सत्यमेव जयते

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY
INDIA INITIATIVE *INTERIM REPORT*
WORKING DOCUMENT

Nature Protects if She is Protected

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INDIA INITIATIVE *INTERIM REPORT*

WORKING DOCUMENT

Supported by

Ministry of Environment, Forests
and Climate Change,
Government of India
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What of thee I dig out
Let that quickly grow over
Let me not hit thy vitals
Or thy heart

-Atharva Veda, 1000 BC

अशोक लवासा
ASHOK LAVASA, IAS

सत्यमेव जयते

सचिव
भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Secretary
Government of India
Ministry of Environment, Forests & Climate Change

Foreword

Sustainability concerns in enhancing human wellbeing amidst a cultural tradition of reverence for Nature are integral to India's developmental philosophy. India's National Environment Policy stresses that the most secure basis for protection of nature is to ensure that people dependent on natural resources obtain better livelihoods through conservation rather than from degradation of such resources. This is well articulated in several national strategies and programmes of this Ministry.

Our country, identified as one of the 17 mega-diverse countries in the world, faces unique circumstances as well as challenges in conservation of our rich biological heritage. Her 1.2 billion people coexist with over 47,000 species of plants and 91,000 species of animals so far identified. Several among them are keystone and charismatic species. Rapid growth of our vibrant economy needs to ensure that our natural capital is maintained so that ecosystem services continue to support human well-being and prosperity.

Valuation of the benefits societies derive from ecosystems and biodiversity acquires strategic significance in guiding our economy on a sustainable path. By making the hidden values of ecosystems explicit, valuation can support their incorporation in public decision making processes as well as alert society on the consequences of consumption choices and behavior. The TII (The Economics of Ecosystems and Biodiversity – India Initiative) marks an important step by the Ministry in making nature's economic values visible, so as to support their mainstreaming in economic development.

A scoping report on the state of art of valuation of ecosystem services derived from the three ecosystems, viz. forests, inland wetlands and coastal and marine ecosystems, and the manner in which TII can contribute to improved policy making was compiled and released on the occasion of 11th Conference of Parties Meeting of the Convention on Biological Diversity held in Hyderabad in 2011.

This document is an interim report that has clarified further the TII study approach and methodology. In a marked departure from TEEB international study, largely built on collation of published literature, under TII it has been decided to invest in 12 pilot studies to demonstrate practical approaches for applying ecosystem services economics to improve conservation planning and policy making. The present publication outlines a synthesis of assessment approaches and methodology for the three ecosystem types. It also outlines the ways in which TII supports India's national biodiversity targets adopted on the lines of Aichi Targets following the CBD Strategic Plan 2011-2020.

I congratulate Dr. Kirit Parikh (Chairman, Scientific and Technical Advisory Group of TII and former Member, Planning Commission), Mr. Hem Pande (Additional Secretary) and Dr. J.R.Bhatt (Scientist G) for their efforts in preparing this report.

I am confident that this report will help in establishing policy paradigms that recognize, demonstrate and realize benefits from India's biodiversity and natural resources. I also hope that the findings of this report will provide the basis for various academic and research institutions to establish an interdisciplinary school of thought on economics of biodiversity. Techniques of valuation of such resources bestowed by nature are extremely important as they underscore the eternal values of our gratitude to nature's bounty which we can preserve through harmonious coexistence.

(Ashok Lavasa)

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Abbreviations

ACFGC	Ashtamudi Clam Fisheries Governance Council
BMC	Biodiversity Management Committee
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
BOBP-IGO	Bay of Bengal Programme Inter Governmental Organization
CA	Compensatory Afforestation
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLAMFIL	Clam Filtration Model
CMFRI	Central Marine Fisheries Research Institute
CMPAs	Coastal and Marine Protected Areas
CMS	Convention on Migratory Species
COP	Conference of Parties
CSO	Central Statistical Organisation
CSR	Corporate Social Responsibility
CUM	Cubic Metre
CVM	Contingent Valuation Method
CWRA	Central Wetlands Regulatory Authority
DID	Difference in Difference
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMCaB	Environmental Management Capacity Building Technical Assistance
FAO	Food and Agriculture Organisation of the United Nations
FDA	Forest Development Agency
FDC	Forest Development Corporation
FSI	Forest Survey of India
FYP	Five Year Plan
GDP	Gross Domestic Product
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IEG	Institute of Economic Growth
IGIDR	Indira Gandhi Institute of Development Research
INR	Indian National Rupee
ISFR	India State of Forest Report
IUCN	International Union of Conservation Network
JFMC	Joint Forest Management Committee
LAMPS	Large Sized Agricultural Multi-purpose Cooperative Societies
LRK	Little Rann of Kuchchh
MBI	Market Based Instruments
MDF	Moderately Dense Forests
MEA	Millennium Ecosystem Assessment
Mha	Million hectare
MoEFCC	Ministry of Environment, Forests and Climate Change
MoSPI	Ministry of Statistics and Programme Implementation
MoUD	Ministry of Urban Development
MoWR	Ministry of Water Resources
MPA	Marine Protected Areas
MSC	Marine Stewardship Council
MSE	Madras School of Economics
MSP	Marine Spatial Planning
Mt	Million tonne
MW	Mega Watt
NAPCC	National Action Plan on Climate Change
NBA	National Biodiversity Authority
NBAP	National Biodiversity Action Plan
NBFGR	National Board of Fish Genetic Research
NEP	National Environment Policy
NF	Non Forest
NGOs	Non-Governmental Organizations
NGT	National Green Tribunal
NLCP	National Lake Conservation Plan
NPCA	National Programme on Conservation of Aquatic Ecosystems
NPV	Net Present Value
NSAIDs	Nonsteroidal anti-inflammatory drugs
NTCA	National Tiger Conservation Authority
NTFP	Non-Timber Forest Product
OF	Open Forests
PA	Protected Area
PES	Payment for Ecosystem Services
PSC	Project Steering Committee
REDD+	Reducing Emissions from Deforestation and Forest Degradation+
RSC	Regional Steering Committee
SBB	State Biodiversity Board
SEEA	System of Environmental-Economic Accounting
SFB	Seasonal Fishing Ban
STAG	Scientific and Technical and Advisory Group
tC	Tonne Carbon
TCM	Travel Cost Method
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
TII	TEEB India Initiative
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UN-STAT	United Nations Statistics Division
USD	United States Dollar
UTs	Union Territories
VDF	Very Dense Forests
VFC	Village Forest Committee
VSZ	Vulture Safe Zone
WWF	World Wildlife Fund for Nature

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CHAPTER 1
Introduction

HEMANT KIROLA

The Economics of Ecosystems and Biodiversity – India Initiative (TII) has been launched by the Ministry of Environment, Forests and Climate Change (MoEFCC) with the aim of highlighting the economic consequences of loss of biological diversity and associated decline in ecosystem services.

During the 11th Conference of Parties (CoP) to the Convention on Biological Diversity (CBD), hosted by India in October 2012, the first report *TEEB-India: Initial Assessment and Scoping Report – Working Document* was released, containing the outcomes of scoping studies commissioned under the initiative (Parikh et al., 2012). Post CoP 11 the issues to be addressed, approach and methodology was finalized and TII case studies were selected and launched. The current report outlines the progress made under TII since the CBD CoP 11, in particular, highlighting the policy connect in the 12 identified studies.

RAMAN SUKUMAR

RUPAL VAIDYA

DEEPAK APTE

1.1 National circumstances

India is recognized globally as one of the mega-diverse countries. Around 1.2 billion people co-exist with 7-8% of all recorded species, including over 45,000 species of plants and 91,000 species of animals, of which several are keystone and charismatic ones.

The Indian economy is growing rapidly. The average compound growth rate of the economy during 2004-05 to 2011-12 exceeded 8% (MoF, 2014). India also has around 269 million poor who constitute some 30% of its population, with limited access to electricity and clean cooking fuels and also generally lack conveniences of piped drinking water or sanitation facilities. It is therefore imperative that India's economy grows at a high rate, at least for a few decades, to find resources to improve the well-being of its people.

This is a daunting challenge for India with its relatively skewed endowment of natural resources. With more than 16% of the global population, it has only 2.4% of the world's land area. Also, with only 38 million hectares of pasture land (Planning Commission, 2011), supplemented by other fodder sources, it supports almost one sixth of the world's livestock population. Thus, India needs to ensure that its natural resources do not degrade but are both enhanced as well as utilised in a sustainable manner. Millions of people depend for their livelihood on forests, coastal ecosystems and wetlands. India's tribal population exceeds 104 million (MoTA, 2013), mostly living in rural areas and dependent on forests and natural resources to a significant extent. (Table 1)

While rapid economic growth is imperative for India, preservation of its natural resources on which millions of its people depend, is equally important to ensure that growth is both inclusive and sustainable. This has been the objective of India's 12th Five Year Plan titled *Faster, More Inclusive and Sustainable Growth.* It is vital that India preserves the biodiversity and health of its diverse ecosystems.

Environmental sustainability has acquired a prominent focus in India. To achieve and sustain higher levels of income and standard of living for everyone, overall development with greater opportunities for employment with better and optimum use of natural resources is critical. Balancing environmental conservation and economic growth is a challenging task. Conflicts and trade-offs arise all too often. Much of India's mineral resources are under forests that are also home to tens of millions of poor people, especially tribals. Thus mining for minerals will destroy forests and displace people. When a forest is cut down for timber or cultivation, one who cuts the forest gains but others lose, not just those who depend directly to obtain food, fodder, fertilizer, fuel or non-timber forest products (NTFPs), but people faraway lose the ecosystem benefits the forest provides through regulation of water, soil erosion and impact on weather. Similarly, when a wetland is drained for infrastructure or real estate development, vital ecosystem services from the wetland such as provision of fish and fresh water, groundwater recharge, flood control, etc. are lost.

Table 1: India: Some Key Indicators

CRITERIA	Measure
Population (million, 2011)	1,210
Area (million hectares)	328.73
GDP at factor cost (2004-2005 prices) ₹ billion	57,417.9
Per capita net national income (2004-2005 prices) ₹	39,904
Share of industry in GDP in 2013-14 (%)	26.1
Share of services in GDP in 2013-14 (%)	59.9
Share of agriculture in GDP in 2013-14 (%)	13.9
Net area sown (million hectares)	141.58
Urban population as percentage of total population	31.16
Forest cover in 2011 (million hectares)	69.79
Livestock population excluding poultry in 2012 (million)	512
Population below poverty line in 2011-12 (million)	269.3
Life expectancy at birth (years) (2006-10)	66.1
Literacy rate in 2011 (%)	74

Sources: Economic Survey, 2013-14 (MoF, 2014); Census of India, 2011; Pocket Book of Agricultural Statistics, 2013 (MoA, 2014); India State of Forest Report, 2013 (FSI, 2013)

India's planned approach to socio-economic development and poverty eradication has underlined sustainability. Conservation and resource management is integral to development plans. A sound environmental policy and law framework is also in place. At the same time, Indian society's traditional respect for the ecology, rivers and nature continues to remain as strongly rooted as ever.

Achievement of sustainability is a long term process that requires investments in human and natural capital. Energy efficiency and conservation, promotion of renewables, and the building up of natural resources and forests are key aspects of India's development objectives.

Despite the pressure on land from a growing population and expanding economy, India aims to have 33% of its land area under green cover. According to *India State of Forest Report 2013*, (FSI, 2014) in 2013 India had 24.01% of its land area under forest and tree cover of which 21.23% (69.79 million hectares) was under forests. Compared with 2011, forest cover increased by 0.587 million hectares. Forests are critical for millions of poor people who depend on them to varying extents for food, fodder, fuel and NTFP in support of their livelihoods.

While forests provide diverse benefits to millions of people, they indirectly benefit almost all the people in India from the ecosystem services they provide through regulation of water, soil erosion and impact on weather. Also forests provide habitat for many species and the biodiversity they support is valuable for all.

Surrounded by the Indian Ocean, Arabian Sea and Bay of Bengal, India has a coastline of over 7,500 km spanning nine maritime States and two Union Territories (UTs) in the mainland, and two island UTs. The Exclusive Economic Zone (EEZ) extends to 2.02 million sq km and the continental shelf area to 0.18 million sq km. The Indian coasts support about 30% of the total 1.2 billion human population. Indian coastal ecosystems comprise mudflats, sandy beaches, estuaries, creeks, mangroves, coral reefs, marshes, lagoon, sea grass beds, and sandy and rocky beaches that extend to 42,808 sq km. They are known for their high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna. The number of species in the coastal and marine ecosystems is suggested to be more than 13,000 (Venkataraman and Wafar, 2005; MoEF, 2009). However, this is an underestimate considering the fact that the inventory is extensive in the case of commercially important resources, but incomplete for minor phyla and microbes.

Wetlands are prominent features of Indian landscape. India, owing to wide variations in rainfall, hydrology, physiography, geomorphology and climate, has a rich diversity of inland wetlands. Their distribution in the country range from high altitude lakes and swamps of the Himalaya, fertile alluvial floodplains of the Ganga and Brahmaputra, salt lakes of the arid zone, tanks of the Deccan plateau, and lakes and marshes on the east and west coasts. As per data contained in National Wetland Atlas of 2011, India has 15.26 million ha area under wetlands, roughly equal to 4.6% of her land area. Of this, inland wetlands constitute 69.22% (10.56 million ha)

1.2 India's approach

Respect for all life forms as well as conservation and wise use of resources have been a way of life in India since ancient times. This has been enunciated in scriptures and texts such as Vedas, Upanishads and Puranas. Religions such as Buddhism, Bahá'í, Jainism, Sikhism, Islam and Zoroastrianism among others, have added to this understanding and appreciation of nature in the sub-continent. Even today, trees, animals, rivers are revered and worshipped. Following traditional Oriental wisdom, in 1928 Rabindranath Tagore initiated a tree plantation drive at Shantiniketan. This came to be known as *Van Mahotsava* (festival of tree planting). This was later popularised in 1949 by the then Union Minister

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for Agriculture, KM Munshi as a remembrance for the death anniversary of Rabindranath Tagore on 22 Shravana (falling on 7-8 August) every year. The importance of preserving forests for local populations is exemplified by the 'Chipko' movement of 1970s, when women clung to trees to protect them, challenging tree fellers to stop felling or else to cut them down along with the trees.

India has extensive constitutional provisions, laws and policies to promote environmental conservation and sustainable use of natural resources. The Indian Constitution clearly assigns responsibilities between the Union and State Governments on various subjects. One of the most significant recent legislative steps has been the setting up of the National Green Tribunal (NGT). The NGT is a dedicated statutory environmental court with the mandate to deal with civil cases which have substantial relation to environment, including biodiversity. In addition, the Supreme Court of India has also played a significant role in the conservation of biodiversity. In 2013, the Supreme Court of India set up a 'Green Bench' to deal with environmental issues replacing the existing Forest Bench. The jurisprudence on environment is continuously evolving in India.

India is signatory to various international conventions and treaties related to environmental protection and has also taken numerous initiatives towards their implementation. India has prepared National Biodiversity Targets towards implementation and achievement of Aichi Biodiversity Targets at the national level. Apart from the impact on environment due to locally generated pollution, the threat of climate change from global emissions has also been of considerable concern to India as it is highly vulnerable to climate change. Thus Prime Minister's Council on Climate Change was set up in 2008, and it prepared the National Action Plan on Climate Change (NAPCC). The Government also set up an Expert Group on Low Carbon Strategies for Inclusive Growth, which seeks to incorporate faster, inclusive and sustainable growth in an integrated framework.

The effectiveness of many laws and policies can be further improved if economic instruments are used that create awareness and incentives for appropriate actions. In other words, environmental externalities need to be internalized into policy and decision-making.

With growing recognition that contemporary national accounts are not sufficient for economic and environmental evaluation in an integrated manner, the Government of India set up an Expert Group to develop a Framework for Green National Accounts in India. To a limited extent, India has been applying some economic instruments for conservation of ecosystems. For instance, when forest land is diverted or de-reserved for non-forest uses such as mining and essential development works, the user or project proponent is required to compensate for the loss in forest and associated ecosystem services by way of payment towards Compensatory Afforestation (CA) over at least equal land area as the diverted forest land. In addition, a Net Present Value (NPV) of the diverted forest is required to be paid in lieu of lost forest ecosystem services till the compensatory afforestation area starts providing comparable benefits. Funds collected under CA and NPV are utilized by the Government for afforestation and conservation activities. (MoEF, 2009)

For encouraging the State Governments to retain area under forest cover, the 13th Finance Commission (Finance Commission, 2009) has allocated ₹ 50 billion to States based on three factors viz. a) the share of the total forest area in the country falling in a particular State, b) whether or not the share of forested area in a State is greater than the national average and c) the quality of the forest in each State as measured by density. (GoI, 2009)

Large sections of the population depend on forests to meet their subsistence requirements. The basic thrust of the forest policy is on environmental stability through preservation and restoration of ecological balance. In India, the deforestation rate per unit population is one of the lowest among all the major tropical countries. Forest with over 40% crown cover has continuously increased. The National Wasteland Development Board (NWDB) was set up in 1985 and the National Afforestation and Eco-Development Board (NAEB) in 1992. The NWDB is responsible for regenerating degraded non-forest lands and private lands, whereas the NAEB is responsible for regenerating degraded forestlands and the land adjoining forest areas, as well as ecologically fragile areas. The efforts made by NAEB and NWDB have increased the sustainable component of biomass use in the country. The Government has also formulated a National Agroforestry Policy, 2014, for increasing green cover and building resilience of farmers by providing them with agroforestry based economic opportunities (MoA, 2014).

In 2010, the Government introduced a clean energy cess on raw coal, raw lignite and raw peat at the rate of ₹ 50 per metric tonne. The revenue so generated feeds into a National Clean Energy Fund that provides low cost finance to research and innovative projects relating to clean energy technology. In 2014, the clean energy cess has been increased to ₹ 100 per metric tonne and the scope of purposes of levying the cess has been expanded to include financing and promoting clean environment initiatives and funding research in the area of clean environment.

In the liberalised market economy, environmental regulations can be substantially complemented by economic instruments for conservation and sustainable use of natural resources. To be able to design effective and efficient economic instruments for conservation, we need to have a good basis of policy relevant valuations of biodiversity, natural resources and ecosystem services. This is where the present TII study becomes highly useful, relevant and necessary for India.

1.3 TII – The Economics of Ecosystems and Biodiversity India Initiative

The continued loss and degradation of natural capital and role of economic drivers therein, urgently call for communicating the diverse values of natural resources, and the consequences of loss of vital ecosystem services, in a language of world's dominant economic and ecological paradigm. The TEEB India Initiative is an effort to make the values of biological diversity and linked ecosystem services explicit to enable consideration and mainstreaming in developmental planning and decision making.

The TII builds on previous efforts made in the country for 'green accounting' and valuation of natural capital. One of the earliest significant recommendations for accounting for natural capital wealth of the country came up from the MS Swaminathan Committee set up in 1989 to chalk out India's Action Plan for Environment. In 1992, the UN Conference on Environment and Development "Earth Summit", as per Agenda 21, recommended that countries implement environmental-economic accounts. Following this, Indira Gandhi Institute of Development Research (IGIDR) prepared a framework for natural resources accounting at the behest of MoEFCC (Parikh et al., 1993). At around that time, the UN's Statistical Office had come out with a framework for System of Environmental-Economic Accounts (SEEA). This gave incentives to many researchers to prepare case studies of economic valuation for specific research and regions, see for example Parikh and Parikh (1997, 1998).

The Central Statistical Organization (CSO), which prepares India's national income accounts, commissioned a number of research institutes in 2002 to carry out integrated economics and environmental accounts for specific sectors and States. This was followed up by integration of these studies to prepare a road map to develop such accounts for the country (Murty and Panda, 2012). At the same time, at instance of MoEFCC, the Ministry of Statistics and Programme Implementation (MoSPI) set up another expert group to chalk out a framework for preparing Green GDP. The Expert Group has recommended using a comprehensive notion of 'wealth' comprising reproducible capital, human capital and natural capital as yardstick for economic evaluation. (CSO, 2013).

The coinage of term 'ecosystem services' has recently acquired prominence as a reflection of development-environment interactions. Believed to have been introduced by Ehrlich and Ehrlich (1981) building on the earlier literature on nature's functioning (Brauman et al., 2007), this coinage is in response to the compelling need felt by the natural scientists during the 1970s and the 80s to advance conservation arguments using utilitarian framing in a practical attempt to reach economic decision making circles. In the following decades, ecologists and economists have further elaborated the notion of ecosystems as life-support systems, providers of ecosystem services and economic benefits, through milestone studies as Millennium Ecosystem Assessment (MEA, 2005) and more recently the international TEEB study. The foundational construct of the ecosystem services is appreciation of the nature-human well-being inter-linkages, as an intertwined stock-flow relationship wherein the ecosystem (including its components and processes) is perceived as a 'stock of natural capital' and the benefits derived, i.e. 'ecosystem services' as the flows which emanate from the stock of ecosystem assets (Mäler et al., 2009). MEA raised concerns on the capacity of economic systems to ensure maintenance of the natural capital stock for sustained provision of ecosystem services recognizing limits to substitution by human or manufactured capital (Barbier, 1994; Daily, 1996).

Given the role of economic decision-making on resources allocation, there is a renewed interest in applying valuation of ecosystem services to promote better decision making related to use and management of natural resources by making explicit how decision making would affect ecosystem service values, and expressing these value changes in units that allow for their incorporation in public decision making process (Mooney et al., 2005). Most importantly, economic valuation is increasingly recognized as a tool for alerting the society on the consequences of consumption choices and behaviour, ultimately serving as a societal feedback mechanism related to natural resources (Zavetoski, 2004).

The TII aims to make the economic values of ecosystem services explicit to ultimately enable their mainstreaming in developmental planning and decision-making. Following a stakeholder consultation meeting held in September 2011, in which over 70 ecologists, economists, representatives of concerned State and Central Government agencies and civil society participated, it was agreed that the TII will not focus on generating macro-economic indicators for natural capital, but instead focus on demonstrating application of economic approaches to improve policy and decision making. Three ecosystem types, namely forests, inland wetlands, and coastal and marine ecosystems were selected in the first phase. The MoEFCC provides grants to State Governments and UT administrations for conservation and integrated management of these ecosystems. It is desired that the outcomes of the TII would improve the overall efficiency and targeting under the schemes operated by the Ministry.

TII makes significant departure from the approach of international TEEB study in two ways. First, while the international TEEB study was a global assessment of ecosystems and biodiversity values, TII has prioritized focus on three ecosystems (forests, inland wetlands, and costal and marine ecosystems) to ensure that tangible outcomes can be integrated in policy and planning for these ecosystems based on recommendations emerging from the TII. Secondly, while the international TEEB study was based only on secondary

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sources and meta-analysis of existing studies, TII incorporates a stakeholder-oriented approach to conduct policy-relevant field based primary assessment of biodiversity and ecosystems values in order to elucidate the desired changes at all levels of decision making, including the local level.

TII has been designed with the following outputs:

- Synthesis of the latest ecological and economic knowledge to structure the evaluation of ecosystem services under different scenarios.
- Targeted research and pilot projects on the assessment and economic valuation of biodiversity and ecosystem services, for representative sites and ecosystems.
- Recommendations at National, State and Local levels to foster sustainable development and better conservation of ecosystems and biodiversity. This may include, but not limited to, consideration of incentives, environmental liability, national income accounting, cost-benefit analysis, and methods for devising and testing various economic instruments.
- Information and tools for improved biodiversity-related business practices – from the perspective of managing risks, addressing opportunities, and measuring business impacts on ecosystems and biodiversity
- Recommendations for raising public awareness of the contribution of ecosystem services and biodiversity towards human welfare, and on human impact on biodiversity and ecosystems, as well as identifying areas where action(s) can make a positive difference.

1.4 TII governance

The MoEFCC, Government of India is implementing the TII in collaboration with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH under Indo-German Development Cooperation.

A Project Steering Committee (PSC) chaired by the Secretary, MoEFCC has been constituted to provide overall guidance and direction to TII, including approval and review of operational plan, periodic review of progress in implementation, and review and approval of assessment findings and outcomes of the TII.

A Scientific and Technical Advisory Group (STAG) comprising eminent ecologists and economists has been constituted to guide and provide scientific and technical guidance to TII.

Prof NH Ravindranath, Centre for Sustainable Technologies, Indian Institute of Science, Bangalore; Prof Haripriya Gundimeda, Indian Institute of Technology, Bombay and Indu K Murthy, Centre for Sustainable Technologies, Indian Institute of Science, Bangalore; are coordinating the work related to forests. Dr Ritesh Kumar, Wetlands International (South Asia) New Delhi is coordinating the work related to inland wetlands. Dr E Vivekanandan, Central Marine Fisheries Research Institute is coordinating the work related to coastal and marine ecosystems.

1.5 The process so far

The *TEEB-India: Initial Assessment and Scoping Report – Working Document* was released by the Hon'ble Minister for Environment and Forests in October 2012 during CBD CoP 11 in Hyderabad. The scoping report synthesized an overview of the extent and state of the three ecosystems in India (forests, inland wetlands and coastal and marine ecosystems), their key conservation challenges, state of art on valuation of ecosystem services and biodiversity in India and way forward for implementation of TII.

In addition to the existing knowledge on ecosystems values, the TII envisions establishing new policy relevant evidences for ecosystems values and their relation to human well-being through field based primary case studies in each of the three ecosystems. An open call was made seeking proposals for conducting field based case studies on economics of ecosystem services and biodiversity in context of relevant policy or management challenges for the three ecosystem types. In response, over 200 proposals were received. Key criteria for appraisal of the case study proposals were policy relevance, societal relevance, scientific excellence, and feasibility of completing the study within the time frame. Finally, the STAG recommended 12 proposals for commissioning. With approval of the PSC, the 12 case studies have been commissioned. Summary overviews of these case studies are presented in the next chapters.

1.6 TII contribution to Aichi and National Biodiversity Targets

In 2010, the Contracting Parties to the CBD adopted the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. The 20 Aichi Biodiversity Targets focused attention on specific steps and measures that can lead to conservation of ecosystems and biodiversity. As a commitment towards the international targets, India has formulated 12 National Biodiversity Targets and associated indicators and monitoring framework. The studies commissioned so far, and more that will be commissioned following this first set, are expected to cover wide ranging issues of importance to many stakeholders in various parts of the country (Table 2). The fact that 200 proposals were received from all over the country to take up case studies shows that there is significant awareness among the research community. An effective dissemination strategy will create widespread awareness, a precondition for any effective action in India's multicultural democracy. The relevance of specific studies being undertaken in TII and their contribution to various Aichi targets is indicated in subsequent chapters of this report.

1.7 The relevance of TII

For a country of India's diversity, the aforesaid twelve case studies are just a beginning. We expect to follow up with

Table 2: TII contribution to Aichi and National Biodiveristy Targets

National Biodiversity Target	Related Aichi Biodiversity Target	TII contributions
Target-1: By 2020, a significant proportion of the country's population, especially the youth, is aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	1	All pilot studies demonstrate application of ecosystem service values in a particular policy context, creating awareness on the various ecosystem service values, and alluding to specific measures that can ensure conservation and sustainable use.
Target-2: By 2020, values of biodiversity are integrated in national and state planning processes, development programmes and poverty alleviation strategies.	2	The studies will show the need for it and economic logic for taking action. It will inspire a number of advocates in states and centre to push for reforms.
Strategies for reducing rate of degradation, fragmentation and loss of all natural habitats are finalized and actions put in place by 2020 for environmental amelioration and human well-being.	5, 15	Several projects build scenarios of alternate management, indicating the costs and benefits of addressing degradation, fragmentation and loss of natural habitats. These scenarios will feed into management plans enlisting actions for addressig environmental degradation and improving human well-being.
Target-5: By 2020, measures are adopted for sustainable management of agriculture, forestry and fisheries.	6, 7, 8	Demonstration projects address production sectors related to fisheries and forestry and will lead to recommendations for sustainable management.
Target-8: By 2020, ecosystem services, especially those relating to water, human health, livelihoods and well-being, are enumerated and measures to safeguard them are identified, taking into account the needs of women and local communities, particularly the poor and vulnerable sections.	14	The studies aim to improve delivery and effectiveness of ongoing government schemes related to inland wetlands, forests and coastal and marine ecosystems. Methodological innovations adopted in the studies aim to articulate stakeholder and livelihood implications of changes in ecosystem services.

others and create a body of case studies covering different types and aspects of ecosystems and biodiversity. Valuation of ecosystems and biodiversity is critical for taking rational policy decisions even when we recognize that valuation can never be complete and at some stage ethical judgment must be employed. Certain ecosystems and biodiversity habitats have to be considered of 'incomparable value.' According to the National Environment Policy (2006), "…individuals or societies would not accept risks for compensation in money or conventional goods and services. A conventional economic cost-benefit calculus would not, accordingly, apply in their case, and such entities would have priority in allocation of societal resources for their conservation without consideration of direct or immediate economic benefit."

India requires that large projects of certain types obtain an environmental clearance from the MoEFCC. For this, the promoters have to provide an Environmental Impact Assessment (EIA) report. EIAs often consider only the direct impacts, while the consequences of disturbing regulatory services of ecosystems are not accounted for. Such consequences can impact people far away from immediate vicinity of the project. Apart from aiding decisions at the local levels, TII has a larger objective of guiding national level policies. The outcomes of the pilot projects, and subsequent sectoral synthesis are expected to provide better recommendations for improving sectoral schemes related to forests, wetlands and coastal and marine ecosystems.

For their well-being and economic development, humans have been using natural resources as if they are non-depleting and/or inexhaustible assets. These assets are, however, depleting at rates faster than the rates of regeneration. As the resources deplete, our ability for economic development and improving human well-being often gets diminished. Thus, for sustainable development of a large developing country like India, it is necessary that natural resources and assets are maintained at optimal levels.

Development policies have to account for their consequences on natural resources. Many of these

consequences are external to the profit and loss consideration and therefore get neglected. Thus, even the estimates of GDP excludes the value of depreciation of natural resources. A business that neglects the cost of depreciation of its assets may eventually go wrong. Similarly, an economy that neglects the loss in value of its natural resources may also find its growth not sustainable.

Natural resource accounting is recognized as an effective tool and barometer or compass that can guide economic decision making while factoring in preservation of natural assets at socially desired levels. Unless natural capital is accounted as an asset, it is likely to receive little attention and lead to its degradation.

Valuation of natural resources is often a complex task as these resources are not traded in a market. Even when they are, the value that the society should put on them may be different than what the market may ultimately determine. Valuation techniques have to be developed that mimic the market and account for social values.

E VIVEKANANDA

The issues of valuation of natural resources have become much more important and at the same time more complex. Growing population and prosperity is putting ever increasing pressure on natural resources. Our understanding of the importance of ecosystem services and biodiversity is adding new dimensions in valuation. In fact the UN-STAT has only in 2012 come out with an experimental system for ecosystem accounting (UNSTAT, 2013).

It is not necessary that an economic activity leads to depletion of natural assets. If good principles of natural resource management are followed, asset value does not have to deplete during the process of execution of projects or economic development in general. This possibility makes Natural Resources Accounting worth doing. Often asset values of the whole ecosystem is difficult to work out but estimate of depletion can be done, for example value of lost asset can be calculated.

Valuation studies for different resources were carried out at the IGIDR beginning early 1990s such as for soils (Parikh and Ghosh, 1991), forests (Haripriya GS, 2000) and landfills (Yedla and Parikh, 2001). These showed the feasibility of estimating environmentally adjusted national income or Green GDP.

To scale valuation efforts to national level, sustained long term efforts are needed to develop more rigorous methods, identify data needs and ways to collect the needed information.

Valuing natural resources is a complex, spatial and institutional cross-scale problem (Turner et al., 2003). Economic valuation is one of the several diagnostic and assessment tools and political-institutional mechanisms that facilitate understanding of natural capital as complex socio-ecological systems (Ostrom, 2009). Economic valuation has an intrinsic appeal and utility in terms of supporting informed decision making, and in particular exposing the impacts of conventional economic thinking on health and functioning of natural capital. It is also associated with several critiques of the method and approach.

These limitations notwithstanding, the continued loss and degradation of natural capital and role of economic drivers therein, urgently call for communicating the diverse values of natural resources, and the consequences of loss of vital ecosystem services, in a common man's language that is understood by those who are involved in the very decision-making processes.

The TII aims to create a body of case studies based on which to generate wider awareness that will lead to sustainable policies as India faces threats from climate change and chalks out a "strategy for low carbon inclusive growth". In implementing such strategies TII can make important contribution.

This report presents the progress made, the ongoing work, and preliminary findings of the case studies initiated post COP-11, under the TII".

CHAPTER 2
Forests

S SURESH

Forests account for a third of the earth's land area and about 80% of terrestrial biodiversity. The livelihoods of close to 1.6 billion people are dependent on forests. Forests provide multiple supporting, provisioning, regulating and cultural services to human well-being. According to studies reviewed by TEEB, the contribution of forests and other ecosystems to the livelihoods and incomes of poor rural households is significant. The contribution of the forest sector to the national GDP is high in many tropical regions and countries. The state and health of forests, in particular tropical forests, is crucial for the economy and livelihoods of vast populations in tropical countries, the poor in particular. Further, there is a growing recognition of the role forests play in global climate change.

- The total Forest and Tree cover of India is 789,164 sq. km, which is 24.01 per cent of the geographical area of the country (FSI, 2013). There is an increase of 5,871 sq km in the forest cover of India in comparison to 2011 assessment. India has added about 3 million hectares of forest and tree cover over the last decade.
- The total growing stock of India's forest and trees outside forests is estimated as 5,658.046 million cum which comprises 4,173.362 million cum inside legally designated forest areas and 1,484.68 million cum outside such forests.
- Forests neutralize approximately 21% of India's Green House Emissions. Total carbon stock in forests is estimated to be 6,941 million tonnes. There is an increase of 278 million tonnes in the carbon stock of India's forests as compared to the last FSI assessment of 2011.
- Through its various programs, India is addressing critical issues such as deforestation, degradation of forests and sustenance of forest dependent communities. Government of India has been persistently working towards increasing the total forest cover in India by initiating targeted afforestation programs such as Green India Mission (GIM).
- From a network of 54 National Parks covering 21,003 sq km and 373 Sanctuaries covering 88,649 sq km, giving a combined coverage of 1, 09,652 sq km or 3.34% of the India's geographical area in 1988, the network has grown steadily, and as of 2014 there are 690 Protected Areas (102 National Parks, 527 Wildlife Sanctuaries, 57 Conservation Reserves and 4 Community Reserves) covering 1, 66,851 sq km or 5.07% of the India's geographical area.
- India is one of the 17 mega-diverse countries on the planet, with only 2.4% of the world's land area, yet accounts for 7-8% of all recorded species. India has 10 biogeographic zones and is home to 8.58% of the mammalian species documented so far, 13.66% avian species, 7.91% reptiles, 4.66% amphibians, 11.72% fishes and 11.80% for plants.
- Four of the 34 globally identified biodiversity hotspots, namely the Himalaya, Indo-Burma, the Western Ghats-Sri Lanka and Sundaland, are represented in India. India is also an acknowledged centre of crop diversity and harbours hundreds of varieties of crop plants such as rice, maize, millets etc.
- India's successful endeavour in expanding forest cover is widely acknowledged. An effective Forest (Conservation) Act, 1980, further strengthened by the National Forest Policy, 1988, a massive afforestation programme, establishment of biosphere reserves, and re-vegetation of degraded lands through Joint Forest Management and people's participation, account for the success in forest and biodiversity conservation.

RITESH SHARMA

2.1 Area under forests in India and trends

In India, forests account for 22% of the geographic area and 200 million people live in and around forests, and depend on it for their livelihoods. Many rivers have headwaters in forests. The forest sector contribution to GDP, though low (at 1.7% during 2011), could be high for the livelihood of forest dependent communities or poor in general. Forest resources have an important bearing on the environmental/ecological security and well-being of the country and people (FSI, 2013). The importance of forests as natural resource has been recognized by the Government of India and, therefore large emphasis has been laid on the conservation, restoration and development of forests.

Table 1 presents the net area under forests in India during the period 1985-87 to 2009-11 and it can be seen that the forest area in India is generally stable and consistently increasing since 1995-97.

Table 2 presents the forest cover change matrix for the period 2009 to 2011 as reported by FSI (2013). As can be seen from Table 2, a net increase in very dense forest is reported. However for the same period, a net decrease in area under moderately dense forest is also reported. The recent assessment reveals that there is a decrease of 199,100 ha of moderately dense forest (FSI, 2013) during 2009-2011.

The current assessment indicates an increase in area under very dense forests (VDF), a change potentially from moderately dense forest (MDF) (43,300 ha) and open forest (OF) (400 ha) categories. On the other hand, about 25,500 ha of VDF have been converted into a lower density class of MDF, OF and non-forest (NF) categories.

The factors driving change in forest cover in the different States are varied. Factors causing a decrease in forest cover include shifting cultivation in the north-eastern States such as Manipur, Mizoram, Nagaland, and Assam to rotational and planned felling by the Forest Department in Andhra Pradesh and Haryana to encroachments as reported from Andhra Pradesh, Assam, Chhattisgarh, Madhya Pradesh and Maharashtra (FSI, 2013). The factors contributing to increase in forest cover in some of the States such as Gujarat, Delhi, Bihar, Kerala, etc., include conservation leading to regeneration and afforestation.

2.2 Threats, gaps and challenges in forest conservation and management

In India, according to an assessment of forest conversion and loss made by Ravindranath et al. (2012) at the district level, about 63,650 ha was lost annually during the period 2003-05 and 99,850 ha annually during 2005-2007. Further, forests in India are also subject to degradation due to non-sustainable extraction of fuelwood and non-timber forest products (NTFPs), over-grazing by livestock, forest fire, fragmentation and encroachment (Afreen et al., 2011). According to FSI (2013), only 13% of the recorded forest area has no biotic influence. About 11% and 20% of the recorded forest area have high and moderate biotic influence, respectively. The key pressure on forest ecosystems in India include:

- **Forest conversion:** According to NBAP (2008), about one million hectares (mha) of forest area has been diverted for implementing about 14,997 developmental projects since the enactment of the Forest Conservation Act in 1980.
- **Extraction of timber and NTFPs:** Fuelwood is the dominant source of cooking energy for rural population in India with forests contributing significantly to this. According to FSI (2013), about 216 million tonnes (mt) of fuelwood is consumed in India, of which about 27% is sourced from forests. Domestic demand for timber and fuelwood is well above the sustainable level.
- **Livestock grazing:** Grazing has profound influence on forest vegetation – while light controlled grazing is beneficial, heavy uncontrolled grazing is harmful (FSI, 2013). Harmful impacts of uncontrolled grazing include death of seedlings, reduced porosity of soil due to compaction resulting in poor aeration and increased run-off and loss of palatable grasses. According to FSI (2013), incidence of moderate to high grazing pressure is reported for more than 30% of the recorded forest area.
- **Forest fire:** The area estimated to be fire prone by the Forest Survey of India (FSI, 2013) is about 54% of the

Table 1. Net forest area (Mha) under different density classes at different time periods

Forest density class	Year of assessment								
	1985-87	1995-97	1997-99	1999-01	2001-03	2003-05	2005-07	2007-09	2009-11
Dense	36.14	36.73	37.74	41.68	39.06	38.72	40.25	40.42	40.22
Open	28.16	26.61	25.99	25.87	28.78	28.99	28.84	28.78	29.57
Total	64.20	63.34	63.73	27.55	67.83	67.71	69.09	69.20	69.79

Source: FSI (1985 to 2011)

Table 2. Forest cover change matrix for India between 2009 and 2011 (in hectares)

Density Class	VDF	MDF	OF	Scrub	NF	Total of 2009
Very dense forest (VDF)	8,306,500	25,500	4,500	0	10,600	8,347,100
Moderately dense forest (MDF)	43,300	31,701,000	178,600	200	150,500	32,073,600
Open forest (OF)	400	82,000	28,508,400	6,000	185,200	28,782,000
Scrub	0	300	60,600	4,087,100	69,600	4,217,600
Non-forest (NF)	0	65,700	813,000	45,000	254,382,300	255,306,000
Total – 2011	8,350,200	31,874,500	28,782,000	4,217,600	254,798,200	328,726,300
Net change	3,100	-199,100	783,100	-79,300	-507,800	

Source: FSI, 2013
Note: Green indicates gain and red indicates loss

recorded forest area, of which heavy fires are estimated to affect about 1.3% and moderate and mild fires are estimated to affect about 6.5% and 46%, respectively. The extent of forest area estimated to be experiencing surface fire that affects ground flora and organic matter in the soil is 3.69% and this pole crop and regeneration is affected in an estimated area of 1.42% (FSI, 2013).

- **Mining:** Mining, particularly open cast mining, has significant impacts on forest and biodiversity of India. In the Western Ghats region, iron ore mining activity has resulted in degradation of land and forest area and impacted the water quality in the Bhadra River on account of siltation and contamination of water by the ore.
- **Forest fragmentation:** Fragmentation decreases habitat simply through loss of land area, reducing the probability of maintaining effective reproductive units of plant and animal populations. Landscape fragmentation, which results in less connectivity of habitat to allow natural migration, limits the adaptive capacity of species and the viability of ecosystems (Vos et al. 2008).
- **Invasive alien species:** Invasive Alien Species are one of the major threats to biodiversity throughout the world, yet it is expected that further increases in trade, transport and tourism will only aggravate the problem. In India, a country with four of the world's important 'biodiversity hotspots', the invasion of alien plants is beset with ecological, economic and social consequences (Bhatt et al., 2012). The major forest invasive species include *Lantana camara, Eupatorium glandulosum, Parthenium* species, *Mimosa* species, *Eichornia crassipes, Mikania micrantha, Ulex europaeus, Prosopis juliflora, Cytisus scoparius, Euphorbia royleana*, etc. Highly invasive climbers like *Chromolaena odorata* and *Mikania* species have over-run the native vegetation in north-east Himalayan region and the Western Ghats (NBAP, 2008). A study conducted by Forest Survey of India for the State of Forest Report concludes that about 60% of the recorded forest area has moderate to scanty presence of weeds while about 20% of the area has very dense distribution of weeds (FSI, 2013).
- **Anthropogenic climate change:** Gopalakrishnan et al. (2011) conducted an assessment of the impact of projected climate change on forest ecosystems in India based on climate projections of the Regional Climate Model of the Hadley Centre and the global dynamic vegetation model IBIS for A1B scenario for the short-term (2021–2050) and long-term (2071–2100) periods. The assessment of climate impacts showed that at the national level, about 45% of the forested grids is projected to undergo change. This means the future climate is not optimal for existing forest types and biodiversity, leading to forest die-back and change in biodiversity in the long run.

2.3 Issues in conservation and restoration of forest biodiversity and ecosystem services

Biodiversity is integral to almost all ecosystem processes, with some species playing key functional roles that are essential for maintaining the value of ecosystems to humans. However, many ecosystem services remain non-valued, and decision-makers rarely consider biodiversity in policy development, in part because the relationships between biodiversity and the provision of ecosystem services are not generally appreciated. Some of the potential issues in conservation and restoration of forest biodiversity and ecosystem services were elaborated in the scoping report and a summary of the same is provided below:

- Lack of periodic assessments and monitoring that generates knowledge, information and data on the status of biodiversity and ecosystem services and the threats and drivers of degradation and loss
- Lack of awareness on the economic value of biodiversity and ecosystem services requiring due recognition and demonstration of the value of forest ecosystems

- Lack of integration of biodiversity and ecosystem services' concerns in planning and designing of conservation and restoration policies and programmes
- Lack of technical and institutional capacity for conservation and restoration of forest biodiversity and ecosystem services

2.4 Existing evidence base on ecosystem services and valuation

While the number of studies based on economic valuation of biodiversity and ecosystem services is growing worldwide, there is still a dearth of similar studies in India. An extensive review is provided in the TEEB Scoping Report (Parikh et al., 2012). Studies conducted could be categorised as those that estimated provisioning, regulating, supporting and cultural services and there are a few that have adopted a holistic approach and evaluated multiple ecosystems services. In all, there have been about 10 holistic studies covering either a single state or a group of states or the entire country (Chopra, 1993; Parikh et al., 2008; Verma, 2000; Verma et al., 2010; Verma et al., 2007). Provisioning service of forest ecosystems is quantified by several studies (Negi and Semwal, 2010; Joshi and Negi, 2011; Mahapatra and Tewari, 2005; Purushothaman et al., 2000; Narendran et al., 2001; Murthy et al., 2005; Sarmah and Arunachalam, 2011; Appasamy, 1993). There is one study by Kiran and Kaur, 2011, which has quantified the nutrient retention (supporting) service of forests. Badola et al. (2010) and Hadker et al. (1997) have evaluated the recreation service (cultural) of forest ecosystems in Corbett Tiger Reserve, Uttarakhand and Borivili National Park, Maharashtra. The regulating service of forest ecosystems have been quantified for a single forest type (Badola et al., 2010) or the entire forests of India (Kadekodi and Ravindranath, 1997 and Singh, 2007).

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2.5 Gaps in valuation of forest ecosystem services and biodiversity

The scoping study revealed that in India, there have been few studies aimed at assessing economic value of biodiversity and ecosystem services, largely focused on the use value or the marketable products. However, the following limitations were identified:

- Inadequate and incomplete coverage of ecosystems/ forest areas of the country.
- Focus on one or a few of the ecosystem services arising from a forest ecosystem leading to incomplete valuation and hence not reflecting the total economic value of the forests.
- Macro level valuation at the State or National level, based largely on secondary and international sources of economic value of forest products and services, making them limited in relevance to local situations and policy making. These estimates are further based only on current rates of extraction and not sustainable rates of extraction.
- Absence of empirical data based valuation of biodiversity and ecosystem services.
- Absence of full valuation of biodiversity and ecosystem services.
- Lack of standard methods for valuation of biodiversity and ecosystem services, making them incomparable.

2.6 TII case studies – building new evidences on valuation of forest ecosystem services and biodiversity

An important aspect of the TII is building new evidences though policy relevant case studies. Based on primary research at the field level, the case studies would address key policy and management challenges for conservation and sustainable use of biodiversity and ecosystem services. The case studies aim to demonstrate practical application of ecosystem services valuation in decision making contexts. A summary of study sites and key policy question that is being addressed by the three ongoing case studies in forest ecosystems is presented in Table 3 below. The outcomes of the study will be fed into a synthesis report.

Table 3: List of selected case studies in forest ecosystems and their key aspects

Study site and partners	Key biodiversity and ecosystem service values	
Valuation of forest ecosystem services in Western Ghats *NH Ravindranath, Indian Institute of Sciences, Bangalore* and *Haripriya Gundimeda, Indian Institute of Technology, Mumbai*	The Western Ghats spread over an area of 164,280 sq km traverses across 51 districts of six states – Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. The Western Ghats is one of the biodiversity hotspots and the water tower of Peninsular India. Western Ghats harbours as many as 4,000-4,600 species of flowering plants of which 2,100 species are endemic. The Western Ghats form the major watershed in India, with 58 major Indian rivers originating from it. The Western Ghats is also the home for about 50 million people.	
The economics and efficacy of elephant-human conflict mitigation measures in southern India *Raman Sukumar, Asian Nature Conservation Foundation*	Elephant man conflicts are deterrent to recognizing, capturing and valuing the ecosystem services provided by the former. Such conflicts have sharply escalated in recent years in many parts of India leading to damage and loss of agricultural crops (0.8~1 mha area), property and human (500 mortalities) as well as elephant lives (100 individuals). Mitigating this conflict is imperative if conservation of elephant habitat and biodiversity is to find acceptance among local people who share this habitat. The appropriateness, efficacy or economic viability of mitigation measures have never been critically assessed. In fact, over 70% of the annual budget of Project Elephant (a centrally-sponsored scheme) is used for conflict, leaving little resources for other aspects of management of elephants and their habitats. At the same time, the elephant is a keystone species in the biodiversity-rich tropical forests, making it imperative to conserve this creature and its habitat.	
An economic assessment of ecosystem services provided by vultures: a case study from the Kanha-Pench Corridor, Central India *N M Ishwar, IUCN India office*	The decline in Asia's vultures attributed to Diclofenac salts in vet-pharmaceuticals, resulted in the loss of several critically important ecosystem services. With the decrease in primary scavengers like vultures, carcasses are now being left to openly rot, leading to significant waste disposal problems, and a growing range of health concerns to humans. A recent study in India by Markandya et al. (2008) estimates that concurrent with the vulture die-off there has been an increase of 5.5 million feral dogs, which has resulted in over 38.5 million additional dog bites, and more than 47,300 human deaths from rabies. This study estimates that the increased number of rabies victims may have cost the Indian economy over USD 34 billion.	

	Policy context	Contribution to TII
	An analysis of the area under forests in the states and districts of the Western Ghats region over a 10-year period of 2003 to 2013 shows that the area under forests has increased by 7,839 sq km. However, when area under forests in the different density classes is seen, the area under dense forests is reported to have increased but the area under moderately dense forests has decreased by 481 sq km, with area under open forests increasing simultaneously. A close look at the area under various crown density classes in the different districts of the six states for the 10-year period of 2003 to 2013 indicates a net loss in forest area across states. The loss in area under very dense and moderately dense forests in some of the districts of the six Western Ghats' states is a cause of concern as such losses in native forests are irreversible and the biodiversity losses are at times permanent as the Western Ghats is home to some of the most endangered and threatened species. Such forest losses also have implications for the biomass and carbon stocks as well as the dependent livelihoods and economy of local communities.	Western Ghats case study focuses on the following: • Assessment and estimation of the status of biodiversity and flow of ecosystem services from selected forest types in the Western Ghats – bio-physical services. • Estimation of economic value of ecosystem services in the Western Ghats. • Recognition and demonstration of the importance of monetary and non-monetary benefits of forest ecosystems. • Understanding policy and institutional issues and barriers in the Western Ghats region with respect to forest biodiversity and ecosystem services. • Assess existing programmes, policies and institutions and suggest financial mechanisms, policy and institutional options for providing financial incentives for promotion of conservation and sustainable flow of economic benefits to local communities. • Assist decision-makers in rationalizing the need for investment by providing financial incentives for conservation and restoration and for regulating extraction.
	This project has major policy relevance to planning for appropriate measures for mitigating elephant-human conflicts and in management of elephant populations for maintaining a healthy and diverse habitat. The two major users of the results of this study would be Project Elephant of the MoEFCC, Government of India (in formulating country-wide conflict mitigation policy and budgeting of financial resources) and Karnataka State Forest Department (in their planning and implementation of conflict mitigation on a site-specific basis).	The project would generate a technical analysis of the economics and efficacy of elephant-human conflict mitigation measures, as well as analysis of the role of the elephant in maintaining biodiversity of their tropical forest habitats in the state of Karnataka. It would also come up with specific recommendations on the type of site-specific conflict mitigation methods to adopt, including strengthening the capabilities of local communities to manage conflict and improve livelihoods.
	Governments of India and its neighbour have adopted a Regional Declaration on the Conservation of South Asia's Critically Endangered Vulture Species and the governments agreed to the constitution of a Regional Steering Committee (RSC) in order that policy makers in the range countries are able to make informed decisions particularly on Vulture Safe Zones as well as regulatory requirements of vulture-safe drug formulations	The TEEB approach draws attention to the economic benefits of biodiversity and helps decision-makers to recognize and capture values of ecosystem services and biodiversity. A first of its kind, it is envisaged that the project will also help in developing a framework for species-related to valuation studies. This study will undertake a valuation of human health costs, and costs related to livestock upkeep, due to the absence of vultures. It will also address various policy and economic issues related to Diclofenac ban, and the costs for subsidizing alternative NSAIDs (e.g Meloxicam). A cost–benefit analysis of Diclofenac and Meloxicam will be undertaken.

2.6.1 Valuation of forest ecosystem services and biodiversity in the Western Ghats

Lead Authors: • N H Ravindranath • G Haripriya

The Western Ghats is spread over an area of 164,280 sq km, traversing across six States of India viz. Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu, spanning 188 taluks in 51 districts. The study shows preliminary assessment, which will be reviewed. The Western Ghats is a treasure trove of biodiversity and one of the biodiversity hotspots and the water tower of peninsular India. Floristically, the Western Ghats are one of the richest areas in the country and harbours as many as 4,000-4,600 species of flowering plants, of which 2,100 species are endemic. A number of endangered or rare plant species have their type locations in the Western Ghats. The Western Ghats are part of the Western Ghats-Sri Lanka global hotspot, running roughly in a north-south direction for about 1,500 km parallel to the coast bordering the Arabian Sea. The importance of the Western Ghats in terms of their biodiversity can be seen from the known inventory of their plant and animal groups and the levels of endemism in these taxa. Western Ghats harbour 7,388 species of flowering plants. Of these, 5,584 species are indigenous, 377 are exotic naturalised and 1,427 are cultivated or planted. Of the indigenous 5,584 species, 2,242 species are Indian endemics (found only in India) and 1,261 are the Western Ghats endemics. Apart from the above, there are 586 taxa with subspecies and variety status, bringing total taxa in the Western Ghats to 7,974 (Nayar et al, 2014). Thirty nine sites in the Western Ghats in the States of Kerala, Karnataka, Tamil Nadu and Maharashtra were inscribed in the UNESCO World Heritage List in 2012, considering their outstanding universal value and high levels of endemism. The Western Ghats form the majority of watershed in India and as many as 58 major Indian rivers originate there. It is also the home to about 50 million people, across six States in the country. There are four major phenological forest types in the Western Ghats, moist deciduous forests occupying the largest area, followed by semi evergreen, evergreen and dry deciduous.

An analysis of the area under forests in the States and districts of the Western Ghats region over a 10-year period of 2003 to 2013 shows that the area under forests has increased by 7,839 sq km. However, when area under forests in the different density classes is examined, the area under dense forests is reported to have increased but the area under moderately dense forests has decreased by 481 sq km with area under open forests increasing simultaneously (Table 4).

A close look at the area under various crown density classes in the different districts of the six States for the 10-year period of 2003 to 2013 indicates a net loss in forest area across States:

- **Maharashtra:** A net loss of about 79 sq km area in the very dense and 58 sq km area in the moderately dense forest categories over the period 2003 to 2013.
- **Gujarat:** A loss in moderately dense forest area of 587 sq km.
- **Goa:** A loss of 670 sq km in north and south Goa districts.
- **Karnataka:** A loss of only 2 sq km in the very dense forest. category but a loss of 1,621 sq km in the moderately dense forest category in all districts, except Mysore.
- **Kerala:** A reported loss in area under very dense as well as moderately dense forest categories is reported and the loss is 50 and 749 sq km, respectively over the decade.
- **Tamil Nadu:** About 278 and 103 sq km loss has been reported for the decade in the very dense and moderately dense forest categories.

The loss in area under very dense and moderately dense forests in some of the districts of the six Western Ghat States is a cause of concern as such losses in native forests are irreversible and the biodiversity losses are at times permanent as the Western Ghats is home to some of the most endangered and threatened species. Such forest losses also have implications for the biomass and carbon stocks as well as the dependent livelihoods and economy of local communities.

2.6.1.1 Objectives of Western Ghats Study

Western Ghats study adopts the TEEB approach. TEEB presents an approach that can help decision-makers

Table 4: Area under forest according to density classes in the Western Ghats districts for the period 2003 to 2013

	Very dense forest	Moderately dense forest	Open forest	Total
2003	3096	46838	29534	79468
2005	3949	46086	29685	79720
2009	6322	45977	33124	85423
2011	6370	46001	33267	85638
2013	6844	46357	34106	87307

Source: State of Forest Report (FSI, 2003, 2005, 2009, 2011 and 2013)

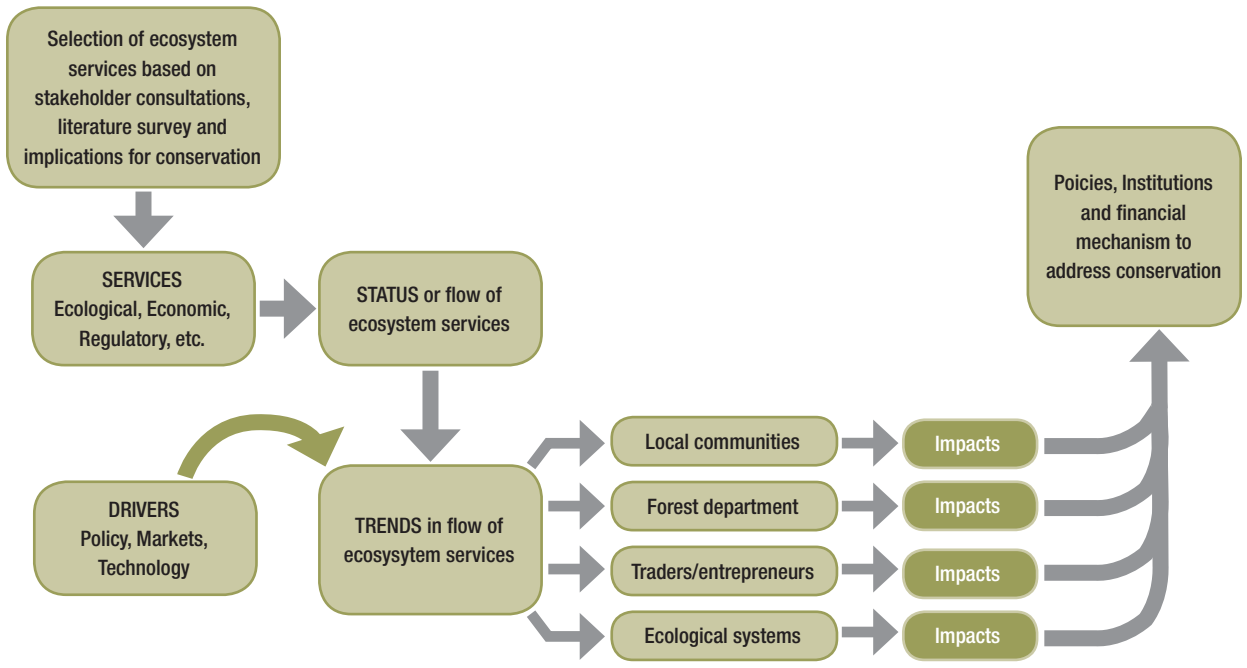
recognize, demonstrate and capture the value of ecosystems and biodiversity in decision making. The Western Ghat study has the following objectives:

- Assessment and estimation of the status of biodiversity and flow of ecosystem services from selected forest types in the Western Ghats – Bio-physical services.
- Estimation of economic value of ecosystem services in the Western Ghats.
- Technical analysis of the economics and efficacy of animal-human conflict mitigation measures.
- Recognition and demonstration of the importance of monetary and non-monetary benefits of forest ecosystems.
- Understanding policy and institutional issues and barriers in the Western Ghats region with respect to forest biodiversity and ecosystem services.
- Assess existing programmes, policies and institutions and suggest financial mechanisms, policy and institutional options for providing financial incentives for promotion of conservation and sustainable flow of economic benefits to local communities.
- Assist decision makers in rationalizing the need for investment by providing financial incentives for conservation and restoration and for regulating extraction.

The study approach is presented in Figure 1.

Uttara Kannada district in the Western Ghats region was selected for the TII study. Forests comprise 80% of the geographical area of Uttara Kannada and hence apt for

Figure 1: Approach to Western Ghats assessment



ROHAN PANDIT

assessment. Uttara Kannada is a hilly district in Karnataka situated towards the middle of the west coast of the Indian peninsula and lies between 13.92°N to 15.52°N and 74.09°E to 75.09°E latitudes. The district has five ecological zones – coastal, evergreen, semi-evergreen, moist deciduous and dry deciduous forests. The area is very rich in floral and faunal biodiversity. In the western part where the district experiences heavy rainfall, the vegetation is mainly composed of evergreen and semi-evergreen types and towards the eastern part it is mostly moist and dry deciduous forests. A variety of crops are cultivated in roughly 13% of its land area. Uttara Kannada is especially popular among the tourists for the natural attractions as well as for religious practices. The region has several rivers, waterfalls and pilgrimage places. Given the limited time and resources, only six key provisioning services, one regulating and one recreational service was considered for assessment and a range of valuation methods have been used.

2.6.1.2 Quantification of Biodiversity and Ecosystem Services

The first step towards valuation of biodiversity and ecosystem services from forests is its recognition, which has been documented extensively by various institutions and individual researchers over the decades. The next step is demonstration of the value of biodiversity and ecosystem services, which is dependent on the forest type, the status of forest, the current level of dependence on the forests, market or demand, access to technology for extraction and processing and socio-economic status of the communities. To arrive at a value for a resource, it is imperative to quantify the benefits (biophysical valuation) that accrue from a resource – both use and non-use values, and/or both tangible and intangible benefits. The current study aimed at biophysical quantification of biodiversity and some of the key ecosystem services (Table 5) in 1-ha permanent plots established during 2009-10 by the Indian Institute of Science in the forests of Uttara Kannada district of Karnataka part of the Western Ghats. Table 6 provides biophysical stock estimates of timber, fuelwood and carbon, to derive flow values for estimation of the economic value of the forests ecosystem services.

Biodiversity refers to the number, abundance, and composition of genotypes, populations, species, functional types, communities, and landscape units in a given system. Biodiversity is both response variable, that is affected by changes in climate, resource availability, and disturbance and a factor with the potential to influence the rate, magnitude, and direction of ecosystem processes. Biodiversity affects

Table 5: Biodiversity and ecosystem services assessed in this study

Ecosystem Service	Services assessed
Provisioning	Food, fodder, fuelwood, timber, manure, medicine
Regulating	Climate regulation - biomass and soil carbon
Supporting	Biodiversity
Recreational	Eco-tourism

numerous ecosystem services, both indirectly and directly. Table 6 presents biophysical quantities of services estimated in this study for different types of forests. The total area of forests in the Western Ghats is 164,280 sq km, of which evergreen forests constitutes about 22%, semi evergreen about 9%, moist deciduous about 29% and dry deciduous about 12%.

- ***Biodiversity:*** On an average, the diversity index of trees in the evergreen forest type was 3.02, followed by the moist deciduous plots with a Shannon Weiner diversity index of 2.98 and then the dry deciduous plots with 1.54.
- ***Provisional services:*** The present study has generated an evidence base relevant for understanding the significance of provisional services provided by evergreen, moist and dry deciduous forest types in Uttara Kannada district of the Western Ghats.

  Food: About 40 different species are used as food in the evergreen forest type while in the moist and dry deciduous forest types, 32 and 8 different species are used as food, respectively. Although the total number of species used in the evergreen forest type is 40, the number of species yielding food varies across locations. Few of the species that are specifically used in this region as food and food substitutes or flavouring agents are *Murraya koenigii, Garcinia indica, Garcinia cambogea, Artocarpus lakoocha, Eugenia jambolana, Flacourtia montana,* etc.

  Timber: Forests are the prime source of timber for the local people. This includes wood for making furniture, agricultural implements, fencing poles, and planks for roofs. Among the three forest types highest amount of timber is recorded in the moist deciduous forests (184 t/ha), followed by dry deciduous (164 t/ha) and evergreen forests (162 t/ha).

  Fuelwood: Fuelwood is the main-stay of rural population of India for cooking, along with other household and non-agricultural uses. The average quantity of fuelwood available for extraction is highest in the evergreen forest type (146 t/ha), followed by moist deciduous (101 t/ha) and then the dry deciduous forest type (83 t/ha).

  Fodder: Fodder yielding species in the study area included *Gmelina arborea*, *Grewia tiliifolia*, *Lagerstroemia parvifolia*, *Schleichera trijuga*, *Dillenia pentagyna,* etc. Here again, although the above mentioned species are distinctly documented to be fodder species, local communities use lops and tops of many species.

Table 6: Biophysical quantities of services per hectare

Services	Stock/flow	Evergreen	Moist deciduous	Dry deciduous
Biodiversity (Shannon Wiener Index)	Index	3.02	2.98	1.54
Manure (tonnes/year)	Flow	1.54		
Timber (tonnes)	Stock	162.00	184.00	164.00
Fuelwood (tonnes)	Stock	146.00	101.00	83.00
Carbon (tonnes of Carbon)	Stock	229.00	222.00	182.00
Food, fodder, medicine – non-timber forest produce (kg)	Flow	Includes edible fruits, medicinal plants, honey, gum, structural timber, poles, fodder, etc. – cannot be added into a single value		

Note: Shannon's index accounts for both abundance and evenness of the species present. The proportion of species relative to the total number of species is calculated, and then multiplied by the natural logarithm of this proportion to obtain the diversity index.

Medicinal: The number of species used for medicinal purposes in the study region ranged between 91 in evergreen forest type to 30 in dry deciduous forest type. Species used for medicinal purposes include *Actinodaphne hookeri*, *Calycopteris floribunda*, *Glycosmis pentaphylla*, *Knema attenuata*, *Mappia foetida*, *Myristica beddomei, Cinnamomum zeylanicum, Emblica officinalis, Terminalia bellerica, Terminalia chebula, etc.*

Manure: Manure yielding species in the plots studied include *Careya arborea*, *Calycopteris floribunda*, *Terminalia bellerica*, *Terminalia chebula*, *Aporosa lindleyana*, *Macaranga peltata*, *Ixora brachiata* and *Grewia tilifolia*. About 1.54 tonnes of manure is obtained from a hectare of forest in the region for application to areca gardens.

- ***Regulating services:*** Carbon regulating service is an important service from forest ecosystems. Forests are one of the world's major carbon stores, containing about 80% of above-ground terrestrial biospheric carbon and 40% of terrestrial below-ground carbon, thereby playing an important role in the global carbon cycle.

  Biomass + Soil carbon: The carbon regulatory service when analysed for the three distinct forest types exhibited that carbon (above-ground + below-ground + soil) in dry deciduous forest type was 182tC/ha compared to 222tC/ha for moist deciduous and 229tC/ha for evergreen forest type.

2.6.1.3 Economic Valuation of Biodiversity and Ecosystem Services

As mentioned in the previous section, the Western Ghats provide valuable ecosystems services for human well-being that often goes unrecorded due to lack of quantified values. This leads to underestimation in policy-making. One of the objectives of TII is to demonstrate the value of ecosystem services. The Western Ghats study consists of two case studies namely; firstly, economic valuation of forests and secondly assessment of contribution of elephants to biodiversity and ecosystem services. Demonstration of such values for example, can help society better understand the costs incurred in maintaining Western Ghats intact vis-à-vis the range of benefits that these ecosystems provide.

Western Ghats ecosystems have been heavily researched and there exists some starting values for some of the ecosystem services. However, a systematic study that provides quantitative insights into the comprehensive analysis of the bundle of ecosystem services provided by these ecosystems are few.

For this region, six provisioning services, one regulating and one recreational service are assessed. As mentioned in the previous section, all services were quantified in ecological units; amount of wood harvested, quantity of fuelwood consumed, range and amount of NTFPs collected, the number of visitors for tourism purposes, the amount of carbon sequestered, etc. Once the physical indicators were obtained, appropriate valuation techniques were used to value in monetary terms. From the values generated both producer surplus and consumer surplus were estimated and then aggregated.

Value of Timber

Western Ghats are very valuable for wood production and a range of different wood qualities is harvested. The main beneficiaries are the local sawmills. A value chain analysis has been attempted and a primary survey of all the stakeholders has been carried out to understand the nature and extent of benefits from timber. The timber is sourced from the forests through government depots, and from non-forest areas and plantations. There is a ban on clear felling of trees from natural forests for commercial exploitation and the Forest Department can remove trees only as part of silvicultural practices. Based on the net primary productivity of forests in Western Ghats, the annual timber availablity is 1.8 million cubic metres. The forest depots auction timber four times annually and the highest bidder's price is the purchase price and the prices vary across the species. For example, the price of *Dalbergia latifolia* (Sissum) is ₹7,70,332/cu m (US$ 12,655/cu m), *Tectona grandis* (Teak) is ₹1,22,657/cu m (US$ 2,015/cu m), *Terminalia paniculata* (Kindal) is ₹16,477/cu m (US$ 271/cu m), *Terminalia elliptica* (Matti) is ₹17,789/cu m (US$ 292/cu m) and *Pterocarpus marsupium* (Honne) is ₹39,811/cu m (US$ 654/cu m) (at 2013 prices). There is variability in prices depending on the diameter of the logs as well, which makes it more complicated to assign unit price for timber. The main consumers are sawmills, retailers, other States, house constructors, etc. The main value addition takes place at the saw mills, who buy timber at a weighted average price of ₹23,907/cu m (US$ 393/cu m) and sell at an average price of ₹27,605/cu m (US$ 454/cu m) leading to a value addition of 15.46%. Processing of timber leads to further value addition of 44.5%.

Looking at the demand side, the total timber available to cater the demand in Karnataka is around 2.3 million cu m per annum of which only 0.75% is sourced through forests and rest comes from trees outside forests, plantations, neighbouring States and imports. In addition to forests, timber also comes from *malki* land and plantations from forest land and private land which in fact should also be considered for valuation. However, this study did not consider this. Thus, based on the current scenario of selective and regulated harvesting regime, the value of timber per hectare per year in Uttara Kannada is estimated to be ₹ 95,524/ha (US$ 1,569/ha).

Other very important benefits provided by Western Ghats forests are fuelwood, fodder and NTFPs generated to the local economy. To estimate the real value of fuelwood

and NTFPs, a household production function approach was adopted, separately for fuelwood and NTFPs.

Value of Fuel-wood

From the primary data, it is apparent that fuelwood is mainly a subsistence commodity and most of the households collect as much as they need for short-term use. The fuelwood is often transported using headloads by foot. Thus the distance to the fuelwood source, the effort (measure of labour input which is measured as the number of hours spent in collecting fuelwood) put in collecting the fuelwood, number of members in the house (a measure of labour supply) and the size of the landholdings and livestock possessed can be some important factors in determining the quantity of fuelwood collected from forests. From this, the shadow price of fuelwood was computed as a mean value of quantity of fuelwood collected, the mean hours spent collecting the fuelwood times the marginal product of labour. The shadow price of fuelwood has been estimated to be ₹ 19/kg (US$ 0.312/kg) as against ₹ 5/kg (US$ 0.082/kg) used in local markets. Based on the existing demand for fuelwood in Uttara Kannada, the fuelwood benefit to the local community dependent on forests is estimated to be around ₹ 37,746 million (US$ 620) or approximately ₹ 10,446/ha/year (US$ 172/ha/year). Here the assumption is that only a part of forests would be just sufficient to meet the demand and not the entire forest. It is also assumed that whatever is the demand, it is supplied from forests only through removal of twigs and branches and not through clear felling.

Value of NTFPs

The use of NTFPs make a substantial contribution to livelihood strategies of rural people in providing building materials, fodder and wildfoods. This contribution is likely to be especially important for poorer sections of the community, who might be able to benefit from policies designed to maximize the values of NTFPs. The task of estimating the use values of NTFPs is extremely complex as they do not have a market price and these NTFPs in many cases are used as substitutes for a range of products. A primary survey of households (478) was conducted in the villages where vegetation study was conducted to understand community dependence. Most of the NTFPs are used for consumption or subsistence purposes, and

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very few are sold. Not all the households are engaged in NTFP collection. The mean contribution of NTFPs to households is around ₹3,039 (US$ 50) with a maximum of ₹125,400 (US$ 2,060) (based on imputed prices). As the contribution of NTFPs is often underestimated, household production function was adopted as in the case of fuelwood to explore the factors determining the collection of NTFPs and from this shadow price was computed to assign values to products consumed by households. Extrapolation of these estimates to entire Uttara Kannada district indicates the value of NTFPs to be ₹28,442/ha (US$ 467/ha). This estimate provides an indicative figure of the use value of forests in Western Ghats. However, the extrapolated values from small case study or sample areas to the Western Ghats region should be viewed with caution, since expanded supply will lower unit values, and data on the amount of time spent collecting and processing of NTFPs and other costs, especially opportunity costs would vary.

Recreation Value of Western Ghats Forests

The Western Ghats is envisaged to have huge value for future generations and the people are willing to conserve for future generations, thereby generating huge option values. However, no attempt was made in this study to quantify, but instead the perception of the local stakeholders was recorded. Western Ghats commands very high recreational value and to valuate this, a primary survey of tourists in Dandeli-Anshi Wildlife Sanctuary and National Park was conducted. The Dandeli Sanctuary and Anshi Tiger Reserve are mainly comprised of moist deciduous and semi-evergreen forests and is a natural habitat for wildlife. The area has a population of more than 20,000 people living within and on the periphery of the reserve. The Sanctuary attracts many local and foreign tourists for adventure sports, wildlife, birds and natural attractions. The number of people visiting Dandeli-Anshi Tiger Reserve increased from 6,000 in 2001 to 41,175 in 2011. This has led to increased tourism revenues. There are eco-development committees of the local communities who are engaged in tourism and forest management activities.

To estimate the value of the park and sanctuary, a random survey of park visitors (face-to-face interview) was conducted during June 2014. Many of the tourists came in groups and in all 75 groups (450 in all) were surveyed. The prime purpose of this survey was to understand the visitors' purpose of visit, their spending patterns, their socio-economic background, their attitude towards environment and the Western Ghats. The Dandeli-Anshi Tiger Reserve,

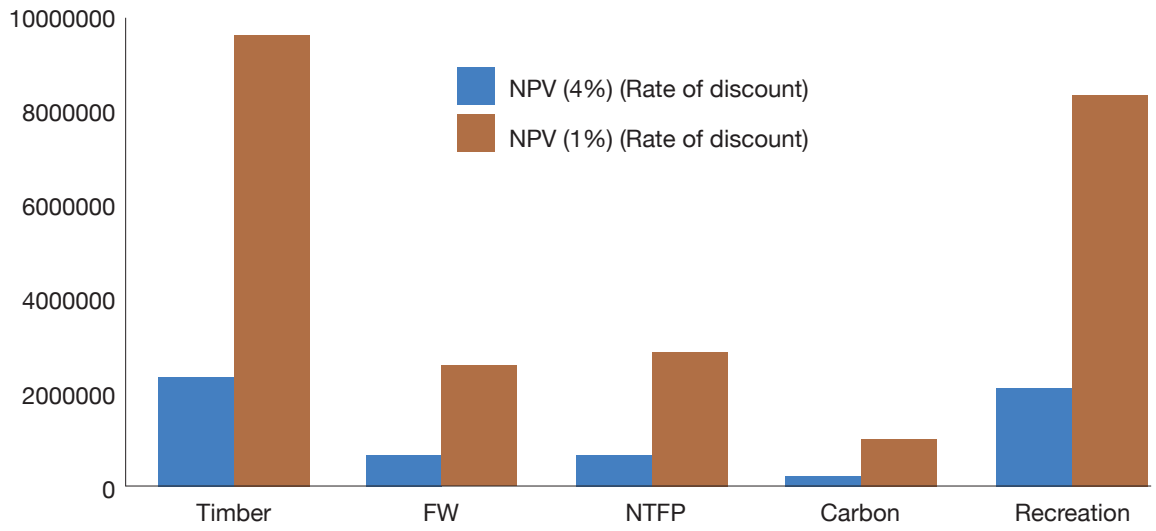
covering 1,315 sq km is entirely scenic by itself and also has multiple sites and attractions and tourists visit for any of these or a combination of these. So our survey was not for a single site but for the entire area spanning the Dandeli-Anshi Tiger Reserve. Therefore, no attempt to value site-specific characteristics was attempted. From the sample surveyed, trip generating function for which obtaining visitation rate is crucial was obtained. Based on this trip generating function, a demand curve for the site was generated from which the total consumer and producer surplus from recreation for the study period was estimated. The average distance in kilometres travelled by the tourists is 36 km and average time spent on site is 24 hours (3 days assuming 8 hours of recreation in a day). The mean on-site expenditure by the tourists was ₹ 24,037 (US$ 395). The average size of the group is 2.5. In the process of ensuring demand curve, it was ensured that there is no loss in statistical integrity. From this, the total surplus that the economy derives per hectare of Dandeli Anshi Protected Area is around ₹ 83,337/ha/yr (US$ 1,369/ha/year), based on the estimate that on an average there are 41,175 visits to the Sanctuary in a year. The surplus to the economy from all visitors visiting the Dandeli and Anshi Protected Area is ₹ 11,375 million (US$ 187 million) per annum for the year 2014.

Value of Carbon Regulatory Service

The carbon sequestration benefit is estimated from the biophysical measures given in the earlier section. The carbon sequestration clearly depends on the vegetation type, species mix, the organic matter content of the species, the age distribution, soil, climate and the below ground biomass. Using the estimates derived earlier, carbon sequestration in terms of the social cost of carbon was derived. Varying estimates are available based on the emission scenarios, damage and abatement functions considered and the choice of discount rate since Nordhaus (1991) and Cline (1992). The most conservative estimate of social cost of carbon used in literature has been $20 per tC (see discussion summary in Atkinson and Gundimeda, 2006). However, there has been some discussion on the appropriate estimate of social cost of carbon and the latest estimate proposed has been $ 37/tC (Atkinson and Gundimeda, 2006). The field level analysis showed that in the district of Uttara Kannada, the total stock of carbon is 183 MtC which is equivalent to 672 $MtCO_2$. The annual carbon sequestered in forests of Uttara Kannada is 1.12 tC/ha/year. The value of this stock of carbon based on the distribution of different forest types in Uttara Kannada district alone is estimated using avoided social costs. Social cost of carbon is the extra climate change impact that would be caused by the emissions of one more tonne of carbon dioxide in the atmosphere. Thus the benefit of carbon sequestered in the forests is the avoided social costs, which is estimated at ₹7.56 billion (US$ 124.199 million) annually, equivalent to ₹9,673/ha/year (US$ 159/ha/year) which would accrue to the global community.

To sum up, the net present value of the five ecosystem services in the current high protection regime (discounted at 1% and 4%) is expressed in Figure 2. The provisioning values of timber, fuelwood and NTFPs at present are very conservative and estimated at ₹745,618/ha/year (US$ 12,249.4/ha/year)as there are restrictions on the use of

Figure 2: NPV in Rs/ha at discount rate of 1% and 4% for the year 2013



forests. These values do not include extraction from non-forest areas. One can see that the recreational value is high. There would be trade-offs between recreational values and other provisioning services. The study did not include many of the other services provided by forests, particularly those related to water, due to limitation of time.

Comparative Estimates of Selected Ecosystem Services

Table 7 provides comparative estimates of economic value of selected ecosystem services (timber, fuelwood, NTFPs, recreation and carbon), based on the sustainable rates of extraction and the carbon sequestration compared to household survey, demand and supply assessments. It can be observed that the values of timber, fuelwood and recreation vary according to the two estimates. The total value of forest ecosystem, considering the five key services is in the range of US$ 4,151/ha considering sustainable rates of extraction to US$ 11,681/ha, based on the survey and market analysis. These values are higher than the reported value of US$ 1,151 (for food, raw material and recreation) reported by Costanza et al (2014).

2.6.1.4 Economic Incentives for Conservation

India has, fairly well developed forest and biodiversity conservation and development policies and institutional frameworks with clear principles and norms for engagement of communities and for benefit sharing (Table 8). These policies and institutions are relevant to Uttara Kannada district of the Western Ghats as well. All National and State level institutions, policies and programmes apply to the Western Ghats also. The relevance of key policies and existence of opportunities for providing incentives is reviewed and presented in Table 8. The review demonstrates the existence of several opportunities even in the existing policies and programmes for providing financial incentives for conservation in the Western Ghats.

The forest policies and legislations have led to establishment of state, district and village level institutions that are responsible for conservation and development of forests and biodiversity. However, there are certain barriers in the current policies as well as institutions for providing incentives to conservation, in the Western Ghats.

- The existing forest related policies and programmes

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Table 7: Preliminary estimates of the economic value of selected key forest ecosystem services based on sustainable rates of extraction, and household survey and timber and fuelwood market analysis

Service	Economic value based on primary survey, value chain and timber/fuelwood market survey ₹ (US$) per hectare	Sustainable rates of extraction	Economic value based on sustainable rates of extraction [₹ (US$) per hectare (ha)
Timber	306,788 ($ 5,040)	0.67 t biomass/ha	95,524 ($1,569)
Fuelwood	10,446 ($172)	1.35 t biomass/ha	35,720 ($587)
NTFPs	28,442 ($467)	NA	28,442 ($467)
Recreation	355,679 ($5,843)	NA	83,337 ($1,369)
Carbon	9,673 ($159)	0.9 t carbon/ha	9,673 ($159)
Total value for the services	711,028 ($11,681)		252,696 ($4,151)

Table 8: Selected policies incorporating financial incentives/compensations for conservation relevant to Western Ghats

Policies	Compensation/economic incentives/mechanisms
Forest Conservation Act, 1980	• Forest dependent communities are granted access to forests for collection of forest products. • CAMPA-funding mechanism for conservation and management of forests by utilising funds received towards compensatory afforestation.
National Forest Policy, 1988	• Recognition of rights of forest dependent communities and granting them access for collection of forest products. • Establishing conveniently located market depots for the local communities to purchase forest produce and their substitutes at reasonable prices. • Replacing contractors with institutions like tribal cooperatives, labour cooperatives, government corporations, etc. • Ensure investment from forest-based industries by establishment of direct relationship with individuals who grow or collect forest products, by supporting the individuals with inputs, including credit, technical advice, harvesting and transport services.
Joint Forest Management (JFM), 1990	• Capacity building of village communities through formation of institutions such as VFC, VSS, FDA, etc. • Provides livelihood opportunities and income security through participatory forestry. • Cost and Benefit Sharing – VFCs have share in timber and NTFPs accruing from JFM plantations.
Biological Diversity Act, 2002	• Access and Benefit Sharing – imposition of benefit sharing fee or royalty or both conditions including the sharing of financial benefits arising out of the commercial utilization of biological resources with local resources users.
The Scheduled Tribes and Other Traditional Forest Dwellers Act, 2006	• Access to forests for collection of forest products, which is crucial to meet their income generating and subsistence needs.

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largely focus on providing rights for collection and sharing of benefits from forest products, often with the Forest Department, as in the case of NTFPs such as Bamboo, Cane, *Garcinia cambogea*, etc. Currently these policies and programmes do not provide financial incentives for conservation, sustainable harvest and use.

- The financial incentives that are provisioned under some of the Acts such as for e.g., access and benefit sharing under the Biodiversity Act are not backed by operational guidelines.
- The existing provisions on providing incentives have not led to effective implementation of even the existing provisions due to lack of information, data on the true value of forest products, sustainable rates of extraction and legally established market and institutional mechanisms as seen even in the study region.
- There is limited scope and absence of operational guidelines for industry, corporate companies and entrepreneurs to participate in delivering real benefits to local communities or in full market development.
- There are also shortcomings in the current institutions that are currently in existence in the Western Ghats, when it comes to providing financial incentives. They include:
- Lack of empowerment of local institutions such as the JFMC (Joint Forest Management Committees) or BMC (Biodiversity Management Committee) in enforcing real economic charges for forest products and services.
- Lack of capacity, knowledge and information at the local institutional level (BMCs and JFMCs) to measure and monitor biodiversity and ecosystem services and to determine and seek the true economic value of forest products and services.
- Dependence of village level forest institutions on government corporations for sale of certain forest products, despite corporations not providing the true or market prices.
- Inequitable benefit sharing among members of institutions such as the LAMPS.
- Absence of institutional linkages between local institutions such as the BMCs and JFMCs, and entrepreneurs, industry and corporate companies.

2.6.1.5 Options and Mechanisms for Incentivization of Conservation

Some of the key options for incentivizing conservation efforts in the Western Ghats even within the current policy and institutional framework are presented in Table 9.

Options to utilize the existing institutions for operationalizing economic valuation of forest resources and providing economic incentives for the conservation of biodiversity and ecosystem services in the Western Ghats are provided in Table 10.

Table 9: Potential institutional options and mechanisms for incentivization

Mechanisms and guidelines	• Operational guidelines for participation of corporate companies/entrepreneurs in long term arrangements with JFMCs/VFCs/BMCs for sustainable forest product supply. • Develop new domestic mechanisms for rewarding conservation and sustainable use of carbon, watershed services, NTFPs, eco-tourism, etc. • Example: domestic CDM for carbon; domestic REDD+ for forest conservation, payment for watershed Services in river basins; markets for recreation, etc. • Empower BMCs and JFMCs to extract, market and charge (excluding local non-subsistence users), the real economic value for forest products. Ensure a minimum price for forest products with commercial value, eliminating auctioning or marketing through contractors. • Develop guidelines and programmes for economic valuation of ecosystem services and biodiversity, generate, publish and disseminate information on economic value of forests and alternate land uses.
Institutional options	• Develop norms for sustainable extraction of economically valuable forest products in different regions and create awareness. • Develop guidelines for BMCs/JFMCs for charging true value of forest products/services. • Identify forest products that require monitoring of status of resource. • Capacity building in BMCs/JFMCs/LAMPS.

Table 10: Institutions and options for operationalization of economic valuation and incentivization of conservation in the Western Ghats

Institutions	Options
JFMC/VFC/BMC	• Capacity building to determine the true value of forests and forest products to enable efficient conservation and management and sustainable flow of economic benefits to communities. Capacity building for sustainable utilization of forest products and services
Forest Development Agency (FDA)	• Improve efficiency to become financially self-sufficient Social Venture Capital Companies to independently provide financial, technical and managerial inputs to JFMCs.
Forest Development Corporation (FDC)	• Profits generated through sale of forests products by FDC should be shared with JFMCs/VFCs as incentives for sustainable management of forests or should at least provide fair market prices for forest products.
National Biodiversity Authority and State Biodiversity Board (NBA/SBB)	• Operationalizing setting up of venture capital fund for aiding the cause of resource conservers/ users. • Payment of monetary compensation and other non-monetary benefits to the resource conservers/users as the National Biodiversity Authority may deem fit. • Capacity building to determine the economic value of forests and forest products to enable equitable flow of benefits to local BMCs.
LAMPS	• Develop mechanisms to provide economic incentives to those members who directly contribute to conservation and sustainable management of forests.
Corporate companies	• Develop long-term agreements with forest product collectors and growers to meet resource needs, provide sustainable flow of benefits to local communities and encourage conservation of forests. • Utilize CSR funds to set up financial mechanisms to promote conservation of forests. • Provide incentives JFMCs and BMCs to adopt sustainable rates of extraction and processing and value addition activities
NGOs	• Help build capacity of local institutions to determine the true value of forest and forest products, enabling them to demand fair compensation for conservation and sustainable management of forests, and also develop fair price markets for forest products. Create awareness on the need for adopting sustainable rates of use of forest products and services

2.6.2 The economics and efficacy of elephant-human conflict mitigation measures in southern India

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2.6.2.1 Background

Elephant-human conflicts have sharply escalated in recent years in many parts of India. Agricultural crops, property and even human lives are lost due to elephants. Many elephants are also killed in retaliation by people. Elephants annually damage 0.8 to 1 million hectares of cultivated crops affecting about 500,000 families in and around Project Elephant reserves in the country. Across the country, over 500 people are killed annually at present (as opposed to 150 people annually during the early 1980s) by elephants and about 100 elephants are killed by people annually in retaliation over conflict. In one district of Karnataka alone, 38 elephants and 39 human deaths were reported in the last two decades. There has also been steady increase of crop damage incidents with elephants appearing in places they were not seen during the past 4-5 decades. Mitigating this conflict is imperative if conservation of elephant habitat and biodiversity is to find acceptance among local people who share this habitat.

This conflict is cause for concern as it threatens to erode societal support for nature conservation in conflict-prone areas. Although several conflict mitigation measures have been undertaken since the 1980s by the Government, the appropriateness, efficacy or economic viability of these measures has never been critically assessed. In fact, over 70% of the annual budget of Project Elephant (a Centrally-sponsored scheme) is used for conflict, leaving little resources for other aspects of management of elephants and their habitats. At the same time, the elephant is a keystone species in the biodiversity-rich tropical forests, making it imperative to conserve this creature and its habitat.

2.6.2.2 Methodology

The project would basically conduct an economic cost-benefit analysis of the existing conflict mitigation measures (mainly trenches and electric fences) in relation to the extent of crops damaged and human lives lost from conflict in two regions of Karnataka – the Kodagu district that is a mosaic of tropical moist forest, coffee plantations and paddy cultivation, and the Bannerghatta park close to a rapidly urbanizing Bangalore.

The capabilities approach would then be used to address human-elephant conflict and the effects it has on the loss of both life and property. It looks beyond the traditional practice of identifying an ideal solution and then trying to impose it on both humans and animals that may not find that solution suitable. By focusing on the capabilities of humans and the behaviour patterns of elephants, it tries to intervene in existing processes rather than assuming these practices can be done away with altogether. It thus looks at the possibility of altering the capabilities of humans in a manner that reduces their necessary contact with territory frequented by elephants, even as it explores the possibility of influencing elephant behaviour in a way that reduces their incursion into territories with concentrated human populations.

The project would also attempt to quantitatively assess the contribution of elephants to the biodiversity of the region as well as an economic evaluation of this ecosystem service. While the efficacy of conflict mitigation measures has been evaluated in some studies, there has never been a systematic attempt to look at this issue in economic terms. Also, the capabilities approach that we would be taking as outlined above has hardly been used in any study of wildlife-human conflicts.

The compensation data, basically the money that the Karnataka State Forest Department has paid to the elephant raid affected farmers over the last decade, has already been collected. Also the data about the presence of elephants in various coffee estates over the last six months has been collected. This compensation and elephant presence in coffee estates data will be analysed to assess the various elements that are attracting the elephants outside of their natural habitat.

The baseline geospatial data for the study areas that covers the physical and human geographies is also being compiled in a GIS (Geographic Information System).

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This will also help in evaluating the habitat integrity of the elephant's natural habitat. All this will help in understanding the patterns of elephant movement, and also why they move in such patterns. This assessment will be used to minimize the elephant human interaction and thus conflict, because unless we understand these patterns we will not be able to come up with a good strategy for mitigation.

2.6.2.3 Expected outcomes

The project would generate a technical analysis of the economics and efficacy of elephant-human conflict mitigation measures, as well as analysis of the role of the elephant in maintaining biodiversity of their tropical forest habitats in the State of Karnataka. It would also come up with specific recommendations on the type of site-specific

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conflict mitigation methods to adopt, including strengthening the capabilities of local communities to manage conflict and improve livelihoods.

2.6.2.4 Policy relevance

This project has major policy relevance to planning for most appropriate measures for mitigating elephant-human conflicts and in management of elephant populations for maintaining a healthy and diverse habitat.

The two major users of the results of this study would be Project Elephant of the MoFCC, Government of India (in formulating country-wide conflict mitigation policy and budgeting of financial resources) and Karnataka State Forest Department (in their planning and implementation of conflict mitigation on a site-specific basis).

As explained above, the outcome of the work would be useful to Government agencies in formulating site-specific policy and mitigating elephant-human conflicts using the most appropriate means. Conflict mitigation would bring considerable relief to local communities at the interface of forest and settlement. At the same time, action to reduce pressure on forests and improve the status of biodiversity would be beneficial to the long-term conservation of elephants of this region.

RAMAN SUKUMAR

2.6.3 An economic assessment of ecosystem services provided by vultures: A case study from Kanha-Pench corridor, Central India

Lead Author: • N M Ishwar

2.6.3.1 Background

The IUCN Red List of Threatened Species identifies 10 of the world's 23 vulture species as threatened with extinction, with the most rapid declines occurring in Asia. In the last 20 years, South Asia has witnessed the precipitous decline of three vulture species: the white-rumped vulture (*Gyps bengalensis*); the Indian vulture (*Gyps indicus*); and the slender-billed vulture (*Gyps tenuirostris*). Once numbering in tens of millions, the combined population of these three species has now been reduced by 99%. All three species are listed as Critically Endangered on the IUCN Red List of Threatened Species, and face extinction in the wild.

Extensive research revealed that *Diclofenac*, a non-steroidal anti-inflammatory drug (NSAID), widely used as a painkiller in domestic animals, is the primary culprit for the catastrophic decline of vulture populations across South Asia. The Governments of India, Nepal and Pakistan subsequently banned the manufacture and distribution of *Diclofenac* in 2006. *Meloxicam*, which is proven to be safe for vultures, is now being promoted as an effective alternative drug for treatment in livestock. Unfortunately, misuse of

human formulations of *Diclofenac* in the veterinary sector remains a significant threat to vultures, along with the wide-scale use of other untested NSAIDs in the region. Recent surveys suggest that vulture numbers have stabilized in South Asia as a consequence of a range of conservation measures being implemented, although population numbers still remain very low across the region. The decline in Asia's vultures has resulted in the loss of several critically important ecosystem services. It was estimated that vultures once removed some ten million tonnes of carrion a year from the landscape. With the decrease in vultures, carcasses are now being left to openly rot, leading to significant waste disposal problems, and a growing range of health concerns to humans. The easy availability of this decaying food source has led to a significant increase in the number of feral dogs, which is turn has led to an increase in dog attacks on humans, and a reported increase in incidence of rabies and anthrax amongst humans. A recent study in India by Markandya et al. (2008) estimates that concurrent with the vulture die-off there has been an increase of 5.5 million feral dogs, which has resulted in over 38.5 million additional dog bites, and more than 47,300 human deaths from rabies. This study estimates that the increased number of rabies victims may have cost the Indian economy over US$ 34 billion.

The corridor between Kanha and Pench Tiger Reserves in Central India has been identified as the focus landscape for this study. The corridor has long been recognized for the significant biodiversity it supports and in facilitating easy movement for large mammals. Tigers and other large fauna have long used the wildlife sanctuaries of Amba Barwa, Narnala, Wan and the division forests of North Balaghat, South Balaghat, West Mandla and South Seoni to travel between Kanha and Pench. This corridor is now the focus of several eco-developmental initiatives led by the State Forest Department and the National Tiger Conservation Authority, along with several civil society organizations. This is also the only corridor in the country with a management plan, and financial provisions for implementing the plan in order to strength the corridor as well as facilitate tiger and other large mammal movements. Given this background the corridor is an ideal candidate for creation of Vulture Safe Zone (VSZ) in Central India.

2.6.3.2 Research Questions – the Approach

The overall goal is to estimate the ecosystem services values provided by vultures in the Kanha-Pench landscape. It is intended that these values be integrated into vulture conservation-related policies in the region, as well as to advise other vulture range countries. Furthermore, based on

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the valuation of the ecosystem services, the study will provide recommendations for a policy framework on the economic viability of establishing VSZ in India.

The objectives of the study include estimating:

- the economic value of ecosystem services once provided by vultures in the Kanha-Pench landscape,
- the economic costs of banning *Diclofenac* and replacing it with other substitute NSAIDs,
- the economic value of benefits from ecosystem services (including human health) as a result of a potential increase in vulture populations in the VSZ,
- the cost of creation of VSZs.

2.6.3.3 Methodology

The TEEB approach draws attention to the economic benefits of biodiversity and helps decision-makers to recognize and capture values of ecosystem services & biodiversity. This project aims to adapt and apply this framework to a highly threatened species to understand its intrinsic value to biodiversity conservation and human well-being. A first of its kind, it is envisaged that the project will also help in developing a framework for species-related, ecosystem services valuation studies.

This study will undertake a valuation of human health costs, and costs related to livestock upkeep, due to the absence of vultures. It will also address various policy and economic issues related to the *Diclofenac* ban, and the costs for subsidizing alternative NSAIDs (e.g. *Meloxicam*). A cost–benefit analysis of *Diclofenac* and *Meloxicam* will be undertaken. The study will also help understand the implications of changes in population structure of secondary scavengers as a result of the loss of vultures as primary scavengers, as well as the financial outlay for the forest department in controlling and managing disease outbreaks due to decaying carcases in the Protected Area (PA).

2.6.3.4 Expected Outcomes

As such, IUCN will leverage the results of this study to:

- Develop irrefutable justifications for integrating vulture-recovery related interventions into the existing Kanha-Pench Corridor management plan,
- Upscale the methodology, approaches and outcomes of this study within India and in other vulture-range countries in South Asia,
- An understanding of costs involved in the creation of a Vulture Safe Zone,
- Integrate the results of this study into national-level interventions (including the Vulture Action Plan, India 2006, which is currently under revision)
- Relate project outputs to disease surveillance and the monitoring of secondary scavengers in PAs. Discussions will be held with the National Tiger Conservation Authority (NTCA), the Forest Department of Madhya Pradesh, and the Health and Animal Husbandry department of Madhya Pradesh, to better advise policy and advocacy, and the implementation of management plans for both the tiger reserves and the corridor.

It is argued that the increase in vulture populations will have several cascading impacts in PA's and human dominated landscapes. Firstly, there will be a decrease in rotting carcasses; in human dominated landscapes particularly, this will lead to a decrease in associated adverse health impacts (and the feral dog population), as well as prevent the contamination of freshwater sources. As such, Governments will not have to spend large amounts of money on carcass disposal and on public health. The number of active working days for people will increase, thereby increasing the economic status of the family. In the PA's the park managers will have to invest less resources in mitigating the negative impacts of decaying carcasses. Furthermore, the population of secondary or obligate scavengers will be automatically controlled, which will lead to a better balance in the overall biodiversity.

2.6.3.5 Policy Implications

In 2012, IUCN and the Government of India were instrumental in uniting the Governments of Bangladesh, India, Pakistan, and Nepal and to address the long-term conservation of South Asian vultures. They adopted a Regional Declaration on the Conservation of South Asia's Critically Endangered Vulture Species and the Governments agreed to the constitution of a Regional Steering Committee (RSC) for South Asian Vulture Conservation. Key recommendations made by the RSC included a first of its kind TEEB analysis of vultures, in order that policy makers in the range countries are able to make informed decisions particularly on VSZs, as well as regulatory requirements of vulture-safe drug formulations.

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CHAPTER 3

Inland Wetlands

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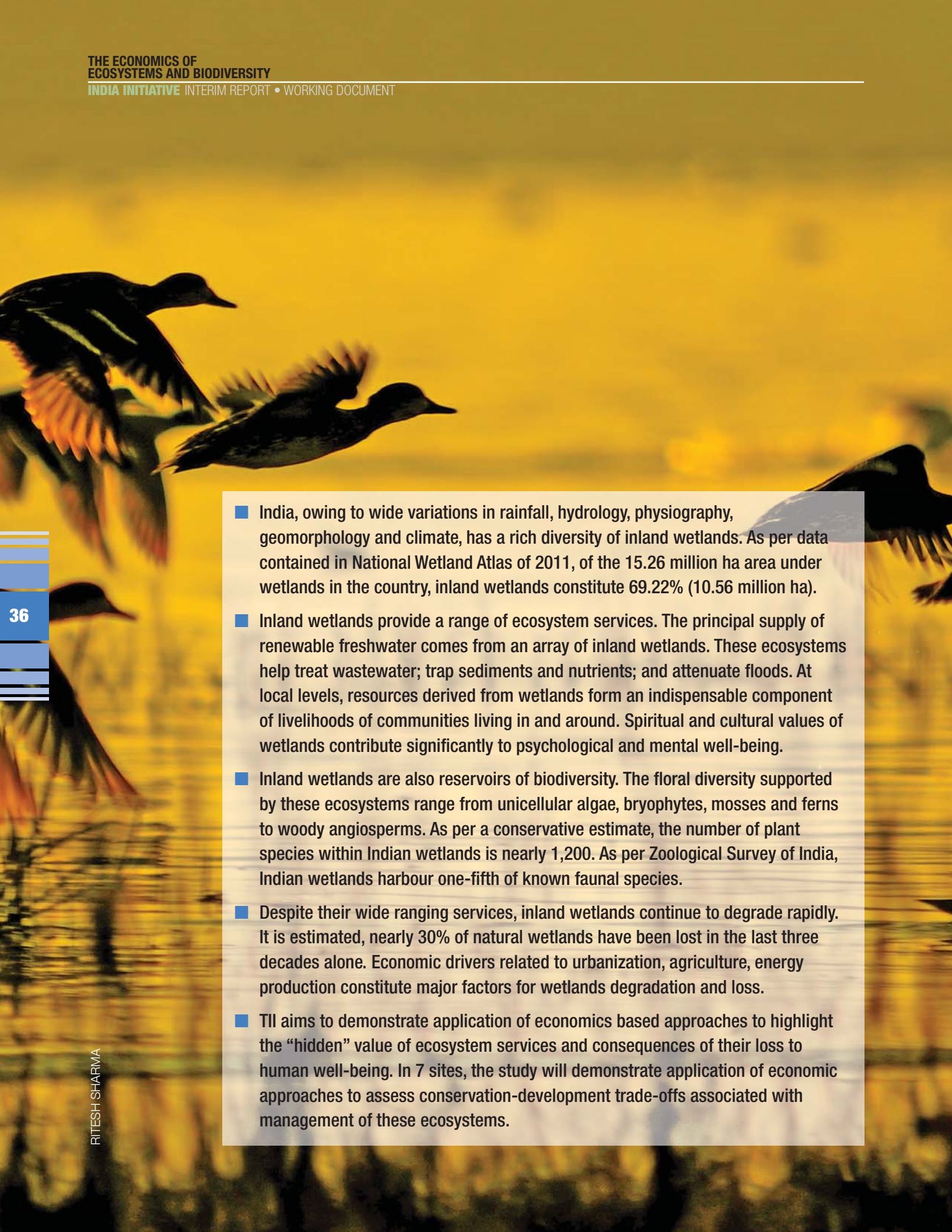
Wetlands are ecosystems located at the interface of land and water. Inland wetlands refer to those wetlands which do not have a direct connection with the sea. India, owing to wide variations in rainfall, hydrology, physiography, geomorphology and climate, has a rich diversity of inland wetlands. Their distribution ranges from high altitude lakes and swamps of the Himalayas, fertile alluvial floodplains of the Ganges and Brahmaputra, salt lakes of the arid zone, tanks of the Deccan plateau, and lakes and marshes on the east and west coast. As per data contained in National Wetland Atlas of 2011, India has 15.26 million hectares (mha) area under wetlands, roughly equal to 4.6% of her land area. Of this, inland wetlands constitute 69.22% (10.56 mha).



- India, owing to wide variations in rainfall, hydrology, physiography, geomorphology and climate, has a rich diversity of inland wetlands. As per data contained in National Wetland Atlas of 2011, of the 15.26 million ha area under wetlands in the country, inland wetlands constitute 69.22% (10.56 million ha).
- Inland wetlands provide a range of ecosystem services. The principal supply of renewable freshwater comes from an array of inland wetlands. These ecosystems help treat wastewater; trap sediments and nutrients; and attenuate floods. At local levels, resources derived from wetlands form an indispensable component of livelihoods of communities living in and around. Spiritual and cultural values of wetlands contribute significantly to psychological and mental well-being.
- Inland wetlands are also reservoirs of biodiversity. The floral diversity supported by these ecosystems range from unicellular algae, bryophytes, mosses and ferns to woody angiosperms. As per a conservative estimate, the number of plant species within Indian wetlands is nearly 1,200. As per Zoological Survey of India, Indian wetlands harbour one-fifth of known faunal species.
- Despite their wide ranging services, inland wetlands continue to degrade rapidly. It is estimated, nearly 30% of natural wetlands have been lost in the last three decades alone. Economic drivers related to urbanization, agriculture, energy production constitute major factors for wetlands degradation and loss.
- TII aims to demonstrate application of economics based approaches to highlight the “hidden” value of ecosystem services and consequences of their loss to human well-being. In 7 sites, the study will demonstrate application of economic approaches to assess conservation-development trade-offs associated with management of these ecosystems.

RITESH SHARMA

3.1 Status, trends and key management issues

As per National Wetland Atlas of 2011, India has 10.56 mha area under inland wetland (SAC, 2011). These ecosystems make wide ranging contributions to societal development and well-being. Cities, as Bhopal (Madhya Pradesh), New Delhi and Kollam (Kerala) depend on wetlands for their water supplies. East Kolkata Wetlands (West Bengal) form an important component of waste water treatment infrastructure of the city; treating nearly 600 million litres of sewage daily through an ingenious practice of waste based pisciculture, agriculture and horticulture. In Kashmir Valley, Wular Lake accommodates a significant proportion of summer flows of the Jhelum River protecting the picturesque city of Srinagar from floods. Similarly, floods of River Brahmaputra in Guwahati (Assam) would be several times more devastating if Deepor Beel and associated wetlands did not accommodate monsoon flows. Dal Lake (Kashmir), Khajjiar Lake (Himachal Pradesh), Nainital Lake (Uttarakhand) and Kodaikanal (Tamil Nadu) are important tourism and recreation destinations.

At local levels, resources derived from wetlands form an indispensable component of livelihoods of communities living in and around these ecosystems. Over 15,000 households living in and around Kanwar Jheel (Bihar) harvest fish, fodder, molluscs and a range of vegetables for domestic purposes. The combination of agriculture and aquaculture practiced in the East Kolkata Wetlands (West Bengal) provide livelihood support to large, economically underprivileged, peri-urban population of 20,000 households. Spiritual and cultural values of wetland contribute significantly to psychological and mental well-being. Wetlands are also settings for rich, diverse and vibrant cultural heritage. Khecheopalri Lake (Sikkim) is revered as 'wish fulfilling lake' and considered most sacred by Sikkemese people. Tarsar and Marsar in Kashmir are revered places for Hindus. The festival of Chhath celebrated in North India is one of the most unique expressions of association of people, culture, water and wetlands.

Inland wetlands are also reservoirs of biodiversity. The floral diversity supported by these ecosystems range from unicellular algae, bryophytes, mosses and ferns to woody angiosperms. As per a conservative estimate, the number of plant species within Indian wetlands is nearly 1,200. The faunal diversity supported by Indian wetlands is equally rich, with some species fully using the aquatic habitat for the entire lifecycle (e.g. fish, dolphins, otters, etc.), whereas some using it partially or even obligately (swamp deer, hog deer, fishing cat, rhinoceros, elephant, wild buffalo, etc.). The Zoological Survey of India has assessed the faunal diversity of Indian wetlands at 17,853 (19.9%) of 89,451 species occurring in India. As per assessments carried by National Board of Fish Genetic Research (NBFGR), Indian waters provide habitat for 2,438 fish species. Since the establishment of Asian Waterbird Census (AWC) in 1987, waterbirds in 3,296 sites have been counted till 2007 which has led to recording of 171 waterbird, 25 raptor and nine kingfisher species.

Despite their wide ranging ecosystem services and biodiversity, inland wetlands continue to be degraded and under threat from a range of developmental pressures emanating from urbanization, agriculture intensification, industrialization, and aquaculture. As per various estimates, nearly 30% of the natural inland wetlands in the country have been lost in the last three decades alone. Such degradation and resulting impairment of ecosystem services affects biodiversity and human well-being in myriad ways. Reclamation of urban lakes in Bangalore and Chennai is considered as one of the major factors for increased urban flooding. Conversion of marshes associated with Wular Lake (Kashmir) for agriculture has reduced the capacity of wetland complex to regulate flow regime leading to increased floods and droughts. Livelihoods of over 15,000 fishers living around Kanwar Jheel in North Bihar have been completely disrupted owing to increased predominance of permanent agriculture within the wetland. Agriculture in turn has been impacted by lowering of ground water levels and flooding attributed to shrinkages in wetland regimes.

The following are some of the major drivers of degradation of inland wetlands in the country:

a) **Fragmentation of hydrological regimes:** Wetlands are adapted to their hydrological regimes. Water regimes set the template which structures their biodiversity and ecosystem services. Fragmentation of hydrological regimes through water regulating structures has a high impact on the wetland in the form of reduced water availability, loss of connectivity with biodiversity habitats, impeded nutrient exchange and other processes which significantly exacerbate their degradation. For example, construction of Ithai Barrage downstream of Loktak Lake to divert water for hydropower generation has converted a natural floodplain lake with fluctuating water levels into a reservoir, critically affecting the habitat of Manipur Brow-antlered deer and near complete obstruction of migratory pathways of fishes from Chindwin – Irrawaddy River system.

b) **Catchment degradation:** The water holding capacity of wetlands plays a crucial role in determining its ability to regulate flow regimes, cycle nutrients and support biodiversity. Degradation of wetland catchments has a direct impact on water holding capacity and overall water regimes accentuating degradation. Bathymetric surveys for Harike Lake (Punjab) carried out in 2010 have indicated a loss of 86% of water holding capacity since 1954 due to catchment degradation. This has led to shrinkage in overall wetland area and supported proliferation of invasive species *Eicchornia.* Surajkund and Badhkal Lakes, tourists hotspots in the vicinity of Delhi have run dry on account of excessive mining in the catchments, which prevents inflow of rainwater, and recharge of groundwater critical to maintenance of hydrological regimes of these wetlands.

c) **Pollution:** Wetlands, particularly in urban areas are used as landfills and waste dumping grounds. This affects water quality, promotes encroachments and reduces the overall aesthetics of the wetlands, besides creating health hazards for dependent communities. The source of pollution need not be the immediate surroundings but could also be upstream reaches in case of connected riverine systems. Most of the Gangetic floodplains wetlands are in advanced state of eutrophication due to discharge of untreated sewage as well as runoff from nutrient rich agricultural fields. A Pollution Audit of Indian waterbodies carried by Comptroller and Auditor General of India in 2010 (covering 140 projects across 24 river stretches and 22 lakes in 116 blocks across 25 States of India) indicated high levels of organic pollution, low oxygen levels for aquatic organisms, and high contamination with protozoa and viruses of faecal origin. With only one tenth of waste water generated in the country treated, there is a higher likelihood of a significant proportion invariably finding its way to wetlands.

d) **Invasive species:** Most of the inland wetlands have been invaded by exotic species which have acquired nuisance proportions threatening the very existence of many of the habitats, and have considerably influenced the native biota and total biodiversity. The list is topped by the water hyacinth, which was introduced in India about a century ago (Gopal, 1987) and occurs now throughout India except in the cold regions of high altitudes and Jammu and Kashmir. The other major species that have gradually spread over large parts of the country are *Salvinia molesta*, *Ipomoea carnea* spp and *Alternanthera philoxeroides.* Yet another exotic, *Fistulosa,* introduced as a terrestrial species, has invaded wetlands all over India, and often forms dense stands. Over 300 exotic species have been brought to India for experimental aquaculture, sport fishing, mosquito control and aquarium keeping of which several have established in Indian water bodies. Devastating impacts have been observed in case of Tilapia, *Oreochromis mossambicus,* which has invaded the fresh and brackish water bodies replacing the native

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fish fauna. Introduction of silver carp has depleted the native population of Catla and Mahaseer in Govind Sagar (Menon, 1979; Molur and Walker, 1998).

e) **Over-harvesting of resources:** Wetlands in India have high direct and indirect dependence, often leading to over-harvesting of resources. The resources of economic importance are utilised to an extent of posing threat to the existence of the species and the population depending on it in the food chain. This being true in case of fishing, where resources are exploited unsustainably by using different detrimental practices such as smaller mesh size nets.

f) **Limited awareness and participation:** There is limited awareness on the totality of wetland ecosystem services and biodiversity in general. Wetlands are multiple use systems with role of a range of stakeholders in their management. Management approaches also fail to internalize informal and traditional community led resource management practices, often leading to conflicts. There are limited incentives for local resource stewardships.

3.2 Current management efforts and gaps

National scale efforts for wetland conservation in India started taking shape since the 80s coinciding with India's accession to Ramsar Convention in September 1982. A dedicated scheme for financing wetland restoration was initiated by the Ministry of Environment, Forests and Climate Change (MoEFCC) in 1987 to provide financial assistance to the States for implementation of site management plans. The programme implementation structure envisaged creation of committees at State/Union Territories (UT) level to oversee design and implementation of wetland restoration plans. In 2001, National Lake Conservation Plan (NLCP) was introduced to address pollution issues in urban and semi-urban environments through interception, diversion and treatment of pollution load entering the lake. As on December 2013, nearly 170 sites were identified for management under the two schemes.

In 2006, the pronouncement of New National Environment Policy provided space for articulation of several elements of national policy for wetlands. The policy identified wetlands as 'freshwater resources' and suggested actions including integration in developmental planning, management based on prudent use strategies, promotion of ecotourism, and implementation of a regulatory framework. Integration of wetlands in river basin management was identified as a strategy for management of river systems.

A regulatory framework for wetlands was introduced in the form of Wetland (Conservation and Management) Rules, 2010 under the provisions of the Environment (Protection) Act, 1986. The rules stipulate prohibition and regulation of a range of developmental activities within a wetland notified under its provision by the State/UT Governments. A Central Wetlands Regulatory Authority (CWRA) was constituted for the purpose of enforcement of the rules, evaluate proposals for wetland notification sent by the State Governments and set thresholds for activities to be regulated. Besides Union Government, several State Governments (notably West Bengal, Odisha, Kerala, Manipur, Assam) have also enacted their own legislations pertaining to wetlands.

More recently, programmes on wetlands have also been initiated by ministries other than MoEFCC. In 2013, the Ministry of Urban Development (MoUD) has issued an advisory on conservation and restoration of waterbodies in urban areas, identifying funding streams of the MoUD and Ministry of Water Resources (MoWR) for urban wetlands. The financial allocation for these programmes is significantly higher than the allocations to MoEFCC.

The aforementioned programmes have created the basic fabric of a 'biodiversity centric' wetland conservation programme in the country. There has been a gradual increase in allocation of resources of the national flagship programmes, and also concomitant increase in coverage. At the same time, developmental pressures have been surmounting, and complex policy issues have emerged. The following are major challenges for furthering the cause of inland wetland conservation and sustainable management in the country:

a) **Insufficient recognition of wetlands within state level developmental planning:** While 'water' and 'land', the two important ecological constituents of wetlands are state subjects, very few States (Odisha being an exception) have created a dedicated budget for wetland management. Wetlands are rarely considered as a part of State level developmental planning, rather their conservation is looked upon as one of the several funding commitments of the Union Government.

b) **Lack of consideration of wetlands in sectoral policies:** Wetlands figure, at the best, marginally in sectoral policies, indicating lack of clarity and understanding on their functioning. The National Water Policy (2012) refers to wetlands in a very narrow sense. While recommending allocation of water for maintaining ecosystems, the policy does not consider wetlands as a solution in achieving water management objectives as flood control, groundwater recharge and increasing overall freshwater availability. The National Action Plan on Climate Change includes wetlands as minor subcomponent of National Water Mission, without referring to the role they play in climate change adaptation, and the risks imposed on wetland ecosystems by maladaptation. Wetlands do not find mention in National Agriculture Policy, despite agriculture being one of the most significant drivers of wetland degradation nationally.

c) **Wetlands not included within land use categories:** The nine fold land use classification used in the country does not include wetlands, thereby preventing any systematic

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capture of trends in changes in their spatial extent or condition.

d) **Absence of cross sectoral institutional arrangements for managing wetlands:** Implementing wetland restoration plans requires cross sectoral institutional arrangements. This was envisaged to be achieved through creation of dedicated authorities responsible for developing management plans, monitoring and evaluation and implementation through line departments. However, only six States have been able to designate distinct authorities. Further, in very few cases, the designated authorities have any form of regulatory backing.

e) **Limited uptake of regulatory framework for wetlands:** The State/UT Governments are yet to come forward to notify wetlands under the rules. In their current form and state, the rules remain applicable only to Ramsar sites.

3.3 Relevance of an ecosystem services economics approach

Despite supporting societal well-being in a number of ways, wetlands are increasingly ending up on the crosshairs of developmental projects. A rational appreciation of inter-linkages of wetlands with developmental planning and decision making is important to secure future of these fragile ecosystems. The need for maintaining wetland values and functions, while at the same time delivering services and benefits now and into the future for human well-being necessitates adoption of management approaches which recognize linkages between livelihoods, wetland functioning and biological diversity.

It is under these pretexts that the "wise use" approach was promulgated by the Ramsar Convention as guiding principle for managing wetland ecosystems. Wise use of wetlands involves their sustainable utilization for the benefit of humankind in a way compatible with maintenance of natural properties of the ecosystem. The text of Ramsar Convention defines wise use as "the maintenance of their ecological character, achieved through implementation of ecosystem approaches, within the context of sustainable development". Notably, this articulation came in much before the famed 1992 Rio Conference on Environment and Development

The wise use principle encourages stakeholder engagement and transparency in negotiating trade-offs and determining equitable outcomes for wetland conservation while promoting maintenance of environmental, economic and social sustainability. Inclusion of ecosystem services within the definition of ecological character brings strong emphasis on livelihood and well-being outcomes, along with ecosystem components and processes which underpin provision of these services. India as a Contracting Party to Ramsar Convention is committed to 'wise use' of all wetlands within her territory. Wise use principle has also been highlighted as the guiding approach for wetland conservation in the National Environment Policy (2006), National Biodiversity Action Plan (2008) and as the primary objective of the National Wetland Conservation Programme (presently merged into the National Programme on Conservation of Aquatic Ecosystems (NPCA).

Ecosystem services are one of the critical elements of ecological character of wetlands. An ecosystem services based management approach brings to fore an explicit focus on the functional aspects of biodiversity. Given the rapid degradation of wetlands in the country, and the increasing anthropogenic pressure as indicated by evidences presented earlier, an ecosystem services led approach is expected to change the societal approach to these ecosystems inculcating a conservation approach which is not necessarily triggered by intrinsic values, but is necessitated for well-being, through considering the role of these ecosystems in broad developmental processes of urbanization, livelihoods, food and water security and climate change adaptation. The TII can contribute in multiple ways towards this agenda, as is summarized below under the three major intervention areas, namely recognizing ecosystem services, valuing ecosystem services and capturing ecosystem services. (Table 1)

3.4 Existing evidence base on ecosystem services and valuation

Economic valuation has received attention as a major research area only since the last two decades. One of the early attempts was under the MoEFCC's eco-development programme, wherein an application of valuation of Keoladeo National Park (Rajasthan) was carried out with an aim to provide possible policy options for improving people-park relationships. Subsequently, the World Bank supported 'Environmental Management Capacity Building Technical Assistance' (EMCaB) Project, implemented during 1996 – 2004 by the MoEFCC with Indira Gandhi Institute of Development Research (IGIDR), Mumbai, Institute of Economic Growth (IEG), New Delhi, Madras School of Economics (MSE), Chennai and other agencies put significant focus on promoting research using economic valuation tools, of which wetlands were one of the priority areas. Since then, the subject matter has been accorded high priority within research programmes of MoEFCC and several universities.

A review of 20 studies on economic valuation studies on inland wetlands, published in the last two decades (1994 – 2014) indicate the following trends:

- The number of studies is small considering the overall inland wetland extent in the country. In terms of wetland types, high altitude wetlands of Himalayas, man-made tanks, salt pans and waterlogged areas have been under-represented. The Deccan Peninsular region and the west coast have limited studies as compared to other regions.

Table 1: Intervention areas off TII-Inland Wetlands

Recognizing ecosystem services	• Improving information base on ecosystem services through integration of ecosystem services assessment with wetland inventory and assessment tools (based on site and regional scale projects) • Capacity building on ecosystem services assessment
Valuing ecosystem services	• Investing into valuation of wetland ecosystem services with specific reference to ecosystem type representativeness and policy trade-off contexts • Developing national standards and benchmarks for wetland valuation
Capturing ecosystem services	• Using ecosystem services as a criterion to identify priority wetlands under National Wetland Conservation Programme • Targeting conservation and sustained provision of ecosystem services within wetland management plans • Use of economic instruments to rationalize incentive systems linked with ecosystem services, particularly rewarding local stewardship • Linking physical accounts of changes in wetland extent, biodiversity and ecosystem services to national accounting framework as a means to prioritize investment allocation and conservation efforts

- A majority of the studies have focused on assessing monetary values of wetland ecosystem services with an objective of demonstrating their contribution to the local or regional economy. Also, there is limited use of economic valuation studies in decision making contexts.
- In terms of ecosystem services, one can infer an emphasis on provisioning services followed by cultural services. Regulating services have received almost no attention. Hydrological functions of wetlands, in particular (for example, flood control, water regime regulation) have not been the subject of assessments in any of the studies.
- Trade-offs emerging from policy decisions form a useful application area of economic valuation tools. Again, very few valuation studies involve assessment of trade-offs. The study of Yamuna floodplains involved assessing the opportunity cost of converting the floodplains for development and concluded that the same could not be justified on the grounds of economic efficiency (Kumar et al., 2001). Economic valuation was used as a tool to assess the impacts of freshwater flow regulation on ecosystem services of Chilika Lake. The assessment highlighted the positive benefits of floods to floodplain agriculture as well as downstream wetland fisheries. It also indicated that reducing the freshwater flows had negative economic consequences in terms of values of fisheries, flooding and waterlogging likely to be created due to policy decisions (WISA, 2004).
- Only two studies have attempted extrapolation of economic values of wetlands or impacts of change in wetland extent to State or National level aggregates. Pandey et al. (2004) have computed State level aggregated values of wetland wealth using the data on wetland extent (from Directory of Wetlands, 1990) and economic values from Costanza et al. (1997) and Mitsch and Gosselink (2000). More recently, a framework for accounting inland wetland ecosystems for selected Indian states has been proposed by Kumar (2012). The

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study uses benefit transfer method to determine the impacts of physical area losses of wetlands in Gujarat, Jammu and Kashmir, Kerala, Rajasthan and West Bengal. Value estimates from 18 wetlands have been used to develop a meta-regression model to finally compute the loss of per capita wetland wealth for 1991-2001.

- A review of the methodologies used indicates a distinct preference for revealed preference based approaches (market prices, shadow prices). This is commensurate with the focus on provisioning services, as most of the wetland products can be linked to prices in some form. Contingent valuation follows next in terms of application; however the theoretical rigour varies across the studies. A good emphasis can also be seen on use of Travel Cost Methods to assess the recreational benefits derived from inland wetlands. Methodologies which require validation of ecological relationships for determining ecosystem services (e.g. production function, damage cost, replacement cost) in general have been under-emphasized. Again, this finding is related to the observation of lesser emphasis placed on valuation of regulating services of inland waters.

3.5 TII – Inland wetlands

The TII aims to promote mainstreaming of ecosystem services and biodiversity values in developmental planning and decision making processes. Work under inland wetland components aims to demonstrate practical application of ecosystem services economics based approaches in decision making contexts related to the following thematic areas:

- improving recognition of wetland ecosystem service values
- integrated management
- integrating wetlands in water and land management
- equity in property rights and improving distribution of costs and benefits
- monitoring and evaluation
- building incentives systems for community led management of ecosystem services

A critical component of the initiative is building the evidence base though studies at seven sites, which address at least one of the above mentioned dimensions. A summary of study sites and key policy questions that are being addressed is presented in Table 2 below. The outcomes of the study are being fed into a synthesis report.

Table 2: List of selected case studies in Inland wetlands and their key aspects

Study site and partners	Key biodiversity and ecosystem service values
Loktak Lake, Manipur *Ritesh Kumar, Wetlands International South Asia and Sanjoaba Meitei Loktak Development Authority*	• Loktak is a floodplain wetland of Manipur River spread over 289 square kilometre and a designated Wetland of International Importance (Ramsar Site). Phumdi, floating heterogeneous masses of soil, vegetation and organic matter are a characteristic feature of the wetland ecosystem • Annual catch of 1,500 million tonnes (mt) of fish and a range of aquatic plants are source of livelihoods of 50,000 households living in and around Loktak. The marsh vegetation helps improve water quality by trapping nutrients. Loktak buffers adjoining settlements from floods by accommodating large parts of monsoon runoff from the catchments and the rivers. • Keibul Lamjao Natural Park located in the southern part of Loktak is the only known natural habitat of globally endangered ungulate species *Rucervus eldii*
Kanwar Jheel, Bihar *Ritesh Kumar, Wetlands International South Asia*	• Kanwar Jheel is a riverine marsh spanning 6,900 ha in Gadak-Kosi floodplains of North Bihar. Exchange of water, sediment and species with the flood pulses of River Burhi Gandak (and Kosi prior to 50s) support highly productive fisheries and agriculture sustaining livelihoods of nearly 15,000 households living in 16 villages in and around the wetland. Kanwar accommodates significant proportion of rainfall and bankflows of River Burhi. Gandak protects the adjoining settlements from flood risk as well as recharges groundwater. • It is also one of the important congregation areas in North Bihar, particularly for migrating ducks and coots. Over 200 bird species have been recorded at Kanwar of which 58 are migratory waterbirds.
Ousteri Wetland, Puducherry *L Venkatachalam, MIDS and Zareena Begum, MSE*	• Located on the fringes of Pondicherry Town, Ousteri is a shallow lake of 690 ha spread between Tamil Nadu and Union territory of Pudducherry. It is one of the major wintering grounds for the migrating birds in the region. The Puducherry segment of Ousteri has been declared as a bird sanctuary. In the recent past, Ousteri was one of the largest breeding sites for common coot in South India. Ousteri also helps recharging groundwater and maintaining overall hydrological regimes within the region.
Little Rann of Kachchh, *A M Dixit, Center for Environmental and Social Concern, Ahmedabad*	• LRK is a salt marsh extending 4,000 sq km area in Kachchh District of Gujarat. It is possibly the world's last refuge of the Indian Wild Ass (khur), and has been declared as the Indian Wild Ass Sanctuary. The landscape supports rich biodiversity, including a rich diversity of migrating and resident waterbirds. The wetland is also used for commercial salt production and shrimp farming.
River Ken *Brij Gopal and Dinesh Marothia, Center for Inland Waters in South Asia*	• River Ken, a ~420 km long tributary of River Yamuna, draining a basin of 28,000 sq km is a perennial river of Central India. The River hosts the Ken Gharial Wildlife Sanctuary and flows for over 70 km of its course through the Panna National Park. Its course also has two magnificent falls as tourist attraction. The river course is yet to be subject to any kind of water storage or flow diversions, and urban or industrial pollution.
Wular Lake, Kashmir *Rahul Kaul, Wildlife Trust of India*	• Wular is the largest wetland of the Kashmir Valley having an extent of nearly 160 sq km and 18 sq km as associated marshes. During summers, as River Jhelum, its tributaries and hill streams ebb with high volumes of water received from the melting glaciers, Wular accommodates the huge volumes of floodwater thereby protecting Srinagar City and upstream settlements from devastating floods. Migrating waterbirds of the Central Asian Flyway use Wular and its associated marshes as habitat for feeding and roosting. Communities living around the wetland harvest fish, water chestnut, and lotus rhizomes for their livelihoods. In 1990, Wular was designated as a Ramsar Site.
Lake Chilika, Odisha *Ritesh Kumar, Wetlands International South Asia and Gurdeep Rastogi Chilika Development Authority, Government of Odisha*	• Chilika is a brackish coastal lagoon spanning between 906 sq km - 1,165 sq km on Odisha coastline. The lagoon forms the base of livelihood security of more than 0.2 million fishers and 0.4 million farmers living in and around the wetland and its adjoining catchments. The diverse and dynamic assemblage of fish, invertebrate and crustacean species in Chilika provide the basis of rich fishery which generates more than US$ 17.3 million annual revenues and contributes over 6% of the state's foreign exchange earnings. The marshes associated with Chilika support highly productive agriculture. Over one million migratory birds commonly winter here. • Chilika is one of only two lagoons in the world that support Irrawaddy Dolphin (Orcaella brevirostris) populations.

Policy context	Contribution to TEEB – India
• Since 1983, Loktak has been regulated through construction of a barrage downstream for providing water to National Hydroelectric Power Corporation run 105 MW Loktak Hydroelectric project. • Regulation of a naturally fluctuating wetland regime for hydropower generation has led to degradation of habitat of Keibul Lamjao National Park. There has been a near complete decimation of migratory fisheries, and rapid transition in community fisheries to the detriment of overall ecology and hydrodynamics of the wetland.	The study aims at demonstrating integration of wetland ecosystem services and biodiversity values in planning for water resources management.
• Wetland water regimes have been transformed to support agriculture and flood control objectives. River Burhi Gandak was channelized though construction of embankments during early 50s as a part of flood protection measures impeding the natural hydrological connectivity of the rivers with the wetland complex. Agriculture has gradually intensified with shrinking inundation areas, and traditional varieties giving way to more water demanding crops like sugarcane and peppermint. Shrinking resource base further accentuated conflicts between farmers and fishers, the latter having to shift to culture fisheries and agriculture labour as source of livelihoods.	A scenario based approach is being used to demonstrate value of hidden hydrological services, and assess conservation – development trade-off associated with landuse transformation in Kanwar for agriculture.
• Wetland values are being threatened due to rapid industrialization and urban development. Wetland ecosystem services have not been taken into account in developmental planning for the region.	Proposed identification of institutional arrangements that will promote cooperative behaviour amongst various stakeholders to promote integrated management of Ousteri.
• Intensification of infrastructure development on the fringes of LRK (construction of roads, bridges, salt pans) has consequences for hydrology, which underpins maintenance of biodiversity in the region.	Economic valuation tools will be used to demonstrate implications of hydrological regime changes on wetland ecosystem services.
• A significant water diversion is proposed by linking the River Ken to River Betwa – another tributary of River Yamuna, largely for irrigation and domestic supplies. This project, if implemented, will submerge a part of the National Park, while also affecting downstream biodiversity.	The project will demonstrate use of economic valuation as a tool to integrate ecosystem services and biodiversity values changes in planning and decision making related to developmental projects.
• Introduction of willow plantations within the wetland have aggravated siltation and have significantly reduced Wular's ability to regulate hydrological regimes. Management planning for the site thereby focuses on removal of willow plantations as a major intervention area.	The project demonstrates application of economics based approaches to assess efficiency of management interventions.
• Hydrological intervention in 2000 and subsequent investment in integrated catchment scale management has led to rejuvenation of fisheries and restoration of biodiversity. Several community stewardship models based on tourism and fisheries have emerged as an outcome.	The case study aims to focus on property rights dimension of ecosystem service values, particularly highlighting factors that promote community stewardship of ecosystem services and biodiversity values.

3.5.1 Economics of ecosystem services and biodiversity for conservation and sustainable management of inland wetlands

Lead Authors: • Ritesh Kumar • Kalpana Ambastha

3.5.1.1 Background

The current project aims to demonstrate application of ecosystem services economics based approaches to evaluate conservation-development trade-offs and support conservation and wise use of inland wetland ecosystems'. Transformation in ecosystem services associated with developmental planning for three wetland sites, namely Loktak Lake (Manipur), Chilika Lake (Odisha) and KanwarJheel (Bihar) are proposed to be assessed using economic approaches, to help define management strategies that ensure maintenance of critical ecosystem components and processes that underpin ecosystem service provision as well as biological diversity.

3.5.1.2 Research questions

Loktak Lake, Manipur

Loktak, a floodplain wetland associated with the Manipur River system is the lifeline of Manipur state. Ecological and livelihood security of the communities is inextricably linked with the ecosystem services derived from the wetland which is spread over 289 sq km within a basin of 6,872 sq km. *Phumdi*, floating heterogeneous masses of soil, vegetation and organic matter at various stages of decomposition are a characteristic feature of the lake. Keibul Lamjao National Park located in the southern part of the lake is the only known natural habitat of globally endangered ungulate species *Rucervuseldii*.

Loktak is central to food and water security for the state of Manipur. It supports livelihoods of over 200,000 people living in and around. Loktak yields 1,500 tonnes of fish each year. Alongwith fish, there are range of aquatic plants, vegetables, fuel, fodder and building material sourced from the lake. Villages on the lakeshore and islands use the lake as the main mode of transportation. Loktak accommodate large parts of monsoon runoff from the catchments and the rivers, buffering floods and protecting adjoining settlements. The fringing marshes absorb nutrients and enhance quality of water.

Since 1983, Loktak is the source of water for the National Hydroelectric Power Corporation run 105 MW Loktak Hydroelectric project. Interventions to regulate a naturally fluctuating wetland regime for hydropower generation has led to degradation of habitat of globally endangered ungulate species, *Rucervuseldii*, which inhabits the Keibul Lamjao National Park located in the south of wetland. There has been a near complete decimation of migratory fisheries, and rapid transition in community fisheries to the detriment of overall ecology and hydrodynamics of the wetland. The project intends to address following research questions:

- What trade-offs are inherent in the policy decision to regulate Loktak Lake for hydropower generation?
- What are the opportunities for revising barrage operations to ensure that water needs for human purposes (hydropower and irrigation) are addressed along with ecological requirements for wetland functioning?

KanwarJheel, Bihar

KanwarJheel and its associated *maun* and *chaur* areas constitute the largest floodplain wetland regime of North Bihar. With a peak monsoon inundation of over 10,000 ha in the shallow depression between River Burhi Gandak and paleochannel of River Bagmati, these wetlands sustain livelihoods of over 15,000 households through highly productive fisheries, agriculture, and a range of plants used as food, fiber and fodder. Kanwar reduces flood risk and recharges groundwater by accommodating significant proportion of rainfall and bankflows of River Burhi Gandak. The wetland complex teems with waterbirds in the winters, and is one of the important congregation areas for migrating ducks and coots in the Central Asian Flyway. The island of Jaimanglagarh located at the southern tip has archaeological significance, and highly revered by communities living in and around. A part of Kanwar, extending to 6,311.63 ha, has been notified as a Bird Sanctuary by the name of Kanwar Jheel

Pakshi Vihar under the provisions of Wildlife (Protection) Act, 1972.

Exchange of water, sediment and species with flood pulses of River Burhi Gandak creates conducive conditions for highly productive fisheries and agriculture coexisting with high aquatic biodiversity, especially of waterbirds. The wetland also provides flood protection by accommodating bankflows and monsoon rainfall, as well as recharges groundwater. Historically, a social contract between the fishers and farmers living around the wetland complex enabled the two dominant community groups to manage diverse resource use within an intra-annual variation of inundation regime.

Interventions aimed at reclaiming wetland since the 1950s have led to gradual predominance of agriculture, impacting the ability of wetland ecosystem to buffer floods, recharge groundwater and support fisheries. Economic assessment of ecosystem services transformation is intended to address the following questions:

- What are the trade-offs linked with expansion of permanent agriculture in Kanwar?
- What are the alternate scenarios for managing land and water resources in the wetland catchments to ensure provisioning of full range of ecosystem services of Kanwar?

Chilika, Odisha

Chilika, a brackishwater coastal lagoon situated in the Odisha State forms the base of livelihood security of more than 0.2 million fishers and 0.4 million farmers living in and around the wetland and its adjoining catchments. Spanning between a monsoon maximum of 1,165 sq km to a dry season minimum of 906 sq km and flanked by an ephemeral floodplain extending to 400 sq km, Chilika is an assemblage of shallow to very shallow marine, brackish and freshwater ecosystems and a hotspot of biodiversity. The diverse and dynamic assemblage of fish, invertebrate and crustacean species in Chilika provide the basis of rich fishery which generates more than US$ 17.3 million annual revenues and contributes over 6% of the State's foreign exchange earnings. The marshes associated with Chilika support highly productive agriculture.

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Over one million migratory birds commonly winter here. Chilika is one of only two lagoons in the world that support Irrawaddy Dolphin (*Orcaella brevirostris*) populations.

The inclusion of Lake Chilika as a demonstration site is to showcase the benefits of investment in wetland restoration and creation of community stewardship. Range of catchment scale interventions implemented in the last two decades (including restoration of connectivity with the sea) have led to dramatic increase in resources and resurgence of biological diversity. Several positive examples of community led restoration initiatives related to mangrove restoration, revival of fisheries institutions and ecotourism, have emerged in the process. Economic assessment is intended to address the following questions:

- What is the economic efficiency of restoration investment done in Chilika since the last decade?
- What are the enabling institutional and capacity factors that support creation of incentives of ecosystem services stewardship?

3.5.1.3 Methodology

In each of the three wetland sites, a sequential methodology involving definition of policy context of economic assessment, description of ecosystem services transformation and linked distributional consequences, economic valuation of welfare change, multi-criterion assessment and identification of response options will be applied. Specific steps are as follows:

- Land use – land cover change assessment to develop the background for defining transformation in ecosystem service provision.
- Developing indicators for provisioning, regulating, cultural and supporting services, classified in a framework of intermediate and final services
- Developing a multi-scalar, stakeholder linked welfare change matrix for major ecosystem services transformation to capture distributional implications
- Economic valuation of welfare change with specific emphasis on use of deliberative methods for value articulation
- Multi-criteria analysis of ecosystem services transformation to assess ecological, social and institutional implications
- Identification of management interventions required to balance objectives of ecosystem services provision and biodiversity conservation under the overarching objective of wise use

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3.5.1.4 Expected outcomes

The study will focus on assessing ecosystem services trade-offs related to management interventions at Loktak Lake (Manipur), Chilika Lake (Odisha) and Kaabar Jheel (Bihar). Specific outcomes expected are as follows:

- Economic values of provisioning, regulating and cultural ecosystem services.
- Stakeholder linked economic assessment of trade-offs inherent in policy decisions aimed at enhancing provisioning services at the cost of regulating and cultural services.
- Management strategies that ensure maintenance of critical ecosystem components and processes that underpin ecosystem service provision as well as biological diversity.

3.5.1.5 Policy implications

Each of three sites has an ongoing wetland management planning / updation process in place, and the research outcomes would feed into these processes. Specifically, the project will demonstrate application of following ecosystem services led management approaches which form the core of national flagship wetland conservation programmes i.e. the National Plan for Conservation of Aquatic Ecosystems (NPCA):

- Inventorying wetland ecosystem services
- Identifying trade-offs in cases when wetlands are managed for a narrow range of ecosystem services, altering the services associated with natural state
- Applying economic assessment tools to assess trade-offs related to various ecosystem service bundles associated with ecosystem states and stakeholder linkages
- Identify mechanisms for identifying full range of ecosystem service values in integrated management planning for wise use of wetland ecosystems.

3.5.2 Economics of Biodiversity and Ecosystem Services of Rivers for Sustainable Management of Water Resources

Lead Authors: • Brij Gopal • Dinesh K. Marothia

3.5.2.1 Background

Water is the most critical natural resource for all kinds of economic development. At the same time, all developmental activities affect the water resources. However, water resources managers have not appreciated, at least until recently, that diversion and abstraction of water from the rivers for irrigation, domestic and industrial supplies and hydropower among other economic uses, seriously impact the riverine ecosystems, both upstream and downstream of the diversion structures, and accordingly, their multifarious ecosystem services. Whereas the provision of water for various uses is over-emphasised and over-exploited, other regulating, supporting, and socio-cultural services of the rivers and associated wetlands along with the livelihoods of local river (wetland)-dependent communities are ignored. The loss of biodiversity and ecosystem services caused by altered flow regimes are not yet accounted in the cost-benefit analysis of the water resources development projects.

The study, first of its kind in India, aims at a rapid assessment of biodiversity and ecosystem services of a medium sized river in Central India. River Ken a tributary of River Yamuna (the largest tributary of Ganga), is so-far among the rivers least impacted by any major storage or flow diversion (except for two barrages) on the main channel, and urban or industrial pollution. The river hosts the Panna National Park and a *gharial* sanctuary, along with two magnificent falls as tourist attraction. A significant diversion is proposed to transfer Ken's water to River Betwa – another tributary of River Yamuna, largely for irrigation and domestic supplies. The diversion will submerge a part of the National Park, affect downstream biodiversity and also affect other ecosystem services.

3.5.2.2 Research Question

The specific questions being addressed by the study are: (a) which ecosystem services of the river are affected, and to what extent, by the storage and diversion of flows from a river, and (b) do the net economic benefits from the use of stored and diverted water fully compensate or exceed the costs in terms of the loss of ecosystem services and

Table 3: Major ecosystem services and their biophysical and socio-economic indicators

Ecosystem Services	Biophysical indicators	Socio-economic indicators
Provisioning services • Fisheries • Plant resources • Water supply	• Fish catch (composition, weight) • Kinds & amount of plants harvested • Amount of water abstracted for domestic use/ agriculture/ other use	Number of fishers Fishing effort and income No. of persons using plant material No. of cattle grazed; irrigated area crop yield; health status of people
Regulating services • Groundwater recharge	Change in groundwater table	Number of borewells/dugwells Crop area/yield from use of groundwater Energy use for water withdrawal
Cultural services •Ecotourism	Natural /cultural sites of tourist interest	Number of visitors Number of persons employed Revenue to government Income of local people

BRIJ GOPAL

livelihoods over a long time scale. The question can then be extended to determine the extent to which the flow regimes of a particular river can be altered without affecting the total ecosystem services (including those of diverted water).

3.5.2.3 Methodology

The study will attempt a rapid assessment of the biodiversity of River Ken, along with its relationship with the flow regime, identify relevant stakeholder groups and various ecosystems services of direct and indirect benefit, and assess their economic value. A few sites representing areas upstream and downstream of the proposed diversion point and the areas of biodiversity and human use (e.g. fisheries) will be selected. Impacts of different levels of flow alteration on the habitat availability and biology of important components will be assessed through expert panels. A scoping workshop will help identify stakeholder groups and ecosystems services. The quantifiable provisioning services will be assessed in the field and through questionnaire surveys. Data will be obtained on both surface and ground water use at different times of the year. Cultural services (e.g. eco-tourism) will be assessed through questionnaire surveys and stakeholder meetings.

Following major ecosystem services and their biophysical and socio-economic indicators will be examined.

3.5.2.4 Expected Outcome

The major outcomes expected from the study are:

- A step towards development of methodology for rapid assessment of ecosystem services of rivers and their economic valuation
- Guidance towards management decision-making by considering the cost-benefit aspects of biodiversity, ecosystem services and livelihoods.

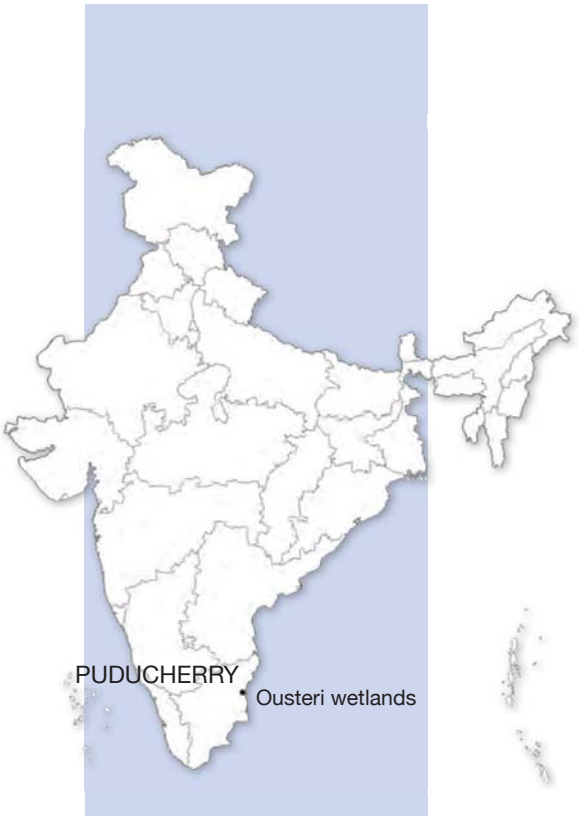
The study will also contribute to the current debate on environmental flows assessment for protecting the river ecosystems.

3.5.2.5 Policy Relevance

An assessment of various ecosystem services and their economic value promises a balanced approach towards the interest of all stakeholders while ensuring the ecological integrity of the rivers. The study will directly contribute to the policies on water resources management by emphasising the need to account for the value of conservation of wetlands and their biodiversity.

3.5.3 Economic Valuation of Ecosystem Services: A Case Study of Ousteri Wetland, Puducherry

Lead Authors: • L. Venkatachalam • Zareena Begum I



3.5.3.1 Background

The Ousteri wetland generates multiple ecosystem benefits but, there is trade-offs between different types of benefits generated. Encroachment and dumping of solid and liquid wastes inside the wetland reduce other ecosystem benefits such as, water for drinking and irrigation purpose, commercial fishing, tourism benefits and aesthetic benefits. Most of the benefits and costs are non-marketed in nature and weakly addressed in trade-offs.

3.5.3.2 Research Questions

The major objective of the present study is to estimate the economic value of the 'marginal benefits' of major conservation measures identified in the wetland management plan. The present study aims to answer the following research questions: a) What are the major ecosystem services generated by the Ousteri wetland, and what are the 'stock' and 'flow' of these services in terms of physical and monetary units?; b) Does the marginal value of ecosystem services exceed the marginal cost of conservation measures?; and c) What institutional arrangements are required for conservation of the Ousteri on a sustainable basis, with the participation of stakeholders?

3.5.3.3 Methodology

The proposed study will utilize the 'natural resources accounting' (NRA) framework. Within the NRA framework, the 'stock' (i.e. the natural capital) and the 'flow' (i.e. the value) of the ecosystem services will be estimated in physical units by using inputs from ecology and hydrology. Once the physical accounting has been established, effort will be made to develop monetary accounts. In the case of economic valuation, it is proposed to adopt the 'total economic value' TEV framework (i.e. TEV = direct use values + indirect use values + option value + existence value). Both the revealed preference (RP) and the stated preference (SP) methods will be utilized for placing monetary values on the ecosystem services. In the case of fodder, fuel-wood, fish, etc., the 'direct market price' will be used; in the case of irrigation water, drinking water, waste disposal service, etc., either 'production function approach' or 'hedonic pricing method' will be used. In the case of aesthetic and recreational benefits, a combined 'travel cost method' and 'contingent valuation method' will be deployed. In order to estimate the option value, the 'choice experiment' becomes the choice. Since the valuation methods are flexible (e.g. choice experiment can be used for capturing TEV), appropriate valuation methods will be chosen depending on the context. A historical analysis of information/data about the wetland is carried out for understanding the trend in the stock and flow of benefits, as well as the negative externalities causing such trend. A 'trade-off' analysis to analyse the nature and extent of conflict between utilization of different ecosystem services will be carried out.

3.5.3.4 Expected outcomes

As part of the study, it is proposed to conduct many stakeholder workshops where the preferences about the ecosystem services of different stakeholders would be elicited and will be used in the decision making process; the stakeholder workshops will serve as platforms to disseminate information about the ecosystem services of the wetland, trade-off between different ecosystem services, management plan, issues involved in implementing the Payment for Ecosystem Services (PES) schemes, etc. The trade-offs in ecosystem services in the Ousteri wetland is the outcome of the 'non-cooperative game' played by different economic agents who are interested in maximizing their direct, immediate individual benefits. Different stakeholders have different interests and as a result, the wetland experiences a 'tragedy of the commons' problem. The challenge is how to bring collective action among different stakeholders so that all of them could play a 'cooperative game' in order to maximize both the private and social benefits on a sustainable basis. So, the study would explore institutional arrangements that would bring a required collective action among various stakeholders so that non-zero sum outcomes are achieved. In order to do that,

different stakeholders will be identified, their pay-offs will be quantified and their roles will be defined in order to ensure collective action and cooperative outcomes for maximizing the benefits in an inter-temporal way.

3.5.3.5 Policy Relevance

The results of the study would be used to produce policy briefs; the study output would serve as inputs for training programmes for different stakeholders and as manual for future ecosystem valuation. The overall outcome of the study would be to improve the management of wetlands with more inputs from environment economics. The results of the study would help the policy makers to develop better management plan for the Ousteri wetland, in particular. In recent years, the national and state level environmental policies are aimed at, wherever possible, introducing market-based instruments (MBIs) for environmental management. In this regard, the study results would provide inputs for designing appropriate MBIs for managing Ousteri wetland. One such MBI comes in the form of PES that brings together the market, the government and the communities to reap the wetland ecosystem services on a sustainable basis. The study would explore the possibility of implementing PES with the appropriate mix from the role of government and other stakeholders so that the wetland can be managed on a sustainable basis.

ZAREENA BEGUM I

3.5.4 Economic Valuation of Landscape Level Wetland Ecosystem and its Services in Little Rann of Kachchh (LRK), Gujarat

Lead Author: • Arun Mani Dixit

3.5.4.1 Background

The Little Rann of Kachchh (LRK) is a large, pre-dominantly flat ephemeral wetland extending to 4,000 sq km. Several ephemeral rivers drain into the LRK during monsoon, when the region functions as a hydrological 'sink'. The LRK is also connected to the Gulf of Kachchh through the Surajbari creek, allowing saline sea-water to mix with fresh water. The dynamic hydrologic and salinity gradients have led to the creation of unique habitats for a wide range of unique flora and fauna, such as Flamingoes, winter migratory birds, wild ass etc. The wilderness and biodiversity values are not only evident from rising tourism in the region, but also from increased research, education and awareness activities that have the potential to boost conservation and tourism for the future. Parts of the LRK are also highly productive, particularly in terms of commercially valuable prawns, exploited by native fishermen communities.

3.5.4.2 Research Questions

The multiple conservation goals of LRK wetlands have been recognized, and are notified as a protected area

(PA). Currently, prawn production, tourism and research and education are some of the obvious use and non-use benefits derived from the wilderness and biodiversity values of these wetlands. However, altering land and water use systems at both local and landscape levels threaten the flow of these ecological goods and services. While no empirical studies have clearly established this yet, proximate causes of such changes seem to be: (i) Rapid expansion of salt works and linear infrastructure development (e.g. roads, rails and power transmission lines) in and around Surajbari creek which altered the tidal water flow into LRK and thus its inundation pattern, and (ii) Promotion of water harvesting structures in the catchment area of LRK reduced fresh water and associated nutrient flows in the wetland. Furthermore, despite being part of a PA, lack of effective regulatory mechanism forces many unsustainable harvesting practices of wetland resources including the prawn capture with significant impact on in-situ trophic structures. These factors threaten the ecological integrity of LRK wetland and thus affect its biodiversity base and key ecological functions which ultimately jeopardize various societal benefits including support to local economy.

Specifically, this study attempts to find answers to the following ecosystem and biodiversity related questions within ecological-economic framework:

1. What are the landscape level changes in catchment areas of LRK wetland system?
2. How the landscape level changes influence the economic values of LRK wetlands in terms of prawn fishing, tourism and migratory bird diversity?
3. What are the key trade-offs for sustainable delivery of ecosystem services from LRK wetlands, considering its PA status and landscape level linkages?

3.5.4.3 Methodology

In order to answer above questions, study adopts following approach:

a. Detailed inventory of biodiversity and documentation and profiling of socio-economics of fisher folk households, tourism and, interpretation and nature education activities
b. Undertake rigorous economic valuation of three major services of LRK wetlands, using standard tools and methods. These services include: (i) Fish/ prawn production (ii) Tourism and (iii) Biodiversity in the context of habitat for migratory birds.
c. Evaluate and analyse developmental trajectories in the catchment areas of LRK wetlands with major focus on (i) development in and around Surajbari creek and (ii) development of minor and major water harvesting schemes in the watershed areas of LRK.
d. Identifying key trade-offs for wise use of LRK wetlands by juxtaposing above derived information.

The study undertake following methodological steps:

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a. Macro level understanding of wetland ecosystems of LRK and their landscape level interactions with developmental pathways through exhaustive literature review, analysis of relevant secondary data and field verifications.
b. Recording perception of farmers in watershed areas and salt producers in creek areas about the changing water appropriation and use practices vis-à-vis ecological functioning of LRK wetlands. This will be done through focused group discussions and household level surveys.
c. Economic valuation of different use and non-use values accruing to different stakeholders using standard methods and tools. For example, market value assessment for prawn/fish production; Contingent Valuation Method (CVM) for biodiversity values especially the migratory birds; and Travel Cost Method (TCM) for tourism activity. These goods and services are important to understand because of their role in sustainable wetland and PA management. For the purpose, we conduct primary surveys of key beneficiaries (e.g. fishers, naturalists, salt workers, tourists and students) and, collating and analysing relevant time-series secondary data.
d. Juxtaposing all the above understanding about ecology, biodiversity conservation, economic values, development scenarios and, existing regulatory and management regimes, we assess and analyse key trade-offs for wise wetland management.

3.5.4.4 Expected outcomes

On its completion, study would describe the key ecology - economic interfaces and thus the values of LRK wetland. Importantly, the study would help identifying key landscape level issues that influence the hydrological characteristics of LRK wetlands and thus their key economic outcomes.

Appreciation of the broad, critical, linkages between LRK wetlands and developmental activities in its catchment area as derived from above key ecological and economical understanding will help initiate cross-sectoral dialogue and engagement of stakeholders including the conservationists, local prawn fishers, tour operators, farmers and salt producers. This eventually produces institutional structures that are generally more appropriate for the governance towards wise-use of LRK wetlands. Finding of this study can also be dovetailed with the ongoing efforts of integrating biodiversity conservation and rural livelihood systems in LRK landscape, which is also part of a PA.

3.5.4.5 Policy relevance

Above outcomes while assist landscape level management of wetland system, specifically, it help in shaping policies related to water resource appropriation and alteration due to developmental activities in the catchment areas of wetland and its impacts on sustained flow of key ecological and economical values.

3.5.5 Economic Feasibility of Willow Removal from Wullar Lake, Jammu and Kashmir

Lead Author: • Rahul Kaul

3.5.5.1 Background

Wular Lake, in the state of Jammu and Kashmir, is the largest lake of the state, functioning as the most important flood sink for River Jhelum. The lake also provides several other important ecosystem services including fish and aquatic plants for local consumption. However it is suggested that recent changes in the land-use patterns of the lake are drastically impairing its key ecosystem functions, which could entail severe economic implications. One such important land change is the promotion of Willow (Sallix sp.) plantations on the lake. The onset of large plantations in the lake to supplement fire-wood needs of local communities since the 1916, up to 2002 is suggested to have reduced the gross area of the lake starkly, besides affecting other natural phenomena of the lake, such as siltation, reduction of depth, and overall biodiversity, etc. Consequently, today large sections of willow plantations are planned to be removed and the freed up area of the lake being dredged to increase the lake's potential as a flood sink. The key issue however remains that the effect of willow plantations on the lake's ecosystem services, especially as a flood sink is only bleakly understood. While this lacunae remains, it is well known that dredging of lakes often severely impairs several of its ecosystem functions, and especially impacts its natural biodiversity. Moreover, willows also have several positive attributes and their removal may, at least in the short term, be detrimental to the lake and its longevity. The project therefore attempts at unravelling the impact of willow presence and absence on Wular lake, in terms of comparative economic valuation of various services provided by the lake.

3.5.5.2 Research Question

Does willow removal from the Wular Lake enhance the flood sink functions of Wular or do they impair other important ecosystem services of the lake? The research question intends to assess the anticipated benefits of removal of willow from Wular Lake that is currently driving the lake management to eradicate these plantations from the lake. One of the main anticipated benefits, is enhancement of the lake's function as a flood sink.

But it has also been suggested that these plantations initiated since 1912, provide various benefits, in the form of enhancement of certain ecosystem services of the lake. The most predominant of these are;

- The willow biomass feeds local needs for firewood as well as national/international trade in cricket bats.
- Increasing the dissolved nutrient content and therefore increasing primary and secondary production, which is harvested for local consumption and trade.

- Localising siltation along plantation zones (due to reduced flow rates) conferring to sustained water depth in the rest of the lake area, and eradicating the need of dredging at regular intervals.

The research question therefore attempts to evaluate the economic costs associated with the loss of the above functions vis-à-vis the costs of removal of willow, and the subsequent anticipated management costs, such as dredging on an annual basis to increase or even sustain water depth. This will provide a clear understanding of the economic implications of the removal of these plantations from the lake, for times to come.

3.5.5.3 Methodology

The primary methodological framework will adhere to collection of secondary data on different cost variables involved, such as,

- Data on costs incurred in removal of willow and ensuing dredging of the cleared area.
- Data on economic benefits of secondary and primary produce of the lake (including willow itself)
- Comparative data on water quality, dissolved nutrient content, siltation rates, as well as primary produce in areas with and without willow in Wular Lake.
- Costs incurred in controlling flood sink functions, as well as in the damage caused due to flooding of Wular Lake.
- Expected benefits of flood control.
- Data will be collected either through both review of existing baseline data sets as well as through questionnaire surveys as relevant for different variables involved.

3.5.5.4 Expected Outcomes

The key expected outcomes of this study are the economic valuation of the various ecosystems services of the lake and their comparative links. The study anticipates producing a comparative picture, using standardised economic valuations, of what the economic implications are of removal or retention of willow plantations in Wular Lake. Such standardised comparison will allow for not just wide scale replication of this initiative but also allow for comparison across different predictive models on similar aspects of other lake ecosystems.

3.5.5.5 Policy Connect

These findings would therefore be crucial in developing or amending existing lake management policies. For instance, the study is expected to directly trigger the revision of the Wular Management Action Plan, which has been adopted by the Wular Conservation and Management Authority. The study is also anticipated to influence other related policy frameworks that control, manage or aim to enhance various other ecosystem services of the lake directly or indirectly.

ARUNMANI DIXIT

CHAPTER 4

Coastal and Marine Ecosystems

J R BHATT

Coastal and marine ecosystems are among the most productive ecosystems in the world, provide many services to human society and are of great economic value (UNEP, 2006). The services include provision of food and water resources, and raw materials like sand, and other high-value heavy minerals like ilmenite, zircon, monazite etc., which are collected from beach sand. They also provide regulating and cultural services, like storm protection, erosion control, tourism and support functions such as climate regulation, water balance, flood control, waste management etc. According to some estimates, the oceans and coastal biomes may provide as much as, two-thirds of the ecosystem services that make up the planet's natural capital (TEEB, 2010).

- Indian coastal ecosystems comprising of mudflats, sandy beaches, estuaries, creeks, mangroves, coral reefs, marshes, lagoon, sea grass beds, and sandy and rocky beaches extend to 42,808 sq km. The Exclusive Economic Zone of India is 2.02 million sq km.
- The number of species in the coastal and marine ecosystems is suggested to be more than 13,000. It is also known for high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna. India has established 31 Coastal and Marine Protected Areas (CMPAs) and several species have been listed under Wildlife (Protection) Act 1972.
- Major human-induced drivers of ecosystem degradation include habitat conversion to other forms of land use, overexploitation of resources and associated destructive harvesting practices, spread of invasive alien species, pollution from agricultural, domestic and industrial effluents, and climate change.
- All the maritime states of India are implementing Marine Fishing Regulation Act for the last 15 to 25 years.
- Marine fish production has increased from 0.5 million tonnes in 1950 to 3.8 million tonnes in 2013, contributing substantially to nutritional security, income and livelihood of a large population of the country.
- Available information indicates that the oceans and coastal biomes contribute substantially to the ecosystem services that make up the country's natural capital. India has opportunities to reap many economic benefits from living and non-living resources of coastal and marine areas including fisheries and biodiversity.
- A TEEB approach at country level could provide much needed data on the economic value of these resources as well as on the full range of costs associated with extracting and using them. Managing the marine and coastal ecosystems requires an understanding of the socio-ecological systems and their inter-connections.
- Recognising blue carbon ecosystem services, Marine Spatial Planning and suggestions on the effectiveness of current management measures are a few initiatives that would pave the way for enhancing delivery of ecosystem services.
- In order to achieve this, there is a need to bridge the gaps in knowledge on coastal and marine ecosystem services and functions and support mainstreaming of biodiversity and ecosystem considerations into both national policy-making and broader societal perspectives.

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4.1 Introduction

Coastal and marine ecosystems are probably the least understood, most biologically diverse, and most undervalued of all ecosystems. From mangroves, coral reefs and seagrass beds to deep oceans, coastal and marine systems suffer from a lack of recognition of their economic value – including vital services such as providing food, livelihood and carbon capture for climate mitigation. Valuing these services would provide policy-makers with a strong rationale to improve coastal and marine ecosystem management and invest in conservation for its risk management value and economic benefits.

Building upon the foundations of the global TEEB studies, TII component for coastal and marine ecosystems will seek to draw attention to the economic benefits of healthy coastal and marine ecosystems, and emphasize the benefits of preserved and enhanced ecosystem structures and their functions in the well-being of humans and nature. In order to achieve this, it will bridge the gaps in knowledge on coastal and marine ecosystem services and functions, and support mainstreaming of biodiversity and ecosystem considerations into both national policy-making and broader societal perspectives. Coastal and marine ecosystem valuation studies will be used to inform the decision making process concerning policies or specific measures needed to support a better economic paradigm.

4.2 Status, trends and key management issues

Surrounded by the Indian Ocean, the Arabian Sea and the Bay of Bengal, India has a coastline of above 7,500 km, spanning nine maritime States and two Union Territories (UTs) in the mainland, and two island UTs. The Exclusive Economic Zone (EEZ) extends to 2.02 million sq km and the continental shelf area to 0.18 million sq km. The Indian coasts support about 30% of the total 1.2 billion human population. Indian coastal ecosystems comprising mudflats, sandy beaches, estuaries, creeks, mangroves, coral reefs, marshes, lagoons, seagrass beds, and sandy and rocky beaches extend to 42,808 sq km (Table 1). They are known for their high biological productivity, which provide a wide range of habitat for many aquatic flora and fauna.

The number of species in the coastal and marine ecosystems is estimated to be more than 13,000 (Venkataraman and Wafar, 2005; MoEF, 2009). However, this is an underestimate, considering the fact that the inventory is extensive in the case of commercially important resources, but incomplete for minor phyla and microbes. The species richness of well-surveyed groups include: marine algae – 844 species; sponges – 451 species; hard corals – 218 species; polychaetes – 250 species; crustaceans – 2,934(+) species; Copepoda – 1,925; Cirripeds – 104; Amphipoda – 139; Brachyura – 705; Prawns – 243; Stomatopoda – 121; Cladocera – 3; Ostracoda – 120; Anomura – 162; lobsters – 26; mysids – 3; molluscs – 3,370; echinoderms – 765; fishes – 1,546; reptiles – 35; mammals – 26.

Table 1: Extent of coastal ecosystems of India

Coastal ecosystem	Area (sq km)
Tidal/Mudflats	23,621
Sandy beaches/bars/spits	4,210
Mangroves	4,445
Coral reefs	2,375
Estuaries & backwaters	1,711
Salt marshes	1,698
Lagoons	1,564
Other vegetation (including seagrass beds)	1,391
Aquaculture ponds	769
Salt pans	655
Creeks	192
Rocky coasts	177
Total	42,808

Source: MoEF, 2005

India has highly diverse and vibrant fisheries resources sustaining production as also livelihoods of millions of fishers and their families. Another important attribute of the fisheries sector is the large fisher population, almost entirely in the small-scale category and totally dependent on the sector for livelihoods.

The Indian fisheries sector (both marine and inland) has witnessed a highly satisfactory growth trajectory since the launching of the First Five-Year Plan (FYP) in 1950-51. Fish production has increased from 0.72 million tonnes (mt) in 1950-51 to reach 8.288 mt in 2010-11, comprising 3.220 mt from marine sources and 5.068 mt from inland fisheries (including aquaculture). With an average growth of about 6% over the FYP periods, fisheries sector's performance has been one of the best amongst all food production sectors in the country. Its contributions to foreign exchange earnings have also been substantial. During 2010-11, export of marine products reached 813,091 tonnes valued at ₹129 billion and US$ 2,856.92 million.

An ambitious target of 6% growth in fish production has been proposed by the Government to be achieved at the end of the 12th FYP period (2017). The growth rate perhaps stems from the excellent performance of the sector in the past FYPs.

To ensure sustainability in the fisheries sector, many management measures are implemented such as rationalization of the fishing fleet capacity, closed area and

closed season to allow fish to breed, and regularize use of gear, such as trawls. The 2004 Comprehensive Marine Fisheries Policy also brings in greater cooperation between different Ministries/Departments at the Central Government level as also with the State/UT administrations to harmonize actions, reduce conflicts and adverse impact on the environment and facilitate sustainable and responsible management of fisheries resources in the country.

In India, a large number of people are dependent on the coastal and marine ecosystems and their resources for survival and livelihood. In spite of their ecological and economic importance and the existence of a policy and regulatory framework, India's coastal and marine ecosystems are under increasing threat. The major drivers of change and degradation are mainly anthropogenic. Numerous direct and indirect pressures arising from different types of economic development and associated activities have adverse impacts on coastal and marine biodiversity across the country. Major anthropogenic direct drivers of ecosystem degradation and destruction include habitat conversion to other forms of land use, overexploitation of resources and associated destructive harvesting practices, spread of invasive alien species, pollution from agricultural, domestic and industrial effluents, and climate change.

A number of emerging issues continue to threaten and do not allow rapid progress towards sustainable development of coastal and marine ecosystems. Some of them are:

- Direct dependence of a large poor population on coastal and marine ecosystem services and biodiversity.
- Increasing use of coastal and marine areas for a range of economic activities such as industries, oil and gas exploitation, maritime transport, etc.
- Lack of integration of concerns about ecosystem services and poverty, and the lack of attention on poverty reduction through sound management of ecosystem services.
- Increased nutrient, over-enrichment and eutrophication, contributing to pollution, hypoxia and habitat degradation.
- Continuing threats to coral reefs and other major ecosystems from ocean acidification, warming, pollution, habitat loss, and invasive species.
- Barriers to implementation due to other political and administrative priorities, insufficient institutional and scientific understanding of the mechanism and capacity, market issues, lack of financing and unwillingness of stakeholder communities.

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4.3 Current management efforts and gaps

For conserving and managing coastal and marine resources and ecosystems, a strong legislative framework exists in India. The acts and supporting rules and regulations directly and indirectly related to management of coastal and marine areas and biodiversity are as follows: Coast Guard Act, 1978; Merchant Shipping Act, 1958; Wildlife (Protection) Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976; Forest Conservation Act, 1980; Marine Fishing Regulation Acts, 1981 (separate acts promulgated by each coastal State/UT based on a model bill prepared by the Union Ministry of Agriculture); Coastal Pollution Control Series, 1982; Environment Protection Act, 1986; Coastal Regulation Zone Notification, 1991 and 2011; National Environmental Tribunal Act, 1995; Coastal Zone Management Plans,1996; The Biological Diversity Act, 2002; and Coastal Aquaculture Authority Act, 2005. In addition; India is a signatory to a number of international conventions on biodiversity and ecology such as the United Nations Convention on the Law of the Sea (UNCLOS) and Convention on Biological Diversity (CBD), which include management of marine and coastal ecosystems. India is also a signatory to several international fisheries management/advisory instruments and arrangements such as the Code of Conduct for Responsible Fisheries, 1995; an Ecosystem Approach to Fisheries (both FAO) and the Indian Ocean Tuna Commission and the Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO). These commitments have strong bearing on India's management of its natural resources.

India has established 31 Coastal & Marine Protected Areas (CMPAs). The Gulf of Kachchh Marine National Park, the Gulf of Mannar National Park and Wandoor Marine National Park are some of the CMPAs.

Wildlife (Protection) Act, 1972 has listed the following coastal and marine species for protection: molluscs (mainly

Table 2: India and International Agreements

Instrument	Accession, Acceptance Ratification	Entry Into Force
International Convention for the Regulation of Whaling (Washington DC, 1946)	Adherence 09 March 1981	09 March 1981
Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington DC, 1963)	Ratified 20 July 1976	18 October 1976
Convention on Wetlands (Ramsar, Iran, 1971)	01 February 1982	01 February 1982
Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973	20 July 1976	01 July 1975
The Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979)	1 November 1983	1November 1983
Convention on the Conservation of Antarctic Marine Living Resources (Canberra, 1980)	Acceptance 17 June 1985	17 July 1985
United Nations Convention on the Law of the Sea (Montego Bay, 1982)	29 June 1995	29 July 1995
Convention on Biological Diversity (Rio de Janeiro, 1982)	Ratification 18 February 1994	18 February 1994
Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities (Declaration, Washington DC, 1995)	23 November 1995	23 November 1995
Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (New York, 1995)	Accession 19 August 2003	19 August 2003

gastropods): 24 species; whale shark (one species); other elasmobranchs (9 species); grouper fish (one species); seahorse (all species); seacucumber (all species); sponges and sea fans (all species); corals (all species); turtles (all 5 species); marine mammals (all 26 species).

India has so far ratified major international agreements and arrangements and has also undertaken significant measures for their successful implementation. (Table 2)

In spite of these efforts, several gaps exist in the management of coastal and marine areas. There is lack of understanding on the effective functioning of the measures and quantification of benefits accrued. For example, there are no strong evidences to support recovery of biodiversity to improve livelihood of coastal communities. Policies on environmental protection are now gaining momentum, but poorly integrated. The important interactions between marine, coastal and other terrestrial systems need to be integrated to understand the ecosystem services. In examining the incidence of poverty among people who are dependent on coastal and marine ecosystem services, the existing national policies have to be disaggregated to address micro-level issues. Decisions on management follow a top-down approach and people's participation on devising policy decisions at the village level is weak. There are few examples of mechanisms to enhance ecosystem services and alleviate poverty. There are many and significant knowledge gaps, including about how the flows of ecosystem services are linked to the stocks of ecosystems, processes and rates of change, complex causality, behavioural responses, economic responses and social impacts of change. Governance of ecosystem services is influenced by global markets, and powerful commercial interests, which are not considered.

4.4 Relevance of an ecosystem services economics approach

India has opportunities to reap many economic benefits from living and non-living resources of coastal and marine areas, including fisheries and biodiversity. The ability to manage the resources and improve capacities to enforce management, requires economic valuation information. In order to fully leverage ecological and economic knowledge of coastal and marine ecosystems and their services, there is a need to generate and provide access to more and better data regarding key ecosystem services including biological, economic and societal measures. A TEEB approach at the country level could provide much needed data on the

economic value of these resources as well as on the full range of costs associated with extracting and using them. Thus, the economic valuation of coastal and marine ecosystem services and biodiversity could:

- substantially improve the management of critical coastal and marine ecosystems and resources;
- improve governance, regulation and emerging policies,
- provide a better understanding of the potential economic challenges that arise from changing coastal and marine environments; and
- provide some basis to develop a more inclusive management plan for coastal resources by taking into account the opinion of primary village level stakeholders.

One of the concepts that has emerged globally in recent years is to develop the green economy. In its report, IOC (2011) has listed several key dimensions as the contribution of coastal and marine sectors to the green economy (for example, protection and restoration of coastal and marine ecosystems and biodiversity, including beyond national jurisdiction; development of blue carbon markets; change in fisheries and aquaculture management regimes toward equitable, non-subsidised and sustainable practices; adaptation to sea level rise and climate change; integrated coastal zone management; increasing sustainable use of bio-resources, including biotechnology and bioprospecting, etc). In a developing country like India, if economic development is to contribute to sustainable well-being of the people, it is important to balance market and non-market values, living and non-living resources, and uses now and in the future. Such an approach does not rule out industrial uses of coastal and marine areas. It recognises the pressures that such activities exert on ecosystems and natural capital and identifies opportunities to reduce those pressures while promoting environmental and economic benefits. It identifies opportunities to extract more value and revenue from coastal and marine ecosystems without diminishing natural capital. Such information is necessary to ensure that trade-offs made by decision-makers are based on sound scientific evidence.

Moving towards these goals requires a better understanding of the economic value of coastal and marine ecosystems and biodiversity, as well as contributions of these ecosystem services to societal, cultural and ecological well-being. By collecting improved information, finding answers to relevant questions and adopting best strategies, it is possible to achieve the goals of economic valuation.

***Transition to greener economy*:** What economic information related to coastal and marine ecosystems is needed? What are the best strategies?

***Fisheries*:** How could fisheries management affect both extractive and non-extractive values of commercially important and their associated species? Can a better understanding of economic values of seafood and fish stock-in-the-sea lead to better management strategies and coordination among fishers, managers and conservationists?

Marine Spatial Planning (MSP): Coastal and marine management that considers single sectors treats commercial and non-commercial uses as competing with one another. Through MSP, various management scenarios can be identified and evaluated, and spatial trade-offs such as those between industrial developments and ecosystem services can be made in order to balance many potential uses of the ecosystem. A TEEB approach that could find methods for estimating cumulative impacts of changes in the coastal and marine ecosystem services would be useful for MSP.

***Marine Protected Areas (MPAs)*:** What are the biological, social and economic dimensions? What is the potential for green accounting that considers the contribution of MPAs to long-term ecosystem recovery, human well-being and poverty alleviation?

***Blue carbon ecosystem services*:** Placing an economic value on the carbon stored within coastal habitats such as mangroves, coral reefs, seagrass meadows and salt marshes allows comparison of the value of development against the value of carbon stored within these systems. This also helps making investments in preserving these systems in order to offset carbon emissions. Valuing carbon in coastal ecosystems can help policy makers identify the areas where the need to protect blue carbon is high and prioritise their protection.

***Integrated management of mangroves and coral reefs*:** Mangroves and coral reefs can provide many goods and services to coastal communities, if properly managed. Management plans that could harness the full value of mangrove and coral reef ecosystem services need to be developed for integrating these values into national planning. While some initiatives have been made to value mangrove and coral reef services in India, analysis on the roles of rights, incentives and governance and optimisation of benefits from mangroves and coral reefs are lacking. A TEEB approach can contribute to this area by synthesizing the available information and developing guidance on these critical elements of mangroves and coral reef management.

4.5 State of art on value of ecosystem services of coastal and marine ecosystems

In India, there have been only few attempts to estimate the value of coastal and marine resources. However, there is now a growing literature of micro-studies that look at either specific sites or services using a multiplicity of techniques. A few studies in India that are linked to coastal and marine ecosystems have been presented by Vivekanandan and Mukhopadhyay (2012).

Anoop and Suryaprakash (2008) have used a

contingent choice technique to estimate the option value of Ashtamudi estuary (US$ 64,667). Using a discount rate of 4%, the present value has been assessed to be US$ 1.5 million. Dixit et al. (2012) found the value of ecosystem services emanating from coral reefs of Gulf of Kachchh to be US$ 3.7 million (2007 price) and US$ 132,500 per sq km.

It is important to note that valuation needs an interdisciplinary approach and the need for bio-economic modelling cannot be overstated when we are dealing with issues of valuation. Empirical examples in India are rare. One such attempt was by Bhat and Bhatta (2006) who estimated sustainability in fisheries but not with the objective of explicit valuation. They argued that increase in mechanisation and access to technology has made it possible for large-scale fishing activity but increased fishing effort has made the fish stocks unsustainable without substantially improving profitability of the fishers. An extension of such an exercise may allow an estimation of shadow values of fishery services and better management of resources.

At a micro-level using the direct market values, Hussain and Badola (2010) provided estimates of livelihood support from mangroves in the Bhitarkanika conservation area on the Odisha coast. They considered only two items of provisioning support from mangroves, namely fishery and forest products. In order to examine the contribution of mangroves to fishery, they separately valued flows from inshore fishery, offshore fishery, and as nursery ground for fish and shellfish. The price at first sale (local market prices) was used for market valuation. They also considered timber and non-timber extraction from mangroves. An average household derived about US$ 107 per annum worth of livelihood support per year. In comparison to the average family income in this area of US$ 603 per annum, the dependence on ecosystem services as a livelihood support was found to be significant.

Chopra et al. (2010) examined the ecological loss due to biodiversity decline in the Sundarbans driven by over-extraction of shrimp larvae. The biodiversity decline is perpetuated by aquaculture farms, which acquire seedlings from the wild, and thereby deny the natural ecosystem of the shrimp larvae. This decline in shrimp in the natural ecosystem disrupts the ecological balance of higher trophic fishes, which feed on shrimps.

While direct market methods are often used to estimate provisioning services, Jyotish and Iyengar (2007) considered the regulating service provided by the coastal zones by way of soil salinity prevention to agricultural farms in Gujarat. They examined the differences in agricultural productivity in two areas – one where there is salinity ingress and another where

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there is no ingress, and found that the per acre cost of salinity ingress ranges between ₹ 72,221 to ₹ 98,145 (depending on the discount rate). Their study did not undertake valuation of ecosystem services, but their estimates are an indicator of the value of the regulatory services that nature provides by preventing salinity ingress.

Apart from application of direct market techniques, there have been some studies that use non-market valuation techniques. A study based in Kendrapada, Odisha on the storm-protection services of mangroves during the Super Cyclone of 1999 suggests that mangroves reduced loss of human life, house damage, livestock damage, etc. Their cost-benefit calculations show that it is economically beneficial to reconvert land surface which earlier had been under mangrove cover (Das and Vincent, 2009). If house damage alone is considered, the protection benefit was US$ 1,218 per hectare of forests (Das, 2009). Further, 94% of the human death toll in Kendrapada district due to a super cyclone could have been avoided if the mangroves were conserved as they existed in the 1940s (Das, 2007). It has also been shown that mangroves provide storm protection from cyclonic wind in addition to protection from storm surges (Das and Crepin, 2013), which establishes that ecosystem services of coastal resources could be much wider than what has been discovered so far.

The travel cost method has been applied in India to coastal and marine areas. For example, to estimate the recreation value of the Indian Sundarbans, which is a UNESCO World Heritage and also a Ramsar site, Guha and Ghosh (2007) used a zonal travel cost method to estimate the annual recreational value to Indian citizens of the Indian segment of the Sundarbans and found that it amounts to approximately US$ 377,000 (in the year 2006). Their study suggested that by hiking the entry fees to Sundarbans park, the authorities could raise revenues amounting to US$ 0.12 million per year. This would be useful for improving park maintenance.

In a study based in Gujarat, Hirway and Goswami (2007) attempted to find the Total Economic Value (TEV) of mangroves. They found that the direct use value (2003 prices) of mangroves was ₹1,603 million, and the indirect use value was ₹2,858 million per year. The total use value (direct and indirect) of mangroves was estimated at ₹7,731.3 million per year (2003 prices).

In recognition of the critical role that coastal and marine ecosystems play in human well-being, Marine

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Protected Areas (MPAs) have been designated in the world's oceans. In India, while considerable conservation efforts have been made to protect terrestrial areas (especially forests), marine protection is yet to see similar focus. The Coastal Zone Regulation Act provides a degree of protection, but its implementation is not uniform across different States. There is an urgent need to address coastal and marine ecosystem management issues that are beyond the Coastal Zone Management bill, which received a mixed response from the public and different stakeholders. The discussion with stakeholders needs to be based on independent evaluation of the ecosystem services.

Managing marine and coastal ecosystems requires an understanding of the socio-ecological systems and their inter-connections. We need suitable mechanisms to incorporate our knowledge on thresholds and regime shifts into our policies. Management strategies must complement scientific knowledge of marine and coastal ecosystems with social concerns of distribution, equity and justice.

The valuation literature in marine and coastal ecosystem services is significantly limited. The reason for this is the comparative lack of relevant natural science and socio-economic data. This is true not only for India, but also globally. One could use the benefit transfer method to extrapolate values from other parts of the world but these need to be done with care as it could lead to inaccuracies (see Beaumont et al., 2006). Some of the values that have been generated for India need to be peer-verified for commonality of methodology. Scaling up from micro-studies to macro-region has limitations. They do not account for regional variation (unless specifically incorporated). Many marine fish stocks are straddling and highly migrating and move across several administrative boundaries and international borders, therefore raising accounting problems.

Valuation of natural resources is expected to help better management of sustainable use and social allocation. Under-valuation can cause excessive extraction whereas over-valuation would result in under-utilisation. Given the state of knowledge on the scientific processes as well as methodological limitations, there are restrictions on doing valuation satisfactorily, as many of the non-market valuation techniques are not proven. Within the domain of valuation techniques, revealed preference methods are considered more reliable and robust and nearest to market valuation. Stated preference methods remain controversial despite the large body of literature that has now been accumulated.

Apart from the estimation of costs and benefits, the inter-temporal nature of the service flows causes additional problems. Over-extraction of resource today may be beneficial to the current generation, but may reduce the future generation's well-being. Therefore, there is an ethical need for balancing the needs of the current generation against that of the future.

For valuation, it is "marginal" values that are required rather than aggregated values. As "marginal" values are surrounded by uncertainties of threshold effects, judging "marginal" effect is not straightforward. A likely complication of collecting "marginal" values would be due to non-linearity between critical habitat variables and changes in ecosystem services. For instance, fringe mangroves may cause small losses, and not economic benefits of storm buffering. Data on such non-linear functions of marginal losses are hard to collect.

Another challenge is to identify sources of double counting. Nutrient recycling, for example, will support a series of outcomes such as clean water, better support to life systems, higher productivity, etc. It should be kept in mind that economic values relate to end products, and not to nutrient recycling *per se*. It is important that the full range of complementary and competitive services are distinguished before initiating valuation.

Given the need for understanding the value of ecosystems and the wide differences in the available estimates, this is an area that will continue to engage researchers. Economic valuation will remain a challenging enterprise as it will have to negotiate with ecological non-linearity, uncertainties, existence of ecological thresholds, and conceptualization of resilience in the social context. Even if well executed micro-studies are available, there would remain the issue of scaling up values of ecosystem services.

4.6 TII for coastal and marine ecosystems: An approach

TII for coastal and marine ecosystems aims at demonstrating pathways for mainstreaming the diverse range of ecosystem service values in developmental planning and decision making. Towards this objective, TII intends to build evidence base from assessments, in the form of pilot projects, centered on key challenges associated with management of coastal and marine ecosystems. A summary of these projects is given in Table 3.

A sectoral synthesis will be developed, building on the review and analysis of existing datasets, scientific publications, and management plans, to provide specific recommendations for improving integration of coastal and marine ecosystem values within the current programmes of the Ministry of Environment, Forests and Climate Change (MoEFCC). The following thematic areas are the focus of sectoral synthesis:

- Ecosystem services and integrated site management.
- Regulation, land use and coastal zone planning.
- Property rights and improving distribution costs and benefits.
- Using market-based instruments to secure biodiversity and ecosystem services.
- Participatory monitoring and evaluation.
- Sustainable financing.

Table 3: List of selected case study sites in coastal & marine ecosystem and their key aspects

Study site and partners	Key biodiversity and ecosystem service values
Assessment of eco-labelling as tool for conservation and sustainable use of biodiversity in Ashtamudi Lake, Kerala (south-west coast of India) *Sunil K Mohammed, Central Marine Fisheries Research Institute*	Since Ashtamudi Lake is a clam dominated estuarine ecosystem, we considered clams as the key species controlling the bio-physical processes in the system. Their unique filter feeding behaviour influences the productivity and the benthopelagic coupling in the ecosystem. Depletion of the clam stock was reverted with the help of management plan which includes introduction of Marine Steward Council (MSC) certification for obtaining higher value for the harvested catch using sustainable practices.
Economic valuation of seasonal fishing ban on marine fisheries services in selected maritime States of India *R Narayan Kumar, Central Marine Fisheries Research Institute*	Seasonal Fishing Ban (SFB) during the breeding and spawning seasons of fishes is supposed to impact remaining fish stock to be harvested throughout the year. But there are some questions pertaining to the following points: a) Has the quantum of the natural capital and its value of the marine ecosystem increased due to SFB? b) Is there an improvement in the services provided by the marine ecosystem due to SFB?
Economic value of biodiversity loss: A study of by-catch from Andhra Pradesh marine fisheries *Jyothis Sathyapalan, Centre for Economic and Social Studies*	Non-compliance with fishery regulations and destructive fishing practices also contribute to the waste generation in the form of by-catch, which has serious implications on marine biodiversity. In India, various studies on bottom trawling concluded that by-catch is within a range of 25 to 54 % of the total catch. This practice is leading to marine biodiversity loss and loss to total economic value and consequentlyt to be discouraged.
Evaluating the flow of ecosystem services from regenerated mangroves compared to natural mangrove forest: *Saudamini Das, Institue of Economic Growth*	Ecological restoration of degraded and depleted mangrove habitats by planting mangroves is a worldwide phenomenon because Mangroves are considered to provide a bunch of welfare enhancing ecosystem services to coastal community especially fisheries. It is empirical to assess whether the flow of ecosystem services from these regenerated ecosystems are similar to the flow of such services from the natural mangrove forests? The study will evaluate (a) the role of planted mangroves as nursery ground and habitat for fishery and (b) impact of mangrove plantation on coastal erosion.

	Policy context	Contribution to TII – India
	The outcome from the project would serve as policy guidance for similar ecosystems and small-scale fisheries in the developing world. This assessment will guide policy in understanding cost and benefit to ecology and economics of the stakeholders while replicating this model to other fisheries.	The study will provide overall assessment of cost and benefit of MSC certification to ecological services of clam and the lake.
	This study will guide the policy of seasonal fishing ban in the following context: a) To substantiate SFB as a single regulatory measure or to implement along with a combination of other regulatory measures. b) Formulate more efficient and alternate management options to achieve enhanced ecosystem services and net social benefits. c) Help the government to decide the level of institutional support and quantum of financial support (towards compensation) to the fishers during SFB. d) Reduced fuel consumption and carbon emission due to SFB as the potential for use in carbon trading and saving in foreign exchange.	The study will assess the effectiveness of SFB. This study will provide the net social benefit of implementation of SFB. The difference between the value of the marine fish landings and the cost of enforcement of SFB will give the net social benefit or otherwise. If the result is a benefit, the Government can substantiate and/or plan to improve the outcome of SFB.
	The Indian mechanised fishery is subsided by providing fuel and fleet subsidies, which may act as an incentive for overfishing. This study will review the subsidy policy and suggest measures to revise it. Moreover, by-catch does not appear generally in any official statistics. So the database of this study will help to understand the proportion of catch and by-catch, which will be useful in formulating policies.	The study will attempt to assess the total value lost due to by-catch as the total value lost will be estimated by shadow price time total quantity of by-catch produced in a given period of time. From an operational point of view the study will focus on the by-catch generated by the mechanised fishing and its effects on future mechanised fishery as well as inshore small-scale fisheries of Andhra Pradesh.
	The results will have the following policy connect: (a)Provide important guidelines (like where the plantation is working best) to coastal forestry department engaged in mangrove restoration and management in Gujarat and elsewhere in the country or outside the country; (b) Help in correct accounting of ecosystem service flow from regenerated forests in green national accounting, which has become an important objective of the government; (c) Work as a baseline survey to find out if investment in coastal afforestation is paying results.	The study will make the following important contribution to TII: (a) Provide evidence on whether and to what extent the ecological restorations are contributing to flow of ecosystem services; (b) Evaluation of ecosystem restoration through the use of a sophisticated technique like difference-in-difference; (c) Help in preparing guidelines for ecological restoration; (d) Provide link between forest health and flow of ecosystem services.

4.6.1 Evaluating the flow of ecosystem services from regenerated mangroves compared to natural mangrove forest

Lead Author: • Saudamini Das

4.6.1.1 Background

Ecological restoration of degraded and depleted mangrove habitats by planting mangroves is a worldwide phenomenon and is also being practiced by some of the maritime states of India, the state of Gujarat being the front runner. In Gujarat, mangrove cover has gone up from 427 sq km in 1987, to 1,058 sq km in 2011, depicting a growth rate of 148%, a remarkable achievement for any developing economy. Though enough scientific research has gone into making this effort a successful venture, so far there has been no rigorous economic research on the societal welfare implication of this investment in mangroves. Mangroves provide a bunch of welfare enhancing ecosystem services to coastal communities, and it remains to be seen whether the coastal community in Gujarat has been benefited because of these investments or whether the flow of ecosystem services from these regenerated ecosystems are similar to the flow of such services from the natural mangrove forests. Meta-analysis of studies that evaluated the performance of regenerated forests in different biomes indicates the restored ecosystems to improve the biodiversity and provision of ecosystem services by 44% and 25% respectively compared to natural forests (Benayas et al., 2009). However, studies on flow of ecosystem services from regenerated mangroves present mixed findings (Crona and Ronnback, 2007; Walton et al., 2006) and most of these studies are based on limited survey data that may be suffering from biases due to temporal fluctuations or spatial differences among study sites.

4.6.1.2 Research Questions

The present study will evaluate the relative flow of some ecosystem services from regenerated mangroves compared to natural mangroves and will use a data set that takes care of such biases. The specific research questions of the study are the following:

- How effective are regenerated mangroves as habitat and nursery grounds for fishery compared to natural mangroves?
- How far does the mangrove-fishery linkage get modified by biodiversity (areas having plantation of many diverse species compared to areas with a single species plantation), age of the plantation and anthropogenic pressures (diversion of freshwater, affluent discharge etc)?
- How does the flow of ecosystem services from mangroves planted in non-mangrove habitat compare to those of mangroves planted in a mangrove habitat?
- Identify the contribution of planted mangroves to local livelihood and the social strata that are the maximum beneficiaries of such investments.
- Has mangrove plantation provided any coastal protection in the form of reducing coastal erosion?

One of the most important services of mangroves being its role as 'nursery ground for fish fry', this proposal will primarily value this ecosystem service along with some provisional and one regulating service (coastal erosion protection). These evaluations will be carried out for the regenerated mangrove forests of Gujarat where mangrove restoration has been going on since the early 1990s and good database exists to test the hypothesis. Further, the regenerated mangroves of Gujarat are in a different state of health depending on plantation date, some being planted in a non-mangrove habitat and part of the state's coastline being erosion prone. All such research questions can be evaluated cost-effectively in this study.

4.6.1.3 Methodology

Keeping the scientific accuracy of results in mind, the Difference-in-Difference (DID) technique, which is a well-accepted method in programme evaluation literature, will be used to evaluate the regenerated forest's contribution. The simplest set up of DID is one where outcomes are observed for the two groups (A and B) for two time periods. One group (B) is exposed to a treatment (mangrove plantation) in the second period but not in the first, and the second group (A) is

not exposed to the treatment at all (either never had or always had mangroves). The generic DID equation expresses Y (the variable measuring the effect of treatment, say fish catch) to be a function of the group dummy, the period dummy, the interaction term of these two dummies and a constant term.

The coefficient of the interaction term, which is again a dummy variable equalling one for those observations in the treatment group in the treatment period, captures the treatment effect after the equation is estimated. This equation can be generalised for panel data that includes repeated observations over time for multiple groups. The panel data equation, along with the above mentioned dummy variables, can include many other control variables that could be affecting the outcome of interest but not the treatment, can also control for the heterogeneous characteristics of the groups as well as many other features that could be affecting the outcome. This way panel data DID regression gives an accurate effect of the treatment. Present research will use a panel data DID regression to estimate the effect of planted mangroves.

Species-wise fish catch at different ports in years before and after the mangrove plantation along with detailed information on fishing effort, mangrove features, other variables affecting fish growth, etc. will be used to estimate the equation. Five fishing ports having either planted, natural or no mangroves have been identified in Gujarat from where detailed fish landing data will be collected to estimate the models. These ports are Mandvi, Lakhpat, Veraval, Pipavad and Khambhat. Conclusions will be drawn depending on the data of which ports are used in estimation. For artisanal fishery, fishermen will be surveyed at least for 15 days each to generate an individual panel data.

4.6.1.4 Expected results

The study is expected to provide evaluation of regenerated versus natural mangroves in light of the investment made and ecosystem services harvested, especially mangroves as habitat and nursery grounds for fishery compared to natural mangroves. It will explore mangrove-fishery linkages with age of the plantation and anthropogenic pressures

The results will act as a baseline for future research to generalize for other ecosystem services of regenerated mangroves or regenerated forests at other sites. Agencies like Gujarat State Forest Department, international donors financing mangrove afforestation and researchers will find the results useful.

4.6.1.5 Policy connect

This study is primarily an evaluation of coastal afforestation programme and the results will indicate whether investment in mangrove plantation is paying back and where is it paying back. The results will have the following policy connect: (i) provide important guidelines (like where the plantation is working best) to coastal forestry department engaged in mangrove restoration and management in Gujarat and elsewhere in the country or outside the country; (ii) help in correct accounting of ecosystem service flows from regenerated forests in green national accounting which has become an important objective of the government; (iii)work as a baseline survey to find out if investment in coastal afforestation can be partially recovered from the beneficiaries (can the gain to commercial fishery be used as a basis to explore the scope of having a mangrove tax on this sector to share the cost of replanting mangroves).

PRADEEP VYAS

4.6.2 Assessment of eco-labelling as tool for conservation and sustainable use of biodiversity in Ashtamudi Lake, Kerala

Lead Author: • K. Sunil Mohamed

4.6.2.1 Background

Ashtamudi Lake, a Ramsar site in Kerala on the southwest coast of India contributes approximately 80% of the overall clam export trade in India and provides livelihood to at least 3,000 local people. Short-neck clams (*Paphia malabarica*) in Ashtamudi Lake are collected by hand rake, diving, or handpicking by about 1,500 fishers. In the late 1980s and early 1990s, the short-neck clam resources in the lake depleted due to overexploitation caused by indiscriminate fishing practices. In response, the fisher community, assisted by the district administration, the Central Marine Fisheries Research Institute (CMFRI) and WWF India established fishing regulations in the lake requiring nets with a minimum mesh size of 30 mm, a minimum export size of 1400 clams/kg and a seasonal fishing ban. These self-imposed conservation measures have shown positive effects since 1994, when production began to increase considerably, allowing the fishers to sustainably exploit short-neck clams. A 20 member Ashtamudi Clam Fisheries Governance Council (ACFGC) has been established to administer and regulate the fishery. Recent data collected by CMFRI indicate that the stock is currently being fished sustainably, with an annual catch of approximately 12,000 tonnes, which is close to the maximum sustainable yield.

Given the successful co-management practices for clam fisheries in the lake, the WWF India approached the Marine Stewardship Council (MSC) for eco-labelling the clam fisheries of Ashtamudi Lake so that the local fishers could benefit from access to the growing market for certified seafood. MSC pre-assessment of the fishery has been completed, and the fishery is likely to get certified shortly. It will potentially be the first MSC certified fishery in India. This is expected to further catalyse the interest in sustainable fishing and MSC certification in the state of Kerala and throughout coastal India.

Certification or eco-labelling offers the opportunity for capturing the values created by sustainable management of biodiversity through market access and could potentially be applied as a tool for attracting private investments and promoting local stewardship for biodiversity conservation. While certification could create economic as well as ecological benefits, there are also costs involved – both direct and indirect. Direct monetary costs have to be incurred towards the certification process. The sustainable resource management regime, which is necessary for certification, has indirect cost implications for the affected people, e.g. cost incurred towards changing the fishing gear, costs imposed due to seasonal fishing ban, costs incurred towards sustainable harvest and post-harvest management, etc. If eco-labelling or certification has to be successfully applied as a tool for conservation and sustainable management of biodiversity, these direct and indirect costs and benefits, both economic and ecological have to be analyzed. The costs of certification need to be compared with the real and perceived benefits (ecological and economic benefits) to the resource and along the supply chain of the certified product. Stakeholder analysis to understand the distributional aspects of cost as well as benefits is very important for drawing recommendations (who bears the costs and who reaps the benefits).

4.6.2.2 Research Questions

The case study analyses the economic, social and ecological benefits and costs of MSC certification of clam fisheries in Ashtamudi Lake and the impact of the fisheries management interventions on recovery of clam stocks, biodiversity and livelihood in the lake. The study probes into the following specific questions:

- What is the total cost (direct and indirect; economic and ecological) of certification process? Who/which stakeholders bear the costs?
- What is the catch and economic value of the Short Neck Clam fishery after the management initiatives?
- Has the ecosystem goods and services improved after

the management? Who/which stakeholder benefits from the management initiative? Who has lost out?
- Is it possible to replicate the success of clam fishery management initiatives to other fisheries in the Lake?
- If so, what will be the potential improvements in the ecosystem and economic value of the Lake as a whole?

4.6.2.3 Study approach

The study attempts a pre and post management intervention comparison on the following aspects:

- Total economic value of the fishery resources of the Ashtamudi Lake.
- Preliminary assessment of ecological services provided by clams in the Lake.
- Assessment of ecological services provided by benthic fauna in the Lake.
- Avian faunal density in the Lake.
- Social and economic conditions of clam fishers in the Lake.
- Valuation of direct and indirect costs incurred towards

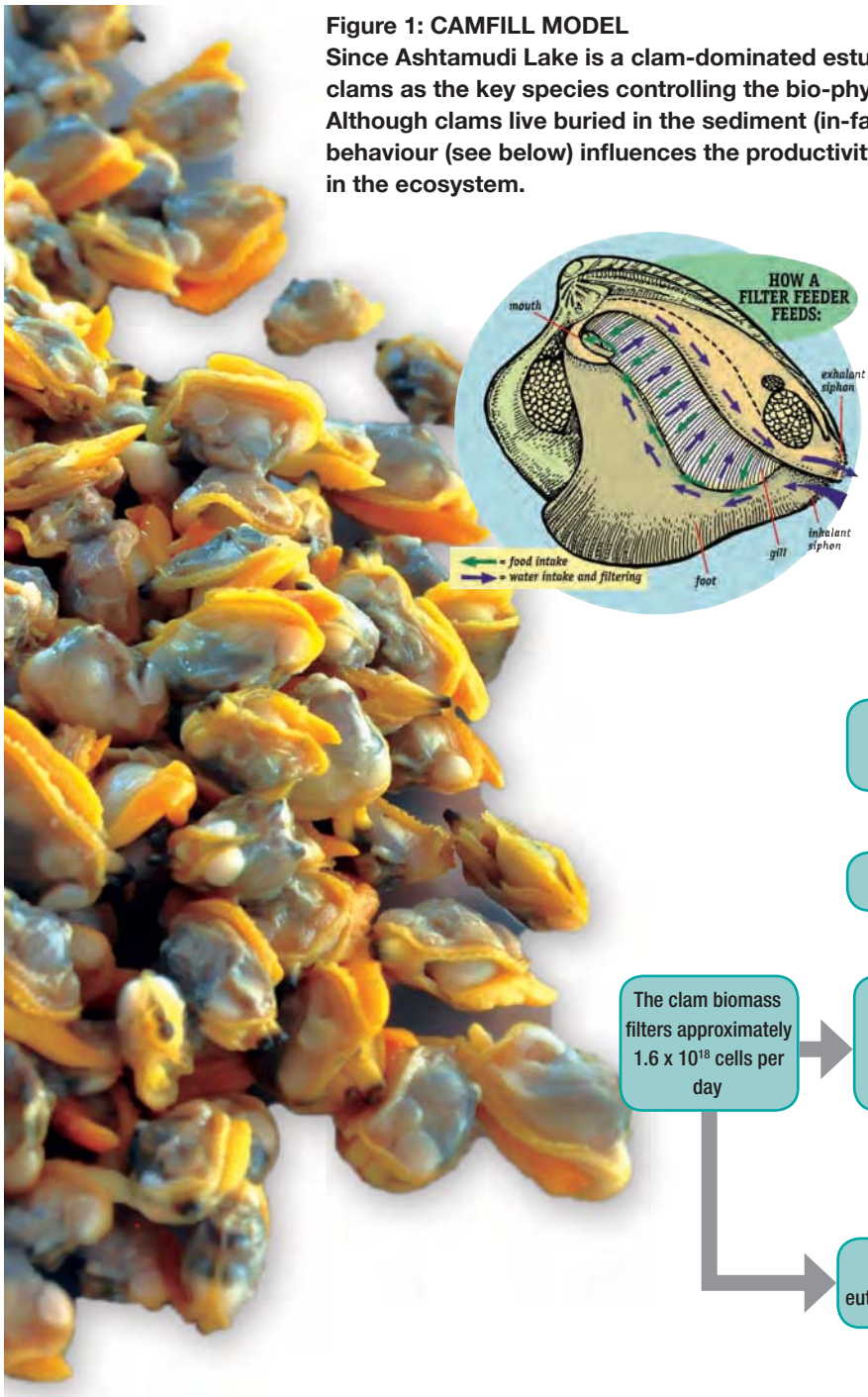
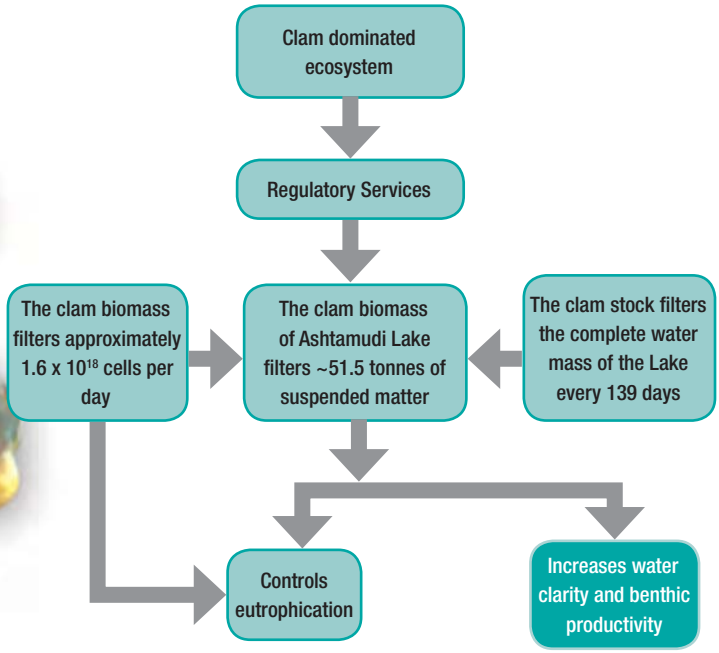


Figure 1: CAMFILL MODEL

Since Ashtamudi Lake is a clam-dominated estuarine ecosystem, we considered clams as the key species controlling the bio-physical processes in the system. Although clams live buried in the sediment (in-fauna), their unique filter feeding behaviour (see below) influences the productivity and the bentho-pelagic coupling in the ecosystem.

The term clam generally refers to bivalve molluscs that live buried in sand or silt, many of which are edible. Clams feed on plankton by filter feeding.

Clams filter feed by drawing in water containing food using an incurrent siphon. The food is then filtered out of the water by the gills and swept toward the mouth on a layer of mucus. The water is then expelled from the animal by an ex-current siphon.



MSC certification process.

- Valuation of economic and ecological benefits from sustainable clam fisheries in the lake.

4.6.2.4 Preliminary findings

Some of the preliminary findings of the study are as follows:

- The estimated market value of fish and bivalve catch in Ashtamudi Lake is ₹ 985 million (US$ 16.4 million). This value is based on average catches over a 5-year period at current prices. A major share of the value originated from clams (51%), followed by crabs (18%) and shrimps (13%).
- Evaluation of ecosystem services (arresting eutrophication) of fisheries is done using CLAMFIL model (see figure 1, previous page) developed by CMFRI, which made two scenarios. It was found that in Scenario-1 when there is good clam fisheries management with yields maintained at 12,000 tonnes ± 20%, clams would take ~139 days to completely filter the lake water; and Scenario-2 when there is poor clam fisheries management, and yields are close to the very low, it would take almost double or 277 days. Thus if the clam fisheries are not maintained at sustainable level, the eutrophication index of the ecosystem is likely to be considerably higher leading to serious impairment of water quality of the lake and affect all living resources and ecosystem service flow from the lake.
- A rough estimate of the financial costs for the MSC eco-labelling scheme was estimated as ₹ 0.65 million.

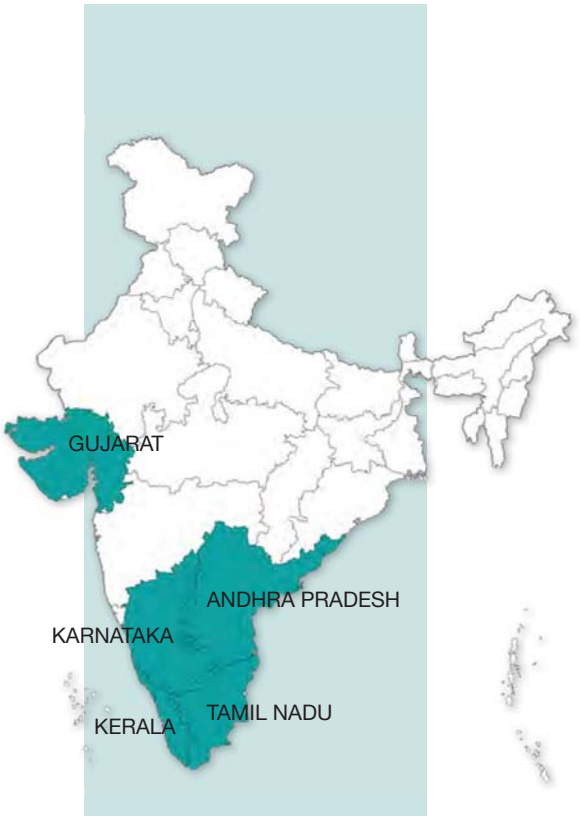
4.6.2.5 Policy implications

This study has clear policy input to National Fisheries Policy and establishing impact of novel mechanisms like MSC certification on sustainable fishing practices. It would help in catalyzing the interest of fishermen and other stakeholders in sustainable fishing and using MSC certification as a tool in a country like India with a very large coastline.

SUNIL K MOHAMED

4.6.3 Economic valuation of seasonal fishing ban on marine fisheries services in selected maritime states of India

Lead Author: • R.Narayana Kumar



4.6.3.1 Research issues to be addressed

Marine fisheries in India are open access resources with a common property regime to a large extent. Due to this, it leads to overfishing and decline in several fish stocks, which is not sustainable. Also, intra-sectoral conflicts arise in sharing the renewable but finite resources among fishermen operating different gear. To regulate fishing, the Government of India intervened and suggested regulation of fishing by implementing Seasonal Fishing Ban (SFB), which was adopted from different years by all the maritime state governments under their Marine Fishing Regulation Act. This intervention is received with mixed response by the fishing communities. As benefits and disadvantages are uncertain, even 25 years after implementation of SFB the governments are unable to substantiate the policy intervention to convince the fishing communities. Under this situation, this study will attempt to answer the following questions to bring more clarity to the implementation of SFB in select states, namely, Gujarat, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh.

- Has the quantum of the natural capital and its value of the

J R BHATT

marine ecosystem increased due to the ban?

- Is there an improvement in the services provided by the marine ecosystem due to SFB?
- Has the transaction cost of implementation of SFB increased and reduced the net social benefit?
- Is there perceptible difference in the performance of ban between the maritime states?

4.6.3.2 Approach (Methodology)

a) The value of the fisheries resources estimated based on the revalidated potential yield of the Indian EEZ level will be treated as the value of natural capital fisheries capital assets. Estimation will be based on the primary data collected and revalidated marine fisheries potential yield.

b) The impact of SFB on ecosystem services like increase in fish catch and profit will be assessed in a phased manner. The incremental biomass due to SFB and its economic value will be estimated using the time series data on marine fish landings in the selected states for a period of fifteen years before and after the ban period.

c) The net social benefit due to implementation of SFB will be evaluated by estimating the management cost or transaction cost and then deducting it from the value of natural capital (gross benefit). The management cost will be arrived at by summing up information costs, administration cost, enforcement cost of implementing SFB and the compensation given to fishers, both in cash and kind.

d) The ecological value of the services provided by the ecosystem like respite to the sea floor and reduced CO_2 emissions due to SFB will be estimated using direct and indirect use value methods.

e) Biodiversity indices as indicators of health of ecosystem will be calculated for selected major fishing centres by gathering species level records from the national marine fish landings database of CMFRI to document the biodiversity during pre and post ban scenario. Biodiversity indices valuation will be done based on existence value, altruistic value and bequest values.

4.6.3.3 Expected outcome

a) **Assessment of the effectiveness of the SFB**. This study will provide the net social benefit of implementation of SFB. The difference between the value of the marine fish landings and the cost of enforcement of the ban will give the net social benefit or otherwise. If the result is a benefit,

the Government can substantiate and/or plan to improve the outcome of SFB.

b) Recommend alternate/improved management measures: If the net social benefit is not favourable, the Government can explore the possibilities of formulating alternate and improved management options to aim at sustainable harvest.
c) Explore the possibilities of promoting co-management and reducing management cost.
d) Conservation of resources against issues facing ecosystem approach to fisheries management.
e) Sustainable fishery harvest and sustainable income to the stakeholders.
f) Pave the way for expansion at national level exercise.

4.6.3.4 Policy Connect

a) Assist the governments to substantiate SFB as a single regulatory measure or to implement along with a combination of other regulatory measures.
b) Formulate more efficient and alternate management options to achieve enhanced ecosystem services and net social benefits.
c) Help the government decide the level of institutional support and quantum of financial support (towards compensation) to the fishers during SFB.
d) Reduced fuel consumption and carbon emission due to SFB as the potential for use in carbon trading and saving in foreign exchange.

R NARAYAN KUMAR

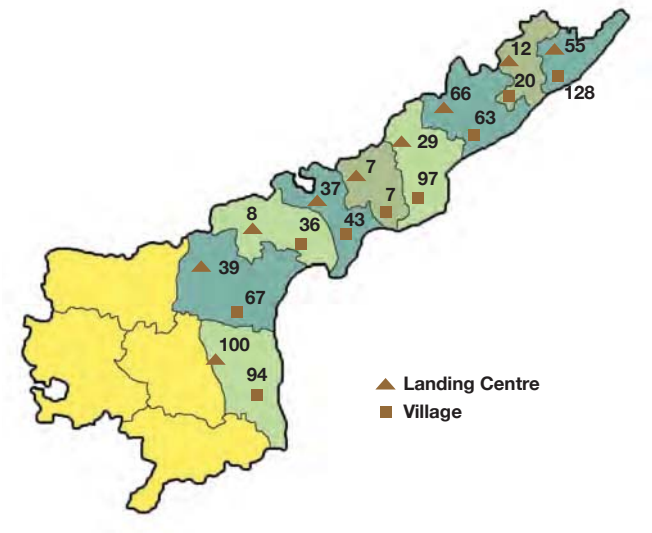
4.6.4 Economic value of biodiversity loss: A study of by-catch from Andhra Pradesh marine fisheries

Lead Author: • Jyothis Sathyapalan

4.6.4.1 Background

The limited growth potential of marine fishery sector in India due to over fishing is well recognized. Recent changes in the fishing sector, particularly application of modern technologies for identifying potential fishing grounds, emphasis on exploitation of deep sea fishery resources and use of various types of gear generate considerable amount of waste, mostly in the form of juvenile fish and other living organisms. Non-compliance with fishery regulations and destructive fishing practices also contribute to the waste generation in the form of by-catch, which has serious implications on marine biodiversity. According to FAO database, 8% of the global catch (7.3 million tonnes yearly) during 1992-2001 characterizes by-catch. In India, various studies on bottom trawling concluded that by-catch is within a range of 25 to 54% of the total catch. Marine mammals are also found in by-catch (Yousuf et al., 2008). Diversity of species found in tropical waters is the main reason of the higher magnitude of by-catch. In India, by-catch is a more complex issue due to the multi-species and multi-gear nature of fisheries. It is also important to note that more than 250 fish species were reportedly found in by-catch in various studies conducted

Figure 2 Fishing location in coastal Andhra Pradesh



by CMFRI on by-catch. By-catch is usually small fish, which indicates loss of juvenile species that have implications on marine biodiversity. In this context, the study focuses on economic and ecological issues of regulating by-catch.

4.6.4.2 Research Questions

By-catch is generally disposed off in sea or brought to shore as trash for poultry feed or for fishmeal production. It is considered of no value or little value by boat owners. There is no incentive for boat owners to minimize by-catch. Therefore, it is important to understand the economic and ecological value of regulating by-catch. The study tries to answer: (a) what is the implication of by-catch on marine biodiversity loss? (b) What is the true economic value lost due to by-catch across different gear and scale of fishing? (c) What is the role of fuel and fleet subsidy (an incentive for fishing) in generating large quantities of by-catch? In short, it helps to understand the economic and ecological value associated with by-catch in marine fishery and the need to regulate it. The case study will be focussing on marine fisheries of Andhra Pradesh .

4.6.4.3 Importance of the study

The marine fishery in developing countries plays a vital role in sustaining well-being of millions of people. They follow different fishing practices and gear to maximize production. They employ several types of gear, target multiple species and often do not comply with conservation measures to maximize private benefits. Maximization of economic benefits without complying with fishing regulations generate waste in the form of by-catch. The resulting economic value of biodiversity loss constitutes a social cost which is seldom accounted for while estimating fishery income at the state level. Internalizing the cost of by-catch in the estimates of fishery income can help in promoting ecologically balanced fishing operations. Understanding the implications of by-catch across different scales of fishing also helps us design a more inclusive approach towards small-scale fishery. By-catch reduction policies also help to reduce moral issues

JYOTHIS SATYAPALAN

and conflicts between small-scale operators and their large counter parts. Therefore, this study is important from the perspective of income accounting, formulating marine policies based on incentive mechanisms, and for adopting an inclusive approach in fishing.

4.6.4.4 Methodology

Like many other economic activities, fisheries also have multiple outcomes. It produces food, creates employment, and affects ecosystem and biodiversity and well-being of aquatic life. Biodiversity loss can arise if the joint outputs are generated in a wrong proportion that exhibits the characteristics of externalities because it is a welfare reducing output for which limited or no market exists. The negative joint outputs of the fishery production process undermine social goals that is the economic viability of fishery. Taking of undersized or juvenile fish can produce several types of externalities. It can result in potential growth over-fishing and recruitment overfishing. Hence, it affects not only the potential future benefits to the fisher him/herself, but all other fishers as well (Pascoe, 1997). Therefore, forgone income associated with by-catch constitutes an important measure of value lost.

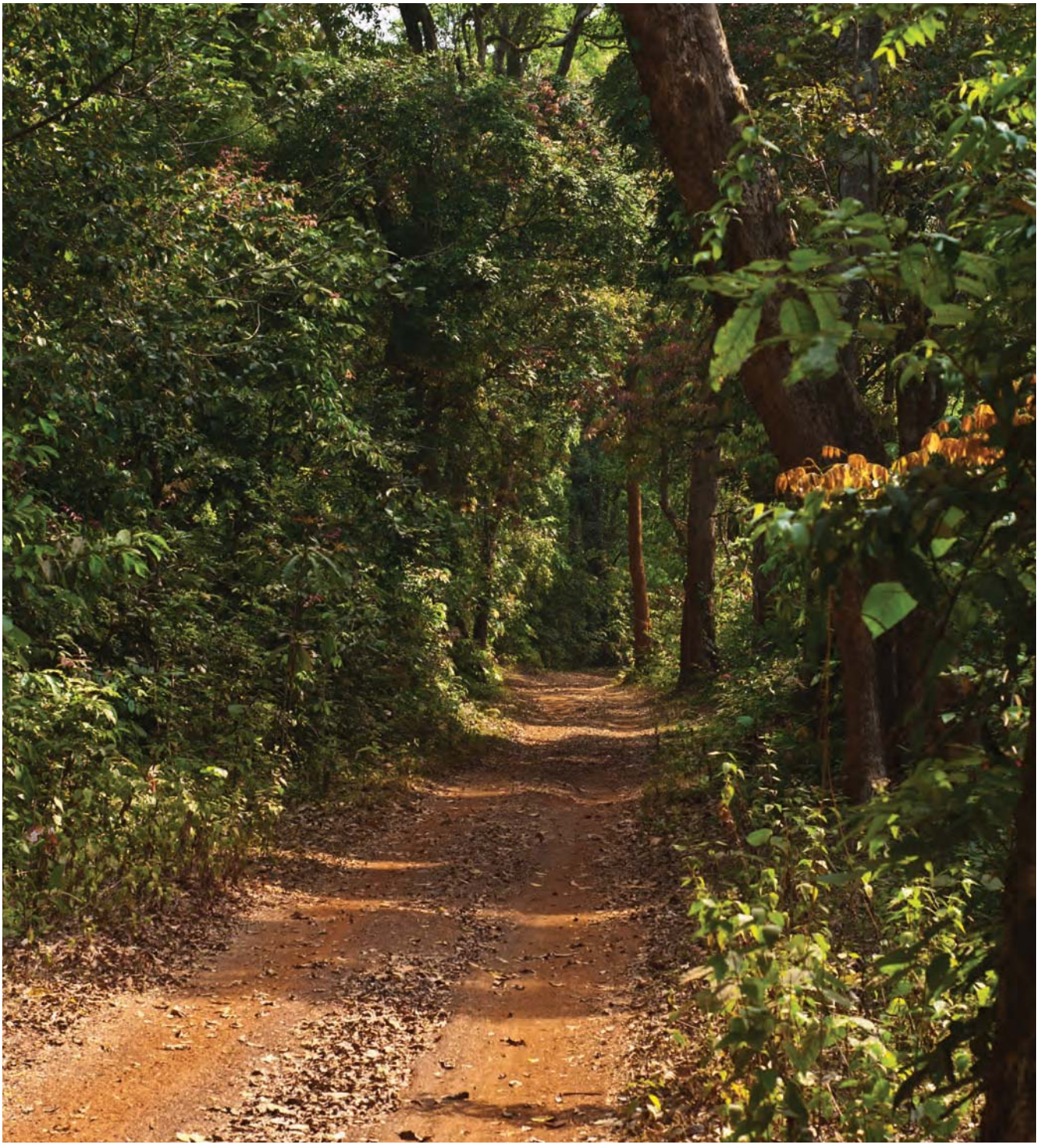
Taking of juvenile fish in fishery can also impinge on the potential profit in other fisheries. For example, taking of large quantity of juvenile fish through mechanised bottom trawling reduces the potential yield in other fisheries say inshore shrimp fisheries targeted by small-scale fishers. Therefore, inter-fishery cost associated with juvenile by-catch constitute part of the value lost. This is resulting from forgone value of by-catch on other sectors of fishing industry. These are costs of juvenile fish being caught as by-catch in one fishery. If these fishes had not been caught they could have resulted in higher yields in other fisheries in which they may form the key target species. Empirically, this can be worked out based on the number of juveniles that would have survived to harvestable age, and the proportion that would have been caught in other (e.g. inshore small-scale) fishery. Thus the total social value of biodiversity loss is a summation of current and future value lost through by-catch. The total value lost due to by-catch can be estimated as the total quantity of by-catch multiplied by the shadow price of by-catch. Estimating shadow price is the first step of estimating the value lost. Then the total value lost will be estimated by shadow price time total quantity of by-catch produced in a given period of time. From an operational point of view the study will focus on the by-catch generated by the mechanised fishing and its effects on future mechanised fishery as we well as inshore small-scale fisheries of Andhra Pradesh. This study uses sample data collected during June 2013 to May 2014 as part of research on fishery income accounting (Sathyapalan, 2014). Using stratified random sampling, we conducted 4 sample surveys during this period in monsoon, winter, summer and ban periods. Total number of sample for all season is 3,630 active marine fishers from 57 landing centres and 4 harbours, which provides species-wise data on catch, by-catch and fish disposal and input data on gear, crafts and fuel consumption. Additional data on species composition of by-catch will be collected this year to understand the species diversity in detail. Following the methodology developed by CMFRI (Srinath et al., 2005), we provide a global estimate for catch and by-catch for Andhra Pradesh using the above said data basis. Moreover, this study also provides a model to evaluate the trade-offs (shadow prices) involved in the selection of alternative policy options for two conflicting biological objectives (a) minimizing by-catch of all species and (b) maximizing total catch by developing an optimization model.

4.6.4.5 Expected outcome

In India, most of the research on by-catch focuses on biological and technological aspects (Sujatha, 1996; Zacharia et al., 2006; Boopendranath, 2007 and 2009; Boopendranath et al., 2008; Gibinkumar et al., 2012; Yousuf et al., 2008; Kizhakudan et al., 2013) An important observation of these studies is that by-catch is a more complex issue in India due to multi-species and multi-gear nature of fisheries. There are less studies focusing on economic valuation of biodiversity loss due to by-catch. This study will add value to the literature on by-catch focusing on economic valuation. As far as policy is concerned, measures to reduce by-catch generally focused on technical solutions. These include measures such as regulating mesh sizes and by-catch reduction devises attached to the gear. However, it is realised that policy measures should also focus on the economic behaviour of fishers through incentive mechanisms. The Indian mechanised fishery is subsided by providing fuel and fleet subsidies which act as an incentive for overfishing. This study will review the subsidy policy and suggest measures to revise it. Moreover, by-catch does not appear generally in any official statistics. So the database of this study will help to understand the proportion of catch and by-catch, which will be useful in formulating policies.

Finally fishery is a multi-stakeholder sector. Introduction of any polices create many losers and gainers. Since we focus on by-catch across different gear and scale of fishing, there is a high likelihood to find certain gear and scale of fishing with high negative impact on biodiversity and there by higher contribution to value lost. They might be the losers while revising policies to internalise these values. On the other hand, there will be beneficiaries if we internalise these values particularly those faced due to inter-fishery costs associated with juvenile by-catch. It will also benefit the state to devise policies to revise fishing subsidies based on incentives for sustainable marine fishery. This study can contribute towards revising Indian marine policy, which is under review.

CHAPTER 5
Way Forward



RITESH SHARMA

The TII Interim Report highlights the current status of valuation of biodiversity and ecosystem services in India as well as measures to integrate these values in planning and decision-making. In the coming period an effective communication and dissemination strategy will be worked out and followed. This would help in understanding the real benefits of biodiversity and ecosystems and in improving programme management guidelines. The recommendations emerging from sectoral synthesis reports will be evaluated for integration in management guidelines and policies for inland wetlands, forests, and coastal and marine ecosystems.

At the same time additional case studies will be taken up to cover other aspects and types of ecosystems. With the results being effectively communicated and disseminated, this will help in achieving the Aichi Biodiversity Target number 1.

It is proposed that the teams involved in the case studies will meet periodically in workshops to exchange knowledge, experiences and provide peer group comments to each other. It is also planned to organize training courses by leading researchers and practitioners in the field. This will lead to a network of ecosystem economics practitioners. The network of research teams that involve leading ecologists and economists will be developed as a think-tank to support integration of ecosystem services economics-based approaches in environmental planning and decision making.

Once a substantive body of case studies and knowledge is built up, it is expected to introduce ecosystem economics-based curricula in academic institutions. The MoEFCC has identified a shortlist Institutions wherein ecosystem services economics based curricula would be developed and training imparted to graduate and post graduate levels, as well as midcareer professionals. The insights gained will also be disseminated to members of Parliament and State Legislative Assemblies, and senior and middle level officials in various concerned government agencies at both the State and Central level. This will help achieve Aichi Biodiversity Target number 2.

Once stakeholders become aware of the values and need for ecosystems and biodiversity conservation, and once ways to do so are indicated, progress towards achieving the Aichi Biodiversity Target number 5 and 15 will take place.

Some of the projects directly address measures to improve sustainability of agriculture, forestry and fisheries. Measures which are found to be effective will be promoted and when accepted Aichi Targets 6, 7 and 8 could be realized.

The outcomes of the studies will be synthesized so that they can support and inform green accounting that factors in ecosystem and biodiversity. Sectoral synthesis will be considered for integration in development of national green accounting methodology, development of which is being led by Central Statistical Organization.

TII recommendations will support implementation of Aichi Targets, Ramsar Strategic Plan, Bonn Convention and other international commitments made by the country. These should help achieve Aichi Biodiversity Target number 14.

At the local level the next steps in TII will be critical. The case studies will begin to provide an opportunity for testing valuation methods and empirically establish instruments for the incentivization of conservation and sustainable use of biodiversity and ecosystem services. This could include ensuring better returns on livelihoods based on such goods and services. It will also help to enhance conservation and thereby, potentially lead to an increase in biodiversity.

The importance of the TEEB approach has been widely recognised across countries as helping to make the case for both conservation and sustainable use. Since COP 11 Brazil, India and Germany (also referred as BIG) have come together on two occasions for the BIG TEEB Dialogue, which is a platform for sharing lessons and comparing achievements in the respective countries. Among other findings, the Dialogue has helped establish that the TEEB approach is a cost-effective, yet robust way of achieving the Aichi Targets of the CBD. It has generated knowledge, information and data to contribute, to national reporting, besides CBD, on Ramsar, CMS, CITES and other international conventions. TII is envisioned to improve and refine our collective capacities for sustainable management of our country's national capital.

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