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If you take care of the parts, the whole will take care of itself
VALUING ECOSYSTEM SERVICES: A CASE STUDY OF PAKKE TIGER RESERVE OF ARUNACHAL PRADESH, INDIA

Pradeep Chaudhry¹, Shashi Kumar² and Yogesh³

Arunachal Pradesh state of India has about twelve percent of its geographical area under protected area network against the national average of five percent. Pakke Tiger Reserve (PTR) forms an important portion of this network in the state. Tropical forest ecosystem of this reserve provides a continual flow of vital life supporting ecological, economic, social and cultural services at regional, national and global level. Economic valuation of these services can be used as a tool to estimate true value of natural capital contained therein and help in framing appropriate public policy emphasizing more investments in wildlife sector. An effort has been made in the present paper to make a conservative estimate of major ecosystem services emanating from this reserve. Annual flow benefits worth Rs 8.25 billion and stock worth Rs 144.30 billion make it a unique asset in the North East region of the country. Nature based tourism has immense potential in this reserve, which has not been explored yet fully to ensure livelihood and ecological security to the local communities.

INTRODUCTION

More than half of the world’s tiger population resides in India. Tiger, the national animal of India, lies at apex of the food chain in forest ecosystem and being an umbrella species, its protection indirectly conserves habitats of other faunal species found in the forest. With a view to protect and conserve tigers in the country, Government of India launched “The Project Tiger” scheme in 1973. Currently the scheme includes forty seven tiger reserves across the country, covering more than two percent (68000 sq km) of country’s geographical area (Verma et al, 2015). Pakke Tiger Reserve (PTR) of Arunachal Pradesh state of India is one of them.

Conservation and protection of tiger also leads to indirect benefits like protection of rivers/lakes/streams, prevention of soil erosion, improvement in pollination, hydrological services and range of other ecosystem services benefitting humankind. Main objective of the present paper is to have a firsthand approximation of these benefits or quantification of ecosystem services emanating out of PTR in terms of monetary value. Recognition of these benefits is likely to create an evidence base which will pave the way for more targeted and enhanced investment in these protected areas which can rightly be called as repositories of genetic wealth. Further economic valuation of ecosystem services can be used as a tool to communicate the value of natural capital and help in prioritizing investments.

STUDY AREA DESCRIPTION

The forests of North-East India are recognized as “Global Biodiversity Hotspot” and “Endemic Bird Area” due to their richness in floral and faunal species. The landscape has high species diversity and endemicity as it forms the transition zone between the Indian and Malayan eco-

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regions. The two important parts of the North-East Indian tiger landscape are the Brahmaputra flood plains and the North-East Indian hills. Pakke Tiger Reserve is an important part of North-East Indian Tiger landscape, covering an area of 861.95 sq km in the East Kameng district of Arunachal Pradesh state. The core area of PTR extends between latitude 26°54’ to 27°016’ N and longitude 92°036’ to 93°009’ E. The altitudinal range of the reserve lies between 150 m to 1500 m above mean sea level and average annual rainfall is around 2500 mm.

Pakke Tiger Reserve occupies about 20% of the overall geographical area of the East Kameng district, Arunachal Pradesh, having evergreen and semi-evergreen vegetation typical of a tropical rain forest. Lower plains and foothills are dominated by Polyalthia simiarum, Pterospermum acerifolium, Sterculia alata, Stereospermum chelonioides, Altingia excelsa, Ailanthus grandis and Duabanga grandiflora (Singh, 1991; Datta and Goyal, 1997). Hill slopes are dominated by Mesua ferrea and Castanopsis species. Moist areas near streams have a profuse growth of bamboo, cane and palms. Eight species of bamboo and seven commercially important cane species grow in moist areas along with Livistona jenkinsiana, a species used extensively by locals for thatching roofs (Singh, 1991). A high percentage of species are animal dispersed (78%) while about 22% are dispersed abiotically. Of the animal dispersed species, 54 species are primarily bird dispersed, 25 mammal dispersed and 21 species are dispersed by both groups (Datta and Rawat 2008). The important plant families having mammal-dispersed species include Anacardiaceae (4), Euphorbiaceae (3), Clusiaceae (2), Elaeocarpaceae (2) and Verbenaceae (2). The most common mammal-dispersed species are Turpinia pomifera, Dillenia indica and Terminalia bellirica. The important plant families having bird-dispersed species are Lauraceae (16), Meliaceae (6), Euphorbiaceae (5), Rutaceae (3), Myrtaceae (2) and Myristicaceae (2), whereas most common bird-dispersed species are Amoora wallichii, Syzygium syzygioides, Knema angustifolia, Livistona jenkinsiana and Phoebe species (TCP, 2014).

Pakke Tiger Reserve has 296 documented bird species (Singh, 1991, 1999; Datta et al 1998; Birand & Pawar 2004 and TCP, 2014). Most important are hornbill species i.e. the Great hornbill (Buceros bicornis), Wreathed hornbill (Aceros undulatus), Oriental Pied hornbill (Anthracoceros albirostris) and the Rufous-necked hornbill (Aceros nipalensis). The last one occurs only at higher elevations of the park (Datta 1998, 2001, Datta and Rawat 2003, 2004, 2008). Major frugivorous/granivorous birds frequently sighted at PTR include eight species of bulbuls (Pycnonotus), five species of mynas (Acridotheres), four species of green pigeons (Treron), three species of doves (Streptopelia, Macropygia and Chalcophaps), four barbet and three parakeet species. Apart from this, broadbills, cuckoos, red headed trogon, fairy blue bird, oriole and four species of flowerpeckers have been recorded (TCP, 2014). The rare Oriental Bay Owl, a first record from western Arunachal Pradesh has also been recorded in the area (Datta 1999). Besides these birds, PTR has 31 documented species of amphibians and 30 species of fish (Kamei et al 2012). The invertebrate diversity of the area has not been completely explored. Athreya and Karthikeyan (1995) recorded 85 butterfly species on a short visit but speculated that a comprehensive survey would yield about 250-350 species.

PTR has 59 documented mammal species (TCP, 2014). Based on IUCN red list, PTR has six species of endangered mammals: Hog deer (Axis porcinus), Asian elephant (Elephas maximus), Tiger (Panthera tigris), Fishing cat (Prionailurus viverrinus), Wild dog (Cuon alpinus), and the Chinese pangolin (Manis pentadactyla). Apart from these PTR has ten vulnerable species i.e. Gaur
(Bos gaurus), Sambar (Rusa unicolor), Capped langur (Trachypithecus pileatus), Slow loris (Nycticebus bengalensis), Clouded leopard (Neofelis nebulosa), Marbled cat (Pardofelis marmorata), Himalayan black bear (Ursus thibetanus), Binturong (Arctictis binturong), Oriental small-clawed otter (Aonyx cinerea) and Smooth coated otter (Lutrogale perspicillata).

Tigers have been found to be distributed all over the reserve. Gopi et al. (2012) identified 8 individual tigers from 58 tiger photographs, 7 individual leopards from 52 photographs. The study was conducted for 2160 trap nights over a period of two years (2009-10). In 2010, they found 7 tigers (2 males and 5 females), 5 leopards (3 males and 4 females). Using Ivlev’s index, they concluded that tigers preferred Barking deer, Sambar, Wild pig and Gaur in order of preference as prey and despite immense human pressure, PTR holds moderate wild prey abundance, which could harbor a good population of large carnivores.

RESEARCH STUDIES UNDERTAKEN IN PTR
Tourism in PTR is not at a high scale presently and around three hundred visitors arrive annually (TCP, 2014). On the other hand, numbers of researchers, students, academicians are visiting the reserve regularly for conducting research on various aspects. Abundance (relative abundance and density estimates) estimation of key faunal groups has been carried out in various studies. The relative abundance of squirrels, primates, hornbills and pheasants was estimated in a study during 1995-96 to determine the responses of these groups to logging (Datta & Goyal 1997) and relative abundance of these faunal groups was compared between sites inside Pakke TR and in surrounding Reserve Forests (primates: Datta & Goyal 1997, squirrels: Datta & Goyal 2008, hornbills: Datta 1998, and pheasants: Datta 2001a). The abundance of hornbills and other frugivores has also been assessed during another study (Sethi & Howe 2009). The abundance/density of pheasants, elephants and ungulates was estimated by Gopi et al. (2010), while elephant populations were enumerated by Verma et al. (2008). The abundance/density of large carnivores has also been estimated by researchers through various studies since 2009 e.g. wild dogs (Gopi et al. 2010), leopards (Gopi et al. 2010) and tigers (Chauhan et al. 2006, Gopi et al. 2010).


Some studies have looked at human wildlife conflict around PTR and its relationship with socio-economic status (Verma et al. 2008, Kumar & Solanki 2009). However, further studies are needed in order to understand elephant movement patterns and possible solutions to the conflict.

A short-term study on hunting patterns of different tribes across Arunachal Pradesh, including Pakke has been done by Aiyadurai et al. 2009. Another study addressed the detrimental effects of malaria on park protection (Velho et al. 2011). Wildlife Trust of India (WTI) has undertaken several measures to help PTR management with veterinary care of domestic livestock, assistance
in mitigation of elephant conflict, and established a black bear rehabilitation centre at Seijusa, the reserve headquarters. Some of the released bears have been radio-collared and their movements have been monitored. WTL also initiated with Mr. Chuku Loma, earlier Divisional Forest Officer of PTR, a program to fabricate and distribute fibreglass hornbill beaks in an attempt reduce hunting of hornbills and the need/demand for hornbill beaks for preparation of head gears by local tribes.

There have been some focused studies/surveys on fish (Sankararaman, 2012), amphibians, reptiles and birds (Pawar & Birand, 2001, Birand & Pawar, 2004), however more intensive systematic surveys are required to fully document the invertebrate, fish and lesser-known mammal groups like bats and rodents.

No study has been conducted on PTR for quantification of ecosystem services or tangible/intangible benefits generated by fauna, flora and ecosystem of the area. A team of experts, mainly from Indian Institute of Forest Management, Bhopal, India quantified twenty five (25) ecosystem services from selected Tiger reserves across various tiger landscapes of the country with financial support of National tiger conservation authority of India (Verma et al, 2015). The study findings indicate the monetary value of flow benefits emanating from selected tiger reserves range from Rs 8.30 to 17.60 billion annually. In terms of unit area, this translates in to Rs 50,000 to Rs 1,90,000 per ha per year. In the present paper, we have followed same methodology as contained in Verma et al (2015) i.e. consulting secondary literature in the form of technical reports, research articles, benefit transfer approach by adopting results of similar studies conducted in other parts of world with suitable modifications and personal professional experience of the authors.

**ECOSYSTEM SERVICES EMANATING FROM PTR**

**Employment generation**

There are forty nine (49) sanctioned permanent posts of executive and ministerial staffs in PTR against which thirty two (32) are in position at present which includes Divisional Forest Officer, Forest Rangers, Deputy Forest Rangers, Foresters, Forest guards, Forest watchers, vehicle drivers, Elephant drivers, office clerks, office peons etc. Majority of these posts (26) are equivalent or below Forest guard rank. Considering an average salary of Rs 25000 per month, the economic value of permanent employment generated is approximately Rs 7.80 million per year. In addition to these posts, about sixty two (62) contingency/casual workers are also deployed in protection and management of PTR. Considering average local wage rate of Rs 250 per man day, the economic value comes around Rs 5.65 million per year, thereby overall economic value of annual employment generated by PTR is approximately Rs 13.45 million.

**Standing stock**

No harvesting of timber is carried out in PTR but the standing stock of timber has a significant economic value. In the past prior to 2002, timber used to be harvested from Papum reserve forest (buffer area of PTR) as per prescriptions of the approved working plan of the forest. Growing stock estimates of tropical evergreen and semi evergreen forests of North East India from the forest inventory database of Forest Survey of India (FSI) and working plan of the Papum reserve forest were taken into account. Assuming forests of moderately dense forest (MDF) canopy cover...
category and multiplying this growing stock by the area of the reserve, it is estimated that about 6.78 million cu m of standing stock of timber is contained in PTR.

### Table 1

<table>
<thead>
<tr>
<th>Canopy cover density class</th>
<th>Growing stock (cu m/ha)</th>
<th>Area (sq km)</th>
<th>Total stock (million cu m)</th>
<th>Economic value (Rs billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDF</td>
<td>85</td>
<td>798</td>
<td>6.78</td>
<td>135.50</td>
</tr>
</tbody>
</table>

Source: Modified from Verma et al 2015

The economic value of this resource using an average price of timber at Rs 25000 per cu m and accounting for maintenance and transportation costs at 20% of market price is approximately equal to Rs 135.50 billion (Table 1).

**Carbon Storage**

In PTR, tropical wet evergreen forests occupy 489 sq km, tropical wet semi-evergreen forests cover 116 sq km, coniferous forests cover 193 sq km and rest of the area comprises of grassland and degraded habitat (PTR, 2014). Further disaggregation according to canopy cover density classes is not available for the reserve. Under these circumstances, the calculations on carbon storage have been conducted assuming that forests belong to MDF canopy cover category. The carbon stock for tropical wet evergreen forests, tropical semi evergreen forests and subtropical pine forests of North East India for various canopy cover density has been worked out by Forest survey of India (FSI) in a recent study which has been used here to estimate the carbon storage of PTR (FSI, 2006).

Taking into account, different forest type areas and using above statistics of carbon stock in various carbon pools as shown in Table 2, the total carbon stored in PTR is approximately equal to 8.32 million tonnes. According to a study conducted at Yale University, the social cost of carbon for India at a low discount rate is US$ 37.17. This social cost takes into account the losses in the form of health damages and damages to areas like agriculture, forests, fisheries and other allied sectors (Nordhaus, 2011). Considering this cost, the total economic value of carbon stored in PTR has been estimated to be Rs. 8.80 billion. This valuation has been done by making necessary adjustments for purchasing power parity and inflation in India by the methodology suggested by Verma et al (2015).

### Table 2

<table>
<thead>
<tr>
<th>Forest type</th>
<th>Above ground biomass (AGB)</th>
<th>Below ground biomass (BGB)</th>
<th>Dead wood (DW)</th>
<th>Litter</th>
<th>Soil organic matter (SOM)</th>
<th>Total Carbon stock (t C/ha)</th>
<th>Total Carbon stored (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Wet Evergreen</td>
<td>27.44</td>
<td>8.17</td>
<td>0.37</td>
<td>3.18</td>
<td>72.85</td>
<td>112.01</td>
<td>5.40</td>
</tr>
<tr>
<td>Tropical Semi Evergreen</td>
<td>19.58</td>
<td>4.03</td>
<td>0.37</td>
<td>1.81</td>
<td>54.97</td>
<td>80.76</td>
<td>0.92</td>
</tr>
<tr>
<td>Subtropical Pine</td>
<td>31.72</td>
<td>8.01</td>
<td>0.37</td>
<td>1.29</td>
<td>63.15</td>
<td>104.54</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Source: Modified from Verma et al 2015

**Carbon Sequestration**

Apart from storing 8.32 million tonnes of carbon, forests of PTR sequester carbon on an annual basis. As no primary study estimating carbon sequestration in PTR exists, the same has been estimated here based on the forest inventory database of FSI. The total biomass for tropical...
evergreen and semi evergreen forests of North East India in the MDF category has been taken from forest inventory database of FSI. Based on total biomass per unit area, the mean annual increment (MAI) has been estimated using the Von Mantel formula and physical rotation period of 75 years.

### Table 3

<table>
<thead>
<tr>
<th>Canopy cover density</th>
<th>Total biomass (t/ha)</th>
<th>MAI (t/ha/yr)</th>
<th>Annual carbon sequestration (tC/ha/yr)</th>
<th>Area (sq km)</th>
<th>Total carbon sequestration (kilo ton C/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDF</td>
<td>68</td>
<td>3.4</td>
<td>1.70</td>
<td>798</td>
<td>135.66</td>
</tr>
</tbody>
</table>

Source: Modified from Verma et al 2015

Assuming a biomass to carbon conversion ratio of 50 %, the MAI in above ground biomass has been converted to carbon sequestered in dry matter. Using this methodology, the total carbon sequestered in the forests of PTR is approximately equal to 135.66 kilo tones annually (Table 3). Using the social cost of carbon for India and making necessary adjustments for Purchasing Power Parity and inflation as per the methodology suggested by Verma et al (2015), the total economic value of carbon sequestered in PTR is estimated to be Rs 138 million/year.

**Biological Control**

Forest ecosystem in PTR is also responsible for lowering the risk of infectious diseases by keeping the populations of disease organisms like viruses, bacteria and parasites, their hosts and disease vectors like rodents etc in control. Scientific evidence is available showing that deforestation results in an increased spread of human infectious diseases (Patz et al, 2000; Vittor et al 2006). Due to non availability of site specific studies for estimating the economic value of the ecosystem service pertaining to biological control regulating diseases, the method of benefit transfer has been used here. Using estimates of economic value of biological control for tropical forests (Rs 660/ha/yr) and grasslands (Rs 1860/ha/yr) from a global meta-analysis study (Costanza et al, 2014), the economic value of approximately 605 sq km of tropical evergreen and semi evergreen forests and 62 sq km of grasslands in the core of PTR, is equal to Rs 51.46 million per year.

**Habitat/Refugia**

Pakke Tiger Reserve provides suitable living space and food for wild life. In addition, buffering functions like cooling effects, interception of precipitation and evapo-transpiration, water storage etc can significantly contribute to the mitigation and adaptation to extreme weather events. For example, the shade of riparian forest may help in reduced thermal stress to aquatic life as climate warming intensifies (FAO, 2013). Due to non availability of site specific studies for estimating the economic value of the ecosystem service pertaining to habitat and refugia, the method of benefit transfer has been used for PTR. Using estimates of economic value of habitat/refugia for tropical forests (Rs 2340/ha/yr) and grasslands (Rs 72840/ha/yr) from a global meta-analysis study (Costanza et al, 2014), the economic value of approximately 605 sq km of tropical evergreen and semi evergreen forests and 62 sq km of grasslands in the core of PTR, is equal to Rs 593 million per year.

**Gene pool protection**

The economic value of gene pool protection can be envisaged in term of its biological information value and insurance value. Natural organisms, especially endemic species in reserved forests, have
evolved certain chemical compounds in themselves to escape predators, capture prey and fight infections. These compounds have proved to be of great value to human beings, especially in pharmaceutical industry. For example, taxol, a chemical derived from a coniferous tree species (*Taxus baccata*) of Arunachal Pradesh state, is used in treatment of cancer. The insurance value of such areas relates to the role of biodiversity in production of ecosystem services, especially regulating kind of ecosystem services, leading to higher adaptability and resistance to environmental changes. This value of biodiversity is likely to play an important role in future as climate change impacts may threaten survival of life on the planet (Mace et al, 2012; Holling et al, 1994; Perrings, 1998 and Heal, 2004). Due to lack of site specific studies for estimating economic value of gene-pool conservation, the method of benefit transfer has been used. Using estimates of economic value of gene pool protection for tropical forests (Rs 91020/ha/yr) from a global meta-analysis study, the economic value of 798 sq km of forests of PTR is equal to Rs 7.26 billion/yr.

**Gas regulation**

Natural ecosystem within the tiger reserve regulates chemical composition of atmospheric gases like oxygen, ozone and sulphur dioxide. Due to unavailability of site specific studies for estimating the economic value of gas regulation, the method of benefit transfer has been used. Using estimates of economic value of gas regulation for tropical forests (Rs 720/ha/yr) from a global meta analysis study, the economic value of 798 sq km of forests of PTR is equal to Rs 57 million per year.

**Recreation**

Tiger reserves in India attract number of domestic and foreign tourists. Tourism cum recreational value of few tiger reserves in the country has been estimated using mainly ‘Travel Cost Method’ e.g. Rs 30 million per year for Corbett Tiger Reserve of Uttarakhand state (Badola et al 2010); Rs 383.70 million per year for Kanha Tiger Reserve of Madhya Pradesh state (Verma and Mishra, 2010); Rs 21.50 million per year for Kaziranga Tiger Reserve of Assam state (Bharali and Mazumdar, 2012); Rs 37 million per year for Sundarbans Tiger Reserve of West Bengal state (Guha and Ghosh, 2009) and Rs 423.15 million per year for Periyar Tiger Reserve of Kerala state (Manoharan et al 1998). No such recreational value has been assessed for PTR due to low tourist arrival figure of around 300 per year (TCP, 2014). Insurgency from neighbouring state of Assam seems to be the main reason for low tourist visitation rate. Bodo (a local tribe in Assam state) militancy and other militant groups of the region pose a serious challenge to the protection and conservation of the reserve as they indirectly help poachers and timber mafia involved in illegal felling/logging of trees. Longer duration of rainfall for about six months in a year is also responsible for less tourist arrival figure.

**Pollination**

The forest ecosystem of PTR provides a natural habitat to pollinators which subsequently help in quality and quantity of agricultural and horticultural crops in surrounding areas of the reserve. Due to lack of site specific study for estimating the economic value of pollination, the method of benefits transfer has been used. Using estimates of economic valuation of pollination for tropical forests (Rs 1800/ha/yr) from a meta analysis study (Costanza et al, 2014), the economic value of 798 sq km of tropical evergreen and semi evergreen forests of PTR is equal to Rs143.64 million per year.
DISCUSSION
The benefits generated by Tiger reserves of India are not limited to their boundaries but flow beyond local, sub national and national level. Verma et al (2015) while estimating flow benefits for some selected Tiger reserves of India made certain broad assumptions, expressed as percentage of benefits from different ecosystem service accruing at local, national and global scales (Table 4).

Table 4
Assumptions for benefits accruing at different spatial scales

<table>
<thead>
<tr>
<th>S No</th>
<th>Ecosystem services</th>
<th>Local</th>
<th>National</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Employment generation</td>
<td>100 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Carbon storage</td>
<td>30 %</td>
<td>70 %</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Carbon sequestration</td>
<td>30 %</td>
<td>70 %</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Standing timber/stock</td>
<td>100 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Gene-pool protection</td>
<td>50 %</td>
<td>50 %</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Biological control</td>
<td>70 %</td>
<td>20 %</td>
<td>10 %</td>
</tr>
<tr>
<td>7</td>
<td>Pollination</td>
<td>70 %</td>
<td>30 %</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Gas regulation</td>
<td>30 %</td>
<td>60 %</td>
<td>10 %</td>
</tr>
<tr>
<td>9</td>
<td>Habitat for species</td>
<td>30 %</td>
<td>70 %</td>
<td></td>
</tr>
</tbody>
</table>

Source: Verma et al 2015

These were based on the discussions with stakeholders and existing literature. Based on these assumptions, approximately 2 % of flow benefits generated by PTR accrue at the local level, 48 % at national level and 50 % at the global level. It is worth mentioning here that carbon storage and standing timber in above table constitute ‘stock’ and rest of the ecosystem services come under ‘flow benefits’ accruing on annual basis.

Due to paucity of information/data, economic benefits generated by fishing, grazing, NTFP (cane, bamboo, medicinal plants mainly) and fuel wood collection by local villagers from buffer area of PTR, sediment regulation, water provisioning and purification etc by forests of PTR could not been assessed. Therefore quantification of tangible and intangible benefits from PTR may be considered as a conservative one. Summary of these benefits or ecosystem services generated by PTR based on stock and flow benefits framework is given in Table 5.

Table 5
Summary of ecosystem services based on flow benefits & stock framework

<table>
<thead>
<tr>
<th>S.No</th>
<th>Type of value</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Flow benefits</td>
<td>8.25</td>
<td>Rs billion/year</td>
</tr>
<tr>
<td></td>
<td>Like Employment generation, carbon sequestration, Biological control, Habitat/refugia, Gene-pool protection, Gas regulation, Pollination</td>
<td>0.96</td>
<td>Rs lakh/ha/yr</td>
</tr>
<tr>
<td>2.</td>
<td>Stock</td>
<td>144.30</td>
<td>Rs billion</td>
</tr>
<tr>
<td></td>
<td>Like Standing timber, carbon storage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Modified from Verma et al 2015

Total expenditure incurred in PTR during 2012-13 on the development, conservation and related activities, including salary and wages of staff was Rs 4, 81, 35, 682 (approx Rs forty eight millions). This includes assistance from Ministry of Environment, Forests and Climate change, Govt of India in the form of centrally sponsored schemes like ‘Integrated development of wildlife habitats, Project Tiger and Project Elephant’. Based on the flow benefits of Rs 8.25 billion/year,
for every rupee spent on management costs in PTR, flow benefits of Rs 171 are realized within
and outside Tiger Reserve. Flow benefits per ha per year for PTR are equal to Rs 0.96 lakh, which
are almost same to that of Kaziranga Tiger Reserve in spite of the fact that average investment per
year in Kaziranga Tiger Reserve is more than 200 times than Pakke Tiger Reserve (Table 6).
However ‘investment multiplier’ i.e. quantum of benefits derived from a tiger reserve by spending
one rupee on its management costs, is much lower in case of PTR (171) in comparison to other
tiger reserves of India (Table 6). Possible reasons are lack of assessment of tourism recreational
value of PTR (due to low tourist arrival rate), lack of data/information for estimating other
tangible and intangible benefits generated in PTR as mentioned above. Kaziranga Tiger Reserve
(KTR) lies in the North East India and in the vicinity of PTR in comparison to other tiger reserves.
When one compares various flow benefits between these two reserves, it is found that PTR fares
better than KTR in terms of various ecosystem services or benefits e.g. standing timber, carbon
storage and sequestration, gene pool protection, gas regulation and pollination (Table 6).

Table 6
Comparison of ecosystem benefits among various tiger reserves of India

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Standing Timber (Billion Rs)</td>
<td>135.50</td>
<td>251.10</td>
<td>172.78</td>
<td>21.40</td>
<td>299.74</td>
<td>44.19</td>
</tr>
<tr>
<td>Carbon Storage (Billion Rs)</td>
<td>8.80</td>
<td>10.65</td>
<td>20.50</td>
<td>0.99</td>
<td>16.76</td>
<td>5.01</td>
</tr>
<tr>
<td>Carbon Sequestration (Million Rs/yr)</td>
<td>138</td>
<td>214.10</td>
<td>219.41</td>
<td>17.37</td>
<td>181.18</td>
<td>68.83</td>
</tr>
<tr>
<td>Employment generation (Million Rs/yr)</td>
<td>13.45</td>
<td>82.50</td>
<td>Not available</td>
<td>Not available</td>
<td>24.58</td>
<td>Not available</td>
</tr>
<tr>
<td>Biological control (Million Rs/yr)</td>
<td>51.46</td>
<td>77.22</td>
<td>89.96</td>
<td>149.72</td>
<td>130</td>
<td>51.48</td>
</tr>
<tr>
<td>Habitat/Refugia (Million Rs/yr)</td>
<td>593</td>
<td>273.78</td>
<td>318.94</td>
<td>5.73</td>
<td>3.56</td>
<td>182.50</td>
</tr>
<tr>
<td>Gene pool protection (Billion Rs/yr)</td>
<td>7.26</td>
<td>10.65</td>
<td>12.41</td>
<td>3.49</td>
<td>7.86</td>
<td>7.10</td>
</tr>
<tr>
<td>Recreational value (Million Rs/yr)</td>
<td>Not Available</td>
<td>30</td>
<td>383.70</td>
<td>21.50</td>
<td>425.15</td>
<td>Not available</td>
</tr>
<tr>
<td>Pollination (Million Rs/yr)</td>
<td>143.64</td>
<td>210.60</td>
<td>245.34</td>
<td>86.79</td>
<td>167.79</td>
<td>140.40</td>
</tr>
<tr>
<td>Gas regulation (Million Rs/yr)</td>
<td>57</td>
<td>84.24</td>
<td>98.14</td>
<td>20.05</td>
<td>61.15</td>
<td>56.16</td>
</tr>
<tr>
<td>Overall flow benefits (Billion Rs)</td>
<td>8.25</td>
<td>14.70</td>
<td>16.50</td>
<td>9.80</td>
<td>17.60</td>
<td>8.30</td>
</tr>
<tr>
<td>Average Investment (Million Rs/yr)</td>
<td>48.13</td>
<td>36.74</td>
<td>60.26</td>
<td>9760</td>
<td>38.36</td>
<td>30.45</td>
</tr>
<tr>
<td>Investment multiplier</td>
<td>171</td>
<td>368</td>
<td>273</td>
<td>200</td>
<td>459</td>
<td>273</td>
</tr>
<tr>
<td>Area (ha)</td>
<td>86195</td>
<td>128800</td>
<td>205100</td>
<td>103000</td>
<td>92500</td>
<td>147300</td>
</tr>
<tr>
<td>Flow benefits/ha/yr (Rs lakh)</td>
<td>0.96</td>
<td>1.14</td>
<td>0.80</td>
<td>0.95</td>
<td>1.90</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Source: Verma et al 2015 (for Tiger reserves other than Pakke)

India is known for its biodiversity, large ecosystems especially the Himalaya and the Western
Ghats. The country has 689 protected areas (PAs) with 102 National Parks, 526 Wildlife
sanctuaries, 57 Conservation reserves and 4 Community reserves in different geographic zones
covering nearly 5 % of total geographic area of the country (MoEF & CC, 2015). Wildlife viewing
in National parks/sanctuaries is becoming an important aspect of global ecotourism and
sustainable management of such areas can provide much needed financial resources for developing countries in future (Navrud and Mungatana, 1994). If properly managed, community based eco-tourism programmes in tiger reserves of India can generate lot of employment and revenue to local community. For example, eco development committees (EDCs) in Periyar Tiger Reserve of Kerala state generated about 36000 mandays of employment in 2009 while implementing events like Tiger trail, Bamboo rafting, Nature walk, Jungle inn, Tribal trekkers and Tribal heritage. The economic value of these mandays @ Rs 400/day is estimated approximately Rs 14.58 million/yr (Shukla, 2011). Similarly during 2013-14 in Sundarbans Tiger Reserve (STR) of West Bengal state, a total of 1,57,600 mandays were generated for various management activities in which local communities were involved. Thus the economic value of the employment generated by STR was estimated as Rs 32.47 million/year using unskilled wage rate of Rs 206/- per manday (STR, 2014). Eco development committees and Forest protection committees in STR are actively involved in promoting tourism activities in the reserve. A portion of revenue accrued to forest department through tourism is flowed back to these committees for implementing developmental activities in neighbouring villages.

Department of Environment and Forests, Govt of Arunachal Pradesh supports eco-tourism activities within buffer area of PTR vis-à-vis guidelines issued by the National Tiger Conservation Authority (NTCA), 2012. Eco-development committees (EDCs) can play a major role in successfully promoting and managing eco-tourism activities in PTR just like Periyar and Sundarbans Tiger reserves. A community run tourism enterprise (Pakke jungle camp) has been started recently by the Ghora-Aabhe (a local NGO) with support of forest department and in partnership with local village elders to help tourism promotion.

In true sense, Ghora Aabhe is a society of sixteen village heads that helps in protection of the reserve. ‘Kebang’ or a group of village heads settle disputes, enforces customary laws and provide penalties against hunting and logging. Women self help groups were formed in 2007, alert reserve authorities about poaching. Half of the fines collected go to this group for reporting. Village forest development councils help in conservation and awareness activities on the periphery of the reserve. The Ghora Aabhe also works towards sensitizing people for nature conservation. It is a small beginning and is a fully community owned and run programme. It is important for the host community to gain benefits from tourism and to be owner of such facilities. Responsible nature based tourism has lot of potential in the reserve and should be encouraged like Periyar and other tiger reserves.

**CONCLUSION**

Like other tiger reserves of the country, Pakke Tiger Reserve (PTR) provides a range of associated economic, social and cultural benefits. The findings of the study indicate that the monetary value of flow benefits emanating from PTR is about Rs 8.25 billion per year. In terms of unit area, this translates in to Rs 96000 per ha per year. In addition, PTR also protects and conserves stock (timber and carbon) valued around Rs 144.30 billion. In the light of growing awareness of life supporting functions of ecosystem services and advanced technology to make use of genetic diversity, the economic value of this stock is likely to appreciate in near future (Verma et al, 2015). The present study provides an initial conservative estimate of the economic value of benefits derived from PTR, which are likely to increase if a detailed study is undertaken in future.
Keeping in view of the regional, national and global significance of the benefits, especially intangibles, derived from such protected areas, Government of India must provide sufficient funds to ensure uninterrupted flow of ecosystem services in future. This would provide a viable platform to meet challenges of livelihood and environmental security of local communities and also tackle issues of climate change.

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