Valuing & Investing in Ecosystems as Development Infrastructure: economic analysis of options for climate-compatible development in coastal zones of Kenya & Sri Lanka

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VALUING & INVESTING IN ECOSYSTEMS AS DEVELOPMENT INFRASTRUCTURE:

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Lucy Emerton, May 2014

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List of Acronyms

BAU	Business as usual
CCD	Climate-compatible development
GN	Grama Niladhari
MEA	Millennium ecosystem assessment
NPV	Net present value
TEV	Total economic value

1. Introduction

This working paper is a research output from the project 'understanding the fiscal and regulatory mechanisms necessary to achieve CCD in the coastal zone' (iCoast). The aim of iCoast is to support climate-compatible development (CCD) in the coastal zones of Kenya and Sri Lanka by elaborating what fiscal and regulatory mechanisms are necessary to achieve CCD; these changes must be capable of strengthening coastal ecosystems against climate change, decrease environmental degradation while providing economic benefit to communities, with an emphasis on the poor.

The current document applies the approach and methodology laid out in the background paper on 'Economics in the iCoast project' (LTS 2013). It reports on economic valuation activities carried out under Work Package 1 ('undertake evidentiary analysis of the social, cultural, political and environmental barriers to CCD implementation at the coastal zone'), as well as the economic analysis of CCD specified under Work Package 2 ('assess the economic and financial benefits, costs and opportunities for different stakeholders from applying CCD to the coastal zone[1]').

The paper seeks to demonstrate how economic valuation can be used to strengthen CCD planning and implementation in coastal areas: by making the economic case for green CCD options, and highlighting needs and opportunities to capture ecosystem values as incentives and financing for CCD. It builds on three data sets generated under other components of the iCoast project (see Kumara, 2014; Bournazel et. al. in prep.; Huxham et al. in prep.) in order to aassess ecosystem-based options for climate-compatible development in southern Kenya and north-western Sri Lanka. The focus is on valuing the costs, benefits and trade-offs associated with investing in mangrove rehabilitation and conservation as a means of strengthening climate adaptation and resilience at the same time as generating other development co-benefits for coastal populations.

Section 2 describes how ecosystem undervaluation has traditionally posed a problem for development planning and decision-making. It lays out the various frameworks and tools that can be used to integrate ecosystem service values into the economic calculations that are used to inform decision-making. It relates these issues and approaches to the challenge of justifying, planning and implementing ecosystem-based approaches to climate adaptation in coastal areas.

Section 3 describes how ecosytem valuation has been applied in the iCoast project, to make the economic case for green CCD options that incorporate ecosystem conservation and rehabiliation. It describes the findings of an assessment of the the costs and losses that result from a failure to factor mangroves into coastal development processes in Puttalam Lagoon, Sri Lanka, and an analysis of the gains and value-added from investing in mangrove rehabilitation and conservation as a core component of coastal development on the south Kenya coast.

Section 4 concludes that there needs to be a shift in the way in which development trade-offs are calculated and land, resource and investment planning is carried out in coastal areas — moving from approaches which fail to factor in ecosystem costs and benefits, to those which value and invest in ecosystems as an integral part of climate-comaptible development infrastructure. It looks at further using the results of ecosystem valuation to identify needs and niches to capture ecosystem values as incentives and finance for CCD.

[1] Revised from the original work package title of 'cost-curves of applying REDD+ in coastal mangrove systems in Kenya and Sri Lanka developed'.

2. Posing the challenge: ecosystems as an economic part of coastal infrastructure

Rethinking coastal development trade-offs

Coastal zones have long been the focus of intense development processes. Needs for income, employment, industry and infrastructure are particularly pressing: it is estimated that more than two billion people (Brown et al., 2008) and nearly half of the world's major cities (Millennium Ecosystem Assessment, 2005) are found within 50km of coastlines, with population densities that are on average two and a half times higher than those of inland areas (Agardy et al., 2005). Much of this population has been attracted by the rich economic opportunities that are associated with the natural resources that are found there. At least three billion people, globally, are thought to depend directly on marine and coastal biodiversity for their livelihoods (SCBD, 2009), and many more owe their income, employment or economic survival to related industries and sectors. Together with this striking concentration of human settlement and industry, and alongside high levels of affluence, rates of poverty however remain high. There are thought to be more than 250 million coastal poor (Brown et al., 2008), many of whom are living at the margins of the economy.

It would be extremely naïve to overlook the fact that there exists an inherent tension between coastal development and ecosystem conservation. This is fundamentally to do with making choices about how, where and why to produce, consume and invest (Emerton, 2006). While ecosystems provide a suite of services which underpin, enable and protect coastal populations and economies, there is little doubt that the rapid development processes that have been taking place in the coastal zone have placed severe stresses on the natural environment. Although coastal ecosystems are among the most productive systems in the world they are also the most highly threatened; the single greatest threat is development-related loss of habitats and services (Agardy et al., 2005).

One of the most critical coastal development trade-offs involves achieving a balance between the benefits that can be gained from economic activities and investments which modify, degrade or deplete natural ecosystems, and the costs and losses that are incurred as a result of ecosystem change. Across the world a host of policies, laws and institutional arrangements have for some time existed which attempt balance the competing demands on coastal lands and resources in a way that does not cause undue environmental harm. The dominant rhetoric under which development planning in coastal areas is now carried out in most countries, such as 'green economic growth', 'sustainable development' or 'integrated coastal zone management', is founded on such principles. Along similar lines, 'climate-compatible development' (CCD) is a concept that has entered into development discourse over recent years. It aims for triple wins: change that enhances adaptation to current and anticipated climate change impacts, whilst also mitigating the production of greenhouse gases and leading to increases in human welfare (Mitchell & Maxwell, 2010).

The massive challenges and potentially devastating impacts posed by climate change have begun to stimulate a great deal of debate over as to what are the most effective, equitable and sustainable options for strengthening the resilience of vulnerable coastal populations. In relation to CCD, one key trade-off relates to the choice of whether to invest in 'hard' or 'grey' options to mitigate the hazards and reduce the vulnerabilities associated with climate change, or to consider alternative, ecosystem-based solutions (Renaud et al., 2013). Over recent years, green options have increasingly been promoted as a way of complementing or even substituting built infrastructure measures in relation to climate change adaptation and CCD (Boyd, 2010; Olivier et al., 2012). The key characteristics of such approaches is that they integrate the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the adverse impacts of climate change and increase the resilience of socio-economic and ecological systems (Tamelander et al*.,* 2010).

This working paper describes and applies a conceptual framework for using economic valuation to address these questions and understand these linkages, so as to assist in planning and implementing CCD in coastal areas. It contends that, rather than posing 'grey' and green approaches as being necessarily in opposition to each other, or as mutually incompatible, it is more productive to see both as being part and parcel of the same basic infrastructure that is required to deliver essential services in coastal areas. In turn, if CCD is to reach its full potential, decision-makers must be willing to explicitly recognise the values associated with ecosystem services, and factor them into their calculations. This requires a shift in the way in which development and conservation trade-offs — moving from a paradigm which overlooks the value of natural ecosystems to approaches which count and invest in them as an economic part of development and climate adaptation infrastructure.

Why ecosystem undervaluation is a problem for coastal development decision-making

It is hardly a novel insight that coastal and marine resources make a major contribution to local, national and even global economies. These values are well-recognised and well-documented. Marine fisheries are, for example, estimated to generate income in excess of USD 80 billion a year, provide for around 35 million jobs and support the livelihoods of more than 300 million people worldwide (Beaudoin and Pendleton, 2012). Fish has become the most valuable agricultural commodity that is traded internationally: export revenues are now worth more than coffee, cocoa, sugar and tea combined (OECD, 2008). Coastal tourism is currently one of the fastest growing components of the leisure and recreation industry: the World Tourism Organisation's statistics show that twelve of the world's fifteen top tourist destinations are countries with coastlines (UNEP, 2009). The economy-wide impact of these activities is immense, and in most countries extends far beyond the immediate income they generate. In West Africa, for example, fishing provides employment for more than two percent of the economically-active population and contributes almost a third of daily protein consumption (Neiland, 2006). Marine and coastal resources provide for the welfare of well over 60% of the people living in the coastal plains of Indonesia (Emerton 2009), and in Samoa are estimated to account for almost one third of GDP (Mohd-Shahwahid, 2001). Coastal tourism directly accounts for a fifth of the Maldives' GDP, while its wider effects generate more than sixty percent of foreign exchange receipts, over ninety percent of government tax revenues and almost forty percent of employment opportunities (Emerton et al*.,* 2008).

There has, however, long been a tendency for economists to focus only on the value of coastal resources that form major inputs into major commercial activities (Emerton, 2006). Indeed, most development strategies have been based on finding ways to better exploit this rich natural capital base. The majority of development decision-makers are well aware of the role that resource-based industries (such as fisheries and tourism) play in coastal economies, and these values are commonly (although usually incompletely) reflected in most national-level economic statistics and development indicators. Yet the view of coastal land and resource values that has traditionally dominated economic thinking and development decisions remains narrow, and incomplete. It largely excludes consideration of the host of other values that coastal ecosystems generate for the economy – especially those associated with local-level and non-market production and consumption, and with ecosystem regulating, supporting and cultural services.

Not only does the undervaluation of coastal and marine resources (or their selective valuation) massively underestimate the 'real' economic value of natural ecosystems, but it also tends to automatically favour development options which focus on their large-scale or extractive commercial exploitation (Emerton, 2013). Given the undervaluation of ecosystem services, it is hardly surprising that the most 'productive' or 'economic' activities in coastal areas have frequently been seen as those which over-exploit, replace or otherwise degrade natural ecosystems. In many ways ecosystem undervaluation can be seen to have resulted in a negative investment process in coastal areas, whereby ecosystems have been destroyed, degraded and converted in the course of expanding the built environment or stimulating particular economic activities (Emerton, 2006). In many parts of the world, the expansion of agriculture, aquaculture, urban and tourist infrastructure has resulted in the conversion and reclamation of coastal habitats. Intensive resource harvesting has often been promoted as a means of generating income, employment and foreign exchange earnings, placing high and often unsustainable demands on the natural environment. Ample evidence exists to suggest that these activities have weakened the resilience of coastal ecosystems and undermined their ability to provide goods and services. Around a third of fish stocks are now considered to be overexploited or depleted (FAO, 2010), and it is thought that more than a third of mangrove area has been lost or converted in the last few decades and a fifth of coral reefs have been destroyed (Agardy et al., 2005).

The effects of marine and coastal undervaluation are also manifested at the policy level. Economic policies which aim to stimulate production and growth have often hastened the process of ecosystem degradation and loss. Fisheries subsidies, estimated to be worth between USD 30-34 billion a year worldwide (MRAG, 2009) or 20-25% of gross fisheries revenues (Naylor et al., 2001) have, by artificially increasing the capacity of fishing fleets, resulted in the over-exploitation (and in some cases collapse) of fish stocks (UNEP, 2004). The loss of potential economic benefits in the global fishery, due to stock depletion and over-capacity, is estimated at close to USD 40 billion per year (World Bank and FAO, 2009). Various tax breaks and fiscal inducements, often combined with low or non-existent environmental penalties and fines, provide a powerful incentive to modify and reclaim coastal habitats for more 'productive' commercial uses. One instance of this is the generous tax breaks, import duty exemptions, export credits and preferential loans offered to shrimp farming in many countries (Primavera, 1997; Bailly and Willmann, 2001). Another example is when the incentives applied to other sectors of the economy are not offered to environmentally sustainable products, technologies and activities. In the Maldives, for instance, import duty reductions focus almost entirely on the products that are required for construction and expansion of the tourism, fisheries and industrial sectors in coastal zones, and make no explicit effort to encourage 'green' products or technologies: the relatively higher import duty levied on solar panels (25%) as compared to that for diesel-based electricity generation equipment (20%) is one example of this (Emerton et al*.,* 2008).

Perhaps most serious – and of great relevance to CCD – is the effect that undervaluation has on the markets, prices and incentives that land and resource users in coastal areas face, and which shape their economic opportunities and behaviour. An underlying problem is that most markets do not capture the non-monetary values of coastal ecosystem services, and so they are rarely considered when resource management decisions are made (Mohammed, 2012). One impact of ecosystem undervaluation on prevailing prices and market opportunities is that it frequently remains more profitable to choose development options and engage in economic activities that degrade coastal ecosystems – even if the costs and losses that arise for other groups, or to the economy as a whole, outweigh the immediate gains to the landholder, resource user or investor that is causing the damage. Work carried out in the Togean Islands in Indonesia for example shows that while the costs associated with the loss of ecosystem services caused by commercial logging and agriculture in coastal areas outweigh the income they generate by a factor of more than four, it is still more profitable to clear and reclaim coastal habitats than to engage in other more sustainable land and resource uses (Cannon, 1999; Emerton, 2009). Similarly, in Sri Lanka, it is possible to gain high market returns from clearing mangroves for shrimp farming; however, if the costs and negative externalities associated with ecosystem service loss were factored into prices and markets, shrimp farming would cease to be a financially viable land use option (Gunawardena and Rowan, 2005).

If coastal ecosystems have no value, then such policies, decisions and development trajectories would be perfectly rational ones from both a financial and an economic point of view. Should there be assumed to be few benefits associated with the conservation of coastal ecosystems and low or zero costs attached to their degradation and loss, then there would be no advantage to be gained from considering ecosystem values when policies are formulated, fiscal instruments are designed or prices are set. The reality is however not that coastal ecosystems have no economic value, but rather that this value is poorly understood, rarely expressed in numerical or monetary terms, and as a result is frequently omitted from decision-making. A pressing question then becomes: how do we overcome the problems associated with the undervaluation of coastal ecosystems, and ensure they are better reflected in decision-making – and, in the context of CCD, how can we articulate the economic opportunities, value-added and costs avoided that are associated with ecosystem-based approaches ? These issues are further addressed in the next section.

Extending the concept of coastal ecosystem values

Changes in the way in which both economists and conservation planners understand ecosystem services have resulted in the development of a set of useful (and increasingly widely-used) tools to assist in overcoming the problems associated with undervaluation.

Over the last two decades, the concept of total economic value has emerged as one of the most commonly-applied frameworks for identifying and categorising ecosystem values (Pearce et al., 1989). This represents a move away from the very narrow definition of benefits that economists have traditionally applied, which sees the value of ecosystems only in terms of the raw materials and physical products that they generate for human production and consumption. Total economic value also encompasses subsistence and non-market values, ecological functions and non-use benefits (Figure 1) – in other words, the full gamut of provisioning, regulating, supporting and cultural services that are associated with ecosystems (Millennium Ecosystem Assessment, 2005; Figure 2).

Figure 1: The total economic value of coastal ecosystems

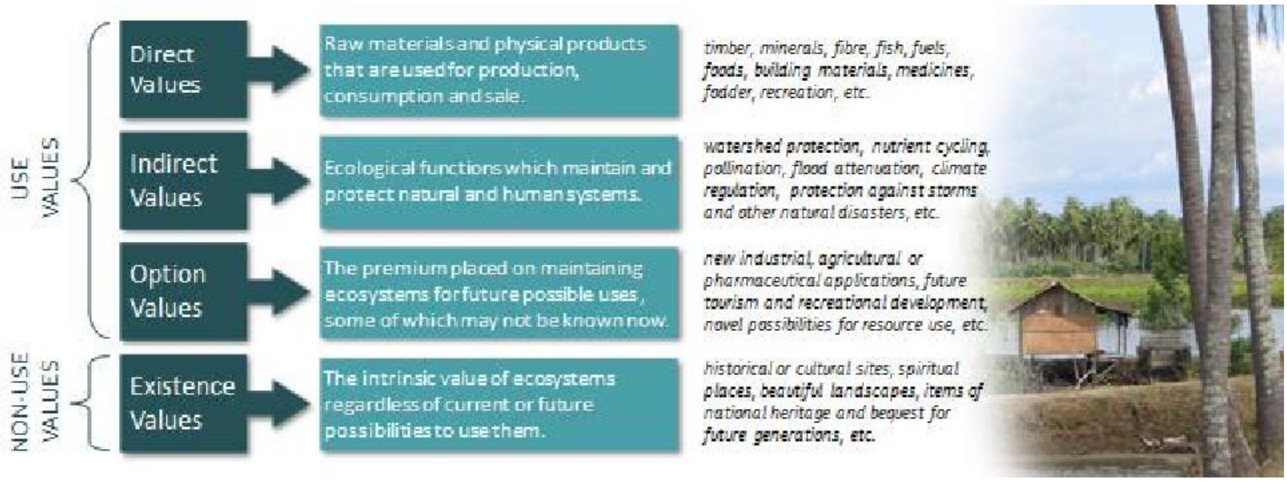
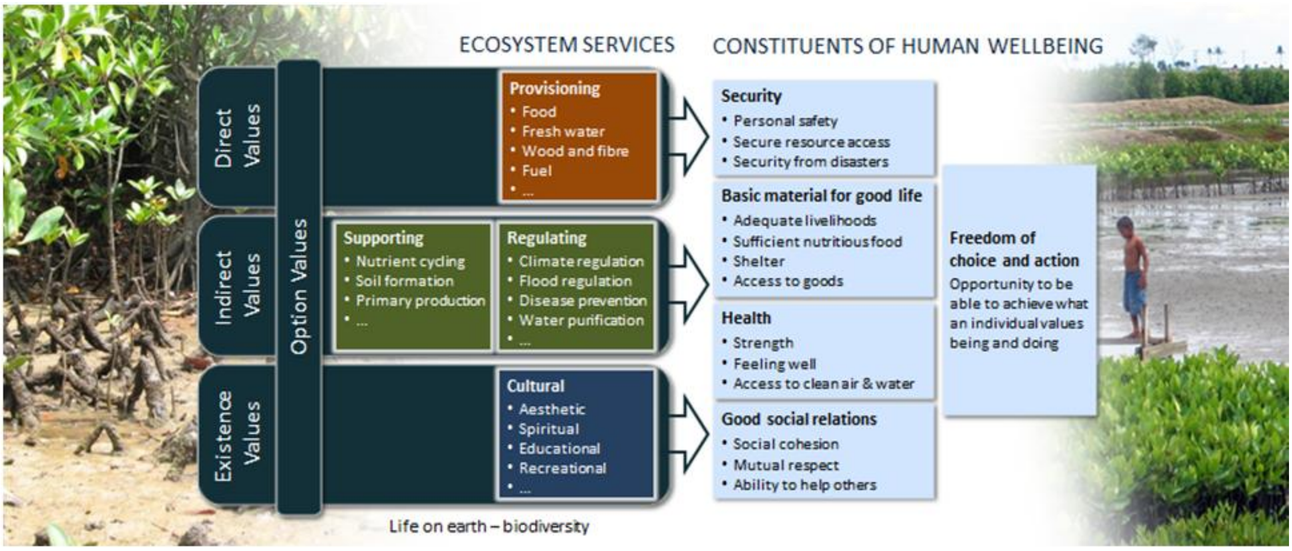


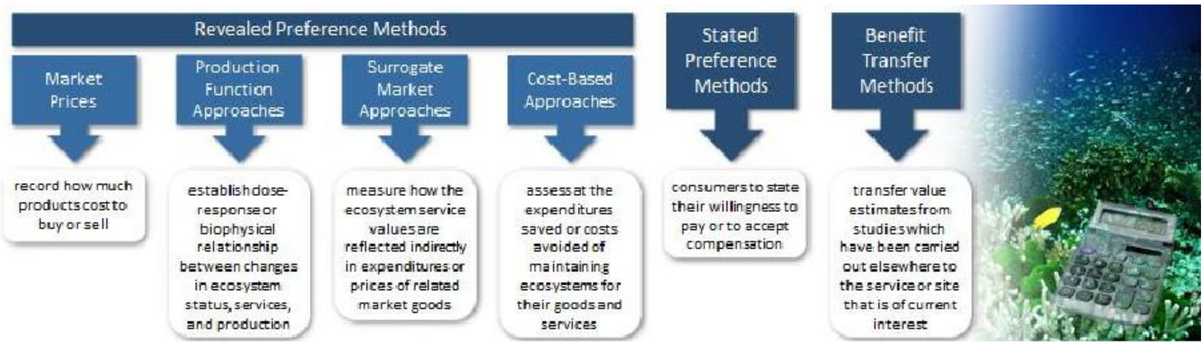
Figure 2: Total economic value and ecosystem service categories



The question of how to place a monetary value on ecosystem services has long posed something of a challenge to economists. The easiest and most straightforward way to value goods and services, and the method used conventionally, is to look at their market price: what they cost to buy or are worth to sell. However, as ecosystem services very often have no market price (or are subject to market prices which are highly distorted as regards their real value), these techniques obviously only have very limited application.

Parallel to the advances made in the definition and conceptualization of the economic value of ecosystem services, techniques for quantifying ecosystem values and expressing them in monetary terms have also moved forward over the twenty years or so. Today a suite of methods is available for valuing coastal ecosystem services that cannot be calculated accurately via the use of market prices (Figure 3). This ecosystem valuation toolbox is now commonly-accepted and widely-used in conservation and development planning (see, for example, van Beukering et al., 2007; UNEP-WCMC, 2011; Wattage, 2011). These methodological developments have enabled a wide range of formerly unvalued or undervalued coastal ecosystem goods and services to be expressed in monetary terms, and – in principle at least – incorporated into the calculations that are used to inform development decisions. A large volume of studies now exists on the economic value of coastal ecosystems, covering most major habitats and regions of the world.

Figure 3: Commonly-accepted ecosystem valuation methods



One significant advance has been the inclusion of subsistence-level values, long excluded from traditional economic analyses because they lie largely outside formal markets. Mangrove forests have, for example, been shown to sustain more than 70 direct human activities, ranging from fuelwood collection and medicinal products to artisanal fisheries (Dixon, 1989). Studies carried out in Southern Thailand indicate that they are worth around USD 1,500 a year to household income (Sathirathai, 1998), equivalent to almost a quarter of per capita GDP. In West Papua, mangrove goods and services are worth more than USD 3000/hectare/year, contributing up to half of income among the poorest households: more than the returns from either cultivated crops or wage earnings (Ruitenbeek, 1992). Around Wakatobi National Park in Indonesia, marine and coastal resources together account for around 60% of the annual net primary income: all residents name seafood as their main (and in many cases their only) source of protein, half or more had built their houses from natural materials, over 40% utilise mangroves for fuel and other purposes, and almost two thirds stated direct financial dependence on natural resources (Cullen, 2007). Local resource utilisation activities in Bunaken National Marine Park, including artisanal and commercial fisheries, seaweed production and gleaning, are worth more than two and a half times the average annual income of fishing households (USAID, 1996; Fauzi and Anna, 2005.

A better understanding of the economic value of ecosystem regulating and supporting services is of immense importance to resilience, adaptation and climate-compatible development. The protective functions of coastal ecosystems have received particular attention over recent years, in the wake of a series of major natural disasters and in relation to growing concerns about the effects of climate change. The storm protection services provided by mangroves in Sri Lanka were for example estimated at almost USD 8,000/km^2/year just before the 2004 Indian Ocean tsunami (Batagoda 2003), while studies carried out in the south of Viet Nam show net present values of USD 5,000/km^2 or more in guarding against extreme weather events (Tri et al., 1998). In Southern Thailand, mangrove coastline protection and stabilization services are thought to be worth up to USD 3000/ha/year (Sathirathai, 1998). In Indonesia, the value of coral reefs in protecting coastlines against the effects of storms, waves and tidal surges has been calculated to range between USD 829 and USD 1 million per kilometre (depending on the economic activities and settlement patterns in adjacent areas) in terms of costs and losses foregone (Cesar, 1996).

The value that well-managed natural ecosystems add to fisheries productivity and catch is also of clear relevance to coastal development decisions. For instance, on the Baluchistan coast of Pakistan, mangroves have been found to provide the nursery and breeding habitat upon which up to a half of off-shore commercial fish stocks depend, to a value of some USD 900/hectare (Adhikari et al., 2010). Each additional metre of coral coverage in Lampung Province, Indonesia is estimated to increase fish yields by 2kg/ year (Putra, 2001). Work carried out around Apo Island Reserve in the Philippines shows a sevenfold increase in the densities of large predatory reef fish after eleven years of protection through the establishment of Marine Protected Areas (Russ and Alcala, 1996), including a tenfold increase in catch per unit effort in the hook and line fishery (Maypa et al., 2002).

Integrating ecosystem values into CCD planning

The implication of the foregoing paragraphs is that, from an economic perspective, coastal ecosystems should be treated, counted and invested in as development infrastructure — as a stock of facilities, services and equipment which are needed for the economy and society to function properly. In order to ensure their productivity and continued support to human development, they need to be maintained and improved to meet both today’s needs and intensifying demands and pressures in the future — just like any other component of infrastructure (Emerton, 2006). In contrast, a failure to value ecosystems when choices are made about allocating land, resources and investment funds can incur far-reaching economic costs. It may ultimately undermine many of today’s efforts at sustainable and equitable development, integrated management, and long-term reconstruction and economic growth in coastal areas.

As yet there however remains a weak awareness among coastal decision-makers of the development returns that can be gained (and the economic costs that can be avoided) from investing in the rehabilitation, conservation and sustainable management of natural ecosystems. For the most part, the economic calculations that underpin coastal development decisions remain flawed, and fundamentally incomplete, because they continue to omit an important set of costs and benefits — those associated with ecosystem goods and services (Emerton, 2014). As a result, even though substantial amounts of public and private investment funds have been ploughed into establishing the built infrastructure that is required to stimulate and sustain economic development in coastal zones, much less attention has been paid to maintaining the natural capital base that underpins economic production and consumption, and which provides such critical services in relation to climate change adaptation.

Thus, even though ecosystem-based climate adaptation and green CCD options are gaining in popularity, they are largely yet to be mainstreamed into development decision-making as compared to conventional 'sector-based' and 'hard' adaptation measures (Renaud et al., 2013). One key reason for this is cited as being the lack of economic arguments and justification as to why investing in ecosystems is a cost-effective, economically equitable and sustainable option to secure development and climate adaptation benefits (UNEP, 2011a). Clearly there is a need to demonstrate and communicate the value of coastal ecosystem services to decision-makers, if better and more informed choices are to be made between different land, resource and investment options (Agardy et al., 2005; Brown et al., 2008; UNEP-WCMC, 2011).

The ecosystem valuation approaches and techniques referred to above provide a useful source of information for CCD planning, because they make it possible to articulate key costs and benefits that have traditionally remained absent from the economic calculations that are used to inform development decision-making. Ecosystem valuation offers a means of showing the economic opportunities, cost savings and avoided losses that are associated with green CCD options, in terms of the substantial climate and other development-related co-benefits that arise.

One particularly valuable set of insights concerns the ability to demonstrate that managing ecosystems for their services is frequently a far cheaper and more cost-effective option than employing artificial technologies or taking remedial or mitigative measures when these essential functions are lost. Every dollar invested in ecosystem-based mitigation in coastal communities is, for example, estimated to save the US taxpayer four dollars in losses from storm-surge effects and other natural hazards (MMC, 2005). In Vietnam, it was calculated that planting 12,000 hectares of mangroves cost $1.1 million but saved an estimated $7.3 million/year in dyke maintenance (Powell et al., 2010). In a Sri Lanka, long-term climate adaptation benefits and costs saved were found to be more than twice as high of the costs of rehabilitating and conserving coastal ecosystems (De Mel and Weerathunge, 2011). Another key making explicit the foregone benefits, or opportunity costs, that occur when ecosystems are converted, modified or replaced to make way for other land uses and economic activities.

The next section of the working paper describes how economic valuation was applied to address these issues in the iCoast project sites. It describes work carried out to assess the costs, benefits and trade-offs associated with investing in mangrove rehabilitation and conservation as a means of strengthening climate adaptation and resilience at the same time as generating other development co-benefits for coastal populations. The intention was to make the economic case for green CCD options by assessing the costs and losses that result from a failure to factor ecosystems into coastal development processes (in Sri Lanka) and articulating the gains and value-added from investing in ecosystem rehabilitation and conservation as a core component of coastal development (in Kenya).

3. Making the economic case for green CCD options: valuing coastal ecosystem services in Sri Lanka and Kenya

Counting the opportunity costs of mangrove conversion in Sri Lanka

Issues addressed by the economic analysis

The major focus of the iCoast project in Puttalam Lagoon was on identifying options and enabling mechanisms for applying the concept of CCD to shrimp farming. This was envisaged to include both the restoration of mangroves in areas containing abandoned farms, and the promotion of environmentally sustainable aquaculture practices among functioning and developing enterprises.

The reason for this focus was that aquaculture development has for some time now been accorded a particularly high priority in local and national development plans in Sri Lanka, and significant areas of shrimp farms have been established in Puttalam Lagoon over the last twenty years. This has had devastating impacts on the natural environment of the Lagoon, including the loss of a third or more of mangrove cover since the early 1990s (Bournazel et al*.,* in prep.). Meanwhile, many shrimp farms have performed poorly in financial terms, leading to their being abandoned after a relatively short time (Dahdouh-Guebaset et al*.,* 2002; Westers, 2012). All of these factors were considered by the iCoast project to pose potentially serious risks to development in the Puttalam Lagoon area, in terms of negative effects on local livelihoods and increased vulnerability to the impacts of climate change (Harkes et al*.,* in prep.).

This broader context is not described in detail in the current paper. The impacts of unsustainable shrimp farming on the ecological status and integrity of Puttalam Lagoon are well-documented elsewhere (see, for example, Dayaratne et al*.,* 1997; Dahdouh-Guebaset et al*.,* 2002; Munasinghe et al*.,* 2010; IUCN 2003b, 2012). Other iCoast documents assess the institutional, socio-economic and biophysical conditions pertaining to Puttalam Lagoon (see Nunan, 2012; Kumara and Jayatissa, 2013), analyse the dynamics and structure of the shrimp farming sector (Tejedor, 2013; Harkes et al*.,* in prep.; Kumara 2014), and propose options and scenarios for CCD (Harkes et al*.,* in prep.).

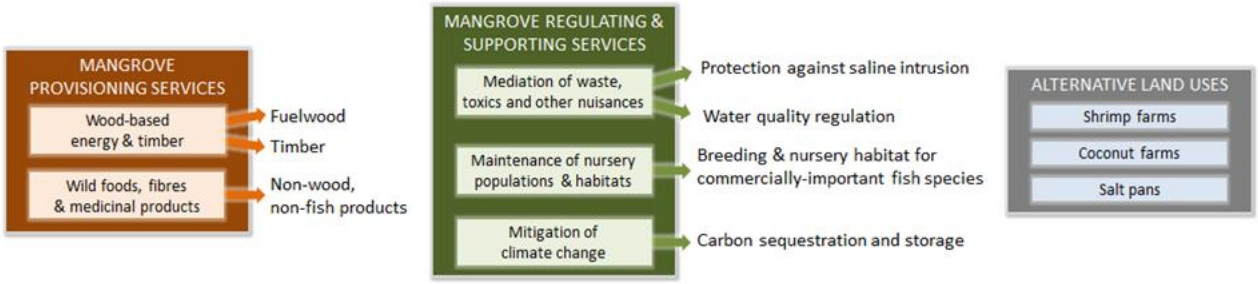
The economic analysis assessed the opportunity costs and trade-offs associated with different land use options in Puttalam Lagoon. It focused specifically on the economic gains and losses to coastal populations which have arisen from past patterns of mangroves conversion to shrimp farms and, to a lesser extent, coconut and salterns. It built on work carried out under the iCoast project on the changes in land use and carbon storage that occurred in Puttalam Lagoon between 1992/4 and 2012 (Bournazel et al., in prep.) and on the relative profitability of alternative uses of mangrove land (Kumara 2014).

Valuation scope and methods

Seven mangrove ecosystem services were identified as being of key economic importance in Puttalam Lagoon, and were selected for valuation: fuelwood, timber, non-wood/non-fish products, protection against saline intrusion, water quality regulation, mitigation of climate change and breeding and nursery habitat for fisheries[2] (Figure 4). Three alternative uses of mangrove land – shrimp farms, coconut farms and salterns – were also considered.

[2] It should be noted that two key mangrove ecosystem services that are typically important in other sites do not pertain (although have often been mistakenly attributed to Puttalam Lagoon in other studies): protection against shoreline erosion and extreme weather events. This is due to the fact that the sheltered lagoon/estuary system is not exposed directly to the sea, and mangroves are found only on inside the lagoon not on the coastline abutting the Indian Ocean.

Figure 4: Puttalam Lagoon: ecosystem services considered in the valuation study



A variety of methods were used to value ecosystem services, drawing on the toolbox of methods described above in Section 2 (Table 4).

Table 1: Puttalam Lagoon: ecosystem service valuation methods, indicators and data sources

Ecosystem service	Component	Valuation method	Indicator of value	Notes on data sources and calculations
Alternative uses of mangrove land	Shrimp farms, coconut farms, salterns	Market prices	Gross margins of enterprise	Establishment and running costs, yields and prices obtained from field interviews, District / GN statistics, literature review, project reports.
Wood-based energy & timber	Fuelwood	Market prices (benefit transfer)	Net value of harvest	Incidence and quantity of use, reliance on mangroves, average prices and costs obtained via benefit transfer from comparable Sri Lankan sites. Valued only for households living in GN Divisions which contain mangroves. Net values calculated (i.e. harvest and production costs deducted) Includes both licensed and unlicensed use.
	Timber			
Wild foods, fibres & medicinal products	Non-wood, non-fish products			
Mediation of waste, toxics and other nuisances	Protection against saline intrusion	Mitigative & avertive expenditure (benefit transfer)	Reduced expenditures on fresh water	Valued only for households that rely on surface water sources for domestic supplies, living in GN Divisions in which rivers enter the lagoon through mangrove areas. Benefit transfer from comparable Sri Lankan sites used to obtain mitigative and avertive expenditures of local purchase price of domestic water from alternative local sources
	Water quality regulation	Replacement cost (benefit transfer)	Saved costs of alternative technologies and infrastructure	Valued only for mangrove areas in GN Divisions located on the inner lagoon shoreline, through which major rivers discharge significant wastewater loads into the lagoon. Benefit transfer from comparable Sri Lankan sites used to obtain replacement cost installing and operating equivalent wastewater treatment facilities
Maintenance of nursery populations & habitat	Breeding and nursery habitat for commercially-important fish species	Effects on production (benefit transfer)	Contribution to lagoon, near shore and offshore capture fisheries (finfish and crustaceans) value	Catch composition, quantity, average prices and costs obtained from published records, statistics and reports for Puttalam District and Lagoon. Net values calculated (i.e. harvest and production costs deducted) Valued only for mangrove-dependent finfish and crustaceans species Benefit transfer from comparable Thailand site used to infer marginal losses in catch associated with reductions in mangrove area
Mitigation of climate change	Carbon sequestration and storage	Market prices	Value of carbon sales	Annual sequestration calculated based on work at site, covering above-ground, below-ground and sediment. Valued based on prevailing average voluntary forest carbon price in Asia

The iCoast project entailed only limited field data collection. Information was obtained on the returns to aquaculture, coconuts and salt production from Grama Niladhari[3] (GN), Divisional and District Secretariat

[3] Grama Niladhari Divisions are the lowest administrative unit in Sri Lanka. There are 70 GN Divisions in the three Divisional Secretariat Divisions (Kalpitiya, Puttalam and Vanathavilluwa) that surround Puttalam Lagoon.

offices as well as from interviews with local landholders (Tejedor, 2013; Kumara, 2014). A comprehensive analysis of land use and carbon storage was undertaken based on aerial and satellite images (Bournazel et al., in prep.). Aside from these two studies, no primary data were generated on the natural resource utilisation and harvests, or on the biophysical linkages between ecosystem status and the provision of non-carbon regulating and supporting services.

Calculations of the value of provisioning, regulating and supporting services other than shrimp, coconut and salt production and carbon sequestration/storage therefore draw on the considerable body of statistics, studies, project reports and other documents that are collected by government and have been generated for Puttalam Lagoon by past researchers and projects. Of necessity, the study relied heavily on benefit transfer techniques. A 'value function transfer' approach was used (see Brander, 2013), which took unit value estimates from other studies (expressed per hectare of mangrove or per user/beneficiary). A variety of adjustments were made to bring estimates to 2014 Sri Lanka price levels, including applying a consumer price index deflator and using appropriate Gross Domestic Product Purchasing Power Parity conversion rates. With just one exception, the source of benefit transfer data was valuation studies that had been carried out in the past in Puttalam Lagoon or other sites in Sri Lanka. The links between mangrove loss and fish productivity were estimated based on figures generated in southern Thailand, as no such data were available for Sri Lanka.

Interviews were carried out with local landholders and government officials to determine the returns to alternative uses of mangrove land (shrimp farms, coconut farms, salterns), supplemented with data collected from a variety of secondary sources (Kumara, 2014). Information was collected on yields, prices and costs of production. The costs of clearing mangroves were factored into enterprise establishment costs. Data were also collected on the costs of rehabilitating and restoring mangroves on former shrimp farms, coconut farms and salterns.

Market and surrogate market price techniques were used to calculate the value of wood-based energy & timber and wild foods, fibres & medicinal products. The proportion of households collecting mangrove wood products was obtained from a recent study carried out in Kalpitiya (Ratnayake, 2010), while the percentage harvesting non-wood/non-fish products was obtained from estimates generated in Hambantota District (Ranasinghe and Kallesoe, 2006). Calculations took account only of households living in GN Divisions which contain mangroves (calculated from population data provided by Puttalam District Census and Statistics Division and sourced from DCS, 2001, 2012a,b, and administrative and land cover maps provided in Weragodatenna, 2010). Estimates from past studies carried out in Puttalam Lagoon and other mangrove areas of Sri Lanka were used to obtain per household average utilisation values (Batagoda, 2003; IUCN. 2003a, 2006, Ranasinghe and Kallesoe, 2006).

Mitigative and avertive expenditures techniques were used to calculate the value of mangroves for protection against saline intrusion. Calculations took account only of households that use surface water sources for their domestic supplies, living in GN Divisions in which rivers enter the lagoon through mangrove areas (calculated from population data provided by Puttalam District Census and Statistics Divsion and sourced from DCS, 2001, 2012a,b, and administrative, hydrological and land cover maps provided in Weragodatenna, 2010). Estimates from past studies carried out in Puttalam Lagoon were used to calculate the local purchase price of obtaining water for household consumption from alternative sources (IUCN, 2003a).

Replacement cost techniques were used to calculate the value of mangroves for water quality regulation Calculations took account only of mangrove areas in GN Divisions located on the 'inner' lagoon shoreline, through which major rivers discharge significant wastewater loads into the lagoon (calculated from administrative, hydrological and land cover maps provided in Weragodatenna, 2010). Estimates from past studies carried out in Puttalam Lagoon and other mangrove areas of Sri Lanka were used to calculate the cost of installing and operating wastewater treatment facilities which would bring the quality of water being discharged into the lagoon to an acceptable level (Emerton and Kekulandala, 2002; IUCN, 2003a).

Effect on production techniques were used to calculate the value of mangroves for maintenance of nursery populations & habitat for commercially-important fish species. Values were calculated only for that portion of catch comprised of mangrove-dependent species of finfish and crustaceans, taking account of fisheries in both the Lagoon and adjacent nearshore/off-shore areas. Historical data on fisheries catch were obtained from a variety of published records, statistics and reports for Puttalam District (MOFARD, 2013) and Puttalam Lagoon (Jayasuriya, 1985; Alwis and Dayaratne, 1992; Dayaratne et al*.,* 1997; IUCN, 2003b, 2012). Catch composition figures (from MOFARD, 2013) were used to identify mangrove-dependent species (as listed in Rönnbäck 1999). Historical data on fish prices at Puttalam Lagoon landing sites were obtained from records provided by the Statistics Unit of Ministry of Fisheries and Aquatic Resources. The costs of operating fishing enterprises were obtained from a variety of past studies carried out in Puttalam Lagoon and other mangrove areas of Sri Lanka (Murray and Little, 2000; IUCN, 2003a, b; Gunawardena and Rowan, 2005; de Croos, 2007).

It is worth emphasising that considerable caution must be exercised when attributing fisheries productivity to the existence of mangroves (see Saenger et al*.,* 2013). Many of the valuation studies which have been carried out in Sri Lanka and elsewhere incorrectly assume that the entire value of inshore and offshore fisheries can be attributed to the existence of mangroves. Unfortunately, even though the dependency of both Lagoon and nearshore/offshore fisheries on mangroves is well-documented for Puttalam, no numerical data exist on the marginal losses in catch that are associated with reductions in mangrove quality and area. Benefit transfer techniques were therefore applied to come up with very approximate estimates, based on figures generated in southern Thailand for similar ecological, socio-economic, fisheries management, access and demand elasticity conditions (Sathirathai, 1998).

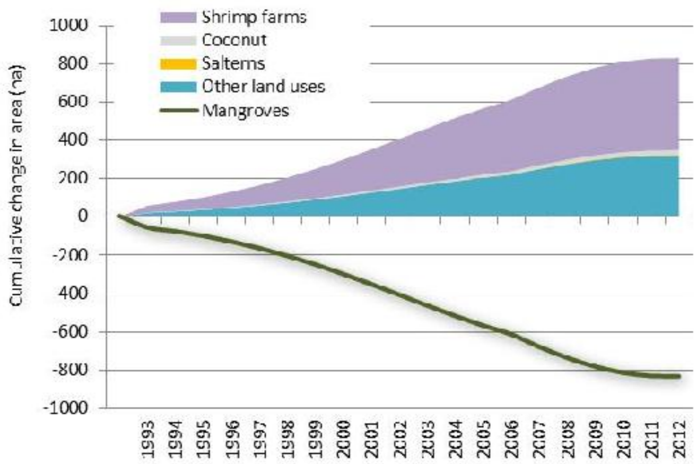
Market price techniques were used to calculate the value of mangrove carbon storage and sequestration services. Data on changes in land use and carbon dynamics in mangrove forests, coconut plantations, salterns and shrimp farms in Puttalam Lagoon relied wholly on information presented in Bournazel et al., in prep. Total gains and losses over the period 1992/4 to 2012 were expressed as average annual figures, assuming a non-linear trajectory of land use shifts and carbon stock changes (see below). Carbon sequestered in mangrove areas which remained unconverted was not included in the calculations, as the analysis was concerned with the effects of land use change. Carbon was valued according to the prevailing average voluntary forest carbon price for Asia (from Peters-Stanley and Yin, 2013).

Ecosystem change

As described above, the focus of the analysis was on valuing the economic impacts of the land use changes which took place in Puttalam Lagoon between 1992/4 and 2012. It looked only at mangrove-related land use change over the 20-year period of analysis: in other words, it considered just those areas of mangroves which were converted to other uses and the areas under other land uses which were returned to mangroves. This comprises a sub-set of the data presented in Bournazel et al., in prep., which also incorporates land use changes that do not involve mangrove conversion or restoration.

Over the 20 year period of analysis, Puttalam Lagoon saw a net loss of almost 763 hectares of mangroves, most of which was converted to shrimp farms and other land uses such as settlements, buildings and infrastructure (Figure 5). Loss of mangroves to shrimp farms increased progressively over the period 1992/4 to 2007, and then slowed down somewhat between 2007-2012. To reflect the variation in the rate of land conversion, a non-linear trajectory of land use change was assumed in the valuation study.

Figure 5: Puttalam Lagoon: land use change in mangrove areas 1992/4-2012



	1992/4-2006	2007-2012	1992/4-2012
Hectares of mangroves lost to:			
Shrimp farms	374.67	64.14	484.15
Coconut farms	15.57	0.48	24.93
Salterns	2.28	1.71	5.24
Other land uses	221.34	102.84	324.18
Hectares of mangroves gained from:			
Shrimp farms	0.29	1.02	1.31
Coconut farms	0.96	1.38	2.34
Salterns	0.52	0.00	0.52
Net change in land area (ha):			
Mangroves	-612.09	-166.77	-834.33
Shrimp farms	374.38	63.12	482.84
Coconut farms	14.61	-0.90	22.59
Salterns	1.76	1.71	4.72

Source: Bournazel et al., in prep. Note: land use change figures for the period 1992/4-2012 are not a simple sum of those between 1992/4-2006 and 2007-2012, because land use change calculations also takes into account areas that changed between 1992/4-2007 and then stayed unchanged until 2012 (for example: if a mangrove areas was converted to shrimp farm between 1992/4-2007, and then remained shrimp farm between 2007-2012, it was counted as an area which changed from mangroves to shrimp farm in the 1992/4-2012 total).

Unlike most of the mangrove valuation studies that have been carried out to date in Sri Lanka, the economic analysis was not concerned with the absolute or total economic value of production in Puttalam Lagoon, but rather with the incremental benefits and costs of land use change in mangrove areas. It compared the additional income generated by the conversion of mangroves to other land uses with the costs arising from the loss of mangrove ecosystem service values. It was thus the marginal change which was of interest: the figures presented below refer to the gain or loss in economic value as compared to that which would have been available had the area under mangroves remained at 1992/4 levels.

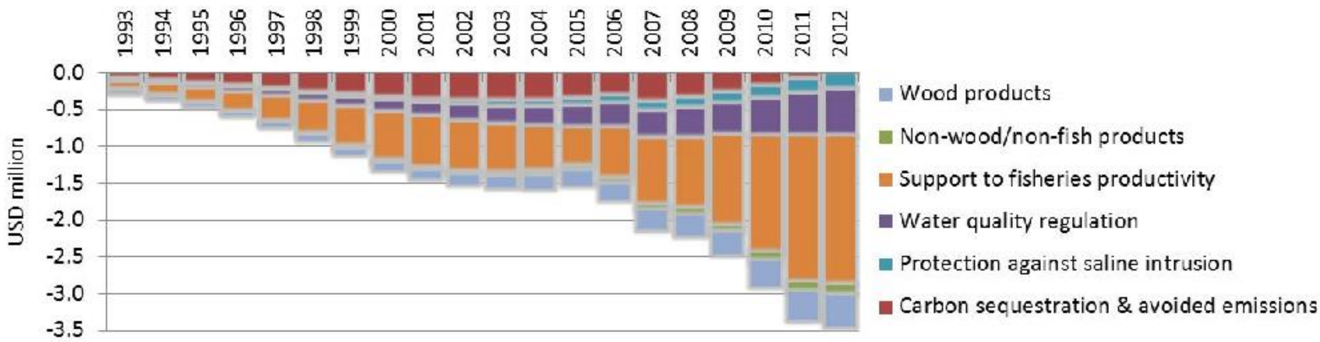
It was necessary for the analysis to account for the considerable socio-economic changes which have occurred in Puttalam Lagoon between 1992/4 and 2012 (these are well-documented in the literature: see, for example, IUCN, 2012; Kumara and Jayatissa, 2013). The unit value of ecosystem services did not remain constant in real terms over the study period. Shifts over time in production and demand, changes in relative scarcity and abundance, and varying human dependency on mangroves as a source of goods and services all affect the real value of ecosystem services. For example while harvesting pressures on wood and non-wood/non-fish products was assumed to increase as population grew and mangrove areas declined, the period also saw a diminishing dependence on wood-based sources of domestic energy among the local population. The steady growth in capture fisheries is reflected in an increase in the (realised) per unit area value of mangroves for the maintenance of nursery populations and habitat for commercially-important fish species. Worsening pollution loads registered in rivers and streams entering Puttalam Lagoon, combined with the increasing water demands associated population growth, urbanisation and industrialisation, all suggest an increase in unit values for protection against saline intrusion and water quality regulation services over the study period.

Certain limitations and caveats should also be mentioned in relation to the economic analysis, mainly relating to the lack of biophysical information on the links between changes in land use, ecosystem status and the provision of key ecosystem services (other than production from shrimp farms, coconut and salterns, and the carbon storage calculations presented in Bournazel et al., in prep.). As interesting (and hopefully useful) as the aggregate numbers generated may be, it should be borne in mind that they inevitably mask some important elements of ecosystem service values, and over-simplify the complex dynamics and relationships at play when looking at the impacts of ecosystem change on ecosystem service provision and economic values. Of particular concern is the lack of information on the sustainability of ecosystem management and resource use. Another important issue is that calculations do not account for non-linearity and threshold effects in ecosystem functioning.

Findings on the economic value of mangrove ecosystem services

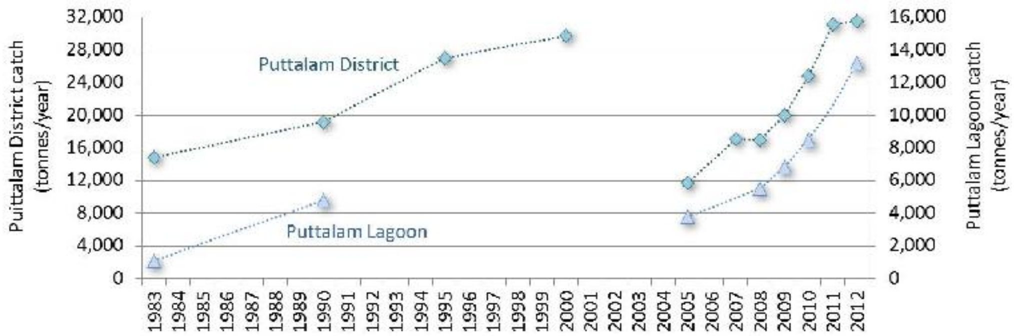
Land use change in Puttalam Lagoon between 1992/4 and 2012 resulted in a steady decline in the value of ecosystem services (Figure 6). As more and more mangroves were converted to other land uses, an increasing loss was incurred as compared to the ecosystem values that which would have been available had the area under mangroves remained at 1992/4 levels.

Figure 6: Puttalam Lagoon: change in mangrove ecosystem service values 1993-2012



For most ecosystem services, values show a steadily increasing rate of loss over time, as the cumulative area of mangroves cleared increases. There are two exceptions to this: carbon (accounted for by the varying rate and nature of land use conversion patterns, and hence carbon gains/losses, between 1992/4-2007 and 2007-12), and fisheries. The marked fluctuation in mangrove ecosystem service value between 2004 and 2006 and then slowed rate of decline between 2006-2008 can be attributed mainly to a the sharp drop and then slow recovery of fish catch that is registered in fisheries statistics over that period, and which can be attributed to the impacts of the 2004 Indian Ocean tsunami (Figure 7).

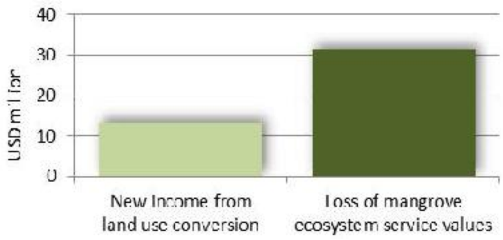
Figure 7: Puttalam Lagoon: annual fish catch 1993-2012



Based Jayasuriya, 1985; Alwis and Dayaratne, 1992; Dayaratne et al., 1997; IUCN, 2003b, 2012; MOFARD, 2013.

The economic analysis shows that, in total, mangrove ecosystem services worth USD 31.54 million were lost between 1993 and 2012 as a result of land use change, with a net present value (NPV) of USD 9.61 million (Table 2). This figure is around two and a half times as much as the income generated from converted mangrove land: shrimp farms, coconut and salterns together earned income worth some USD 13.46 million (with a NPV of USD 3.78 million) over the same period. Putting these figures together shows that mangrove conversion incurred economic losses of USD 18.07 million, even taking account of the value of production from new land uses: a net present cost of USD 5.84 million.

Table 2: Puttalam Lagoon: financial and economic impacts of land use change 1993-2012



	Total (USD mill)	NPV (USD mill)
Shrimp farms	13.29	3.77
Coconut	0.04	0.01
Salterns	0.13	0.00
New income from land conversion	13.46	3.78
Loss of mangrove ecosystem service values	-31.54	-9.61
Net economic gain/loss from land use change	-18.07	-5.84

A comparison of the returns to alternative land uses in mangrove areas shows that, at full production value[4], shrimp farming is by far the most profitable enterprise of those considered (Table 3). While both coconut farming and salterns generate considerably less value on a per hectare basis than mangrove ecosystem services, it is worth noting that the direct cash income generated for the landholder is far higher. The bulk of mangrove ecosystem service values accrue as indirect support to other production, as non-cash benefits, or to beneficiaries other than the landholder.

Table 3: Puttalam Lagoon: comparison of the returns to alternative land uses in mangrove areas

	Full production value (USD /ha)	NPV over 20 years (USD /ha)
Wood products	503	1,851
Non-wood/non-fish products	166	20,610
Support to fisheries productivity	2,421	4,281
Water quality regulation	762	1,413
Protection against saline intrusion	263	2,240
Carbon sequestration & avoided emissions	217	6,489
Total mangroves	3,830 - 4,115*	32,603 - 35,033*
Shrimp farms	5,846	20,120
Coconut	2,825	10,866
Salterns	1,911	12,440

** a range of value is given, as ecosystem service values are not additive. Some are mutually exclusive: for example extraction of wood products and carbon sequestration / avoided emissions.*

In the light of these figures, it is hardly surprising that shrimp farms accounted for the majority of mangrove conversion between 1992/4 to 2012. It remained more immediately profitable, in cash terms, to engage in alternative land uses than to maintain mangroves. Looking at longer-term economic returns and the sustainability of earnings however gives a slightly different picture. If the full 20-year period is considered, mangrove ecosystem services generate the highest net present value. This is because shrimp farm productivity, and income, can rarely be sustained beyond 5-10 years (Munasinghe, 2010; Westers, 2012; Tejedor, 2013).

[4] In other words when operating at peak output levels: once the enterprise has been established and, in the case of shrimp farms, before productivity starts to taper off.

Issues addressed by the economic analysis

On the south Kenya coast (comprising the four sites of Funzi, Gazi, Mwache and Vanga), the iCoast project focused on the role of mangrove ecosystems in enhancing resilience and reducing vulnerability to climate change, including both climate adaptation and mitigation benefits. It aimed to investigate how the conservation and sustainable management of mangroves could contribute towards CCD.

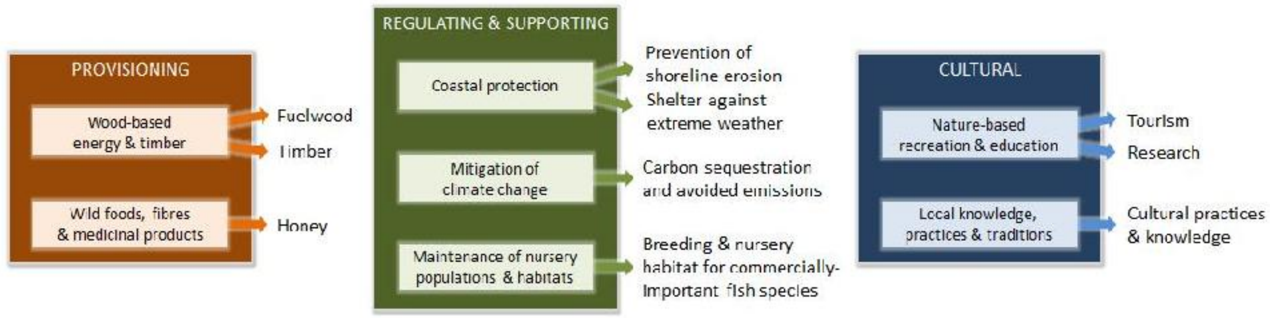
Local stakeholders were engaged in developing two plausible storyline scenarios for business as usual (BAU) and climate-compatible development (CCD) over the next 20 years. A detailed description of these scenarios, including the process by which they were developed, can be found in other iCoast documents (see Huxham et al, in prep.). In brief, BAU was assumed to entail gradual loss of mangrove coverage and degradation of remaining forests, loss of fisheries resources, increasing coastal vulnerability and increasing poverty, while CCD emphasised ecosystem conservation and sustainable management, resulting in healthy mangroves supporting improved local livelihoods and enhanced resilience.

The economic analysis articulated the economic consequences of BAU and CCD for coastal development on the south Kenya Coast. It focused on comparing the changes in mangrove ecosystem service values that would result under each of these two alternative scenarios, aiming to assess the economic gains and costs avoided that might be associated with investing in ecosystem rehabilitation and conservation as a core component of future strategies for climate-compatible development in the coastal zone. It built on the work of Huxham et al, in prep., which documented mangrove cover, carbon storage and ecosystem service provision on the south Kenya coast and modelled the biophysical and socio-economic changes that were projected to occur over the next 20 years under BAU and CCD scenarios.

Valuation scope and methods

Ten main ecosystem services were identified as being of key economic importance on the south Kenya coast, and were selected for valuation: honey, fuelwood, timber, protection against shoreline erosion, protection against extreme weather, mitigation of climate change, breeding and nursery habitat for fisheries, tourism, research, cultural practices and knowledge (Figure 8).

Figure 8: South Kenya coast: ecosystem services considered in the valuation study



A variety of methods were used to value these ecosystem services, drawing on the same toolbox of methods as was applied in the Sri Lanka case study, and is described above in Section 2 (Table 4). Data sources and valuation techniques are described elsewhere in detail in (see Huxham, 2013; Huxham et al, in prep.), and summarised in the bullet points below.

Table 4: South Kenya coast: ecosystem service valuation methods, indicators and data sources

Ecosystem service	Component	Valuation method	Indicator of value	Data source and calculations
Wild foods, fibres & medicinal products	Honey	Market prices	Net value of harvest	Incidence and quantity of use, reliance on mangroves, average prices and costs obtained from household surveys and interviews with licensed harvesters and secondary sources. Net values calculated (i.e. harvest and production costs deducted) Includes both licensed and unlicensed use.
Wood-based energy & timber	Fuelwood			
	Timber			
Coastal protection	Prevention of shoreline erosion	Mitigative & avertive expenditures, replacement costs (benefit transfer)	Saved costs of alternative technologies and infrastructure	Mangrove areas and shoreline retreat measured using satellite imagery. Benefit transfer used to obtain mitigative and avertive expenditures of establishing and maintaining coastal defence structures to guard against erosion (from De Mel and Weerathunge 2011, Emerton 2012), applied to mangrove-protected coastline.
	Shelter against extreme weather effects			Mangrove areas measured using satellite imagery. Local costs of seawall storm protection applied only to mangrove-protected coastline with settlements
Mitigation of climate change	Carbon sequestration and avoided emissions	Market prices	Value of carbon sales	Annual sequestration calculated based on work at site, covering above-ground, below-ground and sediment. Voluntary carbon project costs and revenues based on *Mikoko Pamoja* project records
Maintenance of nursery populations & habitat	Breeding and nursery habitat for commercially-important fish species	Effects on production	Contribution to nearshore and offshore capture fisheries (finfish and crustaceans) value	Catch composition, quantity, average prices and costs obtained from household surveys, interviews with fishers, and catch records. Net values calculated (i.e. harvest and production costs deducted) Species classified according to mangrove dependence
Nature-based recreation & education	Tourism	Market prices	Revenues generated	Figures for actual spending on tourism and research at Gazi collected and applied to other sites.
	Research			
Local knowledge, practices & traditions	Cultural practices & knowledge			Applied to Gazi only. Actual income earned from ritual consultation at *Kaya* forest area.

Information on the incidence of household utilisation of mangroves, product quantities harvested and prices was gathered via 645 household questionnaires, 10 focus groups and 74 interviews (see Huxham, 2013). These data formed the basis for calculating the value of local fuelwood, timber and honey utilisation. Net values were estimated: wherever possible, harvest and production costs were deducted from estimates of earnings. Both licensed and unlicensed production were included in the calculations, although it should be noted that for the latter, estimates remain approximate due to the absence of reliable records and survey respondents' reluctance to talk about what are essentially illegal resource uses.

Mitigative and avertive expenditure techniques were used to calculate the value of mangroves for prevention of shoreline erosion. First, average rates of shoreline retreat over the past 11 years were calculated along a beach to the south of Gazi village which has been denuded of mangroves, using satellite imagery. This provided an estimate of rates of shoreline loss after mangrove removal which was also applied to the other sites (see Huxham, 2013). The length of mangrove-protected shorelines at each of the four sites was measured from aerial and satellite images. The value of erosion control along mangrove-protected shorelines was calculated by applying estimates of costs of the establishing and maintaining coastal defence structures such as groynes, breakwaters, revetments and sand replenishment that would be required to restore eroded coastal areas and continue to protect them in the future to an equivalent level should well-functioning mangroves have been in place. These were taken from a recent study carried out at a site in Sri Lanka which displays similar biophysical, ecological and socio-economic conditions to the south Kenya coast (De Mel and Weerathunge, 2010; Emerton, 2013). The resulting annualised figure of USD 20.81/metre/year (converted to 2014 Kenya purchasing power parity price levels) was applied to the length of mangrove protected coastline at each site.

Replacement costs techniques were used to calculate the value of mangroves for shelter against extreme weather effects. The cost of building and maintaining seawalls for storm and wave protection was calculated, using data from the Vanga site (UNEP, 2011b). The resulting annualised figure of USD 52.16/metre/year was applied only to settled areas of the mangrove-protected coastline, identified using satellite imagery to include areas that were situated behind mangrove stands of at least 100m thickness in which housing or buildings were located within 300m of the coastline.

Market price techniques were used to calculate the value of mangrove carbon storage and sequestration services. Sequestration rates were estimated using data generated at the site (Njoroge, 2013), combined with measurements that had earlier been made by the *Mikoko Pamoja* project (a recently validated community-based mangrove conservation programme in Gazi Bay which is funded by carbon credits). These encompassed the above and below ground carbon sequestered by the new growth of branches, trunks and roots, as well as carbon sequestered in and on the sediment, through root exudates, autochthonous production and the trapping of sediments and organic material from outside the forest. This yielded total average sequestration figures of 6.85 tC/ha/year. Estimates of avoided emissions were made based on recent experimental work using small-scale forest cutting, which show rates of carbon losses of 4.85 tC/ha/year from sediment following forest removal (Langat et al., 2013). A value of USD 10/tCO_2 was applied, taken from the actual price received by the *Mikoko Pamoja* project. The costs of establishing and operating a forest carbon scheme were subtracted from these gross income figures.

Effect on production techniques were used to calculate the value of mangroves for breeding and nursery habitat for commercially-important fish species. A species or group was classified as 'mangrove dependent' if it had been recorded as a juvenile in mangrove habitat at the iCoast sites, This drew on a large volume of studies that had been carried out to assess catch composition and mangrove-dependent species on the south Kenyan coast (see, for example, Huxham et al., 2004, 2007; Rönnbäck et al., 2007). An average of 39% of the value of offshore catch was found to be composed of mangrove-dependent species, while all of the mangrove fishery was assumed to be mangrove-dependent. Data on fish catch (including both weight and species) were based on Department of Fisheries records and interviews with local fishers. Net values for mangrove-dependent fisheries production were calculated after removing annual costs, using information obtained in interviews with fishers at the landing sites on costs of salaries, licences, fuel, gear and boat maintenance and replacement.

Market prices were used to calculate the value of mangroves for tourism, research and cultural practices and knowledge. These extrapolated the income earned from tourism revenues and research grants at Gazi (as recorded in UNEP, 2011b) to the other three study sites. The income earned by a traditional ritual specialist operating at a mangrove shrine in Gazi was used as a very partial indicator of the market values associated with cultural practices and knowledge.

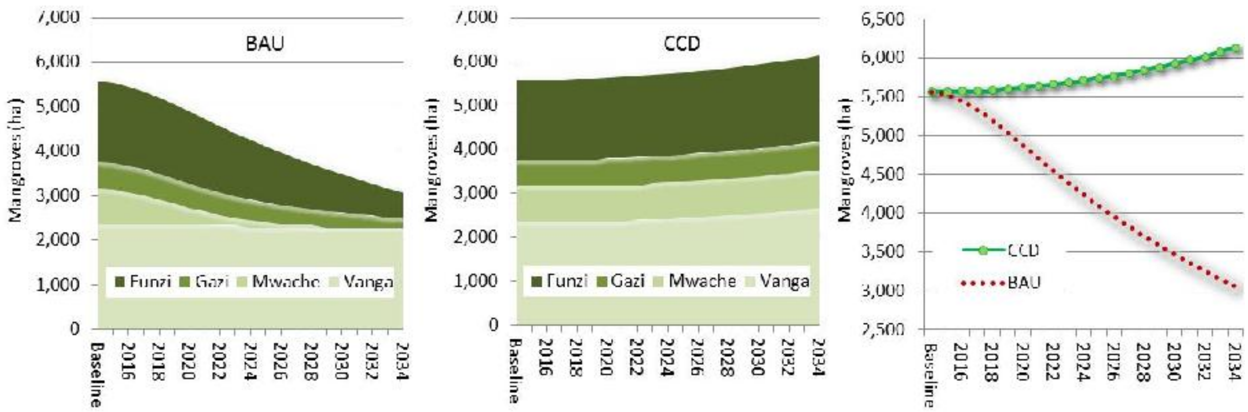
Ecosystem change

As described above, the focus of the analysis was on assessing the value-added and costs avoided of investing in an ecosystem-based approach to climate-compatible development, as compared to a business as usual situation where mangroves continue to be degraded and lost. This meant that coming up with a single, 'snapshot' estimate of ecosystem values was of little meaning. It was not a case of trying to show that 'mangroves on the south Kenya coast are worth *x* amount', but rather 'undertaking an ecosystem-based approach to CCD would add this much additional value (or incur this much additional cost) as compared to a continuation of BAU'. This makes the current analysis slightly different from most of the valuation studies that have been carried out on the Kenyan coast to date (as was also noted above for Sri Lanka), which have tended to focus on generating static estimates of the what the value of ecosystem services is in absolute terms at a particular place and time.

To do this, the study first assessed the baseline situation: it identified the services that are currently being generated by mangroves on the south Kenya coast, and estimated their economic value. It then modelled the two possible development scenarios of BAU and CCD over the next 20 years. The difference between the baseline value and BAU represents the loss in economic value that was projected to occur should mangroves continue to be degraded and lost (the cost of policy and management inaction as regards integrating ecosystem conservation into coastal development strategies), while the difference between the baseline value and CCD represents the gain (the benefit of adopting an ecosystem-based approach to CCD). Together, these figures show the value added by CCD as compared to BAU or, conversely, the costs incurred by BAU as compared to CCD.

Under the baseline, there are currently just over 5,500 hectares of mangroves in the study sites of Mwache, Gazi, Funzi and Vanga, and around 22,000 people or 4,500 households live in the villages adjacent to the mangroves. A quantitative risk mapping was undertaken by the iCoast project, projecting recent land use trends over the next twenty years. This suggested a 43% loss of forest cover over that time (with 100% loss at the most vulnerable sites) under BAU; under the CCD scenario, forest coverage is assumed to expands by 8%, 7%, 9% and 13% respectively in Funzi, Gazi, Mwache and Vanga (Figure 9; see Huxham *et al*., in prep. for a detailed description of how these projections were made). As in the Sri Lanka case study, a non-linear trajectory of land use change was assumed in the valuation study to allow for variation in the rate of mangrove loss over time.

Figure 9: South Kenya coast: changes in mangrove area under BAU and CCD



Source: Huxham et al., in prep.

Various projections were made about the changes in other key socioeconomic and biophysical parameters that might take place under BAU and CCD scenarios. Stakeholder and expert consultation, as well as a review of relevant literature, informed these assumptions (see Huxham et al, in prep. for further details). Under both scenarios, population growth was assumed to follow the projections provided in the 2090 Census (KNBS, 2010), which show an annual growth rate for Coast Province of 3.05%. Although there are grounds to suppose that the real price of mangrove products and services may change over the next twenty years (for example due to changes in demand, availability and consumer preferences as well as shifts in relative dependence on mangroves as contrasted to alternative sources and products), insufficient information exists to predict with any accuracy what these trends will be. For this reason, real prices were assumed to remain stable in both scenarios, but adjustments were made to account for changes in the coverage and quality of mangrove ecosystems (see below).

For provisioning services, average harvest or consumption rates per user were also assumed to remain stable, as there are no convincing grounds to suppose otherwise. The percentage of the local population which utilise mangrove wood products (i.e. depend on mangroves to source key goods and services) was however projected to decline under both BAU and CCD scenarios. This reflects a continuation of the changes that are currently ongoing in the lifestyles, aspirations and demands of both coastal dwellers and the Kenyan population more generally (e.g. a shift away from reliance on woodfuel, moves towards brick-based construction, etc.). It should however be noted that these effects are counterbalanced somewhat by the increase in population size (in other words, although the percentage of households sourcing products from mangroves is assumed to decline, the absolute number of households living in the four study sites will increase). No change was assumed in the percentage of households consuming or trading fish.

Two indices were applied to ecosystem values, so as to ensure that changes in mangrove cover and quality were reflected in the calculations. A 'product availability index' was applied to provisioning services; this accounts for the change in product supply or yield that will occur as mangrove area and quality decline (under BAU) or increase (under CCD). This was used to estimate changes in the percentage of a given physical product that is obtained from mangroves (as compared to other sources of, say, firewood or building poles). For regulating and cultural services, a 'quality of ecosystem service index' was applied to the value of the ecosystem service per unit area. Indices were calculated based on the year-on-year change in area, multiplied by a factor that is determined by the baseline forest status and quality at each site and its assumed decline (under BAU) or improvement (under CCD) over time.

As was described above for Sri Lanka, the assumptions made in the scenario modelling are in many cases highly speculative. Gaps in (especially biophysical) information mean that considerable uncertainty remains about current sustainability of mangrove management and utilisation, ecosystem status, service provision, and how the relationships between changes in mangrove status and ecosystem service provision will play out in the future. For these reasons, it should be emphasised that the results of the valuation study should be understood to be partial, approximate estimates which have been generated for indicative and planning purposes. As better and more accurate biophysical and socioeconomic data become available in the future it can be hoped that these values estimates can be revised, updated and improved.

Findings on the economic value of mangrove ecosystem services

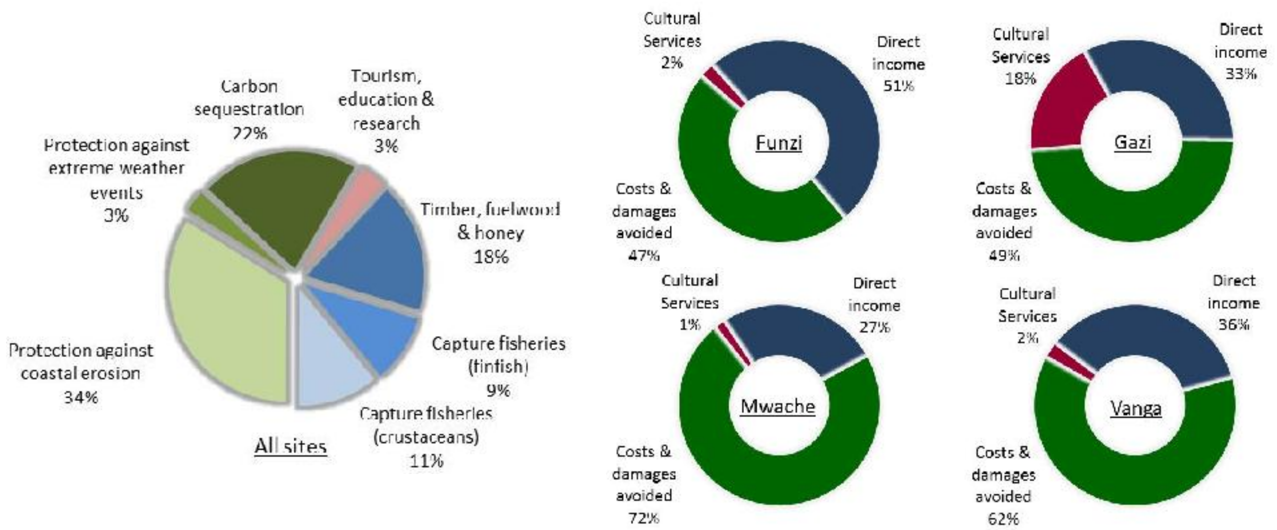
Baseline calculations suggest that the ecosystem services generated by mangroves on the south Kenya coast are currently worth just under USD 6.5 million in total or some USD 1,166/ha/year (Table 5). There is some variation between sites, reflecting both mangrove coverage and quality, as well as socioeconomic characteristics of the area and dynamics of ecosystem use and service provision. Although the total value of mangrove ecosystem services is considerably higher for Vanga and Funzi, where much larger areas of mangroves can be found, the overall value of mangrove ecosystem services is highest at Mwache, which contains a relatively small area of mangroves. This is largely due to the high value of the mangrove-dependent shrimp and crab fishery and the vulnerability of the area to coastal erosion.

Table 5: South Kenya coast: baseline economic value of mangrove ecosystem services

		Funzi	Gazi	Mwache	Vanga	All sites (USD)	Average value per ha
Provisioning Services	Timber, fuelwood & honey	761,179	49,801	47,757	289,378	1,148,115	206
	Capture fisheries (finfish)	186,956	123,378	44,796	253,826	608,956	109
	Capture fisheries (crustaceans)	82,525	55,466	267,664	310,541	716,196	129
Regulating Services	Protection against coastal erosion	496,234	195,161	677,335	827,770	2,196,500	395
	Protection against extreme weather events	63,175	40,045	73,561	15,725	192,506	35
	Carbon sequestration	409,897	100,115	231,159	656,126	1,397,297	251
Cultural Services	Tourism, education & research	37,970	124,512	16,903	49,183	228,568	41
Area of mangroves (ha)		1,815	592	808	2,351	5,566	
Total value (USD)		2,037,936	688,478	1,359,177	2,402,549	6,488,139	
Average value per ha		1,123	1,163	1,682	1,022	1,166	

Values are dominated by the costs and damages avoided that are associated with mangrove coastal protection services (Figure 10). These account for around a half or more of total value in all four sites. Direct income (from wood, non-wood products and fisheries) comprises just under a third of value, overall, and is particularly important in Vanga (mainly due to the relatively high value of forest products harvested there). It should be noted that the relatively small contribution of cultural services to the total reflects the partial coverage of the current study and its inability to generate estimates of these values, rather than the low importance of mangroves on the south Kenya coast in terms of cultural significance and value.

Figure 10: South Kenya coast: contribution of mangrove ecosystem services to baseline economic value



Running the economic scenario model shows that BAU will result in a progressive decline in mangrove values over the next 20 years, while CCD will see a sustained increase in ecosystem benefits over time (Figure 11). The rate of increase in value under CCD will initially be slow, as measures to achieve CCD are set in place; it will then rise as these measures take effect, before slowing again as mangroves are restored to a healthy functioning state and area. The NPV of mangrove services to 2034 under the BAU scenario is USD 42.85 million; under CCD it is USD 61.01 million (Table 6).

Figure 11: South Kenya coast: change in mangrove ecosystem service values under BAU and CCD 2014-34

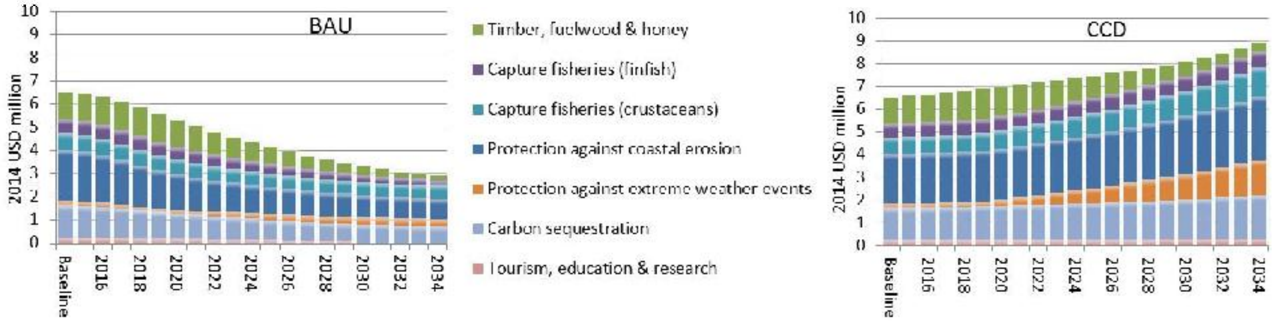


Table 6: South Kenya coast: value of mangrove ecosystem services under BAU and CCD 2014-34

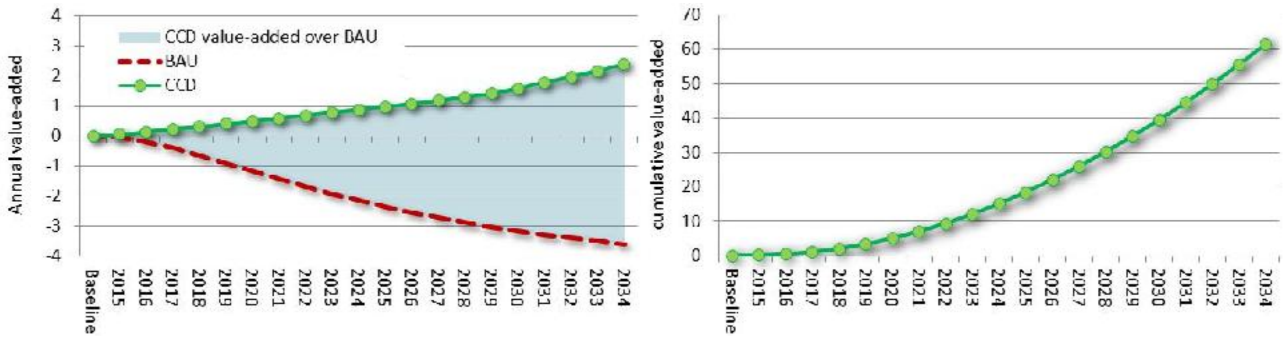
	BAU value (US mill)		CCD value (US mill)	
	Total over 20 years	NPV@10%	Total over 20 years	NPV@10%
Timber, fuelwood & honey	16.17	8.01	19.82	9.20
Capture fisheries (finfish)	9.25	4.20	13.78	5.45
Capture fisheries (crustaceans)	12.92	5.43	19.68	7.42
Protection against coastal erosion	28.36	12.94	50.24	19.72
Protection against extreme weather events	5.11	1.81	14.29	4.14
Carbon sequestration	20.10	9.02	33.55	13.04
Tourism, education & research	3.07	1.44	5.13	2.03
Total	94.98	42.85	156.48	61.01

Looking at the incremental gains and losses that will result over the 20 year period from BAU and CCD as compared to the ecosystem service values that would have been available had the area and quality of mangroves remained at current levels, BAU will incur total losses of around USD 41 million and CCD will add value worth more than USD 20 million in total (Table 7). These figures equate to a net present cost of USD 12.38 million for BAU over and above the baseline, and a net present value of USD 5.77 million for CCD.

Table 7: South Kenya coast: value-added by BAU and CCD over the baseline 2014-34

	BAU value-added over baseline (US mill)		CCD value-added over baseline (US mill)		CCD value-added over BAU (US mill)	
	Total	NPV@10%	Total	NPV@10%	Total	NPV@10%
Timber, fuelwood & honey	-7.94	-1.76	-4.29	-0.57	3.65	1.19
Capture fisheries (finfish)	-3.54	-0.98	0.99	0.26	4.53	1.25
Capture fisheries (crustaceans)	-2.12	-0.67	4.64	1.32	6.77	1.99
Protection against coastal erosion	-17.76	-5.76	4.11	1.02	21.87	6.78
Protection against extreme weather events	1.07	0.17	10.25	2.51	9.18	2.33
Carbon sequestration	-9.24	-2.88	4.21	1.15	13.45	4.02
Tourism, education & research	-1.73	-0.50	0.33	0.08	2.06	0.59
Total	-41.27	-12.38	20.23	5.77	61.50	18.16

Figure 12: South Kenya coast: CCD value-added over BAU 2014-34 (2014 USD million)



More than USD 61 million additional value (with a NPV of USD 18.16 million) will be generated over the next 20 years from CCD as compared to BAU (Table 7, Figure 12). This is, in effect, the return to investing in ecosystem-based climate-compatible development measures (or, conversely, the cost of policy inaction as regards sustainable coastal ecosystem management). By the year 2034, mangrove ecosystem services will be generating values worth almost USD 10 million a year under the CCD scenario (almost 40% more than what they are worth today), as compared to under USD 3 million under BAU (less than half of today's value).

4. Changing business as usual: capturing ecosystem values as finance and incentives for CCD

The valuation exercises carried out at both iCoast project sites succeed in making a strong economic case for green CCD options. They articulate the gains from investing in ecosystems as a key component of coastal development, adaptation and mitigation infrastructure. On the one hand, the findings from the Puttalam Lagoon study demonstrate clearly the losses that can arise from failing to factor ecosystem values into coastal development strategies. Since 1992/4, mangrove conversion has cost the local economy more than USD 31 million in foregone ecosystem service values. These losses are almost two and a half time higher greater than the additional income which was generated by shrimp farming and the other land uses that replaced mangroves (just over USD 13 million). On the south Kenya coast, ecosystem valuation shows the value-added from undertaking ecosystem rehabilitation and conservation as a core component of coastal development activities. Ecosystem-based CCD has the potential to secure an additional USD 60 million of mangrove service values over the next 20 years as compared to a business as usual situation. Conversely, the cost of policy inaction as regards ecosystem conservation is calculated at more than USD 40 million to the year 2034.

These economic analyses make the important point that ecosystem-based approaches to CCD have value not just because they provide a cost-effective way of securing climate adaptation and mitigation gains, but also due to the considerable development co-benefits that they generate for coastal populations in terms of value-added and costs avoided to other economic sectors and processes. The Kenya and Sri Lanka studies demonstrate that CCD approaches which integrate mangrove rehabilitation, conservation and sustainable use yield potentially high and wide-ranging economic gains. Conversely, omitting these values runs the risk of giving an incorrect picture of the relative economic desirability of alternative land, resource and investment choices, resulting in missed economic opportunities to strengthen development processes and enhance resilience in the face of climate change. At worst, in the absence of information about ecosystem values, substantial misallocations of resources can occur and go unrecognized, and immense economic costs can be incurred – often to the groups and sectors that are least able to bear them, or to cope with the effects of the loss of ecosystem services.

The economic analyses carried out under the iCoast project have focused on ecosystem valuation and on making the case for green CCD options. There is a growing body of literature on the economic value of coastal ecosystem services around the world. Such approaches are gaining currency as a convincing, and usually much-needed, way of demonstrating the development gains from ecosystem-based approaches to CCD. It is, nevertheless, important to underline that valuation is not an end in itself, but rather should be seen as a means to an end – better and more informed decision-making (Emerton 2014). Even if information on ecosystem values is a necessary condition for changing the way in which coastal trade-offs are calculated and development decisions are made, by itself it is rarely sufficient. However much coastal ecosystem services are demonstrated to be worth for climate adaptation and sustainable development in theory, this has little meaning unless it translates into real-world changes in the way in which policies are formulated and decisions are made, and is reflected in the prices and profits that people face as they choose between alternative land, resource and investment options (Emerton, 2012).

The Sri Lanka case, in particular, illustrates that what might be the most profitable or desirable or beneficial land, resource or investment choice from the perspective of the wider economy is not necessarily the one which has the most immediate appeal to landholders in coastal areas. Converting land to aquaculture and agriculture makes more financial sense to local landholders than sustainably using and managing mangroves. Shrimp farming, coconut farming and salt production all generate higher cash returns and more immediate sources of earnings for the landholder – even if (as is the case for shrimp farming) this income cannot be sustained over the long-term, or imposes significant negative impacts and externalities on other groups and sectors. The bottom line is that there remain few economic incentives for landholders to maintain mangroves on their land.

To a large extent these issues relate not so much to the absolute value of ecosystem services in relation to alternative land uses and development options, but concern how the ecosystem costs and benefits are distributed over time, space, and between different groups and sectors. While the direct and opportunity costs of coastal ecosystem conservation tend to be immediate and are incurred almost exclusively on-site, the benefits typically build up more slowly, and accrue to a wide range of other groups aside from the landholder. Conversely, while the bulk of the gains from ecosystem conversion accrue to the individual landholder or investor, the costs and losses that are associated with the loss of ecosystem services are felt much more widely, across the economy. Not only is this asymmetry of benefits and costs inequitable, but it is rarely efficient or sustainable in economic terms. There is no reason why coastal landholders (who are often among the poorest and most marginal groups) should subsidise the provision of economically valuable ecosystem services to others (especially when the beneficiaries are relatively affluent, or are gaining considerable value-added and costs avoided from their consumption or use of these services). In most cases landholders are unwilling – and often also economically unable – to do so.

Being able to shed light on where, for whom and in what form such imbalances in values are manifested provides important information for planning CCD actions. It indicates where there are needs, niches and opportunities to use economic and financial instruments to fill these gaps, align private and social costs and benefits and, ultimately, provide incentives and financing for ecosystem-based CCD. If valuable services are being gained at low or zero cost by off-site beneficiaries or are generating large economic surpluses for them, this may indicate that there is a niche or opportunity to tap into this uncaptured value so as to provide some kind of cash or in-kind payment, transfer or funding back to the landholder, in support of sustainable ecosystem management. Even where sustainable ecosystem management actions are clearly and unambiguously in the private interest of the landholder, the fact that offsite benefits are simultaneously being generated may also be grounds to argue that some form of redistributive mechanism is justified in order to remunerate or otherwise reward these actions.

The key challenge then becomes one of moving beyond merely articulating the value of coastal ecosystem services, and identifying where there are needs and niches to capture these values as concrete incentives and finance for CCD. The aim is to help to change the economic conditions and circumstances that cause landholders to convert or degrade ecosystems in the course of their economic activities, and instead set in place the economic opportunities and rewards which will stimulate the investments which are required to encourage, enable and motivate ecosystem-based CCD in coastal areas.

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