Sustainable Land Management (SLM)

A compilation of SLM technologies and approaches in India

2024

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WOCAT
World Overview of Conservation Approaches and Technologies

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List of acronyms

BMZ	Federal Ministry for Economic Cooperation and Development, Germany
CDE	Centre for Development and Environment
CIAT	International Centre for Tropical Agriculture
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
ProSoil	Global Programme "Soil Protection and Rehabilitation for Food Security"
SLM	Sustainable Land Management
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
WOCAT	World Overview of Conservation Approaches and Technologies

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Definitions

Sustainable land management (SLM) is the use of land resources, including soils, water, animals, and plants, to produce goods to meet changing human needs while ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.

An SLM technology refers to a physical practice on the land that controls land degradation and enhances productivity and/or other ecosystem services. It consists of one or more measures, such as agronomic, vegetative, structure, and management measures.

An SLM approach defines the ways and means to implement one or more SLM technologies. It includes technical and material support as well as the involvement and roles of different stakeholders. It can refer to a project/programme or activities initiated by land users.

Source: WOCAT[1]

Vegetable growth on trellis ©GIZ

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[1] WOCAT, "Glossary," https://www.wocat.net/en/glossary/.

Acknowledgments

We wish to acknowledge the invaluable contributions of all the farmers who are implementing sustainable land management (SLM) technologies and approaches, spreading knowledge of SLM, contributing to sustainable soil use and the rehabilitation of degraded soils.

The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), as a Consortium Partner of the World Overview of Conservation Approaches and Technologies (WOCAT), led this compilation and data collection. This data derives from the soil rehabilitation technologies and approaches implemented by the Global Programme "Soil Protection and Rehabilitation for Food Security" (ProSoil), implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. ProSoil is commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) as part of Germany's special iniative "Transformation of Agricultural and Food Systems". It is co-funded by the European Union and the Bill & Melinda Gates Foundation.

Under the coordination of Noel Templer, Santosh Gupta collected data on the SLM practices. We thank the WOCAT team members Nicole Harari, Joana Eichenberger, and Rima Mekdaschi Studer, and the GIZ team in India, for their invaluable contributions. We also acknowledge the diligent work of the technical editors and reviewers Noel Templer, Stephanie Jaquet, Stephanie Katsir, Kim Arora, Rima Mekdaschi Studer, Udo Höggel, and Joana Eichenberger.

Tabitha Nekesa developed this compilation under the technical leadership of Stephanie Jaquet. Special thanks go to Sherry Adisa for her excellent infographics and layout.

About

Germany's Federal Ministry for Economic Cooperation and Development (BMZ) has significantly invested in sustainable land and soil management (hereafter, SLM) and climate change adaptation efforts, exploring co-benefits with carbon sequestration in Africa and India. The Global Programme "Soil Protection and Rehabilitation for Food Security" (ProSoil) is part of BMZ's special initiative "Transformation of Agricultural and Food Systems", implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, and a Consortium Partner of the World Overview of Conservation Approaches and Technologies (WOCAT). ProSoil supports smallholder farmers in Benin, Burkina Faso, Ethiopia, India, Kenya, Madagascar and Tunisia through training and capacity building in sustainable land management (SLM). The programme promotes the adoption of climate-smart, agroecological practices in its partner countries to protect land from erosion and restore and maintain soil fertility. ProSoil collaborates with local governments, and public and private sectors in the advancement of sustainable food and agricultural systems. The European Union (EU) is co-funding the programme's work in the field of agroecology in Kenya, Ethiopia, Madagascar and Benin. Another co-funder is the Bill & Melinda Gates Foundation.

The World Overview of Conservation Approaches and Technologies (WOCAT – www.wocat.net) is a global network on SLM that promotes documenting, sharing, and using knowledge to support adaptation, innovation, and decision-making in SLM. WOCAT supports governments and their development partners in effectively using knowledge management and decision-support tools and processes to prevent and reduce land degradation and restore degraded land. Following this, WOCAT and its partners developed standardised questionnaires for assessing and documenting SLM practices. Such practices include both approaches and technologies. Questionnaire data are included in the Global SLM Database, the primary recommended database by the United Nations Convention to Combat Desertification (UNCCD) for reporting on SLM best practices.

The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) provide research-based solutions to global challenges of climate change, biodiversity loss, environmental degradation, and malnutrition. The organisation, a consortium partner of the WOCAT network, supported WOCAT's work on documentation, sharing, mainstreaming, and scaling out SLM practices in ProSoil partner countries.


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Foreword

To ensure our plates tomorrow are full, we must tend to our land today. Implementing sustainable land management (SLM) practices and building an open knowledge ecosystem around them is key to that effort.

In India, ProSoil is implemented in the states of Maharashtra and Madhya Pradesh. The SLM practices from India in this compilation represent a broad spectrum of activities and interventions the project has undertaken since 2015. These practices are typified by local innovation and resource efficiency. They leverage local materials in a way that benefits soil health and is financially sustainable for farmers. Through its efforts, the project has helped rehabilitate 54,658 hectares of land in the implementation area. We have validated business models for products such as crop residue-based biochar and quality-tested urban organic waste-derived compost. This has cemented the financial viability of the project's SLM practices, incentivising their self-sustaining proliferation.

While these interventions respond to specific challenges within each local context, there is also potential for applicability and scale in other regions. To explore and operationalise the practices, India and other ProSoil global programme partner countries have already been working consistently to deepen South-South SLM knowledge exchange.

The partnership between the United Nations Convention to Combat Desertification (UNCCD) and the World Overview of Conservation Approaches and Technologies (WOCAT) has established a database platform. This platform enables SLM specialists to share best practices in technology through an international database. This collaboration has significantly aided global knowledge sharing and discovery in soil protection and land rehabilitation.

It has brought several of us from around the world together to work toward a common goal. Within this partnership, the Alliance of Bioversity International and CIAT spearheaded the documentation of 12 SLM practices featured in this compilation.

None of us are working toward soil protection in isolation. The spirit of the Sanskrit phrase "Vasudhaiva Kutumbakam," or "the world is one family," is truly appropriate in our efforts here. We hope this compilation contributes constructively to our global family.

Rajeev Ahal

Director, Natural Resource Management and Agroecology,

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH India

Context

Natural resources are the base of Indian agriculture, with about 60.5 per cent of the county's land used for farming (CCAFS, 2023), and agricultural production consumes over 90 per cent of freshwater resources (CGIAR, 2022). Agriculture is pivotal in securing food security, community livelihoods, and the nation's economic growth. Accounting for about 147 million ha of land (GIZ, 2019), land degradation, especially soil erosion, threatens the agricultural systems. Overexploitation of natural resources, excessive use of fertilisers and agrochemicals, improper irrigation, and poor soil management and agricultural practices are major drivers of land degradation in the country. Climate change and variability further exacerbate land degradation.

In the states, where ProSoil India impiments, Madhya Pradesh and Maharashtra, agrarian economies are significantly affected by soil erosion and droughts. Agriculture and agro-allied industries employ over 60 per cent of the population in Maharashtra, with over 70 per cent of the population in Madhya Pradesh involved in the sectors (Testbook Edu Solutions Pvt. Ltd., 2023a, 2023b). Unsustainable agricultural practices are key causes of land degradation in the states and nationally. Following degradation, the adoption of SLM practices assures human welfare, biodiversity, ecosystem services, carbon sequestration, and climate resilience for sustainable development.

Agriculture related causes of land degradation in India

- Shifting cultivation
- Improper irrigation (saliniation)
- Deforestation
- Overuse of agrochemicals
- Cultivation in marginal lands

Figure 1: Land degradation summary in India

Methodology

The WOCAT documentation process was carried out in four main stages:

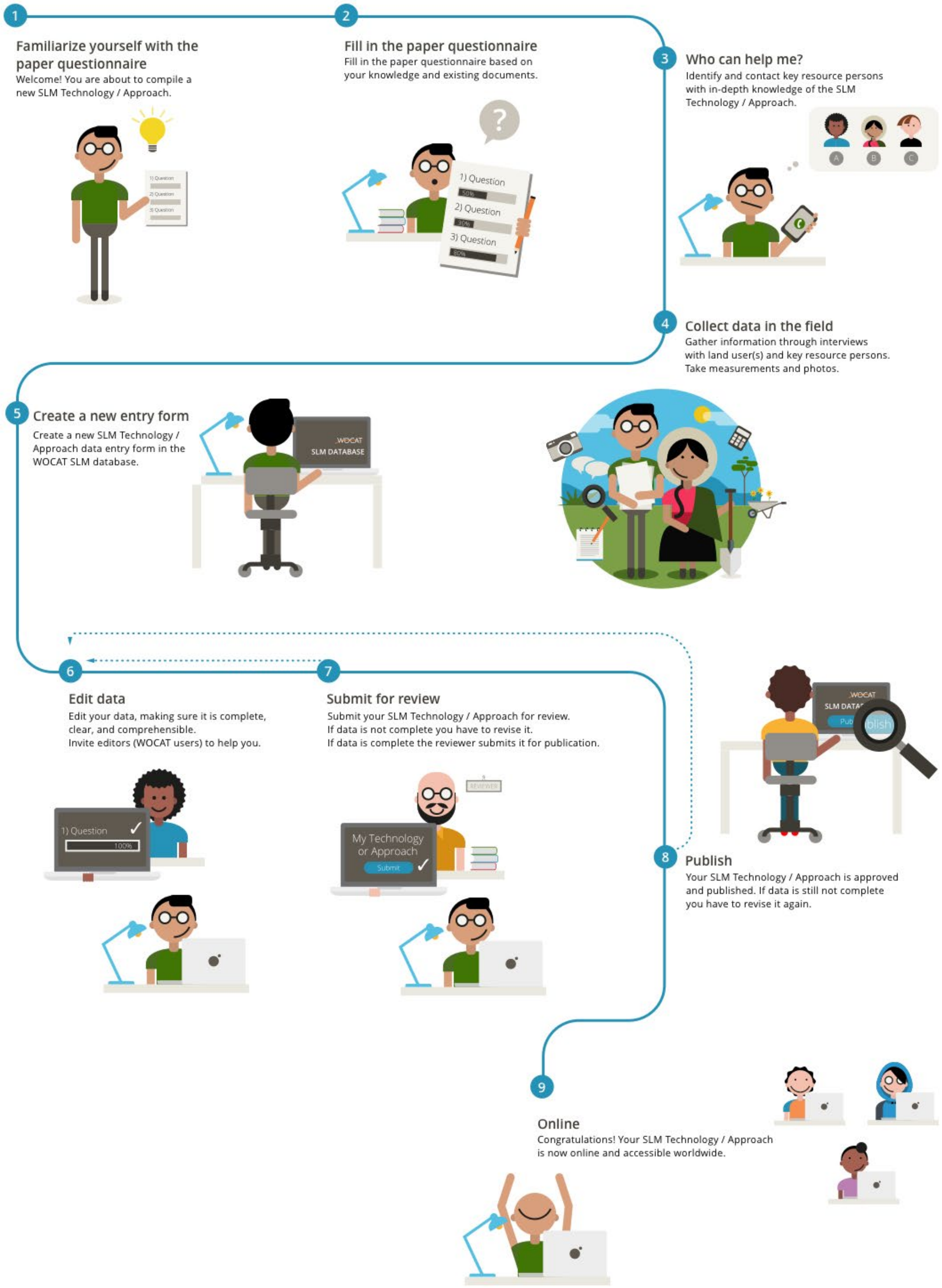
1. **Selection of practices for documentation.** The ProSoil country package India has disseminated SLM practices across the Madhya Pradesh and Maharashtra states. The 12 practices for documentation were selected based on their presence or absence in the WOCAT SLM database. The criteria considered whether the practice:
    - Responds to the country's priorities defined by the UNCCD PRAIS 4 report
    - Holds status as a priority for the government, GIZ, and ProSoil partners
    - Demonstrates adoption by farmers without external support

2. **Training on the questionnaire and validation of the practices to be documented.** A 3-day training course on WOCAT documentation organised by WOCAT consortium partners, the Alliance-CIAT, the Centre for Development and Environment (CDE) of the University of Bern, Switzerland, in collaboration with the ProSoil by GIZ, was conducted in Aurangabad. The workshop involved training on the WOCAT documentation framework and linkage to UNCCD best practices, training on the use of WOCAT questionnaires and the database, and the selection of SLM practices implemented by ProSoil India and its partners for potential documentation on the WOCAT database.

3. **Data collection and addition to WOCAT's online Global SLM Database.** Data collection on SLM technologies and approaches was conducted through field visits in ProSoil implementation areas areas using WOCAT questionnaires. This task was carried out by a consultant in collaboration with the ProSoil team, SLM specialists, and farmers, with support from the Alliance-CIAT. The WOCAT questionnaire covers several modules, including general information on the SLM technology or approach, descriptions and classifications of SLM practices, technical specifications and implementation activities, inputs and costs, and the natural and human environment. Documentation of impacts, concluding statements, and references with accompanying links are included.

4. **Reviewing and publishing of SLM technologies and approaches.** ProSoil and the Alliance-CIAT teams undertook an initial review of the questionnaires. Technical editors, compilers, and the WOCAT secretariat conducted the final review for data completeness. After approval, the SLM technologies and approaches were published in WOCAT's global database.

SLM technology/approach documentation process



1 **Familiarize yourself with the paper questionnaire**
Welcome! You are about to compile a new SLM Technology / Approach.

2 **Fill in the paper questionnaire**
Fill in the paper questionnaire based on your knowledge and existing documents.

3 **Who can help me?**
Identify and contact key resource persons with in-depth knowledge of the SLM Technology / Approach.

4 **Collect data in the field**
Gather information through interviews with land user(s) and key resource persons. Take measurements and photos.

5 **Create a new entry form**
Create a new SLM Technology / Approach data entry form in the WOCAT SLM database.

6 **Edit data**
Edit your data, making sure it is complete, clear, and comprehensible.
Invite editors (WOCAT users) to help you.

7 **Submit for review**
Submit your SLM Technology / Approach for review.
If data is not complete you have to revise it.
If data is complete the reviewer submits it for publication.

8 **Publish**
Your SLM Technology / Approach is approved and published. If data is still not complete you have to revise it again.

9 **Online**
Congratulations! Your SLM Technology / Approach is now online and accessible worldwide.

Figure 2: Steps of the WOCAT documentation process

Categories of SLM practices

12 selected SLM practices were published on the WOCAT database as categorised:

Soil fertility management

- SLM technology: Community-based soil rehabilitation for grassland on common lands after eradication of the invasive Lantana camara
- SLM technology: Biochar production from the invasive species Lantana camara
- SLM technology: Preparation of bio-inputs such as vermicompost, biofertilisers, and biopesticides
- SLM technology: City compost – a solution for waste management and soil health improvement

Agricultural and agroforestry practices and techniques

- SLM approach: Dissemination of soil test results to farmers through a participatory approach
- SLM approach: E-Prakriti - an approach toward GIS-based planning for natural farming
- SLM technology: Eradication of the invasive Lantana camara for soil rehabilitation on private land
- SLM technology: At the farm level, improved cattle shed flooring for conserving cow dung and urine for biofertiliser production
- SLM technology: Pre-monsoon dry sowing (PMDS)
- SLM technology: Biochar application on homestead land
- SLM technology: Multilayer farming systems for ensuring food diversity and increasing resilience 4
- SLM technology: Sustainable biochar production through agroforestry systems and its application

Women belonging to a village institution prepare indigenous grass seed balls (FES)

Community Based Soil Rehabilitation for Grassland on Common Lands After Erdadication of the Invasive Lantana Camara (India)

DESCRIPTION

Community-based soil rehabilitation by eradicating the invasive plant Lantana Camara using the 'cut rootstock' method (refer to WOCAT technology 6660) is an effective, cost-efficient, and sustainable approach to restoring grasslands on common lands in the Mandla District of Madhya Pradesh. The three-tier institutional structure used in this eradication process involved the formation of informal women groups at the hamlet level (village organisational structure), the Village Environment Committee (VEC) at the village level, and an Executive Committee at the cluster level (higher organisational structure) so to ensure community involvement and ownership.

Community-based soil rehabilitation after the eradication of the invasive plant species, Lantana Camara, is an effective technique for restoring grasslands on common lands that had earlier been invaded by this species. The invasion of Lantana Camara can have significant negative impacts on the ecosystem, reducing the diversity of plant life and disrupting the local communities' use of common lands for grazing, for agriculture, and for collecting non-timber forest products.

To address these issues, a three-tier institutional structure is being used by the project-implementing organization Foundation for Ecological Security (FES). This structure includes the formation of informal women groups at the hamlet level, the Village Environment Committee (VEC) at the village level, and an executive committee at the cluster level. The VEC prepares proposals on common issues and plans with budgets that are presented to the executive committee, which is made up of a mix of individuals, with 50% of the seats reserved for women.

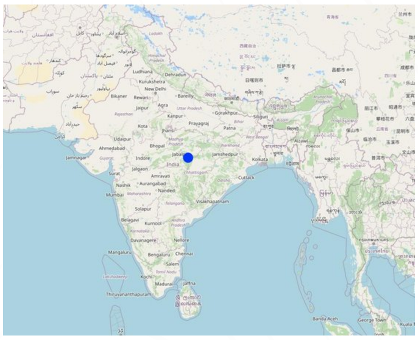
The first step in the process is for the village executive committee to take the Gram Sabha (Village Governing Body) into confidence and prepare bylaws for the restoration and conservation of the Lantana-eradicated site. These bylaws are regularly discussed in the village institution meeting to refresh the memory of the community and different stakeholders on how to properly conserve the site. Local resource persons facilitate the implementation of work.

One of the major works undertaken by these communities in the Mandla District is the soil rehabilitation from Lantana Camara for grassland restoration on common lands. The uprooting of Lantana is a tricky process, and improper methods can result in an even more forceful recurrence of the species. Therefore, the "cut rootstock" method is used, which involves cutting the root of the plant three inches below the ground and lifting the bush upside down to prevent it from gaining ground. This method is done between July and September before fruiting to avoid seed fall, which can cause recurrence for up to three years, also this is the time when the soil has enough moisture thus softness to uproot the Lantana plants.

The Cut Rootstock (CRS) method to control the spread of Lantana Camara is cost-effective and sustainable as it does not require the use of chemical herbicides or heavy machinery. In addition to using the CRS method, perching trees are located, and saplings are removed from under their canopies and along the nearby surface runoff zone. Regular monitoring and follow-up actions may be necessary to ensure the long-term success of this method in controlling the spread of Lantana Camara.

To prevent a recurrence, measures such as mopping for three years continuously, planting and seed sowing in areas where rootstocks seem to be less, and grass seed sowing are executed. The community institution ensures the collection of indigenous grass species, which are made into seed balls and sown before the advent of monsoon. These grass seeds germinate and grow in the rainy season, reducing the suitable environment for Lantana seed germination. Revegetation measures involve selecting and planting grazing hardy, fire hardy, and water

LOCATION



Location: Village: Changaniya, Block-Bichhiya, Mandla, Madhya Pradesh, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 80.71107, 22.45255

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2016

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☑ during experiments/ research
- ☑ through projects/ external interventions

hardy tree species such as bamboo, Khameer, Java Plum, Karanj (Pongame oil tree), Aonla, Harra, and other non-timber forest product-producing tree species. These plants are selected to create a three-tiered forest and sustainably provide food, fuel wood, and fodder. Once established, they do not allow Lantana to grow.

Biomass assessment is undertaken every year to assess the improvement in the status of the biomass in the plot, and the findings are shared with the community to motivate them to follow the rules and regulations formulated by the village institution. Cut and carry practices are allowed from the second year, but open grazing is prohibited, and Lantana eradication from nearby areas is required while cutting the grass. This helps to bring Lantana under control while sustainably utilizing the grass resources.

This initiative has ensured access to common lands for the local communities, access to fodder and green grass for livestock and the emergence of biodiversity in the area. This initiative is well recognised by Government institutions and policy makers.

Preparation of seedballs of indigenous grassland seeds

Restored Grassland after eradication of Lantana Camara

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☑ create beneficial social impact

Land use

Land use mixed within the same land unit: Yes - Silvo-pastoralism

Grazing land

- Transhumant pastoralism
- Cut-and-carry/ zero grazing
- Improved pastures
- Eradication of Lantana and restoring the grasslands

Animal type: buffalo, cattle - dairy, goats
Is integrated crop-livestock management practiced? No
Products and services: economic security, investment prestige

Species	Count
buffalo	n.a.
cattle - dairy	n.a.
goats	n.a.

Forest/ woodlands

- (Semi-)natural forests/ woodlands. Management: Dead wood/ prunings removal, Non-wood forest use

Tree types (deciduous): n.a.
Products and services: Fuelwood, Fruits and nuts, Grazing/ browsing, Nature conservation/ protection

Water supply

☑ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☐ prevent land degradation
☑ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

biological degradation - Bc: reduction of vegetation cover, Bq: quantity/ biomass decline, Bf: detrimental effects of fires, Bs: quality and species composition/ diversity decline, Bl: loss of soil life

SLM group

- area closure (stop use, support restoration)

SLM measures

- pastoralism and grazing land management
- improved ground/ vegetation cover

vegetative measures - V4: Replacement or removal of alien/ invasive species

management measures - M1: Change of land use type, M5: Control/ change of species composition

TECHNICAL DRAWING

Technical specifications

Drawing of this technology does not require as there no technical structure being build as part of the intervention. The images indicated a rehabilitated field after the eradication of Lantana.

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1**; conversion factor to one hectare: **1 ha = ha**)
- Currency used for cost calculation: **INR (2023 April)**
- Exchange rate (to USD): 1 USD = 82.12 INR (2023 April)
- Average wage cost of hired labour per day: 204

Most important factors affecting the costs

The density of lantana in the field is categorized into 3: more than 1500 bushes are considered high density, and between 500-1500 are considered moderately dense, while less than 500 is known as lowly dense. Such categories have a decicive impact on the costs.

Establishment activities

1. Removal of lantana (Timing/ frequency: September-October (After Monsoon))
2. Preparation of seeds for sowing (Timing/ frequency: Before the onset of Monsoon)
3. Sowing of seeds (Timing/ frequency: Just before the onset of monsoon or during the monsoon (June/July))

Establishment inputs and costs (per 1)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR (2023 April))**	**Total costs per input (INR (2023 April))**	**% of costs borne by land users**
Labour					
Removal of lantana	ha	1.0	7229.0	7229.0	20.0
Land preparation for plantation	Person day	1.0	200.0	200.0	100.0
Sowing of seeds	Person days	2.0	200.0	400.0	100.0
Equipment					
Land preparation for plantation	ha	1.0	1000.0	1000.0	50.0
Plant material					
Seeds or planting material	Ha	1.0	1000.0	1000.0	50.0
Cow dung and compost material	Ha	1.0	2500.0	2500.0	100.0
Total costs for establishment of the Technology				**12'329.0**	
Total costs for establishment of the Technology in USD				*150.13*	

Maintenance activities

1. Regular monitoring of the plantation area (Timing/ frequency: July to November)
2. Application of compost (Timing/ frequency: June-July)

Maintenance inputs and costs (per 1)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR (2023 April))**	**Total costs per input (INR (2023 April))**	**% of costs borne by land users**
Labour					
Monitoring of plantation area	Person days	12.0	200.0	2400.0	100.0
Plant material					
Application of compost	Ha	1.0	2000.0	2000.0	100.0
Total costs for maintenance of the Technology				**4'400.0**	
Total costs for maintenance of the Technology in USD				*53.58*	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☑ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1427.7
Monsoon season is June-September which has the majority of the rainfall
Name of the meteorological station: District at glance report of Ministry of Water Resources, Central Groundwater Board, North Central Region BHOPAL, 2013
The National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) developed twenty agroecological zones based on the growing period as an integrated criterion of adequate rainfall and soil groups. It delineated boundaries adjusted to District boundaries with a minimal number of regions. Mandla District of Madhya Pradesh lies

in a hot subhumid ecoregion with red and black soil.

Precepitation - 1000–1500mm; Potential Evapotranspiration -1300–1500 mm; Lenght of Growing Period-150–180days

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☑ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☐ plateau/plains
☑ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☑ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☐ good
☑ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable

Water quality refers to: both ground and surface water

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☑ high
☐ medium
☐ low

Habitat diversity
☑ high
☐ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☐ 10-50% of all income
☑ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☑ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☑ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☑ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor	☐	☑	☐	good
education	poor	☐	☑	☐	good
technical assistance	poor	☐	☑	☐	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☑	☐	good
energy	poor	☑	☐	☐	good
roads and transport	poor	☑	☐	☐	good
drinking water and sanitation	poor	☐	☑	☐	good
financial services	poor	☑	☐	☐	good

Comments
Parts of the District suffer from poor road and transportation network

IMPACTS

Socio-economic impacts

fodder production	decreased	☐☐☐☐☐✓☐	increased	From the second year onwards after the restoration of the grassland, the grass can be made available for cattle through a cut and feed method. This involves cutting the grass in a controlled manner and providing it to the cattle as feed. By using this method, the grass can be harvested at its optimum stage of growth, and the cattle can be provided with high-quality feed throughout the year. Additionally, this method allows for better utilization of the grass, minimizing any waste or overgrazing of the grassland.
animal production	decreased	☐☐☐☐☐✓☐	increased	Availability of fodder to villages from common lands
land management	hindered	☐☐☐☐☐✓☐	simplified	Lantana Camara is a problematic weed that has many disadvantages. It can reduce biodiversity, decrease soil fertility, and impede the growth of other plant species. Moreover, it can also be toxic to livestock and humans if ingested. The restoration of grasslands and the eradication of lantana can help in land management. By removing the weed, the growth of other plant species can be promoted, leading to increased biodiversity and improved soil fertility. The removal of lantana can also help to reduce the risk of wildfires, as it is known to be a highly flammable plant.
Restoration of grassland and regulating the use of indigenous grasses as fodder for cattle	None	☐☐☐☐☐✓☐	None	The restoration of grassland and regulation of indigenous grasses for cattle fodder can benefit villagers both socially and economically. Socially, it promotes community involvement and ownership of the land, while promoting sustainable land use practices benefit the environment and community. Economically, the restoration provides a sustainable source of income through the sale of milk and meat products, and eco-tourism can help to boost the local economy.

Socio-cultural impacts

Ecological impacts

soil cover	reduced	☐☐☐☐☐✓☐	improved	Lantana is known to release allelopathic compounds into the soil, which can inhibit the growth of other plant species. By removing Lantana, the negative impact of these compounds on the soil are reduced, which can promote the growth of a wider range of plants.
vegetation cover	decreased	☐☐☐☐☐✓☐	increased	Diversified vegetation cover supports land restoration
plant diversity	decreased	☐☐☐☐☐✓☐	increased	
invasive alien species	increased	☐☐☐☐☐☐✓	reduced	
animal diversity	decreased	☐☐☐☐☐✓☐	increased	
fire risk	increased	☐☐☐☐☐✓☐	decreased	Eradicating Lantana Camara reduces the risk of wildfires as it is highly flammable and provides a significant fuel source. Removing Lantana reduces the fuel source for fires, especially in areas prone to wildfires or near human settlements. Moreover, removing Lantana can promote the growth of more fire-resistant plant species, creating a more resilient ecosystem that can better withstand natural disasters.

Off-site impacts

damage on neighbours' fields	increased	☐☐☐☐✓☐☐	reduced	The spread of Lantana Camara seeds was reduced within neighboring fields

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐☐☑	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

Overall, this is a very cost effective technology without having any negative impact on the human and the natural environment

CLIMATE CHANGE

Climate-related extremes (disasters)

forest fire	not well at all	☐☐☐☐☑	very well
land fire	not well at all	☐☐☐☐☑	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 11-50%
☐ 51-90%
☐ 91-100%

Number of households and/ or area covered

On more than 100 locations common land locations this work has been undertaken

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Eradication of Lantana Camara reduces its spread and provided access into the forest areas
- The common lands are restored to grasslands
- Fodder available for cattle

Strengths: compiler's or other key resource person's view

- Rehabilitation of the soil by eradication of Lantana Camara
- Sustainable use of common resources for the purpose of biodiversity restoration
- A participatory approach for resolving common issues

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Continuous monitoring of the regrowth of Lantana Camara as the seeds stay dormant in the soil for many years Monitoring, and promoting growth with indigenous grasses, local trees, etc. so that the land is not kept fallow
- Conflict among the members of community institutions for the management of the common property resources Handholding and training of community institutions

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Currently, the program funds the eradication of Lantana Camara undertaken by the local community Including the work under Mahatma Gandhi National Rural Employment Guarantee Act 2005 or MGNREGA
- Mechanism to scale up the program participatory approach to manage common land resources Integrating it with other government schemes

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir Kim Arora	Udo Höggel Joana Eichenberger

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Last update: Sept. 14, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6689/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit - India (GIZ India) - India
- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Key references

- Ecological Restoration of Lantana-Invaded Landscapes in Corbett Tiger Reserve, India Suresh Babuy Amit Love and Cherukuri Raghavendra Babu: https://www.jstor.org/stable/43441335
- Impacts of biochar application on upland agriculture: A review Kumuduni Niroshika Palansooriyaa,1, Yong Sik Oka,1, Yasser Mahmoud Awada, Sang Soo Leeb, Jwa-Kyung Sungc, Agamemnon Koutsospyrosd, Deok Hyun Moone,∗: https://pubmed.ncbi.nlm.nih.gov/30616189/

Links to relevant information which is available online

- Lantana Demo Video: https://www.youtube.com/watch?v=1d80KyKPkDo

Farmers preparing biochar using a small technology developed by ICAR (Indian Soil Science Research Institute, Bhopal) (Santosh Gupta)

Biochar Production from the Invasive Species Lantana Camara (India)

DESCRIPTION

Lantana Camara, an invasive species in India, negatively impacts biodiversity and agriculture. Biochar made from its biomass can help manage the species effectively. Traditionally farmers produce biochar in soil pit kilns. Another low-cost portable kiln unit of biochar preparation is a viable option for rainfed areas, designed to work on the direct up-draft principle with bottom ignition and circular vents for uniform heat transfer.

Lantana Camara was introduced into India as an ornamental plant in 1809 by the British in Calcutta Botanical Garden. Lantana Camara negatively impacts biodiversity and native biota, disrupting the succession cycle, altering the structure and floral composition of native communities, and causing problems in agricultural lands in various regions of India. Its dense thickets outcompete native pastures, block the movement of grazers, and can cause poisoning. Its allelopathic activities also affect the growth of other species in its proximity. One of the measures to manage invasive species is by turning it into biochar.

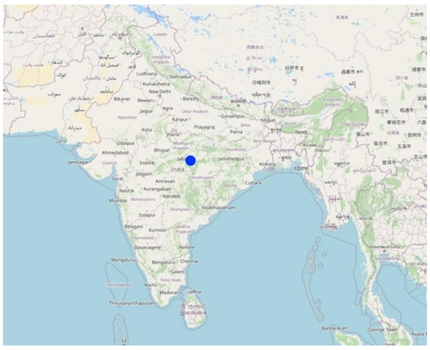
Biochar is the charred biomass produced by slow pyrolysis in which organic material is heated under controlled temperatures (300-500°C) without oxygen. Lantana Camara is an ideal biomass for biochar production due to its high diversity and wide distribution. In addition to protecting ecosystems, invasive plant-derived biochar has potential applications in environmental remediation and soil amendment due to its unique structure, composition, and adsorption properties.

In the Mandla district of Madhya Pradesh, low-cost technologies for producing biochar are being practised. A low-cost portable kiln unit has been used in the Mandla District to cater to the needs of small and marginal farmers. One unit costs approximately Rs. 7000-12000 depending upon the design and location, including a metal drum, vent-making charges, and side fittings. The kiln is designed to work on the direct up-draft principle with bottom ignition. It is a vertical, single-barrel structure with a perforated base. The kiln has a square-shaped loading hole at the top, which can be closed at the end of conversion with a metal lid with a handle. The kiln has circular vents, a staggered arrangement to avoid rows, and a central vent to hold a wooden pole. Under open atmospheric conditions, the vents at the kiln base hasten hot gas movement through the bio-residues for uniform heat transfer by primary air movement. The kiln's top hole vents the released water vapours and hot gases. A strip of metal is welded around at 3/4th height of the kiln, to which two metal rods are welded on opposite sides to serve as lifting jacks. Dry Lantana Camara feedstock is placed inside the kiln unit, and a fire is lit at the bottom. Through a pyrolysis process, the organic compounds present in the biomass decompose at a specific temperature in an oxygen-limited environment.

Prior to use, the stalks/twigs of lantana are manually cut into appropriate pieces 15-19 cm long and 0.9-1.0 cm in diameter using a commonly used axe in order to achieve better packing density. Dry residues are a prerequisite to hasten satisfactory and quicker conversion. The dried residues of lantana are placed in the unit and are burned from the bottom in an oxygen-limited environment. Generally, the burning process takes 6-8 hours through a slow pyrolysis process. Once complete, the kiln is quenched with soil and left to cool for 3-4 hours. This simple and affordable biochar production method can help manage invasive plant species and benefit agriculture, the environment, and energy. The conversion ratio from biomass to biochar in the case of Lantana is around 20-25%. Farmers have reported of burning around 100 kg of dried Lantana biomass to get ~20 kg of biochar in one operation of the unit. The application rate of biochar varies from crop to crop and the type of soil and other characters. In studied project farmers do apply 20 kg of biochar mixed with 20 kg of cow dung and 20 kg of cow urine in an area of around 1 acre.

The burned biomass of Lantana after the process looks like the coal sticks, these sticks are pulverised through a pulveriser to make a powdered material for application in the field. The

LOCATION



Location: Mandla, Madhya Pradesh, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 80.3717, 22.6033

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2020

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

biochar is mixed with an equal quantity of cow dung and cow urine before the application. Some farmers also mix the native soils in biochar to get better results.


Lantana Camara which was used for biochar production (Santosh Gupta)

A farmer is mixing biochar with cow dung for application in the field (Anoop Thakur, FES)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Land use mixed within the same land unit: Yes - Agroforestry

Cropland

- Annual cropping: cereals - millet, vegetables - other, Fallow - maize/sorghum/millet

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Grazing land

- Transhumant pastoralism
- Cut-and-carry/ zero grazing

Animal type: buffalo, cattle - dairy, goats
Is integrated crop-livestock management practiced? No

Forest/ woodlands

- (Semi-)natural forests/ woodlands. Management: Dead wood/ prunings removal, Non-wood forest use

Tree types (mixed deciduous/ evergreen): n.a.
Products and services: Timber, Fuelwood, Fruits and nuts, Other forest products, Grazing/ browsing, Nature conservation/ protection

Water supply

☑ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

physical soil deterioration - Ps: subsidence of organic soils, settling of soil, Pu: loss of bio-productive function due to other activities

biological degradation - Bc: reduction of vegetation cover, Bh: loss of habitats, Bf: detrimental effects of fires

SLM group

- natural and semi-natural forest management
- agroforestry
- improved ground/ vegetation cover

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

vegetative measures - V4: Replacement or removal of alien/ invasive species

management measures - M1: Change of land use type, M5: Control/ change of species composition

TECHNICAL DRAWING

Technical specifications

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 80.0 INR
- Average wage cost of hired labour per day: 204

Most important factors affecting the costs

Cost of the biochar kiln

Establishment activities

1. Pyrolysis of Biomass (Lantana camara) in Biochar kiln unit (Timing/ frequency: October-November and June-July (Before the winter and monsoon cropping seasons).)
2. Pulverisation of coal sticks received after the Pyrolysis process (Timing/ frequency: October-November/June-July (Immediately after the Pyrolysis process))

Establishment inputs and costs

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Equipment					
Biochar Kiln	Number	1.0	7000.0	7000.0	25.0
Pulverizer unit	Number	1.0	20000.0	20000.0	25.0
Total costs for establishment of the Technology				**27'000.0**	
Total costs for establishment of the Technology in USD				*337.5*	

Maintenance activities

1. Preparation of Biochar (Timing/ frequency: Before the sowing of Rabi and Kharif season (Month of October/November and June/July))
2. Application of Biochar in the field (Timing/ frequency: During the crops seasons;)

Maintenance inputs and costs

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Labour					
Labor cost for removal of lantana	ha	1.0	5000.0	5000.0	25.0
Preparation of biochar	Person-day	2.0	200.0	400.0	100.0
Application of biochar in the field	Person-day	0.5	200.0	100.0	100.0
Transportation of lantana	Trip	1.0	200.0	200.0	100.0
Fertilizers and biocides					
Cow dung	kg	20.0	5.0	100.0	100.0
Cow urine	kg	20.0	5.0	100.0	100.0
Total costs for maintenance of the Technology				**5'900.0**	
Total costs for maintenance of the Technology in USD				*73.75*	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☑ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1427.0

Monsoon season is June-September which has the majority of the rainfall

Name of the meteorological station: District at Glance report of Ministry of Water Resources, Central Groundwater Board, North Central Region BHOPAL, 2013

The National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) developed twenty agroecological zones based on the growing period as an integrated criterion of adequate rainfall and soil groups. It delineated boundaries adjusted to district boundaries with a minimal number of regions. Mandla District of Madhya Pradesh lies in a Hot subhumid ecoregion with red and black soil. The part of the district also lies in a semi-arid region as these regions don't have irrigation facilities and the length of the growing period lies between 75-179 days.

Precepitation - 1000–1500mm; Potential Evapotranspiration -1300–1500 mm; Lenght of Growing Period-150–180days

Slope
- ☐ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☑ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☑ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☑ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☐ medium (1-3%)
- ☑ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☑ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☑ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Water quality refers to: both ground and surface water

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☑ high
- ☐ medium
- ☐ low

Habitat diversity
- ☑ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial)
- ☐ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☑ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☑ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☑ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☑ men

Age
- ☐ children
- ☑ youth
- ☑ middle-aged
- ☐ elderly

Area used per household
- ☑ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☑ small-scale
- ☐ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☑ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☐ open access (unorganized)
- ☑ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor		✓		good
education	poor		✓		good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor		✓		good
markets	poor		✓		good
energy	poor		✓		good
roads and transport	poor		✓		good
drinking water and sanitation	poor		✓		good
financial services	poor	✓			good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐☐☐☐☑☐☐	increased	Approximately increase of 15-20% across the crops. Where biochar was used, since this has happened in multiple commodities specifying the number for any crop will not do justice.
crop quality	decreased	☐☐☐☐☐☑☐	increased	Grain size, the strength of biomass and overall taste of the grains. These are the qualitative measures which can not be addressed in numbers.
land management	hindered	☐☐☐☐☑☐☐	simplified	
irrigation water availability	decreased	☐☐☐☐☑☐☐	increased	Biochar maintains soil moisture thus, farmers need to use less quantity of water for irrigation.

Socio-cultural impacts

SLM/ land degradation knowledge	reduced	☐☐☐☐☐☑☐	improved

Ecological impacts

vegetation cover	decreased	☐☐☐☐☐☑☐	increased	Lantana Camara negatively impacts biodiversity and native biota. Its dense thickets outcompete native pastures, blocks the movement of grazers, and can cause poisoning. Its eradication helps improving the vegetative cover.
plant diversity	decreased	☐☐☐☐☐☑☐	increased	As the density of Lantana Camara in the forest increases, allelopathic interactions increase, and hence, species richness declines (Day et al., 2003).
invasive alien species	increased	☐☐☐☐☐☑☐	reduced	The invasive alien species of Lantana Camara are removed from private and common land.
animal diversity	decreased	☐☐☐☐☑☐☐	increased	
habitat diversity	decreased	☐☐☐☐☐☑☐	increased	
fire risk	increased	☐☐☐☐☐☑☐	decreased	

Off-site impacts

water availability (groundwater, springs)	decreased	☐☐☐☐☑☐☐	increased

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☑☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

The cost of biochar production is almost negligible for farmers as it is made using local resources, while the benefits are multifold in terms of crop production, quality, and soil health improvement.

CLIMATE CHANGE

-

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 11-50%
☐ 51-90%
☐ 91-100%

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

Several farmers adopted biochar production using a traditional method of digging a pit and preparing the biochar.

To which changing conditions?

☐ climatic change/ extremes

☐ changing markets
☐ labour availability (e.g. due to migration)
☑ Technology

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Communities have found biochar as an essential input to meet the nutrient requirement of their soil. They have improved the quality of their farm produce by applying biochar.
- Preparation of Biochar using Lantana Camara has emerged as an excellent use for the invasive species, which otherwise was not having any use and was growing like fire in the area
- Improved production of the farm produce

Strengths: compiler’s or other key resource person’s view

- Biochar is an excellent input for improving soil organic carbon. It can lead to healthy soil with an improved capacity of the soil to sequester carbon.
- Over the years, soils have degraded to a great extent in the project geography. Biochar can reverse this process.
- Farmers can grow short-duration crops and fodder for their animals in a rainfed area, with improved soil moisture. This will help improve farmers' income.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- The capacity of existing biochar kiln units is limited, and farmers have to wait for their turn More units can be mobilized with community-based engagement and support from externally funded projects
- Hard work and a long process involved uprooting lantana, drying, transportation, burning, and application Communities need handholding and training about its importance and more technological advances

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- In the long run, the easy accessibility of Lantana may be a concern if it is implemented on a large scale. The availability of other biomass is very much limited. An assessment of the availability of Lantana and its annual requirement for biochar preparation can be done
- Biochar has long-term benefits, while communities look for short-term solutions Handholding the communities along with linking them with carbon credit-related projects may be a good option to keep farmers motivated
- Regular application of biochar over the years Regular communication with farmers about the positive outcome aligned with other financial incentives linked to soil organic carbon improvement

REFERENCES

Compiler	**Editors**	**Reviewer**
Santosh Gupta	Noel Templer Stephanie Katsir Kim Arora	Udo Höggel Joana Eichenberger

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Resource persons
Santosh Gupta - SLM specialist

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_6690/

Linked SLM data
n.a.

Documentation was faciliated by

Institution
- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) - Germany
- Ecociate Consultants (Ecociate Consultants) - India

Project
- Soil protection and rehabilitation for food security (ProSo(i)l)

Key references
- Invasive plants as potential sustainable feedstocks for biochar production and multiple applications: A review, Qianwei Feng a, Bing Wang a b c, Miao Chen a b c, Pan Wu a b c, Xinqing Lee d, Ying Xing e: https://doi.org/10.1016/j.resconrec.2020.105204
- Biochar for Soil Health Enhancement and Crop Productivity Improvement, Awtar Singh1*, A.P. Singh2, V. Singh1, Arijit Barman1, Sagar Vibhute1 and R.S. Tolia: Innovative Farming, 1(4): 137-140, 2016
- A review of Lantana camara studies in India, Neena Priyanka*,**, P. K. Joshi*: International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013 ISSN 2250-3153
- Annual Progress Report on Promotion of Biochar in Mandla, developed by FES for the year 2021-22: Internal document of FES, shared as part of the project report to GIZ. This document can be obtained from the GIZ office, India

Links to relevant information which is available online
- District at a glance by Central Ground Water Board: http://cgwb.gov.in/District_Profile/MP/Mandla.pdf
- Low cost Kiln for Biochar Production: http://www.nicra-icar.in/nicrarevised/images/Home/NICRA%20Technical%20Brochure%20Portable%20Kiln.pdf
- Baiga Tribes: https://en.wikipedia.org/wiki/Baiga_tribe
- Biochar on soil properties and crop performance: https://www.indiascienceandtechnology.gov.in/research/biochar-soil-properties-and-crop-performance
- Video by FES on Biochar production (Hindi): https://www.youtube.com/watch?v=MPj4_I5BFRE
- A review of Lantana camara studies in India: https://www.ijsrp.org/research-paper-1013/ijsrp-p2207.pdf
- Low Cost Portable Kiln for Biochar Production: http://www.nicra-icar.in/nicrarevised/images/Home/NICRA%20Technical%20Brochure%20Portable%20Kiln.pdf

SLM technology: Preparation of bio-inputs such as vermicompost, biofertilizers, and biopesticides

Production of biological inputs and vermicompost using a Bio- Resources Enterprise model (Santosh Gupta)

Preparation of Bio-Inputs such as Vermicompost, Biofertilizers, and Biopesticides (India)

Kechua khaad, Beej Amrutham, Jeevamrutham, Dashparni and compost

DESCRIPTION

Bioresource Center (BRC) is an enterprise model to promote the preparation and commercialization of bio-inputs to help farmers adopt natural and sustainable agriculture practices. The bio-inputs and composting material under such models are prepared using locally available material at very affordable prices.

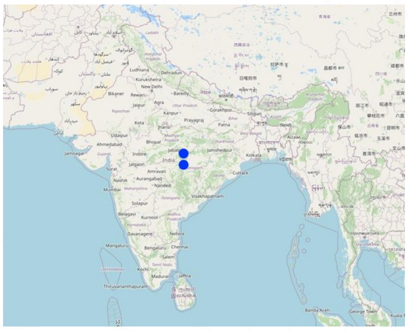
Bioresource Center (BRC) is a community-led enterprise to produce bio-inputs and compost from locally available bioresources for improving soil health and fertility, managing pest and disease, and meeting the nutrient requirement for the crops. BRCs have been envisaged as a potential enterprise solution to meet the requirements of small and marginal farmers who do not have time and resources to make their own bio-inputs and composting material. Such farmers can purchase the bio-inputs at very affordable prices from the BRCs being operated by either individual entrepreneurs or community-based institutions of male and female farmers.

Essentially it is an enterprise-led platform that can create the necessary conditions to scale the adoption of better farming practices. The technology for bioresource units is applied in both natural and human environments to promote sustainable agriculture and improve livelihoods in rural communities. The establishment and maintenance of a bioresource unit require inputs such as organic waste materials, earthworms, inoculants, and water, as well as activities such as vermicomposting, biofertilizer and biopesticide production, training and capacity building, and monitoring and evaluation.

The technological inputs produced include various type of tried and tested local formulations like microbial preparations such as Jeevamrut (Soil life elixir), Ghana Jeevamrith(compact and aggregated form of Soil Life Elixir), Beejamrut (Microbial Seed Dressing), Waste Decomposer, etc.; botanical decoctions like Panchagavya (5 cow based products formulation - Milk, Curd, cow-urine, cow-dung, ghee), Dashparni (Extract of 10 leaves available locally), Neemastra (Extarct of Neem leaves and seeds (Azadirachta indica), Brahmastra (Referes to the highly effective pest controlling material made out of chilli, garlic and other local materials), agniastra (Refers to the fire powering material for controlling pest), NSKE (Neem seed kernel extract) ; and biopesticides cultures like Beauveria, Verticillium, Trichoderma, Pseudo-monas, NPV formulations/cultures. Beyond this, the platform enables the supply of seeds of green manuring crops, vermiculture/compost, Neem / karanj cake, Cow dung/cow urine, briquets, seeds/seedlings of trap crops, etc. For a detailed list of different sub-technologies - preparations, their ingredients and processing one can refer to BIO-INPUT RESOURCE CENTER MANUAL FROM NATIONAL COALITION FOR NATURAL FARMING at: (https://indiaclimatecollaborative.org/wp-content/uploads/2022/09/BRC-Technical-manual.pdf)

This technology does not require much investment and material. 2-3 plastic containers of 200 litres and 2-3 containers of 100 litres or any other locally available utensil are good enough to make these bio-inputs. The preparation method for each of the inputs is a bit different from each other, while some of the inputs are being prepared by extracting the paste from leaves or other materials like chilli, garlic etc, others are prepared by mixing them with cow dung and cow urine. Cow urine is one of the most important substances for preparing these inputs. The urine of indigenous cows are considered more effective for preparing these inputs. The document shared above can be refereed to for the preparation method of each of the bio-inputs.
The bioresource unit technology has numerous benefits and impacts, including improved soil health, reduced dependence on synthetic inputs, increased crop yields, reduced environmental impact, enhanced biodiversity, reduced greenhouse gas emissions, and improved human health. Land users generally appreciate the benefits of the bioresource unit technology, particularly its cost-effectiveness, improved soil health, and reduced environmental impact. However, there are also challenges related to the labor-intensiveness of the technology, the need for technical knowledge, and the dependence on local resources.

LOCATION



Location: Bichhiya Block, Mandla District, Madhya Pradesh, Madhya Pradesh, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 80.68359, 21.28937
- 80.71063, 22.45388
- 80.7108, 22.45388
- 80.70982, 22.454
- 80.70982, 22.454
- 80.70974, 22.45388
- 80.70974, 22.45388
- 80.70974, 22.45388

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2018

Type of introduction
☑ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

By using natural inputs and locally available resources, this technology can help to create a more sustainable and equitable food system for people and for land also. These functions contribute to a healthier environment, healthier crops, and healthier communities.


Bio-pesticides packaged for selling to farmers (Santosh Gupta)


Vermicompst prepared by the bio resource centre enterprise (Santosh Gupta)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☑ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☑ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☑ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact
- ☑ Control pest and diseases

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - maize, cereals - rice (wetland), cereals - wheat (winter), legumes and pulses - lentils, oilseed crops - sunflower, rapeseed, other, vegetables - leafy vegetables (salads, cabbage, spinach, other)

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Purpose related to land degradation

- ☐ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion), Cp: soil pollution

biological degradation - Bp: increase of pests/ diseases, loss of predators

water degradation - Hp: decline of surface water quality

SLM group

- integrated crop-livestock management
- integrated soil fertility management
- integrated pest and disease management (incl. organic agriculture)

SLM measures

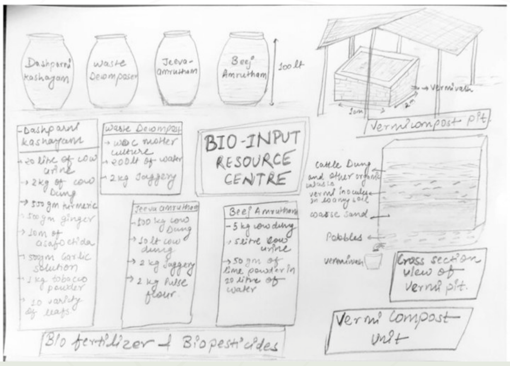
agronomic measures - A2: Organic matter/ soil fertility, A4: Subsurface treatment, A6: Residue management (A 6.4: retained)

other measures - Pest and diseases management measures to reduce the use of chemical fertilizers and pesticides

TECHNICAL DRAWING

Technical specifications

The drawing indicates the overall flow and design of the bioresource unit as seen in one of the enterprises in the project area. It consists of vermicompost pits of 6ft in length, 4 ft in depth, and 2 ft in width. The enterprise has 10 such pits. The drawing also covers the placement and structure of other equipment such as vermiwash and bio-inoculate units.



Author: Payal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **Vermicompost unit is a pit, biofertilizer and pesticides unit in litre, Materials is in Kg**)
- Currency used for cost calculation: **n.a.**
- Exchange rate (to USD): 1 USD = 82.0
- Average wage cost of hired labour per day: 3

Most important factors affecting the costs

The availability of locally available raw materials and labor

Establishment activities

1. Digging for vermicompost pits (Timing/ frequency: October)
2. Construction of vermicompost pit (Timing/ frequency: October)
3. Construction of Cattle Management Shed (Timing/ frequency: March)

Establishment inputs and costs (per Vermicompost unit is a pit, biofertilizer and pesticides unit in litre, Materials is in Kg)

Specify input	Unit	Quantity	Costs per Unit (n.a.)	Total costs per input (n.a.)	% of costs borne by land users
Labour					
Digging for vermicompost pit	piece	2.0	1000.0	2000.0	100.0
Construction of vermicompost pit	piece	2.0	4000.0	8000.0	100.0
Equipment					
Drum 500 lts	piece	5.0	600.0	3000.0	100.0
Plant material					
Pulse flour	Kg	3.0	70.0	210.0	100.0
Jageery	Kg	3.0	60.0	180.0	100.0
Turmeric	Kg	0.5	100.0	50.0	100.0
Ginger paste	Kg	0.5	120.0	60.0	100.0
Asafoetida	Gramm	10.0	3.0	30.0	100.0
Chillies	Kg	1.0	100.0	100.0	100.0
Garlic	Kg	0.5	160.0	80.0	100.0
Tobbaco	Kg	0.5	200.0	100.0	100.0
Fertilizers and biocides					
Cow dung	Kg	120.0	2.0	240.0	100.0
Cow urine	Litre	25.0	5.0	125.0	100.0
Lime	Gramm	50.0	0.25	12.5	100.0
Farm Yard Manure for Vermicompost	Kg	1000.0	10.0	10000.0	100.0
Construction material					
Brick	Piece	100.0	10.0	1000.0	100.0
Cement	Sack	3.0	300.0	900.0	100.0
Stone	Sack	2.0	500.0	1000.0	100.0
Other					
Vermi inocules	Kg	40.0	450.0	18000.0	100.0
Total costs for establishment of the Technology				**45'087.5**	
Total costs for establishment of the Technology in USD				*549.85*	

Maintenance activities

1. Preparations (Timing/ frequency: Every season)
2. Packaging and Selling (Timing/ frequency: Everyseason)
3. Capacity building (Timing/ frequency: Every season)
4. Application at field (Timing/ frequency: Kharif and Rabi Seaon)
5. Harvesting of vermicompost (Timing/ frequency: In every 3 months)
6. Filling of pit (Timing/ frequency: In every 3 months after Harvesting)

Maintenance inputs and costs (per Vermicompost unit is a pit, biofertilizer and pesticides unit in litre, Materials is in Kg)

Specify input	**Unit**	**Quantity**	**Costs per Unit (n.a.)**	**Total costs per input (n.a.)**	**% of costs borne by land users**
Labour					
Preparation of bio-inputs	Person days	50.0	200.0	10000.0	100.0
Packaging, marketing	Person days	10.0	250.0	2500.0	100.0
Fertilizers and biocides					
Cow dung or FYM for filling pit	Kg	100.0	10.0	1000.0	100.0
Different material to prepare bio-inputs	kg	200.0	15.0	3000.0	100.0
Other					
Packaging and Selling	Sack	100.0	5.0	500.0	100.0
Total costs for maintenance of the Technology				**17'000.0**	
Total costs for maintenance of the Technology in USD				*207.32*	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☐ sub-humid
- ☑ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1427.0
The highest rainfall period is from June to September during the monsoon season.
Name of the meteorological station: Mandla, Madhya Pradesh
The climate of the district is tropical, with moderate winters, severe summers, and well-distributed rainfall received from the southwest monsoon. However, due to higher general elevation and abundance of forests, summer temperatures do not rise as much as in other areas.

Slope
- ☐ flat (0-2%)
- ☐ gentle (3-5%)
- ☑ moderate (6-10%)
- ☑ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☑ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☑ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☐ medium (1-3%)
- ☑ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☐ 5-50 m
- ☑ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☑ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☑ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Water quality refers to: both ground and surface water

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☑ high
- ☐ medium
- ☐ low

Habitat diversity
- ☑ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial)
- ☐ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☑ poor
- ☐ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☑ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☐ individual/ household
- ☑ groups/ community
- ☐ cooperative

Gender
- ☑ women
- ☑ men

Age
- ☐ children
- ☑ youth
- ☑ middle-aged

☐ employee (company, government)

☐ elderly

Area used per household
- ☑ < 0.5 ha
- ☐ 0.5-1 ha
- ☑ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☑ small-scale
- ☐ medium-scale
- ☐ large-scale

Land ownership
- ☐ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights
- ☐ open access (unorganized)
- ☑ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor ☐ ☑ ☐ good
education	poor ☐ ☑ ☐ good
technical assistance	poor ☐ ☑ ☐ good
employment (e.g. off-farm)	poor ☐ ☑ ☐ good
markets	poor ☐ ☑ ☐ good
energy	poor ☐ ☑ ☐ good
roads and transport	poor ☐ ☑ ☐ good
drinking water and sanitation	poor ☐ ☑ ☐ good
financial services	poor ☑ ☐ ☐ good

IMPACTS

Socio-economic impacts

Crop production

Crop production	decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased	The use of compost, bio-fertilisers and other nutrient-rich material has improved farm productivity to a great extent
crop quality	decreased ☐ ☐ ☐ ☐ ☐ ☑ ☐ increased	Improvement in crop quality such as size of the grains and vegetables, nutrient content, their aroma has improved due to application of inputs made at BRC
risk of production failure	increased ☐ ☐ ☐ ☐ ☑ ☐ ☐ decreased	The local material including the local seeds are more resilient to the extreme climatic events and offer a reduced risk to the farmers
product diversity	decreased ☐ ☐ ☐ ☐ ☑ ☐ ☐ increased	
expenses on agricultural inputs	increased ☐ ☐ ☐ ☐ ☐ ☐ ☑ decreased	Use of local materials, low-tech home-based processing, and open source availability of technology enables farmers to produce their organic inputs at home essentially only costing capital such as plastic container and labour, thus improving the accessibility of good farming inputs to even disadvantaged groups such as small farmers, marginalised communities, landless farmers, ultra-poor, etc.
farm income	decreased ☐ ☐ ☐ ☐ ☑ ☐ ☐ increased	Farmers have reported of getting better prices for their produces produced with low or no chemical inputs
diversity of income sources	decreased ☐ ☐ ☐ ☐ ☑ ☐ ☐ increased	BRC as an enterprise activity offered an additional source of income to the farmers

Socio-cultural impacts

food security/ self-sufficiency	reduced ☐ ☐ ☐ ☐ ☑ ☐ ☐ improved	
health situation	worsened ☐ ☐ ☐ ☐ ☐ ☑ ☐ improved	Lesser use of chemical fertilizers and pesticides improve the negative impact of these on human and animal health
cultural opportunities (eg spiritual, aesthetic, others)	reduced ☐ ☐ ☐ ☐ ☐ ☑ ☐ improved	Cultural opportuities develop through livestock integration, concoction preparations and an improvemetn of the local economy
community institutions	weakened ☐ ☐ ☐ ☐ ☑ ☐ ☐ strengthened	
SLM/ land degradation knowledge	reduced ☐ ☐ ☐ ☐ ☐ ☑ ☐ improved	
situation of socially and economically disadvantaged groups (gender, age, status, ehtnicity etc.)	worsened ☐ ☐ ☐ ☐ ☑ ☐ ☐ improved	

Ecological impacts

water quality	decreased	☐☐☐☐✓☐☐	increased	Use of chemical based intensive farming has proven to be disastrous for water quality and strenuous for water quantity. The BRCs help farmers adopt biological means of improving fertility and reducing pest damage and have no long-term polluting effect on groundwater and canal resources. Adoption of sustainable agriculture practices that effectively substitute chemicals, improve as well natural resource cycles have been shown to improve water availability in the field and thus also improve water use efficiency.
surface runoff	increased	☐☐☐☐✓☐☐	decreased	
soil moisture	decreased	☐☐☐☐☐✓☐	increased	
soil loss	increased	☐☐☐☐☐✓☐	decreased	
nutrient cycling/ recharge	decreased	☐☐☐☐☐✓☐	increased	
soil organic matter/ below ground C	decreased	☐☐☐☐☐✓☐	increased	
biomass/ above ground C	decreased	☐☐☐☐✓☐☐	increased	
plant diversity	decreased	☐☐☐☐☐✓☐	increased	
animal diversity	decreased	☐☐☐☐✓☐☐	increased	
beneficial species (predators, earthworms, pollinators)	decreased	☐☐☐☐☐✓☐	increased	Reduced usage of chemical pesticides prevent loss of beneficial insects and micro organisms, thus improve the population of beneficial species
habitat diversity	decreased	☐☐☐☐☐✓☐	increased	Reduced usage of chemical pesticides prevent loss of beneficial insects and micro organisms, thus improve the overall farm diversity
pest/ disease control	decreased	☐☐☐☐☐✓☐	increased	This technology is meant for pest/disease control purposes. The usage of these inputs is very effective in controlling the pest and diseases.
emission of carbon and greenhouse gases	increased	☐☐☐☐☐✓☐	decreased	Emission reductions happen through substitution of chemical inputs. Agri chemicals have high emission intensity in production, transportation and use. Studies show that the use of urea contributes to higher methane emissions because of ammonia decomposition. Carbon sequestration benefits are also achieved because of the increase in SOC by adopting natural inputs, higher photosynthetic efficiency, more microbial carbon use efficiency and improved residue cycling.

Off-site impacts

groundwater/ river pollution	increased	☐☐☐☐✓☐☐	reduced	
damage on neighbours' fields	increased	☐☐☐☐☐✓☐	reduced	Adoption of this tech means reduced chemical runoff, better biodiversity supporting neighbouring fields and providing other ecosystem services.
impact of greenhouse gases	increased	☐☐☐☐✓☐☐	reduced	Emission reductions happen through substitution of chemical inputs. Agri chemicals have high emission intensity in production, transportation and use. Studies show that the use of urea contributes to higher methane emissions because of ammonia decomposition. Carbon sequestration benefits are also achieved because of increase in SOC by adopting natural inputs, higher photosynthetic efficiency, more microbial carbon use efficiency and improved residue cycling.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐✓☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐✓☐☐☐☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐✓	very positive

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	☐	☐	✓	☐	☐	very well	
seasonal temperature increase	not well at all	☐	☐	✓	☐	☐	very well	Season: summer
annual rainfall decrease	not well at all	☐	☐	☐	☐	✓	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- ☑ single cases/ experimental
- ☐ 1-10%
- ☐ 11-50%
- ☐ > 50%

Number of households and/ or area covered

8

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- ☐ 0-10%
- ☐ 11-50%
- ☐ 51-90%
- ☑ 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- ☑ Yes
- ☐ No

To which changing conditions?

- ☐ climatic change/ extremes
- ☑ changing markets
- ☐ labour availability (e.g. due to migration)

New variants of locally produced bio-based enzymes, catalysts, fertilizers, pest repellants

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- The technologies reduce costs and increase savings.
- Improved crop production and quality through sustainable management.
- Reduces exposure to hazardous chemicals.

Strengths: compiler's or other key resource person's view

- Protection and sustainable use of local biodiverse resources.
- Adoption of sustainable and organic practices.
- Local circular economy and strengthened institutions.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Low demand for produced inputs. Increase extension efforts for agroecological practices
- Labor shortages. Improved technologies and automation of production and delivery
- Availability of raw materials. Improved common land management

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Disadoption threats. Increase demand for products
- Spurious input production. Standardization and certification

REFERENCES

Compiler

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Editors

Noel Templer
Stephanie Katsir
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Reviewer

Udo Höggel
Joana Eichenberger

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Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6695/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) - Germany
- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online

- Bio-input Resource Center Manual from National Coalition for Natural Farming: https://drive.google.com/file/d/1MpJGpyIm1oq1ro-GKvhJVNMqCSjkCE99/view?usp=share_link
- Glimpse into the Bio-Input Resource Centre of South India by National Coalition for Natural Farming: https://www.youtube.com/watch?v=cfHeecl6OEo

Farmers with city compost bags in their field (Nitin, WOTR)

City Compost: A Solution For Waste Management And Soil Health Improvement (India)

Khachra Khad

DESCRIPTION

The use of city compost is a sustainable solution for addressing the problem of waste management and soil degradation. Under this technology, urban municipal waste is composted and used as organic fertiliser in agriculture. This relieves the cities' waste management, enhances rural soils and in turn improves farm productivity.

In India, over 377 million people live in almost 8,000 cities or towns. They generate 62 million tons of municipal solid waste annually, according to the country's government. More than 80% of such solid waste is deposited indiscriminately without treatment at dump yards in an unhygienic manner. In the Indian countryside, the ecological sustainability of agriculture has been at risk due to the excessive use of chemical fertilizers and monoculture since the 'Green Revolution' led to the degradation of land.

City compost is one of the solutions to both problems. Waste collected by municipal corporations is processed to make compost. During this process, organic waste is collected in the cities, recycled, processed to compost, and finally used as organic matter by farmers complementing the traditional farmyard manure. In such manner carbon that is contained in the waste is recycled back into the soil thus enhancing agricultural production.

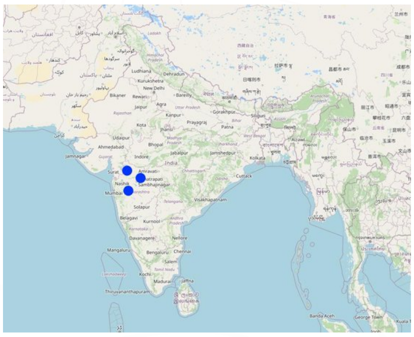
Nashik Municipal Corporation in Nashik town of Maharashtra State in India has set-up a waste processing plant in the town. This plant processes the city's organic waste into compost through a scientific process. The processed city compost is packed into bags of 50 kg each and these bags are supplied to fertilizer companies and further on to farmers. There are Government subsidies available to farmers for the purchase of compost bags subject to documentary proofs and other conditions.

Under the "Soil Protection and Rehabilitation for Food Security (ProSoil)" project of GIZ, farmers and FPOs (farmer producer organizations) have been supported for the application of city compost in their fields. Supported by the implementing agency WOTR (Watershed Organization Trust) the city compost application in farmer's fields in 3 districts of Maharashtra namely Ahmednagar, Jalna and Dhule has been introduced. Interventions covered more than 3000 farmers and around 1100 Acres of land. The entire intervention is implemented with the help of FPOs, which procured the city compost from 'The Nashik Waste Management Centre' and sold the procured material further to the farming communities. This has ensured easy availability to the farmers without incurring undue travel cost. Farmers applied the city waste compost in their farms during the month of May/June (before the onset of monsoon) to different crops.

City compost was applied to different crop combinations such as paddy-chickpea in Dhule District (moderate irrigation facility), greengram-sorghum in Ahmed Nagar District (Rainfed conditions) and soyabean-wheat in Jalna District (irrigated conditions). Farmers have seen the benefits of city compost across all crop combinations and geographies. The application of city compost has been of benefit to farmers in reducing the usage of synthetic fertilizers along with reducing the dependency on farmyard manure as it is getting scarce day by day. Farmers have also realized the improved soil health leading to better productivity of their farms.

The Indian government has also launched several initiatives to promote the use of city compost in agriculture. For example, the National Mission for Sustainable Agriculture provides financial assistance to farmers for the purchase of city compost, and the Fertilizer Control Order allows the use of city compost as a fertilizer. Although developing city waste as compost and its application in the farmer's field is a nascent approach from the India Government and other stakeholders, however looking at the availability of waste, the commitment of the Indian Government through its 'Clean India Program' and the vast issue of synthetic fertilizers usage and high subsidy burden, the use of city compost in agriculture has

LOCATION



Location: Ahmednagar, Jalna, Dhule, Maharashtra, India

No. of Technology sites analysed: > 1000 sites

Geo-reference of selected sites
- 74.44158, 19.00006
- 75.77338, 20.26124
- 75.7733, 20.26112
- 75.7733, 20.26112
- 75.77343, 20.26055
- 74.31354, 20.99405

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2021

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

the potential to contribute to sustainable solutions in the area of waste management while improving soil health and reducing the use of synthetic fertilizers in India.


Procurement of city compost by FPO (Nitin, WOTR)


Farmer mixing the city compost before application (Nitin, WOTR)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact
☑ Reduce municipal waste

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - rice (upland), cereals - sorghum, cereals - wheat (winter), legumes and pulses - beans, legumes and pulses - soya

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☐ prevent land degradation
☐ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

SLM group

- rotational systems (crop rotation, fallows, shifting cultivation)
- integrated soil fertility management
- waste management/ waste water management

SLM measures

agronomic measures - A2: Organic matter/ soil fertility

TECHNICAL DRAWING

Technical specifications

An overview of the field where city compost is applied

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **Hectare**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 80.0 INR
- Average wage cost of hired labour per day: 200

Most important factors affecting the costs

The cost of city compost is available at a subsidised price of INR 1000 per ton incl. transportation. Non-subsidised prices range at INR 3000 per ton plus transportation. Project farmers could get it at subsidised rates. However, the non-availability of required documents may be a hindrance for farmers to avail the subsidised prices.

Establishment activities

n.a.

Maintenance activities

1. Purchase of city compost by FPO and transportation to the base location (Timing/ frequency: April/May)
2. Selling of the city compost among the farmers (Timing/ frequency: May)
3. Application of city compost in the field by farmers (Timing/ frequency: May or early June)
4. Mixing of the city compost in soil using the cultivator or rotavator (Timing/ frequency: May/June (Immediately after the application))
5. Irrigation of the field (Timing/ frequency: Mid June or at the onset of Monsoon (farmers having assured irrigation due with their own sources))
6. Sowing of the seeds (Timing/ frequency: June or early July)
7. Intercultural operations (Weeding, nutrient management, pest application, crop monitoring) (Timing/ frequency: July-October)
8. Harvesting of the crops (Timing/ frequency: October/November)

Maintenance inputs and costs (per Hectare)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR)**	**Total costs per input (INR)**	**% of costs borne by land users**
Labour					
Application of city compost	Person days	2.0	300.0	600.0	100.0
Irrigation	Person days	2.0	300.0	600.0	100.0
Equipment					
Hired machinery for mixing the city compost in soil	Hours	2.0	900.0	1800.0	100.0
Fertilizers and biocides					
City compost	Ton	2.5	1200.0	3000.0	100.0
Total costs for maintenance of the Technology				**6'000.0**	
Total costs for maintenance of the Technology in USD				*75.0*	

NATURAL ENVIRONMENT

Average annual rainfall **Agro-climatic zone** **Specifications on climate**

☐ < 250 mm
☐ 251-500 mm
☑ 501-750 mm
☐ 751-1,000 mm
☐ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

☐ humid
☐ sub-humid
☑ semi-arid
☐ arid

Average annual rainfall in mm: 566.0
On an average, there are 34 rainy days (i.e. days with rainfall of 2.5 mm or more) in a year in the district. The major rainfall is usually received during months of June to September.
Name of the meteorological station: IMD, Pune
The project area comes under the scarcity zone, which is characterised by very low and erratic nature of rainfall, this affects the moisture content in the soil, therefore, this zone is commonly known as a drought-prone area. There is a high scarcity of irrigation water after the month of December. Thus, farmers mostly cultivate crops which can withstand very low water supplies.

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☐ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☑ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☐ 5-50 m
☑ > 50 m

Availability of surface water
☐ excess
☐ good
☐ medium
☑ poor/ none

Water quality (untreated)
☐ good drinking water
☐ poor drinking water (treatment required)
☑ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: ground water

Is salinity a problem?
☑ Yes
☐ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☑ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☐ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☐ manual work
☑ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☑ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☐ < 0.5 ha
☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure
health poor ☐ ☑ ☐ good
education poor ☐ ☑ ☐ good

Comments

technical assistance	poor	☐	✓	☐	good
employment (e.g. off-farm)	poor	☐	✓	☐	good
markets	poor	☐	✓	☐	good
energy	poor	☐	✓	☐	good
roads and transport	poor	☐	✓	☐	good
drinking water and sanitation	poor	☐	✓	☐	good
financial services	poor	☐	✓	☐	good

In terms of infrastructure and services, Ahmednagar is well-connected with most services. However, still there is a scope to improve these further to make farmers' life better.

IMPACTS

Socio-economic impacts

Crop production	decreased	☐	☐	☐	☐	☐	✓	☐	increased	Quantity before SLM: 1800 kg Quantity after SLM: 2300 kg Based on the assessment of the project implementing agency. However, crop production increases are not only to city compost. There were other technologies, which have also contributed to improving productivity. There is no assessment for the stand-alone compost intervention.
crop quality	decreased	☐	☐	☐	☐	✓	☐	☐	increased	Reduced usage of synthetic fertilisers made the grains and pluses safer for consumption
expenses on agricultural inputs	increased	☐	☐	☐	☐	✓	☐	☐	decreased	Quantity before SLM: 3600 Quantity after SLM: 3200 Reduced cost towards synthetic fertilisers
farm income	decreased	☐	☐	☐	☐	✓	☐	☐	increased	Improved income due to improved productivity. Quantifiable numbers are however, not available.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐	☐	☐	☐	✓	☐	☐	improved	
community institutions	weakened	☐	☐	☐	☐	☐	✓	☐	strengthened	Training and handholding support was provided from the project for procurement of city compost, governance and other areas.

Ecological impacts

soil moisture	decreased	☐	☐	☐	☐	✓	☐	☐	increased	
soil organic matter/ below ground C	decreased	☐	☐	☐	☐	✓	☐	☐	increased	Reported by the implementing agency

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Benefits compared with maintenance costs

Short-term returns	very negative	☐	☐	☐	☐	✓	☐	☐	very positive
Long-term returns	very negative	☐	☐	☐	☐	☐	☐	✓	very positive

City compost does not have any establishment cost at the farmers' level. In terms of maintenance cost, it is beneficial to farmers both in short term and long run.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	☐	☐	☐	☐	☐	very well	Answer: not known
seasonal temperature increase	not well at all	☐	☐	☐	☐	☐	very well	Season: winter Answer: not known
annual rainfall decrease	not well at all	☐	☐	✓	☐	☐	very well	

Climate-related extremes (disasters)

heatwave	not well at all	☐	☐	☐	☐	☐	very well	Answer: not known
cold wave	not well at all	☐	☐	☐	☐	☐	very well	Answer: not known
extreme winter conditions	not well at all	☐	☐	☐	☐	☐	very well	Answer: not known
drought	not well at all	☐	☐	✓	☐	☐	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 11-50%

☐ 11-50%
☐ > 50%
☐ 51-90%
☑ 91-100%

Number of households and/ or area covered
1100

Has the Technology been modified recently to adapt to changing conditions?
☐ Yes
☑ No

To which changing conditions?
☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view
- A good replacement for farmyard manure (dung) as its availability is a challenge due to reduction in numbers of livestock
- Improved productivity of major crops
- Farmers have observed improvement in soil moisture and soil texture which indicates a better soil health

Strengths: compiler's or other key resource person's view
- This is an excellent mechanism to promote the waste management and address this long-standing problem of the country
- An economically cheaper option to meet the composting needs of farmers thus promoting the natural farming
- A good business line for FPOs as city compost is generally not available in the market
- In the longer run, regular application of compost can improve the soil organic carbon

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome
- Currently available in Nashik city only which is 150 km from the project area Collective procurement by FPO and selling it to its members
- Prices of city compost are very high at the non-subsidised prices Farmers can keep their documents updated to get the subsidised compost. Also put up an application to concerned authorities for continuation of subsidy.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome
- Regular supply from the waste processing plants. Many such plants do not operate regularly due to internal and external reasons. FPOs can undertake some longterm contracts with the company. Also in the long run they can set-up small plants for local-level composting.

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir	Udo Höggel Joana Eichenberger

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Resource persons
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Linked SLM data
n.a.

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Institution
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- Ecociate Consultants (Ecociate Consultants) - India

Project
- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online
- City compost in India – from waste to healthy soil: https://www.rural21.com/english/covid-19-dossier/detail/article/city-compost-in-india-from-waste-to-healthy-soil.html

Soil testing lab established by the Foundation for Ecological Security (FES) in Mandla, Madhya Pradesh, India (Santosh Gupta)

Dissemination of Soil Test Results to Farmers through a Participatory Approach (India)

Mitti ki namuna

DESCRIPTION

A systematic approach has been developed under the project for collecting soil samples, conducting the soil test results, issuing soil health cards, building the capacity of farmers to interpret the soil health card and apply the required nutrients to the soil based on the soil test result

Soil testing is a pre-cultivation activity that gives a good idea about soil structure and mineral composition ratios. The essential nutrients required for various crop growths can be estimated during soil testing. The Foundation for Ecological Security (FES) has established a state-of-the-art soil testing laboratory for testing soil samples in India's Mandla District of Madhya Pradesh. The soil test lab was established in 2016 with a capacity to test 1500-2000 soil samples every year. Based on a soil sampling process, it takes around 2 days to generate the soil test results for 20 soil samples. Collected soil samples are tested for 12 parameters. These parameters include Soil Ph, Soil organic carbon (SoC), electrical conductivity (EC), major nutrients like nitrogen(N), phosphorus (P), potassium (K), secondary nutrients like sulphur, magnesium, iron, boron, zinc, manganese, and copper. Based on the soil test report, farmers are issued a soil health card with crop-specific recommendations for additional chemical and organic inputs into the soil.

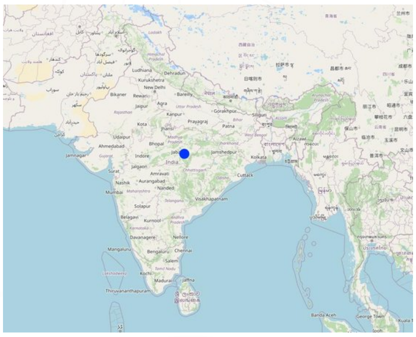
To ensure the accuracy of the sampling process and proper dissemination of generated results among the farmers, FES has developed a very systematic process which consists of:

•the collection of soil samples
•the analysis of collected soil samples in an FES lab
•the issuance of soil health cards
•the interpretation of soil test results
•noticing of test results to farmers
•farmers are able to implement practices, recommended by the test result

The entire process, from soil sampling to dissemination, is briefly mentioned below:

•Developing the grids for a random collection of soil samples: The first step is to develop a geographical grid for collecting random samples based on predefined parameters. In the irrigated areas, samples are drawn in a grid of 2.5 ha, while in rainfed areas, samples are drawn from a grid of 10 ha. While developing the grid, farmers' fields are categorized into the following parameters. Each of the parameters is assigned a specific score, and based on the obtained score, each farmer’s land is given a specific number for easy identification on soil maps. These include the a) type of soil, b) type of field, e.g., upland, medium land, or low land, c) crop cycle (Single crop, multiple crops) d) The slope of the field. This entire exercise is a soil survey exercise used to develop soil maps for each geographical unit village, block, district.
•Collection of soil samples: From each classified grid, soil samples are collected from 5 different locations between the harvest of one crop and the sowing/planting of another crop

LOCATION



Location: Mandla, Madhya Pradesh, India

Geo-reference of selected sites

- 80.37213, 22.59756
- 80.37213, 22.59756

Initiation date: 2018

Year of termination: n.a.

Type of Approach

☐ traditional/ indigenous
☐ recent local initiative/ innovative
☑ project/ programme based

when fields are vacant. The soil samples are collected at a depth of 5 to 15 cm. All the collected soil samples are mixed repeatedly, and a portion of the collected soil is kept aside each time. The mixing process is followed 5-6 times to ensure collected soil samples represent the entire area. Finally, around 500 gm of soil is packed in plastic polythene based on the above grid parameters.

•Soil sample analysis: Collected soil samples are transported to the centralized soil test lab in Mandla (MP) for testing and analysis. The samples are analyzed by qualified lab personnel. The analysis process for the above mentioned 12 parameters takes around 2 days (considering 8-9 working hours in a day).

•Issuance of soil health card: Based on the results obtained from the analysis, soil health cards are issued to farmers. The soil health card contains the following information in the local language (Hindi) so that farmers understand the test results and their implications:

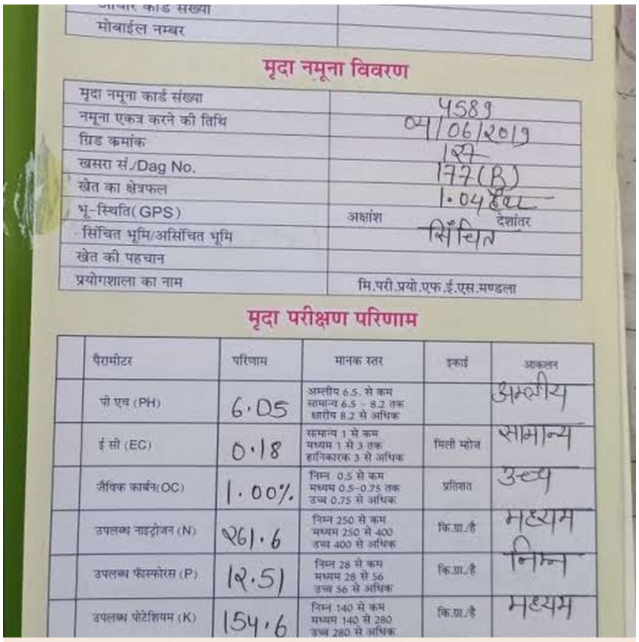
a.Basic details of the farmer: name, address, soil grid, GPS coordinates, field identification number, etc.

b.Soil test results for above mentioned 12 parameters: results of the soil test in their respective units, standard numbers, grading of the obtained result (acidic/saline for PH., high, medium, low for other parameters)

c.Crop-wise soil correction recommendations for major crops: recommendations for synthetic fertilizers, biofertilizers, and compost

d.Pre-printed information with photos for identification of nutrient deficiency in the crops.

•Dissemination of soil health card to farmers: To ensure that farmers understand the results and implement the practices at their field, local community resource persons reach out to every farmer to make them understand the soil test results and closely monitor their farmers' practices across the crop stages. Farmers are also encouraged to maintain farm diaries for their practices. They are also trained in the preparation of various bio-inputs and compost for application in their field.



आधार कार्ड संख्या	
मोबाईल नम्बर	

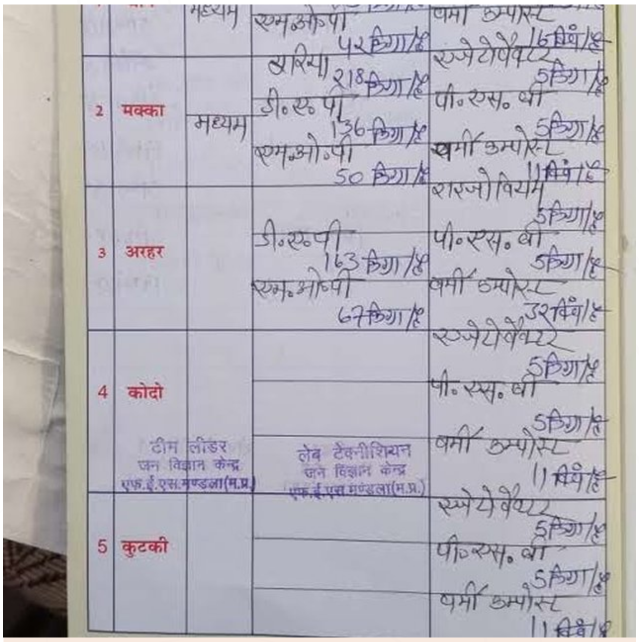
मृदा नमूना विवरण

मृदा नमूना कार्ड संख्या		4589
नमूना एकत्र करने की तिथि		04/06/2019
ग्रिड कमांक		127
खसरा सं./Dag No.		177(B)
खेत का क्षेत्रफल		1.04 हैक्ट
भू-स्थिति(GPS)	अक्षांश	देशांतर
सिंचित भूमि/असिंचित भूमि		सिंचित
खेत की पहचान		
प्रयोगशाला का नाम		मि.परी.प्रयो.एफ.ई.एस.मण्डला

मृदा परीक्षण परिणाम

पैरामीटर	परिणाम	मानक स्तर	इकाई	आकलन
पी एच (PH)	6.05	अम्लीय 6.5 से कम सामान्य 6.5 - 8.2 तक क्षारीय 8.2 से अधिक		अम्लीय
ई सी (EC)	0.18	सामान्य 1 से कम मध्यम 1 से 3 तक हानिकारक 3 से अधिक	मिली म्होज	सामान्य
जैविक कार्बन(OC)	1.00%	निम्न 0.5 से कम मध्यम 0.5-0.75 तक उच्च 0.75 से अधिक	प्रतिशत	उच्च
उपलब्ध नाइट्रोजन (N)	261.6	निम्न 250 से कम मध्यम 250 से 400 उच्च 400 से अधिक	कि.ग्रा./है	मध्यम
उपलब्ध फॉस्फोरस (P)	12.51	निम्न 28 से कम मध्यम 28 से 56 उच्च 56 से अधिक	कि.ग्रा./है	निम्न
उपलब्ध पोटेशियम (K)	154.6	निम्न 140 से कम मध्यम 140 से 280 उच्च 280 से अधिक	कि.ग्रा./है	मध्यम

Sample of the soil health card (Santosh Gupta)



		मध्यम	एम.ओ.पी 42 कि.ग्रा/है	वर्मी कम्पोस्ट 1 क्विं/है
2	मक्का	मध्यम	यूरिया 218 कि.ग्रा/है डी.ए.पी 136 कि.ग्रा/है एम.ओ.पी 50 कि.ग्रा/है	एजेटोबैक्टर 5 कि.ग्रा/है पी.एस.बी 5 कि.ग्रा/है वर्मी कम्पोस्ट 1 क्विं/है
3	अरहर		डी.ए.पी 163 कि.ग्रा/है एम.ओ.पी 67 कि.ग्रा/है	राइजोबियम 5 कि.ग्रा/है पी.एस.बी 5 कि.ग्रा/है वर्मी कम्पोस्ट 3 क्विं/है
4	कोदो	टीम लीडर जन विज्ञान केन्द्र एफ.ई.एस.मण्डला(म.प्र.)	लेब टेक्नीशियन जन विज्ञान केन्द्र एफ.ई.एस.मण्डला(म.प्र.)	एजेटोबैक्टर 5 कि.ग्रा/है पी.एस.बी 5 कि.ग्रा/है वर्मी कम्पोस्ट 1 क्विं/है
5	कुटकी			एजेटोबैक्टर 5 कि.ग्रा/है पी.एस.बी 5 कि.ग्रा/है वर्मी कम्पोस्ट 1 क्विं/है

Soil health card with recommendations (Santosh Gupta)

APPROACH AIMS AND ENABLING ENVIRONMENT

Main aims / objectives of the approach

1. Ensure judicious usage of fertilizers and micronutrients based on the requirement of the soil
2. Ensure quality soil testing and dissemination of results
3. Build farmers' capacity for interpretation of soil health cards
4. Develop soil maps based on the in-house results from the soil test lab

Conditions enabling the implementation of the Technology/ ies applied under the Approach

- **Institutional setting**: The entire dissemination methodology is done through community-based organizations
- **Collaboration/ coordination of actors**: Several stakeholders, such as FES, farmers, equipment suppliers, the scientific community, and soil scientists, are involved in the project
- **Policies**: Soil test results are an excellent input for the agricultural policies around fertilizers, farming practices, and soil health-related policies
- **Land governance (decision-making, implementation and enforcement)**: A soil health card is an excellent tool for farmers to decide on the usage of fertilizers and the kind of farming practices to implement
- **Knowledge about SLM, access to technical support**: Soil health cards inform the farmers and the project management team so to decide on required interventions and farming practices
- **Markets (to purchase inputs, sell products) and prices**: Very much relevant as soil test results quantify the number of farm inputs to be applied to the farm

Conditions hindering the implementation of the Technology/ ies applied under the Approach

PARTICIPATION AND ROLES OF STAKEHOLDERS INVOLVED

Stakeholders involved in the Approach and their roles

What stakeholders / implementing bodies were involved in the Approach?	**Specify stakeholders**	**Describe roles of stakeholders**
local land users/ local communities	Farmers from the project area	Soil samples were collected from the field of farmers. They have actively participated in the projects for managing the soil samples, participating in the capacity building programs, and implementing the recommended practices.
community-based organizations	FES, the implementing NGO, have formed the Villages Environment Committee (VEC) in their project villages as community-based organizations	VECs facilitated the implanting of a project by mobilizing the communities as and when needed. FES reached farmers through the VECs, to collect the soil samples or disseminate the information. VECs also facilitated community-level implementation activities.
SLM specialists/ agricultural advisers	SLM Specialist	Documentation of the activities
NGO	Foundation for Ecological Security (FES) is a well-known NGO registered in India. It focuses on ecology-related issues and works closely with farmers and forest-based communities.	FES played an essential role in the project. Primary activities were as follows: 1. Establishment of soil testing laboratory and hiring the technical team to conduct the soil test lab 2. Collection of soil test samples and building the capacity of farmers on soil sample collection 3. Conducting soil test results and issuance of soil health cards to farmers 4. Developing a soil health map for the project areas 5. Capacity building of farmers for the interpretation of soil health cards and ensuring the implementation of recommended practices
international organization	GIZ, India	Funding of the project

Lead agency

Foundation for Ecological Security

Involvement of local land users/ local communities in the different phases of the Approach

	none	passive	external support	interactive	self-mobilization	
initiation/ motivation	☐	☑	☐	☐	☐	The FES led the initiation of discussions with its donor organizations. Discussions with communities to understand the challenges and opportunities.
planning	☐	☐	☐	☑	☐	Local community institutions played a significant role in the entire process of planning and execution
implementation	☐	☐	☐	☑	☐	Farmers and community-based institutions were actively involved in implementing multiple activities under the project, such as collecting soil samples, supplying them to the soil test labs, and Implementing the recommended practices.
monitoring/ evaluation	☐	☐	☐	☑	☐	Community-based institutions played an important role in monitoring individual farmers for implementing the recommendations provided to farmers. They also monitored the results regarding crop progress, crop productivity, and improvement in soil health status.

Flow chart

Decision-making on the selection of SLM Technology

Decisions were taken by
- ☐ land users alone (self-initiative)
- ☐ mainly land users, supported by SLM specialists
- ☑ all relevant actors, as part of a participatory approach
- ☐ mainly SLM specialists, following consultation with land users
- ☐ SLM specialists alone
- ☐ politicians/ leaders

Decisions were made based on
- ☑ evaluation of well-documented SLM knowledge (evidence-based decision-making)
- ☑ research findings
- ☐ personal experience and opinions (undocumented)

TECHNICAL SUPPORT, CAPACITY BUILDING, AND KNOWLEDGE MANAGEMENT

The following activities or services have been part of the approach

- ☑ Capacity building/ training
- ☑ Advisory service
- ☑ Institution strengthening (organizational development)

☑ Monitoring and evaluation
☑ Research

Capacity building/ training

Training was provided to the following stakeholders
☑ land users
☑ field staff/ advisers

Form of training
☐ on-the-job
☑ farmer-to-farmer
☑ demonstration areas
☑ public meetings
☐ courses

Subjects covered

1. Importance of soil testing for the judicious use of fertilizers
2. Methods for soil sample collection
3. Interpretation of soil health card
4. Dissemination of soil test results and ways and means for implementing the recommended practices following organic and non-organic implementation practices

Advisory service

Advisory service was provided
☑ on land users' fields
☐ at permanent centres

FES has a team of community-based resource persons from the local community and villages to provide advisory services to farmers

Institution strengthening

Institutions have been strengthened / established
☐ no
☐ yes, a little
☐ yes, moderately
☑ yes, greatly

at the following level
☑ local
☐ regional
☐ national

Describe institution, roles and responsibilities, members, etc.
Village-level environment committees were formed to discuss the issues related to environmental concerns, livelihoods, and other social problems at the village level. These committees consist of male and female members representing the entire village.

Type of support
☑ financial
☑ capacity building/ training
☐ equipment

Further details
These committees were provided financial support to implement the identified activities based on the provision under the project and proposals submitted by the local committees. FES regularly provides training and handholding support to these committees.

Monitoring and evaluation

The soil health report card is very useful in monitoring of the status of soil health and measuring the impact of various practices and intervention

Research

Research treated the following topics
☐ sociology
☐ economics / marketing
☑ ecology
☑ technology

FINANCING AND EXTERNAL MATERIAL SUPPORT

Annual budget in USD for the SLM component
☐ < 2,000
☑ 2,000-10,000
☐ 10,000-100,000
☐ 100,000-1,000,000
☐ > 1,000,000
Precise annual budget: n.a.

Externally funded projects (GIZ)

The following services or incentives have been provided to land users
☐ Financial/ material support provided to land users
☑ Subsidies for specific inputs
☐ Credit
☐ Other incentives or instruments

	partly financed	fully financed
equipment: machinery Different equipment used for testing the soils	☑	☐
equipment: machinery: tools Different tools are used for collecting soil samples and for soil testing	☑	☐

Labour by land users was
☑ voluntary
☐ food-for-work
☐ paid in cash
☐ rewarded with other material support

IMPACT ANALYSIS AND CONCLUDING STATEMENTS

Impacts of the Approach

ittle	noderately	greatly

	No	Yes, l	Yes, r	Yes, g
Did the Approach enable evidence-based decision-making? Soil health card-based changes in soil management and developing the evidence for soil health monitoring	☐	☐	☐	☑
Did the Approach improve coordination and cost-effective implementation of SLM? Reduced the cost of applying fertilizers and other inputs through a result-based application	☐	☐	☐	☑
Did the Approach improve knowledge and capacities of land users to implement SLM? Training and handholding by the team of implementing partners have helped land users to interpret the result of soil health card, collection of soil samples and following the recommended practices	☐	☐	☑	☐
Did the Approach improve knowledge and capacities of other stakeholders? Other stakeholders such as implementing team got information about the outcome of their practices. More importantly, the soil health card was helpful in providing precise information on the application of fertilisers and bio-inputs.	☐	☐	☐	☑
Did the Approach encourage young people/ the next generation of land users to engage in SLM? Youths were greatly involved in collection of soil samples	☐	☐	☑	☐

Main motivation of land users to implement SLM

☐ increased production
☑ increased profit(ability), improved cost-benefit-ratio
☑ reduced land degradation
☐ reduced risk of disasters
☐ reduced workload
☐ payments/ subsidies
☐ rules and regulations (fines)/ enforcement
☐ prestige, social pressure/ social cohesion
☐ affiliation to movement/ project/ group/ networks
☑ environmental consciousness
☐ customs and beliefs, morals
☐ enhanced SLM knowledge and skills
☐ aesthetic improvement
☐ conflict mitigation

Sustainability of Approach activities

Can the land users sustain what hat been implemented through the Approach (without external support)?

☐ no
☑ yes
☐ uncertain

Yes. The benefit in both reduced cost and improved soil health are the triggers to sustaining the practices. Also, the involvement of local community institutions will also ensure the sustainability of interventions.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Judicious use of fertilizers and pesticides based on the nutrient requirement of soil, as mentioned under the soil health report
- Separate recommendations for both chemical and organic (bio-inputs) are a good way for land users to make informed decisions
- Tracing the improvement in soil health status based on the land users' agricultural practices

Strengths: compiler’s or other key resource person’s view

- Developing the soil maps for the entire area to design appropriate interventions for the project
- Instead of general recommendations for input application, the soil health card helped develop farmer/village-centric extension services for the farmers
- Understand the impact of various interventions through periodic soil testing to document what has worked and what has not. Even this evidence can be used to monitor the soil organic carbon content for designing carbon-based projects and/or to access national or international carbon reduction credits.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Farmers are still unaware of the soil test facility and its benefits Regular awareness programs along with a demonstration of soil sample collection

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- Farmers' strong belief in the application of a certain quantity of fertilizers to ensure better production This requires specific behavior change campaigns through local demonstration and documentation
- Government authorities also conduct the soil test and issue the soil health card. However the farmers' experience with such system has not been outstanding. Put efforts into conveying the difference between both approaches by promptly issuing the soil health card
- The soil test lab is in the District capital, so farmers in far-away areas may face difficulties in accessing the facility Explore the option of establishing soil test labs near farmers' locations

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir	Udo Höggel Joana Eichenberger

Date of documentation: March 18, 2023

Last update: Sept. 14, 2023

Resource persons

Santosh Gupta (santosh@ecociate.com) - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/approaches/view/approaches_6698/

Linked SLM data

n.a.

Documentation was faciliated by

Institution
- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Ecociate Consultants (Ecociate Consultants) - India

Project
- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online

- Operational Guidelines for implementation of CENTRALLY SPONSORED SCHEME SOIL HEALTH CARD: https://agricoop.nic.in/sites/default/files/GSHC3.pdf

ePrakriti - A workbook for landscape based planning using geo-informatic tools

E-Prakriti - An Approach Towards GIS Based Planning For Natural Farming (India)

E-Prakriti

DESCRIPTION

The e-Prakriti approach is a GIS-based planning approach that integrates natural farming interventions for effective management, monitoring, and conservation of natural resources at the landscape level. It can be applied for projects such as soil and water management, land reclamation, crop and seed systems design and agri-infrastructure mapping. To establish and maintain an e-Prakriti system, it is necessary to collect and manage data effectively, to build capacity among stakeholders, to have the appropriate technology infrastructure in place and to promote the engagement of local communities with conservation organizations.

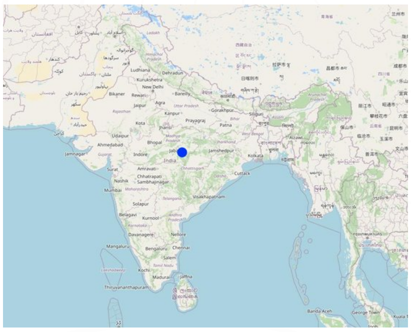
The e-Prakriti approach is a planning method that utilizes GIS tools to integrate ecosystem-based natural farming interventions into agricultural operations. It focuses on creating scientific and efficient planning techniques that consider the landscape as a unit, such as a Village, Block, District and watersheds or river basins. This approach uses open-source datasets, including spatial and non-spatial data, to develop a comprehensive activity plan for natural resource management at a landscape level and having natural farming approaches as its core.

To facilitate the planning process using the various open-source platforms, GIZ has developed a comprehensive guide cum training module under the Pro-Soil Project. This guide comprehensively captures the different open-source platforms and their application to the local context, so to plan and implement natural-farming based interventions. The guide can be used to build the capacity of local-community resource persons, members of local self-governance (Panchayati Raj) institutions and other projects working at the village or cluster level.

The primary purpose of e-Prakriti is to enable effective and efficient management, monitoring, and conservation of natural resources, including sustainable soil management, water management, degraded land reclamation, crop and seed system design, bio-resource and fodder assessment, agro-infrastructure mapping, and the planning of sustainable enterprises. This e-Prakriti approach is used to conduct inventory and management of natural resources, such as forests, wetlands, and wildlife habitats, by mapping the extent and distribution of these resources and tracking their use and status over time. The e-Prakriti approach monitors changes in natural resources, evaluates the effectiveness of conservation measures, and identifies areas that require further intervention. Additionally, e-Prakriti technology can support planning and decision-making related to natural resource management by identifying areas most suitable for conservation or development activities.

Establishing and maintaining an e-Prakriti approach requires data collection on natural resources, effective data management, building capacity among stakeholders, appropriate technology infrastructure and institutional support. The benefits and impacts of the e-Prakriti approach include promoting sustainable development, improving natural resource management, reducing disaster risks, increasing community participation, improving policy

LOCATION



Location: Changariya village, Bichiya block,, Madhya Pradesh, India

Geo-reference of selected sites

- 80.37905, 22.6043
- 80.37814, 22.6039
- 80.37814, 22.6039

Initiation date: n.a.

Year of termination: 2023

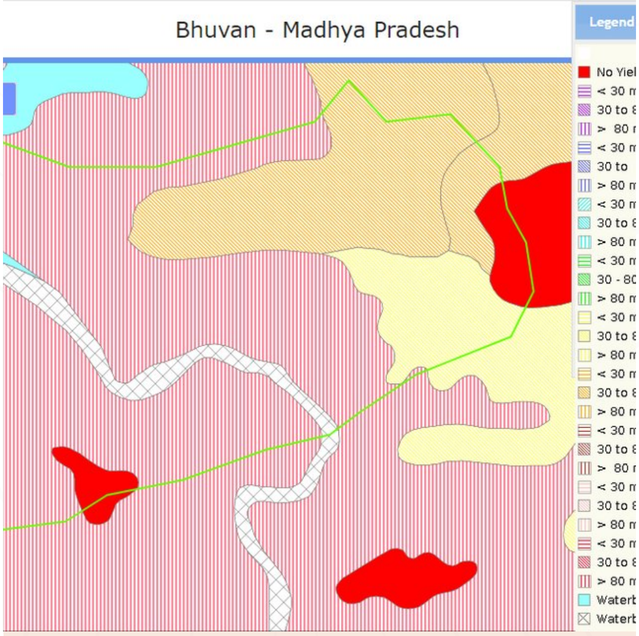
Type of Approach

☐ traditional/ indigenous
☐ recent local initiative/ innovative
☑ project/ programme based

and decision-making and conserving biodiversity. Land users' perceptions and experiences of e-Prakriti may vary depending on factors such as socio-economic background, level of education, cultural values and their relationship with natural resources. It is important to consider these factors when designing and implementing e-Prakriti approaches to meet the needs and expectations of land users.

GIZ has collaborated with the State Rural Livelihood Mission of Madhya Pradesh (MP-SRLM) for the practical application of the e-Prakriti approach in the planning process by the local community resource persons. GIZ provides training and operational support to team members for the successful application of e-Prakriti approaches in day-to-day work.


Watershed and natural drainage lines in Changariya village



Availability of groundwater in Changariya village

APPROACH AIMS AND ENABLING ENVIRONMENT

Main aims / objectives of the approach

The objective of this tool is to create a scientific and efficient approach for planning natural farming interventions through the use of GIS-based mapping

Conditions enabling the implementation of the Technology/ ies applied under the Approach

- **Social/ cultural/ religious norms and values**: E-prakriti proposes comprehensive planning by the adequate blending of technology with sustainability approaches, local wisdom, community participation and departmental convergence
- **Institutional setting**: The effective cooperation of actors like communities, Government Departments and other institutions is enabled by natural-farming planning approaches using GIS Tools.
- **Collaboration/ coordination of actors**: The validation of GIS data is done through on-ground validation and extensive interpretation from maps. Community consultations are crucial in the planning process and convergence planning with the concerned Government Departments is necessary for comprehensive planning. Technical training in basic GIS-based software handling is essential for departmental engineers and other technically competent functionaries.
- **Workload, availability of manpower**: e-Prakriti can significantly reduce the workload of planners and implementers as it reduces the need for physical visits to each and every village to collect ground-level data. A lot of data with very high accuracy can be collected from the satellite-based imaging systems.

Conditions hindering the implementation of the Technology/ ies applied under the Approach

PARTICIPATION AND ROLES OF STAKEHOLDERS INVOLVED

Stakeholders involved in the Approach and their roles

What stakeholders / implementing bodies were involved in the Approach?	Specify stakeholders	Describe roles of stakeholders
local land users/ local communities	Local community members, farmers	They have provided the data and information during the ground proofing exercises
community-based organizations	Local Community - Participation of local groups in implementing the program activities. Community representatives from villages - support/drive the program's activities.	Community consultations are critical in promoting sustainable development interventions. It is vital to adequately prepare the community for the actions required, and community representatives must be involved at all planning levels, starting from the ground level. The principles of inclusivity and cooperation are crucial in building trust and promoting effective collaboration among community members. The community's input is essential in creating a suitable action plan and developing maps at the beginning and end of the

PARTICIPATION AND ROLES OF STAKEHOLDERS INVOLVED

Stakeholders involved in the Approach and their roles

What stakeholders / implementing bodies were involved in the Approach?	Specify stakeholders	Describe roles of stakeholders
local land users/ local communities	Farmers from the project area	Soil samples were collected from the field of farmers. They have actively participated in the projects for managing the soil samples, participating in the capacity building programs, and implementing the recommended practices.
community-based organizations	FES, the implementing NGO, have formed the Villages Environment Committee (VEC) in their project villages as community-based organizations	VECs facilitated the implanting of a project by mobilizing the communities as and when needed. FES reached farmers through the VECs, to collect the soil samples or disseminate the information. VECs also facilitated community-level implementation activities.
SLM specialists/ agricultural advisers	SLM Specialist	Documentation of the activities
NGO	Foundation for Ecological Security (FES) is a well-known NGO registered in India. It focuses on ecology-related issues and works closely with farmers and forest-based communities.	FES played an essential role in the project. Primary activities were as follows: 1. Establishment of soil testing laboratory and hiring the technical team to conduct the soil test lab 2. Collection of soil test samples and building the capacity of farmers on soil sample collection 3. Conducting soil test results and issuance of soil health cards to farmers 4. Developing a soil health map for the project areas 5. Capacity building of farmers for the interpretation of soil health cards and ensuring the implementation of recommended practices
international organization	GIZ, India	Funding of the project

Lead agency

Foundation for Ecological Security

Involvement of local land users/ local communities in the different phases of the Approach

	none	passive	external support	interactive	self-mobilization	
initiation/ motivation	☐	☑	☐	☐	☐	The FES led the initiation of discussions with its donor organizations. Discussions with communities to understand the challenges and opportunities.
planning	☐	☐	☐	☑	☐	Local community institutions played a significant role in the entire process of planning and execution
implementation	☐	☐	☐	☑	☐	Farmers and community-based institutions were actively involved in implementing multiple activities under the project, such as collecting soil samples, supplying them to the soil test labs, and Implementing the recommended practices.
monitoring/ evaluation	☐	☐	☐	☑	☐	Community-based institutions played an important role in monitoring individual farmers for implementing the recommendations provided to farmers. They also monitored the results regarding crop progress, crop productivity, and improvement in soil health status.

Flow chart

Decision-making on the selection of SLM Technology

Decisions were taken by

☐ land users alone (self-initiative)
☐ mainly land users, supported by SLM specialists
☑ all relevant actors, as part of a participatory approach
☐ mainly SLM specialists, following consultation with land users
☐ SLM specialists alone
☐ politicians/ leaders

Decisions were made based on

☑ evaluation of well-documented SLM knowledge (evidence-based decision-making)
☑ research findings
☐ personal experience and opinions (undocumented)

TECHNICAL SUPPORT, CAPACITY BUILDING, AND KNOWLEDGE MANAGEMENT

The following activities or services have been part of the approach

☑ Capacity building/ training
☑ Advisory service
☑ Institution strengthening (organizational development)

Involvement of local land users/ local communities in the different phases of the Approach

	none	passive	external support	interactive	self-mobilization	
initiation/ motivation		✓				They have been discussed to understand their specific needs, resources availability and applications for developing the basic understanding
planning				✓		Local community institutions were involved in the process of planning to understand the local cost specifications, local cropping patterns and to collect and validate the data points
implementation					✓	Local community institutions did implement the interventions with technical guidance from the project implementing team
monitoring/ evaluation				✓		During the monitoring process images and data points collected from the satellites were physically validated from the community members. Also, discussions are held with communities to understand the social and economic impact of the project interventions.

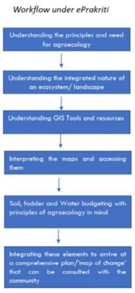
Flow chart

In order to effectively plan for natural farming using GIS tools, it is important to involve the larger systems around the community and the community itself. The first step is to identify and define a unit of intervention, such as a village. Open-source satellite data can then be used to understand and estimate various factors such as geomorphology and geohydrology. This data can be complemented with other available data from sources such as the Ground Water Board or the NREGS portal.

Using QGIS tool, the various data sets can be superimposed to find relationships between them. On-ground validation (truthing) of the GIS data is also necessary to ensure its accuracy. Once the data sets are gathered, an extensive interpretation from maps is undertaken, and the data is translated into easily understandable and implementable material for the community.

Community consultations are a critical part of the intervention, with community representatives being involved at all levels of planning. Inclusivity and cooperation are key principles in engaging the community and government departments and institutions for the judicious use of common resources. Larger community consultations are held at the beginning and end of the planning process to arrive at a suitable action plan using the prepared maps.

The planned actions and locations are plotted on maps on Google Earth, and convergence planning is necessary for the integrated efforts of several concerned departments. Joint consultations are held with these departments, and the district administration can play a facilitative role in bringing everyone on the same page. Lastly, it is important to train departmental engineers, Rozgar Sahayaks, and other technically competent functionaries in basic GIS-based software such as Bhuvan, QGIS, India-WRIS, and Bhuvan Panchayat to extract necessary data.



Author: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Decision-making on the selection of SLM Technology

Decisions were taken by

☐ land users alone (self-initiative)
☐ mainly land users, supported by SLM specialists
☑ all relevant actors, as part of a participatory approach
☐ mainly SLM specialists, following consultation with land users
☐ SLM specialists alone
☐ politicians/ leaders

Decisions were made based on

☐ evaluation of well-documented SLM knowledge (evidence-based decision-making)
☑ research findings
☑ personal experience and opinions (undocumented)

TECHNICAL SUPPORT, CAPACITY BUILDING, AND KNOWLEDGE MANAGEMENT

The following activities or services have been part of the approach

☑ Capacity building/ training
☑ Advisory service
☐ Institution strengthening (organizational development)
☑ Monitoring and evaluation
☐ Research

Capacity building/ training

Training was provided to the following stakeholders

☐ land users
☑ field staff/ advisers

Form of training

☑ on-the-job
☐ farmer-to-farmer
☑ demonstration areas
☐ public meetings
☑ courses

Subjects covered

1 Village boundaries
2 Village Assets and Infrastructure
3 Watershed / Sub-basin Map
4 Natural Drainage line
8 Availability of groundwater
5 Further resources on Water
5 Geomorphology
6 Slopes within the topography
7 Lineaments- cracks in the land for the generation of aquifiers
8 Soil Erosion
10 Soil kinds/data
11 Land usage pattern
12 Crop season land
13 Wastelands Map

Advisory service

Advisory service was provided

☑ on land users' fields
☐ at permanent centres

Monitoring and evaluation

This tool can be used for monitoring the project interventions by having the pre- and post-project images from the satellite

FINANCING AND EXTERNAL MATERIAL SUPPORT

Annual budget in USD for the SLM component

☑ < 2,000
☐ 2,000-10,000
☐ 10,000-100,000
☐ 100,000-1,000,000
☐ > 1,000,000
Precise annual budget: n.a.

The major cost involved is in developing the e-Prakriti module, the cost of which was incurred by the GIZ. Another important cost component is capacity building of the stakeholders.

The following services or incentives have been provided to land users

☐ Financial/ material support provided to land users
☐ Subsidies for specific inputs
☐ Credit
☑ Other incentives or instruments

Other incentives or instruments

Training and handholding of stakeholders

IMPACT ANALYSIS AND CONCLUDING STATEMENTS

Impacts of the Approach

	No	Yes, little	Yes, moderately	Yes, greatly
Did the Approach empower local land users, improve stakeholder participation? The targeted areas that specifically needed conservation work were focused on	☐	☐	☑	☐
Did the Approach enable evidence-based decision-making? This has been the most important purpose of this approach. The use of various spatial tools ensured evidence-based decision-making	☐	☐	☐	☑
Did the Approach help land users to implement and maintain SLM Technologies? The approach may be a great tool for effective and efficient natural farming-based practices and other SLM technologies	☐	☐	☐	☑
Did the Approach improve coordination and cost-effective implementation of SLM? Yes. It has been of great use	☐	☐	☐	☑
Did the Approach mobilize/ improve access to financial resources for SLM implementation? Developing projects using the technology has ensured effective financial planning for the planned interventions	☐	☐	☐	☑
Did the Approach improve knowledge and capacities of land users to implement SLM? Land users and local community resource persons learned about the various tools and technologies available for scientific planning	☐	☐	☐	☑
Did the Approach improve knowledge and capacities of other stakeholders? Community resource persons	☐	☐	☐	☑
Did the Approach build/ strengthen institutions, collaboration between stakeholders? Stakeholders like farmers, FPOs, local community resource persons, NGOs, Government institutions all are in a position to apply a coordinated approach by using this tool	☐	☐	☐	☑

Did the Approach mitigate conflicts? Better mapping of resources could mitigate some conflicts among the community members	☐☑☐☐
Did the Approach improve gender equality and empower women and girls? The promotion of natural farming empowers women members as they are core to it. Families get an access to safe and healthy foods as well.	☐☐☑☐
Did the Approach encourage young people/ the next generation of land users to engage in SLM?	☐☐☑☐
Did the Approach lead to more sustainable use/ sources of energy?	☐☐☐☑
Did the Approach improve the capacity of the land users to adapt to climate changes/ extremes and mitigate climate related disasters?	☐☐☑☐

Main motivation of land users to implement SLM

- ☐ increased production
- ☐ increased profit(ability), improved cost-benefit-ratio
- ☐ reduced land degradation
- ☐ reduced risk of disasters
- ☑ reduced workload
- ☐ payments/ subsidies
- ☐ rules and regulations (fines)/ enforcement
- ☐ prestige, social pressure/ social cohesion
- ☐ affiliation to movement/ project/ group/ networks
- ☑ environmental consciousness
- ☐ customs and beliefs, morals
- ☑ enhanced SLM knowledge and skills
- ☐ aesthetic improvement
- ☐ conflict mitigation

Sustainability of Approach activities

Can the land users sustain what hat been implemented through the Approach (without external support)?

- ☐ no
- ☑ yes
- ☐ uncertain

The approach developed is a guidebook, which can be used by anyone using the available open-access platform which is free to use

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Efficient mapping of the resources available to different stakeholders which sometimes community members may not be aware of
- Convergence opportunities with different line departments once resources are mapped and activities are finalised
- Reduced workload of the community members and their institutions as they need not be physically present every time

Strengths: compiler’s or other key resource person’s view

- Scientific and evidence based method of planning with a lot of saving in time and resources with better accuracy. Sometimes connecting with communities as well as visiting field areas take a lot of time.
- The approach can also be used for developing the financial outlays for the shortlisted interventions by getting the physical inputs, conducting the assessments through images and maps collected from open access platforms
- The e-Prakriti approach can be very effective in the monitoring of the project interventions as satellite-based maps of pre- and post-interventions or geotagged images may provide scientific evidences

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Not much exposed to this approach for planning Handholding through demonstrations
- Availability of computer devices to access the maps Although computers are available at affordable prices in some cases, there may be financial support from the project or government agencies

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- Technology keeps on updating thus the users need to update and upgrade themselves to ensure the usages at ground Regular training and handholding of the users either physically or remotely
- Availability of high speed internet for using the platforms; Currently most land users and CRPs do use internet using their mobile hotspots, access to wi-fi may may not be there Identified planners or CRPs can be provided with internet devices or they can be linked with Wi-Fi available at different Government bodies

REFERENCES

Compiler	**Editors**	**Reviewer**
Santosh Gupta	Noel Templer Stephanie Katsir	Rima Mekdaschi Studer Udo Höggel Joana Eichenberger

Date of documentation: April 14, 2023

Last update: Oct. 9, 2023

Resource persons

Santosh Gupta (santosh@ecociate.com) - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/approaches/view/approaches_6726/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online

- e-Prakriti for comprehensive planning of natural farming practices: Physical copy shared by GIZ

SLM technology: Eradication of the invasive *Lantana camara* for soil rehabilitation on private land

A clean field after the eradication of Lantana camara (Santosh Gupta)

Eradication of Lantana Camara (invasive species) for Soil Rehabilitation on Private Land (India)

Lantana (Ram Phool)

DESCRIPTION

Lantana camara is an invasive species having severe ecological impacts on local biodiversity and economic impact on local communities. Lantana camara has proliferated in central India and occupied many forest lands, commons, and private land. The cut rootstock method provides minimum disturbance to the soil, wherein the plants' roots are cut three inches below the ground. It is followed by lifting the bush and keeping it upside down to prevent it from gaining ground.

Introduced as an ornamental plant to India in the 1800s, Lantana has infested the forests, grazing grounds, and farmlands. It has invaded over 13 million hectares, which is around 4% of the total land area of the country. In the context of Madhya Pradesh, the species has encroached on shared and remote villages' lands along the fringes of protected areas such as the Kanha Tiger Reserve, impacting wildlife and local communities in multiple ways.

Tribals in the Kanha landscape generally inhabit upper catchments of rivers, usually having large portions of uplands as part of their landholdings. These lands have never attracted investments from land development projects. They used to cultivate millets (particularly Kodo and Kutki) every alternate year. Apart from this crop, the farmers collect tendu leaves (Diospyros Melanoxylon) from these lands every year. Keeping the soil quality in view, they take these crops every alternate year and in some cases, once in three years with a gap of two years. This gap of two years helps Lantana spread on private land.

Traditional practices for controlling lantana camara are chopping the main stem, clipping aerial shoots, burning, and grubbing (total uprooting). These practices however, either led to vigorous regeneration of Lantana or were labor intensive. The cut rootstock method/technology applied under the project provides minimum disturbance to the soil, wherein the plants' roots are cut three inches below the ground. It is followed by lifting the bush and keeping it upside down to prevent it from gaining ground.

The Foundation for Ecological Security (FES), an NGO located in India, has been working on the eradication of Lantana Camara from the commons land since 2010-11, however from the year 2016-17 onwards, with the support from GIZ, FES also started supporting village institution in eradicating Lantana from private upland. Significant activities are undertaken for the eradication of Lantana and as shown hereunder:

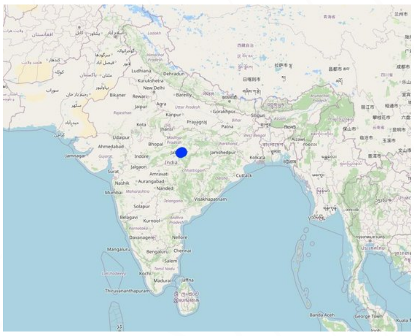
A. Improving community governance mechanism; local communities were engaged by ensuring that the village executive committee took the Gram Sabha (Village Governing Body) into confidence and prepared the by-laws to conserve the lantana-eradicated site. Rules and regulations were framed for the uprooting of the Lantana, its payment process, and usages of the uprooted Lantana for fencing the plot, preparation of biochar, or other usages providing ecological benefits.

B. Adoption of the 'cut rootstock method' for the uprooting of Lantana; removing Lantana is tricky because methods such as burning, haphazard uprooting, or cutting result in the recurrence of the species.

C. Appropriate measures were taken to minimize the recurrence of Lantana seeds through regular monitoring and plantation of grass seeds and other plants.

D. Grass seed sowing; with the active support of the village institution, the collection of indigenous grass species was done. Before the advent of the monsoon, the community prepared the grass seed ball and sowed it in the plot. A seed ball helps the seed to protect it from insects, birds, and runoff. In the rainy season, these grass seeds germinate and grow.

LOCATION



Location: Mandla, Madhya Pradesh, India

No. of Technology sites analysed: 100-1000 sites

Geo-reference of selected sites
- 80.26523, 22.81034
- 80.07561, 22.7431
- 80.07561, 22.7431

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2015

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

With the grasses coming, the lantana seeds do not get a suitable environment to germinate and grow.

Eradication of Lantana from the private lands helps the communities access their lands. This has resulted in the cultivation of millets on the same land, which was otherwise left fallow for so many years.

Farmers removing the lantana from their field and common land (Keertan Bhagel)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☐ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Land use mixed within the same land unit: Yes - Agroforestry

Cropland

- Annual cropping: cereals - millet. Cropping system: Fallow - maize/sorghum/millet

Number of growing seasons per year: 1
Is intercropping practiced? No
Is crop rotation practiced? Yes

Grazing land

- Transhumant pastoralism
- Cut-and-carry/ zero grazing

Animal type: cattle - dairy
Is integrated crop-livestock management practiced? No

Species	Count
cattle - dairy	500

Forest/ woodlands

- (Semi-)natural forests/ woodlands: boreal coniferous forest natural vegetation. Management: Dead wood/ prunings removal, Non-wood forest use

Tree types (mixed deciduous/ evergreen): n.a.
Products and services: Timber, Fuelwood, Fruits and nuts, Other forest products, Grazing/ browsing, Nature conservation/ protection

Water supply

☑ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☐ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

chemical soil deterioration - Ca: acidification

biological degradation - Bf: detrimental effects of fires, Bs: quality and species composition/ diversity decline, Bl: loss of soil life

SLM group

- agroforestry
- integrated soil fertility management

SLM measures

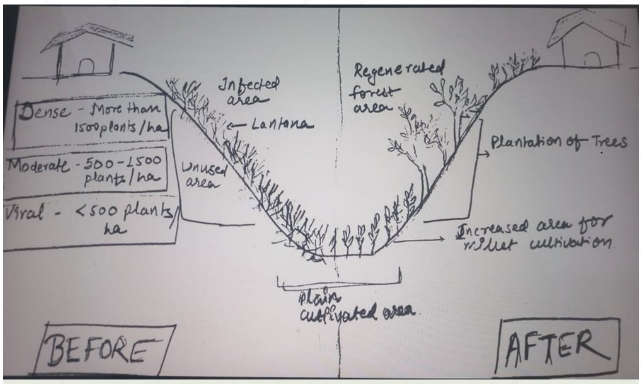
vegetative measures - V3: Clearing of vegetation, V4: Replacement or removal of alien/ invasive species

management measures - M1: Change of land use type

TECHNICAL DRAWING

Technical specifications

Drawing covering the landscape of private land where Lantana eradication was carried out. The drawing indicates the before and after situation with a change in the land profile. It can be seen that before the eradication land was covered with a thick cover of Lantana while after the eradication, land has plants and grass. The drawing also shows the slopes of the land under treatment.



Author: Payal

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1 hectare**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 80.0 INR
- Average wage cost of hired labour per day: 204

Most important factors affecting the costs

The density of lantana in the field is categorized into 3: more than 1500 bushes are considered high density, and between 500-1500 are considered moderately dense, while less than 500 is known as lowly dense.

Establishment activities

n.a.

Maintenance activities

n.a.

Maintenance inputs and costs (per 1 hectare)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR)**	**Total costs per input (INR)**	**% of costs borne by land users**
Labour					
Removal of lantana	ha	1.0	7229.0	7229.0	16.0
Total costs for maintenance of the Technology				**7'229.0**	
Total costs for maintenance of the Technology in USD				*90.36*	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☐ sub-humid
☑ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1427.0
Monsoon season is June-September which has the majority of the rainfall
Name of the meteorological station: Mandla, Madhya Pradesh

Slope

☐ flat (0-2%)
☐ gentle (3-5%)
☐ moderate (6-10%)
☑ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms

☐ plateau/plains
☑ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude

☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in

☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☐ 5-50 m
☑ > 50 m

Availability of surface water
☐ excess
☐ good
☑ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: both ground and surface water

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☑ high
☐ medium
☐ low

Habitat diversity
☑ high
☐ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☐ 10-50% of all income
☑ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☐ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☑ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☐ individual/ household
☑ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐	☑	☐	good
education	poor	☐	☑	☐	good
technical assistance	poor	☐	☑	☐	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☑	☐	good
energy	poor	☐	☑	☐	good
roads and transport	poor	☐	☑	☐	good
drinking water and sanitation	poor	☐	☑	☐	good
financial services	poor	☑	☐	☐	good

IMPACTS

Socio-economic impacts

Crop production	decreased	☐	☐	☐	☐	☐	☑	☐	increased	Quantity before SLM: 242 kg per ha Quantity after SLM: 350 kg per ha These are the estimated figures
fodder production	decreased	☐	☐	☐	☐	☐	☑	☐	increased	
forest/ woodland quality	decreased	☐	☐	☐	☐	☑	☐	☐	increased	
production area (new land under cultivation/ use)	decreased	☐	☐	☐	☐	☐	☑	☐	increased	
drinking water availability	decreased	☐	☐	☐	☐	☑	☐	☐	increased	
water availability for livestock	decreased	☐	☐	☐	☐	☑	☐	☐	increased	
farm income	decreased	☐	☐	☐	☐	☐	☑	☐	increased	
diversity of income sources	decreased	☐	☐	☐	☐	☑	☐	☐	increased	

Socio-cultural impacts

food security/ self-sufficiency	reduced					✓			improved
community institutions	weakened						✓		strengthened
SLM/ land degradation knowledge	reduced						✓		improved
situation of socially and economically disadvantaged groups (gender, age, status, ehtnicity etc.)	worsened						✓		improved

Ecological impacts

soil moisture	decreased					✓			increased
soil cover	reduced						✓		improved
soil loss	increased						✓		decreased
soil crusting/ sealing	increased						✓		reduced
nutrient cycling/ recharge	decreased						✓		increased
soil organic matter/ below ground C	decreased				✓				increased
vegetation cover	decreased						✓		increased
plant diversity	decreased						✓		increased
invasive alien species	increased							✓	reduced
beneficial species (predators, earthworms, pollinators)	decreased					✓			increased
habitat diversity	decreased					✓			increased

Off-site impacts

water availability (groundwater, springs)	decreased					✓			increased
buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced					✓			improved

Increasing soil moisture in the uplands will help improve water availability in the lowlands

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative							✓	very positive
Long-term returns	very negative							✓	very positive

Benefits compared with maintenance costs

Short-term returns	very negative						✓		very positive
Long-term returns	very negative							✓	very positive

Short- and long-term benefits are pretty high compared to the cost involved.

CLIMATE CHANGE

-

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☑ 11-50%
☐ 51-90%
☐ 91-100%

Number of households and/ or area covered

1000 hectares

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- 1. Availability of additional land for cultivation of other crops such as Millets on upland
- 2. Improved land for fodder cultivation
- 3. Reduced losses due to animal attacks on the standing crops as animals are now not finding the space to hide

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

Strengths: compiler's or other key resource person's view

- Reduced human-animal conflict will lead to productivity gains for both forest dwellers and wild animals
- Available land will be used for millet cultivation, which is rich in nutrition and well-suited to the local ecological conditions. The requirement for water is also very minimal for these crops.
- This will also improve local biodiversity as farmers will now grow more plant varieties suitable for climatic conditions.

- Cultivation of crops using chemical pesticides and fertilizers may have a negative impact on both soil and the environment Training and handholding of the farmers around the natural and sustainable farming practices

REFERENCES

Compiler
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Udo Höggel
Joana Eichenberger

Date of documentation: Feb. 21, 2023

Last update: Sept. 14, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6660/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit - India (GIZ India) - India
- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Key references

- FES internal documents prepared during the year 2021-22: Internal documents

SLM technology: At the farm level, improved cattle shed flooring for conserving cow dung and urine for biofertilizer production

Cattle Shed Management (Payal Dewangan)

Improved Cattle Shed Flooring for Conservation of Cow Dung and Urine for Biofertilizer Production at Farm Level (India)

DESCRIPTION

In the cattle shed management system, the cattle shed should be constructed with an elevated concrete floor that slopes slightly toward a cow urine collection point. The collection point should be equipped with a drainage system to easily remove cow dung and urine.

An elevated concrete floor for cow dung and urine collection can improve hygiene, and waste management, and reduce labour costs in cattle sheds. Collected cow urine and cow dung can be used to prepare biological inputs and compost for nutrient and pest management in agriculture.

Cattle shed management technology, including the use of a concrete elevated floor for cow dung and urine collection, is a cost-effective and efficient technology to support the natural farming system. This technology can be applied in both natural and human environments. In natural environments, such as rural or agricultural areas, cattle sheds are typically used for dairy and farmyard manure production. The use of this technology can improve the hygiene of cattle and their environment, reduce waste and pollution, and promote the sustainable use of natural resources. The cow dung and urine so collected can be used as fertilizer to improve soil quality, and the improved hygiene of the cattle can reduce the risk of diseases spreading to other animals or humans. The use of this technology can help to reduce the negative impacts of cattle farming on the surrounding environment, such as odours and pollution. It can also improve the hygiene of the cattle and their environment, which is important for both animal welfare and public health.

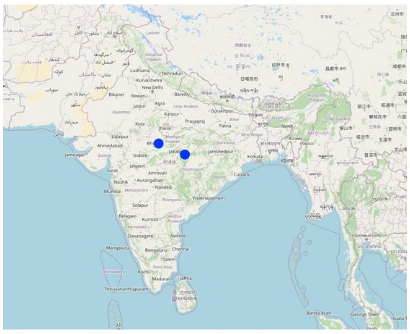
Traditionally farmers were constructing the floors of cattle sheds using mud and soil. These floors absorb the cow urine and the movement of animals also makes holes in it because of that cow urine and cow dung are used to get filled in these halls. Which made the entire floor unhygienic for both animals and farmers. Because of such surfaces, it was very hard to clean these sheds. The use of an elevated floor made with cement-concrete and a waste management system can help to keep the cattle shed clean and dry, which can reduce the risk of disease and infection among the animals. The collection and disposal of cow dung and urine can help preventing environmental pollution, reducing the negative impacts of cattle farming on the surrounding area, and promoting sustainable use of natural resources. The use of a concrete elevated floor can make cleaning the cattle shed faster and easier, reducing labour costs and improving the efficiency of the farming operation.

Technical specifications for the construction of cattle sheds can vary depending on factors such as the size of the herd, local environmental regulations, and available resources. However, in general, the main characteristics and elements of cattle shed management technology are designed to promote animal welfare, hygiene, waste management, and sustainability. Proper cattle shed management technology can provide a comfortable and safe environment for the animals, which can reduce stress and promote animal welfare. Proper waste management and ventilation can help to minimize unpleasant odours from the cattle shed, which thus reduces negative impacts on the surrounding community.

Establishing and maintaining cattle shed management technology requires a combination of technical expertise, labour, and resources. By investing in these inputs, farmers can promote sustainable and efficient cattle farming practices and improve the health and welfare of their animals.

The collected cow urine and cow dung are the main resources for preparing the biological inputs and different types of compost for meeting the nutritional requirement of crops while also addressing the challenges of pest and disease management in a natural or organic farming system. The improved flooring of cow shed units has been a great intervention to replace and reduce the usage of synthetic fertilisers and pesticides in the project region.

LOCATION



Location: Mandla District, Madhya Pradesh, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 77.87109, 23.56399
- 80.72432, 22.47201

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: less than 10 years ago (recently)

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☐ during experiments/ research
☑ through projects/ external interventions

The views of land users, such as farmers or livestock keepers, about cattle shed management technology, including the use of a concrete elevated floor for cow dung and urine collection, can vary depending on their experiences and perceptions. The interviewed land user liked or appreciated, cattle shed management for improving animal health and productivity, increasing farm profitability, cleaning the cattle shed easier and faster, reducing labour costs, improving efficiency, and for environmental benefits.

A newly constructed cowshed unit with cement concrete floor (Santosh Gupta)

Cow urine collection point (Santosh Gupta)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☑ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☐ preserve/ improve biodiversity
- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☐ create beneficial social impact
- ☑ Control cattle diseases

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - maize, cereals - rice (wetland), cereals - wheat (winter), legumes and pulses - lentils, oilseed crops - sunflower, rapeseed, other, vegetables - leafy vegetables (salads, cabbage, spinach, other)

Number of growing seasons per year: 2

Is intercropping practiced? Yes

Is crop rotation practiced? Yes

Water supply

- ☐ rainfed
- ☑ mixed rainfed-irrigated
- ☐ full irrigation

Purpose related to land degradation

- ☑ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

biological degradation - Bp: increase of pests/ diseases, loss of predators

water degradation - Hp: decline of surface water quality, Hq: decline of groundwater quality

SLM group

- integrated crop-livestock management
- integrated soil fertility management

SLM measures

agronomic measures - A2: Organic matter/ soil fertility, A6: Residue management (A 6.4: retained)

structural measures - S9: Shelters for plants and animals

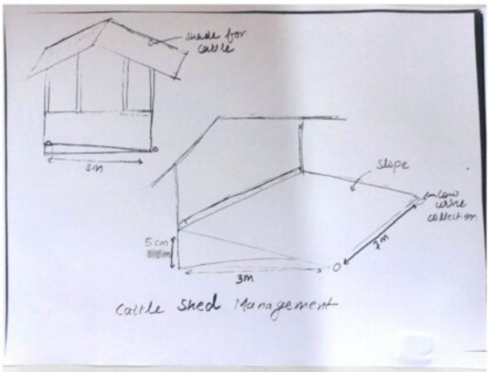
management measures - M6: Waste management (recycling, re-use or reduce)

TECHNICAL DRAWING

Technical specifications

Dimensions of the cowshed (depending on the number of cows kept):

Length: 7m
Width: 3m
Elevated: 5 cm (means in effect the slope: i.e. the front floor of the cowshed is 5 cm higher than the floor at the end, where dung and urine get collected)



Author: Payal Dewangan

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **one cattle shed** volume, length: **meter**)
- Currency used for cost calculation: **Indian Rupee**
- Exchange rate (to USD): 1 USD = 82.24 Indian Rupee
- Average wage cost of hired labour per day: 240

Most important factors affecting the costs

Design and technical specifications: The cost of the technology can vary depending on the design and technical specifications of the cattle shed, including the size and materials used. Construction materials and labor costs: The cost of construction materials and labor can vary depending on local market conditions and availability. Location: The cost of transporting materials and labor to the construction site can vary depending on the location of the farm. Maintenance and repair costs: The cost of maintaining and repairing the cattle shed can also add to the overall cost of the technology. Training and capacity building: Providing training and capacity building to farmers and workers on proper cattle shed management techniques can add to the overall cost of the technology.

Establishment activities

1. Concrete floor construction for cattle shed (Timing/ frequency: March)
2. Cattle shed roof development (Timing/ frequency: April)

Total establishment costs (estimation)

28000.0

Maintenance activities

1. Cleaning of concrete floor (Timing/ frequency: Once in a day)
2. Collection of cow dung (Timing/ frequency: Once in a day)
3. collection of cow urine from the pit or drum (Timing/ frequency: Twice in a week)
4. Fodder and drinking water provision (Timing/ frequency: Twice in a day)

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
■ 1,001-1,500 mm

Agro-climatic zone

☐ humid
☐ sub-humid
☑ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1427.0
Highest rainfall occurs between June to September.
Name of the meteorological station: Mandla, Madhya Pradesh
The climate of the District is tropical, with moderate winters, severe

☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

summers, and well-distributed rainfall received from the southwest monsoon. However, due to higher general elevation and abundance of forests, summer temperatures do not rise as much as in other areas.

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☑ rolling (11-15%)
☐ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☐ plateau/plains
☑ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☑ medium (loamy, silty)
☐ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☐ 5-50 m
☑ > 50 m

Availability of surface water
☐ excess
☐ good
☑ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: both ground and surface water

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☑ high
☐ medium
☐ low

Habitat diversity
☑ high
☐ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☐ 10-50% of all income
☑ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☐ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☑ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☐ individual/ household
☑ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☐ 0.5-1 ha
☑ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor		✓		good
education	poor		✓		good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor		✓		good
markets	poor		✓		good
energy	poor		✓		good
roads and transport	poor		✓		good
drinking water and sanitation	poor		✓		good
financial services	poor	✓			good

IMPACTS

Socio-economic impacts

Crop production

Crop production	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	It was observed and noted from the field site that instead of using chemicals, the application of cow urine and cow dung in the form of farm yard manure has helped in improved production as it led to the reduction of pest infestation and better nutrient uptake from the soil.
crop quality	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Reduction in the use of chemicals in the field and application of collected cow urine and other bioresource products made from cow dung helped in improving the quality of crop in terms of harder crops, good weight of grain, test etc.
animal production	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	The improved cattle shed played a crucial role in maintaining the hygiene of animal sheds, which led to the lesser occurrence of disease among animals. Also, the stress level of animals due to the presence of insects and flies reduced significantly. A combination of all these factors improved the milk yield.
risk of production failure	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	Using sustainable methods for crop production by application of bio inputs not only helps in increasing soil fertility but also contributes to increasing crop resistance, pest control, and better crop development.
product diversity	decreased	☐ ☐ ☐ ✓ ☐ ☐ ☐	increased	
expenses on agricultural inputs	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	decreased	Reduced to some extent as now farmers can make their own bio-inputs using the cow urine and cow dung collected from the cattle shed
farm income	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	A combination of improved productivity, reduced cost towards agriculture inputs and better milk productivity has helped farmers in improving their income.
diversity of income sources	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Some of the farmers have initiated their own bio resource centres to sell cow urine and cow dung-based bio-inputs, vermicompost etc.
workload	increased	☐ ☐ ☐ ☐ ☐ ✓ ☐	decreased	The workload of women members in the household was reduced very significantly due to covering the mud-based cow floor with cement-concrete-based cow floor, earlier cleaning of the cow dung and cow urine used to take a lot of the time. However with new floor, it can be cleaned in less than 5 minutes saving almost an hour in a day.

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐ ☐ ☐ ✓ ☐ ☐ ☐	improved	
health situation	worsened	☐ ☐ ☐ ☐ ✓ ☐ ☐	improved	Improved hygiene is good for both animal and human health
cultural opportunities (eg spiritual, aesthetic, others)	reduced	☐ ☐ ☐ ✓ ☐ ☐ ☐	improved	
community institutions	weakened	☐ ☐ ☐ ✓ ☐ ☐ ☐	strengthened	

Ecological impacts

soil moisture	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Application of cow dung, compost and other bio-inputs have improved the soil moisture
nutrient cycling/ recharge	decreased	☐ ☐ ☐ ☐ ✓ ☐ ☐	increased	Application of cow dung, compost and other bio-inputs will help in improving the nutrient cycling in the soil and will enhance the soil microbial activities
emission of carbon and greenhouse gases	increased	☐ ☐ ☐ ☐ ✓ ☐ ☐	decreased	Some of the farmers are using the collected cow dung as an input for their 'Bio-gas' plants. Thus, the use of biogas plants not only reduces the use of fire wood and LPG for cooking

but its waste (slurry) is also used as inputs for agriculture fields. Thus reducing the overall footprint of GHG emission.

Off-site impacts

damage on neighbours' fields	increased ☐☐☐☐☐✓☐ reduced	
impact of greenhouse gases	increased ☐☐☐☐✓☐☐ reduced	Some of the farmers have installed bio gas plants. Use of biogas plants not only reduces the use of fire wood and LPG for cooking but its waste (slurry) is also used as inputs for Some of the farmers are using the collected cow dung as an input for their 'Bio-gas' plants agriculture fields. Thus reducing the overall footprint of GHG emission. Also the improved floor have helped in proper collection of cow dung and cow urine for the purpose of composting. Composting makes the compounds in manure more stable and therefore reduces the amount that is released into the atmosphere.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative ☐✓☐☐☐☐☐ very positive
Long-term returns	very negative ☐☐☐☐☐✓☐ very positive

Benefits compared with maintenance costs

Short-term returns	very negative ☐☐✓☐☐☐☐ very positive
Long-term returns	very negative ☐☐☐☐☐☐✓ very positive

Low maintenance cost compared with benefits of higher animal productivity and hygienic living

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all ☐☐☐☐✓ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 11-50%
☐ 51-90%
☐ 91-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☑ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Reduced labour of urine and dung collection
- Better animal management

Strengths: compiler's or other key resource person's view

- Reduced GHG emission because of better handling of dung and urine
- Increased productivity because of the use of animal manure

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- High establishment cost Subsidies and grants
- Regular maintenance cost Technological innovation

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Possibilities of disadoption because of maintenance cost Increase returns of the units by extending new products from Urine and dung
- No demand Increase communication and extension on the benefits of different products from animals

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir Kim Arora	Udo Höggel Joana Eichenberger

Date of documentation: April 3, 2023

Last update: Sept. 14, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6721/

Linked SLM data

n.a.

Documentation was faciliated by

Institution
- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) - Germany
- Ecociate Consultants (Ecociate Consultants) - India

Project
- Soil protection and rehabilitation for food security (ProSo(i)l)

Key references

- Repairing cattle shed floor: Foundation for Ecological Security, Mandla, MP, India

Links to relevant information which is available online

- Cattle sheds: one intervention, several benefits for farmers: https://www.youtube.com/watch?v=Gd6u8yZ9DqY

Farmers field with PMDS (Santosh Gupta)

Pre-Monsoon Dry Sowing (PMDS) (India)

DESCRIPTION

The Pre-Monsoon Dry Sowing Technology aims to sow 12 to 15 different crop varieties in April without waiting for rain. To achieve this the seeds are pelletized with a mixture of clay soils, bio-inoculants like dried Ghanjeevamruth and Dravajeevamrit, and ash. The main objective of this technology is to empower rainfed farmers by utilizing the initial rainfall in April and May for crop cultivation. By using pelettized seeds, they can maximize the effectiveness of rainfall showers before the arrival of the monsoon season. Such seeds can also survive, if there are delay in the rainfall as the pellets around the seed help it in maintaining the moisture.

Pre-monsoon dry sowing (PMDS) is a system of sowing, tilling and tending the land wherein the farmer grows crops in non-farming seasons or whenever there is no crop cover on the land. This can be practised before the advent of monsoon, during summer (April-May), after Kharif and before the beginning of the Rabi season (September and October). PMDS harnesses the water vapor from air that gets settled in the form of early morning dew. The dew supplies the required moisture to the soil. (Reference:-https://apcnf.in/wp-content/uploads/2022/05/IDS-2020-2021-APCNF-PMDS-Report.pdf)

In the study where PMDS was practised before the onset of the monsoon season, typically during the dry month of April. The seeds are pelletized with a mixture of clay soils, bio-inoculants, and ash, which creates a protective coating around the seed and helps it to germinate even in the case of delayed rains or very little rainfall. The coating around the seed, helps it to maintain moisture and support its germination. As the name suggests, the technology is good for utilising the pre-monsoon season by advancing the sowing cycles, using the usually dry months of summer and utilising the pre-monsoon rains.

This technology benefits rainfed areas where farmers rely solely on rainfall for irrigation. PMDS aims to promote an extended duration of crop cover under rainfed conditions, allowing farmers to cultivate crops with a reduced risk of crop failure in the cases of delayed or lower rainfall. Since seeds are germinated before the arrival of monsoon, there are times when they can also survive the heavy rains. This technology is useful in utilising moisture to the best extent possible as seeds are covered with the outer layer of clay and other stuff. In the Mandla District of Madhya Pradesh, farmers utilized seeds from their homes, comprising 12 to 15 crops, including cereals, pulses, and spices. These collected seeds were pelletized, dried for 24 hours, and broadcasted into minimally tilled soil. The diversified crop combination was grown until July and mixed with the soil before paddy transplanting. This process improves the soil's microbial activity, resulting in increased yields in crops grown before paddy and in the paddy crop itself. Therefore, the farmers benefit from increased production and yields through this technique of PMDS.

PMDS not only improves the economics of farmers but it also improves soil health. The covering of the soil with different crops protects it from heat, pounding rain, and wind. It also improves diversity in soil microorganisms, beneficial insects and other species. Covering soil for 365 days with plant diversity is also critical to protect soil health and balance climate change. PMDS can facilitate all these functions.

LOCATION

Location: Bichhiya block, Madhya Pradesh, India

No. of Technology sites analysed: 10-100 sites

Geo-reference of selected sites
- 80.71122, 22.45269

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2022

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions


Seed treatment before sowing (Malay, WASSAN)


Seeds of Hope (Malay, WASSSAN)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use
Land use mixed within the same land unit: No

Cropland
- Annual cropping: cereals - rice (wetland)

Number of growing seasons per year: 1
Is intercropping practiced? No
Is crop rotation practiced? No

Water supply
☑ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation
☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed
soil erosion by water - Wt: loss of topsoil/ surface erosion

physical soil deterioration - Pc: compaction, Pu: loss of bio-productive function due to other activities

biological degradation - Bc: reduction of vegetation cover

SLM group
- improved ground/ vegetation cover
- minimal soil disturbance
- integrated soil fertility management

SLM measures
agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A6: Residue management (A 6.4: retained)

management measures - M1: Change of land use type, M2: Change of management/ intensity level

TECHNICAL DRAWING

Technical specifications

PMDS was undertaken at various sizes of plots based on the availability of land with farmers. Some farmers did at 0.10 acres of land while others did at 2 acres. Also, there was no fixed pattern that was followed for the quantity and variety of seeds. Whatever seeds were available were sown. In the image above, it can be seen that the field where PMDS was undertaken has multiple crops at different stages of their growth while the area with no PMDS has no crop and fallow red soil can be seen.

Author: Santosh

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1 acre**)
- Currency used for cost calculation: **INR (March, 2023)**
- Exchange rate (to USD): 1 USD = 82.5 INR (March, 2023)
- Average wage cost of hired labour per day: 204 INR

Most important factors affecting the costs

Availability of seeds, bio-inputs, and rainfall pattern. Usually, there are rains during the pre-monsoon season in the project area, however, in case of no rains at all during the entire summer, farmers may not be in a position to achieve the desired results.

Establishment activities

n.a.

Maintenance activities

1. Collection of seeds (Timing/ frequency: 1 month before the onset of Monsoon (mid May in project area))
2. Seed treatment and preparation of seed balls (Timing/ frequency: End of May in project area)
3. Broadcasting of the seed balls (Timing/ frequency: End of May in project area)
4. Soil rotation (Timing/ frequency: 2-3 days after the broadcasting of seed balls)
5. Harvesting of leafy vegetables, fodder and other produces (Timing/ frequency: Mid of June to mid of July)
6. Mixing the green manure in soils (Timing/ frequency: End of July or before transplantation of rice)

Maintenance inputs and costs (per 1 acre)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR (March, 2023))**	**Total costs per input (INR (March, 2023))**	**% of costs borne by land users**
Labour					
Seed treatment, preparation of seed balls	Person days	1.0	200.0	200.0	100.0
Broadcasting of seeds	Person days	1.0	200.0	200.0	100.0
Harvesting of the crops	Person days	2.0	150.0	300.0	100.0
Equipment					
Agriculture equipment for soil rotation	Hour	0.5	600.0	300.0	100.0
Cultivator	Hour	1.0	600.0	600.0	100.0
Plant material					
Seeds of different crops	kg	6.0	75.0	450.0	100.0
Fertilizers and biocides					
Bio-inputs	LS	1.0	400.0	400.0	100.0
Total costs for maintenance of the Technology				**2'450.0**	
Total costs for maintenance of the Technology in USD				*29.7*	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
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☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone

☐ humid
☑ sub-humid
☑ semi-arid
☐ arid

Specifications on climate

Average annual rainfall in mm: 1427.0
Monsoon season is from June-September, which has the majority of the rainfall.
Name of the meteorological station: District at glance report of Ministry of Water Resources, Central Groundwater Board, North Central Region BHOPAL, 2013
The National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) developed twenty agroecological zones based on the growing period as an integrated criterion of adequate rainfall, and soil groups. It delineated boundaries adjusted to district boundaries with a minimal number of regions. Mandla District of Madhya Pradesh lies in a Hot subhumid ecoregion with red and black soil. Precipitation - 1000–1500mm; Potential evapotranspiration -1300–1500 mm; Length of growing period-150–180days.

Slope

☐ flat (0-2%)
☐ gentle (3-5%)

Landforms

☐ plateau/plains
☑ ridges

Altitude

☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.

Technology is applied in

☐ convex situations
☐ concave situations

☐ moderate (6-10%)
☐ rolling (11-15%)
☑ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

☐ mountain slopes
☐ hill slopes
☐ footslopes
☐ valley floors

☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

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☐ fine/ heavy (clay)

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☐ on surface
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☐ poor/ none

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☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: both ground and surface water

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☑ high
☐ medium
☐ low

Habitat diversity
☑ high
☐ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

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☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☐ 10-50% of all income
☑ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☐ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☑ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☐ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	☐	☑	☐	good
education	poor	☐	☑	☐	good
technical assistance	poor	☐	☑	☐	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☑	☐	good
energy	poor	☐	☑	☐	good
roads and transport	poor	☐	☑	☐	good
drinking water and sanitation	poor	☐	☑	☐	good
financial services	poor	☑	☐	☐	good

IMPACTS

Socio-economic impacts
Crop production

Based on the discussion with land users and implanting agency, production of the main crop (Paddy) increased by 20-25%. (The crop combination under PMDS has some

	decreased	☐☐☐☐☐✓☐	increased	nitrogen-fixing crops and the crop biomass improves the nutrient availability for the next crop which is paddy, also the better moisture helped the improvement in productivity of paddy crop as well.). Additional production from crops sown in April month was generated. An impact assessment study to document the quantifiable results has not been conducted so far.
risk of production failure	increased	☐☐☐☐☐✓☐	decreased	Risk of production failure reduced due to crop diversification
product diversity	decreased	☐☐☐☐☐☐✓	increased	Crop diversification by sowing multi crops of cereals, millets, pulses, and oilseeds in otherwise paddy predominant area
production area (new land under cultivation/ use)	decreased	☐☐☐☐☐✓☐	increased	The gross sown area increased as the land was brought under cultivation from April to July
land management	hindered	☐☐☐☐☐✓☐	simplified	Through this technology crop biomass was added to improve soil to improve its organic content and structure
farm income	decreased	☐☐☐☐☐✓☐	increased	Increase in farm income due to additional crop production and increase in yield of the main crop
diversity of income sources	decreased	☐☐☐☐☐✓☐	increased	12 to 15 different crops are grown in PMDS, reducing the crop failure chances and improvements in soil structure, therefore storing the soil moisture for an extended duration

Socio-cultural impacts

food security/ self-sufficiency	reduced	☐☐☐☐☐✓☐	improved	Diversity in crops will reflect in increased and more diverse food availability

Ecological impacts

evaporation	increased	☐☐☐☐☐✓☐	decreased	Reduction in evaporation loss from April to July and effective utilization of soil moisture and rainfall in this duration
soil moisture	decreased	☐☐☐☐☐✓☐	increased	Improved soil structure due to the addition of crop biomass in the soil leads to the retention of soil moisture. The extended duration of crop cover also reduces evaporation losses.
soil cover	reduced	☐☐☐☐☐✓☐	improved	Extended duration of crop cover from April - July
soil loss	increased	☐☐☐☐☐✓☐	decreased	Reduction in soil loss due to crop cover
nutrient cycling/ recharge	decreased	☐☐☐☐☐✓☐	increased	Crop biomass increases organic carbon in the soil improving the availability of nutrient in the soil
vegetation cover	decreased	☐☐☐☐☐✓☐	increased	Extended duration of vegetation cover of the soil
biomass/ above ground C	decreased	☐☐☐☐☐✓☐	increased	Increase in biomass above ground by using pre-monsoon rainfall
micro-climate	worsened	☐☐☐☐✓☐☐	improved	

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☐✓	very positive
Long-term returns	very negative	☐☐☐☐☐✓☐	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐☐✓	very positive

Long-term returns very negative ☐☐☐☐☐☐☑ very positive

The PMDS technology does not require any higher establishment cost, as most of the material is locally available. The maintenance of technology is also limited as once the pelleted seeds are sown there is hardly any maintenance required. The returns on the use of technology are very positive as an additional source of income is available.

CLIMATE CHANGE

Gradual climate change
Adaptation to climate vulnerabilities by crop diversification and effective utilization of natural resources increase not well at all ☐☐☐☐☑ very well

Climate-related extremes (disasters)
Adaptation to climate change not well at all ☐☐☐☐☑ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 11-50%
☐ 51-90%
☑ 91-100%

Number of households and/ or area covered
Approximately 100 farmers have adopted the newly introduce PMDS technology in 2020-21.

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)
☑ Diversified Combination

The crop combination is diversified based on the seeds available and household nutrition requirements

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Increase PMDS crop productivity and yield 20-25% subsequent crops, especially paddy crops
- Soil structure is improved
- Crop Diversification: 12 - 15 different crops are grown on the same piece of land
- Fodder availability to animals during the summer season

Strengths: compiler's or other key resource person's view

- Ensuring a crop cover for 365 days leads to reduced soil erosion and improved soil health
- Maintaining the soil moisture for the subsequent crops, which are cultivated in the rain-fed conditions
- Regular practice of PMDS can increase the soil's organic carbon as a lot of green manure is incorporated in the soil resulting in higher carbon content

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Open grazing of cattle during summer is a common practice. As there are no standing crops in the field, farmers tend to allow their animals for open grazing. However, the cultivation of crops using the PMDS method tends to attract cattle as other fields in the project areas do not have any green cover. Village-level community institutions can develop a system to minimize the grazing in the fields having crops or the higher adoption of PMDS by the farmers will gradually reduce this risk as PMDS can be a good source of green fodder as well.
- Farmers are putting in extra quantities of seeds for various crops for sowing during the PMDS. In normal cases, they will sow the seeds only after the onset of the monsoon and when the field is ready for sowing. Thus in PMDS, they may feel like losing their seeds if there is no germination due to delays in monsoon or other reasons. Farmers can be supported by providing seeds for the first year to mitigate the risk and exchanging weather-related information in advance. So that they can make an informed decision.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Very low to no awareness of the PMDS methodology and benefits among the project farmers. Regular handholding and demonstrations along with good audio-video documentation for dissemination.
- Possible delay in sowing and harvesting of the Kharif and Rabi crops due to delayed monsoon or appropriate soil conditions. Scheduling the crops based on a crop calendar is one solution; another solution is to explore the seed varieties suitable for delayed sowing.

REFERENCES

Compiler	**Editors**	**Reviewer**
Santosh Gupta	Noel Templer Stephanie Katsir Kim Arora	Udo Höggel

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Resource persons
Santosh Gupta - SLM specialist

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_6697/

Linked SLM data
n.a.

Documentation was faciliated by

Institution
- CIAT International Center for Tropical Agriculture (CIAT International Center for Tropical Agriculture) - Kenya
- Deutsche Gesellschaft für Internationale Zusammenarbeit - India (GIZ India) - India
- Ecociate Consultants (Ecociate Consultants) - India

Project
- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online
- Assessing the Impact of Andhra Pradesh Community Managed Natural Farming: A comprehensive Approach Using Crop Cutting Experiments Pre-Monsoon Dry Sowing Farming in Andhra Pradesh: https://apcnf.in/wp-content/uploads/2022/05/IDS-2020-2021-APCNF-PMDS-Report.pdf

A field with application of biochar (Anoop Thakur, FES)

Biochar Application on Homestead Land (India)

DESCRIPTION

Biochar is a carbon-rich solid formed from the organic residue by pyrolysis. Biochar is a stable, highly water and nutrient-retentive product that benefits microorganisms and has a very high carbon sequestration potential. Farmers in the project area have applied it to their homesteads or kitchen gardens.

Biochar, a sustainable soil amendment, is produced through pyrolysis, where organic matter such as wood or agricultural waste is heated in a closed container under low-oxygen conditions. Applying biochar to soil has numerous benefits for improving soil health, such as enhancing soil fertility, reducing greenhouse gas emissions, improving soil microbiology, and reducing soil erosion. One of the most significant benefits of biochar is its ability to sequester atmospheric carbon dioxide into the soil, which can help mitigate climate change by reducing the amount of carbon dioxide in the atmosphere. Biochar can also remove contaminants from soil and water and serve as a compost component.

Biochar also reduces the emission of ammonia and carbon dioxide (Cabeza et al. 2018), lowers soil compactness, optimizes compost (Liang et al. 2010), improves water retention and the sorption of heavy metals, increases the availability of micronutrients for plants and increases the pH of soils (Van Zwieten et al. 2010). Biochar also stimulates the growth of rhizosphere microorganisms and mycorrhizal fungi (Głuszek et al. 2017). These bacteria and fungi may also promote plant growth (Compant et al. 2010). The pH values of biochars are positively correlated with the formation of carbonates and the contents of inorganic alkalis (Ding et al. 2014). The pH value of biochar ranges from 6.5 to 10.8. It is advisable to test the pH values of both soils and biochar to reach at the optimal quantity of biochar to be applied in the field.

In the Mandla district, agriculture is the backbone of the economy, and farmers are constantly adopting new farming technologies to increase their agricultural production. One such technology that has positively impacted more than a thousand farmers in the region is the application of biochar in homestead land under a GIZ-funded Soil protection and rehabilitation of degraded soil for food security in India (ProSoil) program. Biochar in this region is prepared using low cost Biochar Kiln units developed by Indian council of agriculture research institutions, traditional methods, such as digging soil pits and burning organic residue while covering its top with soil. Since the Mandla district is a high-rainfall region, most farmers broadcast biochar over their fields before growing rabi (winter) crops. Commonly grown rabi crops in this region are mustard, vegetables, and maize.

Farmers in the Mandla district use small units of biochar production. The recovery rate of biochar is 20%, with a capacity of 100kg of organic material. The application rate per unit area varies from farmer to farmer.
1. Landholding: Farmers with more extensive land holdings or generally rotationally applied biochar in the parcels.
2. The intervention of biochar application was introduced in this region in 2020. The new practice is evolving, and the application rate of biochar varies from farmer to farmer depending on the availability of raw materials and labour availability (family/hired)

The most suitable biochar application rate is 10 – 20 t/ha. Moreover, it is essential to consider the compatibility and complementarity between biochar, soil texture, and management factors such as Nitrogen (N) application rate, pH values and growing environment into consideration (Yang Gao et al., 2021). More scientific studies are needed to define the quantity of biochar needed based on the local soil conditions. However, the current quantity of applications is very low compared to suggested in secondary documents.

The immediate effects of biochar application on crop production have been significant, with farmers reporting an increase in crop yield by 20-25% across most crops. Simple indicators such as increased grain weight and improved grain quality imply that the crop produced is of higher quality. Another critical benefit highlighted by farmers of biochar application is the retention of soil moisture over a longer duration compared to non-treated fields. Biochar can

LOCATION

Location: Mandla, Madhya Pradesh, India

No. of Technology sites analysed: 100-1000 sites

Geo-reference of selected sites
- 80.71058, 22.45221

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2020

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

help the farmers of the Mandla district increase their agricultural productivity while promoting sustainable land use practices.

Farmer preparing the biochar for application in the field (Anoop Thakur, FES)

Preparation of biochar by the farmers (Foundation for Ecological Security)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☐ adapt to climate change/ extremes and its impacts
☑ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Land use mixed within the same land unit: Yes - Agroforestry

Cropland

- Annual cropping: cereals - maize, cereals - millet, cereals - rice (wetland), cereals - sorghum, legumes and pulses - lentils, Mustard

Number of growing seasons per year: 2
Is intercropping practiced? No
Is crop rotation practiced? Yes

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

chemical soil deterioration - Cp: soil pollution

physical soil deterioration - Pc: compaction, Pu: loss of bio-productive function due to other activities

biological degradation - Bc: reduction of vegetation cover, Bl: loss of soil life

SLM group

- agroforestry
- improved ground/ vegetation cover
- integrated soil fertility management

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility

management measures - M2: Change of management/ intensity level

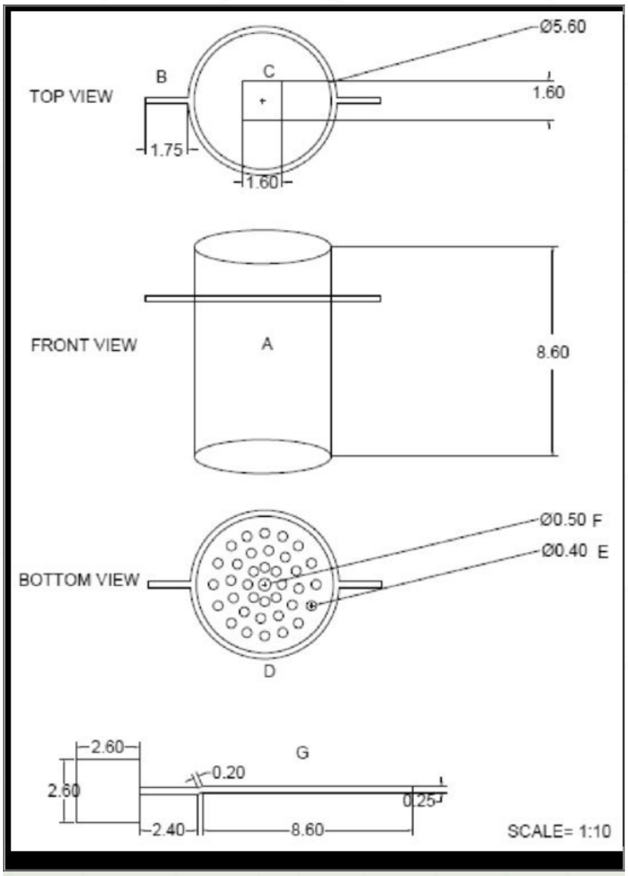
TECHNICAL DRAWING

Technical specifications

The drawing presented here is of a biochar kiln unit being developed by the Central Research Institute for Dryland Agriculture (CRIDA) in India for Biochar preparation. A similar unit was used by the land users in the project area. There were some farmers who also did some modifications to make it friendly for the local context. More details about this unit can be obtained from the following sources.

http://www.nicra-icar.in/nicrarevised/images/Books/Biochor%20Bulletin.pdf

http://icar-crida.res.in/Pubs/Biochar%20Research%20Bulletin%20March%202018.pdf (for a description of the HOW to make biochar)



Author: Central Research Institute for Dryland Agriculture (CRIDA)

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1 Ha**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 82.5 INR
- Average wage cost of hired labour per day: 204

Most important factors affecting the costs

The primary factor affecting the cost is the labor cost for applying biochar to the field and the easy availability of biomass/crop residues/Lantana for biochar production

Establishment activities

1. Purchase of Biochar Kiln Unit (Timing/ frequency: Once in 4-5 years)

Establishment inputs and costs (per 1 Ha)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Equipment					
Biochar Kiln unit	Number	1.0	9000.0	9000.0	10.0
Transportation	LS	1.0	2000.0	2000.0	10.0
Total costs for establishment of the Technology				**11'000.0**	
Total costs for establishment of the Technology in USD				*133.33*	

Maintenance activities

1. Preparation of Biochar using the Lantana Camara (Timing/ frequency: After the monsoon season (September))
2. Preparing the biochar for application by mixing it with cow dung and cow urine (Timing/ frequency: During Rabi Season (Oct-Nov))
3. Application of Biochar in homestead land (Timing/ frequency: During Rabi Season (Oct-Nov))

Maintenance inputs and costs (per 1 Ha)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Labour					
Transportation of biomass and its drying before biochar production	Person-day	2.0	200.0	400.0	100.0
Preparation of Biochar by family members	Person-day	2.0	200.0	400.0	100.0
Mixing biochar with cow dung and cow urine and making it ready for the application	Person-day	1.0	200.0	200.0	100.0
Biochar Application	Person-day	1.0	200.0	200.0	100.0
Fertilizers and biocides					

Biomass for Biochar production (Approximate)		1.0	500.0	500.0	100.0
Cow dung	kg	20.0	5.0	100.0	100.0
Cow urine	kg	20.0	5.0	100.0	100.0
Total costs for maintenance of the Technology				**1'900.0**	
Total costs for maintenance of the Technology in USD				*23.03*	

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☑ 1,001-1,500 mm
- ☐ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☑ semi-arid
- ☐ arid

Specifications on climate
Average annual rainfall in mm: 1427.7
Monsoon season is June-September which has the majority of the rainfall
Name of the meteorological station: District at glance report of Ministry of Water Resources, Central Groundwater Board, North Central Region BHOPAL, 2013
The National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) developed twenty agroecological zones based on the growing period as an integrated criterion of adequate rainfall and soil groups. It delineated boundaries adjusted to district boundaries with a minimal number of regions. Mandla District of Madhya Pradesh lies in a hot sub-humid ecoregion with red and black soil. The length of the growing period varies from block to block based on the availability of irrigation with farmers. Thus both sub-humid and semi-arid agroclimatic zones are being considered for the District.
Precipitation: 1000–1500 mm; Potential Evapotranspiration: 1300–1500 mm; Length of Growing Period: 150–180 days

Slope
- ☐ flat (0-2%)
- ☐ gentle (3-5%)
- ☐ moderate (6-10%)
- ☑ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☑ ridges
- ☐ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☑ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Topsoil organic matter content
- ☐ high (>3%)
- ☐ medium (1-3%)
- ☑ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☑ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☑ medium
- ☐ poor/ none

Water quality (untreated)
- ☐ good drinking water
- ☑ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Water quality refers to: both ground and surface water

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☐ Yes
- ☑ No

Species diversity
- ☑ high
- ☐ medium
- ☐ low

Habitat diversity
- ☑ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial)
- ☐ commercial/ market

Off-farm income
- ☐ less than 10% of all income
- ☐ 10-50% of all income
- ☑ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☑ poor
- ☑ average
- ☐ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☑ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative
- ☐ employee (company, government)

Gender
- ☑ women
- ☑ men

Age
- ☐ children
- ☑ youth
- ☑ middle-aged
- ☐ elderly

Area used per household

- ☑ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☐ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale

- ☑ small-scale
- ☐ medium-scale
- ☐ large-scale

Land ownership

- ☐ state
- ☐ company
- ☑ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights

- ☐ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Water use rights

- ☐ open access (unorganized)
- ☑ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor	☐ ☑ ☐	good
education	poor	☐ ☑ ☐	good
technical assistance	poor	☑ ☐ ☐	good
employment (e.g. off-farm)	poor	☐ ☑ ☐	good
markets	poor	☐ ☑ ☐	good
energy	poor	☐ ☑ ☐	good
roads and transport	poor	☑ ☐ ☐	good
drinking water and sanitation	poor	☐ ☑ ☐	good
financial services	poor	☐ ☑ ☐	good
Advisory and extension (limited to only project teams)	poor	☑ ☐ ☐	good

Comments

Over the years, there has been a development focus from both the Government and other civil society organizations to bring out the facilities at the door of communities, which has improved access of different facilities.

IMPACTS

Socio-economic impacts

Crop production

	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	There has not been any systematic impact assessment study to quantify the impact of the intervention. However, in discussions with farmers and implementing agencies during the field visit, an increase of 20-25% in the production of farm products was reported.
crop quality	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Change in crop weight and colour is observed by farmers
land management	hindered	☐ ☐ ☐ ☐ ☐ ☑ ☐	simplified	Improved Soil Health is indicated by farmers based on their observation of improved soil structure, water-holding capacity and soil texture
farm income	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	On the account of improved productivity, farmers have reported an increase in their income. However, there has not been any systematic study on the same.

Socio-cultural impacts

SLM/ land degradation knowledge

	reduced	☐ ☐ ☐ ☐ ☐ ☑ ☐	improved	The preparation of biochar from invasive species and its application to soil improved the understanding of farmers on the negative impact of invasive species and advantages of biochar application

Ecological impacts

soil moisture

	decreased	☐ ☐ ☐ ☐ ☐ ☑ ☐	increased	Soil structure improved by biochar application, improving water holding capacity of soil
soil loss	increased	☐ ☐ ☐ ☐ ☑ ☐ ☐	decreased	Reduction in soil erosion due to improvement in soil structure
soil compaction	increased	☐ ☐ ☐ ☐ ☐ ☑ ☐	reduced	Reduction in soil compaction due to improvement in soil structure
soil organic matter/ below ground C	decreased	☐ ☐ ☐ ☐ ☑ ☐ ☐	increased	Based on the observation of farmers and implementing agency, random soil tests of farmers have indicated a slight increase in soil organic carbon
invasive alien species	increased	☐ ☐ ☐ ☐ ☐ ☑ ☐	reduced	Reduction in invasive alien species named lantana cantara which was uprooted for preparing biochar

micro-climate	worsened	☐☐☐☐☑☐☐	improved	Improve soil health create an enabling environment for soil micro-organism

Off-site impacts

Biochar is prepared using invasive species of Lantana Camara. Its eradication from private and commercial land improves the ecosystem.	None	☐☐☐☐☑☐☐	None

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	☐☐☐☐☐☑☐	very positive
Long-term returns	very negative	☐☐☐☐☐☐☑	very positive

The benefits as indicated above are much higher than the cost involved. More importantly cost is too less as all the resources are being managed internally by the farmers.

CLIMATE CHANGE

Gradual climate change

When biochar is added to soil, it can sequester carbon in the form of stable organic matter, which can remain in the soil for hundreds or even thousands of years. This carbon sequestration can help to reduce the amount of carbon dioxide in the atmosphere, thereby mitigating climate change. decrease	not well at all	☐☐☐☑☐	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Number of households and/ or area covered

More than 3000 farmers

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 11-50%
☐ 51-90%
☐ 91-100%

Has the Technology been modified recently to adapt to changing conditions?

☐ Yes
☐ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Increase crop production
- Improve the quality of farm produce
- Improve soil water holding capacity

Strengths: compiler's or other key resource person's view

- Improved soil health
- Mitigate climate change
- Increase in soil nutrient content
- Reduction in cost of inputs

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Manual labor is required for the preparation of biochar Innovating/adopting automation in biochar preparation
- Decentralized preparation of biochar Developing enterprise for selling cost-effective biochar in a localized manner

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Limited understanding of standardization of biochar quality and rate of application Conducting more research studies and documenting experiences of farmers

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir Kim Arora	Udo Höggel

Date of documentation: March 17, 2023

Last update: May 10, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6693/

Linked SLM data

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Documentation was faciliated by

Institution

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- Deutsche Gesellschaft für Internationale Zusammenarbeit - India (GIZ India) - India
- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Key references

- Significance of biochar application to the environment and economy, Babalola Aisosa Onia,⁎, Olubukola Oziegbeb, Obembe O. Olawole: https://doi.org/10.1016/j.aoas.2019.12.006
- Impacts of biochar application on upland agriculture: A review, Kumuduni Niroshika Palansooriyaa,1, Yong Sik Oka,1, Yasser Mahmoud Awada, Sang Soo Leeb, Jwa-Kyung Sungc, Agamemnon Koutsospyrosd, Deok Hyun Moone: https://doi.org/10.1016/j.jenvman.2018.12.085
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- Biochar physicochemical properties: pyrolysis temperature and feedstock kind effects: https://link.springer.com/article/10.1007/s11157-020-09523-3

Links to relevant information which is available online

- District at glance - Mandla: http://cgwb.gov.in/District_Profile/MP/Mandla.pdf
- District Census Handbook Mandla: http://lsi.gov.in:8081/jspui/bitstream/123456789/2097/1/38136_2001_MAN.pdf

Multilayer Farming in Maharashtra (WOTR)

Multilayer Farming Systems For Ensuring Food Diversity And Increasing Resilience (India)

Mishrit kheti

DESCRIPTION

Multilayer farming, also known as multi-tier farming, is a technique of intercropping crops of different heights, root and shoot patterns, and maturation times in small plots of land. This technique is cost-effective, easily adaptive, and participatory, providing a large number of food groups to farmers to improve their nutritional levels, providing insurance against crop failure, reducing pest and disease incidence, and improving soil properties and soil fertility conditions. Multilayer farming minimizes crop-weed competition, and soil erosion, and optimizes resource utilization resulting in higher returns and better nutritional value. It promotes sustainable agriculture, maintains a balanced diet, increases income per unit area, and reduces the risk of crop failure.

Multilayer farming is an agricultural model that aims at achieving maximum production per unit area by utilizing water, manure, and land resources to their full potential. This method is based on the synergies between the different crops and plants planted on a given piece of land. This method is cost-effective and yields more benefits than other farming systems. By cultivating four to five crops with the same amount of fertilizer and water required for a single crop, farmers can increase their income, and multiple crops can be harvested yearly using the same piece of land.

Multilayer farming is based on scientific, ecological, and economic principles, promoting crop diversification, maximizing productivity, utilizing resources more efficiently, and promoting intensive input use. Moreover, it ensures the sustainability of farm resources and the environment in the long term.

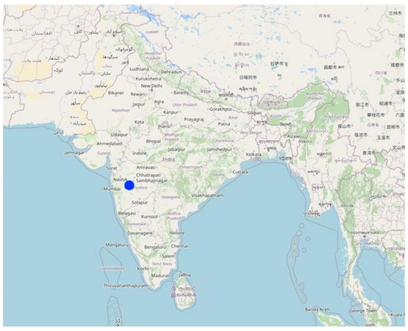
The multilayer farming system mainly consists of an overstory of trees or shrubs with an understory of economic or forage crops. By incorporating these principles, farmers can achieve greater yields and financial success while promoting environmental sustainability.

As a part of the program's approach, WOTR (Watershed Organisation Trust, the project implementing partner trained women change-makers) to spread awareness among villagers about the importance of nutrition and a healthy diet. Since 2018, the active promotion of multilayer farming to address food and nutrition insecurity in Maharashtra is undertaken. As a result, 1124 plots across 150 villages in Maharashtra have adopted this unique farming method to enhance food and nutrition security.

The multilayer farming system involves several steps to ensure maximum productivity from the available resources.

1.The first step is land preparation, which involves applying 300 kg of cow dung or vermicompost along with one kg of Trichoderma powder per 36 x 36 feet plot. Trichoderma is a bio-fungicide that helps to prevent fungal infections in plants and roots.
2.Next, eight beds of 3 x 36 feet are prepared with 1.5 to 2 feet of space left in between. These beds need to be arranged in the North-South direction to ensure that plants receive adequate sunlight.
3.After preparing the bed, 1-foot deep channels are dug to drain excess water so ensuring that the crops are not waterlogged.
4.Finally, in the middle of each bed, vegetable and fruit crops are planted according to a crop planning chart. By planting a variety of crops in the same plot, the multilayer farming system ensures the effective utilization of resources and provides an even distribution of income and employment throughout the year by producing several off-season crops.

LOCATION



Location: Ahmednagar, Maharashtra, India

No. of Technology sites analysed: 100-1000 sites

Geo-reference of selected sites
- 74.75607, 19.09

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2018

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

The multilayer farming system has numerous benefits that make it an effective and sustainable farming method. It makes effective use of soil, water, and other resources, reducing waste and increasing productivity. Additionally the system reduces climate-specific damage and enhances soil health, helping to maintain an ecological balance in the environment. The soil covered minimizes water loss due to soil evaporation, generating a higher income per unit area with an even distribution of income and employment throughout the year. The multilayer farming system generates jobs and allows for better utilization of labor while reducing the impacts of climate-specific hazards such as high-intensity rainfall, soil erosion, and landslides. Multilayer farming also utilizes soil moisture at different depths and solar energy at different heights, improving soil characteristics and adding organic matter to the soil. It reduces pests and disease infestation and provides micro-climate conditions which ensure better productivity of crops underneath. Overall, multilayer farming is a sustainable and efficient farming method that not only maximizes productivity but also enhances soil and environmental health while promoting economic and social well-being.


Bed preparation for multilayer farming (WOTR Team)


Planting of fruits and vegetable crops in multilayer farming (WOTR)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☐ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☐ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☑ create beneficial social impact
☑ Ensure nutritional security

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - sorghum, cereals - wheat (winter), Sugarcane, Horticulture crops like Pomegranate, Guava, Mango etc, Onion, pulses

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Water supply

☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

☑ prevent land degradation
☑ reduce land degradation
☐ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

physical soil deterioration - Ps: subsidence of organic soils, settling of soil

biological degradation - Bc: reduction of vegetation cover, Bq: quantity/ biomass decline, Bs: quality and species composition/ diversity decline, Bp: increase of pests/ diseases, loss of predators

SLM group

- improved ground/ vegetation cover
- irrigation management (incl. water supply, drainage)
- home gardens

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A5: Seed management, improved varieties

vegetative measures - V1: Tree and shrub cover

management measures - M1: Change of land use type, M4: Major change in timing of activities

TECHNICAL DRAWING

Technical specifications

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **1**; conversion factor to one hectare: **1 ha = ha**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 80.0 INR
- Average wage cost of hired labour per day: 200

Most important factors affecting the costs

1. Availability of family labour to manage the field operations 2. Availability of dairy animals at the household level to meet the FYM needs

Establishment activities

1. Land Preperation (Timing/ frequency: June)
2. Preperation of beds for seed sowing (Timing/ frequency: June)
3. Sowing of seeds for fruits (Timing/ frequency: Early June)
4. Fencing of the field (Timing/ frequency: Before the sowing)

Establishment inputs and costs (per 1)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR)**	**Total costs per input (INR)**	**% of costs borne by land users**
Labour					
Land preparation	person days	2.0	200.0	400.0	100.0
Preperation of beds for sowing	Person days	3.0	200.0	600.0	100.0
Equipment					
Fencing material	Lumpsum	1.0	5000.0	5000.0	100.0
Plant material					
Seeds for fruit trees (seeds and planting material)	Plant	100.0	50.0	5000.0	100.0
Fertilizers and biocides					
Fram yard manure	Tons	10.0	600.0	6000.0	100.0
Other					
Miscellaneous		1.0	2000.0	2000.0	100.0
Total costs for establishment of the Technology				**19'000.0**	
Total costs for establishment of the Technology in USD				*237.5*	

Maintenance activities

1. Sowing of seeds (Timing/ frequency: June-July/October-November/April/March/April)
2. Application of organic manures (Timing/ frequency: Across the year at critical growth stages)
3. Irrigation (Timing/ frequency: Across the year at critical growth stages)
4. Bio-inputs (Timing/ frequency: Based on the plant needs)
5. Harvesting of leafy vegetables, fruits, fodder and other produces (Timing/ frequency: Multiple plucking during the year)
6. Sales of farm produces (Timing/ frequency: Multiple times during the year)

Maintenance inputs and costs (per 1)

Specify input	**Unit**	**Quantity**	**Costs per Unit (INR)**	**Total costs per input (INR)**	**% of costs borne by land users**
Labour					
Sowing of seeds	Person days	8.0	200.0	1600.0	100.0
Application of FYM and other inputs	Person days	5.0	200.0	1000.0	100.0
Maintenance and monitoring of the field	Person days	50.0	100.0	5000.0	100.0
Harvesting	Person days	20.0	200.0	4000.0	100.0
Plant material					
Seeds and planting material	Kg	0.25	1000.0	250.0	100.0
Fertilizers and biocides					
Farm yard manure and other inputs	Tons	5.0	750.0	3750.0	100.0
Other					
Other cost	Lumpsum	1.0	1000.0	1000.0	100.0
Total costs for maintenance of the Technology				**16'600.0**	
Total costs for maintenance of the Technology in USD				*207.5*	

NATURAL ENVIRONMENT

Average annual rainfall

☐ < 250 mm

Agro-climatic zone

☐ humid

Specifications on climate

☐ 251-500 mm
☑ 501-750 mm
☐ 751-1,000 mm
☐ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

☐ sub-humid
☑ semi-arid
☐ arid

Average annual rainfall in mm: 561.0
Deccan Plateau, Hot Semi-Arid Eco-Region as per the ICAR classification of Ecological Zone
Name of the meteorological station: https://krishi.icar.gov.in/jspui/bitstream/123456789/30264/1/MH14.pdf
Length of growing period: less than 90 days
Rainy days: 44

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☐ rolling (11-15%)
☑ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☑ hill slopes
☐ footslopes
☐ valley floors

Altitude
☐ 0-100 m a.s.l.
☐ 101-500 m a.s.l.
☑ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☑ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☐ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☐ 5-50 m
☑ > 50 m

Availability of surface water
☐ excess
☐ good
☐ medium
☐ poor/ none

Water quality (untreated)
☑ good drinking water
☐ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: both ground and surface water

Is salinity a problem?
☐ Yes
☑ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☐ high
☐ medium
☑ low

Habitat diversity
☐ high
☐ medium
☑ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☐ subsistence (self-supply)
☑ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☐ less than 10% of all income
☑ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☑ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☐ animal traction
☑ mechanized/ motorized

Sedentary or nomadic
☑ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☑ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☑ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☑ open access (unorganized)
☐ communal (organized)
☐ leased
☐ individual

Access to services and infrastructure

health	poor		✓		good
education	poor		✓		good
technical assistance	poor		✓		good
employment (e.g. off-farm)	poor		✓		good
markets	poor			✓	good
energy	poor		✓		good

Comments

The district is one among the progressive districts of Maharashtra and is well connected with a good network of roads and railways.

☐ 251-500 mm
☑ 501-750 mm
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education	poor	☐	☑	☐	good
technical assistance	poor	☐	☑	☐	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☐	☑	good
energy	poor	☐	☑	☐	good

Comments

The district is one among the progressive districts of Maharashtra and is well connected with a good network of roads and railways.

Benefits compared with maintenance costs

Short-term returns very negative ☐☐☐☐☐☑☐ very positive

Long-term returns very negative ☐☐☐☐☐☑☐ very positive

CLIMATE CHANGE

-

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☐ single cases/ experimental
☑ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☐ 0-10%
☐ 11-50%
☐ 51-90%
☑ 91-100%

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☐ climatic change/ extremes
☑ changing markets
☐ labour availability (e.g. due to migration)

The Vegetable and fruits crops are modified based on the Household requirement

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Diversified vegetables and fruits available for household consumption
- Increase in household income, as the excess produce is sold in the market and also reduced dependency on markets to purchase fruits and vegetables
- Small farm plot (1300 sq. ft) is utilized under multilayer farming, remaining farmland is available for cereal, etc

Strengths: compiler's or other key resource person's view

- Water use efficiency because of the use of micro irrigation and reduction of evaporation as the crops and dry matter cover the soil
- A good micro-climate of the multilayer farm plot is maintained
- Availability of a good range of food groups to farmers may lead to improvement in nutritional parameters especially for women and children
- Improved soil health due to mixed cropping system and enhancement soil microbial activities

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Labor engagement throughout the year Mechanization suitable for small farm plots
- Availability of farm yard manure to ensure cultivation following natural farming practices Promotion of animal husbandry (dairy) in convergence with the government departments

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- The produce from multilayer farming is diversified and comes in small quantities. Therefore the selling of these small quantities of produce is done in the local market. Creation of farmers' collectives for selling larger amounts of produce in the market
- Availability of irrigation is important to ensure the sustainability of intervention Some water based enterprises can be developed to support the farmers not have irrigation facilities

REFERENCES

Compiler	Editors	Reviewer
Santosh Gupta	Noel Templer Stephanie Katsir	Udo Höggel Rima Mekdaschi Studer

Date of documentation: April 10, 2023

Last update: Nov. 20, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6724/

Linked SLM data

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- Ecociate Consultants (Ecociate Consultants) - India

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

Links to relevant information which is available online

- How is multilayer farming done?: https://wotr.org/2020/07/18/how-multilayer-farming-is-done/
- Enhancing Household Food and Nutrition Security With Multilayer Farming: https://www.csrmandate.org/enhancing-household-food-and-nutrition-security-with-multilayer-farming/
- Kitchen Garden, Multilayer Farming Boost Food Security in Maharashtra: https://wotr.org/2020/05/07/kitchen-garden-multilayer-farming-boost-food-security-in-maharashtra-2/

SLM technology: Sustainable biochar production through agroforestry systems and its application

Household production of biochar using diverse feedstock (World Agroforestry)

Sustainable Biochar Production Through Agroforestry Systems And Its Application (India)

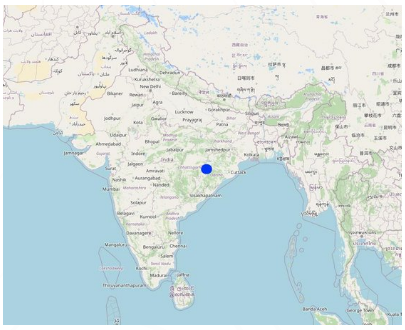
DESCRIPTION

Biochar is a carbon-rich, solid material derived from a wide range of biomass or organic waste through a thermochemical method. It is an organic charcoal material that is the final product of pyrolysis, or high-temperature burning of agricultural biomass without oxygen. Surplus crop residues, agricultural waste, and wood from sustainable sources are used as feedstock (raw material). Such biochar production is linked with agroforestry plantation and agriculture to improve soil health and ensuring sustainable feedstock availability.

Introduction and Background
Intensive cropping systems coupled with monocropping and high usage of synthetic fertilizers have led to the degradation of soils and depletion of nutrients directly affecting agricultural productivity and farmers' income. Farmers in the Balangir district of Odisha are facing similar challenges. To address these issues and promote sustainable farming practices, a biochar production initiative was introduced by utilizing crop residues and waste material from forests to produce biochar, a carbon-rich material that enhances soil fertility and soil structure. The initiative is a part of the Pro-Soil Project of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), India and implemented by the International Centre for Research in Agroforestry (ICRAF). The technology (a kiln for biochar production) and technical inputs for biochar production were sourced from the Indian Institute of Soil Science, Bhopal.
Biochar is a type of charcoal produced from biomass like agricultural or forest waste or organic materials through a process called pyrolysis. The application of sustainable biochar technology in agroforestry systems can lead to better soil structure, increased water retention, reduced nutrient leaching, and improved crop yields. Moreover, it aids in mitigating greenhouse gas emissions by locking carbon into soil for an extended period.
In the project region farmers used crop residues such as rice straw, wheat straw and residue of other crops along with non-usable biomass from local forests, such as branches, twigs, and leaves, to supplement the feedstock for the pyrolysis. Since the District has large forest areas, the availability of forest waste is no problem. The biochar produced was applied into existing crops fields as well as into agroforestry system. Aiming to promote agroforestry, the project promoted the integration of trees (both fruits and timber) and shrubs into existing agricultural practices. Agroforestry offers multiple benefits such as improved soil health, biodiversity, and carbon sequestration. When sustainable biochar production is integrated into these systems, it can create a sustainable cycle where agricultural waste is converted into biochar, which then enhances soil fertility and sequesters carbon when added back into the soil.
The project has actively involved women farmers, entrepreneurial youth, and farmers' groups in the collection, production and application process of biochar thus promoting community participation and creating awareness about the benefits of biochar.

Implementation
The biochar kiln technology, obtained from the Indian Institute of Soil Science, in Bhopal, is employed to convert biomass into biochar through pyrolysis. This technology ensures efficient and controlled production of high-quality biochar. The collected biomass undergoes a controlled pyrolysis process inside the biochar kiln, where it is burned in the relative absence of oxygen. Technical specialization during production includes kiln temperature control, feedstock preparation, and the management of pyrolysis gases to ensure efficient biochar production. This results in the conversion of biomass into biochar, also leaving behind bioenergy-rich gases. Quality control measures are implemented to ensure the production of biochar with optimal characteristics, including high carbon content, porosity, and stability.
The Biochar kiln used was designed with the aim to optimize temperature control and ensure efficient conversion of biomass. An efficient loading mechanism allows easy and controlled feeding of biomass into the kiln. This ensures a consistent flow of material during the pyrolysis process. Although local kilns are usually not equipped with temperature control mechanisms

LOCATION



Location: Odisha, India

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- 83.46593, 20.81621
- 83.35058, 20.81108
- 83.35058, 20.81108

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2021

Type of introduction
☐ through land users' innovation
☐ as part of a traditional system (> 50 years)
☑ during experiments/ research
☑ through projects/ external interventions

to regulate the pyrolysis temperature, the temperature in the kilns may alternatively be regulated through the rate of feeding biomass into the kilns. Such kilns usually have some safety features and proper ventilation so to prevent accidents.

To implement this technology the ICRAF conducted training sessions for farmers on the proper preparation and application of biochar. The trainings were focused on the following aspects:
-The collection and drying process for agriculture and forest waste
-The management of operations for the biochar kiln including the loading of raw material (feedstock) into the kiln, its burning, operation-timing, period check, volumes of raw material to be fed etc.
-Precautions to be taken during the process
-The quality check of prepared biochar charcoal and the process for pulverizing it
-Dosage recommendations for different crops as per local conditions
-The mixing of biochar with cow dung and cow urine before application
-Integration with existing farming practices and the long-term benefits of biochar on soil health

Impact and Knowledge Transfer
The biochar acts as a soil conditioner, enhancing water retention, nutrient availability, and microbial activity. The benefits and impacts on improved fertility, increased water retention, and reduced nutrient leaching, lead to higher crop yields and resilience against climate variability, carbon sequestration aids in reducing greenhouse gas emissions, contributing to global efforts to combat climate change, and utilizing agricultural residues reduces air pollution from open burning and provides a sustainable solution for organic waste disposal. Land users appreciated the enhanced soil productivity and environmental benefits brought by biochar. Overall, the Sustainable Biochar Production Technology represents a promising approach in sustainable agriculture and environmental stewardship.

The project team, in collaboration with local agricultural extension services and the Indian Institute of Soil Science, monitored the impact of biochar application on soil health parameters. This involved regular soil testing, crop yield assessments and feedback from participating farmers. In fact, they also measured the impact of biochar made from different feedstock (raw materials). Success stories were shared with neighboring communities, public stakeholders and researchers and encouraged the further adoption of sustainable soil management practices.

The biochar production initiative in the Balangir District of Odisha in India demonstrates a sustainable approach to addressing soil health issues using locally available resources. Through the collaboration between ICRAF and GIZ, this project not only improves soil fertility but also empowers local communities by providing them with sustainable solutions for agricultural challenges. The success of this intervention serves as a model for future initiatives aimed at promoting environmentally friendly and community-driven approaches to agriculture.

Biochar ready for application to soil (World Agroforestry)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☑ improve production
☑ reduce, prevent, restore land degradation
☑ conserve ecosystem
☐ protect a watershed/ downstream areas – in combination with other Technologies
☑ preserve/ improve biodiversity
☐ reduce risk of disasters
☑ adapt to climate change/ extremes and its impacts
☐ mitigate climate change and its impacts
☑ create beneficial economic impact
☐ create beneficial social impact

Land use

Land use mixed within the same land unit: No

Cropland

- Annual cropping: cereals - millet, cereals - rice (upland)
- Tree and shrub cropping: fodder trees (Calliandra, Leucaena leucocephala, Prosopis, etc.), fruits, other

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Forest/ woodlands

- (Semi-)natural forests/ woodlands. Management: Dead wood/ prunings removal

Tree types (mixed deciduous/ evergreen): n.a.
Products and services: Timber, Fuelwood, Fruits and nuts, Grazing/ browsing

Settlements, infrastructure - Settlements, buildings

Water supply
☐ rainfed
☑ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation
☐ prevent land degradation
☑ reduce land degradation
☑ restore/ rehabilitate severely degraded land
☐ adapt to land degradation
☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

physical soil deterioration - Ps: subsidence of organic soils, settling of soil

biological degradation - Bl: loss of soil life

SLM group
- improved ground/ vegetation cover
- water harvesting
- waste management/ waste water management

SLM measures

agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A3: Soil surface treatment, A6: Residue management

vegetative measures - V4: Replacement or removal of alien/ invasive species, V5: Others

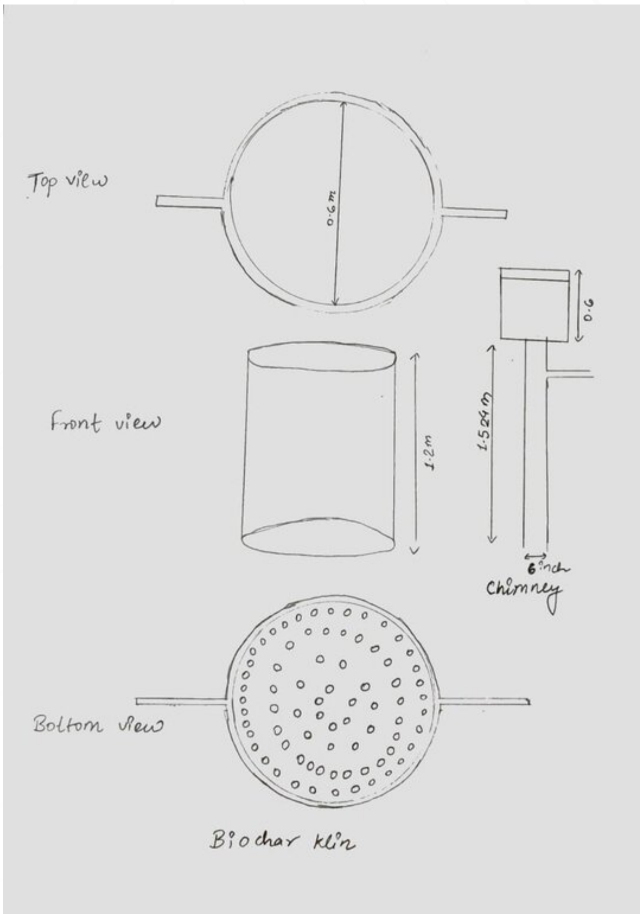
management measures - M6: Waste management (recycling, re-use or reduce)

other measures - Climate resilient soil management by application of biochar using varied feedstock (rwa material) generated through agroforestry

TECHNICAL DRAWING

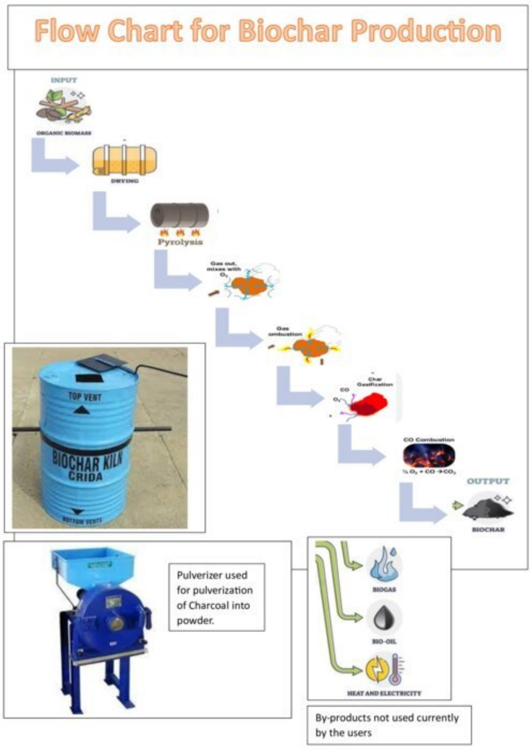
Technical specifications

The single barrel biochar klin was developed by the Indian Institute of Soil Sciences in Bhopal (IISS). The Kiln had already been designed and commercialised by the IISS. Land users can buy a metallic kiln unit from the IISS or get it fabricated from local fabricators based on the design specifications suggested in the drawing.



Author: Payal Dewangan

The flowchart provides a step by step guide for biochar production in the project area by land users



Author: Payal and Santosh

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **200 L capacity** volume, length: **Litre**)
- Currency used for cost calculation: **INR**
- Exchange rate (to USD): 1 USD = 80.0 INR
- Average wage cost of hired labour per day: 204 Rupees

Most important factors affecting the costs

The investment towards the purchase of the kiln- and the pulveriser unit. In the documented project, the investment costs were borne by the project. Therefore, smallholder farmers may find it difficult to purchase the hardware units of kiln and pulveriser, given such investment costs.

Establishment activities

1. Purchase of biochar kiln unit (Timing/ frequency: Can be done any time during the year but need to be ready before the month of September)
2. Purchase of pulveriser (Timing/ frequency: Need to be purchased once and before the start of biochar production)

Establishment inputs and costs (per 200 L capacity)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Equipment					
Biochar Klin	Rs.	1.0	7000.0	7000.0	
Pulvariser unit	Rs.	1.0	20000.0	20000.0	
Total costs for establishment of the Technology				**27'000.0**	
Total costs for establishment of the Technology in USD				*337.5*	

Maintenance activities

1. Collecting the crop residues and forest waste (Timing/ frequency: Needs to be collected and dried before the start of biochar production unit (September and June))
2. Preparation of Biochar (Timing/ frequency: Before the sowing of Rabi (winter) and Kharif (summer) seasons (Months of September/October and June/July))
3. Application of biochar in the field (Timing/ frequency: During the cropping season)

Maintenance inputs and costs (per 200 L capacity)

Specify input	Unit	Quantity	Costs per Unit (INR)	Total costs per input (INR)	% of costs borne by land users
Labour					
Preparation of biochar	Person-day	2.0	200.0	400.0	100.0
Application of biochar in the field	Person-day	1.0	200.0	200.0	100.0
Fertilizers and biocides					
Farmyard manure	Rs.	20.0	5.0	100.0	100.0

Fertilizer	Rs.	50.0	7.0	350.0	100.0
Total costs for maintenance of the Technology				**1'050.0**	
Total costs for maintenance of the Technology in USD				*13.13*	

NATURAL ENVIRONMENT

Average annual rainfall
☐ < 250 mm
☐ 251-500 mm
☐ 501-750 mm
☐ 751-1,000 mm
☑ 1,001-1,500 mm
☐ 1,501-2,000 mm
☐ 2,001-3,000 mm
☐ 3,001-4,000 mm
☐ > 4,000 mm

Agro-climatic zone
☐ humid
☑ sub-humid
☐ semi-arid
☐ arid

Specifications on climate
Average annual rainfall in mm: 1288.0
Name of the meteorological station: Bhubaneshwar, Odisha
The District is located under the West Central Table Land Agro Climatic Zone characterized by hot and sub-humid climate

Slope
☐ flat (0-2%)
☐ gentle (3-5%)
☑ moderate (6-10%)
☐ rolling (11-15%)
☑ hilly (16-30%)
☐ steep (31-60%)
☐ very steep (>60%)

Landforms
☑ plateau/plains
☐ ridges
☐ mountain slopes
☐ hill slopes
☐ footslopes
☑ valley floors

Altitude
☐ 0-100 m a.s.l.
☑ 101-500 m a.s.l.
☐ 501-1,000 m a.s.l.
☐ 1,001-1,500 m a.s.l.
☐ 1,501-2,000 m a.s.l.
☐ 2,001-2,500 m a.s.l.
☐ 2,501-3,000 m a.s.l.
☐ 3,001-4,000 m a.s.l.
☐ > 4,000 m a.s.l.

Technology is applied in
☐ convex situations
☐ concave situations
☑ not relevant

Soil depth
☐ very shallow (0-20 cm)
☑ shallow (21-50 cm)
☐ moderately deep (51-80 cm)
☐ deep (81-120 cm)
☐ very deep (> 120 cm)

Soil texture (topsoil)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
☑ coarse/ light (sandy)
☐ medium (loamy, silty)
☑ fine/ heavy (clay)

Topsoil organic matter content
☐ high (>3%)
☐ medium (1-3%)
☑ low (<1%)

Groundwater table
☐ on surface
☐ < 5 m
☑ 5-50 m
☐ > 50 m

Availability of surface water
☐ excess
☑ good
☐ medium
☐ poor/ none

Water quality (untreated)
☐ good drinking water
☑ poor drinking water (treatment required)
☐ for agricultural use only (irrigation)
☐ unusable
Water quality refers to: both ground and surface water

Is salinity a problem?
☑ Yes
☐ No

Occurrence of flooding
☐ Yes
☑ No

Species diversity
☑ high
☐ medium
☐ low

Habitat diversity
☑ high
☐ medium
☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
☑ subsistence (self-supply)
☐ mixed (subsistence/ commercial)
☐ commercial/ market

Off-farm income
☑ less than 10% of all income
☐ 10-50% of all income
☐ > 50% of all income

Relative level of wealth
☐ very poor
☑ poor
☐ average
☐ rich
☐ very rich

Level of mechanization
☑ manual work
☑ animal traction
☐ mechanized/ motorized

Sedentary or nomadic
☐ Sedentary
☐ Semi-nomadic
☐ Nomadic

Individuals or groups
☑ individual/ household
☑ groups/ community
☐ cooperative
☐ employee (company, government)

Gender
☑ women
☑ men

Age
☐ children
☑ youth
☑ middle-aged
☐ elderly

Area used per household
☑ < 0.5 ha
☐ 0.5-1 ha
☐ 1-2 ha
☐ 2-5 ha
☐ 5-15 ha
☐ 15-50 ha
☐ 50-100 ha
☐ 100-500 ha
☐ 500-1,000 ha
☐ 1,000-10,000 ha
☐ > 10,000 ha

Scale
☑ small-scale
☐ medium-scale
☐ large-scale

Land ownership
☐ state
☐ company
☐ communal/ village
☐ group
☐ individual, not titled
☑ individual, titled

Land use rights
☐ open access (unorganized)
☐ communal (organized)
☐ leased
☑ individual

Water use rights
☐ open access (unorganized)
☑ communal (organized)
☐ leased
☑ individual

Access to services and infrastructure

health	poor	✓			good
education	poor		✓		good
technical assistance	poor	✓			good
employment (e.g. off-farm)	poor	✓			good
markets	poor	✓			good
energy	poor		✓		good
roads and transport	poor	✓			good
drinking water and sanitation	poor	✓			good
financial services	poor	✓			good

Comments

The district is located in the interior parts of eastern India and considered as a backward district with poor access to infrastructure and other facilities

IMPACTS

Socio-economic impacts

Crop production

crop production	decreased						✓		increased	For Wood Biochar or Wood Coconut Husk Biochar (WCB), or Crop Residue Biochar (CRB) the highest grain yield of the crop was recorded with the highest dose of biochar, fertilizer, and manure application. Also, it's application significantly improved the straw yield
crop quality	decreased						✓		increased	The application of Wood Biochar or Wood Coconut Husk Biochar (WCB), or Crop Residue Biochar (CRB) with manure also significantly improved the quality of the crop
fodder production	decreased					✓			increased	It was found with significantly improved straw yield the availability of fodder for the livestock also increased
risk of production failure	increased					✓			decreased	It was observed that the crop in which the application of biochar was with the manure and fertilizer, the crop had better adaptation and standing properties in comparison to another crop without the application of biochar.
land management	hindered					✓			simplified	
farm income	decreased					✓			increased	The yield for the crop in which application was done was increased which led to an increase in income

Socio-cultural impacts

food security/ self-sufficiency	reduced					✓			improved

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)	reduced					✓			improved	Water retention from the soil increased because of the increase in soil organic matter and carbon content
surface runoff	increased					✓			decreased	The water holding capacity of the water increased leading to less surface runoff from the field.
evaporation	increased			✓					decreased	
soil moisture	decreased					✓			increased	With an increase in soil organic matter and improved soil texture the soil moisture increased
soil loss	increased			✓					decreased	The semi-arid climate and limited rainfall, combined with sporadic and intense monsoons, can lead to soil erosion. When rainfall does occur, it can cause rapid runoff, carrying away the topsoil due to the lack of vegetation cover or inadequate soil conservation measures.

nutrient cycling/ recharge	decreased ☐☐☐☐☐☑☐ increased	The application of biochar with manure and fertilizers not only increased the nutrients in the soil but also increased the nutrient uptake of plants from the soil.
salinity	increased ☐☐☐☑☐☐☐ decreased	Biochar can act as a soil amendment to moderate soil pH depending on the initial pH level. Scientifically, biochar tends to be pH neutral, so its impact on soil pH depends on the existing soil condition. The impact of biochar on pH is often gradual and depends on various factors like the type and composition of biochar, soil characteristics and environmental conditions. Biochar acts more as a buffer, stabilizing soil pH over time rather than making drastic immediate changes.
soil organic matter/ below ground C	decreased ☐☐☐☐☐☑☐ increased	
vegetation cover	decreased ☐☐☐☐☑☐☐ increased	The plant biomass as well as the vegetative growth of the plant showed a significant positive reaction to the biochar application on crops
biomass/ above ground C	decreased ☐☐☐☐☑☐☐ increased	
plant diversity	decreased ☐☐☐☐☑☐☐ increased	
pest/ disease control	decreased ☐☐☐☐☑☐☐ increased	Resistance of the crop increases with better uptake of K from the soil. Plants become more resistant to disease and pests.
emission of carbon and greenhouse gases	increased ☐☐☐☐☑☐☐ decreased	

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative ☐☐☐☐☐☑☐ very positive
Long-term returns	very negative ☐☐☐☐☐☐☑ very positive

Benefits compared with maintenance costs

Short-term returns	very negative ☐☐☐☐☐☐☑ very positive
Long-term returns	very negative ☐☐☐☐☐☐☑ very positive

The benefits of technology to soil health, crop productivity and crop quality is much higher than the cost of establishment and maintenance

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all ☐☐☑☐☐ very well	
seasonal temperature increase	not well at all ☐☐☑☐☐ very well	Season: summer
annual rainfall decrease	not well at all ☐☐☐☑☐ very well	
seasonal rainfall decrease	not well at all ☐☐☑☐☐ very well	Season: wet/ rainy season

Climate-related extremes (disasters)

drought	not well at all ☐☐☑☐☐ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

☑ single cases/ experimental
☐ 1-10%
☐ 11-50%
☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

☑ 0-10%
☐ 11-50%
☐ 51-90%
☐ 91-100%

Number of households and/ or area covered

100

Has the Technology been modified recently to adapt to changing conditions?

☑ Yes
☐ No

To which changing conditions?

☐ climatic change/ extremes
☐ changing markets
☑ labour availability (e.g. due to migration)

Refinements in pyrolysis methods and technologies to produce biochar with specific characteristics suited to diverse soil types and climate conditions. This includes adjusting temperature, duration, and feedstock to optimize biochar properties like porosity and water retention capacity. Innovations in application techniques to improve the efficiency and effectiveness of biochar incorporation into agricultural systems. This involves exploring precision application methods, such as localized placement or mixing with organic amendments, to ensure better distribution and utilization of biochar in the root zone. Emphasis on integrating biochar technology into climate-smart agricultural practices, focusing on sustainable intensification while adapting to changing climatic conditions. This involves promoting practices that enhance resilience to drought, water conservation and soil fertility improvement.

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- The soil moisture, soil texture, water retention and water-holding capacity of the soil increases. The uptake of nutrients increases which leads to less application of fertilizers in the field
- There was an increase in crop yield, straw yield, vegetative mass growth, more grains or fruits per plant, and fewer pests & disease attacks on the plants were noticed
- The better use of crop residue from the field increase the soil fertility and promoted better crop growth

Strengths: compiler’s or other key resource person’s view

- The use of biochar helps to combat the climate crisis by sequestering atmospheric carbon into soil as well as processing agricultural and other waste into useful clean energy
- The application of biochar significantly changes the soil’s properties (texture, porosity, bulk density, particle density, surface area, pore size distribution, cation exchange capacity, pH, and water-holding capacity) which, directly influence plant growth
- High porosity and a large surface area of biochar provide space for micro-organisms that are beneficial for the soil and help in binding important anions and cations, improving soil health and enhancing crop productivity
- Reduced nitrous oxide and methane emissions when biochar is applied to the soil

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Need large quantities of wood and crop residue for biochar production on a larger scale A better planning for crop residue management and access to communities to collect forest waste from forest can easily address this problem

  Exploring alternative biomass sources like agricultural residues, crop waste, or dedicated energy crops can reduce reliance on wood or coconut shells, promoting sustainable sourcing. Also, advancements in pyrolysis technologies to optimize biochar production from smaller quantities of biomass, improving efficiency and reducing the overall demand.
- Do not have knowledge about how this biochar can be sold in the market for additional income Creating more awareness among the farmers about biochar will create a market demand for it.

  Conducting market assessments and creating awareness among potential buyers about the benefits of biochar for soil improvement, carbon sequestration, and agricultural productivity. Exploring the development of value-added products or applications derived from biochar, such as soil amendments, filtration systems, or compost blends, to diversify market opportunities.

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- The availability of suitable wood and coconut for biochar production can be limited, and there may be competition between biochar production and other uses of biomass, such as food and fuel production The innovation in technology where biochar can be produced with lesser amount of feedstock will be a great solution
- If not managed sustainably, the production of biomass feedstock for biochar can lead to deforestation or the conversion of natural ecosystems into monoculture plantations, which can have negative ecological consequences The promotion of agro-forestry is important to ensure the availability of feed stock while also ensuring the increased coverage of forest.
  The training of land users and other stakeholders around sustainable biochar production.

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Compiler	Editors	Reviewer
Santosh Gupta	Kim Arora Stephanie Jaquet	Udo Höggel

Date of documentation: April 24, 2023

Last update: Nov. 26, 2023

Resource persons

Santosh Gupta - SLM specialist

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6735/
Video: https://player.vimeo.com/video/288

Linked SLM data

Approaches: Developing professional standards in the installation, maintenance and management of pump units
https://qcat.wocat.net/en/wocat/approaches/view/approaches_2515/

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- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) - Germany
- Ecociate Consultants (Ecociate Consultants) - India
- International Centre for Research in Agroforestry (ICRAF) - Kenya

Project

- Soil protection and rehabilitation for food security (ProSo(i)l)

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- Water Resources of Balangir District (Minor Irrigation Division, Balangir): https://balangir.nic.in/water-resources/
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