Successful tree establishment and the revival of traditional agroforestry

The article highlights the strength of integrating farmer's involvement in identifying native species, establishment of plant nurseries in the vicinity, timeliness of operations and shared ownership in terms of protection measures. This is an effort of CAZRI in collaboration with local farming communities to revive traditional agro forestry systems in Rajasthan.

Arun K Sharma

Drought is a common phenomenon in Rajasthan and the north west of India. Known as the drylands, this whole region has a very high rainfall variability. More than 30 million hectares are defined as a hot arid zone. During thousands of years, the rural people living in this region have integrated woody perennials into their farming systems, thus evading or minimizing the adverse effects of the frequent droughts. According to the climatic, edaphic and socioeconomic characteristics of the different areas, various suitable drought-hardy and multiple-use tree and shrub species have been selected to grow in the crop fields, constituting extensive agroforestry systems.

The integration of arable crops with trees makes a unique combined protective-productive system that works on the principles of ecology, productivity, economics, and sustainability. These systems are now generally referred to as agroforestry. Because most trees are drought resistant, they are still able to provide fuel, fodder, fruit and other products when and if the crops fail. Thus, trees have a very important place in this region: not only are they directly related to the livelihood of its inhabitants, they also provide an important service of climate moderation in many forms in an otherwise inhospitable environment, supporting soil and water conservation, and even improving soil fertility.

As part of this system, woody components contribute in the form of fuelwood, fodder, minor timber, fruits, and many other edibles. As the production of arable crops in the hot arid zone is a gamble, if not impossible, trees guarantee the provision of many essential products and services when the rains fail. The patterns of integration of the principal native woody species with arable crops/grasses are shown in box.

These extensive agroforestry systems are biologically more complex than other forms of using land for arable farming or forestry. But the region is currently witnessing a very rapid rate of deforestation, and the overexploitation of the already sparse woody vegetation, largely as a result of the pressure exerted by the ever-increasing human and livestock populations. Agroforestry systems seem unable to fulfill the demands of this growing population. This state of affairs puts a question mark on the sustainability of these combined productive-protective systems. In spite of all these drawbacks, the important issues remain the same as in the past, the intricate and harmonious relationship between trees and people of the hot Indian arid zone.

Establishment and degradation of the traditional agroforestry system

As the establishment of trees is not an easy task in the arid zones due to water scarcity and poor soils, farmers developed a simple way of increasing the number of trees in their crop fields: they simply protect and look after the naturally germinated seedlings. This process has several advantages. The species require no additional water, are well adapted to the arid environment and serve many purposes later.

But during the last 4 or 5 decades, due to several reasons, this natural regeneration has not been encouraged nor in any way helped. As a result, the last years have seen fast decreasing tree densities in farm lands. Some of the reasons behind this negative phenomenon are that trees which grow in a haphazard manner in crop fields make it difficult for using tractors or other machinery. In similar ways, trees which grow in wastelands, permanent pastures and fallow lands are also diminishing in numbers, as the lands are increasingly used for growing crops. The intensification of land use seen during the last decades has been done at the cost of tree density. On the other hand, tree plantation programmes also have not been found very successful in this region because of different reasons: the scarcity of water, the preference given to

Trees as the keystone for arid zone life

It has been established that in the hot arid environment, trees play an important role in the amelioration of soil and microclimate. Investigations carried out to establish the positive and negative effects of tree cover on soils have clearly reflected that soils under tree crown cover are a little more acidic than soils without trees. Organic carbon content is also higher under the crown cover of (for example) Prosopis cineraria and Acacia nilotica, than in an open field situation. In general, total nitrogen content and available P2O5 decreases with increasing soil depth; however, these nutrients were maximum under the canopy of P. cineraria and A. nilotica, and minimum under the soils of agricultural fields devoid of trees. In a hot arid environment trees improve soil fertility by:

- increasing additions to the soils with nutrient input through nitrogen fixation, nutrient uptake from deep soil horizons, litter fall and closed nutrient cycling;
- reducing losses from the soils through runoff and soil erosion; and
- improving overall soil physical, chemical and biological conditions through complex interactions of the above processes.

Trees also play a vital role in climatic moderation, at least at the microclimate scale. During the peak summer period, air temperature under the canopy to Acacia tortilis declined by up to 2□C. Similarly, it has been established that during the monsoon period, the soil temperature just beneath tree cover can be up to 16□C lower in the top soil zone, and up to 5□C at a depth of 30 cm when compared with open field conditions. This indicates a better soil thermal regime.

non adapted species, or the little attention given to biotic interference.

Success with integration

As part of its regular activities, the Central Arid Zone Research Institute (CAZRI) has been trying to find out a feasible approach for optimizing tree density in this region, and thus promoting sustainable agroforestry systems. CAZRI is part of the Indian Centre for Agricultural Research. For more than six years (since 1999), part of its work has been taking place in the villages of Dunda and Kawas, in Barmer district, Rajasthan. The whole district is highly drought-prone and soils are sandy.

Work started by looking at the traditional agroforestry systems and the programme has been implemented in steps. A survey was done. Results helped define traditional techniques which were to be promoted, such as (i) the use of pond silt for fertility improvement, (ii) the use of leaves of *Calotropis procera* for termite control, and (iii) the selection and growth of native tree species for the best use of prevalent social setup and edapho-climatic conditions.

Three native species well adapted to ecological and social conditions, were selected for planting. These were *P. cineraria*, *T. undulata* and *A. senegal*. A fourth species was chosen: *C. mopane*, an exotic fodder shrub which has been tested for four decades in arid conditions. Uses of these species are traditionally known. Leaves of *P. cineraria*, for example, are used as fodder, and its pods as vegetables. *T. undulata* is used for timber wood, *Acacia senegal* for gum, fodder and fuelwood. As some of these species start economic production from the second year, farmers do not need to wait for a long time before seeing clearly the benefits of their efforts (even if a minimum of 10 to 15 years are required for soil and micro-climatic improvement).

Establishment of a farmer's nursery: All the seedlings required for the programme were grown at a local nursery, managed by one farmer. As expected, this arrangement showed many advantages over the common practice of transporting seedlings from other regions. Farmers of the area were given the choice to select the species they preferred, having an emotional attachment to each from the time the seed germinated. This helped a lot and acted as social fencing in nursery and after transplanting. More importantly, seedlings were grown in exactly the same conditions (soil, water, climate), and no transplanting injury occurred. And, farmers transplanted seedlings as rains occurred - considering the highly unexpected rainfall patterns, this helped a lot in tree establishment.

Profile modification: Soils in these districts are known to have very poor water holding capacities, as well as poor nutrient supply. Various combinations of locally available materials were tested in CAZRI's laboratories for enhancing soil properties. Of all, the one consisting of natural soil, pond silt (Nadi), Farm Yard Manure and sand was preferred and used, basically due to its cost effectiveness and to its inclusion of native biological flora. In fact, the relief work of the government during March-June, which included, desilting of ponds came in handy to this programme. The silt removed from these ponds were used for improving the soil profile. Thus, a well-synchronized activity which on one side increased water storage capacity of the ponds and on the other side improved the water-holding capacity of the plantation pits, was taken up. The improved water holding capacity and better nutrient supply due to profile modifications contributed for enhancing survival and growth of plants.

Rainwater harvesting: Water scarcity in the region necessitates rainwater harvesting for the survival and growth of plants. Five farmers' fields in each village were selected. Two water harvesting techniques i.e. microcatchment and ridge & furrow methods were tried out after necessary land shaping.

Plantation in rows: As mentioned, naturally regenerated trees grow haphazardly in the field and obstruct use of tractors. Since it is very difficult to convince farmers of not using tractors, farmers agreed to plant the seedlings at an optimum distance (20 x 10 m), in a way in which crop cultivation and mechanized field operations were not obstructed. Transplanting was done just after one good rain (saturated soil) preferably in drizzling condition to get maximum benefit of rainwater and minimize transplanting shock. Planting was done with about 50 trees per hectare, having approximately 10 plants of *P. cineraria*, 10 of *A. senegal*, 10 of *T. undulata* and 20 of *C.mopane*, and thus balancing the various benefits of each species. To protect these trees from stray cattle, each newly planted sapling was fenced with locally available thorny wood of *P. juliflora* plant.

Results

CAZRI's experience illustrates that successful tree establishment depends on integrated approach and timeliness of operations e.g. transplanting, protection etc. Results showed that moisture retention due to microcatchment was double as compared to without catchment. This contributed to better survival. Survival was even better in control conditions (52-66%) as compared to other plantation program (10-15%) mainly due to protection. Mean height was also almost double in the treatment of catchment as compared to control. Thus, overall high survival and growth shows the success of this integrated efforts and farmers participation in terms of regular maintenance and protection of plantation. It was also observed that at least 3-4 year care and protection is required for successful establishment of trees. The yield of various produce from these tree species and monetary returns had already been calculated in previous studies. Also, the environmental improvement with trees was studied. Therefore, it can be estimated that the proposed system will increase income from one hectare by Rs.10,000-12,000 with increase in system resilience to drought, the prime requirement for sustainable system in this region.

Farmers of the nearby areas have started making nursery and earning income by selling plants in the village. However, it is difficult to convince the forest department about this highly decentralized and effective way of tree establishment. May be, in due course of time, some policy measures may improve this condition.

■

Arun K Sharma,
Senior Scientist
Central Arid Zone Research Institute (CAZRI).
Jodhpur-342003, India.
E-mail: a.k_sharma@sify.com