8.1 INTRODUCTION

A number of recent publications recommend bundling of the Ecosystem Services in order to maximize cost-effectiveness and efficiency of PES projects (Wendland et al., 2009; Chapter 7). At the same time several studies (Heal et al., 2001; Jackson et al., 2005; MA, 2005; Rodriguez et al., 2006) highlight that the actions to enhance the supply of some ecosystem services, mainly provision of services such as food and timber, have led to declines in many other ecosystem services, including regulating and cultural services such as nutrient cycling, flood regulation, and opportunities for recreation. Therefore, another challenge of establishing markets that is particular to ecosystem services is handling tradeoffs and determination of the best mix of services (Heal et al., 2001; MA, 2005). This in turn requires a study of the interactions between the provisions of various goods/services and consequent tradeoffs and synergies between them, and societies preferences. Both tradeoffs and synergies can then be managed to either reduce their associated costs to society or enhance landscape multifunctionality and net human wellbeing, respectively (Rodriguez et al., 2006). For this reason this chapter reviews the opportunities and tradeoffs in bundling carbon sequestration and recreation services of forests (ES having better market potential) with its watershed services and attempts at identifying the forest management needs for their optimization in a source area.

The Section 8.2 describes the forest management needs for optimizing forest ecosystem services – watershed services, carbon sequestration and recreation – individually. Based on it the bundle of ES and the approaches that enhance cost

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36 Ecosystem service tradeoffs arise when the provision of one service is enhanced at the cost of reducing the provision of another service.
37 Ecosystem service synergies arise when multiple services are enhanced simultaneously.
effectiveness are identified in Section 8.3. Conclusions are presented in Section 8.4.

8.2 FOREST MANAGEMENT NEEDS FOR OPTIMIZING ES

8.2.1 Forest Watershed Services

Scientific researches over the last three decades (Calder et al., 2007; GIST, 2006; Kuczera, 1987; Langford, 1976; Malmer et al., 2009; Serrano-Muela et al., 2008; Singh and Mishra, 2012; van Dijk and Keenan, 2007; Vetessy et al., 1998; Vinnikov and Robock, 1996; Chapter 2, 3 and 4) are increasingly pointing at the differential responses of young and disturbed forest cover, and old forests on the water regime. While increase in area under old and mature forest cover is observed to increase the water yield (total quantity of surface water that can be expected in a given period from a stream at the outlet of its catchment) as well as ground water recharge, disturbed forests and young plantations are more likely to decrease it. The old and dense forests are also observed to be more effective than open forest in reducing turbidity, soil erosion, and water quality impairment by temperature rise, extreme variability in rainfall and catchment contamination likely to be caused by climate change. Research also indicates tradeoffs between the hydrological and provisioning services of the forests i.e. if forests are utilized for providing timber, fuel wood, fodder and other such services there would be loss in the hydrological services (like improvement in water quantity and water quality) extended by them (Singh and Mishra, 2012).

In view of the above there is a need to take special measures for conserving old/mature forests in watersheds of aquifers, reservoirs and other sources. Disturbed forests as also plantations in the source area should similarly be conserved so that with age they are able to extend better hydrological services. The tradeoffs between the hydrological and provisioning services of the forests too emphasize at the need of protected area like status to the forests in the source area. The role of dead, decaying trees and debris in watershed services (see section 3.5 and 4.5) indicates that an unmanaged forest landscape may be preferable to a managed one. Further, the linear relationship between land use and water yield (chapter 3) indicates that larger the area under old and mature forests higher would be the water yield benefits. However, with respect to water
quality, study by Ernst (2004) indicates that forest cover over 60% in the source area may not result in any further improvements in the water quality. Chapter 5 indicates that over 98% of the deforestation induced costs on water supplies are on account of deterioration in the water quality. Hence, it may be appropriate to infer that forest cover over 60% in the source areas may not yield any additional water benefits.

8.2.2 Carbon Sequestration Services

Forest ecosystems make an important contribution to the global carbon budget. They use sunlight to convert CO₂, water, and nutrients into sugars and carbohydrates, which accumulate in leaves, twigs, stems, and roots. Plants also respire, releasing CO₂. Plants eventually die, releasing their stored carbon to the atmosphere quickly or to the soil where it decomposes slowly and increases soil carbon levels. Because of this potential to capture and store carbon in wood and soil (sequester), increasing the amount of carbon removed by and stored in forests has been considered as an option for slowing the rise of greenhouse gas concentrations in the atmosphere, and thus possible climate change.

Young forests sequester more carbon than older forests because of faster growth rate (Harmon, 2001). In addition older forests have more dead trees and decomposition, and hence they are likely to release more carbon than younger forests. So, it is often felt that replacement of older forests would enhance carbon sequestration (Harmon, 2001). But simultaneously, many studies on this subject have concluded that the replacement of older forests by younger ones will result in a net release of carbon into the atmosphere (Cooper, 1983; Harmon et al., 1990; Dewar, 1991; Schulze et al., 2000). The issue is contentious as net carbon released in the atmosphere by the forests depends on many factors, such as prior and subsequent growth rates, the quantity and disposal of cut vegetation, soil impacts, treatment of residual forest biomass, proportion of carbon removed from the site, spatial and temporal scale, and duration and disposal of the products (Gorte, 2009). Hence, effective mitigation (minimize the net emissions to the atmosphere) requires a full systems perspective i.e. a complete accounting of all the different sectors that a forestry project or activity may involve.
Clean Development Mechanism (CDM) favours tree plantations as mode of carbon sequestration on lands that are not being utilized as forest for at least 50 years (afforestation) or was converted to other uses before 31.12.1989 (reforestation). Post-Kyoto protocol, avoided deforestation projects under reduced emission from deforestation and degradation and enhanced forest stocks (now known as REDD+) are gaining favours as it is widely believed to be a cost effective approach to curtail CO₂ (Anger and Sathaye, 2008; Stern, 2007). Other opportunities to increase carbon stock include forest restoration, agro-forestry, reducing use of fuel wood and improved forest management. Hughes (1991) holds that management practices such as silvicultural tending of existing stands can increase biomass production, as well as, aid in mitigating the build up of atmospheric CO₂. Winjum and Lewis (1993) infer that integrated plantations with longer rotations store carbon at less cost per ton of carbon. Thornley and Cannell (2000) demonstrated that the objectives of maximizing timber and carbon sequestration are not complementary. Birdsey (n.d.) points out that converting unmanaged forest to a managed forest may marginally reduce carbon stock but it increases the rate of carbon uptake. Goetz et al. (n.d.) infer that carbon sequestration costs for forests seem to be significantly lower when the forest management regime is changed than when land use is changed, i.e., a change from agriculture to forestry. So, managing an unmanaged forest, increasing the rotation length or increasing the time between harvests may be preferable strategies to increase average carbon stock on the landscape in a cost effective way.

Birdsey (n.d.) suggests that the strategies for carbon sequestration should be evaluated against the following parameters – effects on storage and emissions, the cost of implementation, the timing of benefits, the capacity to offset CO₂ emissions, the risks and uncertainties, and often very important, the tradeoffs and the co-benefits that may occur. Generally a combination of strategies may works best at the landscape scale rather than any one strategy.

8.2.3 Recreation Services

Forests hold a wide range of recreational opportunities which are of consumptive (habitat for game animals and fish sought by hunters and anglers) as well as non consumptive nature (recreational activities such as hiking, bird watching, wildlife
viewing and other such pursuits that occur within forest stands). Thus, eco-tourism and forest-based tourism attract significant number of tourists of the booming tourism industry (Nasi et al., 2002). As a result new demands are being made by society on forest managers who are obliged to implement silviculture practices which prioritize recreation and conservation over wood production (Lacaze, 2000).

Development for recreation, adapted to each individual case, depends upon the environmental conditions. Mostly a fraction of the forests in question is managed through the creation of reserves and tourist facilities. The remainder of the landscape is either left in its natural condition or managed to promote biodiversity viz. ecological zoning, management of landscapes, conservation of patrimonial riches, etc.

Forest recreation and tourism can contribute to the rural economy by generating revenue and employment directly in forest-based enterprises. In addition, the sourcing of products and services with local providers or local tourism taxes paid by visitors can increase income. The extent to which benefits are embedded in local economies will depend on supply chains and tourism enterprises, and the extent to which they are able to generate additional spending.

8.3 TRADEOFFS AND SYNERGIES IN BUNDLING ES

“Natural” forests and forests of old and mature trees emerge as the best scenario for watershed services (Malmer, 2009; Chapter 3). Such forests offer excellent opportunities for biodiversity, scenic beauty and recreational activities such as hiking, bird watching, wildlife viewing, etc. Hence, watershed and recreational services complement each other. However, recreational services require some sections of the forest to be managed which might result in minor tradeoffs. But the economic benefits from synergies are likely to exceed losses through tradeoffs by far.

In contrast carbon assimilation and water use are tightly coupled as the process of photosynthesis by which carbon is sequestered makes use of water. Hence, there are bound to be tradeoffs in the carbon sequestration and water use by the forests particularly when plantations (afforestation and reforestation) are taken as the mode of carbon sequestration. Many studies (Section 8.2.1) confirm higher water use by tree plantations and disturbed forests. Jackson et al. (2005) cautions that
plantations as tool for carbon sequestration should be used cautiously as while they may increase groundwater recharge and upwelling, they tend to reduce stream flow and salinize and acidify some soils (because plantations require additional base cations and other nutrients to balance the stoichiometry of their extra biomass). However, such tradeoffs (between water and carbon sequestration) are greatly minimized when increasing carbon stocks through avoided deforestation is adapted as a strategy for mitigation (Jindal and Kerr, 2007; Wendland, 2009). Hence, carbon sequestration through avoided deforestation broadly complements the watershed services of the forests while carbon plantations maximize one service at the expense of others. Minor tradeoffs can be expected as the forests for carbon need to be managed through harvest and tending operations. However, the best mix of the management practices could be arrived at through detailed studies and analysis.

8.4 CONCLUSIONS

Bundling of watershed services of forests with recreational and carbon sequestration (through avoided deforestation) appears to be a feasible option in the source areas. Such a bundle may warrant some management practices which may result in minor tradeoffs with water. But the benefits of such bundling are likely to exceed the losses by far and hence it is felt that such tradeoffs could be ignored. Major constraint in bundling of the services lies in selling them as some services have a local demand (watershed services), while others have a potentially global demand (recreation and carbon sequestration services). Obviously, local users are unlikely to pay for services that are not valuable to them, while global users will not pay for local services. So, service providers or intermediaries may need either to create separate bundles for local and global consumers or provide a portfolio of environmental services from which buyers can select according to the individual preference (Jindal and Kerr, 2007). Either option, though, will add to the complexity of PES projects.