramsar Convention etc.
Ministry of Rural Development (MoRD)	• The vision and mission of the MoRD is sustainable and inclusive growth of rural India through a multipronged strategy for eradication of poverty by increasing livelihoods opportunities, providing social safety net and developing infrastructure for growth. This is expected to improve quality of life in rural India and to correct the developmental imbalances, aiming in the process, to reach out to most disadvantaged sections of the society. • Department of Land Resources is the key department of the MoRD and mission of the department is: to ensure sustainable development of rainfed cultivable and degraded lands through a participatory approach by involving the stakeholders in decision making in the watershed development programmes. It makes a concerted effort to enhance the productivity of wastelands

	thereby enhancing livelihood opportunities in rural areas, and to put in place effective agrarian reforms, including an efficient land use policy, and a transparent Land Records Management System with the aim to build an Integrated Land Information Management System. • Functions of the Department of Land Resources are: – Implementation of watershed programme for development of rainfed/ degraded areas. – Guide and facilitate States to modernize land record management & build up a land information system. – Facilitate States efforts to usher in conclusive titling system. – Administration of Land Acquisition Act, 1894 (1 of 1894) and right to fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 and matters relating to acquisition of land for purposes of the Union and Registration Act, 1908. – To facilitate adoption of policy for Rehabilitation & Resettlement of displaced people. – Land reforms, land tenure, land records, consolidation of holdings and other related matters. • The major programs of MoRD are Mahatma Gandhi National Rural Employment Guarantee Scheme, National Rural Livelihood Mission, Pradhan Mantri Awas Yojana Gramin, Pradhan Mantri Gram Sadak Yojana, National Social Assistance Program, Sansad Adarsh Gram Yojana and Integrated Watershed Management Program.
Department of Agriculture and Farmers Welfare (Ministry of Agriculture and Farmers Welfare)	• Mission of the Department is "*to achieve targeted growth rate for agriculture sector with the help of State Governments and other Departments of the Government of India by enhancing agriculture production and ensuring farmers welfare by successful implementation of Ministry's schemes*". • Development and implementation of policies and programmes on agriculture, which also define sustainable land use; extension of SLEM practices in agriculture; drought management; development of planting material that stands drought, and for optimizing production in various types of lands, including marginal land, and reducing the overuse of chemical inputs in agriculture
Department of Water Resources, River Development and Ganga Rejuvenation (Ministry of Jal Shakti)	• Mission of the Ministry is optimal sustainable development, maintenance of quality and efficient use of water resources to match with the growing demands on this precious natural resource of the country. • Ministry is responsible for laying down policy guidelines and programmes for the development and regulation of country's water resources.
Indian Meteorological Department (IMD)	• IMD is the National Meteorological Service of the country and the principal government agency in all matters relating to meteorology and allied subjects. • To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.

	• To warn against severe weather phenomena like tropical cyclones, nor westers, dust storms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property. • To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities. • To conduct and promote research in meteorology and allied disciplines.
Indian Council of Forestry Research and Education (ICFRE)	• ICFRE is an autonomous body of the Ministry of Environment, Forest and Climate Change, Government of India. Mission of the ICFRE is to generate, advance and disseminate scientific knowledge and technologies for ecological security, improved productivity, livelihoods enhancement and sustainable use of forest resources through forestry research and education. ICFRE is mandated with undertaking research on and providing solutions to issues related to forestry and environment. • ICFRE carries out forestry research, education and extension programmes and projects through a network of its nine Institutes (Forest Research Institute, Dehradun; Himalayan Forest Research Institute, Shimla; Tropical Forest Research Institute, Jabalpur; Arid Forest Research Institute, Jodhpur; Institute of Forest Productivity, Ranchi; Rain Forest Research Institute, Jorhat; Institute of Forest Biodiversity, Hyderabad; Institute of Wood Science and Technology, Bengaluru and Institute of Forest Genetics and Tree Breeding, Coimbatore) and six Centres (Forest Research Centre for Eco-Rehabilitation, Prayagraj; Forest Research Centre for Skill Development, Chhindwara; Forest Research Centre for Bamboo and Rattan, Aizawl; Forest Research Centre for Livelihood Extension, Agartala, Forest Research Centre for Coastal Ecosystem, Visakhapatnam and Field Station, Kolkata) spread across the various geographic zones in the country. • ICFRE is making concerted efforts to deal with the challenge of desertification and land degradation by engaging all its institutes and centres to work on restoration and reclamation of degraded forest land. • ICFRE made significant contribution in restoration of mined out areas and developed models/ practices for restoration of limestone, coal, rock phosphate, iron and uranium mined out areas, restoration of sodic soil, restoration of degraded forest lands, sand dune stabilization, rehabilitation of salt land, rain water management, soil and moisture conservation, reclamation of water logged areas, agroforestry models for different agroclimatic zones and research on planting stock improvement, productivity enhancement, biodiversity conservation, climate change mitigation and adaptation etc. • Government of India has designated ICFRE as a Centre of Excellence on Sustainable Land Management in 2019 for knowledge sharing and capacity building of the stakeholders for combating desertification and land degradation.
Indian Council of Agricultural Research (ICAR)	• ICAR is an autonomous body under the Department of Agricultural Research and Education, Ministry of Agriculture and Farmers Welfare, Government of India. ICAR is conducting agricultural research, education and extension activities for productivity enhancement and diversification of agriculture through its 69 research institutes, 15 national research centres, 06 national bureaux, 13 directorate and 11 agricultural technology application research institutes.

	• Some of the institutes of ICAR namely Central Arid Zone Research Institute, Jodhpur; Central Institute for Arid Horticulture, Bikaner; Central Research Institute of Dryland Agriculture, Hyderabad; Central Soil Salinity Research Institute, Karnal; Indian Institute of Soil and Water Conservation, Dehradun; Indian Grassland and Fodder Research Institute, Jhansi; Indian Institute of Soil Sciences, Bhopal; Central Agroforestry Research Institute, Jhansi and National Bureau of Soil Survey and Land Use Planning, Nagpur etc. are also working towards combating desertification and land degradation.
Space Applications Centre (SAC)	• SAC is a major research and development centre of the Indian Space Research Organisation, and has developed the following desertification and land degradation atlas under the Ministry of Environment, Forest and Climate Change, Government of India sponsored projects: – Desertification and Land Degradation Atlas of India (Based on IRS AWiFS data of 2011-13 and 2003-05) in 2016 – Desertification and Land Degradation Atlas of Selected Districts of India (Based on IRS LISS III data of 2011-13 and 2003- 05) in 2018 – Desertification and Land Degradation Atlas of India (Assessment and analysis of changes over 15 years based on remote sensing) in 2021 – Space based observation of Indian wetlands in 2021 • SAC has also developed Drought Monitoring System
National Remote Sensing Centre (NRSC)	• NRSC is one of the primary centres of Indian Space Research Organisation. NRSC has the mandate for establishment of ground stations for receiving satellite data, generation of data products, dissemination to the users, development of techniques for remote sensing applications including disaster management support, geospatial services for good governance and capacity building. • As part of Disaster Management Support Programme, Decision Support Centre is established at NRSC for monitoring natural disasters viz. flood, cyclone, agricultural drought, landslides, earthquakes and forest fires in near real-time using space and aerial remote sensing-based inputs.
Forest Survey of India (FSI)	• FSI is a sub-ordinate office of the Ministry of Environment & Forests, Government of India and responsible for assessment and monitoring of the forest resources of the country. • India State of Forest Report is being brought out on biennial basis since 1987.
Soil & Land Use Survey of India (SLUSI)	• SLUSI is a subordinate office of the Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare. It deals with Soil Survey and Land Resource Mapping. • SLUSI is primarily engaged in conducting soil survey of different intensities in order to provide scientific database for developmental programmes encompassing soil and water conservation planning, watershed development, scientific land use planning etc. • Prepared micro-watershed atlas of India

07
Chapter

Sustainable Land and Ecosystem Management: Best Practices and Success Stories

Over exploitation of natural resource, deforestation, forest degradation and unsustainable land use practices lead to desertification, land degradation, climate change and biodiversity loss. There is an urgent need to initiate necessary actions and measures to combat desertification and land degradation, mitigate climate change and conserve biodiversity for safe and sustainable future for all. Sustainable land and ecosystem management (SLEM) is one of the best options for addressing desertification, land degradation and drought (DLDD). SLEM comprises of practices aimed at the protection, conservation and sustainable use of natural resources and restoration of degraded ecosystems. SLEM practices prevent and mitigate land degradation and desertification, conserve soil, water, forest and biodiversity and enhance ecosystem services. Many SLEM practices are being implemented throughout the world for combating desertification and land degradation. SLEM practices which are tested, proven, cost-effective and can be replicated in other similar ecological conditions are known as best practices. UNCCD has defined best practices as "*measures, methods or activities that are considered successful in terms of achieving desired out comes (good performance) and contributing to expected impacts*".

Documentation of SLEM best practices is the formative step in knowledge sharing, capacity building and scaling up, thereby contributing in combating desertification, land degradation and drought (DLDD). Ten-year strategic framework 2008-2018 of UNCCD had highlighted the importance of documentation of SLEM best practices and success stories including traditional knowledge for sharing, capacity building and scaling up for addressing DLDD and emphasised that the Country Parties should also share best practices in their country report (UNCCD, 2007). India in its Fifth National Report to UNCCD Secretariat 2012 documented 15 SLEM best practices (MoEF, 2014 b). As per the UNCCD 2018-2030 Strategic Framework, Country Parties need to establish systems for sharing information and knowledge and facilitate networking on best practices (UNCCD, 2017).

7.1. Database of SELM Practices

Databases of SLEM practices are being developed by various organisations for sharing of knowledge and their implementation for addressing DLDD. In 2014, an agreement was signed between UNCCD and World Overview of Conservation Approaches and Technologies (WOCAT) to prepare a global database of sustainable land management practices. The WOCAT global database provides access to the documentation of field-tested sustainable land management practices from different places in the world and offers practitioners the opportunity to share SLM practices.

WOCAT database contains more than 2380 sustainable land management practices from 136 countries, including best practices reported by UNCCD Parties and others. In India large number of traditional cost- effective SLEM practices are being used in different parts of the country. Information about 81 sustainable land management best practices from India are available on

WOCAT database and best practices related to forest, soil and water sectors from India are given below:

1. Afforestation of degraded lands and sustainable resource utilization by the community in Sunata village in Arunachal Pradesh
2. Ago-horticultural intervention in the wasteland as a part of desertification, land degradation and drought
3. Agro-forestry
4. Agroforestry linked watershed management: best practice to prevent desertification, land degradation and enhance productivity per unit area and time
5. Agro-horticultural intervention for productive utilization of barren land
6. Biochar application on homestead land
7. Biochar production from the invasive species *Lantana camara*
8. Broadleaf plantations, assisted tree regeneration and fodder nurseries for sustainable forest management
9. City compost: a solution for waste management and soil health improvement
10. Common Interest group approach in watershed development
11. Community based soil rehabilitation for grassland on common lands after eradication of the invasive *Lantana camara*
12. Community forest management in the Nakina van panchayat
13. Community managed bio-industrial watershed
14. Comprehensive approach to environmental management through holistic development
15. Comprehensive watershed development
16. Contour "v" ditch
17. Contour trench cum bund
18. Dissemination of soil test results to farmers through a participatory approach
19. Diversion weir
20. Drought proofing perennially drought prone villages
21. Dugout pond
22. Dug-out sunken pond cum contour bund
23. Dugout sunken pond with catchment treatment
24. Dug-out well
25. Environmental regeneration through wasteland development
26. E-Prakriti - An approach towards GIS based planning for natural farming
27. Eradication of *Lantana camara* (invasive species) for soil rehabilitation on private land
28. Farm pond
29. Farmer's manage ground water system
30. Forest catchment treatment
31. Improved cattle shed flooring for conservation of cow dung and urine for biofertilizer production at farm level
32. Integrated farming system

33. Joint forest management
34. Kalpavalli conservation approach: community-centred conservation of the commons
35. Kari (stick) for agarbatti preparation from degraded bamboo forests
36. Legumes in rice-based cropping systems
37. Multilayer farming systems for ensuring food diversity and increasing resilience
38. Natural resource management in degraded land area
39. Naula management and conservation
40. Organic WADI development- an integrated approach for the livelihood enhancement of tribal community
41. Participatory approach in IDCWDP, DANIDA
42. Participatory climate monitoring
43. Participatory sustainable rural livelihood approach
44. Participatory watershed development approach
45. Pepsee micro-irrigation system
46. Pine Briquette a Source of Alternate Fuel
47. Plantation and green belt development around Chandrapura thermal power station, Chandrapura, Dhanbad
48. Preparation of bio-inputs such as vermicompost, biofertilizers, and biopesticides
49. *Prosopis cineraria* based agroforestry
50. Ravine reclamation
51. Recharge ponds and recharge trenches
52. Refined assisted natural regeneration for sustainable and participatory forest management and for biodiversity conservation and livelihoods
53. Rehabilitation of degraded bamboo forests
54. Restoring village common land for sustaining livelihoods
55. Revival of nala / river
56. Sand drift control and sand dune stabilization
57. Shelterbelts
58. Silvi pasture
59. Soil and water management and livelihood improvement
60. Stone check walls and check dams for soil and water conservation
61. Stone wall fencing and firebreak for forest protection
62. Sunken gully pits
63. Sunken streambed structure
64. Supplemental irrigation in a legume-cotton production system
65. Sustainable biochar production through agroforestry systems and its application
66. Sustainable land management through multi-tier cropping system WADI model
67. Sustainable land-use planning at village level for management of natural resources and livelihoods enhancement

The Sustainable Land and Ecosystem Management- Country Partnership Programme (SLEM-CPP) a joint initiative between the Government of India and the Global Environmental Facility was initiated with the overall objective to contribute to poverty alleviation by promoting enhanced efficiency of natural resource use, improved land and ecosystem productivity, and reduced vulnerability to extreme weather events, including the effects of climate change. Replication and scaling-up of successful SLEM practices and technologies was one of the objectives of SLEM-CPP. ICFRE under SLEM-CPP implemented the project titled "Policy and Institutional Reform for Mainstreaming and Scaling-up of the Sustainable Land and Ecosystem Management" and documented following SLEM best practices for further scaling up (ICFRE, 2014 c):

1. Agarbatti preparation from degraded bamboo forests of Madhya Pradesh
2. Agro-biodiversity innovation for sustainable land and ecosystem management in Odisha
3. Aonla based agroforestry as sustainable land and ecosystem management practice in semi-arid dry regions
4. Chauka system for management of common property resources for sustainable livelihood and adaptation to climate change in dry regions of Rajasthan
5. Climate change adaptation by promotion of fodder and pasture development in hills of Uttarakhand
6. Dissemination of sustainable land and ecosystem management practices and traditional knowledge through community radio station in Andhra Pradesh
7. Integrated farm development for sustainable land productivity in Nagaland
8. Lac cultivation for livelihood generation and biodiversity conservation in Madhya Pradesh
9. Land shaping for climate change adaptation and sustainable livelihoods in Sundarbans
10. Managing ground water for adaptation to climate change in southern India
11. Mangrove afforestation in Sunderbans with community participation to combat climate change and sustainable land and ecosystem management
12. Mulberry cultivation- A diversification climate change adaptation practice for sustainable livelihood under semi-arid region
13. On farm conservation of genetically important crop landraces of *Rajmash* for sustainable land and ecosystem in Chamba district of Himachal Pradesh
14. Participatory model for water harvesting and development of community pastures in Thar desert
15. Rain water harvesting and augmentation of water resources for sustainable land and ecosystem management
16. Rehabilitation of degraded bamboo forests in Madhya Pradesh
17. Rejuvenation of *gharats* (Water mills) for sustainable land and ecosystem management in Uttarakhand
18. Role of the Van Panchayats in sustainable land and ecosystem management
19. Sustainable land and ecosystem management in shifting cultivation of Nagaland
20. Sustainable management of resources for livelihood improvement through watershed management in hills of Uttarakhand

21. System of rice intensification for sustainable land and ecosystem management
22. WADI: A tree-based farming system model for sustainable land and ecosystem management

The Department of Land Resources (Ministry of Rural Development, Government of India) documented 117 case studies on water conservation in the form of '*Jal Sangrah*' under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) (DoLR, 2019 a, b & c). NITI Aayog has documented 27 best practices on water management from different states of the country (NITI Aayog, 2023 a). NITI Aayog and UNDP have also documented 7 best practices of agriculture sector and 8 best practices of environment sector for sustainable land management (NITI Aayog, 2023 b).

SLEM practices emerge as effective tools to address land degradation issues. SLEM practices are based on principles of adoption and income generation at the local level, land-user-driven and participatory approaches, integrated use of natural resources on farms and at the ecosystem level and stakeholder's involvement. Combating land degradation and desertification and meeting national targets and international commitments related to land degradation neutrality, climate change mitigation and adaptation and sustainable development goals can be achieved through scaling up of tested and proven SLEM best practices. In this context, the World Bank funded Ecosystem Services Improvement Project (ESIP) was executed to support the aims of Green India Mission in the selected landscapes of Chhattisgarh and Madhya Pradesh. A National database of SLEM practitioners was developed by ICFRE under ESIP to help land practitioners and stakeholders to adopt SLEM practices, locate the organization working in the respective areas of sustainable land management and scale up the tested and proven best practices. Database consists of 362 SLEM practitioners comprising of 117 organizations/ institutions, 159 individuals and community groups of SLEM practitioners, 21 awards winning practitioners and 65 other organizations and also provides information on community-specific traditional/ indigenous practices for water conservation, land management, natural resource management including agriculture in the region. A portal on "SLEM knowledge sharing and reporting system" was developed by ICFRE and database of SLEM practitioners is also available in the portal.

7.2. Scaling up of SLEM best practices under Ecosystem Services Improvement Project

Following SLEM best practices were scaled up in the selected landscapes of Madhya Pradesh and Chhattisgarh under the World Bank funded Ecosystem Services Improvement Project from 2018-2023:

1. Rain Water Harvesting and Augmentation of Water Resources

Brief about the practice: In rainfed areas, agriculture depends substantially on ground water. Locally constructed reservoirs, farm ponds and village ponds play an important role in conserving water for replenishing soil moisture and sub-surface water. Rainwater harvesting structures provide lifesaving/ supplemental irrigation to crops and plantation, improve moisture status of the soil profile and augment groundwater recharge, reduce soil erosion and help in peak flood retardation, and meet water demand for domestic, animal and other use. Selection of suitable site, command area, pond type (excavated ponds for flat topography, excavated cum-embankment ponds in mild sloping topography, and embankment ponds for hilly and rugged terrain) and pond design are major criteria need to be considered for construction of pond. Site clearing, levelling

of area and establishing reference level are the steps for pond construction. Spoil obtained from dug out ponds should be disposed of and treated properly. Environmental and social safeguards should be respected and addressed while constructing the pond. Periodic maintenance of pond is required. Suitable multipurpose tree species and grasses should be planted around the pond for other ecological and socio-economic benefits.

Scaling up of the practice: To harvest rain water, increase water resources and support floral and faunal diversity, this practice was scaled up in 24 locations in Bhaura, Banapura, Budhni, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi and Raghunathnagar Forest Ranges in Chhattisgarh. Environmental and social safeguards were followed during deepening of ponds. The selection of pond sites and identification of silt disposal sites were done prior to the excavation work with the consent of all sections of the society. Knowledge products were distributed and trainings were imparted to the local communities for creating awareness and enhancing the knowledge base. A total of 241 households in 17 villages were benefitted through scaling up of the practice. Scaling up of this practice increased water holding capacity of the ponds by 40 to 60%. Farmers utilized this water for irrigation and livestock use. Through scaling up of this practice, 1 to 1.5 m increase in water level was observed in the nearby wells and round the year water supply was available from nearby hand pumps.

2. Lac Cultivation for Livelihood Generation and Biodiversity Conservation

Brief about the practice: Lac cultivation is the subsidiary source of income for rural and forest dwellers. The natural products derived from Lac i.e. resin, dye and wax, have various applications in industrial sectors such as food products, cosmetics, pharmaceuticals, textile, adhesive, varnish, paints etc. India has vast resource potential to produce lac. Major lac producing states in India are Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, Odisha, Andhra Pradesh, Maharashtra and Uttar Pradesh. Lac production can be enhanced through capacity building and skill development of the local communities for scaling up of best practice on lac cultivation for livelihood generation and biodiversity conservation.

Lac is a natural resin secreted by the tiny lac insects, mainly *Kerria lacca* (Kerr), for protection of mother insect as well as its young ones. The insects are cultured on tender shoots of hosts. It derives its nutrition by sucking the saps from the host plants. There are two strains of lac insect namely *Rangeeni* and *Kusmi*. Each of these strains completes its life cycle twice in a year, thus producing two crops in a year. Strains of lac insect and their life period are tabulated below:

Strain	Crop	Season	Inoculation Period	Harvest Period
Rangeeni	Katki	Rainy	June/ July	October/ November
	Baisakhi	Summer	October/ November	June/ July
Kusmi	Aghani	Winter	June/ July	January/ February
	Jethwi	Summer	January/ February	June/ July

Hot sub-humid areas having specific host plants (*Acacia catechu* and *Schleichera oleosa* for *Kusmi* strain and *Butea monosperma* and *Ficus religiosa* for *Rangeeni* strain) are suitable for cultivation of lac. Pruning of host plants need to be done to ensure availability of good, healthy and succulent (tender) shoots, to ensure availability of large number of shoots (area for lac culture), to provide new sprouts for maintaining its potential and to remove dead, diseased and broken branches. Inoculation with broodlac is done as per the strain of brood lac. Pest management and spray of pesticides (if required) is done to control pests and diseases from affecting the lac crop. The site selected for scaling up must have sufficient host trees. The brood lac is implanted on fresh coppice shoot. The lac resin is produced and spread within seven days of emergence of insect.

Scaling up of the practice: Capacity of local communities of 25 villages in Marwahi, Pali and Raghunathnagar Forest Ranges of Chhattisgarh was built and scaling up of the practice was done through providing brood lac and necessary accessories. Technical support for inoculation of brood lac on host trees (*Butea monosperma*) was also provided for scaling up of this practice. Total 2612 households adopted and scaled up this practice for livelihood generation and biodiversity conservation. On an average an additional income of Rs. 8000/- per beneficiary per year was earned from lac cultivation.

3. System of Rice Intensification

Brief about the practice: Rice is one of the high-water demanding crops in India. System of Rice Intensification (SRI) is a method of rice cultivation for increasing rice yield with reduced seed and less water. SRI involves cultivating rice with as much organic manure as possible, starting with young seedlings planted singly at wider spacing in a square pattern; and with intermittent irrigation that keeps the soil moist but not inundated, and frequent inter-cultivation with a weeder that actively aerates the soil. Traditional paddy growers can adopt SRI practice where water is scarcely available and as such has an immense potential in the paddy growing areas of Chhattisgarh and Madhya Pradesh.

In India rice growing areas receiving about 1000 mm annual rainfall with irrigation facility are suitable for SRI. Well drained loamy to clayey fertile soils having pH within a range of 5.5 to 7 are ideal for SRI. Additionally, land should be levelled, convenient to irrigate and drain, and should not be affected by salinity or alkalinity. The seeds are pre-treated with biopesticides or carbondezim (1 gram) plus menkojab (2 grams) and thiomethoxam (2 grams) per kg of seed before sowing in the nursery. For SRI 5 kg seeds per ha are required and 100 m^2 nursery is sufficient for raising nursey of 5 kg seeds. Surface soil is well pulverized and mixed with well decomposed organic manure (50 kg compost/ farm yard manure or 25 kg vermi-compost). Raised beds of about 6-12 inches are prepared. In a well-drained loamy to clayey soil 15 cartloads or 3 tractors trolley loads of farm yard manure or compost should be applied per acre followed by 1-2 ploughings and 2-3 harrowing. SRI requires perfect levelling and raking for uniform distribution of water. 30 cm wide channels at two meters interval across the field are prepared to facilitate drainage. Seedlings at two leaf stage (8-12 days old) are generally removed from the nursery and transported keeping the seed and soil intact. Single seedling is planted gently at 1-2 cm depth using thumb and index finger at the intersections of 25 x 25 cm.

SRI does not require flooding and irrigation is done to wet and saturate the soil with moisture. Subsequent irrigation is again required to keep the soil moist when it starts developing cracks. First weeding after 10 days of transplant is very crucial. Weeding can be done either through conoweeder or by hand and is operated in criss-cross way for weed control. Weed can also be manually removed and buried in soil to improve the soil fertility. Chemical herbicides are not used in SRI. Harvesting is advised when stem is green and panicles have ripened to prevent shattering. SRI reduces the duration of rice crop by 10 days. Thus, it allows more time for farmers to prepare for the Rabi crop. This practice reduces cost of rice cultivation by 23% and saves irrigation water by 40% and increases land productivity by 45%.

Scaling up of the practice: Training on nursery preparation, handling and transplanting of seedlings, water management and weed control in SRI was provided to the local communities of Marwahi and Raghunathnagar Forest Ranges in Chhattisgarh. Improved variety of paddy seeds and conoweeder were also provided for scaling up of this practice.

4. WADI System – A tree-based Farming System

Brief about the practice: WADI is a kind of tree-based farming system to promote agroforestry and has been practiced traditionally in India. The concept of WADI includes an integrated approach of agriculture, horticulture and forestry systems and aims at promoting socio-economic empowerment of the communities as well as conservation of soil and water resources. A `Wadi plot' is a piece of family-owned land that is developed for agro-horti-forestry system along with soil and water conservation measures. This practice is suitable for low productive lands and drought prone areas, it improves soil productivity and enhances farmers' income through intercropping with pulses and vegetables.

Scaling up of the practice: A total of 16071 households in Chhattisgarh and Madhya Pradesh were provided with bunch of tall seedlings of fruit trees of grafted mango, guava, custard apple, lemon, amla, drum sticks/ jack fruit (two plants of each species) for scaling up of this practice. About 192852 tall plants were distributed and planted under this practice. Technical support in the form of capacity building and technical know-how on planting techniques were provided to the beneficiaries.

In addition, seeds of improved varieties of Rabi season vegetable crops (tomato, radish, carrot, cauliflower, green pea, spinach, coriander, mustard green, fenugreek and amaranthus) to 14320 households and Kharif season vegetable crops (brinjal, chili, french beans, lady finger, cucumber, pumpkin, bottle gourd) to 13100 households for were also provided along with technical support in the form of capacity building and technical know-how on seed sowing and planting techniques. Local communities of the project areas cultivated the vegetable crops which they used for self-consumption and seed collection. Some of the beneficiaries sold the extra vegetables in the local market and earned on an average Rs. 4000/- additional income in a season.

5. Vermicomposting for Sustainable Land Productivity

Brief about the practice: Vermicomposting is a method that uses earthworms to break down, accumulate, detoxify, and convert various waste materials such as organic residues, straw, husk, leaves, stalks, weeds etc. into manure that improves crop productivity and soil health. Vermicomposting aims to enhance the land productivity along with maintaining the ecological balance through utilization of locally available resources. Vermicompost creates a favourable environment for beneficial microorganisms; permanently improves soil quality; prevent soil erosion; increases water-holding capacity of soil, and ultimately increases crop productivity.

Surface dwelling earthworms (*Eudrillus engenial, Eisenia foetida* and *Peronyx excavatus)* are good for vermicomposting. Vermicompost bed can be installed/ constructed in places having shade and are humid and cool. Size of the vermibed depends on availability of space and amount of compost required. Dimension of the bed should be such that works such as mixing of material, harvesting of compost etc. are easily carried out by hand. Different types of beds/ structures such as HDPE vermicomposting beds and structures made of bricks and cement, old cement bags can also be used for vermicomposting. Dimension of the bed should be such that works such as mixing of material, harvesting of compost etc. are easily carried out by hand. In case of HDPE vermibeds, vermiwash outlet is placed in the bottom of the bed at one corner to collect the vermiwash which can be used as biopesticide/ biofertilizer. The surface of vermibeds is wetted and a layer 2-3 inches of crop residue, farm waste and dry grasses is spread over the bed. Waste organic matter (kitchen waste and all biodegradable waste etc.) is filled in the bed. The bed is then filled with 10-15 days old cattle dung up to 1 to 1.5 feet height. After this water is sprinkled (once in 5-6 days) over the bed. After every 2 days, material is mixed and after 5-6 days when the temperature of the material is suitable for earthworms i.e. not warm, earthworms are added uniformly over the material. For a vermibed of size 12 X 4 X 2 ft, 3 kg of earthworms are required. A layer of gunny bag/ banana leaves is placed over the entire bed to protect the earthworms from its preys and also activity of earthworms is enhanced in dark conditions. Maintain 60% moisture throughout the vermicomposting period.

In 45-50 days vermicompost is ready for harvesting, stop watering the bed so that earthworms move towards the bottom of the bed. Vermicompost can now be harvested for application in the fields. Earthworms can be used for next cycle of vermicomposting.

Scaling up of the practice: Vermicomposting unit consisting of vermibed along with shade net, outlet pipe for collecting vermiwash, bamboo sticks for installation and earthworms (3 kg/unit) along with necessary technical support in the form of capacity building and technical know-how on preparation and application of vermicompost were provided to the local communities of Madhya Pradesh and Chhattisgarh. Knowledge products on vermicomposting were also provided to the local communities for creating awareness and enhancing their knowledge base. A total of 5022 vermicomposting units were established in Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi, Pali, Pandaria West and Raghunathnagar Forest Ranges in Chhattisgarh. Average saving @ Rs. 3000/- per household per year was observed due to saving in the cost of purchase of chemical fertilizer and additional benefits in the form of organic food.

6. Micro Irrigation System for Enhancing Water Use Efficiency and Productivity

Brief about the practice: Water being the most critical input for agriculture, its judicious use is important to ensure sustainable productivity and food security. The Government of India is promoting micro irrigation with the objective to enhance water use efficiency in the agriculture sector by appropriate interventions like drip and sprinkler irrigation. Micro irrigation techniques not only help in water saving, but also in reducing fertilizer usage, labour expenses, and other input costs, besides sustaining soil health.

Drip Irrigation System involves dripping water onto the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Drip irrigation helps in conservation of water and is best suited in water scarce areas and in undulating terrains. Water is applied close to plants so that only part of the soil in which the roots grow is wetted and this provides a very favourable high moisture level in the soil for better growth and development of plants. Drip irrigation increases crop yield, utilization of water is optimum and is cost effective. Drip Irrigation System contains main/ submain poly tube, laterals (emitting pipes), screen filter, grommet, lateral end stop, compression adaptor, compression elbow, control valve, compression end cap, water storage tank, connector for connecting non-return valve/ gate valve and screen filter. Gravity based drip irrigation system operates on gravity pressure and are suitable for smaller areas for cultivation of vegetables, cereals, pulses, cotton and other closely spaced crops. These systems do not require electricity, are portable systems that can be easily shifted.

Sprinkler irrigation system is similar to natural rainfall where water is distributed through a system of pipes usually by pumping. Sprinkler irrigation is suited for most of the row, field and tree crops. Sprinkler irrigation is adaptable to any farmable slope, whether uniform or undulating. Sprinklers are suitable for most soils (except for those which form crust easily) but are best suited for sandy soils with high infiltration rates. Sprinkler irrigation system allows application of water under high pressure with the help of a pump. It releases water through a small diameter nozzle placed in the pipes. Water is distributed through a system of pipes, sprayed into air and irrigates most of the field due to wide range of discharge capacity. Portable sprinkle system consists of pump unit, mainline and sometimes sub mainlines, sprinklers. The most common type of sprinkler system

layout consists of a system of lightweight aluminium or plastic pipes which are moved by hand. The rotary sprinklers are usually spaced 9-24 m apart along the lateral which is normally 5-12.5 cm in diameter. The lateral pipe is located in the field until the irrigation is complete. The pump is then switched off and the lateral is disconnected from the mainline and moved to the next location. It is re-assembled and connected to the mainline and the irrigation begins again. The lateral can be moved one to four times a day. It is gradually moved around the field until the whole field is irrigated. Sprinkle irrigation system is suitable in all types of soil except heavy clay, saves water up to 30% - 50 %, suitable for irrigation where the plant population per unit area is very high, helps to increase crop yield, reduces soil compaction and suitable for undulating land.

Scaling up of the practice: To avoid overuse of water during irrigation, enhancing productivity and to promote conservation of water resources, gravity-based drip irrigation system for vegetable crops covering 0.01 ha and portable sprinkler irrigation system for covering 0.4 ha area were provided to the beneficiaries of Madhya Pradesh and Chhattisgarh. 4066 units of gravity-based drip irrigation system were installed in Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi, Pali, Pandaria West, Narharpur and Raghunathnagar Forest Ranges in Chhattisgarh and 1198 portable sprinkler irrigation system were installed Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh for scaling up of micro

irrigation systems. Technical support in the form of capacity building and technical know-how on operation and maintenance of micro irrigation systems were also provided.

7. Azolla Cultivation

Brief about the practice: Azolla also known as mosquito fern, is an aquatic free-floating fern that appears as a green mat over water and fixes atmospheric nitrogen with the help of blue green algae (*Anabaena azollae*) present as a symbiont. The rate of nitrogen fixation is about 25 kg/ha. Azolla is a rich source of protein and minerals. Azolla takes shape of a thick mat within seven days of inoculation. After the seventh day, 1.5 kg of Azolla could be harvested every day. Azolla can be used as a bio-fertilizer/ green manure, a mosquito repellent, and above all as a bio scavenger as it takes up heavy metals. Azolla is suitable for paddy cultivation and increases the rice production by 20%. It is also used as evergreen fodder for cattle, poultry and fish. Harvested Azolla needs to be washed in freshwater before it is fed to the cattle. Azolla cultivation is done in Azolla growing beds which can be of HDPE or cement and of different shapes and sizes. Sieved soil mixed with cattle dung and water is evenly spread at the bottom of bed. Bed is filled with water up to a height of 10 to 15 cm above the soil. Layer of foam and scum formed on the surface of the water is removed as it hampers the growth of Azolla. Azolla inoculum is spread over the surface of the water in the bed.

In 1-2 weeks, a mat of Azolla is formed over the water surface. It is important to maintain water level in the bed especially during the summer months. Azolla bed is covered by shade net to reduce excessive ambient light.

Scaling up of the practice: Azolla cultivation units comprising of UV treated HDPE Azolla growing bed of size 12' x 6' x 1' (> 1.5 ft length and > 30 mm diameter) for bed support and water tap for outflow of water, stitched green shade net (75% shade factor) of size 12' x 10' with 6 UPVC pipes (11-13' length and > 25 mm diameter) for installing shade net, steel sieve and 3 Kg per unit of Azolla seeds were provided and installed for 7000 beneficiaries in Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi, Pali, Pandaria West, Narharpur and Raghunathnagar Forest Ranges in Chhattisgarh. Technical support in the form of capacity building and technical know-how for cultivation and uses were also provided. Technical know-how along with a guide book (Hindi) were given to the beneficiaries for scaling of the practice. Beneficiaries used Azolla as a feed for livestock, poultry and fish. This practice reduces the feed cost and results in increased milk yield.

8. Biopesticides and Biofertilizers Preparation for Sustainable Land Productivity

Brief about the practice: Biopesticides and biofertilizers aim to enhance the land productivity along with improving the soil health and maintaining the ecological balance. It promotes the utilization of locally available natural resources for the preparation of biopesticides and biofertilizers without the use of chemical fertilizers and pesticides. It aims to enhance the sustainable land productivity and promote organic farming. Some of the common biopesticides and biofertilizers are discussed below:

- *Neemastra* is a natural insecticide/ pesticide used to control nymph-sucking insects and mealybugs. Necessary material required for its preparation are leaves of *Azadirachta indica* (5 kg), Neem cake (5 kg), fresh cow dung (3 kg), cow urine (10 litre) and HDPE open top drum (200 litre). Crush neem leaves and neem cake and put them in the drum. Add cow dung and cow urine in the drum and stir the mixture. Now cover the top of drum with cloth and put it in shade. Regularly stir the mixture in clock wise and anti-clock wise direction. *Neemstra* will be ready in a day. Sieve the mixture with cotton cloth and keep it in a covered drum under shade. Mix 10 litre of *Neemastra* in 200 litre of water for spraying in 1 acre field.
- *Amrit Pani* is an excellent biopesticide that is effective against a wide range of insect pests. It also helps in enriching the soil. Necessary material required for preparation of *Amrit Pani* are fresh cow dung (1 kg), cow urine (1 litre), leaves of *Azadirachta indica* (1 kg), jaggery 100 gm), pulses flour (1kg) and HDPE open top drum (200 lit.). Put all the material in the drum and mix well. Now cover the top of drum with cloth and put it in shade for 10 days. Stir the mixture in the morning and evening in clock wise and anti-clock wise direction for 5 to 10 minutes. After 10 days sieve the mixture with cotton cloth. Mix 1 litre of *Amrit Pani* in 100 litre of water for spraying in 1 acre field. *Amrit Pani* should be sprayed every 15 days for effective protection against insect pest.
- *Jeevamrit* is an excellent source of natural carbon and biomass that contains macro and micro nutrients required by crops. Necessary material required for preparation of *Jeevamrit* are cow dung (10 kg), cow urine (10 litre), jaggery (1 kg), pulses flour (2 kg), water (180 litre) and HDPE open top drum (200 litre). Put all the material in the drum and mix well in clock wise and anti-

clock wise direction for 5 to 10 minutes. Repeat the process for 6-7 days and when bubbles stop forming in the mixture, sieve the mixture with cotton cloth and keep it in shade. *Jeevamrit* can be used along with irrigation after 21 days of seed sowing and should be repeated after 21 days.

- *Dashparni* is a completely natural and organic plant-based product effective in controlling all kinds of insect pests and diseases. Necessary material required for preparation of *Dashparni* are leaves of *Azadirachta indica* (5 kg), leaves of *Cleistanthus collinus* (2 kg), leaves of *Pongamia pinnata* (2 kg), leaves of *Nerium oleander* (2 kg), leaves of *Jatropha curcas*/ *Ricinus communis* (2 kg), leaves of *Vitex negundo* (2 kg), leave of *Annona squamosa* (3 kg), leaves of *Gossypium* sp. (2 kg), leaves of *Carica papaya* (2 kg), leaves of *Tinospora cordifolia* (2 kg), cow urine (5 litre), cow dung (2 kg), water (170 litre) and HDPE open top drum (200 litre). Remove all leaves from stem and put them in the drum along with other material. Mix properly and cover the top of drum with cloth and put it in shade for 30 days. Every morning and evening mix the mixture in clock wise and anti-clock wise for 5 to 10 minutes. After 30 days sieve the mixture with cotton cloth. Mix 6 to 10 litre of *Dashparni* with 200 litre of water for spray in 1 acre of field.

- *Bijamrit* is an excellent biopesticide for seed treatment before sowing. Necessary material required for preparation of *Bijamrit* are cow dung (5 kg), cow urine (5 litre), fertile soil (50 gm), slaked lime (50 gm), water (20 litre) and HDPE open top drum (200 litre). Take cow dung in a cloth and tie it properly and hang it in 20 litre water for 10 to 12 hours. Add 50 gm slaked lime in 1 litre of water and leave it overnight. Next morning, squeeze this bundle of the cow dung in that water thrice continuously, so that all essence of cow dung is accumulated in that water. Add soil, cow urine and limewater to the solution and stir it well. Cover the top of drum with cloth and put it in shade.

- *Brahmastra* is the most effective biopesticide which protects all types of crops from all kinds of insect pests as well as diseases. Necessary material required for preparation of *Brahmastra* are cow urine (10 litre), leaves of *Azadirachta indica* (3 kg), leaves of *Pongamia pinnata* (2 kg), leaves of *Annona squamosa* (2 kg), *Ricinus communis* (2 kg), leaves of *Aegle marmelos* (2 kg) and *Datura stramonium* (2 kg) and HDPE open top drum (200 litre). Crush all the leaves and mix in cow urine. In earthen pot put this mix and boil 4-5 time, let it cool in shade for 48 hours and sieve with cotton cloth.

Scaling up of the practice: Capacity of the local communities of Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi, Pali, Pandaria West, Narharpur and Raghunathnagar Forest Ranges in Chhattisgarh was built for preparation and application of biopesticides and biofertilisers namely *Neemastra*, *Amrit Pani*, *Bijamrit*, *Brahmastra*, *Dasaparni* extract and *Jeevamrit* through organizing trainings at village level. Live demonstrations on preparation of biofertilizer and biopesticides were also given to the local communities in all the ESIP villages. Knowledge products highlighting details about the methods for preparation of biopesticides and their application were also distributed to the local communities for creating awareness and enhancing their knowledge base. Scaling up of biopesticides and biofertilizers preparation and application for sustainable land productivity was done by including all the households of 85 villages through formation of clusters. A set of three HDPE open top drums (200 liter) was provided to each cluster along with necessary technical support. Before scaling up of this practice, local communities were using chemical pesticides and fertilizers for protecting their crops from pest and diseases and investing about Rs. 1000/- per crop/ beneficiary for

procurement of pesticides. Now, they have started preparation and application of biopesticides and biofertilizers in their agricultural fields for enhancing sustainable land productivity, and saved a sum of Rs. 1000/- per crop/beneficiary.

9. Improved Cook Stoves for Addressing Forest Degradation

About 72% rural population in the state of Madhya Pradesh and about 76% rural population in the state of Chhattisgarh are dependent on agriculture and natural resources for sustenance. Madhya Pradesh and Chhattisgarh, local communities mainly depend on fuelwood as a primary source of energy for cooking and heating. Local communities were using traditional three stone *chullah*. On an average 17 to 20 kg of fuelwood was collected on daily basis by each household from the nearby forest areas. Maximum distance travelled by the local communities for fuel wood collection in the forest areas varied from 2 to 5 km and time spent varied from 5 to 8 hours depending upon the availability of fuel wood in forests. Women play major role in fuelwood collection in the states of Madhya Pradesh and Chhattisgarh and their maximum time was consumed in fuel wood collection. Furthermore, the open fires and traditional *chullah* consume more fuelwoods and release significant amount of carbon and causes respiratory diseases such as bronchitis and pneumonia. To address the problems associated with traditional cookstove, improved cookstoves (ICS) with improved efficiency were developed with the aim to reduce

deforestation, save cooking time, reduce health impacts through a reduction in environmental emissions, save money, and improve cooking satisfaction. ICS have been designed to maximize thermal and fuel efficiency and minimize emissions that are harmful to human health.

Scaling up of the practice: ICS were provided to 13055 households in Bhaura, Budhni, Banapura, Itarsi and Sukhtawa Forest Ranges in Madhya Pradesh and Marwahi, Pali, Pandaria West and Raghunathnagar Forest Ranges in for addressing the driver of land degradation and to improve the ecosystem services. ICS distributed to the local communities met all the standards prescribed by the Ministry of New and Renewable Energy, Govt. of India. Technical know-how was also provided to the local communities on usage of ICS. Distribution of ICS benefitted 39165 direct beneficiaries. As a result of ICS usage, fuel wood consumption was reduced to about 35 to 45%, and smoke emission was also reduced. ICS provided multiple benefits to the local communities and contributed in improvement of the ecosystem services through addressing forest degradation.

7.3. Success Stories under Ecosystem Services Improvement Project

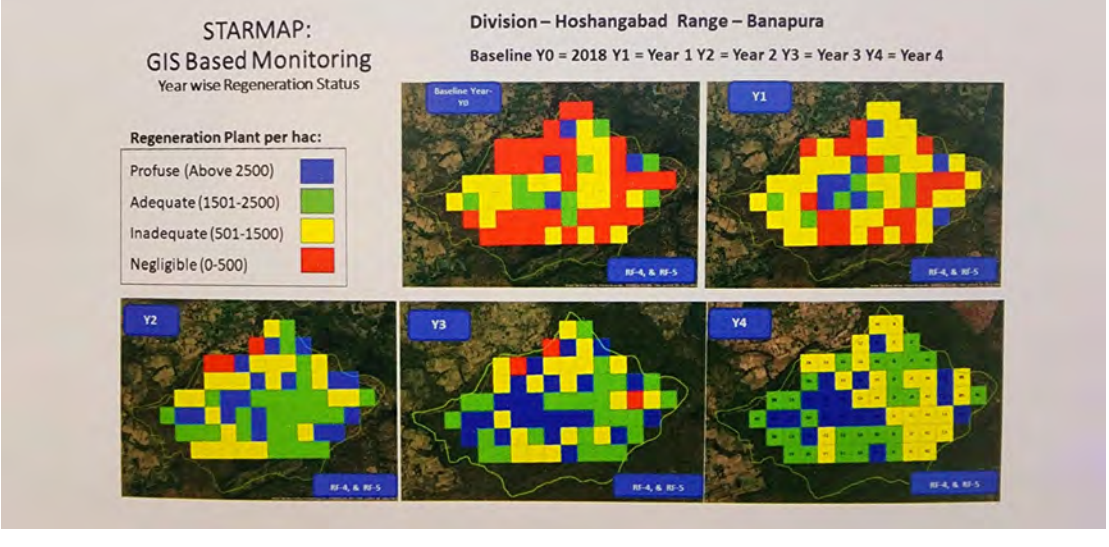
Some of the success stories related to SLEM of Madhya Pradesh Forest Department under are highlighted below:

1. Mahua net- A tool to combat fire

Madhuca longifolia (Mahua) flowers are added source of income for the villagers of Madhya Pradesh and Chhattisgarh as they collect the flowers from the forests in the month of March and April and sell them to liquor manufacturing companies. The traditional practice followed by the villagers for collecting Mahua flowers was to first clean the ground followed by fire to burn dried leaves and shrubs under and around the trees. This practice destroys natural vegetation and spreads forest fires. Under the traditional practice more time of the villages was consumed in collection of flowers and since flowers got soiled by falling on the ground, therefore cleaning of flowers also required additional time and would fetch less price. To overcome the problems associated with traditional method of Mahua flower collection, Madhya Pradesh State Forest Department introduced Mahua nets for collecting Mahua flowers and provided these nets to the local communities. Nets are tied to the trees (two to a tree) and suspended to catch the flowers preventing them from falling to the ground. The nets ensure that the flowers don't get soiled and are not trampled on by animals. The nets have helped villagers save time as it is not required for them to remain for long durations in the forest for collection of the flowers picking the flowers as they fell. While the flowers get collected in the nets, the villagers have time to do their other works. At the end of the day, the flowers are easily collected in straw baskets, dried, and stored for sale.

2. STARMAP- Guiding Restoration with Spatial Precision

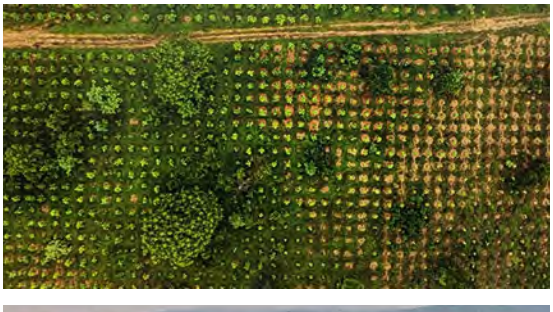
Spatial Technology Approach for Restoration, Mapping and Planning (STARMAP) is a well establish methodology of GIS based online monitoring of treated areas (landscape restoration) and planning of the interventions (tree planting, fencing, water conservation measures etc.).



STARMAP offers a range of positive impacts, including improved planning, targeted resource allocation, enhanced monitoring and data evaluation, stakeholder engagement, and long-term sustainability. By harnessing the power of spatial analysis, STARMAP can help optimize restoration efforts and contribute to the conservation and restoration of ecosystems. The technology is also used for monitoring, impact analysis and progress of the restoration interventions, such as planting and assisted natural regeneration. The system uses drones to take geo-referenced photographs before and after interventions. To make the monitoring part easy a Mobile App (Forest Restoration Monitoring System) was also developed. Using this App, surveying, KML file creation, detailed plantation report can be directly uploaded on the web portal through smart phone. STARMAP has been developed by Madhya Pradesh State Forest Department for monitoring and evaluation of forest restoration works.

3. Restoring the Green Jewel

Madhya Pradesh State Forest Department carried out ecosystem services improvement activities in three landscapes namely Sehore, Narmadapuram, and North Betul Forest Divisions. The implementation units adopted for these landscapes were milli-watersheds and micro-watersheds. A total of 3,624 hectares of land consisting of degraded forests and moderately dense forests showing signs of degradation, was selected for restoration efforts such as site-specific tending operations and assisted natural regeneration to improve their ecological condition. In North Betul 1,175,963 seedlings of various native species, including rare endangered and threatened species, were planted with the aim to enhance biodiversity and restore natural ecosystem. In Narmadapuram 8,924 and in Sehore 8,924 soil and water conservation units were created to increase the ground water level and maintain moisture in the soil. These restoration efforts made showcased successful models for adaptation-based mitigation. Improved ecological conditions, enhanced biodiversity, and livelihood benefits are some of the benefits of SLEM interventions in the area. The restoration activities, including site-specific tending operations, assisted natural regeneration, and the planting of native and RET species, played a crucial role in rejuvenating degraded forests.

7.4. Success Stories from MGNREGS

The Ministry of Rural Development, Government of India launched Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) under the Mahatma Gandhi National Rural Employment Guarantee Act 2005. The scheme supports sustainable management of land and water resources for development of rural landscapes through employment generation to the rural communities of the country. MGNREGA Division, Ministry of Rural Development has documented 117 case studies on water conservation in the form of '*Jal Sangrah*- Stories of Water Conservation under MGNREGA' (DoLR, 2019 a, b & c). Some of the case studies from *Jal Sangrah* are given below:

1. Rejuvenating Khorichimali stream to recharge lives

Amba Talat village in Dharampur Taluka, Valsad District, Gujarat is located in high rainfall zone (2,422 mm average rainfall) of southern hills. Village population comprises mostly of tribal, mainly dependent on agriculture for livelihood. Khorichimali (a tributary of Tan) fulfils the water requirement of the village. Due to undulating and hilly terrain of the area, fast run-off of rainwater in stream causes excessive soil erosion and minimum groundwater recharge. As a result, the surrounding farms were facing severe water stress and extended spells of dry seasons. Watershed development approach 'Ridge to valley' was followed and constructed 23 check walls, 1,330 running metre earthen field, 2,000 stone bunds, 30 farm ponds, 13 *pakka nalas* and 3 gully plugs in and around Khorichimali. Block plantation on barren and uneven lands of farmers was also taken up. After interventions, with increased access to water and improved soil moisture, farmers started cultivating vegetables like little gourd, bitter gourd and bottle gourd, while paddy remained the major crop. As a result of rejuvenation of Khorichimali, 750 hectares of farmland and 341 households were benefitted. The comprehensive treatment of Khorichimali stream and surrounding farmlands have resulted in ecological benefits such as increase in groundwater table, improvement in the quantum of surface water, increase in tree cover, decrease in soil loss and improved farm productivity.

2. Working towards Water Security: Oliamba's Tale of Triumph

Oliamba village, Chhota Udepur District, Gujarat is predominantly populated by the Rathwa tribe. To the north of the village lies Orsanga tributary of Narmada river. Village has undulating land interspersed with small hills, rivers and nallas. Two-thirds of the village land is under agricultural use, most of which (91%) is rainfed. In rabi season due to lack of work in the village people migrate with their families to other parts of Gujarat, mainly to Saurashtra, for livelihood. Oliamba had been facing severe water scarcity due to excess run-off of surface water and low infiltration of water into the soil. This, in turn, affected supply of water for irrigation of farmland. Quantity of rainfall was diminishing in Chhota Udepur Taluka due to indiscriminate felling of trees, which also exacerbated erosion of topsoil. Insufficient and untimely rains made farming not viable in Oliamba. Crop failure was also very common. In order to address this issue, the Gram Panchayat and MGNREGS team collectively identified a common land closer to the farms for taking up water conservation works. Water harvesting structures such as check dams, check walls, earthen bunds, percolation tanks, van talavdis; and soil and moisture conservation activities such as contour trenches, stone bunds, farm bunds, land levelling and afforestation were undertaken. As a result, 86.5 hectares of land was treated and 30 households were benefitted. Due to this intervention

groundwater table improved, net sown area and agricultural production of the village increased thereby migration and school dropout ratio reduced.

3. Saving Rainwater for Prosperous Future of Farmers of Thimmaipally Thanda Village

Thimmaipally Thanda *Gram Panchayat* situated in Addakal Mandal, Mahabubnagar District, Telangana is surrounded by hills with undulating terrain. Agriculture was predominantly rainfed, and village recorded high rate of crop failure due to erratic rainfall. In the absence of any other source of irrigation, numerous borewells were dug which led to groundwater depletion over the years. Scarcity of water lead to migration of villagers in search of employment. *Gram Sabha* decided to revive agriculture by construction of rainwater harvesting structures such as digging of staggered continuous trenches, excavation of percolation tanks, desilting of a minor irrigation tank and digging of soak pits. Staggered continuous trenches aided in cultivation of 88 acres of land belonging to tribal farmers of the village. In addition to reduction of soil erosion, there was also an increase in availability of fodder and drinking water for livestock. Silt deposition in farm ponds and percolation tanks downstream was reduced and water availability in wells and tanks in downstream areas had increased. Because of improvement in the groundwater table, water was found at a depth of 20 feet. It increased flow of water in borewells in the vicinity. After increase in area under cultivation and resultant increase in farmers' income, migration of villagers reduced.

4. Slow the Flow and Save Water: A Tribal Initiative of Ranjan Tanda village

Ranjan Tanda village, Gram Panchayat Kubeer Mandal, Nirmal District, Telangana has hilly terrain and experiences severe drought in summer. Enhancing agricultural production and increasing availability of fodder for cattle and conserving water was imperative for improving livelihoods of people. Gram Sabha decided to resolve water scarcity issue through creation of water harvesting structures such as staggered trenches in ridges of the hills and individual farm ponds. Staggered trenches created in the upper ridges of the village arrested the flow of water and aided in percolation of groundwater thus prevented soil erosion. As a result, water flow from borewells increased, thus meeting domestic and agricultural water requirement of the village. Farmers moved from cultivating food crops like wheat, jowar and pulses to commercial crops like cotton. Increase in production of fodder was also reported. The individual farm pond had increased the crop production by 20–25%.

5. Water Conservation for Improved Horticulture

Kondamanayunipalem village, Kadiri Mandal, Anantapur District, Andhra Pradesh had its water table continuously decreasing due to dry spells and frequent droughts. Majority of farmers depended on groundwater for irrigation and were not able to cultivate their lands due to water scarcity. This, in turn, forced them to migrate to nearby areas in search of livelihood. In the Gram Sabha meeting, it was agreed to develop the village land using ridge to valley approach, which included taking up several activities like digging trenches and sunken pits across the slope of hillocks to address the problem of water scarcity. Staggered trenches and sunken pits were dug on 465 acres of common land along the slopes of the hillocks. After intervention, the green cover over the barren hillocks increased significantly. In the downstream, 25 acres of barren land was brought under cultivation, and the water level increased in 14 wells and 70 borewells. Approximately, 200 households were benefited and fallow lands of many farmers were brought under mango

plantation. Farmers started intercropping mango orchard with bottle gourd, tomato, green gram, leafy vegetables, groundnut, thus doubled their income.

6. Transformation of K.P. Agraharam Gram Panchayat: From Acute Water Shortage to a Water Surplus Village

K.P. Agraharam Gram Panchayat, Butchayyapeta block, Visakhapatnam District, Andhra Pradesh falls under the north coastal zone of Andhra. The terrain of the village comprised of hillocks, rocky red soils at the foothill and gravel red soils. Despite good rainfall during monsoon, village faced severe water shortage problems due to lack of proper water storage facilities. Staggered trenches, 24 farm ponds, 2 check dams, 2 percolation tanks and 5 minor irrigation tanks in downstream of the Kokkirala Konda stream were constructed. The construction of a series of check dams and percolation tanks had increased the groundwater level, which in turn led to recharge of 13 borewells and increase in area under cultivation. Farmers started cultivating multiple crops and as the farmers shifted to commercial crops, their income has doubled.

7. A Dam Conserving Rainwater - Preventing Migration of Villagers

Alaburu Gram Panchayat, Hagaribommanahalli block, Ballari District, Karnataka was facing water shortage issues due to which families living there were prone to distress migration. In order to recharge the groundwater table and to increase the irrigation potential of the locality, the villagers decided to harvest the rainwater by constructing multi-arch check dams so that the effects of drought are mitigated and durable water conservation assets are created. The check dams would help to prevent soil erosion, conserve soil moisture and recharge aquifer. Catchment area of the check dam was 25 hectares, and storage capacity was about 4,250 m^3. Construction of multi-arch check dam resulted in increase in groundwater table. Storage of rainwater led to the cultivation of 12 hectares of additional land of farmers. It supported the surrounding vegetation cover for livestock grazing and natural regeneration of the local forest area. In addition to an increase in the water table in wells and tube wells, the check dam also served as the source of drinking water for more than 1,500 livestock. It played a significant role in preventing the migration of villagers during the drier months.

8. Stream Rejuvenated - Ecological Balance Regained

Karippechal stream flows through Cherthala South, Kadakkarappally and Kanjikuzhi Gram Panchayats of Kanjikuzhi Block Panchayat of Alappuzha District, Kerala. Over the years, the deposits from the shoreline and river pollution silted the flow of the stream, causing flood and other related disasters during the rainy season. This affected the lives of the people, especially those who were living on the shoreline. The floods also led to unhealthy living conditions such as contamination of drinking water, improper sanitation facilities, waterborne diseases, etc., during the monsoon season. Authorities had to shift 100–150 families residing on both sides of the stream to camps for about 4–5 months during the monsoon season. The revival of the stream was done by desilting on a stretch of 5.7 km and at a depth of 1 m. About 55,000 m^3 of silt was transported from the stream to the nearby agricultural lands. As a result of rejuvenation of the stream, the ecological balance was regained, and the ecosystem was re-established in the area surrounding the stream. Additionally, the cropping area was increased by 20 hectares, disease-causing vectors were eliminated and water holding capacity of stream was increased.

Approximately, 50 families were benefited in terms of increase in agriculture produce. No flood was reported during subsequent monsoon and many residents installed fishing nets and earned around Rs. 700 per day per net. The farmer also started seasonal vegetable cultivation.

9. Peruvanthanam's Journey Towards Water Sufficiency

Peruvanthanam Gram Panchayat located in Azhutha block of Idukki District, Kerala a hilly terrain, receives abundant rainfall during the monsoon season. However, the rainwater drains off entirely and Percolation of water is also limited due to topography of the area. This resulted in a severe shortage of water during summer and villagers had to depend on water tankers for their drinking and household needs. Three check dams were constructed at three different locations in the village. After intervention nearly 1,200 villagers in the upstream tea plantation area were benefitted and provided adequate water supply throughout the year to nearly 450 households. With better irrigation, the cultivable land area increased by approximately 150–200 acres. Families stopped purchasing water from private suppliers.

10. Reviving Aquifers Through Recharge Wells

Eachangadu village in Mathur Panchayat Union, Krishnagiri District of Tamil Nadu had water demand greater than its availability. This made groundwater recharge a crucial aspect for overall water resource management through revival of aquifers in the area. Water conservation and harvesting structures such as construction of recharge wells and renovation of minor irrigation tank were undertaken to augment and improve the level of groundwater. The recharge wells were constructed in the area of a minor irrigation tank spreading over an area of 5.53 hectares. The capacity of the recharge well was 106 m^3. Besides, the renovation of traditional water bodies also helped in drought mitigation. Groundwater table increased by 2 ft in 18 open wells and 15 borewells near the minor irrigation tank. About 130 acres of farmland was benefitted and irrigation area was increased by 35 acres, resulting in an increase in agricultural production and farmers' income by 10%. Overall, 535 villagers were benefitted from the project. The drinking water needs of both villagers and livestock were also being fulfilled.

11. Rejuvenating More Than 60,000 Lives Through Water Conservation Efforts

Kaniyambadi block in the Vellore District, Tamil Nadu is surrounded by hills and Naganadhi River. The Naganadhi River flows through eight panchayats. One of the biggest problems faced by Vellore District was water scarcity, which had seriously affected the rural areas of Vellore where people depend on agriculture for their livelihoods. As part of the water conservation efforts to replenish the groundwater 349 recharge wells and 128 gabion structures were constructed in the drought-affected Kaniyambadi block. Construction of recharge wells enabled water percolation from the channels and direct the water back into aquifers to stabilize the water table. The wells not only helped in collection of water but also played a vital role in preventing floods. Gabion structures were constructed at 100–150 m intervals to reduce water velocity and to support the recharge wells. After the intervention a total area of 364 sq. km across 21 Gram Panchayats comprising nearly 60,000 farmers/people were benefitted. Earlier, the farmers in the block were cultivating two crops a year, mainly turmeric and paddy. As a result of the intervention, farmers started cultivating an additional crop every year and crop yield increased and groundwater level increase by about 4–7 ft.

Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management

Desertification and land degradation commonly understood as the reduction in land's natural capacity to perform essential ecosystem functions and services, is a key challenge. It has serious consequences for agriculture-based economies like India, where the economic emancipation of a substantial segment of the population is closely linked with land resources.

A SLEM baseline report on issues, challenges and prospects in sustainable land and ecosystem management highlighted several opportunities, shortcomings and complexity of the institutional arrangement for the management of land resources. It was recommended that a roadmap for integrating SLEM in various activities of line department need to be developed. It also emphasized that the roadmap should provide a practical step by step process for convergence of actions on land management. It should also outline the potential realignment of activities undertaken by various ministries and state government departments in the short, medium and long term (ICFRE, 2014 a).

A number of policy instruments on natural resource management with direct or indirect implications on land are also central to SLEM. Collectively, these policies attempt to advance the sustainable management of the country's natural resources. Institutions play a pivotal role in policy formulation, programme planning and implementation. The structure of institutions, knowledge, skills, finance, human resources at their disposal, the intra-relations within an institutional structure and interrelations with other institutions, and their autonomy in decision-making determine the effectiveness to deliver.

Land is a critical resource for supporting the livelihoods of most people living in the rural areas, and the access to land and allied resources is mediated not only by the economic positions of people but also by caste, gender, ethnicity, geographies and culture. Social aspects, therefore, are of primary concern in sustainable land and ecosystem management. Reduction of poverty and inequality are also key objectives of SLEM. Understanding the contribution and role of people in SLEM is important to engage them in the conservation and management of land, water and forest resources.

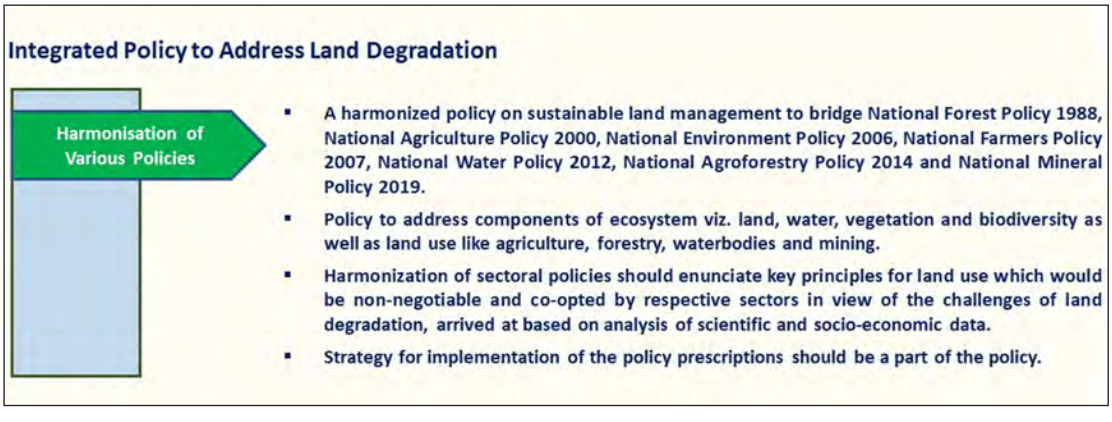
Policies, legislation and programmes have included and advanced the needs and interests of the rural communities and vulnerable groups on the aspects of equity, gender mainstreaming, livelihoods, traditional and indigenous practices, development and management of common property resources, and community rights and management of forests and biodiversity in the tribal regions. Continued emphasis has been given to community engagement in planning and programme implementation as well as in building capacities for playing their role. There are several schemes that combine livelihoods with sustainable management of resources. There are also legal provisions to provide the communities ownership and management of resources they have held traditionally. Various institutions such as Joint Forest Management Committees, Self-Help Groups, Watershed Committees and Water Users Associations have been created as part of these programmes which are the primary organizations through which communities can take care

of their resource and sustainability needs. Several schemes and programs of the Central and State Governments are being implemented for addressing the issues related to desertification, land degradation and drought in the country.

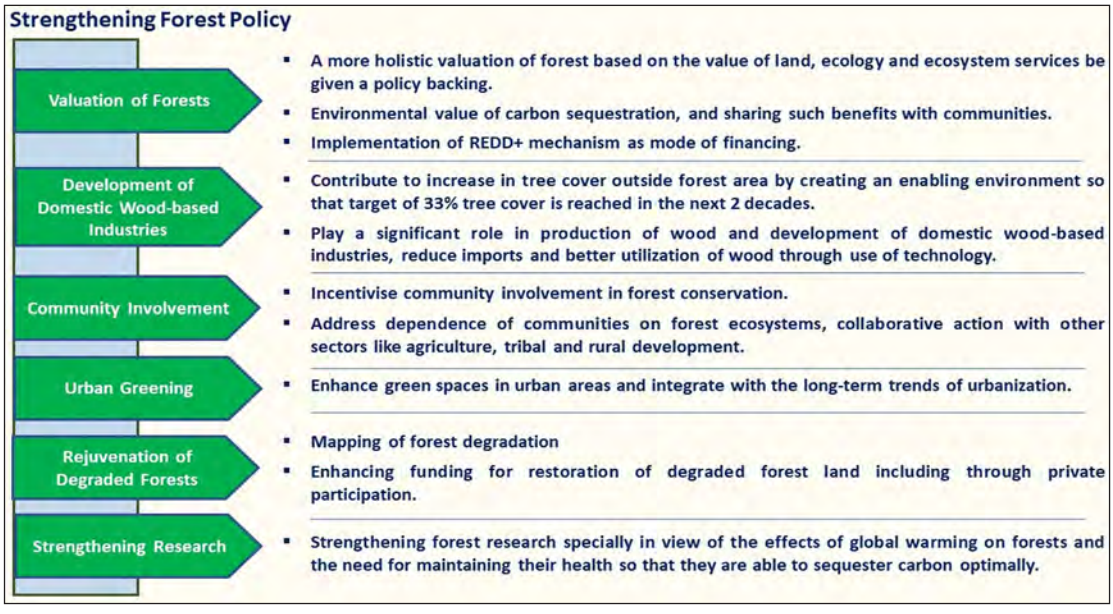
A roadmap for institutional and policy mainstreaming of SLEM in India was developed by ICFRE under the World Bank funded Ecosystem Services Improvement Project (ICFRE, 2022 a and 2022 b). The roadmap provides specific guidelines to different Ministries, Departments, Research Organizations and Civil Society Originations involved in restoration of degraded lands and combating land degradation and desertification. The roadmap also provides guidelines and action plans for achieving Land Degradation Neutrality, Sustainable Development Goals and Nationally Determined Contribution targets of India.

Key recommendations from the "*Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India*" are highlighted below:

1. **Integrated Policy on Land Addressing Land Degradation:** The issues that impact land degradation and conservation of ecosystems are enshrined in several policies such as the National Forest Policy of 1988, National Agriculture Policy of 2000, National Environment Policy of 2006, National Farmers Policy of 2007, National Water Policy of 2012, National Agroforestry Policy of 2014 and National Mineral Policy of 2019. The need to address land degradation has been mentioned as one of the aims in the passing while the policy remains focused on their core sector agenda. In a combined manner, too, the issue of SLEM does not rise to the level of importance that it ought to. An integrated policy on land degradation is required for the holistic management of issues concerning SLEM.

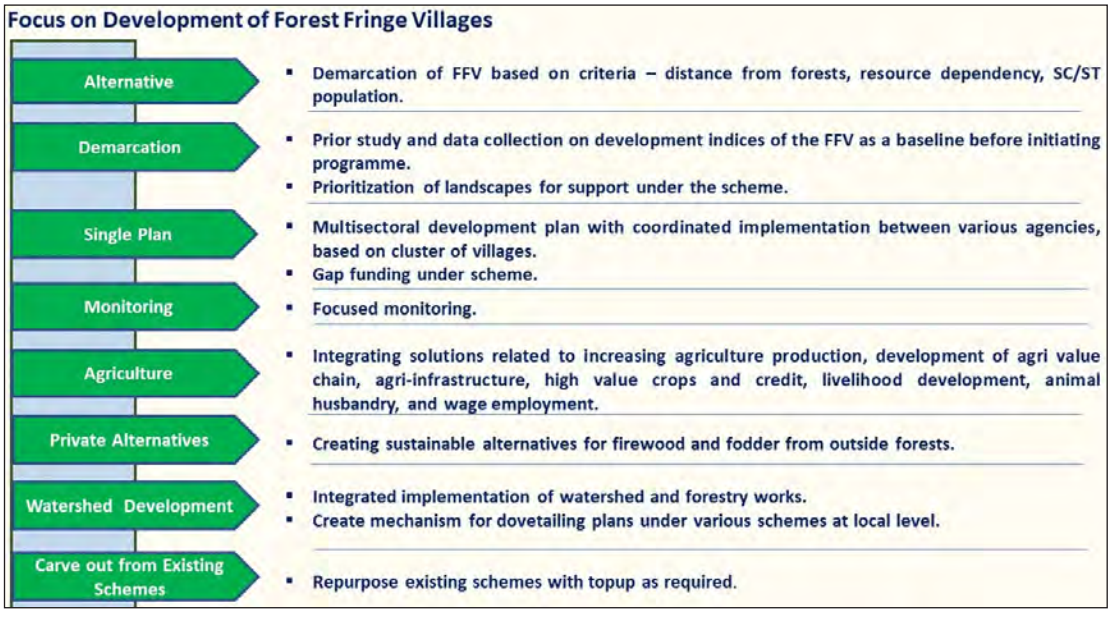


2. **Strengthening Forest Policy:** The National Forest Policy, 1988 has remained a sectoral policy so far, though many aspects of forest conservation depend on sectors outside the forests. The forestry sector has also evolved over the past three decades due deeper understanding of the role of forests in combating climate change, provisioning of ecosystem services and addressing the vulnerability of rural communities. The international understanding on the role of forests has also changed substantially after the 1992 Earth Summit. The role of judiciary has been critical in defining the boundaries and limitations of the legislations related to forests and wildlife in the country. However, these aspects are required to be enshrined in the forest policy in due course. Strengthening of the Forest Policy is therefore proposed.

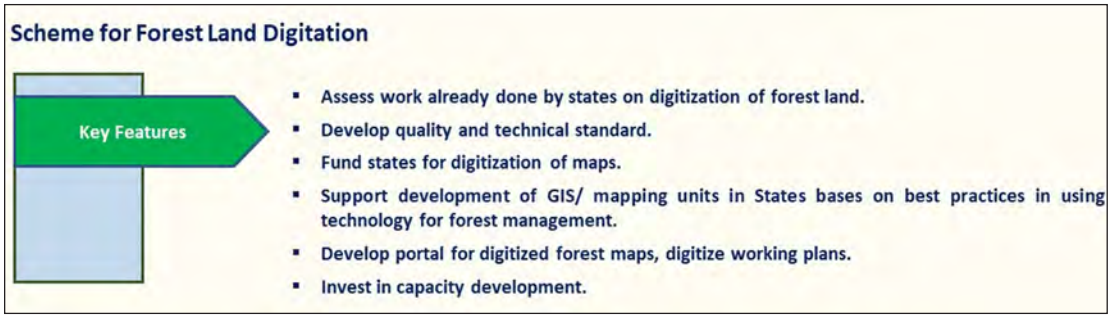


3. **Increasing Funding for Forest Programmes:** Funding at the Central government level has remained stagnant at about Rs. 8 to 9 billion, whereas that of the states combined is at about Rs 200 billion. On the other hand, about 30.5 Mha of forest land are categorized as open forest, i.e. having a canopy density between 0.1 to 0.4. Another 4.6 Mha of land falls under the category of Scrub, having a canopy density of < 0.1. Degraded forest land constitutes a significant proportion of these forest land categories. Restoration of such land has remained a long-term challenge, both from the perspective of finding resources and the local community's dependency on the resources. As the country's GDP grows, and along with-it resources collected in the form of tax and non-tax revenue also grows, the investment by the state in protecting and growing its natural capital should also increase. It is proposed that funding for the sector may be increased to tackle the challenges faced due to environmental degradation and climate change.

4. **Focus on Development of 'Forest Fringe Villages':** The Ministry of Environment, Forest and Climate Change, in collaboration with the Ministry of Agriculture and Farmers Welfare, Ministry of Rural Development and Ministry of Skill Development may consider initiating a special multi-sectoral scheme for the development of forest fringe villages with clear and measurable targets for improvement of various aspects of human development indices. This may be a new scheme or one that is carved out by dovetailing existing Rural, Agriculture and Tribal Sub Plan schemes.

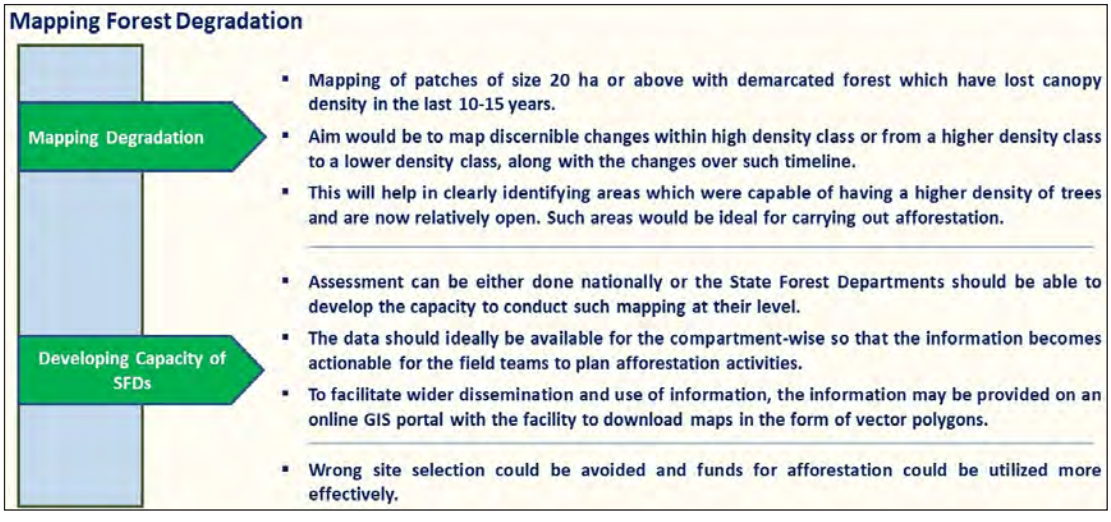


5. **Digitization of Forest Maps:** A scheme on forest land digitization covering all states and union territories for demarcation of forest boundaries and digitization of maps may be initiated. The scheme would also support mapping units/ GIS units in the states which would be helpful for field-level planning and monitoring.

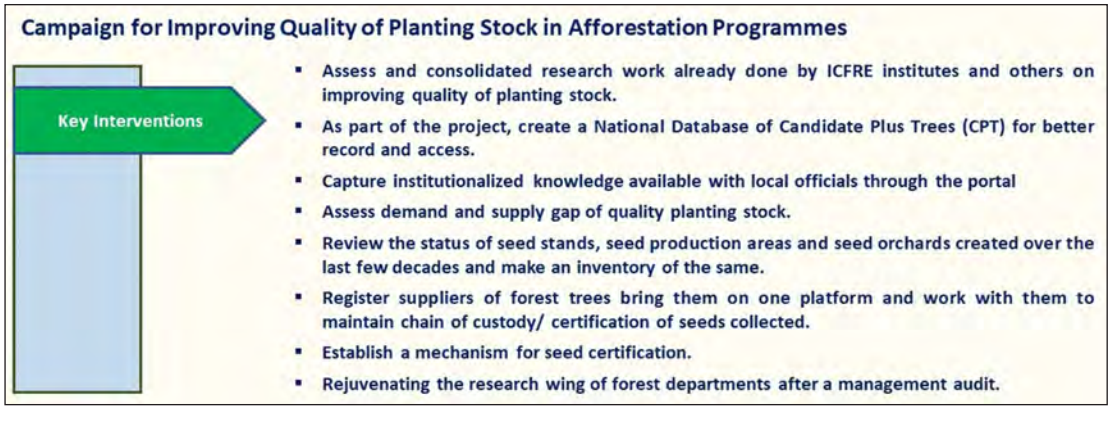


6. **Prioritization in Afforestation on Degraded Forest Land:** Mapping of areas within demarcated forests that have lost canopy density in the last 10-15 years would help in identifying areas for reforestation. This programme can be initiated by Forest Survey of

India and subsequently, the state forest departments should be able to develop their capacity to conduct such assessment at their level.



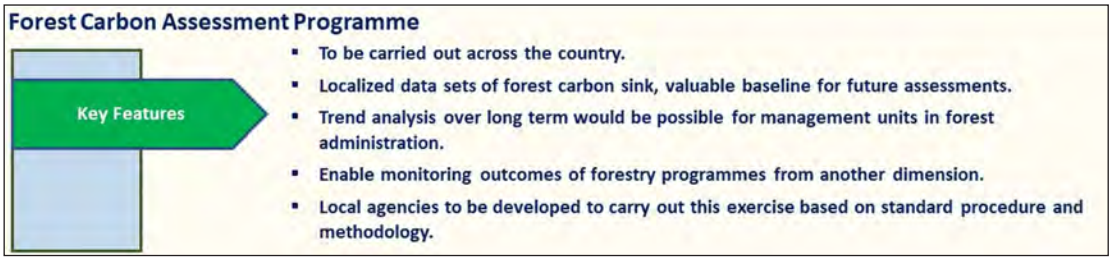
7. **Improving the Quality of Planting Material in Afforestation Programmes:** Using quality planting material in afforestation has been emphasized regularly. However, this area of forestry has been challenging. A project on improving the quality of planting material in forestry is proposed. The project would also consolidate the success and research work already done by ICFRE institutes and help upscale the same. As part of the project, a National Database of Candidate Plus Trees can be created for better record and access of mother trees to all stakeholders. This will also help in institutionalizing the knowledge available with local officials regarding such trees. A mechanism for seed collection from such Candidate Plus Trees and certification needs to be established. The registered suppliers of forest trees can be brought onto one platform to maintain the chain of custody/certification of seeds collected and sold so that only seeds of known origin can be supplied in the market.



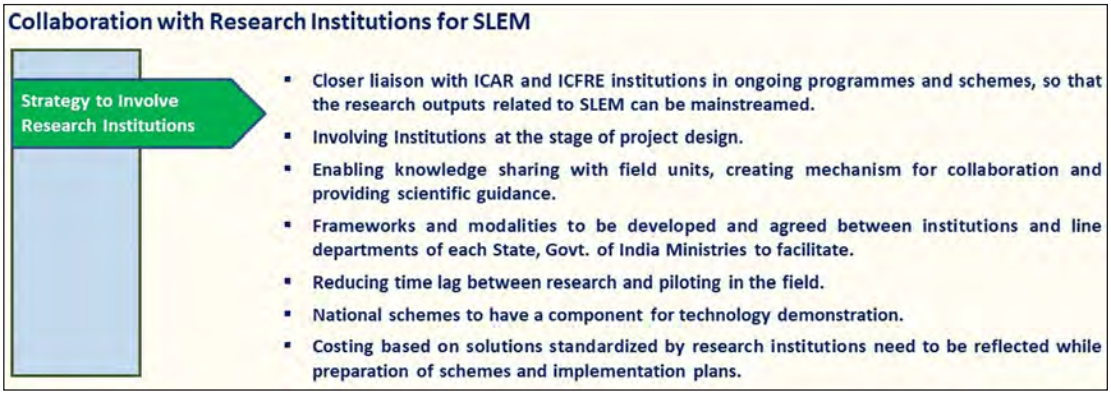
8. **Interventions to Reduce Forest Fires, Invasive Species, Pests and Diseases in Forest Areas:** Investments in technological interventions in pilot projects and in scaling up best practices

may be considered for addressing problems in the forest areas. The use of modern predictive tools based on Artificial Intelligence coupled with RS and GIS can be used for predicting certain incidents and provide valuable lead time to take evasive actions to mitigate the threat. The Ministry of Environment, Forest and Climate Change and State Forest Departments should encourage cross-learning across the states on best practices for reducing forest fires and tackling invasive species and incidences of pests and diseases in forests.

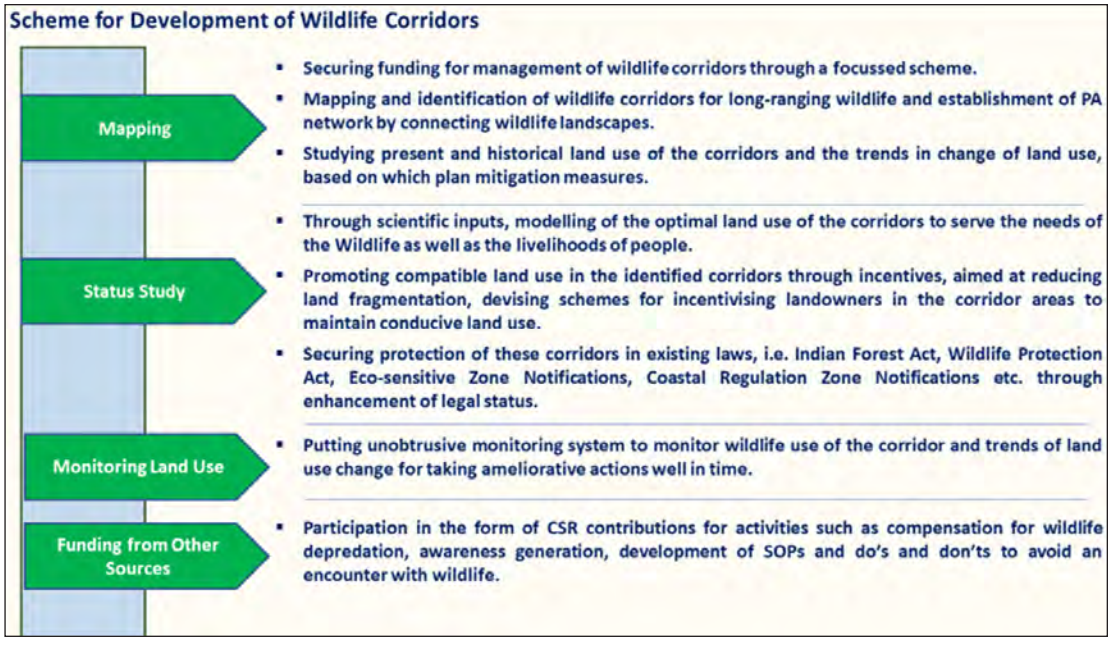
9. **Forest Carbon Assessment:** There is a need to establish permanent forest carbon assessment points/ sample plots at the district/ forest division level for periodic measurement of forest carbon to understand changes in the carbon regime in the forests based on the management interventions. This data also will help foresters to keep a record of the changes in soil carbon over time and trend analysis.



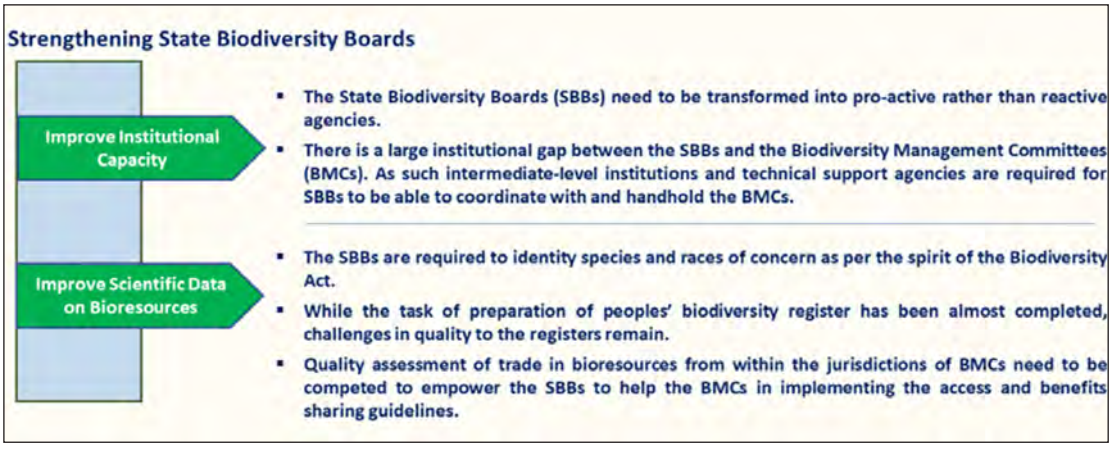
10. **Collaboration with Research Institutions:** For improving the effectiveness of the SLEM interventions, a closer liaison with the Indian Council of Agricultural Research and Indian Council of Forestry Research is proposed with ongoing programmes and schemes so that research outputs related to SLEM can be mainstreamed. This will allow the implementing agencies to promote action research on SLEM and help adopt relevant technologies by including them in the plans under the existing schemes.



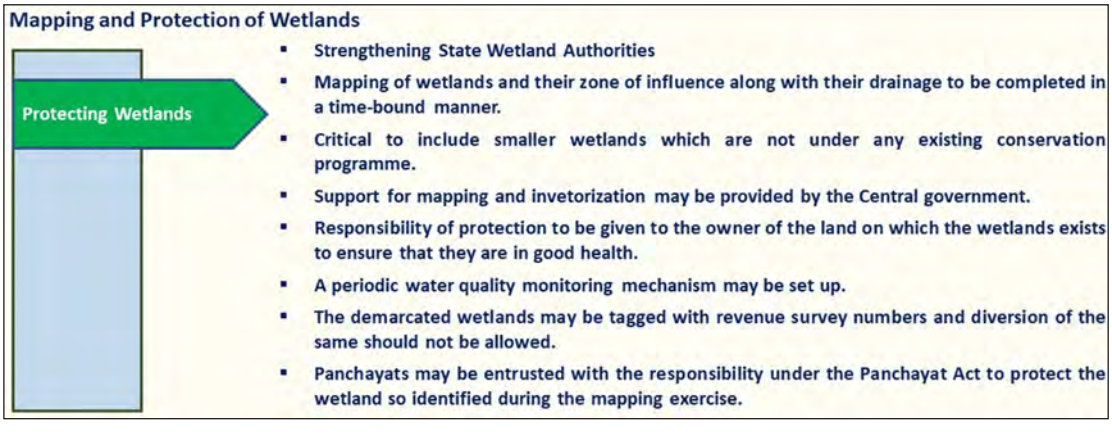
11. **Focus on Wildlife Corridor Development:** Nationwide mapping and development of wildlife corridors and establishment of Protected Area network by connecting wildlife landscapes, securing the protection of corridors in existing laws, i.e. Indian Forest Act, Wildlife Protection Act, Eco-sensitive Zone notifications and Coastal regulation zone notifications are being proposed. This initiative may be taken up by studying present and historical land use of the area and the trends in change of land use, modelling optimal land use in such corridors to serve the needs of wildlife as well as the livelihoods of people, devising schemes to incentivize landowners in the corridor areas to maintain conducive land use, putting in place unobtrusive systems to monitor wildlife use of the corridor as well trends over longer timeframe for taking ameliorative action well in time, allowing Corporate social responsibility contributions for activities such as compensation for wildlife depredation and developing standard operating procedures such as the do's and don'ts to avoid encounters with wildlife.



12. **Strengthening State Biodiversity Boards:** The institutional arrangement within the State Biodiversity Boards (SBBs) need to be reviewed to make them stronger and effective. Intermediate level institutions and quality technical support agencies are required for SBBs to coordinate with and handhold the Biodiversity Management Committees at the Panchayat level. The State Biodiversity Boards also need to be transformed into pro-active rather than reactive agencies.

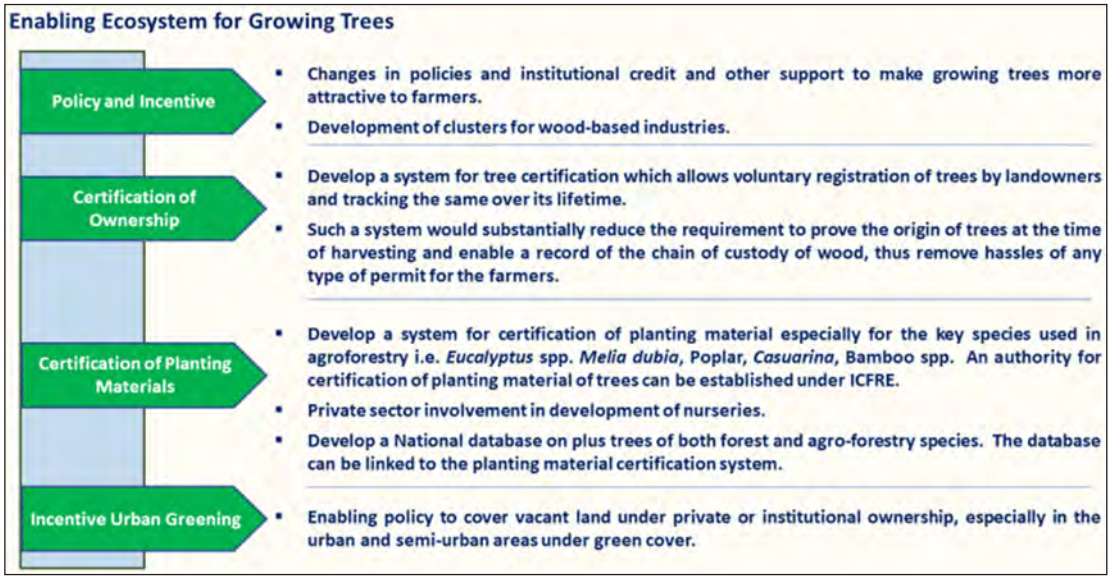


13. **Mapping and Protection of Wetlands:** Mapping of wetlands along with their zone of influence and drainage may be done in a time bound manner. Mapping smaller wetlands, which are not on the list of major wetlands under any existing conservation programmes is critical. Clear responsibility may be given to concerned landowners to conserve the wetlands and ensure that they are in good health. A mechanism for periodic water quality monitoring may be set up. The demarcated wetlands may be tagged with revenue survey numbers, and diversion should not be allowed. Panchayats may be entrusted with the powers under the Panchayati Raj Act to protect the wetlands and waterbodies so identified during the mapping exercise.

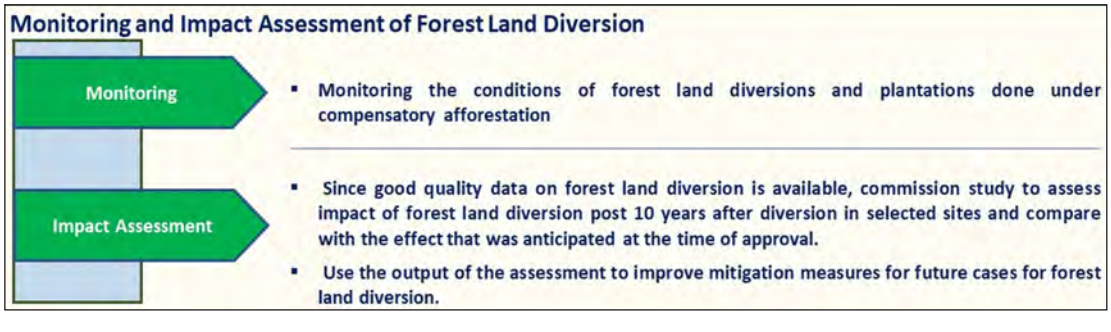


14. **Enabling Ecosystem for Growing Trees:** Policy and institutional support is needed to make tree growing more attractive to farmers and other individuals. Simplification of harvesting

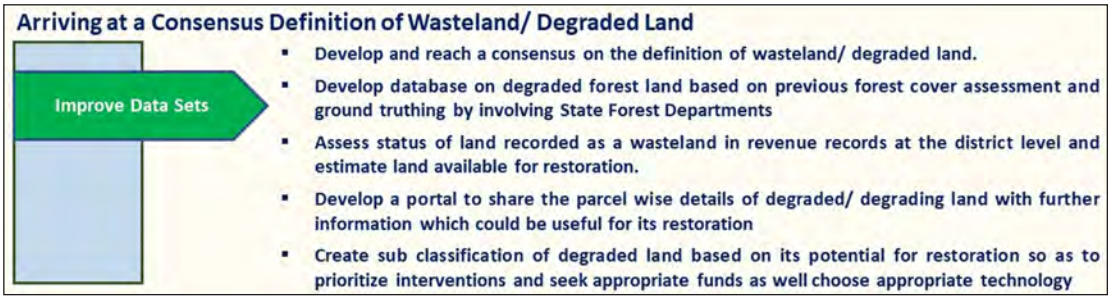
and transit requirements are needed. A system for tree certification may be developed that allows voluntary registration of trees by landowners and tracking the same over its lifetime. Developing a mechanism for the certification of planting material, especially for the key species used in agroforestry, i.e. *Eucalyptus* spp., *Melia dubia*, poplar, casuarina, bamboo species is required. Policy and guidelines may be framed for bringing vacant land under private or institutional ownership under green cover with a provision that such green cover may be allowed to be removed whenever required by the owner/user of the land to incentivize the landowner and users to for bringing such an area under green cover.



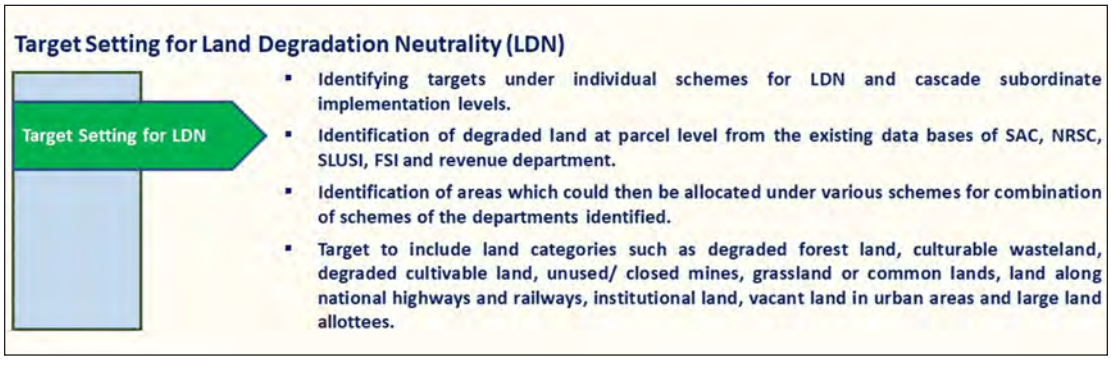
15. **Diversion of Forest Land – Improving Monitoring and Assessing Impact Post Land Diversion:** The conditions under which individual cases of forest land diversion have been permitted need to be properly monitored. An appropriate monitoring system may be established at the central level to enable the same. Since good quality data regarding forest land diversion is available (for land diverted since 1980), the impact of diversion on and beyond the land diverted may be studied and learnings arising out of the study should be used in defining the compensation structure for land diversion in future as many of these unintended consequences, which may be difficult to avoid, are currently not priced in the compensatory value of forest land diverted.



16. **Arriving at a Consensus Definition of Wasteland/ Degraded Land:** A common understanding and agreement on standard definition and methodology for identifying degraded land and its sub-classifications are required. At the same time, dedicated institutions at the Centre and state level should be recognized that can follow the methodology and identify such land and prioritize them for restoration over the next 10 years. Agencies such as National Bureau of Soil Survey and Land Use Planning having long experience in this area may be involved in the exercise.

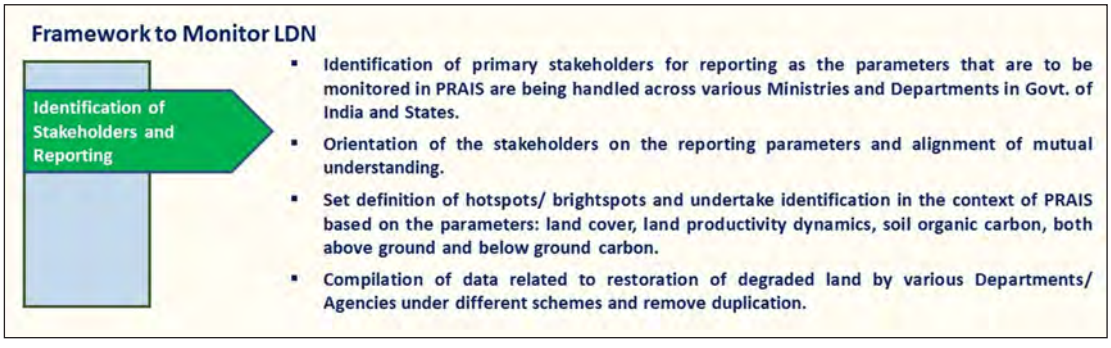


17. **Target Setting for Land Degradation Neutrality:** It is important to consolidate the coverage of area under land degradation neutrality (LDN) taken up under various schemes, remove duplication and subsequently use the information for planning future interventions. The consolidated information should also be compared with the land degradation status map of the country. It will also be important to divide the target under identified key monitoring areas related to SLEM with clear responsibilities to various stakeholders and cascade them to subordinate implementation units for improved outcomes and transparency. Closer coordination at the centre and state level among three key departments - Forest, Agriculture and Rural Development - responsible for achieving most of the LDN targets will be a key enabler. Detailed land planning for restoration will be important to optimize funding requirements by removing duplications, increasing collaboration, fostering convergence and enhancing efficiency.



18. **Framework to Monitor Land Degradation Neutrality:** Primary stakeholders from various ministries and departments in the Government of India, namely MoEFCC, MoRD, MoJS, MOAFW and their subordinate organizations, may be identified for reporting under the UNCCD monitoring framework. Their orientation should be conducted on the reporting

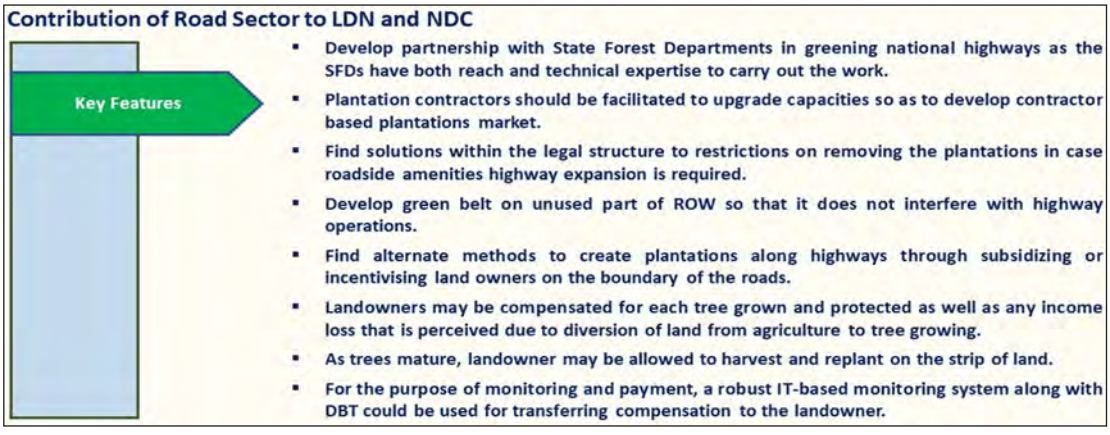
parameters. The definition of hotspots and brightspots across various dimensions related to land management, i.e. land cover area, land productivity dynamics, soil organic carbon and both above ground and below ground, have to be finalized by the nodal reporting authority, i.e. MoEFCC in consultation with other stakeholders for maintaining uniformity in understanding and reporting.



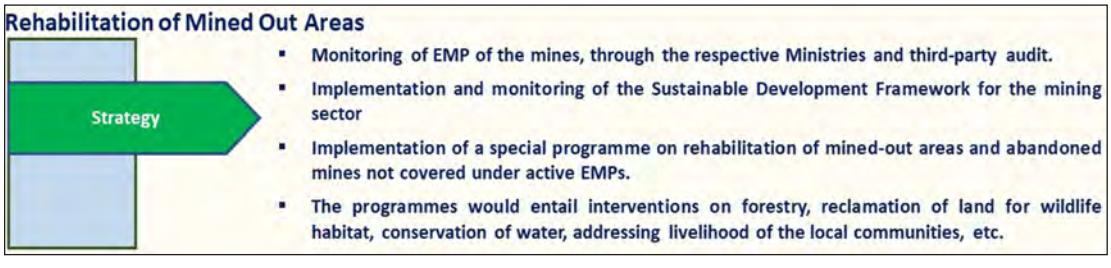
19. **Strengthening of a Centre of Excellence for Sustainable Land Management:** A Centre of Excellence for Sustainable Land Management can provide support at the national level for handholding implementing agencies and coordinating nationwide efforts on SLEM. The CoE execute the activities towards harnessing knowledge, creating a knowledge repository on SLEM and widely disseminating the same for the benefit of practitioners. Besides creating a database on land degradation, training and capacity building, national-level reporting on LDN, coordinating research on SLEM with international agencies for sharing knowledge and best practices on sustainable land management are also being proposed.

20. **Develop Specific Project on SLEM at the National Level:** A special project may be initiated that can become a model for the future to demonstrate a multidisciplinary, multi-sector and people-centric approach in implementing LDN. Funding for such a legacy project can be arranged from international agencies committed to financing climate change mitigation and adaptation project under UNFCCC and LDN project under UNCCD.

21. **Road Sector's Contribution of LDN and NDC:** The National Highways Authority of India may consider a partnership with the State Forest Departments to implement "Green Highways" for improving the outcomes and quality of plantations along new and old National Highways.



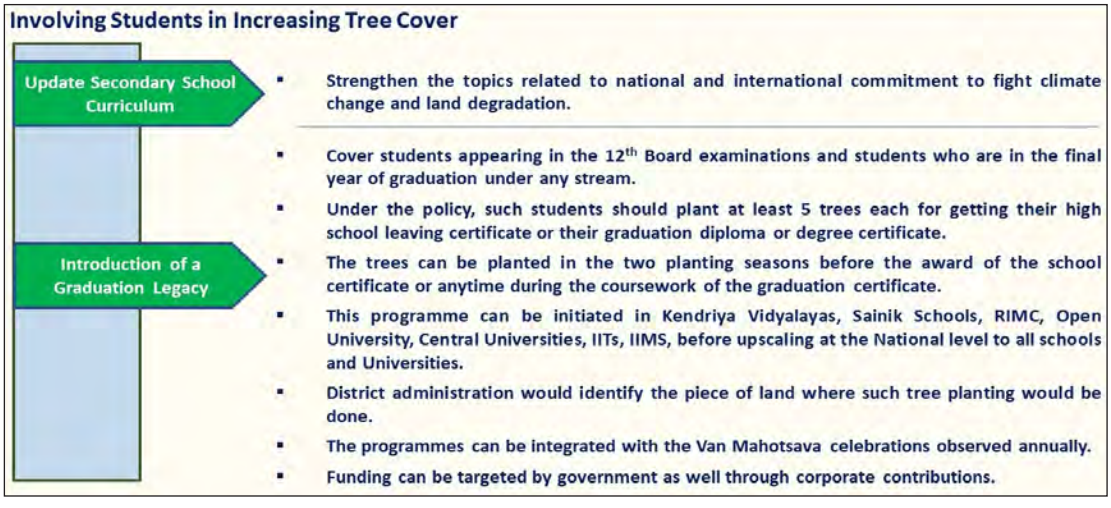
22. **Focussed Attention on Rehabilitation of Mined-Out Areas and Abandoned Mines:** A special programme should be taken up to rehabilitate abandoned mines and other mined-out areas, which are not covered under active Environment Management Plans (EMPs). The programmes would entail interventions on forestry, reclaiming land for wildlife habitat, conservation of water, and addressing livelihoods of the local communities. Funds from the District Mineral Funds can be exploited for this purpose. The Sustainable Development Framework for the mining sector needs to be properly implemented. The quality of monitoring of the EMPs may be enhanced through respective ministries and third-party audits to achieve better outcomes.



23. **National Carbon Market:** Launching a national level carbon market for allowing carbon emissions trading within India will encourage flow of funds from private entities. Such funds could be made available to finance climate change mitigation and adaptation projects including LDN projects in the country.

24. **Enforcement of Sand Mining Guidelines, 2020:** States should adopt stricter rules in the light of Sand Mining Management Guidelines, 2020 issued by the MoEFCC. In addition to the national guidelines, all states should formulate State-level Sand Mining Regulations with strict compliance procedures and plans.

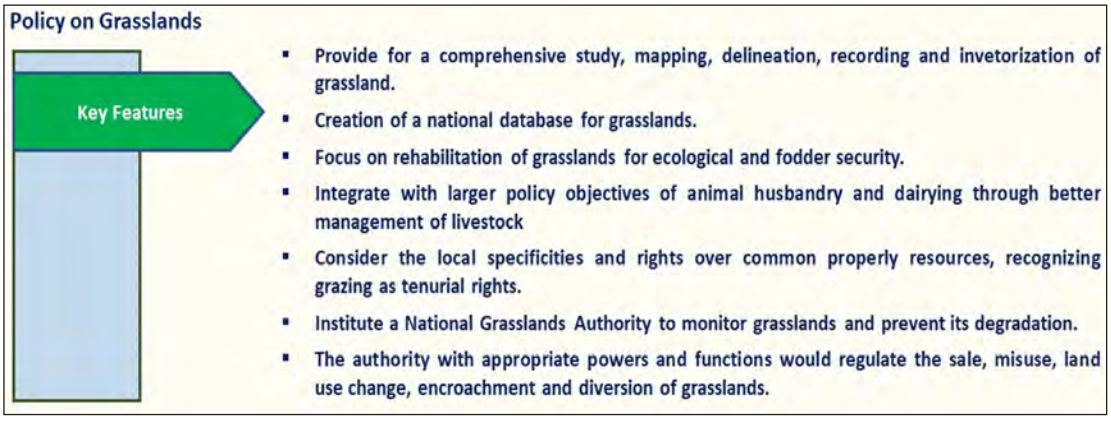
25. **Encouraging the Involvement of Students in Fighting Land Degradation:** A Graduation Legacy Policy is proposed to cover students appearing in the senior secondary board examinations or who are in the final year of graduation under any stream. Under the policy, such students in India will need to plant at least 5 trees for getting their high school leaving certificate or their graduation diploma or degree certificate. The present Van Mahotsav programme implemented throughout the country can co-opt this initiative.



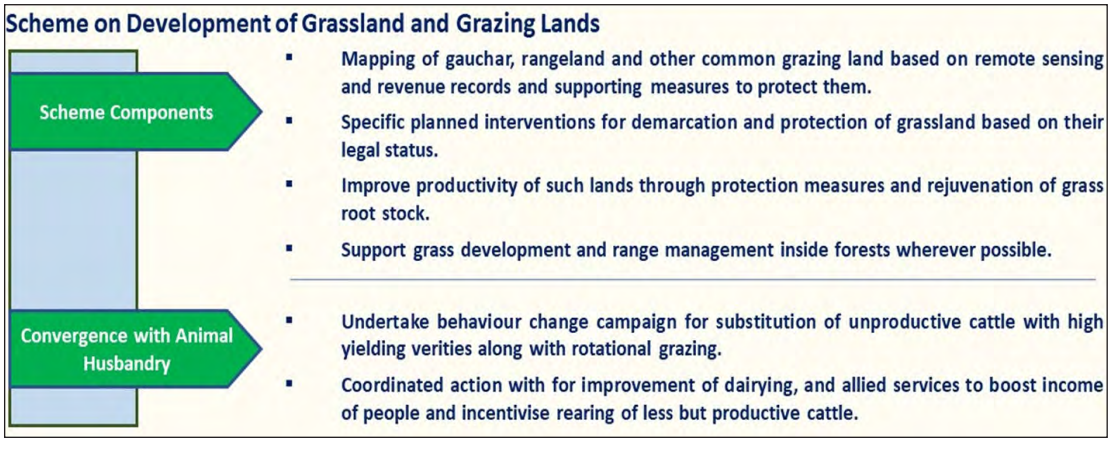
26. **Establishing a Mechanism for Measuring SDG Indicators Related to SLEM:** The introduction of a separate mechanism for measuring SDG indicators related to SLEM may be considered. An SDG dashboard may be developed at the MoEFCC for tracking the progress. District-wise allocation of targets may be undertaken, and relevant systems may be put in place to map and measure progress in the national level indicator with respect to land degradation, sustainable wetland management and wildlife crime.

27. **Policy on Development of Grassland and Grazing Lands:** A grassland policy is proposed as a strategy to arrest land degradation and to promote ecological and fodder security, better management of livestock and fodder availability, and create an enabling environment for recognizing grazing as tenurial rights under the state tenancy acts. There is a need for

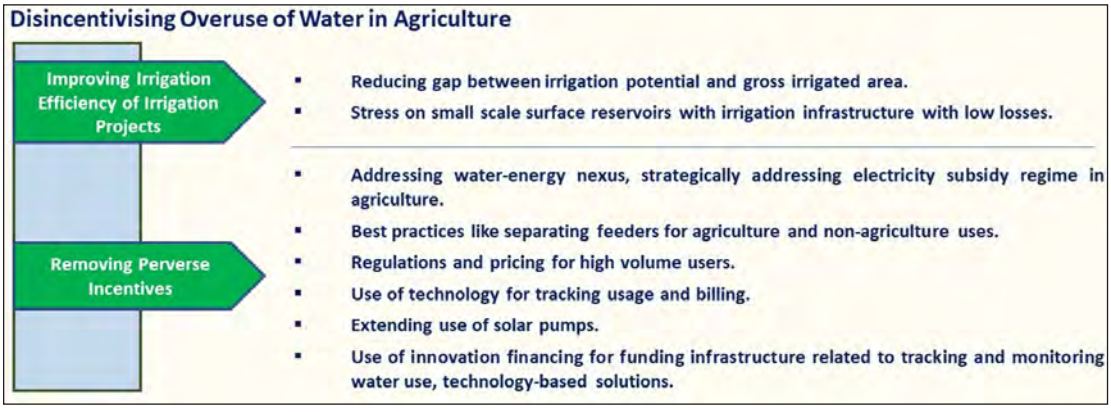
authentic database of grassland based on mapping as current revenue records across states have recorded grasslands under various categories of common lands. There is also a need for a ground-level assessment and corrective action by the authorities as grasslands continue to be under illegal occupation, encroachments and subjected to other pressures. National Grasslands Authority may be a solution to comprehensively address the conservation, development and sustainable use of grasslands.



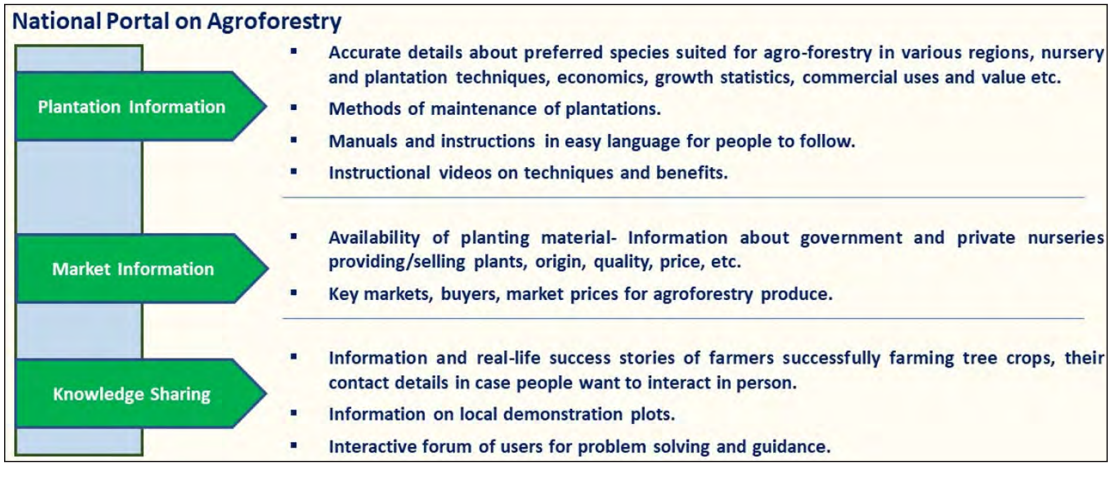
28. **Special Scheme for Development of Grasslands and Grazing Lands:** A special scheme on the development of grazing and grassland may also be taken up which would focus not only on ecological rehabilitation of grasslands but also on livestock improvement, extension of the dairy value chain, diversified livelihood options and behaviour change.



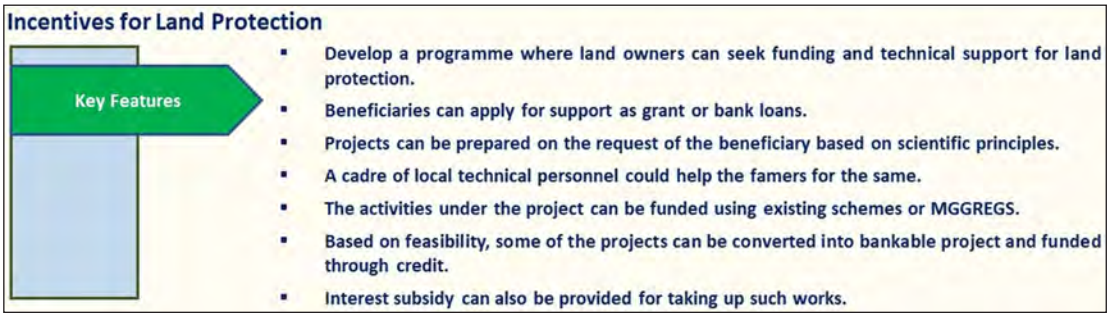
29. **Disincentivizing Overuse of Water for Agriculture:** The national and state-level water policies need to identify measures that would optimize the existing irrigation facilities, including building small reservoirs locally and reducing water transportation and distribution losses through long-distance canals and distribution networks. The groundwater-energy nexus has also created perverse incentives, which have been the major driver of ground water depletion and agricultural land degradation. Policy measures for disincentivizing the overuse of water in agriculture is a need of the hour, keeping future sustainability in perspective.



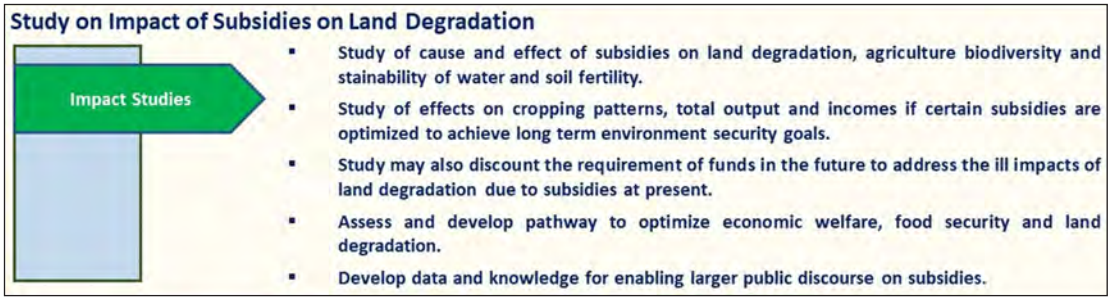
30. **National Portal for Agroforestry:** A National Portal on Agroforestry may be developed as a user-friendly one-stop portal for authentic information on various agroforestry and tree species and methods of growing and maintaining plantations. The portal, in due course, will provide a large users database that can be used in agroforestry extension as well.



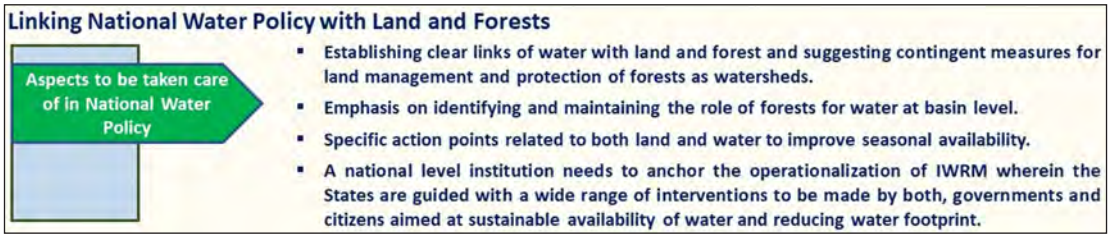
31. **Incentives for Investments in Land Protection:** Policy measures to incentivize investment in land protection measures on private land may be considered. This would be similar to the incentives provided for micro irrigation, horticulture development etc.



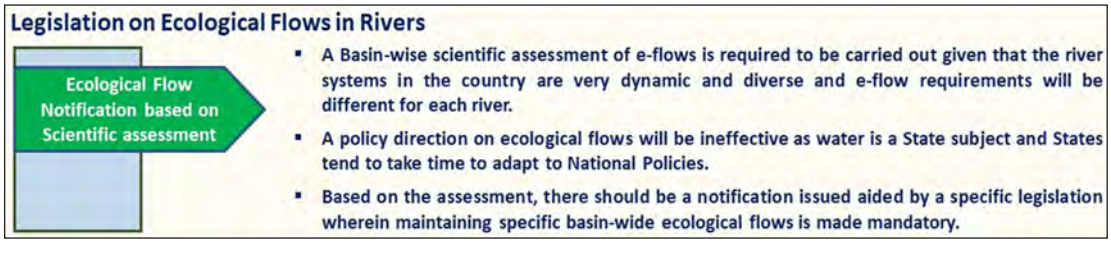
32. **Subsidy Specific Study on Agriculture:** Input and output subsidies affect the entire agriculture value chain as they are connected in a complex web with production, farmers' income, businesses of related industries, and price to consumers. Most of these subsidies are well ingrained in the agricultural economy and changing any one of them has a cascading effect on the entire value chain and evokes drastic responses from the socio-political ecosystem. There have been various studies on the economics of subsidies in general. However, study of incentives and modelling them for impacts on land degradation which have not been taken up so far is recommended.



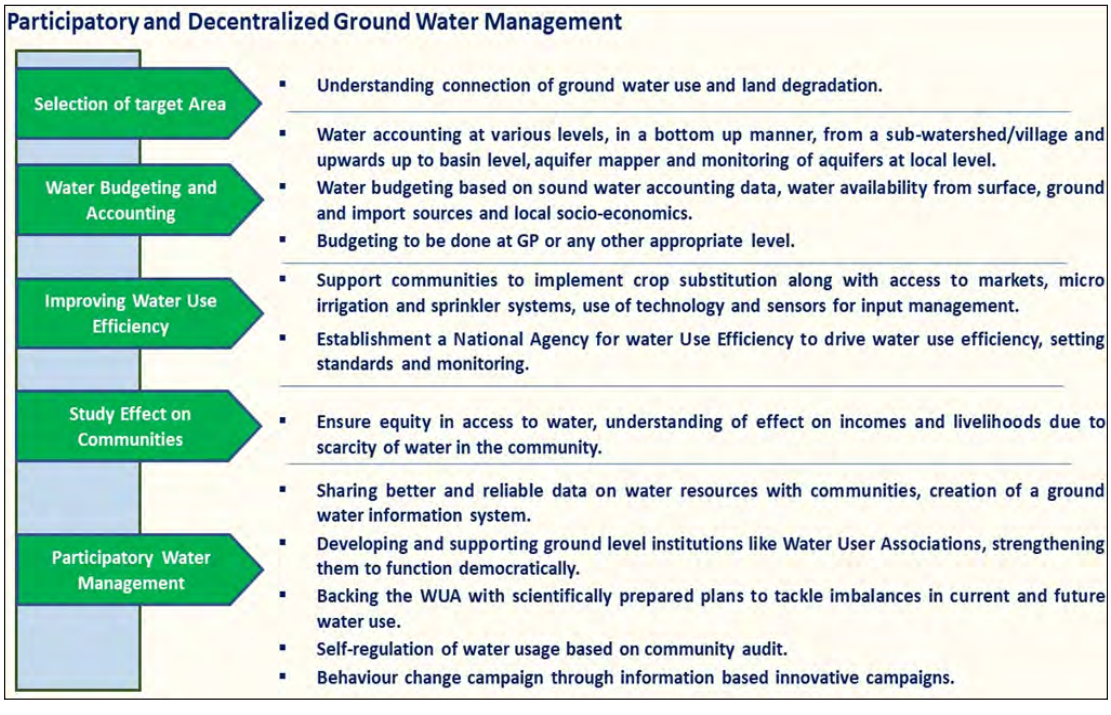
33. **Linking National Water Policy to Land and Forests:** The National Water Policy, 2012 treats water as a hydro-geological and techno-economic entity for managing the demand and supply balance, whereas the supply side management of water is not covered with the same intensity. The quality and quantum of both surface and groundwater largely depend on land and forests, but the role of land and forest in creating water availability, an important provisioning ecosystem service, is not adequality emphasized. Thus, the linking of water with land and forests is required in the National Water Policy which will strengthen the management of land and forests for water security.



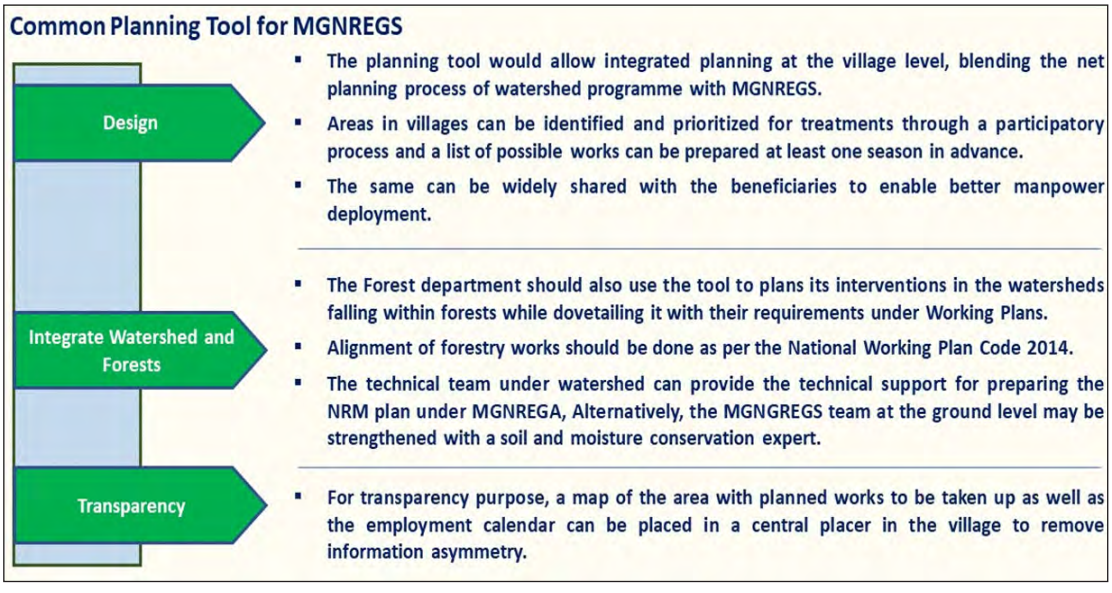
34. **Legislation on Ecological Flows in Rivers:** A scientific assessment of e-flows may be carried out across all major river basins in the country. Based on the assessment, an appropriate notification may be issued wherein maintaining specific basin-wide e-flows is made mandatory. This could be made justiciable by a supporting legislation.



35. **Participatory and Decentralized Groundwater Management:** It is necessary to separate water rights from land rights to regulate the overuse of groundwater. However, the major impediment to delinking land and water rights are the Transfer of Property Act and the Indian Easement Act. A programme to encourage states to discontinue perverse subsidies that exploit groundwater, accelerate soil erosion, and reduce soil health may be initiated. Electricity Regulatory Agencies need to regulate or discontinue electricity subsidies for groundwater pumps taking a cue from innovative practices in some states. The State Electricity Regulatory Commissions and the state governments need to provide adequate emphasis on strategic shift that would reduce groundwater exploitation. To aid transparency and data sharing, an integrated water balance system that indicates how water is being utilized at the local, sub-basin and basin levels may be established.

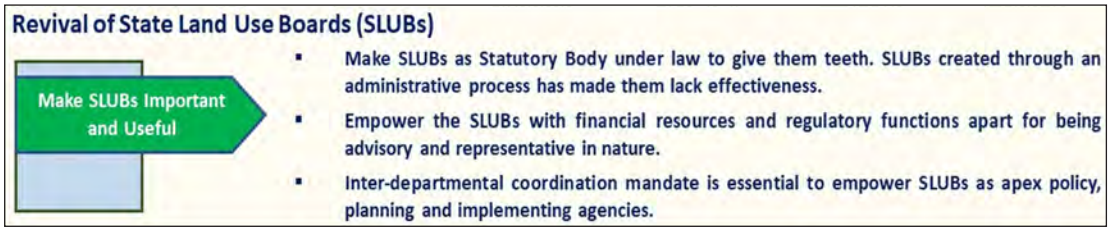


36. **Common Planning Tool for Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Watershed Projects:** A common planning tool for MGNERGS and Watershed projects at the *Gram Panchayat* and micro-watershed level may be developed. The effectiveness of MGNREGS can be improved by blending the net planning process. Areas in villages can be identified and prioritized for treatments, and a list of possible works can be prepared at least one season in advance. The same can be widely shared with the beneficiaries to enable better labour deployment. The *Gram Panchayat* can undertake implementation following "a ridge to valley" approach based on the labour demand. The technical team under the watershed programmes can provide the technical support for preparing the Natural Resource Management plan under Mahatma Gandhi National Rural Employment Guarantee Act, 2005. Working Plans under forest departments may be aligned with the watershed plans and vice versa for better coordination and convergence.



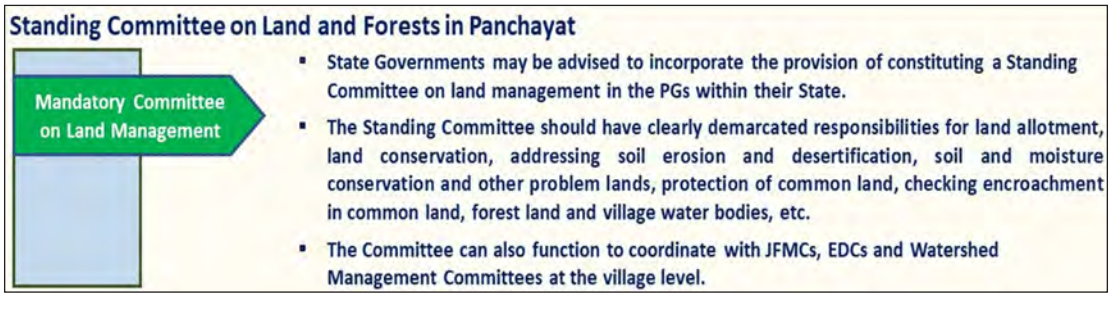
37. **Special Provisions under MGNREGS for Tribal and Forest Fringe Villages:** For improving employment in tribal areas flexibility in MGNREGS rates and increasing the limit for maximum per household employment in forest fringe villages to up to 200 days may be considered. This intervention would be in addition to the targeted programmes for livelihood development being undertaken in such areas. Increased livelihood opportunities for tribal population will reduce the dependence on forests for subsistence, provide other benefits such as addressing distress migration and improving nutrition standards.

38. **Revival of Land Use Boards:** While considerable attention has been given to land reforms throughout formal planning processes in India, institutional response to sustainable land use, management, and governance has been absent. State Land Use Boards were set up by 1974 in most of the states and union territories and restructured in 1985 as the apex body on land use at the state level under a Centrally-sponsored Programme. It had the mandate to provide policy direction for sustainable development of land resources, ensure inter-departmental coordination and initiate integrated planning. However, the State Land Use Boards have remained largely defunct. The boards are required to be revived to act as a unified body at the state level to mainstream sustainable land management and address the issue of land degradation.



39. **Integrating SLEM with Panchayat Development Plans:** SLEM may be integrated into the *Gram Panchayat* Development Plan, Block Development Plan and District Panchayat Development Plan. Secondary data from the line departments, especially MGNREGS, Forest, Agriculture, Watersheds, others like *Bhumi Sudhar*, can be fed into planning through coordination with line departments prior to the preparation of such plans. At the preparation stage of the Development Status Report, prioritization of activities and convergence strategy in the context of SLEM can be finalized for each *Gram Panchayat*.

40. **Standing Committees in Panchayat on Land Management:** State governments may be advised to incorporate the provision of constituting a Standing Committee on land and water resources in the *Gram Panchayats* with clearly demarcated responsibilities for land conservation, addressing soil erosion, desertification, soil and moisture conservation and other problem related to lands, protection and checking encroachment in common land, forest land and village water bodies. These committees can also function as touchpoints for Joint Forest Management Committees, Ecodevelopment Committees and Watershed Management Committees at the village level.

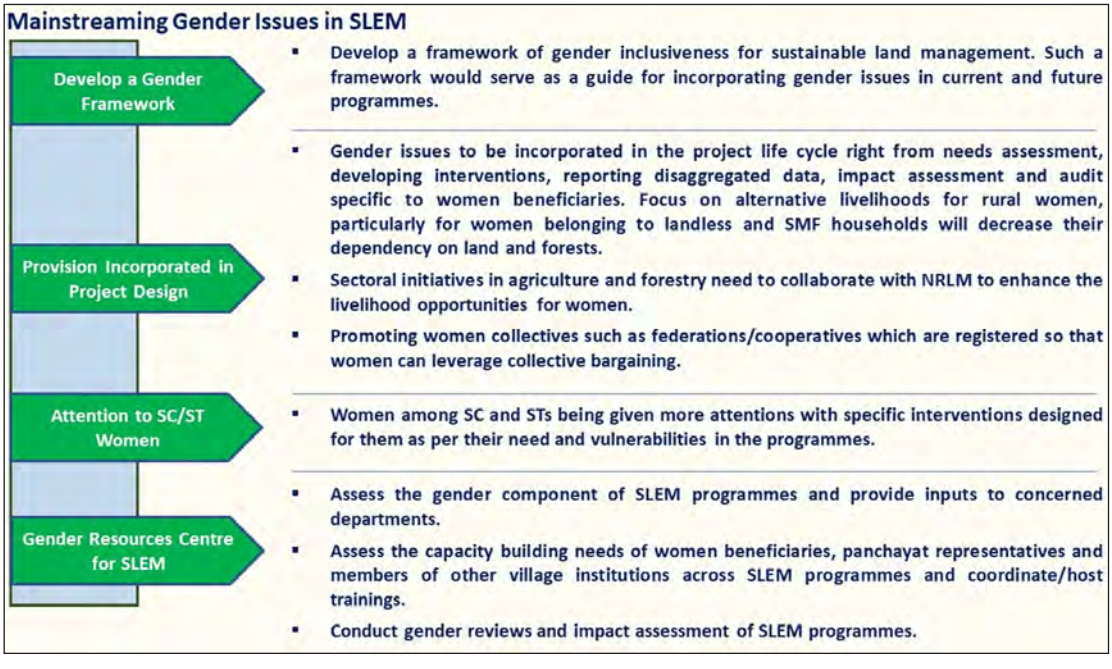


41. **Strengthening Community Participation in SLEM Programmes:** Community participation in the SLEM programmes may be strengthened through facilitation by NGOs and voluntary organisations. Imparting training to the project staff, particularly those at block and panchayat level in participatory planning, implementation and monitoring is recommended. Training programmes for project beneficiaries, *Gram Panchayat* and *Gram Sabha*, to build their understanding of SLEM and their role in sustainable management of natural resources is also recommended.

Community Participation in SLEM Programmes

Training and Mobilization	▪ Involve NGOs in facilitating particularly planning as resource institution. Training of project staff at block and panchayat levels on participatory planning and implementation. ▪ Trainings to project beneficiaries, gram panchayat members to build their understanding of SLEM issues, causes and solutions, and the role they can play in sustainable management of natural resources. ▪ Training on fund management and transparency. ▪ Exposure visit of beneficiaries to the sites of best practices. ▪ Developing and sharing material for awareness generation.
Gender Facilitation	▪ Gender based facilitation to improve interface between women and governance institutions at the block and district.
Institutional Coherence	▪ Effectives linkages of sector committees with Gram Sabha and panchayat as prescribed in policies and programmes. ▪ Institutionalization of monitoring mechanism by involving SHGs, CBOs, and NGOs.
Transparency and Monitoring	▪ Training on social audit to panchayat members, Gram Sabha, members of sectoral committees, SHGs and members of other community groups. ▪ Documentation and dissemination of works done and compilation of best practices.

42. **Gender Mainstreaming in SLEM Policies and Programmes:** Although individual policies and programmes include women as stakeholders, an overarching framework of gender inclusiveness and mainstreaming gender across policies is missing. Mapping the needs of most vulnerable sections, promoting women's participation in the decision-making process at the micro-level, reporting, monitoring and reviewing to include gender-related indicators is required. Besides, gender audit may be institutionalized as part of social audit across programmes.

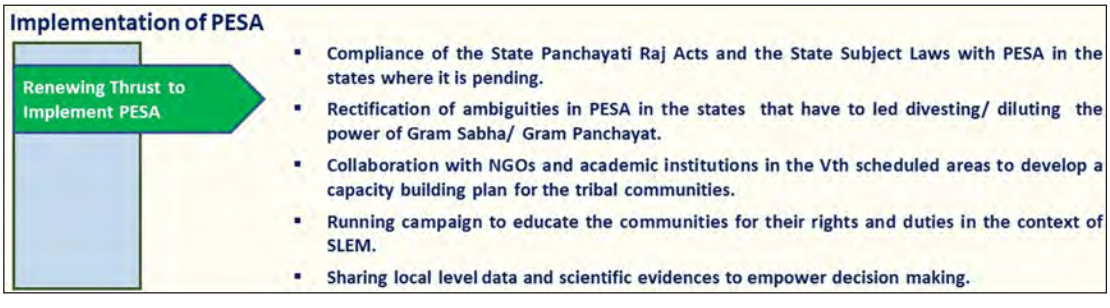


43. **Addressing the Need of Women Farmers in the Implementation of SLEM:** An overall strategy to address the needs of women farmers belonging to diverse groups, such as legal owner-cultivator, cultivators of family farms without legal ownership, tenants and sharecroppers, small and marginal farmers, and agricultural wage workers, need to be considered. Implementation of legal ownership of agricultural land, particularly of women

farmers who belong to women-headed households and farmers who are now widows, single, or physically challenged, also needs attention, if SLEM to be achieved from all social dimensions.

44. **Management of Village Common Property Resources:** For the management of village commons, assessment of the status of Common Property Resources (CPR) and planning by synergizing programmatic interventions across various schemes such as MGNREGS, Integrated Watershed Management Programme/ Watershed Development Component-Pradhan Mantri Krishi Sinchai Yojana, Compensatory Afforestation Fund Management and Planning Authority and Green India Mission is recommended. Further, development of a strategy for alternative fuel or fodder resources in the areas where CPRs are scarce and cannot meet the demands of rural communities is also proposed. Engagement of rural communities in the management of grazing land may also be institutionalized.

45. **Implementation of PESA:** Compliance of the State Panchayati Raj Act and relevant subject laws with the Provisions of the Panchayats (Extension to Scheduled Areas) Act (PESA) needs to be completed where it is pending so that the *Gram Sabha/ Gram Panchayat* can establish ownership and control over the community resources of land, water and forest and take decisions for their management and conservation. Rectifying ambiguities in PESA in the areas that have led to divesting/diluting the power of *Gram Sabha/ Gram Panchayat* is also necessary.



Content of this chapter is taken from the 'Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India' developed by Indian Council of Forestry Research and Education under the World Bank funded Ecosystem Services Improvement Project.

References

Aggarwal, A., Paul, V. and Das, S. (2009). Forest Resources: Degradation, Livelihoods, and Climate Change. *In: Looking Back to Change Track* (Datt, D. and Nischal, S., eds.). New Delhi: TERI. pp. 91-108.

Bansil, P.C. (1990). *Agricultural Statistical Compendium*. Techno-Economic Research Institute, New Delhi, p. 581.

Brandon, C., Homman, K. and Kishor, N.M. (1995). *The Cost of Inaction: Valuing the Economy-Wide Cost of Environmental Degradation in India*. The World Bank, New Delhi.

Brandt, J. and Geeson, N. (2005). Desertification Information System to Support National Action Programmes in the Mediterranean (DISMED). DIS4ME, Desertification Indicator System for Mediterranean Europe.

CSSRI (2004). *Reclamation and management of salt-affected soils*. Central Soil Salinity Research Institute, Karnal, p. 160.

Davidar, P., Sahoo, S., Mammen, P.C., Acharya, P., Puyravaud, J.P., Arjunan, M., Garrigues, J.P., and Roessingh, K. (2010). Assessing the Extent and Causes of Forest Degradation in India: Where Do We Stand? *Biological Conservation.* 143: 2937–2944.

Davies, K. (2019): Land Degradation, Desertification and Food Security in India. Global Food and Water Crises Research Programme. *International Strategic Analysis of Australia's Global Interest.* Strategic Analysis Paper. pp: 1-6.

DoLR (2019 a). *Jal Sangrah*- Stories of water conservation under Mahatma Gandhi NREGA Vol. 1. Department of Rural Development Ministry of Rural Development Government of India.

DoLR (2019 b). *Jal Sangrah*- Stories of water conservation under Mahatma Gandhi NREGA Vol. 2. Department of Rural Development Ministry of Rural Development Government of India.

DoLR (2019 c). *Jal Sangrah*- Stories of water conservation under Mahatma Gandhi NREGA Vol. 3. Department of Rural Development Ministry of Rural Development Government of India.

ELD (2015). The Value of Land Quick guide to the report. The Economics of Land Degradation. Internationale Zusammenarbeit (GIZ), Bonn, Germany.

FAO (1993). *Agricultural extension and women farm workers in the 1980s*. Food and Agriculture Organization of the United Nations. Rome.

FAO (2004). What is agrobiodiversity? *In*: *Building on Gender, Agrobiodiversity and Local Knowledge*. Food and Agriculture Organization of the United Nations. Rome.

FAO (2011). *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk*.

FAO (2021). Land use statistics and indicators global, regional and country trends 1990–2019 FAOSTAT Analytical Brief 28. Food and Agriculture Organization of the United Nations. Rome.

Field, C. B., Malmstrom, C. M. (1995). Global Net Primary Production: Combining Ecology and Remote Sensing. *Remote Sensing of Environment* 51 (1): 74-88.

FSI (2011). *India State of Forest Report* -2009. Forest Survey of India, Dehradun, Uttarakhand.

FSI (2021). *India State of Forest Report* -2021. Forest Survey of India, Dehradun, Uttarakhand.

Gera, M (2014). *Forests and Climate change: A Primer*. Indira Gandhi National Forest Academy, (IGNFA), Dehradun.

Govt. of India (2022). India's Updated First Nationally Determined Contribution Under Paris Agreement (2021-2030). Submission to UNFCCC. Government of India.

Gupta, P.K., Patel, J. G., Singh R. P., Bahuguna, I. M. and Raj Kumar (2021). Space based observation of Indian wetlands, Space Applications Centre, ISRO Ahmedabad, India.

Hariprasad, N.V. and Dayananda, H.S. (2013). Environmental impact due to Agricultural runoff containing heavy metals-a review. *IJSRP* (International Journal of Scientific and Research Publications), 3 (5).

Hofste, R.W., Reig, P. and Schleifer, L. (2019). 17 countries, Home to One-Quarter of World's Population, Face Extremely High-Water Stress. World Resource Institute.

ICFRE (2014 a). SLEM Baseline report Issues, challenges and Prospects in Sustainable Land and Ecosystem Management. Indian Council of Forestry Research and Education, Dehradun.

ICFRE (2014 b). Monitoring and Evaluation Indicator Framework for UNCCD- Desertification Land Degradation and Drought. Indian Council of Forestry Research and Education, Dehradun.

ICFRE (2014 c). Sustainable Land and & Ecosystem Management, Some Best Practices from India. ICFRE, Dehradun.

ICFRE (2022 a). Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India - Summary for Policy Makers. Indian Council of Forestry Research and Education, Dehradun.

ICFRE (2022 b). Roadmap for Institutional and Policy Mainstreaming of Sustainable Land and Ecosystem Management in India. Indian Council of Forestry Research and Education, Dehradun.

INCCA (2010). *India: Greenhouse Gas Emissions 2007*. Indian Network for Climate Change Assessment (INCCA), Ministry of Environment, Forest and Climate Change, Government of India.

IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds.). IPBES secretariat, Bonn, Germany.

IPCC (2007). *Climate Change 2007: Synthesis Report*. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

IPCC (2019). Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Kosmas, C., Ferrara A., Briassouli H., Imeson A. (1999). Methodology for mapping environmentally sensitive areas (ESAs) to desertification. In 'Medalus project Mediterranean desertification and land use. Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification.' C. Kosmas, M. Kirkby, N. Geeson, N. (Eds.), European Union 18882. pp: 31-47.

Kumar, P. (2004). Economics of Soil Erosion. Issues and Imperative from India, Ashok Kumar Mittal Concept Publishing Company, New Delhi, India.

MEA (2005). *Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis*.

Mirzabaev, A., Goedecke, J., Dubovyk, O., Djanibekov, U., Bao Le, Q., and Aw-Hassan, A. (2015). Economics of Land Degradation in Central Asia. *Zentrum für Entwicklung Forschung Center for Development Research University of Bonn. Imprint* 1-4.

Mishra, V., Tiwari, A. D., Aadhar, S., Shah, R., Xiao, M., Pai, D. S. and Lettenmaier, D. (2019). Drought and famine in India, 1870–2016. Geophysical Research Letters, 46, 2075–2083.

MoAFW (2021). Agricultural Statistics at a Glance 2021. Directorate of Economics & Statistics, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

MoAFW (2022). Agricultural Statistics at a Glance 2022. Directorate of Economics & Statistics, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

MoAFW (2023). National Crisis Management Plan for Drought. Ministry of Agriculture and Farmers Welfare, Government of India.

MoDW&S (2013). Drinking water advocacy and communication strategy framework, 2013-17. Ministry of Drinking Water & Sanitation, Government of India.

MoEF (1999). National Forestry Action Programme. Annual Report. Ministry of Environment and Forests, Government of India.

MoEF (2009). *India's Fourth National Report to Convention on Biological Diversity*. Ministry of Environment and Forests, Government of India.

MoEF (2014 a). India's 5th National Report to the Convention on Biological Biversity. Ministry of Environment and Forests, Government of India.

MoEF (2014 b). Elucidation of the fifth national report. Submitted to UNCCD Secretariat. Ministry of Environment and Forests, Government of India.

MoEFCC (2021). National Mission for a Green India: Mission Document Ministry of Environment, Forest and Climate Change, Government of India.

MoEFCC (2023). India's National Plan (NAP) to Combat Desertification and Land Degradation

Through Forestry Interventions. Ministry of Environment, Forest and Climate Change, Government of India.

Morris, G.L. (1995). Reservoir sedimentation and sustainable development in India. *In*: *Proc. Sixth Intl. Symp. on River Sedimentation*, New Delhi, pp: 57-61.

Murthy, T. V. R., Patel, J. G., Panigrahy, S. and Parihar, J. S. (Eds.). (2013). National Wetland Atlas: Wetlands of International Importance under Ramsar Convention, SAC/EPSA/ABHG/NWIA/ATLAS/38/2013, Space Applications Centre (ISRO), Ahmedabad, 230p.

NITI Aayog (2023 a). Best practices in social sector: A compendium 2023. National Institution for Transforming India, National Institution for Transforming India Aayog, Government of India.

NITI Aayog (2023 b). Compendium of Best Practices in Water Management – 3.0. National Institution for Transforming India Aayog, Government of India.

OECD (2008). *Gender equality: Empowering women so that development is effective*. www.oecd.ord/social/gender-development/4231012.pdf.

Planning Commission (2000). Mid-term Appraisal of Ninth Five-Year Plan (1997-2002). Planning Commission, Government of India.

Prince, S.D., and Goward, S. J. (1995). Global Primary Production: A remote sensing approach, *J. Biogeogr.,* 22: 815-835.

Reza, R., and Singh, G. (2010). Assessment of Heavy Metal Contamination and its Indexing Approach for River Water, *International Journal of Environmental Science and Technology*., 7(4): 785-792.

Roose, E. (1996). Land husbandry. Components and strategy. *FAO Soils Bulletin70*. FAO, Rome. 351pp.

Rubio, J.L. and Bochet, E. (1998). Desertification indicators as diagnostic criteria for desertification risk assessment in Europe. *Journal of Arid Environments,* 39 (2): 113-120.

SAC (2011). National Wetlands Atlas. Space Application Centre, ISRO, Ahmedabad.

SAC (2018). Desertification and Land Degradation Atlas of Selected Districts of India (Based on IRS LISS III data of 2011-13 and 2003-05), Volume-1, Space Applications Centre, ISRO, Ahmedabad.

SAC (2021). Desertification and Land Degradation Atlas of India. Space Application Centre, ISRO, Ahmedabad.

Sangodoyin, A.Y. (1991). Groundwater and Surface Water Pollution by Open Refuse Dump in Ibadan, Nigeria. *Journal of Discovery and Innovations*, 3 (1): 24-31.

Sehgal, J. and Abrol, I.P. (1994). *Soil degradation in India: status and impact*. Oxford and IBH, New Delhi.

SERI (2013). *Land Footprint Scenario Report*. Sustainable Europe Research Institute, Vienna (Austria).

Shangle, A.K. (1991). Hydrographic surveys of Indian reservoirs. In: *Course Material for Workshop on Reservoir Sedimentation*, sponsored by IRTCES, China, and UNESCO (New Delhi).

Stocking, M. and Murnaghan, N. (2002). A *Hand book for the Field Assessment of Land Degradation*, FAO, Rome.

TERI (2019). Economic cost of land degradation in India. The Energy Resource Institute, New Delhi.

UNCCD (2007). Decision 3/COP.8 The 10-year strategic plan and framework to enhance the implementation of the Convention.

UNCCD (2009). Draft UNCCD Water Policy Advocacy Framework for: Securing water resources in water scarce ecosystems in the face of desertification, land degradation and drought (DLDD) imperatives. Secretariat of the Convention to Combat desertification.

UNCCD (2014). The land in numbers: Livelihoods at a Tipping Point. http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Land_In_Numbers_web.pdf.

UNCCD (2017). Decision 7/COP.13 The future strategic framework of the Convention. https://www.unccd.int/sites/default/files/2022-02/cop21add1_SF_EN.pdf

UNCCD (2022). Summary for Decision Makers. Global Land Outlook, second edition. United Nations Convention to Combat Desertification, Bonn.

UNEP (1993). Land Degradation in South Asia: Its severity, causes and effects upon the people. *World Soils Research Report No. 78*, FAO, Rome.

Velayutham, M., and Bhattacharya, T. (2000). Soil Resource Management. *In*: *Natural Resource management for agricultural production in India. International conference on Managing Natural Resources for Sustainable Agricultural Production in the 2Ist Century*, Feb. 14- 18, New Delhi. Vision 2025, IISS Perspective Plan. Indian Institute of Soil Science, Bhopal.

Wassmann, R., Jagadish, S. V. K., Heuer, S., Ismail, A., Redona, E., Serraj, R., Singh, R. K., Howell, G., Pathak, H., and Sumfleth, K. (2009). Climate change affecting rice production: The physiological and agronomic basis for possible adaptation strategies. *Adv. Agron*., 101: 59–122.

WHO (2008). *Safer water, better health -Costs, benefits and sustainability of interventions to protect and promote health*. World Health Organization (WHO), Geneva.

World Bank (2013). *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC.

WSP (2010). *Gender in Water and Sanitation*. Mainstreaming Gender in water and sanitation. *Working paper*. World Sanitation Programme (WSP)/The World Bank, Washington, DC.

Yadav. J.S.P. (2007). Soil productivity enhancement: Prospect and problems. *Journal of Indian Society of Soil Science*, 55: 455-463.

Young, A. (1994). *Land degradation in South Asia: its severity, causes and effects upon the people*. FAO World Soil Resources Report, FAO, Rome.

Indian Council of Forestry Research and Education
(An Autonomous Body of Ministry of Environment, Forest and Climate Change, Government of India)
P.O. New Forest, Dehradun - 248006 (INDIA)

ISBN 978-81-967117-2-6