ROLE OF AGRO-FORESTRY IN WATERSHED MANAGEMENT IN THE STATE OF JHARKHAND

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Abstract: Jharkhand consists of both plateau and sub-plateau region having problems of soil erosion, acidity, moisture deficiency and low availability of nutrients mainly phosphate besides erratic rainfall, poor water retention capacity and permeability of soil, which limit the agricultural production. Watershed Management (WSM) has emerged as a new paradigm for planning, development and management of land, water and biomass resources with main focus on social and institutional aspects apart from bio-physical aspects. Agro-forestry, the deliberate cultivation of trees or other woody plants with crops or pasture for multiple benefits, is an important category of planted forests that has the potential to provide farmers, communities, and society-at-large with a wide array of forest-related goods and services. Agro-forestry can complement efforts in WSM by providing a set of tree-based conservation and production practices for agricultural lands.

Keywords: Watershed management, soil & water conservation, sustainable development

Introduction

Jharkhand state's area is 79,714 km^2, which is 2.4 % of country's geographical area. Total population 26.91 million (2.6 % of country's population) of which the rural population 77.8 %, urban population 22.2 % with population density of 338 persons per square km. Tribal population constitutes 22.5 % of state population. It ranks 10^{th} among the state/union territory in respect of forest cover. Jharkhand state with average rainfall of 1372 mm per annum and undulating topography coupled with light texture soil suffers very much from excessive run-off causing soil and water conservation problem in the region. The quest to bring more areas under cultivation for more production and good economy has resulted into unsustainable land use, leading to land degradation and fall in its productivity. About 50% of the country's geographical area is afflicted with different forms of soil erosion and land degradation. In addition to loss of soil fertility, land degradation includes degradation of water resources, pasture resource degradation, etc. Recently, there has been a greater application of the inherent dangers involved in the current unsustainable cultural practices and more emphasis is being laid to alternative approaches, which are ecologically sustainable and socially acceptable. Integrated watershed management is one such approach, where agro-forestry plays a major role, as diversified system with ample scope of increasing vertical productivity of land.

A watershed is all the land and water area, which contributes runoff to a common point. In watershed approach, development is not confined just to agricultural lands alone but covers the area, starting from the highest point of the land to the outlet of the natural stream. Watershed management programme is conducted to (a) increase infiltration into soil, (b) control of damage by excess runoff and to (c) manage and utilize runoff for useful purpose. It has been established that the deterioration of natural resources, particularly soil and water, in an area can be contained and resources properly developed only by adopting a watershed approach, for overall development.

Production constraints of Jharkhand state:

Jharkhand state which consists of both plateau and sub-plateau region has production constraints viz., soil erosion & acidity, moisture deficiency and low availability of nutrients especially of phosphate are the most important production constraints of uplands. Erratic rainfall, lack of irrigation facilities, poor water retentive capacity and permeability of the soil are major problems limiting successful double-cropping. The low land which comprises about 40 % of the total cultivated area remains mono-cropped (under rice) due to their remaining wet, up to January or February.

Based on production constraints and measures to improve the productivity of land on sustainable basis promoting agro-forestry practices in watershed management programme of Jharkhand has ample scope. Therefore, an effort is being made to present the importance of watershed management through agro-forestry measures, which not only help in promoting soil and water conservation practices through different types of vegetative covers but also improves the vertical productivity of lands besides, environmental amelioration.

Agro-forestry: A Sustainable Management Option

Adoption of Agro-forestry practices will help in conservation of soil and water from land surface and will always add to the productivity of resource poor small and marginal farmers of the state. Agro-forestry is a collective name for land use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (agricultural crops, pastures, etc.) or livestock in a spatial arrangement, a rotation or both. Agro-forestry has both productive and service functions. Among the productive functions, the three 'Fs' (fuelwood, fodder and fruit) are the most important besides construction wood, gums, resins, medicines, fibres and a host of other economic base and greater food security. The service functions include shade, reduction in wind speed, control of erosion and maintenance and improvement of soil fertility. Agro-forestry is a medium and a combination of agricultural and forestry technologies to create integrated, diverse and productive land use systems (Garrett et al. 2000). While agroforests are typically less diverse than native forest, they do contain a significant number of plant and animal species. This diversity can, in time, provide ecological resilience and contribute to the maintenance of beneficial ecological functions (Vandermeer 2002). Similar to plantation forests, agroforests can help relieve some of the pressure to harvest native forests.

Contribution of Trees towards Improvement of Soil Water Regime

Trees contribute a lot towards maintenance and improvement of soil fertility (Lefroy et al. 1999, Nair et al. 1999). Table 1 gives the list of processes by which trees maintain or improve soil fertility.

Table 1: Processes by which Trees Maintain or Improve Soil Fertility

(a) Processes, which increase additions to the soil

- Maintenance of soil organic matter, through carbon fixation in photosynthesis and its transfer via decay of litter and roots
- Nitrogen fixation, by many leguminous and some non-leguminous trees
- Nutrient uptake: the taking up by tree roots of nutrients released by rock weathering
- Atmospheric inputs: the provision by trees of favorable conditions for inputs by rain and dust, including transmission by through fall and stream flow

- Increased water infiltration, through better soil physical properties and effects of roots
- Water retrieval: taking up of water from depth by tree root systems

(b) Processes, which reduce losses from the soil

- Protection from erosion and losses of organic matter and nutrients
- Reduction in the rate of organic matter decomposition, by shading and mulching
- Reduction of water loss from evapotranspiration, by shade and litter
- Increased water storage capacity, through better soil physical conditions

(c) Processes, which affect soil physical conditions

- Maintenance of soil properties through organic matter and effects of roots
- Penetration of compact or indurated layers by roots
- Modification of extremes of soil temperature, by shade and litter

(d) Processes, which affect soil chemical conditions

- Reduction of acidity, or rate of acidification, through bases in litter
- Reduction of salinity and sodicity, by trees in association with other management measures
- Reduction of soil toxicities caused by pollution

(e) Soil biological processes and effects

- Production of leaf litter of high quality, containing a balanced nutrient supply, and its transfer to the soil by litter decomposition
- Improvement in nitrogen mineralization through the effects of shade
- Increased availability of phosphorus through mycorrhizal associations
- Increased nodulation on roots of nitrogen-fixing trees in close proximity to roots of non-nitrogen-fixing plants, with possible direct transfer of nutrients between root systems

However, the greatest advantage of trees is in controlling soil erosion by checking the rate of soil runoff. The reduction in runoff is to a small degree, caused by canopy interception and direct transpiration but the greater part of it results from higher infiltration capacity under trees. It helps in improving recharge of ground water, besides perennial flow of stream and better moisture availability through micro-climatic interventions.

Table 2 gives the figures of average runoff and soil loss under different land uses.

Table 2: Average runoff and soil loss under different land uses (Young, 1989)

Treatment	Runoff (%)	Soil Loss (t/ha.)
Chrysopogon fulvus	12.7	8.65
Maize alone	27.5	28.27
Maize + *Leucaena*	21.4	17.83
Maize + Eucalyptus	20.8	13.51
Leucaena + grass	17.6	10.15
Leucaena alone	2.4	1.74

Eucalyptus + grass	6.3	3.52
Eucalyptus alone	2.1	1.20
Cultivated fallow	38.2	56.58

Agro-forestry practices suitable for Jharkhand

For many Agro-forestry situations, especially with areas of low economic productivity (output) valued product/ unit of resources input (e.g. yield/ha) is not a complete indicator of system performance. As important may be the fluctuation of this yield over time (stability), resistance of the system to perturbation and degrading in longer term (sustainability) and distribution of income or production amongst people in a community (equality) and degree of control they have over the performance of and function of the system (autonomy) are key considerations to **s**uccess. From these points of number of agro-forestry system useful for this region of Jharkhand, are being briefly described hereunder:

(A) Intercropping with multipurpose trees (MPT's):

In order to overcome the limitation of land and to attain self sufficiency, the farmers can resort to intercropping for increasing the efficiency of land use, both under limited soil moisture as well as under adequacy of resources. Inclusion of herbaceous pulse crop (grain or forage) in inter-row spaces of widely spaced MPT's or fruits in their complementary role offer great promise. They are divided into various subsystems as under:

(i) Boundary planting: This is a simple but effective practice particularly for small farmers. It consists of planting trees all along the boundaries between the fields and farm or along the margins of footpath, roads and canals. It is also called four-sided forestry with object of gaining production from trees, whilst having no adverse effect on adjacent crops and possibly a beneficial effect through fertilization by trees or their leaf litter, protection from wind or aiding soil conservation i.e. watershed protection.

(ii) Alley cropping: it is the practice of growing arable crops between hedge rows of shrubs and trees, which are periodically pruned to prevent shading of inter-crops, when there are no crops, the hedge rows are allowed to grow freely or cut to meet the fodder needs. MPT's like Subabul (*Leucaena latisiliqua*), Agast (*Sesbania grandiflora*), Siris (*Albizia lebbeck*) may be grown in this system, because they impart floribility to the system.

(iii) Random mix: Under this system ,woody and herbaceous components are randomly mixed but the plants occupy their respective ecological niches, thereby avoiding competition.

(B) Other systems

(i) Agri-Horti-Silvicultural system/Horti-pastoral system: This is the most common system met in Jharkhand. Growing legumes or other inter-crops (Shade tolerant-ginger and turmeric) in the inter space of fruit plantation has been a very old practice. In the Agri-Horti-Silvicultural system, arable crops are grown in inter-spaces till the trees (fruits or MPT's) develop canopy or bear fruit or there is reduction in the crop yields. Later this system can be converted in Horti-pastoral system by introducing suitable grasses like Dinanath grass (*Pennisetum pedicellatum*) or Napier grass (*Pennisetum purpureum*) or Anjan grass (*Cenchrus ciliaris*) etc.

(ii) Home gardens (Backyard planting/home stead garden) : This is most popular system of agro-forestry being adopted by nearly 80 % of small and marginal farmers of the state by tribal and non-tribal population. It is easier to implement and is most rewarding component of agro-forestry. The greatest problem of protection does not exist and is family based need oriented.

Conservation measures

Various types of soil and water conservation measures have been recommended depending on the soil, topography, climate, size of the land holding, etc. for Jharkhand which are described below:

1. Contour cultivation: Contour operations are done across the slope by cultivation of crops, trees on contour. The contour furrows created would form a multitude of mini barriers across the flow path of runoff. Contour cultivation remains the most effective on moderate slopes of 2-7%, besides in-situ conservation of moisture and water harvesting.

2. Contour bunding: This practice comprises of constructing narrow based bunds on contour to impound runoff water behind them, so that impounded water is absorbed gradually into the soil profile. The bunds should be constructed from the top of the catchment and preceded downwards.

3. Graded bunding: Graded bunds are constructed in relatively high rainfall areas. The excess water has to be removed out of the field to avoid water stagnation, especially in deep black soils. These bunds are outlets for safe removal of water. The channels of graded bunds are wide and shallow.

4. Bench terracing: Bench terracing involves converting the original ground into level step like fields constructed by half cutting and half filling, which reduces the degree of the slope. In hilly areas of Nilgiri hills, in North East hill areas of India and in Himachal Pradesh, this approach of bench terracing for agro-forestry models is gradually getting popular.

5. Contour Furrow: Contour furrow is also called as strip farming. The cropping is usually intermittent on strips or in rows with catchment area left fallow. The principle is to collect runoff from catchment area to improve soil moisture on the cropped area, particularly on sloppy land with undulating topography.

Conclusions

Taking into account the land features, climate and extent of forest areas with tribal dominated population of state, adoption of Agro-forestry measures to improve the productivity of watershed is a useful proposition for the Jharkhand state. It is quite appropriate due to availability of biodiversity, ample solar radiation and adequate rainfall, which will be useful in establishing agro-forests on watershed basis, for sustainable production and promoting livelihood opportunities for resource poor small and marginal farmers of the state. This will be also helpful in reducing the pressure on main forest land and will also improve the tree and forest cover of the state on both agricultural as well as wasteland, which are nearly equal to the forests area of the state and is still unexploited.

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