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Appraisal of Forest Ecosystems Goods and Services: Challenges and Opportunities for Conservation

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ABSTRACT Valuation of ecosystem goods and services is essential to formulate sustainable development policies oriented towards the protection or restoration of ecosystems. The present study estimates the value of forest ecosystem of Uttara Kannada district by market price method. The total value of provisioning goods and services from the forests of Uttara Kannada district was estimated at Rs. 15,171 crores per year, which amounts to about Rs. 2 lakh per hectare per year. The study highlights the undervaluation of forest goods and services that is evident when the estimated total economic value of forest and the value of forest resources calculated in national income accounting framework are compared. The quantification of all benefits associated with the forest ecosystem goods and services would help in arriving at an appropriate policy and managerial decisions to ensure conservation while opting sustainable development path.

INTRODUCTION

An ecosystem is a complex of interconnected living organisms inhabiting a particular area or unit space, together with their environment and all their interrelationships and relationships with the environment having well-maintained ecological processes and interactions (Ramachandra et al. 2007, 2015). Ecosystem functions include the exchange of energy between the plants and animals that are needed for the sustenance of life. These functions include nutrient cycling, oxygen regulation, water supply etc. The flow of goods or services which occur naturally by ecological interactions between biotic and abiotic components in an ecosystem is often referred as ecosystem goods and services. These goods and services not only provide tangible and intangible benefits to human community, but also are critical to the functioning of ecosystem. Thus, ecosystem goods and services are the process through which natural ecosystems and the species that make up sustain and fulfill the human needs (Newcome et al. 2005). Ecosystems are thus natural capital assets supporting and supplying services highly valuable to human livelihoods and providing various goods and services (MEA 2003; Daily and Matson 2008; Gunderson et al. 2016). The tropical forests are the rich source of biodiversity and are probably thought of containing more than half of world's biodiversity. Biodiversity is important to human kind in fulfilling its needs by way of providing food (80,000 species), medicine (20,000 species), drug formulations (8,000 species) and raw materials (90% from forests) for industries (Ramachandra et al. 2016a, b; Ramachandra and Nagarathna 2001: Ramachandra and Ganapathy 2007). Among the terrestrial biomes, forests occupy about 31 percent (4,033 million hectare) of the world's total land area and of which 93 percent of the world's forest cover is natural forest and 7 percent is planted (FAO 2010; TEEB 2010; Villegas-Palacio et al. 2016). Forest ecosystems account for over two-thirds of net primary production on land – the conversion of solar energy into biomass through photosynthesis, making them a key component of the global carbon cycle and climate (MEA 2003). The forests of the world harbor very large and complex biological species diversity, which is an indicator for biological diversity and the species richness increases as we move from the poles to the equatorial region. Forest ecosystem services can provide both direct and indirect economic benefits. India's forest has been classified into four major groups, namely, tropical, sub-tropical, temperate, and alpine (Champion and Seth 1968). Tropical forest in particular contributes more than the other terrestrial biomes to climate relevant cycles and biodiversity related processes. These forests constitute the earth's major genetic reservoir and global water cycles (Anderson and Bojo 1992; Gunderson et al. 2016).

The ecosystem provides various fundamental benefits for our survival such as food; soil production, erosion and control; climate regulation; water purification; bioenergy, etc. These benefits and services are very crucial for the survival of humans and other organisms on the earth (MEA 2003; de Groot et al. 2002; Villegas-Palacio et al. 2016). It includes provisioning services such as food and water, regulating services such as flood and disease control, cultural services such as spiritual, recreational and cultural benefits, and supporting services such as nutrient cycling that maintains the conditions for life on earth. Sustainable ecosystem service delivery depends on the health, integrity and resilience of the ecosystem. Policy-makers, interest groups and the public require reliable information on the environmental, social and economic value of regulating services to make informed decisions on optimum use and on the conservation of ecosystems (Kumar et al. 2010). The prime reason for ecosystem mismanagement is the failure to realise the value of ecosystem. Valuation of ecosystem is essential to respite human activities apart from accounting their services in the regional planning (Ramachandra et al. 2011). The range of benefits derived from ecosystem can be direct or indirect, tangible or intangible, can be provided locally or at global scale – all of which makes measurement particularly hard (TEEB 2010). Economic valuation of natural resources aids the social planners to design and better manage the ecosystems and related human wellbeing. Figure 1 shows the interrelationship of ecosystem, ecosystem functions, economic values and its impact on ecosystem through incentive/disincentive.

Valuation of ecosystems enhances the ability of decision-makers to evaluate trade-offs between alternative ecosystem management regimes and courses of social action that alter the use of ecosystems and the multiple services they provide (MEA 2003; Villegas-Palacio et al. 2016). Valuation reveal the relative importance of different ecosystem services, especially those not traded in conventional markets (TEEB 2010).The ecosystem goods and services are grouped into four categories as provisioning, regulating, supporting and information services (MEA 2003; de Groot et al. 2002), based on the Total Economic Value (TEV) framework with significant emphasis on intrinsic aspects of ecosystem value, particularly in relation to socio-cultural values (MEA 2003). TEEB (2010) excludes the supporting services (such as nutrient cycling and food-chain dynamic) and incorporates habitat service as a separate category.

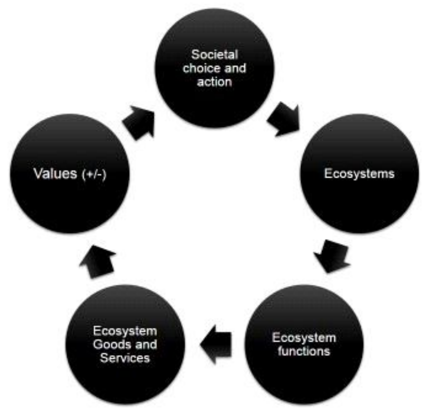

Fig. 1. Ecosystems health and economic values
Source: Author

Integrated framework for assessing the ecosystem goods and services (TEEB 2010; de Groot et al. 2002; Villegas-Palacio et al. 2016) involves the translation of complex structures and processes into a limited number of ecosystem functions namely production, regulation, habitat and information. These goods and services are valued by humans and grouped as ecological, socio-cultural and economic values. All values are estimated using the common metric, which helps in aggregating values of different goods and services (DEFRA 2007). When the market does not capture the value of environmental goods or services, techniques associated with 'shadow pricing' or 'proxy price' are used to indirectly estimate its value. Estimation of the economic values for 17 different ecosystem services (Costanza et al.1997; Villegas-Palacio et al. 2016) highlight that the annual value of the ecosystem services of the terrestrial and aquatic biomes of the world to be 1.8 times higher than the global gross national product (GNP). About 63 percent of the estimated values of ecosystem services were found to be contributed by the marine ecosystems while, about 38 percent of the estimated values were found to be contributed by the terrestrial ecosystems, mainly from the forests and wetlands.

Forests, particularly tropical forests, contribute more than other terrestrial biomes to climate relevant cycles and processes and also to biodiversity related processes (Nasi et al. 2002). Forest ecosystem services with great economic value (Ramachandra et al. 2011, 2016b; Costanza et al. 1997; Pearce et al. 2002), are known to be critically important habitats in terms of the biological diversity and ecological functions. These ecosystems serve as a central component of Earth's biogeochemical systems and are a source of ecosystem services essential for human well-being (Gonzalez et al. 2005; Villegas-Palacio et al. 2016). These ecosystem provides a large number of valuable products such as timber, firewood, non-timber forest product, biodiversity, genetic resources, medicinal plants, etc. The forest trees are felled on a large scale for using their wood as timber and firewood. According to FAO (2010) wood removals valued just over US$100 billion annually in the period 2003–2007, mainly accounted by industrial round wood. Further, 11 percent of world energy consumption comes from biomass, mainly fuel wood (CBD 2001). 19 percent of China's primary energy consumption comes from biomass and 42 percent in India. Non-commercial sources of energy (such as fire wood, agricultural and horticultural residues, and animal residues) contribute about 54 percent of the total energy in Karnataka (Ramachandra et al. 2000).

Timber and carbon wealth assessment in the forests of India (Atkinson and Gundimeda 2006) show the opening stock of forest resources as 4,740,858,000 cubic meters and about 639,600 sq. km of forest area. Biomass density/ha in Indian forests is about 92 t/ha and carbon values of Indian forests is 2933.8 million tones assessed considering a carbon content of 0.5 Mg C per Mg oven dry biomass (Haripriya 2002). The closing stock of the timber is 4704 million cum and the estimate of value is Rs. 9454 billion, the stock of the carbon is 2872 million tons with a value estimate of Rs.1811 billion. Apart from serving as a storehouse of wood which is used for various purposes, there are also equally important non-wood products that are obtained from the forests. The botanical and other natural products, other than timber extracted from the forest system are referred to as non-timber forest products (NTFPs). These resources/products have been extracted from the forest ecosystems and are being utilized within the household or marketed or have social, cultural or religious significance (Falconer and Koppell 1990; Schaafsma et al. 2014; Pittini 2011). NTFP is a significant component due to its important bearing on rural livelihoods and subsistence. NTFPs are also referred 'minor forest produce' as most of NTFP are consumed by local populations, and are not marketed (Arnold and Pérez 2001). These include plants and plant materials used for food, fuel and fodder, medicine, cottage and wrapping materials, biochemical, animals, birds, reptiles and fishes, for food and feather. Unlike timber-based products, these products come from variety of sources like: fruits and vegetables to eat, leaves and twigs for decoration, flowers for various purposes, herbal medicines from different plant parts, wood carvings and decorations, etc. The values of NTFPs are of critical importance as a source of income and employment for rural people living around the forest regions, especially during lean seasons of agricultural crops. NTFPs provide 40-63 percent of the total annual income of the people residing in rural areas of Madhya Pradesh (Tewari and Campbell 1996) and accounted 20-35 percent of the household incomes in West Bengal. The net present value (NPV) of the forest for sustainable fruit and latex production is estimated at US$6,330/ha considering the net revenue from a single year's harvest of fruit and latex production as US$422/ha in Mishana, Rio Nanay, Peru (Peters et al. 1989) on the assumption of availability in perpetuity, constant real prices and a discount rate of 5 percent.

Evaluation of the direct use benefits to rural communities' from harvesting NTFPs and using forest areas for agriculture and residential space, near the Mantadia National Park, in Madagascar (Kramer et al. 1995) through contingency valuation (CV) show an aggregate net present value for the affected population (about 3,400 people) of US$673,000 with an annual mean value per household of USD 108.

Estimation of the quantity of the NTFPs collected by the locals and forest department based on a questionnaire based survey in 21 villages of four different forest zones in Uttara Kannada district (Murthy et al. 2005), indicate the collection of 59 different plant species in the evergreen forests, 40 different plant species in the semi-evergreen forests, 12 different plant species in moist deciduous and 15 different plant species in dry deciduous forests and about 42–80 NTFP species of medicinal importance are marketed in herbal shops. Valuation reveal an annual income per household depending on the goods availability ranges from Rs. 3,445 (evergreen forests), 3,080 (moist deciduous), 1,438 (semi-evergreen) to Rs. 1,233 (dry deciduous).

Assessment of the marketing potential of different value added products from *Artocarpus* sp. in Uttara Kannada district based on field surveys and the discussions with the local people and industries (Ramana and Patil 2008), revealed that *Artocarpus integrifolia* collected from nearby forest area and home gardens is most extensively used for preparing items like chips, *papad*, sweets, etc. *Chips* and *papads* are commercially produced and sold in the markets, and primary collectors get 25 percent and the processing industry get 50 percent of the total amount paid by the consumers.

Forest ecosystems also provide other indirect benefits like ground water recharge, soil retention, gas regulation, waste treatment, pollination, refugium function, nursery function etc. in addition to the direct benefits (de Groot et al. 2002). Forest vegetation aids in the percolation and recharging of groundwater sources while allowing moderate run off. Gas regulation functions include general maintenance of habits through the maintenance of clean air, prevention of diseases (for example, skin cancer), etc.

Forests act as carbon sinks by taking carbon during photosynthesis and synthesis of organic compounds, which aids in maintaining CO_2/O_2 balance, ozone layer and also sulphur dioxide balance. Carbon sequestration potential of 131t of carbon per hectare with the above ground biomass of 349 ton/ha has been estimated in the relic forest of Uttara Kannada (Chandran et al. 2010) and 11.8 metric ton (1995) in forests in India (Lal and Singh 2000) with the carbon uptake potential of 55.48 Mt (2020) and 73.48 Mt (2045) respectively (projected the total carbon uptake for the year 2020 and 2045). The carbon sequestration potential was found to be 4.1 and 9.8 Gt by 2020 and 2045 respectively.

Vegetative structure of forests through its storage capacity and surface resistance plays a vital role in the disturbance regulation by altering potentially catastrophic effects of storms, floods and droughts. Soil retention occurs by the presence of the vegetation cover which holds the soil and prevents the loss of top soil. Pollination is an important ecological service provided by the forest ecosystem and the studies have revealed that forest dwelling pollinators (such as bees) make significant contribution to the agricultural production of a broad range of crops, in particular fruits, vegetables, fiber crops and nuts (Costanza et al. 1997).

Forest also helps in aesthetic benefit, recreational benefit, science and education, spiritual benefits, etc. The scenic beauty of forests provides aesthetic and recreational benefits through psychological relief to the visitors. An investigation of cultural services of the forest of Uttaranchal (Djafar 2006) considering six services namely aesthetic, recreational, cultural heritage and identity, inspirational, spiritual and religious and educational function, highlight the recreational value of forests US$ 0.82/ha/yr for villager's per visit. Aesthetic value derived by the preference of the villagers was estimated as US$ 7-1760 /ha/yr, derived by the preference of the villagers to live in the sites where there is good scenery. Cultural heritage and identity value was estimated as USD 1-25/ha/yr based on 24 places, 43 plant species and 16 animal species. Spiritual and religious areas was about USD 1-25/ha/yr. Educational value was obtained from the research activity and value was similar to spiritual and religious values.

Ecotourism benefit of the domestic visitor using the travel cost method in the Periyar tiger reserve in Kerala is Rs. 161.3 per visitor (Manoharan 1996), with average consumer surplus at Rs. 9.89 per domestic visitor and Rs. 140 for foreign tourists. The value of eco-tourism (as per 2005) is extrapolated as Rs. 84.5 million. The recreational value assessment of Vazhachal and Athirappily of Kerala (Anitha and Muraleedharan 2006) reveal that visitor flow on an average is 2.3 lakh (at Vazhachal) and 5.3 lakh (Athirappily) visitors/year and the average fee collection ranges from Rs. 10 (Vazhachal) to Rs.23.5 (Athirappily) lakh / year. Parking fee for vehicles itself is about Rs. 1.39 (Vazhachal) lakh /year and Rs. 2.7 (Athirappily) lakh/ year. About Rs. 5.6 lakh is earned from visitors entrance fee and parking charges. The estimated aggregate recreation surplus of the sample is equal to Rs 20, 69,214 with an average recreation surplus per visitor of Rs. 2,593.

Recreational value in the protected site of Western Ghats (Mohandas and Rema Devi 2011) based on the relationship between travel cost and visitation rate and the willingness to pay is Rs. 26.7 per visitor and the average consumer surplus per visit is Rs. 290. A similar study carried out in the valley of a national park show the net recreational benefit as Rs. 5,88,332 and the average consumer surplus as Rs. 194.68 (Gera et al. 2008). The total recreation value of Dandeli wildlife sanctuary using travel cost method during 2004-05 shows the total recreation value of Rs. 37,142.86 per Sq. km with the total value of Rs. 1,76,43,600 (Panchamukhi et al. 2008). Similarly, based on the willingness to pay for the preservation of watershed in Karnataka indicate a value of Rs.125.45 per hectare and the total value of Rs. 480 million (for 2004-05).

Valuation of forest in Uttarakhand, Himalayas using the benefit transfer method (Verma et al. 2007) shows a total economic value of Uttrakhand forests as Rs. 16,192 billion, accounting Rs. 19,035 million from the direct benefits (including tourism) and Rs. 173,120 million from the indirect benefits and silt control service is accounted as Rs. 2062.2 million. Carbon sequestration is accounted as Rs.2974 million at US $ 10 per t of C considering the net accumulation of 6.6 Mt C per year in biomass. Aesthetic beauty of the landscape is estimated as 10,665.3 million and pollination service value is accounted to be Rs. 25,610 million/yr. Natural ecosystems also provide unlimited opportunities for environmental education and function as field laboratories for scientific research (de Groot et al. 2002).

Sacred groves present in varied ecosystems viz., evergreen and deciduous forests, hill tops, valleys, mangroves, swamps and even in agricultural fields in Uttara Kannada district represent varied vegetation and animal profiles (Ray et al. 2011, 2015). The protection of patches of forest as sacred groves and of several tree species as sacred trees leads to the spiritual function provided by the forest (Chandran 1993). Sacred groves also play an important role in the cultural service provided by the forest. The groves do not fetch any produce which can be used for direct consumptive or commercial purpose. Creation of hypothetical market fetches price worth Rs. 600/quintal for a woody species and Rs. 40/quintal for non-wood product. The value of sacred grove assessed through willingness to pay to preserve the sacred grove in Siddapur taluk of Uttara Kannada district (Panchamukhi et al. 2008), show the value of Rs. 7280/ per hectare.

The major threat to the forests today is deforestation caused by several reasons such as rise in the population, exploitation activities which include expansion of agriculture land, ranching, wood extraction, development of infrastructure. Shifting cultivation is considered to be one of the most important causes of deforestation (Myers 1984). The loss of biodiversity is the second most important problem in nearly every terrestrial ecosystem on Earth. This loss is accelerating driven by the over-exploitation of natural resources, habitat destruction, fragmentation and climate change (MEA 2003). Even though the Convention on Biological Diversity (CBD) has adopted a target of reducing the rate of biodiversity loss at global, regional and national levels by 2010 (Mace 2005), still the loss of biodiversity is at a high pace. Nearly, 75 percent of the genetic diversity of domesticated crop plants has been lost in the past century. About 24 percent of mammals and 12 percent of bird species are currently considered to be globally threatened. Despite the essential functions of ecosystems and the consequences of their degradation, ecosystem services are undervalued by society, because of the lack of awareness of the link between natural ecosystems and the functioning of human support systems.

Objectives

Forest ecosystems are critical habitats for diverse biological diversity and perform array of ecological services that provide food, water, shelter, aesthetic beauty, etc. Valuation of the services and goods provided by the forest ecosystem would aid in the micro level policy design for the conservation and sustainable management of ecosystems. Main objective of the study is to value the forest ecosystems in Uttara Kannada forest. This involved computation of total economic value (TEV) of forest ecosystem considering provisioning, regulating, supporting and information services provided by the ecosystem.

MATERIAL AND METHODS

Study Area

The Uttara Kannada district with a spatial extent of 10,291sq.km is situated at $74^0$9' to 75^0 10' E and $13^0$55' to $15^0$31' N in the north-western part of Karnataka state (Fig. 2). It extends from north to south to a maximum of 180 km, and from west to east a maximum width of 110 km. Uttara Kannada is bounded by Belgaum district and Goa state in the north, Dharwad and Haveri districts in the east, Shimoga and Udupi districts in the south and the Arabian Sea to the west.

The district has the coastline of 120 km. in the western part. The coast stretches in a long nearly straight line to the south except the shallow Karwar and Belekeri bays (Kamath 1985). The topography of the region can be divided into three distinct zones. The coastal zone, comprising of a narrow strip of the coastline is relatively flat and starts sloping gently upwards towards the east. The ridge zone abruptly rises from the coastal strip, is much more rugged and is a part of the main range of the Western Ghats. Compared to other parts of the Western Ghats, the altitude of the ridge is much lesser and rises to about 600msl. The third zone is the flatter, geographically more homogenous zone that joins the Deccan plateau.

The four major rivers of the district are Kalinadi, Gangavali, Aghanashini and Sharavathi. Varada, Venkatapura, Belekeri, Badagani are some of the minor river and streams in the district. Apart from these river system, large number of other wetlands such as lakes, reservoirs, ponds, puddles, lateritic bogs, wet grasslands, marshes, swamps are present in the district (Ramachandra and Ganapathy 2007; Rao et al. 2008). The district comprises of 11 *Taluks* namely, Supa, Haliyal, Mundgod, Yellapur, Karwar, Ankola, Sirsi, Siddapur, Honnavar, Kumta and Bhatkal. Supa is the largest taluk in Uttara Kannada in terms of area. The district has 11 *taluks* (an administrative sub-division for dissemination of the government programmes) spread over the

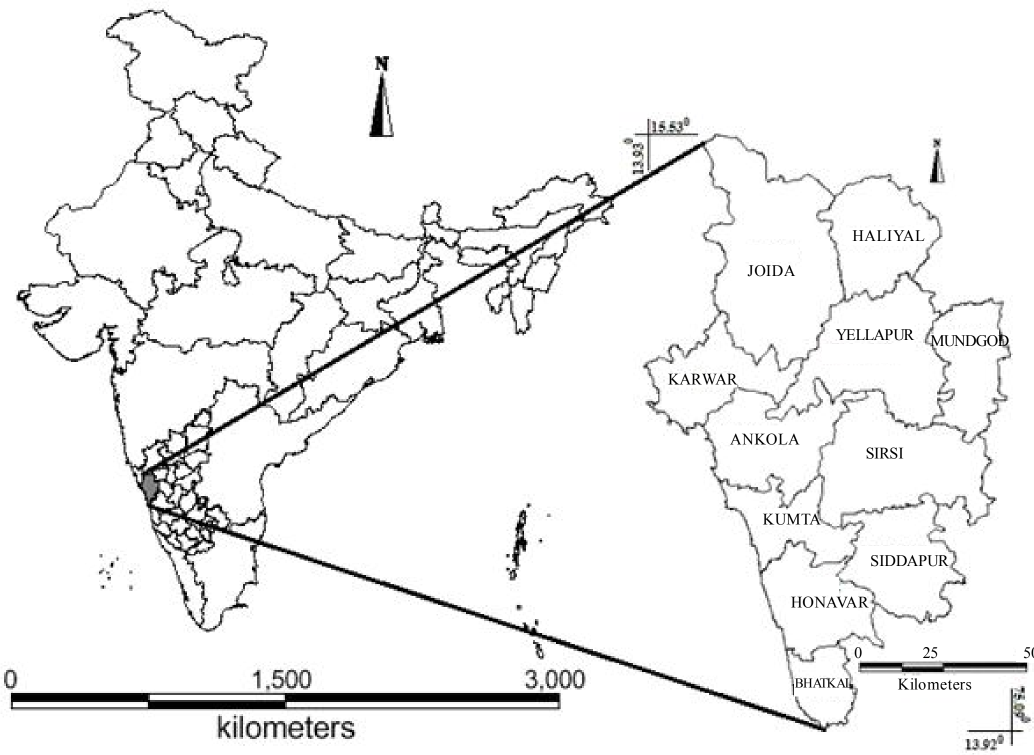

Fig. 2. Uttara Kannada district, Karnataka state

three regions described above. The coast lands comprise of Karwar, Ankola, Kumta, Honnavar and Bhatkal taluks, the forested interior areas which are part of the Western Ghats range comprises of Supa, Sirsi, Siddapur, major parts of Yellapur taluk and the eastern areas which are plateau regions comprises of Haliyal, Mundgod and parts of Yellapur taluks. The climate of the region is tropical monsoon. Generally, the weather is hot and humid in the coastal areas throughout the year. The district experiences south-west monsoon and the rainfall are received mostly between June and September. Average annual rainfall in the district is about 2887 mm which ranges from 4172 mm in Bhatkal *taluk* to 1345 mm in Haliyal taluk. Population density ranges from 0.26 (Supa) to 4.28 (Bhatkal) persons/hectare with an average of 1.69 ±1.09. Spatial extent of forest ranges from 48.14 (Mundogod) to 86.5 (Supa) percent of the respective *taluk.*

Vegetation of Uttara Kannada District

There are mainly five different types of forest in the district – Evergreen, Semi-evergreen, Moist deciduous, Dry deciduous and Scrub land. The district's high rainfall supports lush green forests, which cover approximately 70 percent of the district. Uttara Kannada vegetation is divided into 5 broad zones by Daniels (1989) namely, Coastal zone, Northern evergreen zone, Southern evergreen zone, moist deciduous zone and dry deciduous zone. Uttara Kannada has 21 habitat types according to Daniels (1989), based on a study in 181, 5x5 km grids. They are, Evergreen forests (65 percent), Rocky cliffs (14%), Degraded evergreen thickets (17%), Moist grasslands (9%), Moist/dry teak (29%), Humid *betelnut* (50%), Freshwater marshes (25%), Exotic tree plantations (25%), Rivers (10%), Hill streams (55%), Coastline (9%), Beaches (6%), Coastal coconut (9%), Estuaries (5%), Scrub (2%), Dry deciduous forest (5%), Moist/Dry Bamboo forests (6%), Moist/Dry cultivation (31%), Moist/Dry Eucalyptus (10%), Moist Deciduous forests (18%), Urban population > 1000 (22%). However, in the last few years the evergreen forests of the district have undergone tremendous changes. Most of the evergreen forested area has been transformed into semi-evergreen forests, and some have been converted into plantations such as, Teak, Arecanut, Acacia spp., etc. (Ramachandra and Ganapathy 2007). It is found that evergreen and semi-evergreen to moist deciduous forest types predominate the forested area of Uttara Kannada (Fig. 2). The complete stretch of the central ridge zone (Ghats section), which was once dominated by the evergreen forests, is now dominated by the semi-evergreen forest. Evergreen is seen in patches mainly towards the south-west and in the Ghats section. Moist deciduous is seen in almost all places distributed throughout the district. It is more common in the eastern Sirsi, south of Yellapur, eastern Siddapur and western region of the coastal taluks. Dry deciduous forests are spotted in the taluks of Mundgod, Haliyal, western Sirsi and north-eastern part of Yellapur.

Figure 3 depicts the land use in the district based on the analysis of IRS P6 (Indian remote sensing) multi spectral data of spatial resolution 5.8 m. Area under forest covers 72 percent of the total geographic area of the district (Fig. 4). The forest cover ranges from 50 percent in Mundgod *taluk* to 88 percent in Supa and Yellapur

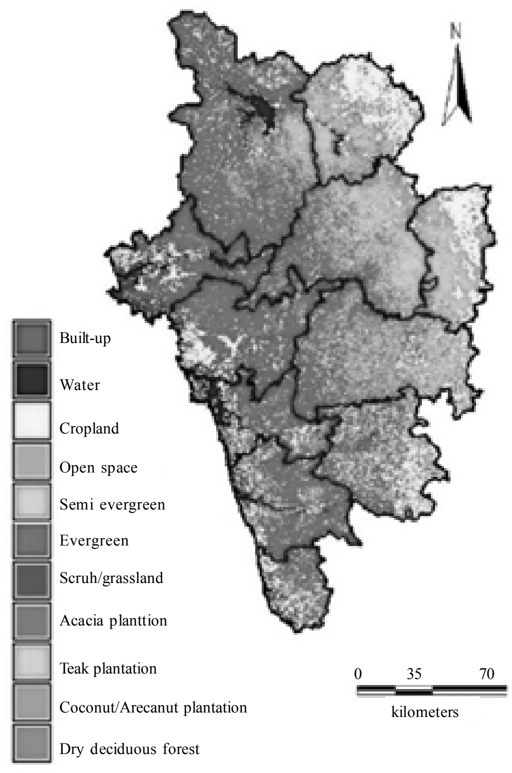

Fig. 3. Land-use classification map of Uttara Kannada district

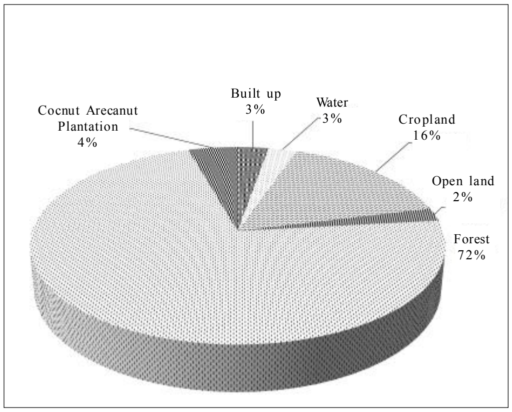

Fig. 4. Share of different land use in Uttara Kannada district

Source: Author

taluks. The forest was categorized as evergreen, semi evergreen to moist deciduous, dry deciduous, teak and bamboo plantations, scrub forest and grasslands and acacia plantations. Table 1 illustrates that about 53 percent of the total forest land in the district is of evergreen type followed by 21 percent of semi-evergreen to moist deciduous forests. Dry deciduous forests are very less and are found in the eastern part of Haliyal and Mundgod taluk. There has been a significant amount of forest loss owing to various developmental activities across district and conversion of natural forests into plantations. Taluks such as Ankola, Bhatkal, Honnavar, Karwar, Siddapur and Supa has rich presence of evergreen forest out of the total forest area, whereas the least share of evergreen forest is found in Mundgod and Haliyal *taluks.* The share of semi evergreen to moist deciduous forest out of total forest area is found to be highest in Sirsi taluk. A considerable share of forest area in Haliyal and Mundgod *taluks* is comprised of plantations of teak, acacia and bamboo.

Method

The framework for incorporating the true value of forest requires thorough valuation of the benefits derived from forest ecosystems. *Taluk* wise forest valuation has been done through the quantification of goods, estimation of values based on the market price, and compilation of values of ecosystem services from literatures. Total economic value of the forest ecosystems in Uttara Kannada has been done considering i) provisioning services, ii) regulating services, iii) supporting services and iv) information services (MEA 2003). Various components of provisioning, regulating, cultural and supporting services are listed in Figure 5. The research includes compilation of data from primary (field investigations) and secondary sources (government agencies, published scientific literatures in peer reviewed journals). Data on quantity of timber and non – timber forest products harvested were collected from Divisional Office (Sirsi) of Karnataka Forest Department, Government of Karnataka. Data on the prices of various marketed forest products were collected through market survey. Data on various other provisioning goods and services were compiled from literature pertaining to ecological and socio-economic studies in the district and also through interview with the subject experts.

Framework of Valuation

Figure 6 outlines the method adopted for valuing forest ecosystems (taluk wise) in Uttara Kannada district. The work entails:

i. Assessment of Different Land Uses in the District: This was done considering remote sensing data of space borne sensors (IRS P6) with spatial resolution of 5.8m. The remote sensing data were geo-referenced, rectified and cropped pertaining to the study area. Geo-registration of remote sensing data has been done using ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also from known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India (1:50000, 1:250000).

Table 1: Vegetation Distribution in Uttara Kannada

Evergreen forest	*Semi evergreen to moist deciduous forest*	*Dry deciduous forest*	*Teak / Bamboo plantations*	*Scrub forest/ Grass lands*	*Acacia/ Eucalyptus plantations*	*Total*
53.02	20.60	0.19	4.75	4.19	17.24	100.00

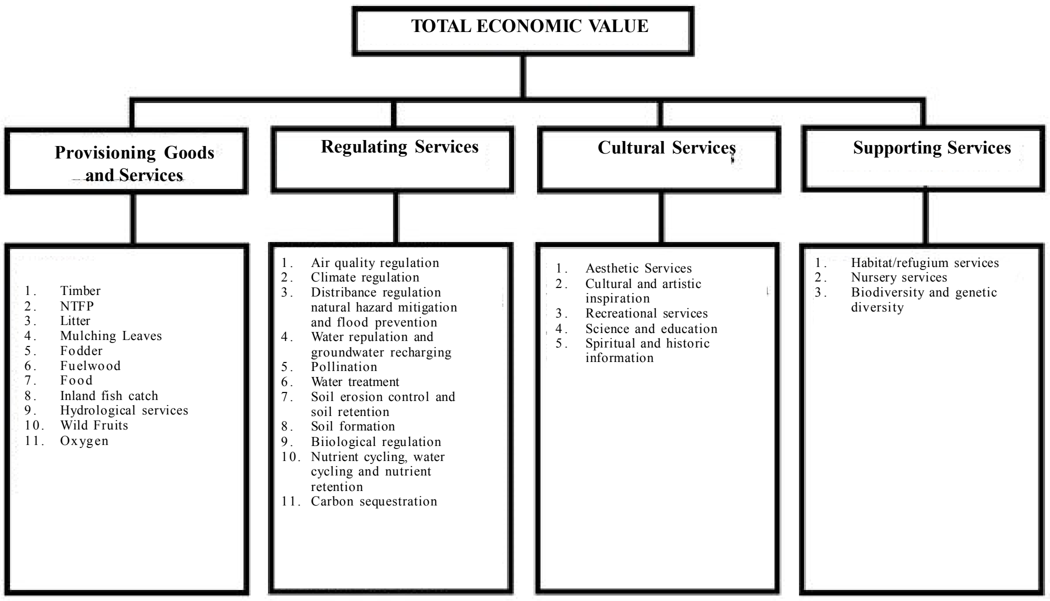

Fig. 5. Classification of forest ecosystem goods and services
Source: Author

Remote sensing data analysis involved i) generation of False Colour Composite (FCC) of remote sensing data (bands – green, red and NIR). This helped in locating heterogeneous patches in the landscape; ii) selection of training polygons (these correspond to heterogeneous patches in FCC) covering 15 percent of the study area and uniformly distributed over the entire study area; iii) loading these training polygons co-ordinates into pre-calibrated GPS; vi) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field; iv) supplementing this information with Google Earth (http://earth.google.com); and v) 60 percent of the training data has been used for classification, while the balance is used for validation or accuracy assessment. Land use analysis was carried out using supervised pattern classifier - Gaussian maximum likelihood algorithm based on probability and cost functions (Ramachandra et al. 2012, 2016a). Accuracy assessment to evaluate the performance of classifiers was done with the help of field data by testing the statistical significance of a difference, computation of kappa coefficients and proportion of correctly allocated cases. Statistical assessment of classifier performance based on the performance of spectral classification considering reference pixels is done which include

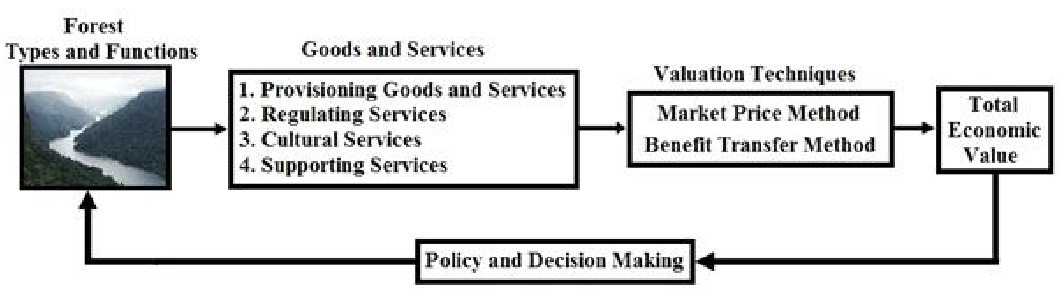

Fig. 6. Framework for valuation of goods and services from forest ecosystem
Source: Author

computation of kappa (κ) statistics and overall (producer's and user's) accuracies.

The forest was classified as evergreen, semi evergreen to moist deciduous, dry deciduous, teak and bamboo plantations, scrub forest and grasslands and acacia plantations. The extent of forest fragmentation was assessed for estimating the carbon sequestration potential of forests through the quantification of the extent of interior and fragmented forests at *taluk* level.

ii. Quantification of Goods and Services: compilation of data from primary (field investigations) and secondary sources (government agencies, published scientific literatures in peer reviewed journals). Data on quantity of timber and non – timber forest products harvested were collected from Divisional Office (Sirsi) of Karnataka Forest Department, Government of Karnataka.

iii. Valuation of Goods and Services: Various functions of forests are the results of interaction between structure and processes, which may be physical (for example, infiltration of water, sediment movement), chemical (for example, reduction, oxidation) or biological (for example, photosynthesis and de-nitrification). Further, various goods and services obtained from the functioning of forest ecosystem were classified as provisioning goods and services, regulating services, cultural services and supporting services. The study uses two approaches of valuation for the computation of TEV of forest ecosystem, namely: 'market price' method and 'benefit transfer' method of valuation.

a. Market Price: This technique estimates the economic values of those goods and services that are bought and sold in established markets. Valuation of provisioning goods and services has been done through 'market price' valuation. For those goods and services which do not pass through market transaction process (viz. water utilization for irrigation and power generation, ecological water, wild fruits) well adopted technique of proxy/shadow prices have been used.

b. Benefit Transfer: This technique involves the application of value estimates, functions, data and/or models developed in one context to address a similar resource valuation question in an alternative context. The cost of surveys in terms of time and money could be avoided by this approach. Benefit transfer method of valuation is used to compute the value of regulating, cultural and supporting services. Some of the components of these services were computed based on unit values of those services for different types of forest based on the discussion and interview with subject experts.

***iv. Quantification of Goods and Services*:** The detailed procedure of valuation of different components of ecosystem services is discussed below:

a. Provisioning Services from Forest Ecosystem: Goods derived from the forests are quantified as follows:

- *Timber:* Timber is an important component of value on forestland properties. In many cases, the value of the timber can be several times the value of the land. Timber includes rose wood, teak wood, jungle wood, etc. Timber is mainly prominent in deciduous forest while it is found in less amount in Evergreen forest patches. Plantation forest is mainly abundant in timber producing trees like Acacia, Teak etc. Industrial produce is also present from the forest which includes round wood, soft wood, match wood etc. The data regarding the quantity of timber harvested and sold was obtained from the Karnataka Forest department (KFD 2015) and the valuation is based on the current market price.
- *Non Timber Forest Product:* The data on the harvesting of non-timber forest product was obtained from the Forest department. The total value of NTFP includes the value of a) NTFPs extracted by Forest Department, b) NTFPs collected by households (Murthy et al. 2005), c) bamboo extracted by the Karnataka Forest department, d) annual bamboo productivity in the forest (NABARD 2015; WCPM 2016), e) cane extracted by Forest department and f) annual cane productivity in the forest .
- *Litter:* Litter is used as manure in horticulture and agriculture fields. Quantity of litter productivity per year for different taluks was based on the earlier work (Ramachandra et al. 2000).
- *Mulching Leaves:* Mulching leaves is used as manure in arecanut gardens. Per year requirement of mulching leaves from forest were quantified by the area of areca-

nut gardens in each taluka multiplied by the minimum quantity of mulching leaves per hectare of arecanut garden.

- *Fodder:* Total value of fodder supplied from forest were quantified by using the data from literature (Prasad et al. 1987a,b) on herb layer productivity in different types of forests, extent of different types of forest and unit market price of the fodder in the district.
- *Medicinal Plants:* Various medicinal plants used by the local people were identified (Harsha et al. 2005; Hegde et al. 2007) and the value of medicinal plants per unit area of forest area (Simpson et al. 1996; Database of Medicinal Plants 2015; SCIL 2015) was extrapolated to different types of forest in the district.
- *Fuel Wood:* The total value of fuel wood includes the value of fuel wood used for domestic purpose, that is, for cooking and water heating and also the value of fuel wood used for various industrial and commercial purposes like jaggery making, areca processing, cashew processing, restaurants and bakery, parboiling, cremation, etc. The quantity of fuel wood for domestic usage in different locations of the district was obtained from Ramachandra et al. (2000) and the quantity of fuel wood required for various other purpose were based on field experiments (Ramachandra et al. 2000; Ramachandra 1998).
- *Food:* 22 varieties of food products derived from forest were identified and the value of food extracted per unit area of forest obtained from literature (Hebbar et al. 2010; PSP 2016; SCIL 2015) was extrapolated to the total forest area in the taluk. Also, the household honey collection which is an important provisioning service from forest was quantified (Ramachandra et al. 2012) for all *talukas* and valued.
- *Inland Fish Catch:* Inland fishing is an important economic activity and a determinant of nutritional requirement of large number of people. Inland fishing happens in rivers, rivulets, streams, reservoirs, lakes, etc. which are inseparable part of the forest area in the district. The quantities of inland fish catch in different taluks were obtained from Fisheries Department, The Government of Karnataka and the economic value of it was determined.
- *Hydrological Services:* Most of the water resources come from the forested catchments. Hydrological services is quantified by the quantity of domestic water utilization, water for irrigation purpose (Ramachandra et al. 1999, 2012, 2016a), water for industrial use and water used for power generation (5 hydro power stations and 1 nuclear power station). The quantity of water required for sustenance of forest ecosystem that is, ecological water available for different types of forest was quantified as per the following equation (Ramachandra et al. 1999; 2016a; 2016b; Raghunath 2006; KPCL 2016; NPCIL 2016; Ray et al. 2015).
- Quantity of Ecological Water = Run off Coefficient x Annual Precipitation x Forest Area

The value of 'runoff coefficient' for different types of forest varied from 0.1 to 0.4.

- *Wild Fruits*: Information on various wild fruits were obtained from literature (Hebbar et al. 2010; Bhat et al. 2003). The productivity of wild fruits was estimated based on Bhat et al. (2003), transect survey data in different types of forest and information from local people. For economic valuation of wild fruits proxy price (in comparison with the price of fruits collected as NTFP) was used.
- *Oxygen Provision*: Value of oxygen provision from forests was quantified based on the values of oxygen production per hectare of subtropical forest (Maudgal and Kakkar 1992).

These provisioning services were valued as per the equations in Table 2 based on market price method.

b. *Regulating Services from Forest Ecosystem:* Regulating services provide many direct and indirect benefits to humans. The maintenance of the Earth's biosphere in a hostile cosmic environment depends on a delicate balance between these regulating services (de Groot et al. 2002). However, regulating services unlike provisioning services poses much greater challenges in valuation. Though regulating services are seldom marketed, the economy heavily depends upon the utility of these services. In the present study,

Table 2: Valuation method for comonents of provisioning services of forest

Provisioning services	*Equation*	*Details*
Timber	$V_{Timber} = \sum_{i=1}^{11}\sum_{j=1}^{6} Q_{i,j} \times P_{i,j}$	Q=Quantity of timber; P = Price of timber; i = no. of taluks; j = variety of timber
NTFP	$V_{NTFP} = \sum_{i=1}^{11}\sum_{j=1}^{30} Q_{i,j} \times P_{i,j}$	Q=Quantity of NTFP; P = Price of NTFP; i = no. of taluks; j = variety of NTFP
Litter	$V_{Litter} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of litter; P = Price of litter; i = no. of taluks
Mulching Leaves	$V_{Mulch} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of mulching leaves; P = Price of mulching leaves; i = no. of taluks
Fodder	$V_{Fodder} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fodder; P = Price of fodder; i = no. of taluks
Fuelwood	$V_{Fuelwood} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fuelwood; P = Price of fuelwood; i = no. of taluks
Food	$V_{food} = \sum_{i=1}^{11}\sum_{j=1}^{22} Q_{i,j} \times P_{i,j}$	Q=Quantity of food; P = Price of food; i = no. of taluks; j = variety of food product
Inland Fish Catch	$V_{Fish} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of fish catch; P = Price of fish; i = no. of taluks
Hydrological Services	$V_{water} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of water utilization for different purpose; P = Price of water used for different purpose; i = no. of taluks
Wild Fruits	$V_{wild\ fruits} = \sum_{i=1}^{11} Q_i \times P_i$	Q=Quantity of wild fruits; P = Price of wild fruits; i = no. of taluks
Oxygen	Value of oxygen provision from forests was quantified based on the values of oxygen production per hectare of subtropical forest (Maudgal and Kakkar 1992).	

ten variables of regulating services were quantified as per the published literatures (Costanza et al. 1997; Maudgal and Kakkar 1992; Seema and Ramachandra 2010), given in Table 3 and the value of carbon sequestration was estimated for each taluk based on the biomass stock and productivity (Ramachandra et al. 2000, 2004; Maudgal and Kakkar 1992; Seema and Ramachandra 2010).

Table 3: Unit values of regulating services from forests (Rs. per hectare)

Regulating services	*Unit value (Rs. per hectare)*
Air quality regulation	6384
Climate regulation	10704
Disturbance regulation, natural hazard mitigation and flood prevention	217872
Water regulation and groundwater recharging	261360
Pollination	1200
Waste treatment	4176
Soil erosion control and soil retention	11760
Soil formation	480
Biological regulation	1104
Nutrient cycling, water cycling and nutrient retention	44256

The value of carbon sequestration has both flow and stock value. The productivity of biomass per hectare per year and the volume of standing biomass for different types of forests of Uttara Kannada were obtained from literature (Ramachandra et al. 2000, 2004; Seema and Ramachandra 2010). The volume of carbon was computed with the assumption that 50 percent of the dry biomass contains carbon (Seema and Ramachandra 2010). The value of carbon sequestration was calculated by considering 10 Euros per tonne of CO_2 (EEC 2012). The total value of carbon sequestration per year for different taluks includes the value of per year increment in the carbon sequestration and per year value of interest (considering 5% interest rate) over the total stock/ volume of carbon in the forest till date.

c. Cultural Services from Forest Ecosystem: Forest has a high cultural value; the main reason can be attributed to the aesthetic

Table 4: Unit values of cultural services from forest

S. No.	*Cultural services*	*Value (in Rs./ hectare)*	*Source*
1.a	Recreational services (for interior evergreen forest)	2,88,000	de Groot et al. 2002
1.b	Recreational services (for other types of forest)	28,944	Costanza et al. 1997
2.a	Spiritual and historic information (for interior evergreen forest)	72,000	Discussion with subject experts
2.b	Spiritual and historic information (for interior evergreen forest)	1,200	de Groot et al. 2002
3	Aesthetic Services	1,500	Discussion with subject experts
4	Cultural and artistic inspiration	480	Discussion with subject experts
5	Science and education	48,000	Discussion with subject experts

beauty, recreational benefit and Kan forest which are the sacred groves present in the district. Sacred groves are communally-protected forest fragments with significant religious connotations (Ray and Ramachandra 2011; Ray et al. 2015). Further, recreational benefits provided by the forest include gaming, walking, hunting etc. Aesthetic beauty of the forest is valuable, the presence of waterfalls and caves adds to the aesthetic value in the district. Science and educational value provided by the forest are also indispensable. The unit value for the services, listed in Table 4 was derived from de Groot et al. (2002) and Costanza et al. (1997), and also the values were finalized in consultation with subject experts.

d. *Supporting Services From Forest Ecosystem:* The supporting service provided by the forest includes the habitat/refugium function, nursery function and biodiversity and genetic diversity function. The forest provides living space for a large number of plants and animals thus, playing an important role in the refugium function. It also acts as a nursery for immense plants and animals. The forest also serves as a store house of information. To maintain the viability of this genetic library, the maintenance of natural ecosystems as habitats for wild plants and animals is essential. The unit value of habitat/ refugium function and nursery function were derived from literature and the unit value of biodiversity and genetic diversity was estimated (Table 5) based on the flow value of selected provision services that represent the least value stock of biodiversity and genetic diversity.

Total Economic Value

The total economic value (TEV) of forest ecosystem is obtained by aggregating provision goods and services (provisioning, regulating, cultural and supporting services).The total economic value that has been calculated for one year is divided by the area of forest in each taluk to obtain the per hectare value of forest in respective *taluk.*

RESULTS AND DISCUSSION

Ecosystem services and the natural capital stocks of the Western Ghats forests make significant direct and indirect contributions to national economies and human welfare. Forests, both natural and planted, and including trees spread across the terrain, have a critical role in the ecology, aesthetics and recreational benefits. The goods and services derived from forest ecosystem are categorized as provisional goods and services, regulating services, cultural services and supporting services (MEA 2003). Land

Table 5: Unit value of supporting services from forest

S. No.	*Supporting services*	*Value (in Rs./ hectare)*	*Source*
1	Habitat/ refugium services	73104	de Groot et al. 2002
2	Nursery services	9360	de Groot et Al. 2002
3	Biodiversity and genetic diversity	40000	Calculated from the flow value selected provisioning services like NTFP, medicinal plants, etc.

Table 6: Talukwise area under different types of forest (in hectares)

S. No.	Taluk	Evergreen forest	Semi evergreen to Moist deciduous	Dry deciduous forest	Teak / Bamboo Plantations	Scrub forest/ Grass lands	Acacia/ Eucalyptu splantations	Total
1	Ankola	53943	8227	0	62	4598	6911	73741
2	Bhatkal	15189	5335	0	130	230	851	21734
3	Haliyal	9853	11609	1253	7720	2532	16062	49030
4	Honnavar	36782	6403	0	0	1508	4007	48700
5	Karwar	39176	9264	0	0	1878	4097	54414
6	Kumta	19873	10697	0	0	746	4615	35931
7	Mundgod	1161	3047	171	10080	1554	16144	32156
8	Siddapur	35882	10214	0	124	3479	9615	59315
9	Sirsi	24666	44070	0	1670	2620	20133	93159
10	Supa	124118	21923	0	492	6090	10882	163504
11	Yellapura	34003	22541	0	15108	5987	35017	112656
	District Total	394645	153330	1424	35385	31223	128334	744341
	%	53.02	20.60	0.19	4.75	4.19	17.24	100.00

use analysis (Table 6) show that Supa taluk has highest forest area (1635 sq.km) and Bhatkal has lowest spatial extent of forests (217 sq.km). Evergreen to semi evergreen type of vegetation cover is about 3946 sq.km (53 %), followed by moist deciduous type (1533 sq.km). Area under monoculture plantations is about 1283 sq.km (17.24%).

Provisioning Goods and Services

Based on the consideration and inclusion of various components in ecological perspectives, total value of provisioning goods and services are presented in scenarios as follows:

- *Scenario - I:* provisional services include timber, NTFP, litter and mulching leaves, fodder, medicinal plants, fuel wood, food, inland fishing and hydrological services;
- *Scenario - II:* components in Scenario-I and wild fruits;
- *Scenario - III:* components in Scenario-II and oxygen services;

Table 7: Provisioning goods and services (different scenarios) for Uttara Kannada

Scenario	Value of provisioning goods and services (in Rs. crores)	Values of provisioning goods and services (Billion Rs)
Scenario I	9707	97.07
Scenario II	11842	118.42
Scenario III	15171	151.71

The estimated total value of provisioning goods and services for Uttara Kannada district per year for three different scenarios are presented in Table 7, which reveals the value of goods and services from forests in Uttara Kannada district ranges from INR 97.07 billion per year (scenario 1) to 151.71 billion per year (scenario 3).

Goods derived from the forests were quantified as discussed earlier and details are:

i. *Timber:* Timber accounts to Rs. 1,457 crores per year with the share of 10 percent in scenario – III of the total value of provisioning goods and services obtained from the forest.

ii. *NTFP:* NTFP being the largest contributor among all the components of provisioning goods and services is estimated at Rs. 3,601 crores per year for the district.

iii. *Litter and Mulching Leaves:* Litter and mulching leaves which is a vital component of sustainable agricultural system of the district is valued at Rs. 689 crores per year.

iv. *Fodder:* The value of total fodder productivity in the forests of the district is valued at Rs. 205 crores per year.

v. *Medicinal Plants:* The value of medicinal plants that has been estimated from the benefit transfer method and extrapolated to the different types of forest is found to be worth of Rs. 25 crores per year.

vi. *Fuel Wood:* Forest, being the important source of energy for domestic and various commercial purposes in the district supplies fuel wood of Rs. 366 crores per year.

vii. *Food:* The value of various food products extracted from forest is of worth Rs. 59 per year. Further the inland fishing in the district is valued at Rs. 22 crores per year.

viii. *Hydrological Services:* The total value of water usage for domestic purpose, industrial purpose, agricultural, water requirement for livestock, power generation and ecological water was termed as hydrological services from the forests. It was found that the forests in the district provide hydrological services of worth Rs. 2,313 crores per year.

ix. *Wild Fruits:* Wild fruits being the important component in ecological sustenance of forest ecosystem are being valued at Rs. 1,922 crores per year that is obtained from the forests of entire district.

x. *Oxygen:* The value of oxygen which is computed by benefit transfer method. The result of the study shows that the total forests in the district supplies the oxygen to the atmosphere of worth Rs. 3,000 crores per year. Further, 10 percent of the total value of provisioning services supplied from forest being considered as miscellaneous benefits that are derived from forest ecosystem is of value Rs. 1517 crores per year (for scenario – III).

In all the three scenarios, NTFP is the major contributor to the total value. The share of the value of food, inland fishing, medicinal plants, fuel wood, fodder, litter and mulching leaves varies from 14 percent in Scenario - I to 8 percent in Scenario - III. These goods have an important bearing on the livelihood of people and especially the livelihood of local people. The value of wild fruits and oxygen provision comprises to about thirty five percent share in the total value in Scenario – III. These components are often neglected in valuation of forest and policy making but they play an important role in ecosystem sustenance, protection of biodiversity and thus, in human wellbeing in the long run. Table 8 presents the taluk-wise breakup in the total provisioning goods and services. This illustrates that Supa taluk contributes the high-

Table 8: Value of various provisioning goods and services across taluks (in Rs. crores)

S. No.	*Provisioning goods and services*	*Ankola*	*Bhatkal*	*Haliyal*	*Honnavar*	*Karwar*	*Kumta*	*Mundgod*	*Siddapur*	*Sirsi*	*Supa*	*Yellapur*	*Total*
1	Timber	10.18	2.64	267.47	104.34	77.23	174.38	271.00	62.52	311.31	95.28	80.45	1456.80
2	NTFP	473.83	135.84	98.93	324.02	345.36	180.37	17.43	333.55	278.31	1095.93	317.04	3600.61
3	Litter and Mulching leaves	48.92	13.29	57.13	41.19	33.80	27.85	52.39	62.41	102.35	139.88	110.25	689.44
4	Fodder	24.18	6.70	9.92	15.11	17.14	10.38	2.96	18.00	24.27	52.09	23.80	204.55
5	Medicinal plants	2.88	0.92	1.04	1.96	2.20	1.38	0.23	2.13	3.12	6.65	2.66	25.17
6	Fuelwood	24.99	34.17	45.05	38.59	32.35	35.57	25.81	34.17	55.45	15.51	24.60	366.26
7	Food	5.65	1.91	3.98	4.81	4.42	3.12	2.57	4.81	7.26	12.08	8.43	59.04
8	Inland fishing	0.77	0.35	2.06	4.02	1.54	1.62	0.73	2.35	1.83	4.34	2.13	21.74
9	Hydrological services	172.74	140.66	341.64	279.89	118.27	185.32	127.89	218.26	319.62	223.46	184.85	2312.58
10	Wild fruits	228.20	71.96	71.62	157.08	174.01	104.36	13.51	164.75	213.22	531.33	191.87	1921.91
11	Oxygen	303.97	94.24	178.13	207.19	230.47	150.88	106.14	240.13	372.87	693.21	418.56	2995.81
12	Others	144.03	55.85	119.65	130.91	115.20	97.25	68.96	127.01	187.74	318.86	151.63	1517.09
	Total	1440.35	558.51	1196.54	1309.11	1152.00	972.47	689.60	1270.08	1877.36	3188.63	1516.25	15170.90

Table 9: Value of various regulating services across taluks (in Rs. crores)

S. No.	Taluk	Ankola	Bhatkal	Haliyal	Honnavar	Karwar	Kumta	Mundgod	Siddapur	Sirsi	Supa	Yellapur	Total
1	Air quality regulation	47	14	31	31	35	23	21	38	59	104	72	475
2	Climate regulation	79	23	52	52	58	38	34	63	100	175	121	797
3	Disturbance regulation, natural hazard mitigation and flood prevention	1607	474	1068	1061	1186	783	701	1292	2030	3562	2454	16217
4	Water regulation and groundwater recharging	1927	568	1281	1273	1422	939	840	1550	2435	4273	2944	19454
5	Pollination	9	3	6	6	7	4	4	7	11	20	14	89
6	Waste treatment	31	9	20	20	23	15	13	25	39	68	47	311
7	Soil erosion control and soil retention	87	26	58	57	64	42	38	70	110	192	132	875
8	Soil formation	4	1	2	2	3	2	2	3	4	8	5	36
9	Biological regulation	8	2	5	5	6	4	4	7	10	18	12	82
10	Nutrient cycling, water cycling and nutrient retention	326	96	217	216	241	159	142	263	412	724	499	3294
11	Carbon sequestration	494	153	143	301	375	209	54	307	391	1171	417	4016
	Total value of regulating services	4619	1368	2885	3025	3419	2219	1853	3625	5602	10316	6718	45647

Table 10: Talukwise value of cultural services (in Rs. crores)

S. No.	*Taluk*	*Aesthetic services*	*Cultural andartistic inspiration*	*Recreational services*	*Science and education*	*Spiritual andhistoric information*	*Total*
1	Ankola	11	4	1196	354	277	1841
2	Bhatkal	3	1	349	104	81	539
3	Haliyal	7	2	243	235	34	522
4	Honnavar	7	2	599	234	131	973
5	Karwar	8	3	893	261	208	1373
6	Kumta	5	2	437	172	95	713
7	Mundgod	5	2	103	154	7	271
8	Siddapura	9	3	584	285	120	1000
9	Sirsi	14	4	656	447	117	1239
10	Supa	25	8	2885	785	679	4381
11	Yellapura	17	5	824	541	150	1536
	District Total	112	36	8770	3573	1897	14388

Table 11: Talukwise value of supporting services (Rs. in crores)

S. No.	*Taluk*	*Habitat/ refugium Services*	*Nursery services*	*Biodiversity and genetic diversity*	*Total*
1	Ankola	539	69	295	903
2	Bhatkal	159	20	87	266
3	Haliyal	358	46	196	600
4	Honnavar	356	46	195	596
5	Karwar	398	51	218	666
6	Kumta	263	34	144	440
7	Mundgod	235	30	129	394
8	Siddapura	434	56	237	726
9	Sirsi	681	87	373	1141
10	Supa	1195	153	654	2002
11	Yellapura	824	105	451	1380
	District Total	5441	697	2977	9115

est amount of provisioning goods and services with Rs. 3,188 crores per year (21% of the district), while Bhatkal taluk contributes the least with the provisional services of Rs. 558 crores per year (4 % of the district).

Regulating Services

Regulation service quantification includes the estimated value of carbon sequestration in each taluk and other regulation services (Table 3 in methods section) multiplied by the forest area. The total value of regulating services in the district from forest ecosystems estimated at Rs. 45,657 crores per year. Table 9 shows the share of each taluks in the district's regulating services. Regulating services such as disturbance regulation, natural hazard mitigation and flood prevention, water regulation and groundwater recharging, and carbon sequestration has the major share in the regulating services provided by the forest ecosystem.

Cultural Services

The cultural services from forest can be aesthetic, recreational, spiritual, science and education. The district of Uttara Kannada is rich in places of recreational interest. There are immense number of waterfalls like Jog falls, Lalguli falls, Magod falls, Sathodi falls and Unchalli falls which adds to recreational and aesthetic values. The recreational sites also include the Anashi-Dandeli Tiger Reserve, Attiveri bird sanctuary and caves in Yana, Kavala, Uluvi, Sintheri, etc. The spiritual value of the Uttara Kannada district is also high due to the presence of many temples and pilgrimage centres like Gokarna, Murdeshwar, and Dhareshwar, Idagunji, Banavasi, etc. The cultural and heritage function is another important cultural service provided by forest. The presence of sacred groves is important for the cultural services as there are many cultural beliefs associated with the sacred groves in India. Some groves have valuable timber in

Table 12: Total economic value goods and services from forest ecosystem in Uttara Kannada district (in Rs. crores)

Scenario	*Provisioning services*	*Regulating services*	*Cultural services*	*Supporting services*	*Total economic value*
Scenario - I	9,707	45,647	14,388	9,115	78,857
Scenario - II	11,842				80,993
Scenario - III	15,171				84,321

them but are not harvested for timber due to sacred beliefs. The taluks of Siddapur and Sirsi in Uttara Kannada district have higher cultural values as the region is rich in sacred grooves. The presence of wild life sanctuaries and grooves in turn increases the educational value of the forest ecosystem. The unit value of different components of cultural services was as per Table 4, considering the conditions and type of forests in Uttara Kannada. The total cultural value of the district was estimated at Rs. 14,388 crores. Talukwise value of each component of cultural services and total value of cultural services is presented in Table 10.

Supporting Services

Table 11 lists taluk wise values of supporting services. The components of supporting services as per Table 5 were considered with the types and spatial extent of forest. The total value of supporting services obtained from forest ecosystem is estimated at Rs. 9,115 crores per year.

Total Economic Value of Forest Ecosystem in Uttara Kannada District

Total economic value (TEV) is calculated by aggregating provisioning services, regulating services, cultural services and supporting services. Total economic value (TEV) for all three scenarios and are presented in Table 12. The TEV of forest ecosystem in Uttara Kannada district is Rs. 78,857 crores, Rs. 80,993 crores and Rs. 84,321 crores for Scenario -I, II and III respectively.

Table 13 presents the share of different categories of services from forest ecosystem for scenario – III. Regulating services underpin the delivery of other service categories (Kumar et al. 2010), contributes to half of the share (54%) of the total economic value of forest ecosystem in the district. Provisioning services (18 %), cultural services (17 %) and supporting service (11 %) contributes to the other half of total economic value. Table 13 also shows that the total value of services per hectare of forest per year in the district. Value of provisioning services provided by the forest ecosystem is about Rs. 2,03,818 per hectare per year and the total value is about Rs. 11,32,832 per hectare per year which is implicit in the subsistence, income and local employment.

Supa taluks with Rs. 19,887 crores per year is the largest contributor (with 24 percent share) to the TEV of forest ecosystem in the district (Table 14) and Bhatkal taluk with the contribution of Rs. 2,732 crores per year is the least contributor (with 3% share) to the TEV of forest ecosystem of the district.

Total Economic Value of Forest Ecosystem and GDDP

Sector-wise district's Gross District Domestic Product (GDDP) is given in Table 15. GDDP of Uttara Kannada is about Rs. 5,978 crores and the contribution of forests' goods is about Rs.

Table 13: Total value of goods and services from forest ecosystem in Uttara Kannada

Services from forest ecosystem	*District value per year (in Rs. crores)*	*Value of services per hectare per year (in Rs.)*	*Percent share*
Provisioning services	15,171	2,03,818	18
Regulating services	45,647	6,13,254	54
Cultural services	14,388	1,93,296	17
Supporting services	9,115	1,22,464	11
Total Value	84,321	11,32,832	100

Table 14: Taluk wise total economic value goods and services from forest ecosystem

S. No.	*Taluk*	*TEV of forest ecosystem (in Rs. crores per year)*
1	Ankola	8803
2	Bhatkal	2732
3	Haliyal	5204
4	Honnavar	5904
5	Karwar	6610
6	Kumta	4344
7	Mundgod	3207
8	Siddapur	6622
9	Sirsi	9859
10	Supa	19887
11	Yellapur	11150
	District Total	84321

180 crores (3% of GDDP), in contrast to the estimated valuation of provisioning services (ranges from 9707 to 15171 crores per year). *This highlights the undervaluation of forest resources in the regional accounting system.* TEV of forest ecosystem of Uttara Kannada district is about Rs. 84,321 crores.

Table 15: GDDP of Uttara Kannada with sectors

Sector	*Sectoral contribution (in Rs. crores)*	*Sectoral share (in percent)*
Primary Sector (Agriculture, Forestry, Fishing, Mining)	1060	18
Forestry and Logging Sector	180	3
GDDP of Uttara Kannada	5978	100

Source: Directorate of Economics and Statistics, Government of Karnataka

The forest products included in the national income account framework includes: (a) Industrial wood (timber, match and pulpwood) and fuel wood and (b) minor forest products (Haripriya 2001). It includes only the recorded values by forest department and thus, all other benefits from forests are unaccounted in the national income. This necessitates relook at the current approach of computations of Gross Domestic District Product (GDDP), State Domestic Product (SDP) and Gross Domestic Product (GDP). Gross underestimation and non-accounting of natural resources and forest resources in particular is responsible for unsustainable utilization of natural resources. Under valuation of ecosystem goods and services is evident from GDDP of Rs. 5,978 crores in 2009-10 (at current prices), which accounts as the sectoral share of forests of Rs. 180 crores, contrary to the estimated valuation of provisioning services (ranges from 9707 to 15171 crores per year). TEV of forest ecosystem accounts to Rs. 84,321 crores per year.

CONCLUSION

Forest resources in the Uttara Kannada district has undergone tremendous change and degradation because the value of it is being poorly understood and not considered in the policy making process. However, valuation of regulating services, cultural services and supporting services are more difficult to estimate and thus pose serious challenges to planners and practitioners. As a consequence the values of these services are often overlooked. Hence, valuation of these services in income accounting of a region/nation is essential to make the plans and policies more sustainable.

Goods and services that forest ecosystems provide are grossly undervalued, evident from GDDP of Uttara Kannada, about Rs. 5,978 crores, which accounts goods of forests as Rs. 180 crores (3% of GDDP), in contrast to TEV of Rs. 84,321 crores from forest ecosystems of Uttara Kannada district. The comprehensive valuation has the potential to provide effective options for management of ecosystem. If the total economic value of forests ecosystem in particular and ecosystem in general are not considered in decision and policy making, the policies thus adopted would lead to detrimental effect on human and societal welfare in the long run. Policies therefore, have an important role in ensuring that benefits from forest ecosystem are accounted in decision making to avoid underestimation of the values of forest, value of conservation and sustainable use of forest resources. Incorporating the values of ecosystem services plays an important role in making the economy resource efficient

RECOMMENDATIONS

Forest resources in the Uttara Kannada district have undergone tremendous change and degradation because the value of it is being poorly understood and not considered in the policy making process. However, valuation of regulating services, cultural services and supporting services are more difficult to estimate and thus pose serious challenges to planners and practitioners. As a consequence the values of these services are often overlooked. Hence, valuation of these services in income accounting of a region/ nation is essential to make the plans and policies more sustainable.

Major threats are habitat fragmentation, negligence, conflict of interest and ineffective restoration/improvement strategies. Poor understanding of the complex ecological processes and proper estimation of the ecosystem benefits have often lead to the destruction of fragile ecosystems. To improve the scenario, thorough understandings of the complex ecosystem dynamics as well as its socio-religious association with community life both are important from conservation and management point of view.

Conservation activities are mostly implemented by Government agencies, NGOs and sometimes by communities. However community participation is often activated by extra mural support which has serious problem in long term sustainability due to financial limitation. The problem could be mitigated to some extent by awareness generation so to raise the interest among people to safeguard its future for their own benefit. The premium should be on conservation of the remaining fragile ecosystems, which are vital for the water security (perenniality of streams), food security (sustenance of biodiversity) and uplift the livelihoods of local population due to carbon credits.

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