THEME:
NATURAL FOREST MANAGEMENT AND BIODIVERSITY

Title of the technology

Rehabilitation of degraded hills through afforestation and rainwater harvestings

A. Nature of technology

Restoration of degraded hills

B. Process in brief

Disturbances to the natural habitats through overgrazing, vegetation removal and mining is a common feature in most of the hilly dry areas throughout the world leading to the biological invasion and land degradation i.e., desertification. The Aravallis in north-western part of India is an ancient mountain and one of the oldest geological formations in the world and the home of many tribes. Mining activities, operation of stone crushers and pulverisers and removal of existing vegetation are disastrous causing environmental degradation in the region. Because of over-exploitation and over-grazing one can see barren hills devoid of vegetation throughout the Aravalli ranges. When put under protection from human or livestock interferences these disturbed habitat may take longer time to recover naturally. But the process of rehabilitation may be accelerated by afforestation and soil and water conservation. Such conservation measures including rainwater harvesting may provide a basis for environmental recovery by facilitating plant growth and vegetation cover because of improvement in infiltration rate, soil water and the availability of soil nutrients. The most effective method is to rehabilitated degraded hills are through integration of afforestation adopting rainwater harvesting and involving local people in the programme.

The study site covers hills of varying height with pediments near Gauapada villages in Banswara, Rajasthan (Fig. 1). The land is dry-subhumid with average annual rainfall 1050 mm from 1993 to 2010 with 53 numbers rain days. Seventy five plots were laid out in June, 2005 covering about 17 ha area in <10%, 10-20% and >20% slope categories. Five rainwater harvesting (RWH) structures including a control were contour trenches (CT), box trenches (BT), V-ditches (VD) and Gradonie ditches (GD). The RWH structures were 30 running meters length in each plot except in the control. The excavated soils of the RWH structures were heaped towards the down slope. Thirty five seedlings per plots (@ 500 plants ha^{-1}) of *Zizyphus mauritiana*, *Acacia catechu*, *Azadirachta indica*, *Emblica officinalis*, *Dendrocalamus strictus*, *Gmelina arborea*, *Holoptelia integrifolia* and *Syzigium cumini* were planted under mixed plantation in August, 2005. Concrete tanks of 1000 litres capacity were constructed to collect one twentieth of run-off water to measure water and nutrient losses. Soil water, nutrients, soil organic carbon, plant growth, diversity of regenerated tree/shrubs and herbaceous vegetation and biomass of trees/shrubs and herbage were recorded throughout the experimental period.

Relatively greater soil water availability in <10% slope resulted in greater survival and growth of the planted seedlings in lower slopes than in the higher slopes. Despite of low SWC better performance of *H. integrifolia* in 10-20% slope showed its preference to soil condition i.e., light soil. *A. catechu* performed best in <10% as well as >20% slope indicating its preference of clayey soil. Relatively better performance of *Acacia catechu* and *Z. mauritiana* in BT plots; *E. officinalis* and *H. integrifolia* in CT plots; and *A. indica* in VD plots indicated the suitability of these rainwater harvesting structures for the respective species. V-ditch and Box trench facilitated water distribution in upper soil layers for vegetation growth, whereas, contour trench facilitated water storage in deep soil profile that was utilized for the growth of tree seedlings.

Figure 1. Five year old plantation and increased water availability under rainwater harvesting and protection.

Fig. 2. Increased availability of fuel wood and fodder, which are collected by the villagers from the experimental area.

C. Beneficiaries of the technology

1. Prominent beneficiaries/user groups

State Forest departments of Rajasthan and Gujarat, Non-government organization working in the area, industries and the progressive farmers as well as the village panchayat of the nearby experimental site are the main beneficiaries/user groups.

2. No. of clients to whom technology has been transferred

This practice is a Rajasthan Forest Department led initiative by the Arid Forest Research Institute. State Forest Department of Rajasthan is linked directly in this technology development by funding as well as providing lands and human support thus state forest department is the main clients. Villagers are the main beneficiaries, who are getting benefits in terms of fuel wood and fodder collection through village forest protection committee. Officials of State Forest Department, Gujarat and other organizations like; Universities and ICAR organization have also been shown. This technology has been discussed at many forums such as workshop/conferences, meeting/ stakeholder meetings, public forum, etc.

3. Potential for further dissemination

Problem of land degradation is a common thoughout the world. There is need to increase the vegetative cover and to conserve the biodiversity in arid, semi arid and dry sub-humid regions of western India. Rainwater micro-catchments and their efficiency in soil water storage in different soil layers influenced growth of tree seedlings and grass production. These rainwater harvesting structures behaved differently in facilitating soil water and nutrient availability among the slope and thus can be replicated accordingly in rehabilitation of the degraded hills depending upon the need i.e., herbage and woody perennials. Soil characteristics was the most dominant factors influencing survival and growth indicated greater height and collar growth of *Acacia catechu* and height of *A. indica*, *E. officinalis* and *Z. mauritiana* in >20% slope (relatively heavy and well drain soil) than in 10-20% slope (shallow loamy sand soil). Both growth and MAI was lowest in the control plots. Among RWH treatments, gradonie structure was poor for plant growth. *Dendrocalamus strictus*, *Emblica officinalis*, *Zizyphus mauritiana*, *Holoptelia integrifolia* and *Syzygium cumini* were best suited to contour trench, *Acacia catechu* and *Azadirachta indica* were best suited to VD structure and *Gmelina arborea* was best suited to BT rainwater harvesting structures. Therefore, it has been proposed that this practice can be replicated at local level, sub national level, subregional and international level with some adaptation depending upon the requirement for fodder or fuel wood and the topographical conditions of the area. Forest department of Rajasthan has adopted this in many places, but it will be more appropriate to adopt it according to the efficiency of the structure for herbage yield/ plant biomass production.

Paper Published

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4. Singh, G., Choudhary, G.R., Ram, B. and Limba, N.K. (2011). Effects of rainwater harvesting on herbage diversity and productivity in degraded Aravalli hills in western India. *J. Forestry Research*, 22(3): 329-340.
5. Singh, G. (2011). Enhancing growth and biomass production of plantation and associated vegetation through rainwater harvesting in degraded hills in southern Rajasthan, India. *New Forests* (In press).
6. Singh, G., Limba, N.K., Baloach, C, Mishra, D. and Singh, K. (2011). Effects of rainwater harvesting on soil water and nutrients availability and growth of *Azadirachta indica* A. Juss in lower Aravalli of Rajasthan, India. *Archive of Agronomy and Soil Science*, (Submitted)
7. Singh, G. (2011). Carbon and nitrogen storage influenced by diversity and soil water relation in a plantation in degraded Aravalli hills in Rajasthan under varying rainfall years. *Journal of Climatic Change* (Submitted).

D. Economic significance

1. Potential to address livelihood issues and generate additional income

Rainwater harvesting, afforestation and protection measures improved soil water and nutrients, reduced the existing gradient in soil water and nutrients between the slopes, facilitated natural regeneration, diversity and productivity and overall sequestered carbon in biomass and soil. Presence of fine shallow truncated soil in 10-20% slope reduced infiltration and facilitated surface run-off to a larger extent in this slope. Water loss reduction was highest in V-ditch plots. The Contour trench and Box trench enhanced the soil water content in lower reaches and utilized by the plants with relatively deeper rooting system i.e., tree species.

2. Productivity enhancement and economic benefits over replaced technology

Adoption of improved water conservation and harvesting technologies contributes to increase in groundwater recharge, soil nutrients and biomass production and supports a higher number of plants, whereas afforestation under protection increases diversity and productivity and help restore these degraded hills along with the benefits of carbon sequestration. Gradonie and V-ditches enhance productivity of the grass/herbaceous layer productivity and the best was V-ditch. Rainwater enhanced the water availability up to February and utilised for domestic and livestock drinking. Grass production increased from 15000 pulia in 2005 to 36000 pullia (1 kg each) at 5 years in collective harvesting (Fig. 2). However, it was observed in January each year that about 10 persons were collecting fodder grass from the area each day i.e., 6750 kg of grass. After grass cutting in November about 15 persons with an average head load of 10-20 kg were used to collect fuel wood of *Lantana camera* and *Prosopis juliflora* up to June each year. Thus, this programme has benefited not only by restoring degraded hills by increased biological diversity, soil water and nutrient status and soil carbon storage but also enhanced the economy of the local people, who have now purchased milching animals due to increase fodder supply at place and now sending their children to school for education, who were engaged for collecting fodder and fuel wood from a longer distance earlier. Increased income through harvesting of fodder grasses (also from selling of grass), fuel wood and increased population of milk producing animals are some of the benefits related to development in livelihood status and human resource.

Benefits associated with this practice

Environmental	**Economic**	**Social**
Increase in production per unit area at the site as well as the adjoining agriculture area.	Increased landscape value and economic status.	Diversion to children in education.
Improvement in soil nutrient status and productivity.	Increased land value.	Improvement in social status.
Increase in diversity of flora and fauna.	Increased fodder and fuel wood supply at the nearest place and increase in population of milching animal.	Reduction in time of fodder and fuel wood collection Increase in social status.
Reduction in soil and water loss at site and increase in water availability.	Increased income due to increased land productivity Reduced silting in water storage dam/rivers.	Reduction in time in collecting/ utilizing water for animal drinking. Increased agriculture production.
Increased soil carbon stock by 26.97 tones ha^{-1} by 2010.	Increased land productivity and its value.	Reduced time in fuel wood collection by the villagers.
Increased vegetation cover.	Reduction in soil loss and increased productivity.	Increase in social status.

3. Impact of the Technology

Rainwater harvesting improved soil water and nutrients status, facilitated rock disintegration to form soil and enhance vegetation diversity from 39 to 92 number of species in a 5 year period. Contour trench and Box trench were best for enhancing soil waterplots. *Azadirachta indica* performed best in V-ditch areas, *E. officinalis*, *H. integrifolia* and *Z. mauritiana* performed better in contour trench and *A. catechu* in Box trench areas. This practice has enhanced the carbon stock by 26.97 tones ha^{-1} in 2010 than in 2005. Rainwater harvesting increased water availability at site up to February (as compared to December, earlier) for drinking of the livestock. Participation of local people was in the form of labour during implementation of this practice, whereas, the area was maintained and utilized by village committee to get benefits of fodder and fuel wood.

E. Developed by {Name of Scientist(s)/officers(s)}

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