Reference Manual

Ecological Considerations

In

Programme Implementation

National Rural Employment Guarantee Programme

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Foundation for Ecological Security

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Dr. Geevan C.P was commissioned by Foundation for Ecological Security for the preparation of this Reference Manual on Ecological Considerations in the implementation of NREGA.

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Introduction

1.1 National Rural Employment Guarantee Act (NREGA)

The NREGA is a radical step that is expected to significantly reduce rural poverty and hunger. It guarantees one hundred days of employment at a certain minimum wage as a matter of right rather than as a great privilege. For those who live on the margin of subsistence, it makes dramatic difference by providing the right to live with dignity by seeking work through a due process. It also provides an opportunity to create useful assets and regenerate degraded ecological resources to enhance livelihood security. One of the best ways to obtain high returns from manual labour is to invest such efforts to increase the land productivity and improve ecological services, which in the long-term would enhance the livelihood and food security situation. Enhancing the natural resources is the critical element for promoting sustainable livelihoods in the poorly endowed arid/semi-arid regions. The field level experiences from arid/semi-arid tracts in the country reinforce the view that ecological restoration is the key to livelihood improvement in these regions. The NGO experience has shown that a landscape-level[1] planning approach – a pre-requisite to ensure ecological security – is not only desirable, but also necessary to promote sustainable livelihoods.

1.2 Why this Manual?

This manual is designed to provide an ecological perspective to the implementation of the programmes under the NREGA in order to

[1] The concepts of landscape ecology and landscape level approach are explained in this manual

achieve long-term livelihood sustainability. The ecological perspective is needed to work for the improvement of the natural resource base and for sustaining the ecological systems on which large number of people depend for their livelihoods. This manual hopes to provide sufficient operational guidelines for such an approach. This is *not* a manual covering all aspects of ecological restoration and confines the discussion to the scope of such work within the limits of NREG projects.

1.3 Focus on Arid/ Semi-Arid Tracts (Drylands)

Providing an ecological perspective to various kinds of development action is certainly much needed in all the diverse ecological contexts and eco-regions. However, the focus in this manual is on the major challenges in the arid/semi-arid tracts (SAT). These regions are also referred to as drylands or areas where agriculture is predominantly dependent on rains (rain-fed agriculture). The environmentally stressed drylands are a dominant feature of the peninsular India. Incidence of poverty and seasonal unemployment is also relatively high in these regions. These regions have tended to suffer from land and ecological degradation due to low per capita availability of natural resources. From the beginning various poverty alleviation programmes have been focussed on these regions (e.g., Integrated Watershed Development in Rainfed Areas, Drought Prone Area Development Programme and Desert Development Programme). The NREG, too, will be implemented in a large number of districts in these regions.

1.4 How to Use the Manual?

This manual is organised under four major parts:

A) Ecological Perspectives

B) Planning & Design Considerations
C) Field Guide
D) Appendices

Part A provides an overview of the ecological perspective in a simplified form. This part provides a glimpse into the larger context of ecological restoration and natural resource regeneration in dry regions. This is intended to orient the facilitating team and to come to terms with the ecological challenges in the arid/semi-arid tracts. It is not complete in itself and will require the facilitating group to think about the issues keeping in mind the local conditions and challenges. They will have to undertake a proper consultative process involving local communities and experts to relate the ideas presented here to the specific local context.

Part B provides the framework within which activities under NREG could be organised to help in the long-term improvement of the ecological resources and its management. Most of NREGP activities will be on areas that are not privately owned. Hence, the emphasis is naturally on activities that can be carried out on what are effectively common resources. It stresses the importance of a landscape approach and the need to harmonise the larger landscape level considerations as well as need-based approaches emerging from village or micro-level plans. Landscape approach does not imply either undermining of micro-plans or an overtly centralised approach. On the other hand, it emphasises the need for a participatory and decentralised process for the harmonising effort, which is central to ecological restoration and regeneration. The material is intended primarily for the facilitating group, which will have to play a decisive role in integrating micro and macro considerations into the NREG Programmes.

Part C is the meant for use at the field level for developing work plans. It provides an indication of the work elements. In practice, the actual work elements would vary to some degree based on the local conditions. Nevertheless, the material presented will help to properly disaggregate the tasks and to exercise adequate caution while allocating the different works.

Part D is the appendix containing important supplementary material, lists for reference, etc. For better readability some of the material related to the main sections is placed here, so that the reader is not distracted.

Part A: Ecological Perspectives

1 Importance of Regenerating Ecological Resources

The major weaknesses of many of the past poverty alleviation schemes have been the inadequate emphasis on creating community capabilities and durable assets that enhance the livelihood security and augment the natural resources. It is evident from the past experience that if the acute rural distress has to be mitigated, arrested or reversed, then there has to be greater emphasis on systematic and comprehensive rural area development focussing on the regeneration of the agro-ecological resources at different scales. The true 'durable' and productive assets are the renewable natural resources of the village. It is the degradation of the natural resources that has aggravated the rural poverty and jeopardized livelihood sustainability. The regeneration of natural resource base requires attention on resources such as land (all types of land – cultivated and un-cultivated), water resources, bio-resources (crops, orchards, grass, fodder, non-timber forest produce, fuel-wood, small timber, herbs, livestock, etc) and various common resources (pastures, tanks, rivulets, woodlots, etc).

It must also be noted that the degradation of the natural resources is most acute in the arid and semi-arid tracts of the country. To compound the problems of these environmentally stressed regions, inadequate attention has been paid to meeting the challenges of natural resource management in such regions. Given the relatively lower land productivity in these regions coupled with increased risks due to large rainfall variability, there is no doubt that livelihood security can be enhanced only if more attention is paid to the NRM

challenges. In other words, it makes great economic sense in the dry-land regions to invest the scarce poverty alleviation finances for improving the natural resources under any kind of Employment Guarantee Scheme (EGS) or workfare schemes.

2 Drylands

Low and erratic rainfall is the most conspicuous feature of the arid/semi-arid regions. The natural rainfall variability is very high: there is large year-to-year variation in the total annual rainfall and the distribution of the rain across regions within each year. The number of rainy days in a year tends to be few: from a couple of days to a few weeks, resulting in short growing period for plants.

Drylands are conventionally defined in terms of water stress and are represented by aridity index where the mean annual ratio of precipitation (P) to potential evapo-transpiration (PET = potential evaporation from soil plus transpiration by plants) is significantly less than one. A set of dryland subcategories (hyper-arid, arid, semi-arid, dry sub-humid) is distinguished on the basis of defined P/PET limits:

- The hyper-arid zone (arid index 0.03) comprises areas without vegetation, with the exception of a few scattered shrubs. Annual rainfall is low, rarely exceeding 100 millimetres. The rains are infrequent and irregular, sometimes with no rain during long periods of several years.
- The arid zone (arid index 0.03 - 0.20) comprise areas with sparse vegetation of annual and perennial grasses, herbaceous vegetation, and shrubs and small trees. There is high annual rainfall variability, ranging between 100 and 300 millimetres.

- The semi-arid zone (arid index 0.20 - 0.50) supports variety of plant species including grasses, shrubs and trees. Annual precipitation varies from 300 to 800 millimetres.
- Arid conditions also are found in the sub-humid zone (arid index 0.50 - 0.75).

Because of the short growing periods (1-74 and 75-119 growing days, respectively), these areas are not well suited for cultivation. Rainfall patterns are unpredictable and are subject to great fluctuations. The occurrence of drought is more frequent in the arid (lower rainfall) areas than in the semi-arid zones.

3 Ecological Issues of Drylands

Naturally sparse vegetation tends to be over-harvested and the over-exploitation of limited biomass resources is a major concern. In particular, pasturelands are often “over-grazed”. Natural resource management is a big challenge as window for regeneration is limited by the uncertainty in water and low soil nutrient availability.

Land degradation assumes a very serious proportion as the land parcels are generally of low productivity and are managed as “open access” resources. In fact, relatively large extent of land in the drylands is classified as “barren” or “uncultivable”. The continuous degradation of land and consequent “desertification” is a major challenge in the arid/semi-arid regions. In some areas, even of the privately owned land parcels are often acutely degraded due to poor management. The problems of soils are worsened by repeated neglect and poor management practices. Many of the flat areas within these regions have very low scope for watershed development and direct eco-restoration strategies are more appropriate.

Perennial rivers are few, seasonal (ephemeral) streams and rivers play an important role in maintaining water balance; but are mostly neglected as they do not carry water most of the year. Traditionally, they were better managed! Some of highly arid regions have true desert or desert like conditions with sand-dune formation and dust storms. Around human settlements some form of protection is needed to withstand the stresses arising from the harsh environment.

These regions, despite several constraints, harbour rich and rare plants and animals. Many of the plant and animal species, adapted to these resource poor and harsh environments, are highly endangered, calling for special efforts for their conservation. The invasion of the landscape by fast spreading plants that is not native to the region pose direct threat to the indigenous plants and animal species.

4 Ecological Services & Benefits

Every ecosystem provides what could be called “benefits or goods” and “services”. Ecosystem services can be defined as “… *the conditions and processes by which natural ecosystems and the species that make them up, sustain and fulfil human life*”. Ecosystem services are the transformation of a set of natural assets (soil, plants and animals, air and water) into things that we value. For example, when various micro-organisms and worms transform the raw plants into the fertile soil through process of decomposition, this transformation is an ecosystem service. In general, ecosystems services and benefits include:

- **Production of Goods:** Food, Medicines, fibre, timber, energy (biomass), industrial products like oils, dyes, rubber and genetic material for the production of other goods.
- **Regeneration Processes:** Detoxification and decomposition of wastes, renewal of soil fertility, purification of air and water, dispersal of seeds necessary for re-vegetation, pollination of crops and other native vegetation
- **Stabilizing Process:** Coastal and river channel stability, control of pest species, moderation of weather, climate stabilization, regulation of hydrological cycle (e.g. flood and salinity control), carbon sequestration
- **Life-fulfilling Functions:** Aesthetic beauty, spiritual inspirations, scientific discovery

Before making any intervention at landscape level, it is important to prepare an indicative list of major services of and benefit flows from different ecological systems. Such a list will help in prioritization of actions.

5 Soils

Soils are the biologically, chemically and physically active foundation of the environment upon which most of the ecosystem functions and structures depends. However, soil of areas under common use or are not managed by anyone (i.e., subject to open-access), mostly faces problems like erosion, compaction, heavy texture, poor organic matter and low diversity and small number of soil organisms. Therefore, soil health management is essential on such lands. In a broad sense, soil health can be defined as “the capacity of soil to function within ecosystem boundaries to sustain biological

productivity, maintain environmental quality, and promote plant and animal health".

> A single gram of soil (about 1/5 teaspoon) can contain over 100 million bacteria, 1 million filamentous bacteria (Actinomycetes) and 100,000 fungi. The weight of these organisms would only account for 0.05 percent of the weight of the soil. However, the exact proportions of each of these organisms will depend on soil conditions such as available moisture, aeration, organic matter levels and the type of plants present. Chemical conditions such as acidity and alkalinity greatly affect these organisms.

Additionally, soils are largest carbon reservoir of the terrestrial carbon cycle as soils contain about three times more carbon than vegetation and twice as much as that which is present in the atmosphere. Soil organic matter (SOM) is a key indicator of soil quality, both economically, by enhancing plant productivity, and environmentally, by sequestering carbon and enriching soil-biodiversity. The increase in SOM can improve: aggregation and the stability of soil structure; infiltration rate and water retention; and resistance to erosion. For long-term sequestration, carbon has to be delivered to large pools with slow turnover and dryland soils are potential sequestration medium. Most of the drylands soils are degraded and have lost significant amounts of carbon and other nutrients. Therefore, the potential for re-storing (sequestering) carbon through the rehabilitation of drylands is substantial.

6 Biodiversity

Biodiversity, in simple terms, is the "totality" of a range of different species, the different groupings with species, the genetic variation within each species and, the numerous habitats and ecosystems in which the living plants and animals exist. It is defined as "the full

variety of life and its processes at various integrated levels including genes, species and ecosystems". It forms a fundamental basis for the evolution of living forms. The conservation of biodiversity is important for the survival of all the living organisms and also human beings. In fact, the socio-economic differentiation and cultural diversity of human society is largely the product of biodiversity of the surrounding environment. Any loss in the biodiversity, i.e., of species (wild or domesticated), ecosystems or populations, therefore, affects the overall progress and quality of life of the human society.

7 Dryland Vegetation

Although vegetation cover in dryland areas is scarce, three general adaptive forms of plants can be identified. Three forms include:

(i) Ephemeral annuals appear after rains and complete their life cycle during a short season of nearly 8 weeks. (e.g., herbs and annual grasses)

(ii) Succulent perennials (able to accumulate and store water that may be consumed during periods of drought (e.g., Cactus)

(iii) Non-succulent perennials withstand the stress of the arid zone environment and comprise the majority of plants in drylands (e.g., perennial grasses, shrubs, and trees). While most of these plants are biologically dormant during the dry season (deciduous nature) there are a few plants (along water courses) which are biologically active throughout the year (evergreen nature)

Generally, arid lands support different vegetation types – scrub, thorn and savannas. It is generally observed that often many people,

including some decision makers, associated with developmental projects are unaware or have limited knowledge of the real nature of the many natural 'forest types' in drylands. This has resulted in the neglect of the conservation and management of the native forest systems of the arid/semi-arid regions.

8 Forestry

Forestry in the semi-arid/ arid tracts must be consistent with the ecological conditions. Some of the production forestry models, often promoted even in dry areas, are not appropriate to the ecological conditions. For the forests in arid/semi-arid to be sustainable, it is necessary to adopt models that could be called 'eco-forestry' rather than production forestry (see Table). These considerations apply to social forestry as well.

	Production Forestry	**Eco-Forestry**
1	Trees are seen as products	Forests are ecological communities
2	Short-term production goals	Long-term sustainability
3	Agricultural production model	Forest ecosystem model
4	Trees are the only cash crop	Diverse forest products and services
5	Trees' survival dependent on humans	Self-sustaining, self-maintaining, and self-renewing
6	Chemicals	No chemicals
7	Clearcuts	Harvesting surplus wood and selective removal
8	Same age stands of trees	All ages of trees
9	Monoculture of single or few species	Diverse species of trees
10	Simplified ecosystem	Natural biodiversity and complexity
11	Capital-intensive and corporate-based	Labour-intensive and locally based
12	Redesigning nature	Accepting nature's design
13	Life span: 60-100 years	Life span: millennia
14	Loss of the sacred	Sense of the sacred and mysterious
15	Older traditions, indigenous knowledge outdated	Older traditions and indigenous knowledge are sources of wisdom
Source: Drengson, A. and Taylor, D. (eds) 1997. Ecoforestry- The Art and Science of Sustainable Forest Use. New Society Publishers, Canada		

Key land related factors in order of importance to forestry plantations include:

- Water erosion
- Drainage and soil depth
- Degree of rockiness
- Soil fertility
- Wind erosion

9 Ethno-Botanical Considerations

Communities use indigenous knowledge (know-how and cultural practices) to manage or conserve different natural resources. Plants are one of the most widely used natural resources across societies and cultures. The local knowledge of plant resources can be integrated into the coping strategies. While documentation of traditional knowledge often have intrinsic merits, quite often they endanger the intellectual property of informants by putting the knowledge in the public domain, without any serious protection measures against their exploitation. Specifically, medicinal plant related traditional knowledge is highly prone to such risks. It is important, therefore, to get Prior Informed Consent[2] (PIC) from knowledge holders, essential for sharing or not sharing the information in public domain.

10 Invasive Species

Almost all the agro-ecological regions of the country, including arid and semi-arid tracts, face threats from invasions of alien plant species. Invasive plant species are those that establish numerical dominance outside their natural range and disrupting ecosystem structures and processes. Rarely are these changes beneficial. The

[2] The relevant documentation and consent forms can be obtained from the National Innovation Foundation (www.nifindia.org) – a national initiative to promote, reward and protect grassroots innovations.

impacts of exotic invasive species are immense and usually irreversible. Today, their control is one of the major natural resource management agenda. In majority of cases, however, the most effective method of control is by manual up-rooting.

11 Sacred Groves

Almost all parts of the country including the dry-lands have a long history of nature worship, and that practice continues today, especially through adoration of several sacred groves. These are dedicated to local deities or ancestral spirits and are protected by local communities through social traditions and taboos that incorporate spiritual and ecological values. Preserved over the course of many generations, sacred groves represent native vegetation in a natural or near-natural state and thus are rich in biodiversity and harbour many rare species of plants and animals. Due to weakening and disintegration of traditional value systems, many of these sacred groves are depleting.

12 Agro-Diversity

Farmers living in arid and semi-arid tracts have the propensity to conserve- conservation for the sustainable livelihood. There are ample documentations of farmer's potential to extract better livelihood by augmenting agro-diversity through continuous *in situ* innovations. In the present context, the term 'agro-diversity' embraces both the agro-biodiversity and the diversity in the methods and practices of cultivation under varied soil-rainfall regimes. Most of these practices also lie within the regime of traditional knowledge system. Important elements are land races, wild relatives of crops, indigenous crop varieties.

Part B: Planning & Design Considerations

1 Planning for Natural Resource Management

Planning for natural resource management is a multilevel task. It must be carried out keeping in view the larger socio-economic and environmental context. For example, water conservation and water harvesting activities at the village level need to be planned with reference to a network of micro-watersheds located within a larger watershed and the relevant river basin. Water harvesting structures like check dams planned at a village level in isolation may corner water at the cost of neighbouring villages and/or may be inconsistent with ecological conditions in the downstream areas. Also, an isolated structure here and another there is not likely to lead to systematic water harvesting or systematic watershed development. Similarly, drought proofing practices have to be promoted under a sound regional strategy. Sporadic forestry activities or creating water structures will not lead to drought proofing. The short-term ad hoc works under the NREG must be consistent with the geo-environmental and ecological characteristics of the larger landscape in which these individual activities would be undertaken.

There are many compelling reasons for an emphasis in the NREG on the village natural resource regeneration with the *panchayats* as the pivots for implementation. Such an approach involves proper identification of works in the short-run that will be part of a long-term plan for the regeneration of the natural resources. This translates into many short-term labour-intensive efforts that have the potential

of creating continuing avenues for employment or increase the labour demand locally in the long-term. Location specific activities can be identified where the unemployed can register for work under the NREG. It must be recognised that the village population is aware of the local resources and is endowed with considerable knowledge, skills and tools required to manage the resources.

The facilitating agencies could provide the much needed area planning inputs that takes into account the nature of the larger landscape and prepare a list of activities that could be undertaken through the NREG to regenerate the natural resources. The area plans and micro-plans for village development could be integrated into a landscape-based plan. This provides an opportunity for a more proactive role for the *Panchayati Raj* Institutions (PRI). These activities will also concurrently strengthen the PRI.

2 Operational Aspects

The deployment of NREG in operational terms to promote sustainable livelihoods and drought-induced vulnerabilities with a landscape-approach to ecological regeneration is outlined below:

1. Preparation of a landscape-level ecological restoration plan through participatory processes and application of local knowledge keeping in view the long-term drought-proofing needs
2. Developing village micro-plans as a well-thought out chain of activities that ensures that labour is deployed in different parts of the landscape so that inter-connected elements of the landscape and needs of the dependent communities are properly harmonized

3. Promoting the implementation of the work plans on the basis of village-clusters as required by the landscape-level plans
4. Facilitating the networking of various village clusters (e.g., federating user groups or NRM committees) in a landscape to strengthen the institutional capacities for mutual cooperation, coordination and benefit from economies of scale
5. Prioritization of the work elements by identifying activities that has the maximum potential for labour deployment and long-term benefits in terms of flows of bio-resources and ecological services
6. Detailing the work elements in such a way as to bring about a proper mix of soil and water conservation work in combination with improving the vegetation cover and biodiversity
7. Strengthening the institutional processes and systems of local governance
8. Infusing sound technical inputs for both supply-side optimization of various inputs as well as better end-uses of resources to improve the demand-side management for increasing the sustainable use of local resources
9. Facilitating coordination of different government line agencies to ensure best possible work plans over the entire landscape
10. Institutionalize technical support to the area-planning and resource base enhancement by promoting cluster-level Technical Support Teams consisting of experts from line departments, local experts, volunteer resource persons and different agencies – NGO and private-sector

3 Landscape and Cluster-Based Approach

Effective conservation and ecological restoration needs to be done on multiple scales such as land-parcel, village, landscape and region. Generally the restoration works are taken with elaborate village level planning exercise while the landscape level planning is ignored. Therefore, conservation and ecological restoration works need to follow the principle of “landscape level planning, patch level action”. Most of the NGOs also have better understanding of smaller units say village or cluster of village but may not always have a through understanding of the larger landscape level NRM issues.

The involvement of technically sound facilitating organisations in the NREG provides the opportunity to integrate larger landscape and ecological considerations into the village level activities so that the overall impact of the different village-level actions is much more than a simple sum of various un-coordinated village-level actions. The core capabilities of a facilitating organisation with considerable experience in working on NRM can be gainfully deployed to add value to the NREG and implement different activities as part of larger plan for landscape level integrated agro-ecological regeneration effort. Some of the initiatives in the acutely environmentally stressed regions have demonstrated how efforts in individual villages could be synchronised and synergised to achieve both economy of scale and holistic landscape level impacts. In operational terms, it is possible to harmonise village level efforts with landscape-level planning through cluster-based approaches and the networking of clusters.

This approach has significant merits such as:

a) It is able to harmonise landscape-level concerns with village-level efforts
b) It provides a ‘natural’ opportunity for federating or coordinating community-based organisations of different kinds to take advantage of the economies of scale and mutual support
c) Provide platform to reconcile competing claims between users from different parts of the landscape
d) Facilitate the strengthening and creation of durable institutional arrangements for community-based NRM to enhance livelihood security

The NREG commits resources over a long-time horizon, the chain of activities under it will be undertaken in a phased manner recognising that efforts in resource stressed arid/semi-arid tracts have typically long gestation periods. To ensure sustainability of livelihoods and natural resources the works undertaken must reckon with both micro and macro-level challenges. The design of activities has to be consistent with the characteristics and environmental vulnerabilities of the dryland areas. The activities outlined here will integrate village, cluster-level and landscape level approaches for natural resources enhancement. The enhanced natural resources of an arid/semi-arid landscape would lead to long-term ‘drought-proofing’ or reduce the drought-induced vulnerabilities of the dependent communities.

4 Major Steps

The major steps in the planning and design exercises are:

- Landscape Visualization
- Assessing Current Status
- Reconstructing the Ecological History
- Understanding Land Capability
- Examining Land Use, Ownership and Control
- Studying Land Cover Features
- Identifying Appropriate Ecological Technologies

This could be integrated into a cluster-based approach to community mobilization. Focussed Group Discussions and PRA could be used effectively – as a tool and on the intrinsic importance of the consultative/ learning process. The different steps outlined here interlock the socio-economic and ecological dimensions of resource management.

5 Landscape Visualization

The main purpose of the landscape visualization is to identify ecologically significant areas and their spatial linkages. Ecologically significant areas could be a wetland, grassland, patch of forest, sacred groves, saline tracts, sand-dunes, wildlife breeding areas, farm-lands etc. Reconnaissance survey along with extensive consultations with local communities, foresters, naturalists etc. can help in identifying such ecologically important areas within the landscape.

Geological, hydrologic and climate factors strongly influence ecological processes. In arid and semi-arid landscape the resources are concentrated in pockets creating mosaic of resource rich and poor patches. A landscape can be perceived as a mosaic of patches of different sizes, shapes, contiguity, structure and composition. Spatial arrangements of these patches and their connections (e.g. riparian corridor between two patches of forests) play important roles in the flow of various resources and ecological benefits across the patches.

Human activities can disrupt the structural integrity of landscapes and is expected to influence ecological processes across the landscape. It is important, therefore, to identify the land-use, land cover and management patterns over the landscape as well as the factors that alter them. It is very important to understand hydrological issues connected with the different parts of the landscape. At the stage of landscape visualisation, the issues of habitat fragmentation and wildlife corridors must also be examined. All such “ecologically important” sites must be identified on the landscape and the best options to address the issue must be discussed. This is necessary to ensure that some activity undertaken under NREG does not unknowingly either fragment an important habitat or disrupt an existing wildlife corridor.

Given the fact that pastures and agriculture are very important, the landscape visualisation exercise must try to understand how these components distributed over the landscape are inter-linked. The linkages could be due to natural processes or features (drainage, hydrologic, terrain features, etc) or through resource use by communities (use for grazing, extraction of biomass, land-use changes, etc). Landscape units of hydrologic significance (wetland, river courses, ponds, traditional irrigation canals, groundwater extraction, recharge potential, etc) must be noted. Consultations

must focus on the best options for harmonising the competing claims on inter-dependent resources distributed over the landscape.

6 Current Status

Making an assessment of the current status is a “critical” step in eco-restoration. The current status is for all practical purposes, the basis of making an action plan and leads to the problem statement. This effort must lead to a clear cut understanding of the immediate and root causes of degradation. Local knowledge of the situation is a crucial input to this analysis and must be sought with the same seriousness an “expert” advice is. This process – participatory and in-depth – will considerably enhance the understanding. A detailed problem-tree analysis could be undertaken with the help of both subject experts and local knowledge-holders. Prepare a note on the status through participatory analysis. Make sure that all the primary stakeholders are consulted during this process. This would also be an opportunity to look at traditional and/or local practices in sound natural resource management. The issues relating to competing claims on a resource between different villages in the landscape could also be included in the assessment.

7 Reconstructing the Ecological History

In order to manage a changing and thus fragile landscape like drylands, it is necessary to ascertain its direction and rate of changes. Especially, for better comprehension and effective planning, it is important to improve understanding of historical changes in the landscape during past 100-200 years. The history about the floral and faunal elements and important habitats and ecosystems can be traced out around the well known, landmark dates. The degradation of resources under grazing lands, water sources, agriculture fields etc. and invasion of many plant species

are some of the common issues which need to be understood in a historical time scale. Consult secondary literature, forest working plans, analyse old maps and aerial photographs (if available). Also discuss with village elders.

8 Land Capability

Before planning any eco-restoration, it is important to understand the capability of a given parcel of land. Each land parcel has some degree of limitation for a particular use. Between the extremes of very high and very low capability is a range of situations providing the possibility to make the land use succeed and to minimize the risk of land degradation. Land capability is the capacity of land to sustain a particular land use, as determined by those land qualities which influence its productive potential and specific management requirements.

Land capability defines the physical attributes of land, which are relevant to a particular use and is usually described by a class number, indicating the degree of physical limitations. Under the classification system used in India, land is divided into 8 capability classes I to VIII (see Appendix). These are divided into two suitability groups:

a) Suitable for cultivation (Class I to IV) and
b) Not suitable for cultivation (Class V to VIII)

Class I is the best, while Class VIII is incapable of supporting much biological productivity. Further on, land capability sub-classes are defined on the basis of erosion hazard, moisture regime, climate conditions and soil characteristics.

It is necessary to make a quick assessment of the different land capability classes that exist in the different villages that are in the landscape. This will help in the choice of eco-restoration and land management options. If land capability information is available with government or other agencies, such sources must be consulted. If any expert is available, assistance must be taken from them. Specifically, the issue of land, water and vegetation must be discussed with the experts. For example, this will help to avoid errors such as undertaking plantation activity with a mix of trees on a land unit that may not be appropriate.

9 Land Cover

The land-cover is what exactly occupies a given geographical location, e.g. the water body, grass land, agriculture, forest, etc. This is a technical category and is what one can see from air or how a satellite “sees” it. These categories are not determined by administrative limits and ownership pattern. A land parcel under one form of ownership or official “land-use” category may have more than one kind of land-cover pattern on it (e.g., a land classified in land-use category as agriculture may have agriculture and tree cover).

The actual land cover pattern depends on seasons and rainfall pattern. In arid/semi-arid regions large tracts of land (existing under different legal land-use categories) may appear as bare in satellite imageries taken during long dry periods. The same land will have completely different mosaic of land cover after a wet period. It is important that these are kept in mind when one examines data from satellite imageries. Very often, adequate care is not taken while explaining such data. The forests are reported under categories of dense, open, sparse etc in the interpretations of satellite imageries.

The data shown as forest do not necessarily coincide with land under the legal category of forest as per official records. Many areas covered by invasive trees may be shown as forest cover in satellite imageries, as the interpretation is only on the basis of the quantity of vegetation (vegetation density) registered in the satellite imagery data. The standard tree cover categories used in the imagery interpretation data distributed by national agencies such as the Forest Survey of India are very broad and do not take into account the peculiarities of natural low vegetation densities in arid/semi-arid tracts. This creates many difficulties in using the national data effectively in micro-planning and much care should be taken to re-check such data for local relevance. A rapid reality check is a must.

10 Land Use, Ownership & Control

The land-use (*not* land cover)[3] implies the purpose for which a particular land unit, usually defined in ownership or administrative terms, is used by human communities (e.g. used as a pasture, farm, conservation reserve, playground, etc). Similarly, a water body may be used as reservoir for supplying drinking water to nearby city or strictly used for irrigation or used as conservation reserves for migratory waterfowls. Essentially, a particular land cover type could be under different uses for various purposes and thus has different implications for planning and management. The Census operations and the Central Statistical Organisation uses nine administrative categories of land-use while reporting the land-use data. Some of the sub-categories under these differ to an extent from state to state. Given the importance of understanding the true nature of the administrative categories, their definition and related issues are given in the Appendix.

[3] It is important to understand clearly the two terms – land-use and land-cover frequently used in natural resource management and landscape level planning

The revenue department and the local authorities responsible for maintaining land records keeps registers showing the use category of each land unit under the “survey number” assigned to it. The fact that a certain land parcel (with a certain survey number) is under a particular category (say agriculture or forest) does not imply that in a given season there is agriculture or forest cover present on that land. Many of the village pastures (village common, grazing land, etc) – a legal category that ensures that a certain portion of each village is available as common land – may have been encroached upon and may not in real terms be available as common land.

In many states, there have been transfers of land from one legal category to another, with or without actual change in how communities use the land or what features are present on it. There have also been some changes in the definitions of sub-categories in certain states. One has to be careful while comparing old data with recent data. It is necessary to check if such changes have been made by authorities. The legal category under which a land unit falls, who the “legal owner” is and who effectively controls it are crucial to the design of interventions. Therefore, it is necessary to undertake a proper ‘mapping’ of the land ownership pattern and hierarchies of control over the land that is brought under eco-restoration or regeneration. Some of the land will be under overlapping jurisdictions with regard to the management rights. All this must be understood, i.e., mapped in terms of which category of land is used, controlled, managed and owned by whom.

11 Appropriate Technologies

Intrinsic to a development approach with an ecological perspective is an emphasis on the use of local materials, preference for labour-

based approaches that involves a combination of biological and mechanical elements where such “appropriate-technologies” provide a sound, cost-effective alternative to the conventional engineering solutions through the smart mix of traditional knowledge, modern science, technology and innovative use of bio-materials. There is a large basket of such eco-technologies, which also creates additional labour opportunities to fabricate many biomass-based materials needed for stabilizing soil, installing lasting soil erosion control measures, etc.

Currently many products based on a combination of natural bio-materials (fibre, wood, etc) and synthetic materials (plastics, nylon, etc) such as Turf Reinforcement Mat, Wood Excelsior Mat, Rolled Erosion Control Products, Compost Filter Tubes, etc are commercially available in countries like USA and are recommended in the approved Best Management Practices. The use of eco-technologies would empower communities by enhancing skills and reducing their dependence on professional agencies and special equipment. In short, the approach will minimize the use of conventional structural works and give greater stress to resource management based on local skills, traditional knowledge and locally available materials.

There are many proven cost-effective technologies based largely local biological resources that can significantly reduce total costs of many of the civil works such as construction of walls, roads, etc. These technologies are also able to increase the strength and durability of engineering works at a lower cost. It allows many costly components used in the conventional approaches to be substituted by locally available biomass-based materials such as small timber and fiber or low cost commercially available materials such as mats made from jute or coconut fiber.

Locally available small timber could be a good substitute in many of the civil works. Materials such as woven and non-woven fiber could be used to make highly durable village roads that will not require frequent repairs. Bamboo grids could be used to strengthen the bottom layer of the new roads. Such options will lead to significant reduction in the use of inputs such as steel rods, cement, and concrete. Some of these options could be successfully integrated to improve the earth works in watershed development as well.

These approaches reduce material costs and also provide opportunity to employ labor. As a spin-off those working on such projects will learn to adopt these cost effective technologies for their own use. In most cases, there will be significant increase in labour component as well in the use of local materials.

Ref: K.R.Datye (1997) Banking on Biomass

Part – C: Field Guide

1. Introduction

The ecological restoration will have major components that include different types of land parcels, river courses, forest (under forest department or outside), wetland and tank systems. The scope of work under NREG will be primarily on the common land and water resources.

The labour would be deployed based on a landscape-based area plan that recognises the environmental specificities of arid/semi-arid regions. Essentially, this falls under the following major categories:

- Ecological restoration/ regeneration in particular vegetation cover management covering all kinds of ecosystems to conserve and enhance the natural resource base
- Soil and water conservation covering various measures on village and public land to counter land degradation and improve the land resources
- Watershed and water resources development to enhance the water availability from local sources
- Wildlife and biodiversity conservation as an integral part of rural development action
- Developing infrastructure support to a limited extent

In the sections that follow, a concise description of the field-level plan for each major intervention is provided. Supplementary material can be found in the Appendix. It must be clearly understood that the work plan given here are indicative and depending on the local

conditions, the ratio of material inputs and labour may change, even significantly in some situations.

2. Schedule of Rates

The works under NREG require a properly authenticated or approved Schedule of Rates (SOR) that will form the basis of paying wages. There are approved standard SOR for most of the earth and civil works. However, there may be difficulties with some of SOR applicable for eco-restoration activities. These issues are briefly discussed in the Appendix.

3. Caution!

All the arid/semi-arid regions have large numbers of free-grazing livestock. The livestock migrate from on region to other in search of better pastures. It is absolutely necessary to protect the eco-restoration sites from free-grazing during the period in which the vegetation is being established. Proper fodder management options must be considered in the initial period to provide alternate fodder to livestock dependent on the site. Subsequently, in the interim phase, before the vegetative cover gets established, some form of controlled removal or rotational grazing could be considered. The issue of free roaming goat and sheep must be addressed. It is necessary to address these issues as an integral part of the restoration work taking into confidence the local communities.

1 Grassland/ Pastureland Development

1.1 Description

In simple terms, grasslands can be defined as “land on which the vegetation is dominated by grasses (members of the family Gramineae excluding bamboo) or grass-like plants with few woody plants. Natural grassland ecosystems are characterised with: periodic droughts, fire, grazing by large herbivores and often low fertility soils.

In arid and semi-arid landscape, grasslands (or pasturelands) are the most appropriate land-use as they can withstand inter- and intra-annual rainfall variations. Livestock rearing, especially, the migratory pastoralism, is one of the most widely adopted occupations in such landscape. In rural settings, most of these pasturelands are managed as common property resource and shows declining trends both in extent and quality. However, in certain parts of such tracts, there are large extents of pasturelands that support rich floral and faunal species diversity, including many globally threatened ones and thus need serious conservation related interventions. Pasturelands exist within a continuum of good grass cover with high conservation values to those subjected to heavy human pressure and found in highly degraded conditions. Large tracts are also covered by saline grasslands. At the landscape level planning, different types of grasslands need to be distinguished to prioritise the restoration objectives and activities.

1.2 Ecological-Economic Consideration

- Groundwater recharge
- Soil binding and reduction of soil erosion

- Corridors between two isolated habitat patches
- Habitat for many rare and endangered plant and animal species and thus biodiversity conservation
- Livestock grazing for both resident and migratory pastoralists

1.3 Design Considerations

- Work according to macro (landscape or cluster level) and micro (village level) plan
- Better to develop savannah like conditions (i.e. grasses mixed with scattered shrubs and trees)
- Site selection: (a) use of village history/local knowledge through consultations (b) traditional grazing areas that are also part of pastoral migration route; (c) soil quality & topography
- Interventions and activities need to restrict before the monsoon to provide maximum length of growing period for plants and also for safer breeding and nesting areas for many wildlife species during the monsoon season
- Use of knowledge of local pastoralist groups in selection of grass & legume species
- Use of mixture of local seeds of grass, legumes and trees to increase the diversity in the fodder (See Box)
- Special focus on grassland that have high Biodiversity Conservation values (e.g. record of globally rare species; large extent; contiguity (juxtaposed) with other conservation important sites like wetland or forest)
- Rate of seeding varies according to site quality. For example, the areas with poor grass cover need heavy seeding.

However, the better sites (i.e. already have good grass cover and thus good seed bank) need limited seeding.

- Preserve all the native plants of shrubs and trees already growing in the restoration site
- Removal of weed and other invasive plants with limited disturbances to the soil. Removed biomass can be used as mulching materials to improve organic matter in the restored land

Collection of Native Grass Seeds

- Commercially, only a few species of grass seeds are available. Therefore, seeds of many of the native grass species need to be collected from local wild tracts.
- All wild growing grasses are not the native ones. Therefore, it is essential to identify native grass species of the locality through botanical publications and consultations with community members.
- Since identification of grasses is difficult, prepare a field herbarium of correctly identified, pressed and dried specimens.
- Often, healthy native grass seeds collected from wild stands may not germinate rapidly and also at the same time (an adaptation against the rainfall variability). Therefore, using native grass seeds in re-vegetation need great patience for results to come.
- Unlike, many other plants, more than often seeds are not easy to find in native grasses. Most native grass seeds are adapted for natural dispersal by wind, water and animals and have hairy structures. The structures attached to the seed are often left intact for use in re-vegetation,
- Care should be taken that seed is not over-collected from any particular patch (population). Seeds of different species should collect and preserved in separate bags/containers. Also, make sure that collected seed is as weed-free as possible.
- Once established, allow plants to set seed in the first year to start the development of a soil seed bank.

1.4 Work Plan & Labour

Activity	Sub-Tasks	Material	Labour
Seed bed preparation for better seed germination and to reduce competitions from unwanted plants	Removal of weed/ invasive species	10	90
	Burning of dry grass	10	90
	Tilling/Ploughing	10	90
	Manuring/ Fertilization	40	60
Seeding practice for better cover, higher productivity and maintain diversity	Collection of local grass seeds	0	100
	Collection of local legume seeds	0	100
	Pellet making	10	90
	Seed sowing	0	100
	Plantation of trees/shrubs	20	80
SMC works to increase effective growth period	Farm bunds	10	90
	Contour bunds	10	90
	Staggered trench	10	90
Protection from livestock grazing	Stone wall fencing	20	80
	Cattle proof trench	0	100
	Live fencing	10	90
	Barbed-wire fencing	40	60
	Patrolling	0	100
Maintenance	Weed removal	0	100
	Pruning of tree/shrubs	0	100
	Protection Fence repair	20	80

2 Afforestation

2.1 Description:

In simple terms afforestation means “the establishment of a forest, stand or tree crop on an area not previously forested, or on land from which forest cover has very long been absent. Effectively, it is to increase woody vegetation cover by creating new or restoring existing vegetation patches. In general the goal of afforestation work may be either for ecological restoration/conservation purpose or for production purpose which include both economical and social gains.

Following major afforestation works relevant for arid and semi-arid tracts can be undertaken:

- Social forestry to meet various biomass (fodder and fuelwood) demands of people
- Agro-Forestry (not included under NREG)
- Regeneration of degraded forests for ecological stability
- Sand dune stabilization
- Windbreaks and Shelterbelt creation

In the arid and semi-arid lands it is often found that in natural conditions plants grow widely apart to avoid competitions for soil moisture and nutrients. The same principle needs to apply for spacing of plantings in arid/ semi-arid areas. However, actual spacing varies with species, site, and the purpose of the plantation.

Three major aspects of plantation that depends on the site, the purpose and forestry model include:

- The **scale** (or size) at which the tree planting is to be done. Considering the resource patchiness in drylands, it is always better to plant smaller areas
- The **arrangement** of the trees to be planted (single block, small groups scattered over the landscape, lines or strip, etc.)
- How **far apart** the individual trees are planted

Sand-Dune stabilization

In some of the very low-rainfall areas, sand dunes are commonly found, particularly near human habitations. Sand dune stabilization involves using structural controls and native vegetation. It is important to remember that dunes are unique ecosystems. While stabilizing a dune, every effort should be made to protect the integrity of the natural dune ecology, which also supports some biodiversity.

Vegetative establishment can be done by planting grasses, trees and shrubs. Plant species can be selected based on surface and soil type (e.g. loamy sand, shifting sand etc.). Suitable grass species should be planted first to provide much needed stability and organic matter for other species to follow. Shrubs and small trees should follow. Important Species which have proved successful in sand dune stabilization are given in Appendix.

Shelterbelt/Windbreak

Windbreaks or shelterbelts are the barriers of trees or shrubs that are planted to reduce wind velocities and, as a result, reduce evapo-transpiration and prevent wind erosion. Shelterbelts along the boundaries of crop fields help to reduce injuries to the tender seedlings from sand blasting and hot desiccating winds. Therefore, while they provide shelter to livestock, grazing lands and farms, agricultural crops also get benefits, resulting in higher yields. By choosing appropriate tree and shrub species, we can combine the benefits of sheltering effect and also the biomass need.

It is generally accepted that a windbreak or shelterbelt protects an area over a distance up to its own height on the windward side and up to 20 times its height on the leeward side. In reducing wind speeds, several rows of trees are more effective. Gaps in the plantation need to be immediately replanted.

Agro & Social Forestry

Agro-forestry, also called as farm-forestry, is a collective name for land-use systems in which woody plants like trees and shrubs are grown in association with crops in a spatial arrangement, and in which there are ecological and economic interactions between the woody and crop components of the systems. Agro-forestry is seen as a means of:

- Providing an alternative source of timber and fuel needs and thus protecting forests.
- Providing stable income to the farmers.
- Enhancing environmental values of the region

- Enhancing the productivity of agriculture

In addition to above, agroforestry operations offer many ecosystem services including the sequestration of carbon, maintenance of hydrological balances that prevent dryland salinity, and the purification of water. Agroforestry also potentially complements the conservation of biodiversity if native trees and shrub species are used.

Regeneration of Degraded Forests

The term forest degradation refers to the reduction of the capacity of a forest to produce goods and services. A degraded forest delivers a reduced supply of goods and services from a given site and maintains only limited biological diversity. It has lost the structure, function, species composition and/or productivity normally associated with the natural forests expected at that site.

2.2 Ecological-Economic Consideration

The ecological and economic considerations that go into NREG planning are:

- Landscape improvement
- Hydrological regime
- Selection of leguminous plant species
- Soil quality improvement
- Wind break, soil erosion control
- Biodiversity and wildlife
- Stabilizing micro-climate

- Carbon sequestration
- NTFP (including fruits, gums, fibre, medicines etc.), fuel-wood, fodder, timber, etc

2.3 Design Considerations

The design considerations include the following:

- Prefer native species and collecting seeds is an important part of the forestry activity. A systematic approach must be followed for seed collection and preservation (see Box)
- Wherever possible create structurally diverse patches of vegetation (vertical foliage layers) by maintaining appropriate over storey (small or large trees) and under-storey (shrub) plants.
- Do plantations in phased wise manner so that create multi-age stand
- Select multi-purpose species and maintain stem density based on land capability
- Create vegetation patches at appropriate location so that to reduce isolation of existing vegetation patches; maintain and create linear vegetation corridor of appropriate width (e.g. ~25 metre)
- Acquisition of mature plant material to use in combination with early successional species (pioneer species) plantings or seeding
- Weed/invasive species; fire; grazing; cutting, re-plantation (i.e. gap filling)

Seed Collection of Woody Native Plants

If seeds are not properly collected and stored, their germinability declined drastically. So following precautions need to adopt:

- Collect seeds as far as possible locally from natural populations. It helps in conserving the genetic diversity
- Collect from the fruits that are fully mature.
- Leave sufficient seeds on the plants for their natural dispersal
- Avoid collection of seeds from the small, isolated patches (population) as they may have poor genetic diversity due to self-pollination (or inbreeding)
- Properly clean and dry the seeds. The drying can be under direct sun or in the shade with free air circulation
- Avoid damage to the seeds
- Storage seeds of different species separately in air-tight containers
- Storage at constant temperature
- Maintain proper records
- For storage purpose, one can use indigenous methods of seed preservation (e.g. earthen 'Kothi')
- Use local plant materials (e.g. Neem leaves) for pest control

2.4 Work Plan & Labour

Activity	Sub-Tasks	Material	Labour
Nursery Development	Clearing of weeds and unwanted species from selected site.	0	100
	Fencing of site	30	70
	Bed preparation (including the filling of soil in polythene bags, seeding etc.)	20	80
	Watering	20	80
Plantation Site Preparation	Removal of weeds and other unwanted vegetation	0	100
Plantation	Collection and storage of seeds of native plant species	10	90
	Pits making for plantation	0	100
	Watering	20	80
	Manuring	40	60
Protection	Cattle Proof Trench	0	100
	Stone wall fencing	20	80
	Patrolling	0	100
Maintenance	Weed Removal	0	100
	Repair of protective fences	20	80
	Pruning of plants	0	100

3 Wetland Revival

3.1 Description

Wetland is one of the major life support systems and is of considerable ecological significance in the arid/ semi-arid regions. In the arid/semi-arid landscapes, the wetland systems assume special significance given the general water scarcity. Generally, wetlands are areas where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Swamps, marshes, and bogs are well-recognized types of wetlands. However, many important specific wetland types have drier or more variable water systems than are generally known. The amount of water present in wetlands fluctuates as a result of rainfall patterns, dry seasons and droughts. The lack of awareness of the significance of these systems has lead to their destruction or degradation. The disruption of wetland functions due to the lack of appropriate management has a high cost – economically, socially and ecologically. Restoration and revival of these systems is an important task that needs to be addressed.

3.2 Ecological-Economic Considerations

- Mostly seasonal due to high evaporation loss of water
- Refuge for many animals and plants
- Help to recharge aquifers

- Help trap nutrients that are carried away by run-off during high intensity rain events
- Help to maintain vegetation
- Help in the management of storm water and to improve water quality
- Direct economic benefits such as fisheries, drawdown agriculture and aquatic plants used for making mats, baskets, etc
- Act as exporters of organic materials and sinks for inorganic matter
- Very productive in terms of biomass
- Habitat to a variety of microbial and plant species due to presence of water

3.3 Design Consideration

The wetlands being a very important ecosystem embedded in an arid/semi-arid landscape, it is important to recognise their full significance. It must be understood that wetlands – small or large – is an important landscape element and must be included in the landscape-level planning. Therefore, wetland, if and when, they are present in an arid/semi-arid landscape is a priority landscape element.

- Ensure that the wetland is not being used as a waste dump
- Ensure that pathways for water inflows are not getting blocked
- Ensure water is not drained out for irrigation
- Inspection before and after each wet season is required.
- Maintain a checklist of plants and animals present in the wetland
- Maintain records of the trees used by birds for nesting and roosting
- Undertake activities on wetlands only during the dry period and do not disturb it during the wet period

- Consult biodiversity experts who are familiar with the wetland before planning any restoration work

3.4 Work Plan & Labour

Part A Work Plan/ Implementation/ Labour & Materials

Activity	Sub-Tasks	Material	Labour
Ensuring water supply to the wetland	Repair drainage paths	5	95
	Revive (deepen/ de-silt) rivulets	5	95
	Repair breaches	10	90
	Repair damage to wetland banks	10	90
Management of undesirable species	Remove from within the wetland (i.e., aquatic weeds)	0	100
	Control weed infestation around the wetland	0	100
Restore the wetland habitat to its natural state	Remove accumulated organic material if there is over accumulation of such wastes	0	100
	De-silting and maintenance of the wetland	0	100
	Remove rubble & debris dumped in the wetland	0	100
Restoring vegetation on the fringes	Plant trees for roosting, nesting and to act as heronry	10	90
	Plant grasses and shrubs to strengthen the banks/ edges	5	90
SMC works in the surrounding areas	Check soil erosion, if any, that is bringing large quantities of soil into the wetland	30	70
	Plant grasses, sedges, shrubs in the fringes of the wetland (vegetated buffers)	5	95

- Remember that de-silting of a wetland is to restore it to its natural state and ***not*** to maximise water storage
- Understand the local use of the wetland resources
- Undertake detailed stakeholder analysis as there are multiple uses of most wetlands
- Do not make any drastic alterations in the wetland hydrology
- Do not deepen beyond its known “natural depth” and do not significantly alter the known depth profile

4 Riverine & Traditional Irrigation Systems

4.1 Description

A riparian area is an ecosystem situated between aquatic and upland environments that are periodically influenced by flooding. Riparian zones often have a rich diversity of plant species and several vegetative layers. The riverine/ riparian areas are important for the sustaining the productivity of the pastures, forests and cropland associated with the river courses. The neglect of these systems has lead to productivity losses and ecological changes. These changes, in most cases, threaten the livelihood security, particularly of the poorest. The restoration and revival of these systems will help to in enhancing the livelihoods of the poorest. The riparian areas are also important habitats for wildlife and for the sustaining of riverine wetlands that is also a refuge for many wetland birds. In arid/semi-arid landscapes, these habitats have very important place in biodiversity conservation.

4.2 Ecological-Economic Consideration

Healthy riparian areas are critically important ecological zones. They provide:

- Water quality protection
- Water capture and storage
- Flood control
- Stabilization of water flow in streams and rivers
- Habitat for aquatic and terrestrial wildlife
- Critical migratory pathway for many fish species
- Aesthetic and recreational benefits

4.3 Design Considerations

- Collect hydrological information to understand water inflow and outflow from the riparian area
- Determine where the different species occur in relationship to the stream channel and water table
- Use this as a biological benchmark for the restoration plan
- Consider wildlife presence and habitat needs; factor that into the restoration plan
- Consider tree/ shrub cover and the local needs; factor this in the plan
- Work out institutional mechanisms to prevent degradation of the restored riverine systems (drainage, habitats)
- Ensure that pathways for water inflows are not getting blocked
- Ensure drainage systems are not altered for private interests
- Inspection before and after each wet season is required to check the following:
    - Silting and/or blocking of waterways/ drainage pathways
    - Breaches
    - Failure of banks
    - Loss of vegetation
- Maintain a checklist of plants and animals present in riparian area
- Maintain records of the trees used by birds for nesting and roosting
- Undertake activities only during the dry period and do not disturb it during the wet period

- Ensure canopy continuity through bank plantation
- Consult biodiversity experts before any restoration work
- Do not make any drastic alterations in the drainage systems

4.4 Work Plan & Labours

Activity	Sub-Tasks	Material	Labour
Vegetation regeneration along river/ rivulet banks	Grasses, sedges, shrubs, create (i.e., vegetated buffers)	10	90
Vegetation cover restoration in the catchments	Planting native grasses, shrubs and trees	10	90
Stream bank stabilization	Plant grasses and shrubs to strengthen the banks/ edges	10	90
	Earth work	20	80
Restoration/ revival of drainage/ streams	Repair drainage paths (earthwork & engineering)	20	80
	De-silting/ deepening of rivulets	0	100
	Repair breaches	20	80
	Repair damage to stream banks	20	80
	Lining drainage channel with vegetation to stabilize the surface from erosion	10	90
	Removal of trees, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway	5	95
	Deepening waterway or modifying/ shaping the line, grade, and cross section remove obstructions to normal flow	5	95
	Compaction of fills to prevent unequal settlement that would cause damage to waterway	0	100
	Managing earth and materials not needed in construction so that it will not interfere with the water flow in the waterway	0	100
Soil Erosion Control	See – WSD and SMC Manuals	30	70
Soil Moisture Conservation	See – WSD and SMC Manuals	20	80

5 Soil Enrichment

5.1 Description

Soil enrichment is recognized as a key element in land reclamation. Initial plant establishment is directly dependent on the capacity of soil (physical, chemical and biological properties). Soils are also a living resource where many micro-organisms and larger living forms are present. The fertile top soils are a product of millions of years of ecological process and considerable attention must be paid to the task of soil enrichment.

Use of soil fauna

In healthy soils, soil fauna are abundant which are known to improve soil structure. To improve soil fauna, mulches can be buried in the ground, which will provide suitable conditions for their growth and reproduction. In arid and semi-rid climate, resources are concentrated in patches forming ‘fertility islands’. Identification of such islands may facilitate restoration works and exploitation of these features will help to reintroduce spatial heterogeneity to the landscape. Because only fungi can break down lignin, the woody component of plant matter, allowing dead wood and woody debris to remain on the ground layer is a major component of the effort to rebuild soil fungi.

Mycorrhizal Inoculation

Mycorrhizae are symbiotic fungi found associated with the roots of wide variety of plant species. In fact, many tree species need mycorrhizae for their growth and survival. Mycorrhizae facilitate availability of greater amount of nutrients like phosphorus, nitrogen

and many trace elements from the soil to the plants. Mycorrhizae increase the drought tolerance of plants and are thus useful in arid and semi-arid climate. In the degraded sites, abundance of mycorrhzial fungi is reduced. Hence, there is a need to reintroduce it through inoculation at the restoration site. However, due to high cost of commercially available mycorrhzial fungi, their application needs to be restricted only to high priority sites.

Hydrogel Application

Hydrogels are natural or artificial water super-absorbers with the capability of absorbing 400 g to 1500 g of water per dry gram of hydrogel. It can be used as alternative water holding amendments and watering methods, especially in locales in reduced water availability. In this manner, Hydrogels may have great potential in restoration and reclamation works where opportunity for post planting irrigation is limited. This is also a very costly option and can be used to a limited extent.

Sewage-Sludge Application

Sewage sludge contains high amounts of organic matter, nitrogen, phosphorus, and carbon, and micronutrients and thus useful in repairing the degraded soils. Sewage sludge is a bye-product of wastewater treatment facilities. Due to risk of carrying some harmful heavy metals, these can be used in highly degraded sites like mine-spoils.

5.2 Ecological-Economic Consideration

- Protecting and enhancing the top-soil
- Biomass productivity – over and under ground

- Carbon sequestration – to enhance organic carbon levels and to support global efforts in addressing climate change
- Multiple ecosystem services of a healthy and living soil regime

5.3 Design Considerations

- Many of the options are expensive and discretion must be used in using these technologies
- Find out if any cost-effective local resources are available for supply of inputs like mycorrhizal inoculums.
- Technologies like hydrogel application must be used sparingly as these are costly and not suitable for extensive application
- Consult experts, before using these techniques in the field

5.4 Work Plan & Labour

Activity	Sub-Tasks	Material	Labour
Use of soil fauna	Collection and transplanting micro-organism rich soil lumps from nearby areas, if available Tilling of land Adding mulch	10	90
Mycorrhizal Inoculation	Procurement Application/ adding the inoculums to soil	100 10	0 90
Sewage-Sludge Application	Transporting Ploughing/ tilling/Application	10 0	90 100

6 Reclamation of Saline/ Alkaline Lands

6.1 Description

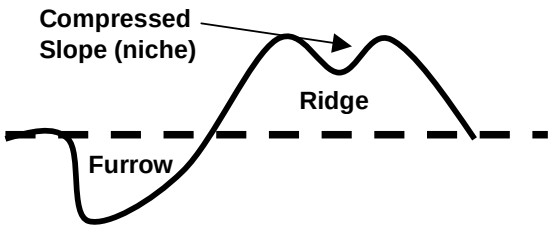
The problem of saline and sodic soils is, to a great extent, inherent to the arid regions. Under natural condition such soils support salt-tolerant vegetation and thus controlling the soil for further degradation. Reclamation of saline and sodic soils is prohibitively expensive and complete reclamation nearly impossible to accomplish in meaningful time horizons.

6.2 Ecological-Economic Consideration

- Inherent salinity or sodicity is part of the ecological mosaic and is part of the natural heterogeneity; it must be accepted as a part of the landscape
- Since it is very costly to reverse or significantly alter the salinity/ sodicity levels of the land, the focus is on enhancing biomass productivity to enhance livelihoods

6.3 Design Consideration

- Increase the abundance of indigenous halophytic (salt-tolerant) vegetation (like Salicornia, Artiplex, Suaeda, Tamarix, Aeluropus etc.)
- Create mounds or 'islands' and ridge and furrows for salinity leaching and to create suitable 'niche' through micro-landscaping to grow grass and shrubs including plant of some economic value, such as medicinals
- Naturally occurring saline areas are also habitats of some wild animals and plants. These must not be disturbed.



6.4 Work Plan/ Implementation/ Labour & Materials

Activity	Sub-Task	Material	Labour
Land Modification	Landscaping to form ridges and furrows to facilitate leaching of salt Drainage Modifications	0	100
Vegetation cover management	Grow salt tolerant plants grass and fodder crops Grow select medicinal and aromatic plants	20	80
Chemical Soil Amendments	Application of calcium chloride and gypsum	40	60

7 Reclamation of Ravine Lands

7.1 Description

Ravines are networks of gullies. They are among the most visible effects of soil erosion caused by high intensity rains where the soils are loose is the creation of ravines. Due to intense action of run-off the land is cut into highly undulating and deep gorges forming ravines. There is heavy erosion and land is rendered unsuitable for productive purposes.

7.2 Ecological-Economic Consideration

- Restoring some productivity to the degraded land
- Providing livelihood opportunities
- Arresting silting in the drainage and river systems

7.3 Design Considerations

- Chose tree species that are well adapted to ravines
- Moderate the flow of rainwater by an approach of maximal absorption or safe diversion
- Use reinforcing materials such as mats to allow grasses to establish
- Undertake extensive gully-plugging, making of bunds and terracing
- Consult experts to locate improved and appropriate designs
- Use vegetation cover that are not usually grazed
- Ensure that grazing is completely stopped till vegetation is fully established

7.4 Work Plan & Labour

Activity	Sub-Tasks	Material	Labour
Bunds & Gully Plugs	Contour bunds Levelling Diversion bunds	*See watershed manual*	
Vegetation cover management	Forestry with trees adapted to ravines Grasses for stabilization	20	80
Providing drainage pathways	Drainage channels Piped outlets	30	70
Check dams		*See watershed manual*	

8 Reclamation of Land Infested by Invasive Vegetation

8.1 Description

Most of the public lands in arid and semi-arid tracts face threats from invasions of undesirable plant species. These species tend to dominate the landscape and create many problems including threats to the local biodiversity.

8.2 Ecological-Economic Consideration

- Restoration of the indigenous biodiversity by management of the invasive species
- Often some of the short-term benefits from invasive species tend to promote it on the landscape causing long-term threat to the ecological integrity of the landscape
- The infested areas act as centres for dispersal and spread to other areas, in some cases aided by free-ranging livestock
- Invasion causes loss of indigenous vegetation that supported livelihood options and fodder

8.3 Design Considerations

- Eradication of invasive vegetation requires complete uprooting
- For invasive species, lopping of trees, cutting or burning of shrubs etc do not result in removal. In some cases, lopping or burning can actually help in promoting vigorous re-growth.

- Care must be taken not to disturb wildlife that has adapted to the existing infested areas; such site should not be cleared of the invasive vegetation
- Any use of chemicals – herbicides/ weedicides/ defoliants must be strictly avoided and is not recommended

8.4 Work Plan

Activity	Sub-Tasks	Material	Labour
Vegetation Management	Uprooting of infested vegetation	0	100
	Planting suitable vegetation	10	90

9 Reclamation of Land Degraded by Mining

9.1 Description

These include areas degraded by mining – stone quarries, soil as in brick, over burden in open cast mines (i.e. public land degraded by mining). The mining activities cause topographic changes creating pits, gullies, dumping of spoils and wastes and vegetation losses. These kinds of changes results in soil erosion, biodiversity losses, and disturbances to hydrological regime, pollution of land and water bodies.

Restoration of mine sites requires amelioration of physical and chemical characteristics of substrate and mainly ensuring the return of vegetation cover. The process of natural vegetation succession on mined soils is slow due to the removal of topsoil, resulting in elimination of soil seed bank and root stocks and due to soil profile disturbances.

9.2 Ecological-Economic Consideration

- Arresting the silting
- Improve land productivity
- Better water management
- Improvement of the biodiversity
- Enhancing the aesthetic quality of the landscape
- Provide livelihood opportunities on the reclaimed land
- Indirectly, reclamation will help to improve the productivity of agricultural lands
- Increase the land value

9.3 Design Considerations

- Overburden management
- Use of abandoned excavated sites as possible water harvesting system
- Explore possibilities for enhancing biomass productivity

9.4 Work Plan

Activity	Sub-Tasks	Material	Labour
Landscaping	Managing overburdens and spoils Stabilization of the dumps	10	90
Improving hydrological regime	Providing new drainage pathways Opening choked drainage pathways Creating water harvesting structures where appropriate	20	80
Vegetation cover management	Forestry for erosion control – wind and water induced soil losses Providing grass cover	10	90

10 Watershed Development

Watershed development activity is the sum total of all the ecological regeneration efforts described here as well as a set of the structural engineering and earth works. All the eco-restoration activities are described here. There are manuals for the civil, structural and earth work aspects of WSD that could be consulted. Therefore, this section describes the perspective and overall goals of the WSD, particularly to reaffirm that a sound WSD project is *essentially* an eco-restoration effort and it is important keep this larger perspective while implementing WSD activities.

10.1 Description

The watershed development approach makes a significant departure in the way poverty reduction programmes are implemented. It attempts to bring about an approach that includes almost all aspects of rural development into a unified framework to ensure sustainability of resources and livelihoods. It takes a manageable hydrologic boundary as the unit for project implementation and community mobilization.

A watershed is unit defined by a hydro-geological boundary – the water-divide or ridge – which by its shape (topography) ensures that all rainwater runoff from within it will eventually drain through a common outlet. It is quite simply a land area that captures all rainfall falling within it and conveys the resulting runoff to a common outlet. The size of watershed could vary from a few square meters to thousands of square kilometers. The watershed development projects usually cover those covering nearly 500 ha.

Although the boundaries of watershed is determined purely in hydro-geologic terms, in terms of resource management and socio-economic development it represents a very complex system. A social and natural resources management challenges in a watershed may require involvement of multiple agencies, several villages, different communities, various ecological systems and so on.

Watershed development refers to the conservation, regeneration and the judicious use of all the resources - natural (land, water, plants, and animals), human capabilities and social capital - within a particular watershed. Watershed management tries to bring about the best possible balance in the environment between natural resources on the one side, and human and other living beings on the other.

10.2 Guiding Principles

From the mid 1980's, the watershed-approach became a national strategy for addressing the productivity and natural resource management constraints faced by areas under dryland agriculture. The approach was a recognition that dryland agriculture cannot be addressed in isolation from the overall natural resource management issues. Soon, it also became evident that WSD should not become reduced to water harvesting or an over-emphasis on water resource enhancement at the neglect of general land and ecological degradation. The numerous phases, experiments and projects showed that the most effective WSD effort is one based on what is called the "Ridge-to-Valley" natural resource regeneration approach, which lays as much emphasis on eco-restoration and comprehensive natural resource regeneration tasks, along with water resource enhancement. The proven WSD approach is one

that is firmly rooted in the Ridge-to-Valley model that integrates this effort with social, economic and institutional interventions. In many of the highly resource stressed flat landscapes, the scope for water harvesting structures is extremely low.

The overall goals of a sound watershed development programme are:

i) Promote the economic development of the village community through rational management (harvesting, storage, distribution and use) of all natural resources (water, vegetation, land etc)
ii) Achieving ecological restoration, all round regeneration of natural resources, enhancing the productivity of cropland, pastures and forests
iii) Ensuring equitable access and distribution of benefits to all sections
iv) Strengthening and developing community-based institutional arrangements for sustainability of the natural resource and livelihood systems
v) Bring about greater harmony on the competing claims on natural resources within each watershed and across the network of watersheds in a larger landscape consisting of multiple watersheds

10.3 Main Components

Some of main components of WSD efforts are:

- Human Resource Development including extensive capacity building effort

- Vegetation Cover Management including forestry and non-forest interventions
- Soil and land conservation
- Water harvesting and management
- Crop and crop-land Management
- Pasture/ fodder Development
- Livestock management
- Rural energy systems
- Improving farm and non-farm incomes

All or most of the activities described in this manual are relevant or applicable in almost every WSD project. It may even be argued that the ecological restoration approach needs to be given precedence over excessive zeal for water harvesting structures. The ecological resource regeneration calls for a more patient, gradual and long-term engagement to achieve long-term sustainable benefits. It must also be noted that more resource stressed an area is, as is the case in most arid regions, greater is the need for comprehensive ecological regeneration effort.

Watershed Development Reference Manuals

For details of civil, structural and earth works under watershed development, please consult:

1. NREG Watershed Works Manual, prepared by the Baba Amte Centre for People's Empowerment and Samaj Pragati Sahayog (2006)
2. Integrated Watershed Management by Rajesh Rajora (1998)

However, please keep in mind that the ecological issues discussed in this manual are an integral part of any WSD and this manual must be used as a companion volume to the manuals for structural engineering and earth works in WSD.

PART – D: Appendix

1 Abbreviations

EGS	:	Employment Guarantee Scheme
GIS	:	Geographical Information System
Ha	:	Hectare
MFP	:	Minor Forest Produce
mm.	:	Millimetre
NGO	:	Non-Government Organization
NRB	:	Natural Resource Base
NREGA	:	National Rural Employment Guarantee Act
NREGP	:	National Rural Employment Guarantee Program
NRM	:	Natural Resource Management
NTFP	:	Non-timber Forest Produce
PA	:	Protected Area
PET	:	Potential Evaporation & Transpiration
PF	:	Protected Forest
PIC	:	Prior Informed Consent
PRA	:	Participatory Rural Appraisal
PRI	:	Panchayati Raj Institutions
RF	:	Reserved Forest
SMC	:	Soil Moisture Conservation

2 Grasses

Species	**Purpose**
Aeluropus lagopoides	SL
Cenchrus ciliaris	PL, DF
Cenchrus setigerus	SL
Chloris barbata	DF
Chloris virgata	DF
Cymbopogon martinii	DF
Cynodon dactylon	DF, AF
Desmostachya bipinnata	DF
Dichanthium annulatum	PL, DF
Echinocloa colonum	PL, DF, SL
Eleusine compressa	SL
Eragrostis spp.	PL
Heteropogon contortus	DF
Lasiurus sindicus	SD
Panicum antidotale	SD
Saccharum munja	SD
Saccharum spomtaneum	DF, SL, SD
Sehima nervosum	
Sporobolus helvolus	SL
Sporobolus marginatus	SL
Urochnondra setulosa	SL

SL-Saline Area, DF – Degraded Forests, AF- Agroforestry, WB- Wind Break, SF- Social Forestry, SD- Sand Dune, PL- Pastureland

Local names for each site must be obtained by forest department or any botanist familiar with the area.

3 Tree & Shrub Species for Eco-Restoration

Species	Local Name	Seed Collection Period	Purpose
Acacia auriculiformis		Dec- Feb	SF, AF, DF
Acacia catechu	Khair	Jan-Mar	DF, SF
Acacia leucophloea		Apr-May	DF
Acacia nilotica	Babul	Apr-Jun	DF, SF,
Acacia Senegal	Gorad	Mar-Apr	DF, SD
*Acacia tortilis**	Israeli Babul	Nov- Feb	SD, SL
Aegle marmelos	Bael		SF, DF
Agave americana	Ketki		SD, AF, DF
Ailanthus excelsa	Adusi	May-Jun	SD, SF
Albizzia lebbeck	Siris	Nov- Feb	AF, SF, SD
Annona squamosa	Sharifa	Sep-Nov	SF, DF, AF
Aloe barbadensis	Ghikunwari		AF, DF
Atriplex lentiformis			SL
Azadirachta indica	Neem	Jun-Jul	SF, AF
Balanites aegyptica	Ingori		SD, DF
Butea monosperma	Dhak	May-Jul	AF
Calligonum polygonoides	Phog		SD
Calotropis gigentia	Madar		DF
Calotropis procera	Aak		DF
Capparis decidua	Kerad		AF, DF
Cassia auriculata,	Senna		SD
Casuarina equistifolia	Sau	Jun-Dec	WB, SD,
Citrullus colocynthis			SD
Colophospermum mopane			SD
Commiphora wightii	Gugal		AF, DF
Cordia rothii	Gundi	Apr-May	SF, SD
Crotalaria burhia	Sangetro		SD, DF
Dalbergia latifolia	Shisham	Feb-Mar	AF, SF
Dalbergia sissoo	Sissoo	Nov-Feb	AF, SF
Dendrocalamus strictus[(l)]	Bans	May-Jun	DF, SF
Dichrostachys cinerea			SD,
Embalica officinalis	Aonla	Nov-Jan	SF, AF
Euphorbia neerifolia	Thor		DF
Grewia tenax	Gangeti		DF
Hardwickia binata	Anjan	Apr-May	AF
Lawsonia inermis	Mehndi		AF, SF
Leucaena leucocephala	Subabool	Mar-Apr	AF, SF
Madhuca latifolia	Mahua	Jun-Aug	AF, SF
Moringa oleifera	Sahjan		AF
Ocimum sanctum	Tulsi		AF, DF
Parkinsonia aculeata			SD, DF, PL
Prosopis cineraria	Khijda	Jun-Aug	AF, DF, SD
Prosopis chilensis (formerly P. juliflora)	Pardesi Babul	May-Jun	SD, SL
Salvadora oleoides	Pilu	Mar-May	SD, DF

Species	Local Name	Seed Collection Period	Purpose
Salvadora persica	Miswak	Mar-May	SL, SD, SF
Sueda nudiflora	Unt morad		SL
Tamarindus indica	Imli	Feb-Apr	DF
Tamarix aphylla			SD, SF
Tecomella undulata	Ragat Rohido		SD, DF, SF
Zizyphus mauritiana	Bor		DF, SD
Zizyphus nummularia	Bor		SD, DF

Notes: * Exotic; (!) Flowers gregariously once in life time (30-35 yrs)
SL-Saline Area, DF – Degraded Forests, AF- Agroforestry, WB- Wind Break, SF- Social Forestry, SD- Sand Dune, PL-Pastureland
Local names for each site must be obtained from forest department or any botanist familiar with the area. The local names mentioned here are in Hindi.

4 Land Capability Classes

The eight main land capability classes are given the following table:

Class	Characteristics
I	Deep productive soils, easily worked on nearly level land, not subject to overland flow, required rotational cropping to maintain soil fertility and structure
II	Moderately deep, productive soils on gentle slopes; subject to occasional overland flow, suitable for cultivation but require drainage and rotational cropping systems
III	Soils are of moderate fertility on moderately steep slopes, subject to more severe erosion but can be used for cropping
IV	Good soils on steep slopes, subject to severe erosion, may be cultivated occasionally with great care; suitable for pasture
V	Land is too wet or stony for cultivation, subject to slight erosion, suitable for pasture or forestry
VI	Shallow soils on steep slopes, suitable for forestry and restricted grazing
VII	Shallow soils on steep, rough lands, subject to erosion, suitable for restricted forestry and grazing
VIII	Very rough lands, not suitable even for forestry and grazing, can make reserve for wildlife and watershed considerations

In general, farm practices are suited for Class I to IV land, while pasture and forestry practices are suited for Class V to VII lands.

5 Land-Use Categories in Official Statistics

1) **Forests**

Forests include all lands with or without tree cover whose ownership rights are with the respective State Forest Department. Any land - whether state owned or private - could be brought under the jurisdiction of the State Forest Department through a due legal process. The term “forest” does not necessarily imply that there is tree cover.

2) Land under Non-Agricultural Use

This category included all lands occupied by buildings, roads & railways or under water, e.g. rivers & canals, & other lands put to uses other than agricultural.

3) Barren & Un-Culturable Land

This category covers all lands where cultivation is not possible under current technologies. Usually, all rocky areas, mountains, etc are placed in this category in the official land-use statistics. In the strict legal terms, this applies to any such “uncultivable” land unit including even parcels within cultivated holdings.

4) Permanent pastures & other grazing land

This category represents a certain portion of the total village area that is set aside for use as the common grazing land. However, the term does not imply that such land has grass cover. Administratively, this category falls within the jurisdiction of the village.

5) Miscellaneous tree crops & groves

This class includes private land holdings having some kind of tree cover, but do not have seasonal crops. This land is excluded from the Net Sown Area, although it is cultivable land. However, there is no uniform criterion across different states for classifying land under this category.

6) Culturable Wasteland

This category includes all lands where cultivation is possible or was cultivated once, but is not cultivated for the last 5 years or more in succession and remains uncultivated in the year when land-use data was compiled.

7) Current fallows

This comprises cultivable land that is not cultivated (fallow) in the current year only. Whole or part of a good farmland may remain fallow for various reasons.

8) Other Fallows

This category includes all cultivable lands that have gone out of cultivation for more than a year and less than five years.

9) Net Sown Area

This term denotes the area sown under crops & orchards, counting areas sown more than once in the same year only once.

6 Schedule of Rates

The implementation of NREG requires approved Schedule of Rates (SOR) for different types of work to determine the wages to be paid. There are approved SOR available for most of the civil works, earth works, and items included in the list of works usually undertaken such as building roads, buildings, check-dams, etc. There may be difficulties in obtaining proper rates for some of the activities described in this manual. The guidelines discussed here can be used in situations where SOR is not readily available.

Almost all the works mentioned here are taken up in small or big way by different agencies and indicative rates can be obtained from one agency or other. However, it will be necessary to ascertain whether the rates available from such sources are "fair", in the sense that under prevailing local conditions one working-day's effort can produce the prescribed result (i.e., SOR) and ensure a one-day's wages. So in many cases, it would be necessary to recheck such rates and if there are problems (for e.g., if given the shortage of seeds or because is widely dispersed, one-day's effort cannot result in the collection of the prescribed quantity), then a review would be needed. A due review process will be required and what is called "Time-Motion Study" will have to be undertaken to define the SOR. The competent authorities will have to sanction such a study and approve the results before it can be used.

Table: Likely sources for obtaining SOR

Focus Area	Work Elements	Source
Soil-Moisture Conservation	Earth Work Masonry work	DRDA, Irrigation Dept., Agriculture Dept.
Forestry and Pasture development	Collection of Native seeds Nursery Raising Land preparation Plantation Maintenance (watering) Protection Mulching	Forest Dept., Horticulture Dept. Animal Husbandry dept.

7 Glossary

Term	Definition
Canopy	The forest layer formed by the leaves and branches of trees or shrubs. There may be several canopy layers in a particular patch of forest. Higher canopies results into shades to many ground level species, limiting their growth.
Conservation	The use of natural resources in a way that ensures their continuing availability to future generations; implies sustainable use of natural resources for long-term benefits.
Deciduous	Denoting all plants that seasonally lose all their leaves. It is an adaptation to prevent excessive water loss by transpiration when water is scarce.
Density	Number of plants (or animals) per unit of area (space).
Domesticated Species	Species in which the evolutionary process has been influenced by humans to meet their needs by taming animals or cultivating plants followed by breeding.
Ecological Restoration	The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.
Ecological Succession	The process in which communities of plant and animal species in a particular area are replaced over time by a series of different and usually more complex communities.
Ecology	The study of the interactions of living (biotic) and non-living (abiotic) components.
Ecosystem	Structural and functional unit of environment that result from the interactions of living (plants, animals, and micro-organisms) and non-living (air, water, soil, temperature etc.) components.
Endangered Species	Species in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are species that may be extinct but have definitely been seen in the wild in the past 50 years.
Ethnobotany	Study of the relationship between plants and people, especially by traditional and indigenous communities
Habitat	An area that provides an animal or plant species with its preferred food, water, shelter, living and breeding requirements
Herbaceous	A plant that is green and leaf-like in appearance or texture and mostly have annual life cycle.
Humus	The organic part of soil formed from decaying plant and animal matter, mostly occurring in the top soils. Its helps the microbial activity in soils.
Invasive Species	Species introduced by human action to a location, area, or region where it did not previously occur naturally, occupy and spreads to newer locations on its own in an uncontrollable manner in the absence of natural factors that can restrain such spread.
Map Scale	The ratio of distance on a map as related to the true distance on the ground.
NTFP	Products of biological origin other than wood obtained from forests and other wooded land (e.g., wax, honey, fruits, leaves, gum, etc)
Prior Informed Consent	A process and document indicating consent by knowledge-holders – an individual or community – to share with others. This ensures some protection over the rights of the knowledge holders.
Protected Area	Legal notified area (land or sea) for the protection and maintenance of biological diversity, and of natural and associated cultural resources. In India following types of Protected Areas are created – National Parks (highest level of protection), Wildlife Sanctuaries, Biosphere Reserves
Rare Species	Species with small world populations that are not at present 'Endangered' or 'Vulnerable', but are at risk. These are usually localized within restricted geographical areas or habitats.
Soil Alkalinity/ Sodic Soils	Soil having a high degree of alkalinity (pH of 8.5 or higher) or having a high exchangeable sodium content (15% or more of the exchange capacity) or both.
Soil Salinity	A measure of the total amount of soluble salt in soil. The salts of sodium, potassium, calcium and magnesium are mainly responsible.
Watershed	A ridge of high land dividing two areas that are drained by different river/ drainage systems. In other words, the area where a river/drainage catches its water is called its catchment or watershed.
Wild Species/ Wildlife	Plants and animals that have not been subject to domestication

8 Readings

Manuals

Watershed Development	NREG Watershed Works Manual Baba Amte Centre for People's Empowerment and Samaj Pragati Sahayog (2006)
	Rajesh Rajora (1998) Integrated Watershed Management, Rawat Publications, Jaipur
Soil and Moisture Conservation	Source Book on Soil and Water Conservation Measures – Foundation for Ecological Security (2002)
Social and Institutional	Source Book on Social and Institutional Aspects – Foundation for Ecological Security (2002)

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Useful Links

Subject	Link
Trees used in agro-forestry	http://www.worldagroforestrycentre.org/SEA/Products/AFDbases/
Plants of arid lands	http://www.winrock.org/fnrm/factnet/factpub/factsh/
Plant used for plantation	http://www.hort.purdue.edu/newcrop/nexus/
Grassland Plant Species	http://www.fao.org/ag/AGP/AGPC/doc/GBASE/mainmenu.htm
Threatened species	http://www.iucnredlist.org/
Soils	http://www.fao.org/AG/agl/agll/prtsoil.stm http://eco.wiz.uni-kassel.de/ecobas/new_db/soilclass_f.html
Seeds of forest plants	http://www.dfsc.dk